THE PARIAH CASE: SOME COMMENTS ON THE ORIGIN AND EVOLUTION OF PRIMITIVE DOGS AND ON THE TAXONOMY OF RELATED SPECIES

By

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Declaration

I, Tony Gonzalez, declare that this thesis, submitted in fulfilment of the requirements for the award of Doctor of Philosophy, in the Archaeology and Bioanthropology Program, Research School of Humanities and the Arts, College of Arts and Social Science, the Australian National University, is wholly my own work unless otherwise referenced or acknowledged. This thesis has not been submitted for qualifications at any other academic institutions.

[Signature]

A. Gonzalez
To Mervin, Roger, Sally and Bill; top dogs and dearest companions.
I heard on the radio an interview to Professor Colin Groves, and I can still remember myself thinking, “I like what I hear but surely he would not feel any interest in my rudimentary ideas”. More out of desperation than self-confidence, I sent him the outline of a project that I had been keeping in a drawer for several years. Surprising events took an unexpected turn when he gave his approval (thank you for that and for the inspiration, the mentoring and the tolerance during all these years). I started then what I consider one of the most exciting professional adventures of my entire life. Colin introduced me to Dr Ragavan Pathnamatan, whose kindness and deep knowledge of the Indian subcontinent, and particularly of the Punjab, was a decisive factor in the development of my work with pariah dogs. The help of his mentor, Dr U.K. Basu, Deputy Director General of the GSI at Chandigarh, a great gentleman of incredible resourcefulness, was crucial to the successful development of my five-month study tour through India. Dr K. S. Roy, Dean and Head of the Anatomy Department at the Veterinary College of Punjab Agricultural University at Ludhiana, very generously facilitated access to their vast collection of canine skeletal material. My very dear friends at the Prehistoric Fauna Section of the Zoological Survey of India, Dr Tarum K. Pal, Dr Supriya Nandy and Mr Raghudeb Bandyopadhyay, were at all times a living example of Bengali hospitality; scientifically speaking their assistance was faultlessly professional. Dr Manomay Ghosh suggested that it could be useful to study the Kanhiapan wolf, which at that stage remained almost forgotten in the collection of the Geological Survey of India in Bangalore; this proved to be great advice as the specimen has added a new perspective to the evolution of wolves in South Asia and the Middle East. At a personal level I found the warmth and outstanding human qualities of the Bengalis a source of encouragement and renewed hope. The impeccable facilities of the Bombay Natural History Society were certainly a very impressive sight; with his deep knowledge of Indian wildlife, its Director Dr Rahmani helped me to understand the role of wolves in contemporary India and showed a great sense of hospitality. Mr Chaturvedy, Curator of the Natural History collection, took excellent care of the logistic aspects of my visit. Dr Geeta Ramesh, Head of the Department of Anatomy at the Madras Veterinary College, managed to secure for me a very comfortable stay in Madras, and facilitated access to a very good collection of skulls of local dogs. Dr Kanlan and Dr Paramasivan also contributed greatly, with their courtesy and local knowledge, to my successful visit to that marvellous town. The generosity and tolerance towards my eccentricities of my friends at Mysore, Mr Kamal Baggai and Ms Pushpa Bobde, was beyond anything I can express with words. They certainly made sure that, at all times, I was making the best out of my visit. Dr Mewa Singh, another great Mysorean, invited me to an exceptional night out and shared with me his deep knowledge of Indian wildlife. Mr Srinivasa gave me the opportunity to measure some very interesting specimens, and showed me the reputed Van Ingen collection at the Regional Museum of Natural History in Mysore. Mr Manu K., from Mysore Amateur Naturalists, hosted me during an exciting visit to the Janapada Seva Trust in Melkote; this gave me the
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Abstract

This thesis describes our current knowledge on the taxonomy and archaeology of some Asian, African and Australasian Canis and explores new approaches to their classification and identity, using the Asian pariah as a pivotal point.

I analysed several populations of primitive dogs, and described processes of diversification. What in many places is simply designated "the village dog" is a subtype of the pariah; the Australian dingo is also connected to the pariah, although there are some peculiarities related to its non-domestic nature; and I propose a hypothesis on the nature of the pariah. Asian wolf populations contain substantial heterogeneity, and a review of the taxa lupus and pallipes and their intermediate forms in Asia is much needed. The so-called wolf jackal is an independent species from the golden jackal but the name Canis lupaster, frequently used for it, does not apply to it. Available documentary and collection data support a strong connection between C. mosbachensis and the pale footed wolf (Canis pallipes). A Pleistocene wolf skull from the Narmada Valley may exemplify the transition from the smaller wolves of the Pleistocene drylands to the larger types that populated the Levantine highlands during the Natufian. The Natufian dogs are a very variable group; Neolithic materials from the Middle East and South and Central Asia are morphologically closest to modern types of pariah. Finally the extensive sampling conducted during this work provided evidence of aberrant specimens among some of the studied populations.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Declaration</td>
<td>2</td>
</tr>
<tr>
<td>Dedication</td>
<td>3</td>
</tr>
<tr>
<td>Acknowledgements</td>
<td>4</td>
</tr>
<tr>
<td>Abstract</td>
<td>8</td>
</tr>
<tr>
<td>Grants</td>
<td>10</td>
</tr>
<tr>
<td>Introduction</td>
<td>11</td>
</tr>
<tr>
<td>Chapter I: Materials and Methods</td>
<td>13</td>
</tr>
<tr>
<td>Chapter II: Literature Review</td>
<td>16</td>
</tr>
<tr>
<td>Chapter III: Extant Primitive Dog Populations</td>
<td>45</td>
</tr>
<tr>
<td>Chapter IV: Wolves: Taxonomical Issues and New Findings</td>
<td>136</td>
</tr>
<tr>
<td>Chapter V: Other Wild <em>Canis</em></td>
<td>185</td>
</tr>
<tr>
<td>Chapter VI: Palaeontological and Archaeological Remains</td>
<td>209</td>
</tr>
<tr>
<td>Chapter VII: Discussion</td>
<td>285</td>
</tr>
<tr>
<td>Chapter VIII: Conclusions</td>
<td>302</td>
</tr>
<tr>
<td>Appendix I: Collections</td>
<td>308</td>
</tr>
<tr>
<td>Appendix II: Measurements</td>
<td>310</td>
</tr>
<tr>
<td>Appendix III Indices and Calculated Values</td>
<td>315</td>
</tr>
<tr>
<td>Appendix IV: Specimens list</td>
<td>317</td>
</tr>
<tr>
<td>References</td>
<td>333</td>
</tr>
</tbody>
</table>
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INTRODUCTION

The origin of the smaller Natufian dogs (Clutton-Brock 1962, Davis and Valla 1978, Tchernov and Valla 1997) has remained until now a mystery (Koler-Matznick 2002), since discrepancies related to matters of scale seem to distance their morphologies from that of the large wolf, that according to the Bergmann’s rule should have inhabited the Mount Carmel area during the Epipalaeolithic (Dayan 1994, Tchernov and Valla 1997). To bridge this gap the Indian wolf (Canis lupus pallipes) and the Arabian wolf (Canis lupus arabs) have been commonly cited as alternative candidates (Allen 1920, Degerbol 1961, Lawrence 1967). Nonetheless scientific works analyzing in depth the morphological affinities, and possible evolutionary links, between these wild canids and primitive dogs are a rarity.

For this very reason this work deals extensively with the origin and evolution of the pariah, the most primitive extant Asian dog type, and also with the taxonomy of the wild species that may be connected to it, either through evolution or hybridization. Accordingly, I have tried to appraise the potential existence of an independent domestication centre in the Levant; data involving other possible domestication centres (mostly in Europe and America) have been deliberately left out for reasons of time and space. I am fully conscious that voices may be raised arguing that the Asian pariahs might be related to other forms from outside; and this is precisely the objective of this thesis - to test the existence of a dog domestication process in Asia that does not involve “external” influences and that exclusively relies on local wild species for its development.

Perhaps one of the first topics coming to mind when one has to confront issues of domestication is: what is the taxonomic status of the central subject of the study (in this case the pariah dog)? Since the grey wolf (Canis lupus), as previously implied, has routinely been quoted as the most acceptable ancestor of the domestic dog (Clutton-Brock 1984, Olsen 1985, Morey 1992, Wozencraft 1993), the latter in turn was described as a subspecies of grey wolf (Canis lupus familiaris) (Wozencraft 1993). Yet there is still much to learn about this transition, as noted by Koler-Matznick (2002); she contends that some dog traits are “possibly plesiomorphic” and not the end result of wolf domestication. To this effect she recommends the re-evaluation of some smaller canids from the Pleistocene. I will try in some of the following pages to address this issue.

The use of scientific names for domestic varieties was questioned by Groves (1995); one of his reasons was that it would be problematic, to say the least, to pass on a scientific name from a wild species to its derived domesticated form, when the latter could be traced to more than one ancestor. This point is particularly applicable to this study, and in consequence I use for the pariah nothing else than its common name. This approach seems to work, as common English names suffice to identify pariah dog populations and its different types.
I have made the attempt to study some wild *Canis*, closely related to the pariah dogs whose taxonomical status remains unclear, after so many years it is quite surprising how poorly researched some canid taxa remain. Needless to say many regions are still under-surveyed and we do not even know what lives there; southern Central Asia comes to mind as a good example of this, but there are many others. I must admit however that the analysis of wild populations entered this research almost by accident; its interest became apparent as I was analyzing the morphology of some small wolf types that seemed good potential ancestors for the pariah.

I have studied as many archaeological specimens of wild and domestic canids from as many relevant sites and chronologies as possible, using as a guideline the available literature and sometimes personal suggestions from well informed scholars. The final results include a number of analyses that seem to shed some light on the possible origin and evolution of the primitive dogs from the Middle East and neighbouring regions. I have also incorporated into my argument some environmental considerations that may help to understand the main forces that shaped the morphology of the pariah dog.

Over the past few years, there has been a considerable amount of DNA research on dogs and their origins; much of this has been published in the past two years or so, while this thesis was in its final revision stages; for this reason, and because my expertise is morphological, not genetic, I have avoided dealing with DNA data except in a few relevant places.

The main lines of enquiry that this work attempts to follow were inspired by Colin Groves (2003 pers. comm.) and by Janice Koler-Matznick's (2002) article. The methodologies were mostly sourced from Simpson (1941), Nowak (1979) and Corbett (1995).
CHAPTER I
MATERIALS AND METHODS

1.1 Study samples

This work is largely based on data obtained at 29 museums, universities and private collections (see Appendix I). A total of 1,041+ recent and archaeological specimens of wild and domestic Canis were studied. As expected, archaeological samples were mostly fragmented, while recent materials were much better preserved; those held at teaching institutions, such as veterinary schools, routinely missed some of the more “vulnerable” elements (notoriously nasal bones and canine and carnassial teeth). Most of the museums I visited displayed admirably well curated research collections.

For identification purposes, and whenever possible, I adhered to catalogue numbering as given by the institutions where the specimens were held. This was not always feasible, particularly in India, where materials at veterinary schools often lacked any code of identification; I found a similar situation at the zooarchaeological collections of the Field Museum, where the abundance and fragmented nature of the samples had made it impossible to bestow collection numbers. In all these cases I followed my own numbering system, as I felt that this would be the best possible option that would allow me to track down specimens, should this need arise.

1.2 Graphic documents

During my study trips I took many photographs of live and osteological specimens, which were highly useful in order to analyze qualitative traits. All my photographs were taken with a Minolta Dimage 7 HL. Photographs of skins and skeletal specimens were often taken indoors using either natural light or whatever means of artificial lighting were available on the premises, but never with the aid of a flash; a dark blue cloth was used as a background in most cases. Photographs of live specimens were always taken outdoors and in natural settings. Some of my friends and colleagues have also generously allowed me to use their own photographs to illustrate some of the more deficiently known taxa (see photo captions).

The website owned by Rajashree Khalap (www.indog.co.in) has interesting photographs of Indian pariahs which I have used to complement my own data on their external conformation. In a similar fashion, the photographs of Israeli pale footed wolves visiting feeding stations in the Negev desert, posted by Yoram Shpirer in the internet (www.pbase.com/shpirery/profile), were very useful in order to document the morphology and colouring of this variety. Very generously, Colin
1.3 Measurements

A total of 44 different cranial, mandibular and postcranial measurements were taken from every complete specimen. Eight non-metrical traits were also evaluated through an arbitrary scoring system.

Most of the osteological measurements used in this work were sourced from von den Driesch (1976). A limited amount was obtained from Corbett (1995). For a list of measurements and a brief description of them see Appendix III.

Linear measurements were collected through a variety of means. When feasible digital callipers were used:

1) A needle point set (Paleo-Tech Hillson-Fitzgerald Dental Calliper) made by Paleo-Tech Concepts to measure teeth and teeth alveoli.

2) A large size set (Paleo-Tech Digital-Linear Spreading Calliper) made also by Paleo-Tech Concepts, capable of taking measurements of up to 269.76 mm to measure the length and width of the larger crania.

3) A standard size set (Absolute Digimatic) made by Mitutoyo, to measure the rest of the metrical traits of the skulls.

A 150.00 cm uncased nylon tape measure, made by Paleo-Tech concepts, was used to measure the perimeter of bone shafts. Cranial capacities were measured by filling the brain case to its full capacity with millet seeds, after blocking all cranial foramina with plasticine to prevent spilling; the full volume of grain was then transferred to a measuring glass cylinder to be calculated. When feasible, body weights were collected, from dead specimens, using a Pesola spring scale with a maximum weighing capacity of 35 kg.

I measured personally most of the specimens included in this work. Exceptions are the materials from Berlin and Frankfurt, measured by Prof. Colin Groves, and those from Strasbourg measured by Emilie Guttmann and Loic Bourie.

1.4 Data analysis

The methodology of this work is heavily grounded on morphometrics. The data were analyzed using univariate, bivariate and multivariate analyses as well as log ratios; the pertinent graphs and diagrams will be found accompanying the text. Most data were analyzed though PASW statistics version 18; indices and values for Corbett's Canonical equation and simple statistics (average, standard deviation and range) were directly calculated using Excel Files.
Following Corbett's (1995) successful approach I used Discriminant Function Analysis (DFA) as the central tool for analysis. The efficiency of this technique in morphometric studies was previously justified by Jolicoeur (1959). It is based on the synchronic maximization of differences among groups, relative to within-group variation, within a multidimensional space; the number of axes, within this space, will equal the number of variables covered by the analysis. The number of variables included in the analysis is not limited; the only proviso is that it should preferably not exceed the number of individuals included in the smallest group. Trial and error suggested that the analysis retains more relevance if the number of groups studied at the time is limited to three, although there is no limit on the number of times that the same group can be compared with others. Multivariate analysis also offers the added advantage of the final result being easy to represent, and visualize, in a bidimensional diagram.

I have also strongly relied on log ratios as described by Simpson (1941), particularly when the samples were too small to conduct DFA of separate individuals, or when the outcomes of DFA were inconclusive. The diagrams generated offer a view of the differences, along an axis or points that represent variables, between a standard specimen or specimens (flat line) and the rest of the specimens included in the analysis (usually zigzagging lines). The farther apart from the standard, and the more circuitous the lines are, the bigger the difference.

Three different indices (cephalic, teeth crowding and teeth overlapping) were also calculated. Body weights were estimated according to methodologies proposed by Clark (1997), or directly collected from dead specimens when possible. All indices and estimates used in this work are listed in Appendix III.

1.5 Data presentation

The reader may notice that in some graphs and diagrams different symbols may represent the same species and varieties; this is due to an attempt on my side to increase contrast, and therefore help with the visualization of the graphic materials.

Also, at times, pale footed wolves may appear as *Canis pallipes* or *Canis lupus pallipes*, in some graphs and diagrams; equally wolf jackals may appear as *Canis lupaster* in others. Both situations have to do with the way this work has been progressing and how I found necessary to change the naming of both taxa as the work evolved.

1.6 Note on identification and intraspecific variability

Reed (1961), following Lawrence (1956), drew attention to the possibility of pariah dogs being misidentified as wolves, and specifically singled out some specimens collected in Mesopotamia, held at the Field Museum, that may have been erroneously classified. This was a constant problem through my study, but I think I was able to disentangle pariahs from wolves at least in most cases. Likewise,
craniometrics proved useful in discovering unlooked-for taxonomic divisions and breaks between neighbouring taxa.

CHAPTER II
LITERATURE REVIEW

2.1 Introduction: methodological approaches to the study of Canis

Jolicoeur (1959) pioneered the application of multivariate analysis to canid morphometrics, finding that many of the previously described subspecies of North American wolf were difficult to justify and that most of the variability was due to climatic factors; he reviewed this assessment later (Jolicoeur 1975) and proposed that that, at least in part, size and shape differences might be genetic.

McCarley (1962) studied the relationship between coyotes and red wolves in the south central United States, through univariate analysis of cranial data. Lawrence and Bossert (1967) followed a very similar approach in their study on North American wolves and coyotes, and centred their attention on the identity of the red wolf which they referred to as Canis niger. In their next work they applied a very similar technique to the study of New England Canis (Lawrence and Bossert 1975). Kolenosky and Standfield (1975) made use of univariate and multivariate analysis to study morphological variability in grey wolves from Ontario.

Gipson et al. (2002) used primarily descriptive techniques to analyse the colour patterns of wolf populations from North America.

In a detailed and wide-ranging monograph on North American Quaternary Canis, Nowak (1979) utilized univariate, multivariate and log ratio analyses. Likewise, univariate and multivariate analyses dominated his work on the wolves from the North American east (Nowak 2002). Nowak and Federoff (2002) also employed multivariate analysis to clarify the taxonomic status of the Italian grey wolf.

Siracusa and Lo Valvo (2004) found, through multivariate analysis, significant differences in the morphometrics of the skull between Italian and Spanish wolves.

Several papers have explored the comparative osteology of domestic dogs and dingoes. Morey (1992) extensively used bivariate analysis and allometric principles to differentiate between size-required and size-related changes. He described the more differential traits of the dogs as size-related. Macintosh (1975) in his study on dingo origins used univariate analysis of morphological indices to investigate differences between dingoes and domestic dogs. It was Newsome et al. (1980) who first applied multivariate analysis to this theme, and they were followed by Newsome and Corbett (1982) and Corbett (1985, 1995); the latter author used multivariate analysis to study dingo morphology and its relationship with other canid populations from Asia.
2.2 Fossil wolves and their geochronological context

In China *C. lupus* is represented for the first time in the fossil record by a medium sized form in Zhoukoudien (Kurten 1968). Pei (1934) portrayed the Zhoukoudien wolf as similar, but not identical, to the current living forms from Manchuria and Mongolia. The main differences are a more slender muzzle, an underdeveloped, or absent, sagittal crest and some small divergences in the shape of the upper carnassial and molars.

Payne (1983) described three medium size hemimandibles found in a Mousterian context in the Douara caves in central Syria, provisionally dated around 40,000 BP although there is now evidence of an older age (Payne, pers. com. 2003). Payne's morphometric study, based on a bivariate analysis of dental and osteological features, related this otherwise highly polymorphic sample to current populations of *C. l. arabs*. He interpreted these findings as a possible indication of a still undescribed type of desert wolf, possibly ancestral to *C. l. arabs*, inhabiting at that time the arid lands to the east of the coastal Mediterranean ranges of the Middle East (Payne 1983). Remains from much larger Mousterian grey wolves, whose dentition size approached that of present-day Northern European wolves, were discovered in the caves of Ksar’Akil near Beirut (Hooijer 1961). A decrease in the body size of this species was documented by Dayan (1994) during the Aurignacian and Levantine Aurignacian in the Middle East; specimens of *C. lupus* from that era, initially much larger, became similar in size to the heaviest of contemporary Israeli *C. l. pallipes* (Dayan 1994). The Geometric Kebaran wolf, living along the seaboard ridges during the Epipalaeolithic, became again much larger and was portrayed as “enormous” (Davis and Valla 1978, Dayan 1994). The intriguing medium-size Natufian canids from Wady-el-Mughara, Kebarah, Zuttiyeh and Shukbah (Bate 1927, Clutton-Brock 1962), were described under the name *C. lupus* by Kurten (1965).

The "wolf event", as it has been described, was a sudden increase in the number of species of the genus *Canis* in Europe during the Late Villafranchian (Rook and Torre 1996); most of these new arrivals had the Asian continent as a point of origin, characterized by the expansion of *Canis etruscus* Major, a medium size wolf-like canid found in China, Georgia, Italy and Spain, which presented some of the archetypical characteristics of a primitive *Canis*, such as a long snout, large auditory bullae, relatively long carnassial teeth, enlarged sagittal crest-occipital ridge region, well developed cingulum on UM1, and a strong metaconid on LM1 (Del Campana 1913, Torre 1967, Sotnikova 2001). The Chinese variety of *Canis etruscus* is probably the oldest, dating back to 3 mya (Rook and Torre 1996); the earliest European remains were discovered in Italy within the context of the Olivola faunal unit (1.8 mya) (Rook and Torre 1996). The species has been described as the probable ancestor of *Canis lupus* (Del Campana 1913, Kurten 1968, Rook and Torre 1996, Arribas pers. com. 2003). Torre (1967) defined it as a small protowolf displaying a primitive dentition. Other authors characterized it as having an intermediate body weight (approx 10 kg), unspecialized dentition, and a wolf-like general appearance (Kurten 1968, Palmqvist et al. 1999, Palmqvist et al. 2002). Torre (1974) interpreted a Middle Pleistocene sample found at L'Escala cave,
central France, as transitional between *etruscus* and *lupus* (Tedford et al. 2009). A relatively similar form, *C. priscolatrans*, has been found in North America in Irvingtonian and Blancan deposits (Kurten 1974).

The first genuine modern wolf (*Canis lupus mosbachensis* Soergel) appeared for the first time in Hundsheim and Susenborn, circa 1 mya, and was common in the later sites of Cromer Forest Bed, Mauer and Mosbach (Kurten 1968). This subspecies was of medium size, similar to the contemporary wolves from the Middle East. Sotnikova (2001) redescribed it as a different species, *C. mosbachensis*, using as reference specimens from the late Early Pleistocene of Untermassfeld; she also allocated to this species the large sample from L'Escala cave (Southeastern France) which had been initially reported by Torre (1974). Similar specimens were also discovered in the Middle Pleistocene of Tarko, Lunel-Viel, Heppenloch and Grey's Thurrock (Kurten 1968).

The main characters differentiating *C. mosbachensis* from *C. etruscus* are said to be the presence of a relatively elevated rostral area, a comparatively narrower frontal shield, and curved lower dental series (Sotnikova 2001). Sotnikova published a rather complete set of measurements from specimens found at Untermassfeld, near Meiningen (Southern Thuringia, Germany); the total length of one skull was 217.0 mm, the average length of a sample of five upper carnassials was 21.64 mm (range= 20.4-23.0), while the length of the lower carnassial averaged 24.44 mm (range= 23.3-25.9) for a sample of 16 specimens. She contended that her skull from Untermassfeld is more similar to *C. pallipes* than to other larger forms, and attributed this to its primitive character (its small size, relatively elevated frontals, comparatively straight dental series, and the presence of a complete buccal cingulum in the first upper premolar), but it differs in that *mosbachensis* has a narrower braincase, a longer muzzle, longer toothrows, less developed canine teeth and larger upper molars; the lower carnassial of *mosbachensis* presents a well developed metaconid.

Nowak (2002) provided measurements for the carnassial length of five specimens found in the Lake Baikal region, dated at 700,000 BP; the mean is 25.4 mm, with a range from 23.0 to 27.5. He also proposed a hypothetical scenario by which the smaller wolf taxa, those currently inhabiting warm weather environments, would be direct descendants of *Canis mosbachensis*.

Tchernov and Tsoukala (1997) identified a lower carnassial tooth found in Bear Cave, an early Toringian site (250,000 BP maximum) of Upper Galilee, as *C. lupus* cf. *mosbachensis*; it presents a well developed metaconid and measures a total length of 22 mm. The possible presence of *C. mosbachensis* in Ubeidiya (Lower Pleistocene, central Jordan Valley) was suggested by Haas (1966), who based his comment on the size of a single second lower molar from this site.

*Canis lupus variabilis*, another small wolf, was described from Zhoukoudian Locality 1, associated with *Homo erectus*, and is recorded in Lantian in Shaanxi Province (Olsen 1985). This taxon is described as being notable by its gracility and small size (Pei 1934, Olsen 1985); some of its salient characteristics are a sagittal crest that is less developed than in typical wolves, a thinner muzzle, and a
mandible whose ventral margin is, in some specimens at least, convexly shaped while the mandibular ramus can be quite shallow in some specimens (Pei 1934). Teeth are, on the other hand, from medium (21 mm) to large size (25 mm) (Pei 1934), which is obviously somewhat closer to what can be found among wolves (Koler-Matznick 2002). Pei (1934) noted the presence in the sample of specimens with rather crowded mandibular dental series, associated with a shorter mandible. Because of these morphological peculiarities (with the exception of tooth size), and because it lived sympatriically with typical wolves for "tens of thousands of years" (Koler-Matznick 2002); this form has sometimes been quoted as a possible ancestor of the domestic dog (Olsen 1985, Koler-Matznick 2002). Of particular interest is that remains from the Early and Middle Pleistocene of Central Asia have been referred to this taxon, or to a closely related form, under the designation Canis ex gr. mosbachensis-variabilis (Sotnikova 2001). It is conceivable that this form had adapted to the relatively isolated cold and arid plains of Turkmenistan, Uzbekistan and Kazakhstan (Harrison pers. com.). Tedford et al. (2009) indicated that the taxa C. mosbachensis and C. variabilis may represent geographic variants of the same species.

The oldest C. l. pallipes remains in the Indian subcontinent (Prashad 1936) were identified from Harappa (3300 BC – 1300 BC), and a badly preserved skull (upper carnassial length= 19.9 mm) found in Langhnaj (2,500 – 2,000 BC) was ascribed to this subspecies by Clutton-Brock (1965). Gosh (1995) referred to the finding of wolf materials in Burzahom, in strata corresponding to the Late Neolithic (1500 BC - 700 BC) and Megalithic cultures (500 BC - 200 BC), and in non-stratified locations. He indicated that the recovered specimens were similar in size to those found in Harappa, and implied that were comparable to those of recent Indian wolves.

A larger form of wolf has been found in a variety of Middle Pleistocene sites in Europe; a particularly good sample of it was unearthed at Tornewton Cave in England (Kurten, 1968). Kurten (1968) and Nowak (2002) proposed that this type would mark the transition from the lightweight C. etruscus to the bulkier, and widespread, grey wolf of later in the European Pleistocene (Kurten, 1968). After the last glacial period, the larger varieties of grey wolf gave way to somewhat smaller ones (Kurten, 1968); since then, documented populations of European grey wolf appear to have changed very little (Owen 1846, Kurten 1968, Aaris-Sorensen 1977).

A number of authors (Bar-Yosef 1980, Munro 2003, Issar 2003, Robinson et al. 2006) have turned to the study of climatic change in an attempt to explain faunal sequences and cultural evolution in the Levant. Bar-Yosef (1980) found that a change occurred, in this region at the turn of the Lower Palaeolithic, from the cool and humid conditions, characteristic of the Lower Mousterian, to a colder and drier weather during the Upper Mousterian and the beginning of the Upper Palaeolithic (42-19,000 BP). He also commented on the development of a humid phase towards 34-22,000 BP, which would partly incorporate the Aurignacian period (40-28,000 BP); conditions turned drier once more after this wet period, and stayed as such until 14,500 BP (Bar-Yosef 1980). Issar (2003) described a slight increase in humidity during the Kebaran (19-14,500 BP) and the development of yet another wet period during the Geometric Kebaran (14,5-12,500 BP); his model is largely consistent with that of Van Zeist (1980, see Issar 2003), who suggested the
development of cold and dry conditions during the Kebaran (24 – 14,000 BP), and their transformation into a warmer climate between 14,000 and 10,000 BP. Munro (2003) placed the beginning of the postglacial period, during which the climate stayed humid, at ca. 19,000 BP until the onset of the Younger Dryas (ca. 13-11,500 BP), a short interlude characterized by cool and dry conditions; it was during this phase that the Natufian period (12,500 – 10,300 BP) started to develop. The climate turned again warm and humid ca. 11.5-7,000 BP (Munro 2003), although Issar (2003) described the commencement of another drier phase ca. 10,000 BP.

A comprehensive review paper on Levantine palaeoclimates was published by Robinson et al. (2006), basing their discussions on palynological and salinity data. They described a perceptible overall increase in temperature and rainfall from the Late Pleistocene to the Holocene. Of particular interest are two Late Pleistocene climatic events, the Bolling-Allerod warm interval (circa 15 – 13,000 BP), and the Younger Dryas (circa 12.7 – 11,500 BP); both bring a degree of discontinuity to the general idea of an even and steady process of increasing warmth and humidity during the transition from the Pleistocene to the Holocene. The Bolling-Allerod has been described as a warm and wet period characterized by a vigorous expansion of oak forests (Rossignol-Strick 1995); but there are some discrepancies in the chronology, intensity and extension of this event, which is based on inconclusive data from the marine record, and there is even a possible misdating of the whole event, which could have started 1,500 years earlier (Robinson et al. 2006). Compared to the Bolling-Allerod and the later Holocene, the Younger Dryas is described as cold and dry, although there seem to be some geological inconsistencies, since the development of aridification processes have not been clearly ratified by the marine strata (Robinson et al. 2006). To complement this view Horowitz (1971, 1989) proposed that, in Israel, the glacial phases were characterized by cold weather coupled with high rainfall, liable to occur also during the summertime; interstadials were to announce the current weather pattern present in the region, with dry long hot summers and short and humid winters, and interglacial periods were hot and dry, dominated essentially by a desert-like type of weather; he did not rule out the occurrence of dry phases in Israel, at the zenith of the glaciations, but insisted that the general weather pattern had to be humid, particularly at low altitude.

A minority of scholars have followed the opposite path, and attempted to infer climatic patterns through faunal assemblages. Bate (Garrod and Bate 1937) detailed a succession of well documented faunal assemblages at Mt Carmel; she covered a substantial geochronological period from the Upper Acheulean (level F of Tabun) to the Natufian (level B of M. Wad). As far as climatological matters concern she suggested that there was no evidence of cold weather events developing in any of the archaeological contexts that she analyzed except perhaps during the Upper Levalloiso-Mousterian (Tabun E), when she identified a sudden change in faunal composition; furthermore she identified a warm and moist climate pattern ("probably tropical") during the Upper Acheulean. She also described the presence of three alternating wet/dry periods between the Upper Acheulean (Tabun E) and the Natufian (Wad B); she based this conclusion on the reduced abundance in the deposits of fallow deer (wet climate indicator) vs. gazelle (dry climate indicator) (in Garrod and Bate 1937). Mostly in disagreement with her main proposals, in the
field of climate, Garrard (1982) argued that the evidence of a humid tropical weather in the level F of Tabun (Upper Acheulean) was rather weak as it was mostly based on the presence of *Megaderma watuwat*, a bat species whose closest extant relatives are currently found in tropical regions (India and Ethiopia). He suggested that this species could be only a relic from the Miocene, when the climate of this area was clearly identifiable as tropical; he also mentioned other authors such as Horowitz (in Jelinek et al. 1973) who had found through palynology that the climate at Tabun from levels G to M was of arid type, and Tchernov (1962, 1968) who could not identify any signs pointing towards the existence of tropical environments at Umm Qatafa, another interglacial site of the Levant. Garrard (1982) downgraded as well the assertion of Bate (in Garrod and Bate 1937) in regards to a “faunal break” during the late Middle Palaeolithic from Tabun C / Skhul B to Tabun B / Wad G, as a detailed examination of the archaeological record could only identify three different species of small mammals, one bat and two ungulates, as permanently disappearing from more modern faunal assemblages. The last contentious issue that Garrard pointed out, in his analysis of Bate’s work (in Garrod and Bate 1937), refers to the uncertain validity of using fallow deer and gazelle remains to identify pluvial patterns; after reviewing a range of ideas (Hooijer 1961, Ducos 1968, Harrison 1968, Saxon 1974), he finally gave his support to Tchernov’s (1968) claims, specifying that climatic inferences could only be based on complete faunal series and not on a selected number of species. Garrard (1982) also gave his support to Tchernov (1968) when he described evidence, among the rodent faunas of the Upper Pleistocene, of increasing aridity during the Wurm glaciation.

The fauna of the Levant at the end of the Pleistocene was in general characterised by Boreal Eurasian species (Payne 1983), corresponding to a temperate type of environment dominated by grassland plains and forested mountain ranges. Some characteristic large herbivores of this period were fallow deer (*Dama mesopotamica*), red deer (*Cervus elaphus*), roe deer (*Capreolus capreolus*), bezoar (*Capra aegagrus*), aurochs (*Bos primigenius*), steppe rhinoceros (*Dicerorhinus hemitoechus*), wild boar (*Sus scrofa*), mountain gazelle (*Gazella gazella*) and two different equine species (Davis 1974, Tchernov 1979, Davis et al. 1988, Bar-Oz and Dayan 1999, Griggo 2004, Rabinovich and Hovers 2004); significant species within the carnivore guild were spotted hyena (*Crocuta crocuta*), wild cat (*Felis libyca*), Eurasian badger (*Meles meles*), stone marten (*Martes foina*), red fox (*Vulpes vulpes*), leopard (*Panthera pardus*) and lion (*Panthera leo*) (Kurten 1965, Bar-Oz and Dayan 1999, Griggo 2004); within the small fauna, the spur-thighed tortoise and the Cape hare seem to have been particularly abundant (Churcher 1994, Munro 2004).

Davis et al. (1988) and Munro (2004) described a faunal sequence in the Levant, during which the species guild rich in large mammals, typical of Mousterian sites, changes in the transition to the Upper Palaeolithic into one characterized by a greater presence of medium size ungulates such as roe deer, mountain gazelle and bezoar; this one also eventually changed, during the Epipalaeolithic, into a faunal assemblage dominated by small game species like tortoises, partridges and hares (Munro 2004). The cause was attributed to the steady increase in hunting pressure exercised by the growing human population of the region (Davis et al. 1988, Munro 2004). Kurten (1965) investigated whether Bergmann’s Rule could account for these changes, but the results were inconsistent. Some support for Bergmann’s
Rule was found by Bar-Oz and Dayan (1999), in the case of a hare found in Neve David (Geometric Kebaran), and by Davis (1974) after studying the fox sample found at Ein Gev I (Kebaran). Davis (1981) gave further evidence supporting the existence of dwarfing, during the transition from the Pleistocene to the Holocene, in five different Levantine species (fox, wolf, wild boar, aurochs and goat), and attributed this to an increase in average temperature, to which some species responded by decreasing their body size.

A very similar assortment of carnivores was described by Mashkour et al. (2009) for Wezmeh Cave, a Late Pleistocene site (35-13,000 BP) in the west-central Zagros; the series includes spotted hyena, brown bear, wolf, red fox, lion, leopard, Eurasian badger and stone marten. Prey species at the site are also quite similar to those found in the Levant, such as bezoar, wild boar, red deer, aurochs and horse, but without fallow deer and roe deer; some forms more specific to this region were also recovered, such as wild sheep (Ovis sp.) and Gazella cf. subgutturosa. Turnbull and Reed (1974) reported on Palegawra Cave, a Zarzian site (15,000 BP) further north in the foothills of the Zagros in Northeastern Iraq; they described the climate of this area during the Zarzian period as “classic Mediterranean”, the slopes covered mainly by an open forest of mixed Quercus and Pistacia, the valley floors and the plains with grasses with sparse cover of oaks and junipers at the edges. The faunal assemblage of Palegawra is reminiscent of that of Wezmeh Cave (Mashkour et al 2009), minus lion, leopard and spotted hyena, and to that of the Palestine Caves (Kurten 1965, Davis 1974, Tchernov 1979, Davis et al 1988, Bar-Oz and Dayan 1999, Griggo 2004, Rabinovich and Hovers 2004) except for fallow deer and roe deer, and with the interesting addition of a canine hemimandibular fragment identified as belonging to Canis cf. familiaris (Turnbull and Reed 1974).

Towards the interior, such as in the surroundings of Douara cave, a Palaeolithic site (55 – 40,000 BP) in the Syrian desert 18 km northeast of Palmyra, the climate at the end of the Pleistocene and during the Holocene was much drier than that of the coastal environments of the Levant (Payne 1983). Summertime here is expected to be long, hot and dry, and the very limited amount of rainfall should fall almost exclusively during the winter; the vegetation is of the steppe type, with drought resistant grasses and forbs, and some shrubs and low trees usually in clumps of variable size. The megafauna consisted of elements of the Saharo-Indian mammalian fauna, like caprovinies (possibly Ovis), equids (possibly onager), desert gazelle, camel and lion; the small fauna included some typical desert taxa that still inhabit the area, especially Meriones, Allactaga, Jaculus and Gerbillus. There were also medium size carnivores: red fox, fennec and caracal.

Some faunal assemblages in some respects intermediate between the two major regions previously described have been described from the Negev desert; one from Rosh-Zin (Natufian) had ibex (Capra nubiana), desert-living gazelle (Gazella dorcas), fallow deer, wild donkey (Equus africanus) and Meriones (Tchernov 1976); another, Nahal Divshon (pre-Pottery Neolithic), included aurochs, ibex, gazelle (possibly the desert species) and fallow deer (Marks 1975); and Gilead and Grigson (1984) reported aurochs, camel and hartebeest (Alcelaphus buselaphus) from Far'ah II, a Mousterian site in the northern Negev (Davis et al 1988).
Grey wolf remains have been recorded at most of the major Upper Pleistocene sites of the Levant; its presence during the Natufian has been, nonetheless, strenuously debated (Hooijer 1961, Kurten 1965, Davis and Valla 1978, Dayan 1994, Tchernov and Valla 1997). Dayan (1994) cited a wolf carnassial found at Tabun B (Mousterian, 45,000 BP) that had a total length of 29.03 mm. Hooijer (1961) provided data of four wolf lower carnassials found at Ksar’Akil, a coastal Lebanese Upper Pleistocene site; three of them were rather large (31.8 – 29.5 mm), of a size comparable to recent central-European wolves, a fourth one was much smaller, similar in size to contemporary *C. pallipes* (25.4 mm). A wolf lower carnassial found at Ein Gev (Davis and Valla 1978), a Geometric Kebaran site (14,000 - 13,000 BP), was again quite hefty (28.6 mm). Another lower carnassial (Dayan 1994) found at Neve David (Geometric Kebaran, 13,000 BP) was of robust type (28.82 mm). In contrast, some more smaller wolf-like lower carnassials have also been described in addition to the one from Ksar’Akil (Dayan 1994) from Kebara E (Aurignacian, 30-25,000 BP) measuring 25.10 mm, and Kebara C (Kebaran, 24-14,000 BP) measuring 23.23 mm.

<table>
<thead>
<tr>
<th>SITE</th>
<th>PERIOD</th>
<th>CHRONOLOGY</th>
<th>CLIMATIC CYCLE</th>
<th>LARGE WOLVES</th>
<th>SMALLER WOLVES</th>
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<tbody>
<tr>
<td>Ksar’ Akil</td>
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<td>31.8 - 29.5 mm (N=3)</td>
<td>25.4 mm (N=1)</td>
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<tr>
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<td>45,000 BP</td>
<td>stadial</td>
<td>29.03 mm (N=1)</td>
<td>25.1 mm (N=1)</td>
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<td>28.6 mm (N=1)</td>
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<td>Kebara C</td>
<td>Kebaran</td>
<td>24-14,000 BP</td>
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<td>Ein Gev IV</td>
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<td>Neve David</td>
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Table 1. Summarizing some of the more relevant data about the modern wolf types found in the Levant at the end of the Pleistocene. In the last two columns, the figures refer to lower carnassial length.

Outside the Levant, a series of three hemimandibular fragments (1983) found at Douara Cave in a Mousterian context (40,000 BP+, Payne pers. comm.) should be also included in the group of smaller-sized wolf-like canids, each fragment belonging to a different individual (Payne 1983); one of the specimens (805.6-1), identified as belonging to a young animal, had a very small LM1 metaconid, a LM1 length of 22.7 mm, and a mandibular height of 24.1 mm; another (809.6-1), thought to be a subadult, had a well-developed metaconid, a LM1 measuring 22.5 mm in length and a rather shallow mandible 17.5 mm in height and with a slightly curved tooth row; the only adult specimen in the whole sample had all its teeth missing, but the horizontal ramus was strongly built with a mandibular height of 22.3 mm and, like the previous specimen, it also had a lightly curved tooth row. All three specimens were tentatively identified by Payne (1983) as *C. l. arabs*.

### 2.3 Bergmann's rule

It has become a commonplace in the scientific literature to defend the idea of how rigorously the grey wolf, on the whole, seems to conform to Bergmann’s rule (Davis 1981, Mendelssohn and Yom-Tov 1999). Davis and Valla (1978), Davis (1981) and Dayan et al. (1991) and Dayan (1994) confirmed that Pre-Natufian Late Pleistocene levantine wolves had larger body sizes than their contemporary counterparts. On
the other hand, when Kurten (1965) identified a decrease in body size in some predators, including the grey wolf, during the transition from the Pleistocene to the Holocene in the Palestine Caves, he did not directly connect it to climate change, but to competition with humans. The identity of Kurten’s sample was questioned by Davis and Valla (1978), Dayan (1994) and Tchernov and Valla (1997), who contended that it consisted of dogs and not of wolves. Davis (1981) argued that Bergmann’s rule does indeed apply to wolves in the Levant, finding a negative correlation between temperature and body size when he compared materials from the late Pleistocene with recent Israeli samples; when he noticed the lack of credible wolf materials from the Natufian, he used inference to argue that there was a “possible” decrease in size during the Pleistocene-Holocene transition (Davis 1981, 1987). Conversely Dayan (1994) and Tchernov and Valla (1997), quoting Horowitz (1989) and Baruch and Bottema (1991), argued that climatic conditions during the Natufian were colder and more humid than they are today, and very similar, in any case, to those of the Geometric Keebaran; therefore they proposed that the body size of the grey wolves should not have manifested any changes during the transition to the Natufian, and attributed the presence of smaller wolf-like canids to an ongoing domestication process. In addition to these arguments, the application of Bergmann's rule as a universal has also been criticised; Meiri and Dayan (2003) highlighted some possible exceptions to it, although in general they supported its applicability to wolf populations; on the contrary Meiri et al. (2007) objected to the concept of temperature having a direct effect on body size and proposed that, conversely, food availability is the key factor driving body size, although in some species this trend may correlate, at times, to latitudinal factors. The application of the rule was also challenged by Geist (1987), who used as one of the cornerstones of his argument data collected from several wolf populations from the USA and Canada; he suggested that Bergmann’s rule is inapplicable beyond 60-65°N for a number of large mammals, including the grey wolf, and he reported a decreasing gradient for body size north of 60-65°N. He also argued that body size operates as a function of the availability of high quality food; his proposals were vigorously rejected by Paterson (1990).

2.4 The modern grey wolf and related forms

Linnaeus (1758) described the species Canis lupus, using as a reference the populations from northern Europe.

Goldman (1944), in his photographic presentation of crania from North American wolves, demonstrated the existence of an overwhelming degree of intraspecific variability, apparently related to geography. This scenario of widespread variability, also documented in Eurasia (Pocock 1935b), resulted in a plethora of more or less spurious species and subspecies that were described worldwide, during the 19th Century and the first half of the 20th Century (Sykes 1831, Gray 1863, Sclater 1874, Cabrera 1907, Pocock 1935b, Anderson 1943, Goldman 1944, Hall and Kelso 1959, Corbet 1978). Currently about 16 different subspecies seem to be commonly quoted and are widely accepted by most scholars (Ellerman and Morrison-Scott 1951, Nowak 1995, Brewster and Fritts 1995). Body size, coat colour, skull shape and tooth size and structure are the phenotypical traits most
commonly used to encompass the bulk of morphological variability within this species (Miller 1912, Goldman 1944, Harrison and Bates 1991, Brewster and Fritts 1995).

One would need to travel to the Far North of either America or Eurasia to find the biggest grey wolves of all: the huge *C. l. occidentalis* from the American North West and the even larger *C. l. albus* from Northern Eurasia (Pocock 1935a, Goldman 1944). The skulls of these Nordic forms are characterized by their strong, thick and straight mandibles, a long rostrum, low frontals, very large sagittal crests and well developed occipital processes (Goldman 1944). The arctic wolf (*C. l. arctos*) from Melville Island and Greenland constitutes a noticeable exception within the northern wolf populations, as it is smaller than either *occidentalis* or *albus* and it has a more elevated frontal region, lighter dentition, larger auditory bullae and curved mandibular rami (Goldman 1944, Clutton-Brock et al. 1994, Clutton-Brock and Kitchener 2000). Interestingly it has been depicted as displaying some traits which are somehow reminiscent of the sledge dogs from that area (Clutton-Brock and Kitchener 2000).

Lawrence and Bossert (1969) attributed the peculiar morphology of canids from New England to an admixture of coyote, wolf and dog genetics. Revisiting the issue Kays et al. (2009) found that *Canis* showing mixed coyote - wolf characteristics have been populating new environments in the northeastern region of United States and neighbouring areas of Canada during the last 70 years; the authors of the study argue that this new variety is very well adapted to the patchy farmland-forest environments that have been developing in these regions recently, and they are also much more proficient at hunting deer than pure coyotes. The genome of the so-called Great Lakes wolf seems to present also a high degree of coyote genes (Leonard and Wayne 2008, Kohlmuller et al. 2009).

Miller (1912b) identified *Canis lycaon* as a separate species, his assessment was supported by Pocock (1935b). Wilson et al. (2000) added that *C. lycaon* is closely related to the red wolf (*C. rufus*); they proposed that both evolved from the coyote 300,000 years ago. Wilson et al. (2009) reinforced this idea and furthermore re-established the notion from Kolenosky and Standfield (1975) that the Tweed wolf, from “Algonquin Park and the southern Frontenac Axis”, is in fact a hybrid of *C. lycaon* and coyote. Grey wolf – *C. lycaon* hybrids seem to be also rather common in the Great Lakes region (Mech and Paul 2008, Wheeldon and White 2009, Wilson et al. 2009, Mech 2010).

For obvious reasons of time and space I will not consider any further in this work the case of the American wolves.

**2.5 European wolves**

The Western European grey wolf (*C. lupus lupus*) as portrayed by Miller (1912) seems to present a range of intermediate characteristics between the larger Northern European forms and the more gracile types (described as *signatus* and *italicus*) from Southern Europe (Cabrera 1907, 1914; Nowak and Federoff 2002). Its
forehead has been described (Miller 1912) as pronounced, but not as prominent as in the domestic dog; sagittal and occipital crests are well developed, although not excessively, and the dorsal outline of the neurocranium appears to be slightly depressed; auditory bullae are more voluminous than in the domestic dog; zygomatic arches are well flared and mandibles are not shallow, but neither overly strong; angular, condylar and coronoid processes are all well developed, with the coronoid apex appearing reasonably straight (Miller 1912). Miller (1912) figured a specimen (subspecies and locality unspecified) displaying a convex lower border of the horizontal ramus and showing signs of overlapping in the lower premolar series. The Italian wolf (C. l. italicus) was described by Nowak and Federoff (2002) as exhibiting wide zygomata and frontal shield as well as being smaller than C. l. lupus which, however, it clearly approaches in tooth size, in the relative straightness of the toothrows and in the large tympanic bulla. C. l. signatus from the Iberian Peninsula may present, at times, some dog-like characteristics such as a recurved coronoid apex (Hemmer 1990). The enigmatic C. l. deitanus, from Moratalla, Murcia, in the Spanish southeast, was described by Cabrera (1907), on the basis of two live captive specimens at the Madrid Zoological Gardens, as having some traits in common with the golden jackal; Miller (1912:315) listed the subspecies, stating that he had seen the two living specimens on which it was based, adding "In general appearance the two Moratalla wolves are strikingly different from Canis lupus".

On the whole, European and American grey wolves share a number of noteworthy dental features, such as the shape of the lower molar and premolar series which, from a lateromedial perspective, usually present a pronounced outward bend (Miller 1912), this characteristic being rather common among dogs. As opposed to other Canidae, but also in common with dogs, the metaconid of LM1 is usually small and the cingula on both upper molars are undersized and incomplete (Miller 1912, Davis and Valla 1978). Dentition in these wolf populations is said to be larger than that of any domestic dog (Miller 1912), as the anteroposterior distance of the upper carnassial will usually exceed ten per cent of the basal length of the skull, and the length of the upper carnassial usually surpasses the combined length of both upper molars (Clutton-Brock 1962, Barker and Macintosh 1979, Manwell and Baker 1983).

2.6 The wolves of the Highlands of Asia

Hodgson (1847) described Lupus laniger from Tibet and commented on its similarities to and differences from the European wolf. He highlighted its wide head, long rostrum, large ears, very bushy tail and woolly coat, which he depicted as brown on the upper side of the body and yellowish below; a drawing of the skull illustrates a powerfully built cranium with well developed crests, large teeth, elevated frontal region, strong mandibles and a large angular process.

Canis chanco, a species from Chinese Tartary (Inner Mongolia), was described by Gray (1863) as similar to the European wolf (Canis lupus) but larger and having shorter legs. The pelage was portrayed as varied in colour, with fulvous hair, mixed with black and grey, dominating along the back, while the undersides were
described as pre-eminently white; the outer side of the legs would often display ashen short fulvous hair; the head is covered by pale grey-brown hair, with the forehead being greyed by short black and grey hair. He noted that both skull and teeth are comparable to those of the European wolf (C. lupus).

Sclater (1874) described *Canis niger* from Tibet, which he identified as different from *Lupus* (sive *Canis*) laniger Hodgson; he characterized the new species as exhibiting a shaggy and almost completely black coat with the exception of the muzzle, feet areas, and a small region of the chest, which are white. One of his specimens had a head and body length of three feet and four inches, and a tail length of one foot and four inches. Additionally he mentioned the possibility of Hodgson's *L. laniger* being only a local form of *C. lupus*. Blanford (1888) likewise synonymised *Canis laniger* with the European wolf (*Canis lupus*); thus, he proposed that *Canis lupus* lives in Baluchistan and western Sind, and from there it probably reaches the northern Punjab, from where it expands into the Himalayas. He noticed, however, that specimens from Tibet and Ladak could be regarded as non-typical as they displayed pale-coloured woolly fur.

Pocock (1935b) brought together *laniger, chanco* and *niger* within the same subspecies, *Canis lupus laniger* Hodgson, which in his opinion inhabits Tibet, Kashmir and China. He described it as different from any of the European subspecies because of its woolly textured coat during the winter, and a widely variable multicoloured pelage; he found that there is a wide range of colour phases, made more complex by seasonal factors, as winter and summer coats have different colouration. He also reported a large amount of craniometric variability, connected mostly to the geographic origin of the specimens.

Allen (1938) agreed that the cluster *laniger-niger-chanco* represents only a single subspecies of *Canis lupus*, but, because of the previous use of *Canis laniger* by Hamilton Smith (1839), to describe a type of domestic dog, he used *chanco* (Gray 1863) as the prior available name. In general terms he described the subspecies as similar to Miller’s European wolf but smaller; he also found a great degree of chromatic variability among seven skins that he studied at the American Museum (Allen 1938).

Ellerman and Morrison-Scott (1951), Mech (1974), Corbet (1978), Corbet and Hill (1992) and Wozencraft (2005) all placed *chanco* and other Eurasian wolves in *C. lupus*, while maintaining the validity of *C. l. chanco* Gray, and Ellerman and Morrison-Scott (1951) outlined a wide area of distribution in eastern Russia, China, Tibet and Mongolia; Mech (1974) also included the Anatolian Peninsula. Olsen and Olsen (1977) drew attention to the recurved coronoid apex found in some individuals of *C. l. chanco*; they stated that domestic dogs were the only other canid presenting this unusual characteristic. Nowak (1995) found the crania of *C. l. chanco*, as well as of the Central Asian wolves *C. l. campestris* and *C. l. desertorum*, indistinguishable from European *Canis lupus lupus* and therefore incorporated them into the latter.

2.7 The southern wolves
Sykes (1831) described *Canis pallipes* as a small wolf with a pre-eminence of reddish tones in a short pelage; other traits were a pendant and bushy tail and small ears. He based his account on two three-quarters grown animals, with head and body length of 35 to 37 inches and tail length of 11 to 12 inches. He quoted simply “Deccan” as the type locality for his new species. Blanford (1888) described a predominance of brownish tinges in the pelage of *C. pallipes*, and stated that at times completely reddish individuals could be found. He proposed that an adult specimen will have a head and body length of about three feet and a tail of 16 to 17 inches. He indicated that the species was rare in Lower Bengal and did not occur, on a regular basis, west of the Indus; he mentioned, as well, that is unknown on the Malabar Coast and in the Himalayas, and that it is very rarely found in wooded areas. In his revision of *Canis lupus*, Pocock (1935b) reclassified *Canis pallipes* as *Canis lupus pallipes*, and expanded its geographic distribution all through northern India, from Lower Bengal to the Punjab and Kutch, and from there to Lower Sind and Baluchistan, establishing Dharwar as the southern limit of the geographic distribution in India (Pocock 1941), and cited Mesopotamia as the westernmost limit of the subspecies (Pocock 1935b). As he was not fully satisfied with the use of a non adult – and fully moulted – specimen to describe this subspecies by Sykes (1831), he also included in his work a series of individuals collected in Hazaribagh (Lower Bengal), Rajasthan, Punjab, Sind and Mesopotamia. In summary, after studying these specimens he validated Sykes’ (1831) description, but maintained that it is only a subspecies of *C. lupus*. In addition, Pocock (1935b) provided a more detailed account of the coloration of the winter coat, which he portrayed as much shorter than that of *chanco*, presenting a layer of fawn-coloured thin underwool around the flanks and darker on the back; the black and grey contour hairs form a band that runs through the generally sandy-fawn coloured back; the nape of the neck will be buff-coloured and the ears are ochraceous (Pocock 1935b, 1941). He gave a body weight of 45 ¾ lb for the Hazaribagh specimen, and emphasized the general gracility of the subspecies.

Pocock (1935a) also described *Canis lupus arabs* from the Arabian Peninsula. This, commonly known as the Desert Wolf, is treated in more detail below.

*C. l. pallipes* and *C. l. arabs* from southern Asia and the Middle East have been described as showing skull and teeth characteristics which are close to dogs (Manwell and Baker 1983, Clutton-Brock 1995), or even, in some cases, to the golden jackal (Harrison 1968, Harrison and Bates 1991), than to the typical grey wolf from Europe and North America. Consequently, in the absence of complete skulls, archaeological and palaeontological materials from this group are reputedly difficult to classify (Lawrence 1967, Harrison 1973, Ferguson 1981, Lawrence and Reed 1983, Olsen 1985, Clutton-Brock 1995). The skull of the southern wolves is often characterized as having a gracile appearance, and by frontals that are more elevated than in the larger European wolf (Clutton-Brock, 1962). Ferguson (1981), however, claimed that the forehead in some *C. l. arabs* is less pronounced than in *C. l. lupus* or in *C. l. pallipes*. 
Shallow mandibles have been described as a characteristic of *arabs* (Lawrence and Reed 1983). A recurved coronoid apex was quoted by Hemmer (1990) as a salient feature that could be found in wolf populations from the Iberian Peninsula, and also from Central, East and South Asia. The length of the upper carnassial in *C. l. pallipes* was described by Degerbol (1961) as being as short as in the domestic dog. This was refuted by Clutton-Brock (1962), although some specimens of her sample did present carnassial teeth similar in size to those of domestic dogs, and Ferguson (1981) found that some Arabian wolves may have upper carnassials which are shorter than the combined length of both upper molars.

A small cingulum on the external aspect of UM1 has been described as one of the most remarkable differences between *C. l. arabs* and *C. aureus*, the Golden Jackal (Harrison 1968, Harrison and Bates 1991), although Ferguson (1981) reported the presence of a complete cingulum in UM1 in a part of his Arabian wolf sample. Reportedly, lower carnassial metaconids are, in *C. l. arabs* and *C. l. pallipes*, as underdeveloped as in the European and North American wolves (Harrison 1968).

Harrison (1968) affirmed that *C. l. pallipes* could be readily distinguished from *C. l. arabs* by its larger cranium, and emphasized the general robustness detectable in the crania of both subspecies in contrast with *C. aureus*.

Lawrence and Reed (1983) pointed out the small body weight of the desert wolf; Tchernov and Valla (1997) gave an approximate average weight of 12kg which makes it, in principle, the smallest existing form of grey wolf, although Ferguson (1981) gave a weight range for *C. l. arabs* in Israel and Arabia from 14 to 19.2 kg. Lawrence and Reed (1983) suggested the existence in *C. l. pallipes* of a size gradient from East to West, the western populations presenting more robust mandibles and perceptively larger body frames.

Sotnikova (2001) claimed that *C. l. pallipes* is almost identical in many cranial, mandibular and dental characteristics to *Canis mosbachensis*. In a similar fashion, Hemmer (1990) deemed *pallipes* a remnant form of *mosbachensis*.

That this form intergrades with *C. l. laniger/chanco* in northern Punjab was claimed by Pocock (1935b, 1941), to the point that some specimens may be impossible to ascribe to one subspecies or another as their physical appearance may have mixed traits from both *C. l. laniger* and *C. l. pallipes*. Elaborating more on issues of variability, Pocock contemplated the possibility of the wolves from Rawalpindi and the Salt Range belonging to a completely different subspecies (Pocock 1935b). Wolf specimens from distant Indian localities (Lower Bengal – Kutch), were found similar in terms of skull characteristics and body conformation (Pocock 1935b). Conversely, one specimen from Sind was described as similar to *laniger* (Pocock 1935b). He also found a skull from Chotair, in the vicinity of Quetta, to be too large for *pallipes*, but still different from *laniger* (Pocock 1935b), and he made the same comment in regard to another specimen from Kandahar (Pocock 1935b). He identified a small specimen (condylobasal length= 182 mm) from Shambar (Rajasthan) as a “dwarf” representative of *pallipes* (Pocock 1941). He described one skull from Tarooma (Iraq) as morphologically similar to *pallipes*, but bigger, and was thus reluctant to classify it; by contrast, skins from Sind and Mesopotamia
were ascribed to *pallipes* (Pocock 1935b); he made a mention, as well, of a living specimen from Mesopotamia which he saw as a possible intermediate type between *pallipes* and the central European wolf (*Canis lupus flaurus* in his terminology), and of a living pair from Kuwait that could be assigned either to *arabs* or *pallipes*; and, after analyzing three specimens from Mesopotamia, he proposed that this region could represent an interface between *C. l. pallipes* and larger subspecies, identifying one specimen as genuine *pallipes* and two others as having intermediate characteristics.

Ellerman and Morrison-Scott (1951), Mech (1974), Corbet (1978), Corbet and Hill (1992) and Wozencraft (2005) agreed with Pocock that *pallipes* is a subspecies of *Canis lupus*, inhabiting the open flatlands of northern India, from Bengal to Sind, southward to Dharwar, and west towards Iraq and Northern Arabia. Mech (1974) proposed that this subspecies covers an even wider region, from East Bengal to the north-western seaboard of the Middle East, and from the border regions of the Anatolian peninsula, and of Central Asia, to almost the centre of the Arabian Peninsula and the southern coastline of the Middle East and most of the Indian peninsula excepting its southern tip.

Harrison (1968) described *Canis lupus pallipes* as larger, and having thicker pelage, than *C. l. arabs*. His list of localities for *pallipes* included Lebanon, Iraq, Kuwait, Syria, Jordan and Israel; he suggested that in Kuwait this subspecies hybridizes with *C. l. arabs*.

The wolf populations of Israel were studied in detail by Mendelssohn (1982); he proposed that two different types of *C. l. pallipes* can be found in Israel, a larger variety (“Mediterranean *pallipes*”) that lives north of the 400 mm isohyet, and a smaller one (“desert *pallipes*”) that inhabits the arid lands between the 50 mm and 400 mm isohyets. Other than in body size, Mendelssohn (1982) found that the Mediterranean variety is in general darker, although dark specimens have also been found along the Arava valley, as Mendelssohn and Yom-Tov (1999) implied by stating that the typical colour pattern of the Mediterranean form is also widespread among the desert populations. He also reiterated the morphological similarity between the Indian and Israeli populations of *C. l. pallipes* (Mendelssohn 1982). The northern limits were unclear to Mendelssohn (1983), although he suggested that a different type of wolf, larger and darker, may be found at times in the Golan Heights and in southern Lebanon; Qumsiyeh (1996) implied, misquoting Mendelssohn (1982), that in Israel *C. l. pallipes* mostly inhabits the lands north of the 400 mm isohyet. Mendelssohn and Yom-Tov (1999) also commented on the darkness of pelage, and the superior size, of the northern populations, while they described the specimens from central and south-central Israel as very similar to the Indian ones; the southern populations were portrayed as similar in size to *C. l. arabs*, but displaying typical *C. l. pallipes* colour patterns.

Nowak (1995) in contrast could not find any substantial morphological differences between *C. l. arabs* and *C. l. pallipes*, in Israel, and in consequence ascribed all Israeli specimens that he studied to *C. l. pallipes*. Sokolov and Rossolimo (1985) proposed that the distribution of *C. l. pallipes* extends from the western side of the Anatolian Peninsula to West Bengal, and from the borderline regions of central Asia.
to the south of the Arabian Peninsula, and the coastline of the Arabian Sea, excluding only the southern tip of the Indian Peninsula (see Nowak 1995). Lawrence and Reed (1983) considered the possibility of a still unreported subspecies of wolf, clearly different from *C. l. pallipes*, currently living along the Zagros Mountains. In an attempt to define the limits of the eastern Indian population, U Tun Yin (1967) and Rabinowitz and Saw (1998) cited several witnesses’ accounts of wolf-like animals having been sighted in northern Burma.

Two different Indian scientific teams (Sharma et al. 2003, Aggarwal et al. 2007) have studied Indian wolf populations, and by extension the wolves from the Middle East, using mitochondrial DNA. Sharma et al. (2003) saw the differentiation of *C. l. chanco* and *C. l. pallipes* as a product of isolating conditions in the Indian subcontinent, that started when the development of the Tibetan Plateau became a physical barrier between the populations of Indian wolves and the wolf–dog clade, and proposed that, under those conditions, the Himalayan wolf started to differentiate from all the other wolf clades between 0.8 - 1.5 Myr ago, and the Indian wolf became isolated from the wolf-dog clade, 400,000 years ago. They proposed two alternative hypotheses to explain this process: the first one refers to the possibility of primitive wolf lineages separating in India during the Middle Pleistocene, whereas the rest of the world was colonized by the more modern wolf-dog clade that progressively absorbed all primitive varieties outside the Indian Subcontinent; the second hypothesis proposes that wolves actually evolved in India, from where the wolf-dog clade expanded into the rest of the world. In any case, wolf populations currently inhabiting western Kashmir seem to belong to the wolf-dog clade. Cautiously, they treated both as separate species: *C. pallipes* and *C. laniger*, the former inhabiting drylands of the Indian Subcontinent, and the latter the Himalayas, from Tibet to eastern Kashmir; the borderline between the distributions is defined by the Terai swamp grasslands and the Himalayan foothills (Hodgson 1847, Sharma et al. 2003). Aggarwal et al. (2007) supported the main findings of Sharma et al. (2003) but went a step further, suggesting that the Indian populations might represent an intermediate evolutionary stage between the jackal and the wolf which became isolated in India 1-2 Myr ago. In addition they proposed changes to the taxonomic arrangement, and renamed the Himalayan variety *C. himalayensis* to differentiate it from *C. l. chanco/laniger* that inhabits "China, Mongolia and South-East Asia", and they reclassified the Indian wolf as *C. indica*, to differentiate it from *C. l. pallipes* that inhabits the "Middle East". (As the Deccan is the type area of *C. pallipes*, this last suggestion is ruled out a priori.)

2.8 *Canis lupus arabs*

Pocock (1934, 1935a, 1935b) described *Canis lupus arabs* from southern Arabia, "from Muscat to Aden", and ventured that the northern limit could be in Mesopotamia. He described *Canis lupus arabs* as similar to *pallipes*, but smaller and with a shorter and more sparse coat, which during summertime will appear short and fine over most of the body, and will grow thicker with some underwool during the winter (Pocock 1935a). The basic colour pattern of this subspecies is a blend of black and grey hair, intermixed with buffy tones, with buffy becoming dominant over the nape and shoulder; cheeks, chin, throat and the undersides are
yellowish white (Pocock 1935a); some specimens present darker tones and even black speckling, in part perhaps attributable to seasonal changes.

Harrison (1968) described this subspecies as comparable to the Golden jackal C. aureus but larger, with longer legs and a more robust conformation; ears were portrayed as long as in C. aureus. He depicted the summer pelage as short and fine over most of the body, with a well developed spinal crest that runs from the start of the cervical region to the base of the tail; the coat of the more brightly coloured individuals is “pale buffy yellow” that darkens towards the spinal crest and becomes light grey on the underside, as well as on the posterior aspect of the hind legs and the lateral regions of the neck; the tail shows a blackish overshadowing along its dorsal aspect. The skull has a more elevated frontal area and a longer rostrum than C. aureus, the zygomatics are rather wide and the interorbital region is wider than in C. aureus; the auditory bulla is however comparatively smaller. The dentition is robust, in general terms, but the metaconid on LM1 and the cingula on the upper molars are less developed than in C. aureus. C. l. arabs intergrades with C. l. pallipes in Kuwait according to Harrison (1968) and Harrison and Bates (1991).

Mendelssohn (1982) noticed the smaller size of the Israeli C. l. arabs, as compared even with the “desert pallipes”. He portrayed the former as exclusively inhabiting remote and dry locations, in the southern tip of Israel and Sinai, almost always below the 50 mm isohyets. He also proposed that in Israel C. l. arabs was being absorbed by the desert C. pallipes populations that were spreading through areas south of the 50 mm isohyets following some of the advances of civilization, like rubbish tips and roads, and that only a small number of C. l. arabs survived at the southern tip of Israel at the time.

2.9 Large wolves in the northern Middle East

Not much information seems to be available, at the moment, on the large wolf varieties that have been said to inhabit the Middle East outside the arid and semiarid regions. Pocock (1935b) analyzed two skins from Smyrna and Xantus; he found them to be quite large and dark and almost in every respect identical to those of European wolves from a variety of locations. A sample of three specimens from Mesopotamia was found rather polymorphic; he identified the first specimen, a skin from Shaiba, as a typical representative of pallipes with its predominantly mixed grey and buffy coloration; a skin from Muskay-yar, south of Ur of the Chaldees, he interpreted as intermediate between pallipes and the wolf from Smyrna previously described; the third specimen, a skull from Tarooma (Iraq), had predominantly pallipes characteristics but was exceedingly long and could not be ascribed to either pallipes or laniger.

Mech (1974) considered the Middle East to be inhabited predominantly by C. l. arabs and C. l. pallipes, with the exception of the extreme north (including the Anatolian Peninsula), which he believed was inhabited by chanco. Nowak (1995) agreed mostly with Mech (1974), but expanded the pallipes area into the northern regions, with the exception of Northeastern Turkey and Northwestern Iran where the predominantly Caucasian subspecies cubanensis was to be found. Quoting
Pocock (1935), Sanborn (1940) identified four wolf specimens (2 complete skeletons and two skulls) collected in Northeastern Iraq as *Canis lupus pallipes*. The presence of wolves in the Golan Heights that were larger and darker than any *C. l. pallipes* was reported by Mendelssohn (1982, 1983), the biggest specimen of his initial sample of four weighing 32.3 kg; and he noted that similar specimens were reported from Eastern Lebanon, and speculated that this form also occurred in Northern Syria and Turkey (Mendelssohn 1983). Mendelssohn and Yom-Tov (1999) later insisted on the distinctiveness of this variety and argued that the skull was also genuinely different from that of *pallipes*, while the now extinct population of Galilee exhibited characteristics that were intermediate to *pallipes* and the Golan wolf.

### 2.10 Golden jackals

Linnaeus (1758) included the golden jackal in the same genus as the grey wolf (*Canis lupus*) and a variety of domestic dog breeds, and named it *Canis aureus*; he reported Africa and “Oriente” as the typical localities of the species. Afterwards Oken (1815-1816), preoccupied by the presence of cingula and metaconids in the dentition of jackals and coyotes, proposed a new genus *Thos* to distinguish these species from *Canis*. Heller (1914) expanded and systematized these differences by describing the presence, in *Thos*, of: 1) long and slender canine teeth, as opposed to thicker and shorter ones in *Canis*; 2) small outer incisors as opposed to large ones in *Canis*; 3) small carnassial teeth as opposed to large ones in *Canis*; 4) upper molars with well defined cingula, this trait being not well developed in *Canis*; 5) fourth lower premolar with a miniscule third cusp which is absent in *Canis*.

Externally the contemporary golden jackal has been characterised as having a smaller body size and shorter limbs than *C. lupus* (Ferguson 1981). In general, the pelage is dominated by either buff or grey tinges interspersed with black-tipped contour hairs, especially on the back where tones tend to be darker, although it may become gradually lighter in the posterior regions, and especially around the base of the tail; the flanks are lighter in tone than the back, and the undersides are usually lightly coloured, from a very light grey to rusty-yellowish; the nape and ears tend to be buffy and the muzzle is usually marked by an abundance of black hair; legs often show a band of brighter buff hair in their outer sides; the tail follows a similar pattern to the back, but becomes increasingly darker towards the tip, which is usually almost completely black (Harrison 1968, Harrison and Bates 1991, Qumsiyeh 1996, Mendelssohn and Yom-Tov 1999).

The cranium of the golden jackal presents remarkably low frontals that become noticeably narrow in the interorbital region; this interorbital constriction should not exceed half the width of the braincase (Tate 1947, Harrison 1968). It also has large auditory bullae and a rostrum than is shorter than in *C. lupus* (Miller 1912, Harrison 1968, Harrison and Bates 1991). The zygomatic are not as strong and flared as in *C. lupus* and the sagittal crest is usually of a medium size; the mandibular ramus is in general dorsoventrally shallow, and teeth are small and well spaced (Harrison 1968, Harrison and Bates 1991). There is no detectable outward bend in the lower dental series (Longman 1929, Barker and Macintosh 1979), and the upper carnassials are shorter than the combined length of both
upper molars (Ferguson 1981). Golden jackal dentitions should also exhibit a complete and well developed cingulum on UM1 (Miller 1912, Barker and Macintosh 1979, Harrison 1991, Qumsiyeh 1996), and a large metaconid on LM1 (Miller 1912, Davis and Valla 1978, Higham et al. 1980). Body weight is highly variable, ranging from 5 kg in the smallest subspecies (Ferguson 1981) to 15 kg in what has been called *Canis aureus lupaster* (Osborn and Helmy 1980). Caution should be exercised when identifying specimens, as similar traits have been reported in *C. l. arabs* (Ferguson 1981). In line with this, Osborn and Helmy (1980) described the difficulties of finding a single character capable of discriminating jackal from dog skulls in Egypt.

This species occupies a wide area, from Indochina to Eastern and central Europe and North and East Africa (Krystufek et al. 1997, Duckworth et al. 1998, IUCN 2004). There are signs of an ongoing expansion in central Asia, through Kazakhstan (Duckworth et al. 1998), as well as in central and Eastern Europe, particularly where the grey wolf has been eradicated (Krystufek and Tvrtkovic 1990, Krystufek et al. 1997, Szabo et al. 2009). Vagrant individuals have been reported in Austria and Germany (Hoi-Leitner and Kraus 1989, Zedrosser 1995, Bauer and Suchentrunk 1995, Mockel 2000).

Fossil remains of *Canis aureus* are remarkably rare (Kurten 1968). Some specimens have been found in Late Pleistocene deposits in Italy, and remains of a small canid, similar to *C. aureus*, have been unearthed in some Middle Pleistocene deposits such as Ternifine in North Africa (Kurten 1968). *Canis (Thos) anthus primaeus* from Ain Boucherit, a fossil bearing stratum located at Ain Hanech, an Early Pleistocene site of Northeastern Algeria, was described by Arambourg (1979); he characterized the new subspecies as being more gracile than the typical form of *C. anthus (= C. aureus)*. Some mandibular and dental remains, attributed by Geraads (1997) to a new species related to *C. aureus*, were excavated from d'Ahl al Oughlam, a terminal Pliocene site close to Casablanca (Morocco). Geraads et al. (1998) reported on the discovery of a skull, attributed to *Canis aff. aureus*, at the same site. Amani and Geraads (1993, 1998) identified *C. aureus* among the faunal remains recovered from the Moroccan Mousterian site of Djebel Irhoud.

### 2.11 The *Canis lupaster* question

Hemprich and Ehrenberg (1832) described a new canid, *C. lupaster*, with Fayum (Egypt) as its type locality; this name has resurfaced from time to time in the literature.

Anderson (1902) recognised the Egyptian *C. lupaster* as a valid species, describing it as being basically yellowish grey, with an abundance of rufous tones around the head, particularly on the back of the ears and between them, and on the upper parts of the head; the anterior and external surfaces of the legs are also dominated by rufous hair; the undersides tend to be paler than the rest of the body; the hairs on the top of the neck and shoulders are longer than on the rest of the body. He gave, for a male specimen, a head and body length of 890 mm and a tail length of 336 mm. He also noted the presence of the species in Algeria and Tunisia, but
described this variety as much darker; a specimen from Tunis in the Senckenberg Museum, Frankfurt, was described as having a predominance of black and variegated hair over the rufous and yellowish. He attributed two skulls from Tunis in the British Museum (46.10.30.155 and 48.1.8.1) to this species, and also highlighted its similarities with *C. pallipes*. He identified the type specimen of *C. sacer* as "a young *C. lupaster". Finally, he denied the presence of *Canis aureus* in North Africa and asserted that *C. lupaster* is the only wild *Canis* species that inhabits the region.

Hilzheimer (1908) recognised *C. sacer* and *C. lupaster* as described by Hemprich and Ehrenberg (1832); the basicranial length of the type specimen of the former species, which he had studied in the Berlin museum, was 147 mm, and a larger specimen which he attributed to the same species reached a value of 155 mm, while representatives of the latter species are considerably larger, the maximum value for the basicranial length reaching a value of 168.5 mm (Hilzheimer 1908). He then described a further species, *C. doederleini* from Egypt, a much larger animal, giving for the type specimen (Strasbourg Museum, number 1837) a basicranial length of 187 mm.

Flower (1932) referred to the existence of two different jackal species in Egypt. The first was *C. lupaster*, the wolf-like jackal - with which he synonymised *C. doederleini* Hilzheimer - said to inhabit Egypt, Lower Nubia and Libya and perhaps Tunisia and Upper Nubia, and he affirmed that a very similar form (or identical) lives in Palestine and Syria, and within Egypt he restricted its distribution to the Fayum, the Nile Valley and the Delta. He gave a body weight of 16.00 kg for a male of this species, and 9.98 kg to 12.00 kg for two females. The second jackal species in Egypt, according to Flower, is found only in the north-west of the country, and was identified by him, "for convenience" as *C. aureus tripolitanus*, a small subspecies from Libya; a more firm identification was left as an open question, for when more specimens from Egypt and the surrounding areas would become available for study.

Harrison (1968) and Harrison and Bate (1991) disagreed with the identification of any canid in Palestine as *C. a. lupaster*.

Cabrera (1921), initially using Oken's (1815-1816) generic name *Thos*, in a brief review of North African subspecies of golden jackal recognised *Thos aureus nubianus*, *Thos lupaster maroccanus* and *Thos lupaster algirensis* as valid subspecies. In his description of his new subspecies *Thos lupaster maroccanus*, based on a specimen from Mogador (Morocco), he described the general tone of the pelage as grayish mixed with black and the underfur with blackish undertones; for the type specimen he gave a condylobasal length of 163 mm, an upper carnassial length of 18.5 mm, a head and body length of 800 mm and a tail length of 300mm. Later the same author (Cabrera 1932) concluded that the name *Thos* was not available since Oken (1815-1816) did not follow a binomial system in his nomenclature, and instead used the name *Vulpicanis* (Blainville 1837), as a subgenus. He also expanded his description of *maroccanus* as having the underfur with variable tones and the legs golden ginger or light ginger; while he had only one specimen to hand, he stated that he had seen others and, based on these
observations, he proposed that the subspecies inhabits the Western parts of Morocco, from the northern tip to Sus (Cabrera 1932). He described *algeriensis* as similar to *marocanus* but with a more yellow coat particularly on the flanks; ears and muzzle were reddish and the legs pale ginger, underfur was buffy on the back and pale brown on the flanks; the shape of the skull was said to be comparable to that of a European wolf, but smaller and with a longer snout. He gave measurements of a skull from an old specimen as condylobasal length = 155 mm, upper carnassial length = 17 mm, and from a live captive male gave head and body length = 780 mm, tail length = 270 mm (Cabrera 1932). The geographic distribution was said to cover the northeast of Morocco and adjacent parts of Algeria (Cabrera 1932). Inspired by Anderson (1902), Hilzheimer (1908) and Lortet and Gaillard (1909), he defended the characterization of both subspecies as *lupaster*, and not as *anthus* (= *aureus*), and made the comment that we may, in these cases, be contemplating taxa that are in fact equally related to both the smaller species of jackals and to the grey wolves (Cabrera 1932). Heim de Balsac (1936) quoted *Canis lupaster algirensis* and *Canis lupaster maroccanus* as inhabiting North Africa, together with *Canis (anthus?)* riparius.

Other authors have also identified large canids, from North Africa and Sinai as *C. a. lupaster* (Schwarz 1926, Ellerman and Morrison-Scott 1951, Corbet 1978, Osborn and Helmy 1980 and Wozencraft 2005), or *Thos aureus lupaster* (Allen 1939). Osborn and Helmy (1980) described *Canis aureus lupaster*, from Egypt and the Sinai Peninsula, as presenting some typical *aureus* characters like in-line mandibular teeth and large bullae, as well as wolf-like traits such as a large skull, inflated frontals and well developed sagittal and occipital crests. The accompanying drawings of cranial and mandibular material depict a moderately shallow mandible, with a convex lower border, a relatively short rostrum, a convex neurocranial outline, and a pronounced occipital process. They also singled out some of the dental similarities with *C. aureus* like the presence of a large metaconid on LM1 and a complete cingulum on UM1. Externally this form, as described by them, was said to have a dorsal mane with black-tipped, three-banded, yellow and reddish, contour hairs, which starts in the occipital region continues to the base of the tail, and widens over the shoulders; the underfur is yellow-reddish. This dominantly dark pattern becomes lighter and more reddish towards the edging areas of the back, flanks are yellowish with interspersed black- and white-tipped hairs; undersides tend to be light-coloured from yellowish to a very light grey. Muzzle and ears are reddish, while the forehead is punctuated by a mix of grey and red hairs. In some specimens the general coloration may be more wolf-like with black and yellow hair predominating. Body weight ranges from 10 to 15 kg. Similarly to Flower (1932), they speculated on the possibility of more than one type of jackal inhabiting Egypt, and they contended that the specimens collected in the northwest of the country – which Flower classified as *C. a. tripolitanus* – were smaller than those from the Delta region. Setzer (1957, 1961) upheld a similar point of view. An analogous situation was described by Hufnagl (1972) in Libya, where the smaller *C. a. algirensis* was said to live along the coast while *C. a. lupaster* inhabits the interior.

Kowalski and Rzebik-Kowalska (1991), supporting the work of Heim de Balzac (1936), referred to three different species of jackal inhabiting Algeria, namely *C.*
lupaster in the northern region, and *C. riparius* and *C. variegatus* from the Hoggar. They provided condylobasal lengths for nine specimens from northern Algeria; all of them exceeded the 148.9 mm mark, and four were over 160 mm. Nonetheless, they were of the opinion that the taxonomic status of the Algerian jackals was in need of more research.

Ferguson (1981) argued that *C. aureus lupaster*, from Sinai and northeastern Egypt, ought to be regarded as a subspecies of *Canis lupus* (*Canis lupus lupaster* new combination). This proposal was based on some noticeable wolf-like traits, like a longer cranium, a dished forehead, sizeable sagittal crest, substantial angular process, and larger mandibles and carnassials, and on the existence of a distinct metrical gap between *lupaster* and *aureus*. Contra Osborn and Helmy (1980), he described the size of the auditory bullae as “small”. He stated that the size of the interorbital constriction is broader than half the width of the braincase, as in *C. lupus*. In general terms, he characterized *C. l. lupaster* by an intermediate body size (10-16 kg), somewhere between *C. l. arabs* (14-19.22 kg) and *C. aureus* (5-12 kg), and by some very wolf-like attributes, and he noted that there are overlaps in the measurements of *C. l. lupaster* and *C. l. arabs*.

*C. lupaster* has been reported to be a common species in Late Pleistocene sites of Palestine and North Africa (Kurten 1968). Kurten (1965) studied it as a part of the carnivore guild present in the Palestine caves of Shukbah, Zuttiyeh and Tabun; he described it as a common find during the Eemian; it became rare afterwards and totally disappeared in the Main Wurm. It returned during the Mesolithic. He stated that it has changed very little since the Eemian or Early Wurm. Petter and Heintz (1970) studied a hemimandibular fragment from the Cave of Haifa (Tabun C) which they attributed to a juvenile specimen of *Canis cf. lupaster*.

### 2.12 General morphology of the domestic dog

Serres (1835) wrote one of the earliest and more reliable accounts to separate wolves from dogs. Nowak (1979) highlighted the main points from this author and portrayed the skull of the dog as displaying a braincase which has a wide base, with inflated frontals and a smaller supraoccipital shield. The canine teeth are shorter dorsoventrally, while the carnassials are shorter anteroposteriorly. The tympanic bullae of domestic dogs have been described as smaller and flatter than those of wild canines (Koler-Matznick 2002, Lawrence and Reed 1983, Higham et al, 1980); they may also present a slightly crumpled appearance with marked ribs (Benecke 1987). A flatter and downward curved sagittal crest (Koler-Matznick 2002, Lawrence and Reed 1983) and a less protruding occipital crest (Lawrence and Reed 1983) have been described as differential attributes of the domestic dog. Wider palates are another characteristic of domestic dog breeds, as well as palates extending further back than the last molar (Lawrence and Reed 1983). The mandible in the dog tends to be thick in a lateromedial aspect and with a convex inferior line (Nowak1979); the convexity of the lower mandibular border was also quoted by Pei (1934) as a typical character of the dog, and was also noted by Kohler-Matznick (2002). The posterior part of the horizontal ramus was described as conspicuously shallow in the Natufian dogs (Tchernov and Valla 1997). Kohler-Matznick (2002) and Benecke (1987) referred to the occurrence of a recurved
coronoid apex as a diagnostic character for the dog; this trait has however also been found in *C. l. chanco* (Olsen and Olsen 1977).

Some scholars have postulated that the orbital angle could be the most reliable single character to separate wolf from dog crania. This is "the angle between a line drawn through the upper and lower edges of the eye socket and a line from ectorbital to ectorbital" (Aaris Sorensen 1977).

It was first quoted by Studer (1901) and afterwards by Reynolds (1909) who emphasized the more oblique nature of the orbital angle in the wolf. Iljin (1941) described it as a very accurate technique capable of achieving total discrimination between dogs and wolves; Aaris Sorensen (1977), however, advised against this after analysing a large sample, finding the technique generally accurate but not always reliable. Nowak (1979) found it generally useful to separate dog from wolf skulls, although his data show the existence of some overlap between the top "lupus" range and the lowest "familiaris" series. Benecke (1987) gave also some partial support to the use of this parameter to discriminate between dogs and wolves.

Tooth size is often considered a key factor in differentiating dogs from wolves (Olsen 1985, Clutton-Brock 1995, Koler-Matznick 2002). In the domestic dog the length of the upper carnassial will be under ten percent of the basal length of the skull (Macintosh in Barker and Macintosh 1979) and will be shorter than the combined length of both upper molars (Clutton-Brock 1962). Manwell and Baker (1983) found that in the domestic dog as body size increases there is a tendency to relative size decrease in the anteroposterior length of the lower carnassial. Domestic dogs seem to present a tendency towards a decrease in size, or even total obliteration, of LP1 and LM3 (Lawrence and Reed 1983). Wayne (1986) stated that the lengths of P3 and P4 in modern dog breeds are negatively correlated to total skull length, and that the opposite would be true in wild canids. The lower dental series appear to show a stronger curve in dogs than in wolves (Lawrence and Reed 1983).

Elevated frontals were another of the more outstanding characteristics described by Endo et al. (1997) to separate Akita-Inu dog specimens from the Japanese wolf (*C. l. hodophilax*). This trait was also described by Lawrence (1967) and Koler-Matznick (2002) as one of the most significant characters within the skull of the domestic dog. Some authors (Clutton-Brock 1962, Olsen 1985, Morey 1986, Benecke 1987, Tchernov and Valla 1997) quoted a reduced length of the rostrum as one of the main differences between domestic and wild canines.

Clutton-Brock et al. (1994) pointed out the remarkable cranial similarity between huskies and *Canis lupus arctos*. Lawrence and Reed (1983) described Eskimo dogs as displaying smaller teeth but more massive mandibles than a sample of wolves from the Iran-Iraq Northern region.

2.13 The pariah group
Menzel and Menzel (1960) defined the pariah as a dog, of primitive type, that usually lives in a more or less loose association with humans; notwithstanding a common assumption that they are always ownerless, pariahs according to them are not always ownerless, and quite often they can be found as working dogs especially among the Bedouin. The opposite can also be true, and they also reported cases of pariahs living in the wilderness, as individuals or in a group, far removed from any human control.

Zeuner (1963) described the morphology of the pariah as that of a medium size dog with vertical ears and a short or medium length pelage which is usually ginger and at times may be mixed with grey or brownish tones. The Egyptian pariah was portrayed by Epstein (1971) as of a medium body size and relatively robust conformation; it has a broad head and a long bushy tail; the ears are pricked and short. The pelage is usually pale, either yellow ginger or white, although some individuals may be brown or greyish; limbs and underside are usually white. The physical characteristics of the pariah group in general were portrayed as somehow intermediate to the grey wolf and the domestic dog (Newsome et al. 1980).

Studer (1901, quoted in Epstein 1971) indicated that "the pariah" has an elongated skull with a domed braincase, a concave facial region and well developed sagittal crest and occipital process; auditory bullae are large and the zygomatic arches are robust but not well flared.

Examples of limited polymorphism within pariah populations were discussed by Menzel and Menzel (1960) and Epstein (1971).

2.14 The dingo

Zeuner (1963) highlighted the likeness between the dingo and the pariah dog; Macintosh (1975) actually considered the dingo ancestral to the pariah, although Gollan (1982) described the dingo as "a primitive generalized dog". Epstein (1971) commented that that the skull of the dingo is more robust than that of the pariah.

Longman (1929) and Macintosh (in Barker and Macintosh 1979) found that in the dingo the length of the carnassial accounts for more than ten percent of the total length of the skull, and that the length of the upper carnassial will approximate the combined lengths of both upper molars.

Macintosh (1975) developed a scoring system, combining metrical and non-metrical characters, to differentiate skulls of domestic dogs from dingoes. With this technique he accomplished a total separation of the two morphotypes. The existence in dingoes of a mandibular diastema, between LP2 and LP3, was the only single trait capable of achieving by itself a complete discrimination within the sample.

Newsome et al. (1980), using canonical variate analysis on a series of skull measurements, again achieved an almost perfect separation between a sample of dingoes from Central Australia and a sample of domestic dogs. An equation to
identify skulls from dingoes, domestic dogs and hybrids was eventually developed (Newsome and Corbett 1982). The basic data on dingoes came from fifty specimens collected in remote areas, and assumed to be pure. Jones (1990), however, in his study of the wild dogs of the Victorian Highlands, questioned the validity of this procedure, as he was unable to find any correlation between canonical scores and coat colour in this area. Woodall et al. (1996) rated a sample from Augathella (Qld) as 95% pure using the Newsome and Corbett (1980, 1985) methodology, but also found a weakness in this technique since the values for the canonical equation of some known hybrid specimens would overlap with those of pure dingoes or of domestic dogs; they also commented that canonical scores tended to be lower in populations with a higher percentage of hybrids, which they also interpreted as a flaw in the methodology. In an effort to improve his method, Corbett (1995) proposed additional restrictions concerning coat colour patterns and skull measurements.

Woodall et al. (1996) found significant differences between the craniometric characteristics of his sample from Augathella and previously described populations from Central Australia (Newsome et al. 1980, Newsome and Corbett 1985); in fact, their specimens were anatomically closer to some tropical populations from the Australian Far North (Woodall et al. 1996).

2.15 The New Guinea highland dog

Longman (1929) described two museum specimens from Papua as genuine dogs, of possible domestic origin, and not strongly linked to the dingo. He pointed out that the length of the upper carnassial, in both specimens, approached ten percent of the condylobasal length, and that it came near to the combined lengths of both upper molars. Wood Jones (1929) regarded these specimens as true representatives of a local dog race, and possibly related to the dingo. Koler-Matznick et al. (2003) questioned the provenance of this sample.

In 1957 Troughton described the New Guinea highland dog as a new species (Canis hallstromi), using as holotype and allotype two specimens kept at the Taronga Zoological Park, in Sydney. Schultz (1969), after studying the captive offspring of the Taronga Zoo pair, concluded that they were the descendant of some feral dog type, connected to the dogs of the Papuan lowlands and to the Australian dingo, basing his opinions on the high degree of morphological and chromatic variability shown by the progeny. In his last article Troughton (1971) opposed Schultz's thesis and reaffirmed the identity of hallstromi as a true wild species; he suggested that C. hallstromi arrived in New Guinea and Australia while this part of the world was still connected to Asia by a land bridge, and considered it ancestral to the Australian dingo.

The New Guinea highland or "singing" dog was later synonymised with the Australian dingo as C. familiaris dingo (Corbett 1985), and both later became C. lupus dingo as the specific name "lupus" was considered more appropriate for the wolf/dog morphotype (Wozencraft 1993).
Koler-Matznick et al. (2003), however, re-described C. hallstromi as a separate species and found it to be similar to the dingo, albeit smaller, with shorter legs, and with a broader head.

### 2.16 Hybrids

Hybridization has been described in different carnivore species. The case of the Scottish wildcats (French et al. 1988) offers good material for comparison. Historical data seem to indicate that the number of feral cats living in the wild increased during the 1940s as a consequence of predator control measures and deforestation, and the classic wildcat gave way to a highly mixed population. When vermin control campaigns relaxed, and forested areas made a comeback, cats living in the wild became more uniform and similar in appearance to the old type. Daniels et al. (1998) suggested the existence of two different morphological groups within the Scottish wild cat population, one more affected by introgressed domestic genes than the other. Daniels and Corbett (2003) compared this situation with that of dingo in Australia and concluded that both species have been exposed to "widespread introgression"; they concluded however that a wild type was still identifiable in both species, although it was different from that of their ancestors.

Clutton-Brock and Kitchener (2000) provided evidence of crossbreeding between Arctic wolves (C. l. arctos) and husky dogs. They explored a similar scenario to the one studied by French et al. (1988), with hybrids becoming more common during the 1930s due to sled dogs being set free as they were replaced by machinery. When intentional releases became more sporadic there was a return to the wild type. The authors found considerable cranial similarity between huskies and Arctic wolves. Maagaard and Grauggard (1994) described a mating event, between a sledge dog and a female Arctic wolf, taking place in Northeast Greenland.

Walker and Frison (1982) analysed 14 prehistoric Canis crania from the Northwestern Plains of the United States, identifying their sample as representative of a widespread wolf-dog hybrid population. Using historical sources, they described a fluid situation, where domesticated animals lived in continuous contact with wild wolves. Their analytic protocols were criticized by Morey (1986), who argued that pooling together all the experimental data would be, as a first step, methodologically inappropriate; but he also confirmed the presence of wolf-dog hybrids, in the northern American Plains, during historical times. Archaeological remains of wolf-dog hybrids have also been recovered from an Eskimo campsite in Alaska, dated to the first millennium B.C (Murie 1948, Olsen 1985), and from a settlement in North Dakota (Olsen 1985), dated from circa 1590 AD to circa 1700 AD (Olsen 1985). A single hybrid specimen from a bison kill-site in New Mexico (1420 AD to 1845 AD +/- 100) was reported by Walker (Olsen 1985).

References to Indian and Middle Eastern wolf-dog hybrids are not numerous. One of the few available accounts describes a population of such hybrids that lived in the village of Jutial (3 miles from Gilgit), in Kashmir, at the turn of the 20th Century (Manners-Smith 1901). The story relates how a wild strain of hybrids developed around the village because of the habit of some she-wolves to mate with the village dogs. Harrison (1973), on the other hand, reported what can be described as a
widespread hybridization process between *C. l. arabs* and pariah dogs in the Arabian Peninsula; within this scenario, he suggested, external characteristics alone would not provide enough data to separate wolves from dogs, and he proposed using the size of the auditory bulla to identify those specimens which are more wolf-like, since dogs usually have a very poorly developed bulla. Mendelssohn (1982) proposed that the disappearance of the wolf from some regions of Israel is causing its replacement by feral dog populations; he insinuated that these circumstances may be increasing hybridization events between both forms, and suggested that some wolf specimens in Israeli collections could be in fact hybrids. He cited one case of a wild she-wolf forming an apparently permanent bond with a pet dog; the event took place in farmlands belonging to a Kibbutz located in the vicinity of Haifa (Mendelssohn 1982). Harrison (1973) as noted above, reported widespread hybridization between *C. l. arabs* and pariah dogs in the Arabian Peninsula, best detectable by the size of the auditory bulla.

### 2.17 Palaeolithic protodogs

Remains of short-faced wolves have been found in a late Palaeolithic mammoth hunters’ campsite at Mezin in Ukraine (Pidoplichko 1998, Olsen 1985). Apart from the shorter rostral area this sample presents a high frontal area and slightly developed sagittal crests (Olsen 1985). They were found alongside other wolf remnants, morphologically similar to the modern subspecies that still today inhabits that area (said to be *C. l. albus*). These specimens have been interpreted as a testimony of an ongoing wolf domestication process, and were consequently named *C. l. domesticus* by Pidoplichko (1998).

Sablin and Kholopachev (2002) analysed remains of primitive dogs found at Eliseevichi I, a Central Russian Upper Palaeolithic site. The crania had a similar size to those of the local wolves, and a general appearance that was reminiscent to huskies. Geronpré et al. (2008) compared the Eliseevichi I sample with other specimens from Ukraine, Russia and Belgium and concluded that domestic dogs could be found in the Aurignacian of Belgium.

Musil (2000) described similar specimens with reduced rostrums and crowded teeth from the Magdalenian of East Germany. He studied a sample of rather fractured crania and mandibles, retrieved from three different horse hunting campsites. The peculiarities of this material refer to traits usually associated with domestication: large premolar teeth appear crowded, as a consequence of shortened snouts. General body size could only be described as small as compared to other Magdalenian wolves. A mandible fragment found in a Palaeolithic grave of Magdalenian age at Bonn-Oberkassel (Germany) was dated as 14,000 BP (Clutton-Brock 1995); Benecke (1987), using discriminant function analysis, concluded that this specimen was closer to a sample of Mesolithic dogs than to dingoes or wolves.

Analogous discoveries took place in muck deposits from the upper Pleistocene in the vicinity of Fairbanks, Alaska (Olsen 1985). Here again two different types of wolf are found; one seems to be related to the typical wild form still living in that area, the other short-muzzled and showing sledge-dog features (Olsen 1985). Some
characteristics of the later group are the contracted and dished rostrum, and the low occipital and supraoccipital crest. The dentition in general appears to be smaller than in the co-existing wolf population. Particular individuals may also present rather extreme traits like very broad heads, wide palates, crowded teeth and rounded neurocranium profiles. Typical wolf characteristics of this last population are a large cranial size and the presence of a well developed occipital process.

2.18 Mesolithic dogs

The Senckenberg dog, characterized by a robust skull, a relatively short face and non-crowded teeth, was called a European Mesolithic dingo by Degerbøl (1961); he indicated the possibility of wild dingo-like canids inhabiting Western Europe during this period. Mertens (1936) considered this specimen akin to the dingo and *C. f. poutiatini*, which was one of the prehistoric dog types studied by Studer (1901). The type specimen of *poutiatini* consists of a well preserved skeleton that was found in the vicinity of Moscow. Epstein (1971) described it as being of either Mesolithic or Neolithic origin and by having a long neurocranium, a broad and slightly dished forehead, high sagittal crest, large orbits and short zygomatic processes.

An incomplete small skull from a young animal found at the Mesolithic (Maglemosian) of Star Carr elicited some degree of controversy, as it had large and crowded teeth and a very flat forehead; it was described as a domestic dog by Degerbøl (1961) and Clutton-Brock (1995). Benecke (1987) found it closer to captive wolves than to domestic dogs or to wild wolves from Europe and Greenland, and he also included the Dobritz-Kniegrotte (Upper Palaeolithic) and the two Mezin specimens (Upper Palaeolithic) into this category. He interpreted some fossil captive wolf types as models of the hypothetical transition between the wild wolf and the domestic dog. Two other individuals from the Mesolithic of Knabstrub and Ertebølle were described as wild wolves (Benecke 1987). Degerbøl (1961) noted that dogs from the Preboreal and Boreal periods of Northern Europe usually presented crowded dental series, whereas contemporary breeds tend to have normally spaced teeth.

2.19 Origins of the dog

As summarized by Manwell and Baker (1983), there are three main hypotheses to explain the origin and development of the dog. Some authors describe the grey wolf as the exclusive ancestor of the domestic dog; others have proposed that although the grey wolf may have had an essential role, coyotes and jackals could have also contributed to the process; finally, some more or less unknown form of wild proto-dog, sometimes referred to as *Canis ferus*, has been suggested as a possible predecessor.

Morey (1992) found that the skull of Neolithic dogs presented a heterochronic pattern contrasting with a sample of grey and red wolves, golden jackals and coyotes. This was attributed to grey wolves undergoing a paedomorphic process.
while being domesticated. He proposed that most differences amongst dog breeds were due to some form of intentional breeding program, and not to biomechanical constraints. Tchernov and Valla (1997) suggested that paedomorphosis in the case of the domestic dog only takes place as an accidental outcome of the domestication process.

Manwell and Baker (1983) concluded that the cephalic index of “normally shaped” medium size dogs coincided with those wild forms of similar size. Small breeds tend to present higher values for the cephalic index while the opposite is true for larger breeds. They therefore proposed a medium-sized wild canine as the most acceptable predecessor of the domestic dog.

Other trends like declining tooth size and shortening of the facial area have been traditionally viewed as essential steps of the transition from wolf to dog (Bokonyi 1970, 1975, 1977; Olsen 1985; Clutton-Brock 1984). Bokonyi (1975) and Tchernov and Valla (1997) suggested that these two processes will affect almost exclusively the frontal part of the snout, transforming the distal regions of the maxilla and the horizontal ramus. At the same time some molars and premolars will experience conspicuous size reductions; this would account for the lack of crowding in the dentition of Natufian dogs (Dayan 1994, Tchernov and Valla 1997, Dayan and Galili 2000). Conversely, dental overlapping has been found in a number of primitive dogs from Europe and North America (Degerbol 1961, Benecke 1987); this event has been attributed to the mandible and maxilla decreasing in size at a faster rate than teeth (Bokonyi 1970, 1975, 1977; Clutton-Brock 1984). Degerbol (1961) created an index of overlapping to compare the combined lengths of molars and premolars in a sample of primitive North-European dogs. He found that only intermediate wolf-dog forms presented a high degree of teeth overlapping.

Using a rationale related to the matter of scaling, the small wolves from Southern Asia have often been upheld as plausible ancestors of most domestic dog breeds (Degerbol 1961, Lawrence 1967), and the small carnassial size of *C. l. arabs* and *C. l. pallipes* was construed as evidence of their direct linkage to the dog ancestry (Lawrence 1965). Olsen and Olsen (1977), on the other hand, interpreted the existence of a recurved coronoid apex in *C. l. chanco* as an indication that it was this subspecies that could be the main forebear to the modern domestic dog. Alternatively, Clutton-Brock (1984) suggested that most local dog races evolved largely from the neighbouring grey wolf populations, and she proposed an independent geographical origin for many of the domestic dog breeds.

What has been called *Canis lupus variabilis* (Pei 1934) has been found in association with *Homo erectus*, in deposits dated between 700,000 BP to 400,000 BP at Zhokoudian, near Beijing, and from somewhat older levels at Lantian in the Chinese province of Shaanxi (Olsen 1985). The skulls are characterized by their small sizes and low sagittal crests (Pei 1934, Olsen 1985), and in some individuals the lower border of the horizontal ramus can be remarkably convex (Pei 1934, Koler-Matznick 2002). Lawrence (1967) found *variabilis* a plausible candidate for a possible ancestor of the domestic dog, and Olsen (1985) advanced *C. l. variabilis* together with *C. l. chanco* as the most plausible predecessors of the dog. Koler-Matznick (2002) also supported the idea of *variabilis* as a forerunner of the dog but
opposed the connection with *chanco*; she went to the extent of advocating its elevation to full species status as *Canis variabilis*.

**CHAPTER III**

**EXTANT PRIMITIVE DOG POPULATIONS**

**3.1 Literature survey**

**3.1.1 The Dingo**

**3.1.1.1 Nomenclature**

The first scientific name given to the dingo was by Kerr (1792), who based the name *Canis antarcticus* on the description and illustration “of a dog of New South Wales” in *The Voyage of Governor Phillip to Botany Bay* (Phillip 1789), as discussed by Barker and Macintosh (1979); Meyer (1793) on the same basis gave it the name *Canis dingo*. The International Commission on Zoological Nomenclature (Opinion 451, 1957) used its plenary powers to determine that *C. dingo* should remain as “the oldest available name for the dingo of Australia” (Mahoney and Richardson 1988), although Macintosh (1975), in contravention of the Commission’s decision, continued to support the name *C. antarcticus* Kerr. Desmarest (1820) considered the dingo as a subspecies of the domestic dog and gave it the name *Canis familiaris australasiae*, based in this case on specimens brought back to Paris by Péron and Lesueur. Gray (1826), however, regarded it as clearly different from the domestic dog and gave it the name *C. australiae*. Voigt (1831) renamed it *C. f. novaeollandiae* (see Corbett 1995). Matschie (1915) described two local species, *C. dingooides* from southern Queensland and *C. macdonnellensis* from the MacDonnell Ranges in the Northern Territory. Wood Jones (1921), asserting its feral dog nature, called it *C. f. dingo*. Melville and Smith (1987) included *C. familiaris* on the Official List of Specific Names, but Corbett (1995) used the subspecific *C. lupus dingo* for the dingo, and the International Commission of Zoological Nomenclature (Opinion 2027, Case 3010, March 2003) deemed that the names given to domestic animals and their feral derivatives should yield precedence to those given to their wild relatives (see Gentry et al. 2004).

**3.1.1.2 Early descriptions of the dingo**

Newsome and Corbett (1985) listed the following early descriptions of the dingo, and emphasized the existence of a number of different colour patterns: Stockdale (1789) describing a live specimen shipped to England by the first Governor of the colony, Arthur Phillip, noted that the pelage was in general “pale brown” becoming white in the belly and the back of both legs; front and back feet were white. White (1790) gave “reddish dun”, with white on the feet, abdomen and chest, as the standard colour of the Australian dingo, but Collins (1798), who probably made his observations around the Sydney area, reported having seen both black and red

45
dingoes, the latter variety "with some white about it". Grey (1841) referred to a variant, which he found in north-western Australia, as "having a blackish tinge". Mitchell (1839), arguably the first white person to travel through the Murray region, mentioned having seen during the course of his journey a "small black native dog". Giles (1889) observed a white dingo in central Australia, west of the Petermann Ranges. Gilbert (1842) indicated the presence of many different colour variants, among the local dingo population, in the Swan River area in south-western Australia; he mentioned red, black, white, light brown and black and white specimens. Gould (1863) in his depiction of the dingo detailed that black and black and white specimens can be found in addition to the more common reddish varieties (for all these descriptions see Newsome and Corbett 1985). In the more recent literature, Troughton (1966) gave his support to the existence of a variety of coat colours in pure populations of dingoes: "yellowish-white, piebald and blackish". Macintosh (in Barker and Macintosh 1979) referred to a diversity of colour patterns, such as rich yellow, tawny, grey and cream, that he documented in dingo populations of the far north-west corner of New South Wales; he attributed this variability to natural polymorphism, not induced by crossbreeding with domestic dogs. Macintosh (1975) also referred to a brindle skin, held at the West Australian Museum in Perth, which was collected in 1876 at the western edge of the Dead Heart; he mentioned, as well, a population of dappled and brindle dingoes living at that time in the Gibson Desert. He interpreted this variability as having adaptive value to different environments.

3.1.1.3 Studies on the zoological position of the Dingo

Morphologically, the dingo has often been portrayed as the quintessential "primitive dog" (Degerbøl 1961, Zeuner 1963, Clutton-Brock et al 1976, Gollan 1982). Indeed, early works on this form emphasized its primitiveness, and quite often its physical characteristics have been portrayed as somehow intermediate between the grey wolf and the domestic dog (Newsome et al. 1980). Gollan (1982) described the dingo as "a primitive generalized dog", and also pointed out its similarities with the Indian wolf.

Newsome et al. (1980), using canonical variate analysis on a series of skull measurements, achieved an almost perfect separation between a sample of dingoes from Central Australia and a sample of domestic dogs. A canonical score, derived from an equation based on eight different characters, was developed to separately identify skulls of dingoes, domestic dogs and hybrids (Newsome and Corbett 1982). The baseline data came from fifty dingo specimens collected in isolated regions of central Australia, and assumed to be pure (Newsome et al. 1980, Newsome and Corbett 1982). Newsome and Corbett (1985) found a higher abundance of ginger coloured specimens, and a larger presence of presumably pure specimens, in outback areas of central Australia, than in the temperate more urbanized regions where pure specimens were rarer and colouring more diverse. In spite of this, specimens from both areas, displaying ginger, black and tan and brindle coats, and a range of other non-typical colours (i.e. black, brown and bluish) were identified as "pure" and they concluded that the distribution of colour patterns among those identified as dingo, hybrids and dogs was not significantly different. Corbett (1995)
eventually established a more complex method to recognize purity in dingoes by using morphological data. The identification process would now have to follow a three step procedure, by which every specimen would be assessed firstly by achieving compliance to the canonical equation previously described; a second step concerns the fitting or otherwise of each of the eight characters, included in the equation, within the so call “dingo range” (only specimens with all eight characters individually fitting within the dingo range would be now acceptable as pure dingoes); the third step proposed that only four coat colour variations could be present in a pure dingo - ginger, black, black and tan and white, and any other chromatic manifestation will disqualify the specimen as a pure dingo. Later on, however, Corbett (2001) restricted the pelt colour options, for pure dingoes, to only ginger. Jones (2009) questioned the validity of applying Corbett’s equation to wild Canis populations from the Victorian highlands; he suggested that the current morphology of these animals was a product of the backcrossing of dingoes with domestic dogs although the final result was a quite stabilized one and bore no resemblance to any breed of domestic dog. Accordingly, values obtained from the application of Corbett’s methodologies to the Victorian population formed a continuum, and no outstanding differences could be detected among “dingoes”, “hybrids” and “feral dogs” as identified by the numerical outcomes of the equation; neither did he find direct evidence of feral dogs living on the highlands. Jones (2009) also re-asserted that the original dingo that populated this region could have been morphologically different from those of Central Australia, on which Corbett based the development of his equation, as the two environments are substantially dissimilar.

Corbett (1995), initially, mentioned the possibility of three different subspecies of dingo existing in, north, central and south-eastern Australia; he tentatively named them as Canis lupus dingo Meyer for the alpine dingo, Canis lupus macdonnellensis Matschie for the desert dingo, and Canis lupus cobourgensis Corbett for the tropical dingo; he advised caution on the issue, outlining that subspecific differences could be based on gradients of both rainfall and temperature across the continent, and that therefore populations seemed to overlap frequently. He eventually dismissed any ideas involving subspeciation, and considered all dingoes living in the Australian continent as belonging to the same subspecies C. l. dingo (Corbett 2001, 2006), albeit he made the proviso that some populations of the southeast may show physical characteristics derived from domestic life at Aboriginal camps in times past (Corbett 2006).

It is worth noting that Newsome and Corbett (1982) initially reported a shortening of the snout in captive-born dingoes; eventually this account was dismissed and instead it was asserted that only a widening of the palate “may have developed” under those circumstances (Newsome and Corbett 1985).

Jones (1990) in his study on the wild dogs of the Victorian Highlands was unable to find any correlation between canonical scores and coat colours in his area. After comparing his own, more recent, data with results provided by Newsome and Corbett (1985), where they covered information from 1966 to 1979, he concluded that there was a perceptible increase in non-ginger canids in the recent samples, which he attributed to cross-breeding with domestic dogs. Complementarily, he
described the animals that he studied as not presenting the usual range of phenotypical variability usually found in domestic dog breeds, and therefore as being relatively homogeneous from the morphological standpoint. He admitted the need of finding a terminology that would suit the real character of the population that he studied, due to a lack of appropriate background information to help to identify “pure” dingoes from this area (Jones 1990). His proposal was to regard this particular population as “dingo like” wild canids that present a wider range of morphological variability than those specimens usually regarded as “pure dingoes” (Jones 1990).

Corbett (2006) defined the dingoes from south-eastern Australia as genuinely different from those of the rest of the country; he attributed the differences to hybridization with domestic dogs, but, as noted above, he also speculated on the possibility of some of the traits being derived from selective breeding practices conducted by the Aborigines previous to the arrival of the Europeans.

Woodall et al. (1996) studied a sample of 100 dingo skulls from Queensland; they grouped the localities of origin in four arbitrary regions. The highest proportion of pure specimens, after applying the Newsome et al. (1980) and Newsome and Corbett (1985) methodologies, was found in the sample from Augathella, south-central Queensland, which they rated as 95% pure, while the highest concentration of hybrids was in southeastern Queensland (Woodall et al. 1996). They also, however, mentioned potential weaknesses in the evaluation method, as canonical scores, for pure specimens, tended to be lower in those populations with a higher proportion of hybrids, thus there was the possibility of some hybrids being identified as pure specimens. They also found significant differences between the sample from Augathella and previously studied populations from Central Australia (Newsome et al. 1980, Newsome and Corbett 1985); in fact, their specimens were morphologically closer to some tropical populations from the Australian Far North, as described by Corbett (1995).

Some authors have reported on hybridization of dingoes with domestic dogs and its effects on the disappearance or rarefaction of the “pure” dingo type from some regions (Newsome and Corbett 1982, 1985; Corbett 1995, 2001, 2006). Corbett (2001) and Daniels and Corbett (2003) postulated that introgression has already occurred in all dingo populations through Australia. Daniels and Corbett (2003) proposed that the morphology of the hybridized populations should be currently evaluated under a different, and more accepting, perspective derived from applying an evolutionary approach, by which contemporary dingo populations still preserve a strong identity, which is nonetheless different from that of their ancestors.

3.1.2 New Guinea highland dogs

De Vis (1910) wrote about a dog skin and skull, collected in the Mount Scratchley area, on the northern side of the then British New Guinea, as a small sized specimen with short legs, a small head and a black and white coat – “black predominant”. He considered it of feral origin, possibly linked to some extinct, and non-documented, domestic variety. Longman (1929) studied the aforementioned
specimen, plus another one from the same locality, at the Queensland Museum; the skin of the second specimen he described as “russet” and mixed with dark hair. Supported by comments from Papuan officials, he expressed his concerns that they might be of domestic origin. He concluded that in principle this type of dog did not appear to be strongly related to the dingo. He also noted that the length of the upper carnassial, in both specimens, approached ten percent of the condylobasal length, and that paradoxically it almost equaled the combined lengths of both upper molars, a characteristic of affinity with the dingo; conversely, he described the breadth of the palate as comparatively larger than in the dingo. Wood-Jones (1929) analyzed the same two specimens, and commented on the well developed nuchal and sagittal crests and the relatively large carnassials. He advised that these were genuine feral dogs, of a primitive type, unrelated to other domestic forms found around the Pacific.

Troughton (1957), as recounted above, described the New Guinea highland dog as *Canis hallstromi*, using as holotype and allotype two live specimens kept at the time in the Taronga Zoological Park in Sydney. He detailed the coloration of both specimens as a mixture of russet to tawny brown, with some yellow tones, and with four “whitish” feet. The ears were described as triangular in shape and kept erect and forwardly oriented, the tail curled and carried over the back against one side. Subsequently he described, in agreement with Longman (1929) and Wood-Jones (1929), that the ratio of upper carnassial to condylobasal length was within the 10% limit (Troughton 1971).

Schultz (1969), after studying the captive offspring of the Taronga Zoo pair, concluded that they were the descendants of some feral dog type, connected to the dogs of the Papuan lowlands and to the Australian dingo, basing his opinion on the high degree of morphological and chromatic variability shown by the progeny. Using mostly unpublished data by Klatt, Schultz demonstrated that the brain size of his sample of highland dogs was comparable to that of the small-brained domestic dog, and in that regard was very different from the larger brained dingoes and indeed wolves. Troughton (1971) opposed Schultz’s (1969) thesis and reaffirmed the identity of *hallstromi* as a true wild species. He considered it ancestral to the Australian dingo, and suggested that *C. hallstromi* arrived in New Guinea and Australia while there was still a land bridge connecting to Asia (which actually there never was during the Cenozoic). Gollan (1982) regarded the New Guinea highland dog as a feral variety of some sort of local village dog, and could not find any particularly strong affinity with the dingo, other than its well developed dentition, and in the remarkable size of the auditory bulla.

Corbett (1985) synonymized the New Guinea highland dog with the Australian dingo as *C. familiaris dingo*, and later as *C. lupus dingo* (Corbett 1995). Koler-Matznick et al. (2003), in strong disagreement, redescribed it as a separate species, *C. hallstromi*; and they described it as similar to the dingo but smaller with shorter legs and a broader head. The colour of the coat in the wild was described as light brown, brown, black and tan, and black, along with white points. They questioned the identity of the specimen studied by de Vis (1910), Longman (1929) and Wood-Jones (1929), as it did not match either the description of the species by Troughton (1957) or their own re-description (Koler-Matznick et al. 2003), and they also
doubted the provenance of its companion specimen (de Vis 1910, Longman 1929, Wood-Jones 1929), “as they were apparently obtained from the indigenous people” (Koler-Matznick et al 2003).

Corbett (2004), after studying 13 skulls, including the holotype and the paratype, concluded that the morphology of the sample was consistent with that of hybrid dingoes, and in consequence he suggested that the true wild populations of New Guinea highland dogs may be currently extinct.

3.1.3 Pariah dogs

Menzel and Menzel (1960) defined the pariahs which they found in Palestine during the first half of the XX century as dogs of a primitive type that occupy a peculiar position between the domestic and the wild stages. They described some populations as living in the wilderness, while others find an intermediate niche living in a more or less symbiotic relationship with nomads, around itinerant camps; still others may live as stray dogs in the cities, or even may be kept as pets or used as working dogs. Morphologically there is a degree of variation among them which they summarized into four different types, “sheepdog”, “dingo”, “collie” and “sighthound”, with a variable number of intergradations between these four basic types. Each of the types was identified by a particular external conformation involving different characteristics such as coat colour, structure of the pelage, body size, head shape, and length of the extremities, but they gave no craniometrical data nor did they make any reference to the morphology of the skull. They emphasized that a characteristic common to all pariah dog populations is the limited amount, if any, of intentional artificial selection that they are subjected to; they also highlighted the existence of pariahs living in the wilderness, away from human settlements, at the time.

Zeuner (1963) described the pariah as a medium size dog with erect ears, short or medium length hair and a tail that can be carried upwards or hanging low as in a wolf. The colour was described as variable, but in most cases wolf-like, reddish, yellowish or fawn, mixed with grey or brown hair. He observed some specimens in Gujarat (north-west India) which he described as very similar to dingoes.

Epstein (1971), using data provided by Studer (1901), described the pariah dog as having a narrow skull with a long neurocranial region, dilated parietals, a shallow and concave frontal region and a narrow forehead. He noted the presence of well developed sagittal and occipital crests. He characterized a basic type of pariah from Egypt as of a medium body size, and as displaying a relatively broad head, erect ears and a long bushy tail, and described the usual colour pattern of this type of dog as a mixture of yellow and white, but also at times completely white, brown or yellow. In agreement with Menzel and Menzel (1960), he also commented upon a range of varieties, which can be either sympatric or allopatric, that he also included under the "pariah" denomination; this variability could encompass specimens rather similar to those studied by Menzel and Menzel, plus much smaller varieties.
similar in size to a small terrier such as the one that he found living in the Atlas region. All these varieties are connected by intermediate forms. The craniology of the North African pariahs that he covered in his studies was also highly diversified (Epstein 1971).

Churcher (1993) mentioned the existence in modern Egypt of a robust type of pariah dog called the shenzi, and detailed a high degree of morphological variability within this variety. Gollan (1982) gave some attention to the dog of the Boyas, a tribal group from the Bellary District in Karnataka; quoting a local informant he described this variety as of medium size (16.5 to 20 kg), the general aspect gracile and well balanced, and the tail usually carried over the hind quarters, closed in a wide loop; the pelage is short and displays a variety of colours, such as brown, combined with white areas on the snout, tip of the tail, limbs, feet, chest or neck, and they can also have a piebald coloration in which case black or brown will combine with white; uniform colour patterns are also common and include tones from light brown to umber. A series of photographs (Gollan 1982) show an animal which is indeed of a medium size and strong build, although gracile, with long legs, full or half erect ears and some face wrinkles. He considered this form a local type of village dog which he equated to a pariah morphotype. Complementarily, his analysis of pariah dog materials from Turkey, Egypt and the Indian subcontinent affirmed that, as far as cranial (non dental) variables are concerned, "the majority of dingoes could be drawn from a population with the pariah parameters"; it is therefore surprising that on the contrary he affirmed that he could not find "precise equivalent to the dingo either from the aspect of a whole skull assessment or at the level of non-metrical morphological traits" among the pariah materials that he studied (Gollan 1982).

Corbet and Hill (1992) supported the existence of a uniform type of “feral” dog (pariah, pye, dingo) all through the Indo-Malayan region, and by extension in Australia; they characterized it as having a medium size body, a curled-up tail, pricked ears and usually displaying a “yellowish brown pelage”, but also other less common colour variations. Corbett (1995) proposed an even larger current geographic distribution for this type, from the valley of the Nile all through the Arabian Peninsula, the Indo-Malayan region, parts of Central Asia, Korea, Japan, New Guinea and Australia; he also included a part of south-central Africa, Madagascar and a section of the southeastern United States. He identified all these populations under the common label of “dingoes”, although differences can exist between populations such as in the shape of the ears and in the length of the coat.

Corbett (1985, 1995) paid particular attention to the pariah dogs from Thailand, which he described as intermediate between the Australian dingo and the domestic dog in craniology and conformation. In general, he observed, the Thai pariahs were smaller in size and body weight than the Australian dingoes, but were almost identical to them in body conformation (Corbett 1985); the majority exhibited ginger coats, although he noted the presence of white, black and tan, sable/brindle, black and finally patchy specimens. Complementarily he dismissed the possibility of any significant amount of hybridization with domestic dogs taking place in the rural areas of northern Thailand, where he conducted his studies, since at the time those
regions were practically devoid of domestic dogs (Corbett 1985); this paradoxically despite the fact that under his complete craniometrical methodology a high percentage of his sample scored as hybrid (81.98 %) and only 0.9 % as pure dingoes, while the remaining 17.11 % were identified, in theory, as modern domestic dogs of mixed origin (Corbett, pers. comm. 2005). He implied (Corbett 1985, 1995) that the Thai population represented an intermediate stage between the Australian dingoes and the modern domestic dogs. Nevertheless, he found that his sample from Thailand could be categorized as a single population, which was significantly different from those of Australia, Korea, Japan and Israel, and he thought it appropriate to propose a separate subspecific treatment for the “Thai dingo”: *Canis lupus siamensis* (Corbett 1995).

Medway (1977) studied a colony of Senoi dogs, which he described as a genuine breed, from peninsular Malaysia; he characterized them by their small body size, short legs, unfeathered and recurved tails, wrinkled forehead and short muzzle; he depicted the pelage as “coarse” and “yellowish dun” in colour, and observed specimens with white front feet and white mottling on the chest and on the inside of the limbs. He also discussed information provided by Macintosh (in Barker and Macintosh 1979), who found that in the adult dingo the length of the carnassial accounts for more than ten percent of the total length of the skull, and that the length of the upper carnassial will approximate the combined lengths of both upper molars. Macintosh (1975) also developed a scoring system, which combined metrical and non-metrical characters, to differentiate skulls of domestic dogs from dingoes. With this technique, he accomplished a total separation of the two morphotypes; the existence in dingoes of a mandibular diastema, between LP2 and LP3, was the only single trait capable of achieving a total discrimination (Macintosh 1975, Gollan 1982).

Medway (1977) also discussed information provided by Scott et al. (1967) on the dogs from Ulu Telom, which he found in accordance with his description of the Senoi dogs; Scott et al. (1967) had found the morphology of this type of dog quite similar to that of the African basenji. Medway referred to the work of other authors (Beccari 1905, Lumholtz 1921) in regard to the conformation of the Dayak dogs from Borneo, portraying this variety as of a small size, with an upright tail with a degree of feathering, and the coat colours showing a wide range of variability from reddish dun to brown and white and also exclusively black (Medway 1977). He argued that Senoi and Telomian dogs are part of the “pariah group”, which in his opinion occupies a considerable expanse of terrain from southern Asia to the Middle East.

Gollan (1982) studied four different clusters of village dog populations from island Southeast Asia and Melanesia: Batak dogs from Sumatra, Iban dogs from Borneo, Tengger dogs from east Java and an assortment of types from New Guinea. He found the first two types quite similar, of a medium-small size (shoulder height circa 40 cm), displaying a tail which is carried over the hips in a closed loop; coat colours were the usual, highly variable combinations of ginger, white, black and brindle, with white and red or white and brindle being uncommon; a photograph of an Iban dog taken 40 km northeast of Kuching shows a long legged and healthy looking animal, with a very deep chest, tucked in stomach, pricked ears, a relatively
broad head and a surprisingly (for this region) bushy tail tightly encircled over the rump. He analyzed two more different types from New Guinea; using material documented from Studer (1901), Boessneck and Meyer-Lemppenau (1969) and Lampert (n.d.), he (Gollan 1982) made the comment that the native dogs from New Britain, New Ireland and the Western Province of Papua appear to belong to a common morph that could be described as the New Guinea village dog, of medium size with long legs and upwardly bent smooth tail, the head relatively broad with a pronouncedly pointed muzzle, with erect ears, while the hair is short, usually light grey in colour combined with darker areas that can be, in some cases, extended to most of the body (ex Studer 1901). The photographs of two dogs from New Britain, included by Gollan in his work, are consistent with this description. He discarded any idea of any of the forms from island Southeast Asia being of a dingo-type.

Jentink (1897) described the external morphology of the Tengger dog, from East Java, as of a medium size and displaying a bushy tail, erect ears and a long coat, usually light brown in colour with reddish undertones and dark streaks, the underside being white shaded with light brown. He described it as less than typical for the region, as it was an unmistakably feral variety with many non-dingo characteristics, such as a very small tympanic bulla, a relatively high brain case, a sagittal crest with a straight dorsal margin, and an intriguingly bifurcated process at the staphylion; body size was however comparable to that of the dingo. The paper of Storm (2001) on recent and archaeological dogs from Java includes some references to the Tengger dog, which he considers currently extinct. His morphometric work with recent pariah dogs suggests the presence of medium size pariahs on the island of Java.

**BOX I**

**Note on pariah dog types from the Middle East**
*(based on Menzel and Menzel 1960, and complemented with my own field observations in India)*

"Dingo" type: Externally this type may superficially resemble a dingo, due to its basic body proportions. The general body profile is square and robust, with well proportioned legs and a slightly convex back. Typical of this form is a well balanced head that sports a medium length muzzle (pear shaped head), with long pricked ears well set almost on top of the postorbital region; the head appears wider and stronger than in the Australian dingo. The neck is quite strong and sometimes, particularly in the males, has a bulging appearance. The tail is usually bushy and shaped as a hook, and is frequently carried over the rump forming a closed circle. Coat colour patterns are variable; from light grey to dark brown; piebald specimens abound displaying a variable array of black, white and brown tones. This variety is often found living a semi-wild existence around the Bedouin camps and in villages of northern India.

"Sheepdog" type: This is the largest of the pariah dog types. It is a rather robust form characterized by an almost square body shape, with a strong short back, an equally short and thick neck and a broad and powerful head. Legs are proportioned and well muscled. Ears are usually floppy; the tail is in general bushy and decidedly shaped as a hook, often held high in a semicircular or a three quarter
circle fashion over the rump region, or carried likewise against one of the sides. The

**BOX I (continuation)**

pelage is normally double-coated and may vary from solid black, or dark brown, to buff, grey or to almost white, and to all the possible combinations between these colours; the facial area is commonly of a darker colour than the rest of the body. This type seems to be more widespread in high altitude regions; it has been documented in Turkey, the Golan Heights and the mountains of Yemen, but abundant anecdotal evidence suggests its presence in many other locations. Data from Turkey suggest that packs of this variety often follow the nomadic herdsmen, and benefit from a degree of protection from them; humans conversely adopt those pups that may look like promising stock wardens.

“Sighthound” type: This type, as the name may suggest, is outwardly different from the ones previously covered. It is characterized by its slender body built, long legs, a rather deep chest, a tucked in abdomen and a long and narrow head; ears can be either pricked or floppy. It may mark the point of origin of the highly valued sighthound breeds of the Middle East and North Africa, known by a variety of names depending on geographic locations and some differential physical attributes, such as tazis, tessems, salukis and sloughgis. This particular variety of pariah it is in any case also valued by the nomads as a hunting aid, and in many cases they seem to constitute a highly priced possession for some groups.

“Collie” type: Menzel and Menzel (1960) made the proviso that the analogies of this type should be searched for in the early type of collie, the one that was common before the Second World War, prior to it becoming a “show breed” in many parts of the world. The body of this type can be described as gracile and of square shape, with a clearly tucked in abdomen and a long neck. The head is long and narrow, with very little or no stop at all and the eyes are slanted. Ears are pricked and well developed and the tail is always hooked and bushy. The pelage presents a variable composition, from long and double coated to smooth and single coated; males frequently present well developed manes. Colour patterns are highly variable, and would involve almost any possible combination of all colours that have been mentioned for the previous types. Obviously this so called “type” only represents a transitional form from the dingo type to the sighthound type. It was described as the most common form of pariah dog found in Palestine during the 1930’s (Menzel and Menzel 1960); the reason for this may be related to its usefulness as herding dog, a role that none of the previous varieties could ever assume with any level of efficiency. Even today border collies, of working type, are highly valued for their tenacity, athletic abilities and working skills by stockmen all over the globe.

It has become apparent now that there are two possible schools of thought attempting to define what is a pariah dog. For some authors the term pariah dog (Menzel and Menzel 1960, Epstein 1971) should include a variety of types (dingo, sheepdog, collie, sighthound, etc.); this group, of variable morphology but nonetheless closely related, would be loosely defined as having a non-modern
origin, and a non-domesticated ecology. Other scholars would consider only the so-called “dingo type” (Menzel and Menzel 1960) as a genuine pariah dog (Studer 1901, Zeuner 1963, Corbett 1995); Lehr Brisbin has used, the expression “long term pariah morphotype” to refer to this variety in particular (www.carolinadogs.org/news/wildcanid.html, www.indog.co.in/Glossary.html).

The geographic area of the pariah dog would cover the Balkan Peninsula, Asia Minor, and from North Africa to India, Java and Japan; in some regions the original type was mixed with other varieties (Zeuner 1963).

3.2 The Present study

3.2.1 The Dingo

3.2.1.1 Introduction

It must be taken into consideration that nowadays, in the scientific world, the morphological identification of dingoes and their hybrids is almost exclusively based on Corbett’s method (1995), whose effectiveness has been criticized (Jones 2009), and whose unrestricted use, it is claimed, may lead to confusing results (Jones 1990; Woodall et al. 1996; Elledge et al. 2006, 2008).

3.2.1.2 Dingo identity

My study sample of 125 hybrid and nine pure dingoes, identified in accordance with Corbett’s methodology, shows a strong morphological identity clearly differentiable from Indian and Thai pariahs (figs. 3.1, 3.2). In clear contradiction to Gollan (1982) and Corbett (1995), my analysis provides little evidence of any strong affinity between dingoes and Indian pale footed wolves; only one hybrid specimen (AMNH197748, possibly a dingo-wolfhound cross) appears to present characteristics which are comparable to those of that form (fig. 3.1). A visual examination of this specimen revealed some abnormal characteristics, such as an exceptionally thick lower first molar that also had a very small grinding surface. Similarly, only two individuals (G157, G206) from this sample showed characteristics similar to Indian pariahs (fig. 3.1). On the other hand the analysis seems to suggest an unexpected degree of morphological affinity between dingoes and wolf jackals, the so-called Canis lupaster (figs. 3.2 and 3.3).
Fig. 3.1. Multivariate diagram showing the ranges of variation of three canid populations, using 17 cranial variables. The first function accounts for 72.2% of the total variance, the second for 27.8%. 
Fig. 3.2. Multivariate diagram showing the ranges of variation of three canid populations, using nine cranial variables. The first function accounts for 79% of the variance, the second for 21%.
Fig. 3.3 Multivariate diagram showing the ranges of variation of three canid populations, using 17 cranial variables. The first function accounts for 65.9% of the variance, the second for 34.1%.

The use of Corbett’s equation (Corbett 1995) categorizes as “dingoes” some specimens belonging to taxa not directly related to dingoes; thus, from my study sample of 480 non-dingo *Canis* specimens of diverse identity and provenance (see Materials and Methods), 169 fulfilled the morphometrical provisos to be classified as a “dingo”, following Corbett’s (1995, 2005 pers. comm.) approach to the study of non-Australian populations of *Canis*. His method, in this case, is based on the exclusive use of the composite score equation, and does not involve the use of confidence limits (Corbett 1995, 2005 pers. comm.). Only three individuals within this sample satisfied the confidence limits restrictions (Corbett 1995) to be identified as a “pure dingo”: one Thai pariah (C84/3), one Arabian wolf (BM 348412) and one wolf jackal (FMNH 321). The rest of the sample remained in the dingo-hybrid category. Groups with a higher proportion of dingo-like characters, as defined by Corbett’s equation, are recent wolf samples from Asia and a small archaeological sample of probable domestic wolves from Alaska. These results may be due to the fact that Corbett’s equation gives more “weight” to wolf-like characters such as longer auditory bullae, a narrow maxilla, larger carnassials, wider nasal bones, lower braincases, and longer rostrum; it also rates high the development of
the occipital process and the presence of a narrow canine, characteristics which are
typical of dingoes, whereas traits which are usual in domestic dogs are negatively
scored. In this way the canonical equation seems to be useful to highlight the
existence of some primitive characters that are shared between the Australian
dingo and other representatives of the genus *Canis*. Table 3.1 summarizes the
findings in this regard, and describes the percentage of specimens in the samples
showing dingo identity.

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<th>TOTAL</th>
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Table 3.1. Total values and percentages of specimens identifiable as dogs, dingoes or hybrid dingoes
after the application of Corbett's canonical equation to non-Australian canid populations.

Fig. 3.3a. Typical dingo skull. Note the slightly dished facial region, low cranial vault, depressed cranial roof, highly developed occipital process, large auditory bulla, well spaced premolars and strong teeth. See below.
3.2.1.3 Bivariate analysis

In order to describe the similarities and differences between dingoes and other canids, I have investigated some bivariate associations between traits found of particular relevance by some authors (Degerbøl 1961, Clutton-Brock 1962, Macintosh 1975, Groves 1989).

The width of the forehead is numerically almost identical in the dingo and in the wolf jackal, while some Indian pariahs present wider foreheads than any other of the wild *Canis* analyzed; Indian pale footed wolves have a tendency to display smaller values for this trait (fig 3.4).

![Graph of forehead width against basion-hormion length in populations of wild and domestic canids.](image)

*Fig. 3.4. Graph of forehead width against basion-hormion length in populations of wild and domestic canids.*
The development of the occipital crest, expressed by the distance between opisthion and inion, is outstanding in the dingo as compared with any of the other three groups (fig 3.5).

Fig. 3.5. Graph of occipital process length against basion-hormion length in populations of wild and domestic canids.
The length of the upper carnassial is very similar between the dingo and the wolf jackal, but is poorly expressed in the Indian pariah; Indian pale footed wolves show a greater development of this trait than any other of the three groups (fig. 3.6).

![Graph of upper carnassial length against basion-hormion length in populations of wild and domestic canids.](image)

Fig. 3.6. Graph of upper carnassial length against basion-hormion length in populations of wild and domestic canids.
The length of the upper carnassial tends to equal the sum of the lengths of both upper molars in the dingo and in the wolf jackal, in the Indian pariah the sum of the length of the molars usually exceeds that of the upper carnassial, while a considerable part of the Indian pale footed sample have significantly bigger ratios for this trait (fig 3.7).

Fig. 3.7. Graph of upper carnassial length against the combined length of both upper molars in populations of wild and domestic canids.
The length of the lower carnassial is very similar between the dingo and the wolf jackal, and is remarkably longer in the pale footed wolf; the small sample of Indian pariahs suggests a poor development of this characteristic (fig 3.8).

Fig. 3.8. Graph of lower carnassial length against basion-hormion length in populations of wild and domestic canids.
Cranial capacity values are very similar between dingoes and wolf jackals and follow very similar patterns of development in Indian pariahs; pale footed wolves display an outstanding development of this trait in comparison with the other three groups (fig. 3.9).

Fig. 3.9. Graph of brain size against basion-hormion length in populations of wild and domestic canids.
Dingoes have the thickest, in a dorsoventral aspect, mandibles of the four groups, pale footed wolves display an intermediate state of development for this trait, pariahs and wolf jackals have relatively thin horizontal rami (fig. 3.10).

Fig. 3.10. Graph of mandibular thickness against basion-hormion length in populations of wild and domestic canids. Slope of the regression line= 0.268.
The auditory bullae are almost equally developed in dingo and wolf jackals although in some dingo are less developed, Indian pale footed wolves follow a very similar pattern to that of the wolf jackal, while Indian pariah show a very poor development (fig 3.11).

Fig. 3.11. Graph of auditory bulla size against basion-hormion length in populations of wild and domestic canids. Slope of the regression line= 0.5.
Dingoes have very low cranial vaults which are comparable in height to those of the wolf jackals, as opposed to pariahs and surprisingly to pale footed wolves which have much higher cranial roofs (fig. 3.12).

Fig. 3.12. Graph of cranial height against basion-hormion length in populations of wild and domestic canids.
Macintosh (1975) highlighted the exceptional development of a diastema between the second and the third lower premolars in the dingo when compared with other canids. A bivariate analysis confirms this (fig. 3.13).

![Graph of the LPM2-LPM3 diastema against basion-hormion length in populations of wild and domestic canids.](image)

**Fig. 3.13.** Graph of the LPM2-LPM3 diastema against basion-hormion length in populations of wild and domestic canids.

### 3.2.1.4 Hybridization: a case study

During two surveys (September 2000 and May-June 2002) that were conducted by me on Bulloo Downs, a cattle property located on the Queensland side of the Channel Country, dingoes were frequently observed in broad daylight, sometimes up to thirty individuals per day; most of the observations corresponded to specimens of apparently typical dingo phenotype (Corbett 1995). From a total sample of 72 specimens collected during both exercises, 67 had a ginger coat, 3 were sable coloured, one was black and tan, and one had the colouring and external conformation of a Siberian husky; craniometrics, however, identified this
last specimen as a dingo hybrid. This suggested that there could be some peculiarities inherent to this population. A more detailed study of the collected specimens showed that at least 8.95% of the ginger coloured sample presented abundant grey hair on the parietal region; later analysis also revealed that at least 13.43% of the cranial sample had husky-like characteristics such as a wide palate, well flared zygomata, and a dished face without trace of inflation in the frontals. Body weight distributions (figs. 3.15 and 3.16) were also less than typical since the average value in both sexes were much closer to the values published by Corbett (1985) for the tropical population (males: 17.4 kg +/- 1.90, females: 15.2 kg +/- 1.12), arguably the largest in the whole continent, than for the desert dingoes from central Australia (males: 14.5 kg +/- 1.51, females: 12.4 kg +/- 1.05); similar figures were also found by Woodall et al. (1996) among other Queensland populations of pure dingoes. Following Corbett's system (1995) all male specimens were deemed hybrid, and only five females were identified as pure. Not a single specimen could be identified as a domestic dog. All of the pure female specimens were ginger coloured and their body weight distribution averaged 15.6 kg, a value slightly over the average provided by Corbett (1985) for the tropical population. Finally multivariate analysis (fig.3.14), using sledge dog types as a comparative sample, shows that this dingo population is comparatively homogeneous and is clearly differentiated from morphotypes closely related to the hypothetical source of hybridization (sledge dogs), and from a extant pariah dog variety (Inner Middle East pariahs). It can be concluded then that, despite an obvious degree of hybridization, this population remains much closer to the original dingo morphotype than to its source of hybridization.
Fig. 3.14. Multivariate diagram showing the statistical position of a dingo hybrid specimen with outstanding Siberian husky characteristics (red asterisk) captured in Bulloo Downs compared with other dogs, using 17 cranial variables. The dingo sample (pure and hybrid) was also collected in Bulloo Downs (Western Queensland). The sledge dog sample includes specimens from Siberia, Greenland, North America and Antarctica. The first function accounts for 87.2% of the variance, the second for 12.8%.
Fig. 3.15. Histogram of body weights in a sample of male dingoes from a remote area.

Fig. 3.16. Histogram of body weights in a sample of female dingoes from a remote area.
3.2.1.5 Dingo morphology

Externally the Australian dingo is similar to some pariah dog types found in Asia and particularly in India (figs. 3.17, 3.18, 3.19), and Thailand (Corbett 1995). It is characterized by a medium size body, with long back, a deep chest with a well sprung ribcage and proportioned legs; the tail is hook-shaped and bushy, usually carried low. The head is strongly built with well developed temporal muscles and a medium length muzzle, ears are of medium length and triangular, the neck is rather thick and of medium length, the mandible is strong. The skull is of a general robust appearance, with well developed sagittal and occipital crests, both reminiscent in shape to those found in some specimens of pale footed wolf, although the occipital crest tends to be larger in the dingo than in most of the Indian pale footed wolves studied; the top of the braincase is usually depressed and low, and the rostral region is relatively narrow, very similar in size to that of the wolf jackal and some Indian pariahs, very often with a degree of dishing. Canines are long and narrow; upper and lower carnassials are usually almost identical in size to those of the wolf jackal and to a part of the Indian pariah sample, the upper carnassial is shorter than in the Indian pale footed wolf, and the length of the upper carnassial tends to be similar to the combined lengths of both upper molars, as in the wolf jackal. The auditory bulla is large, similar in size to that of the wolf jackal and some Indian pale footed wolves, and larger than in the Indian pariah population studied; brain size is very similar to that of the wolf jackal and to a part of the Indian pariah population, and smaller, both absolutely and relatively, than that of the Indian pale footed wolf. Mandible is thicker dorsoventrally than in the wolf jackal, and than in most Indian pariahs; the angular process is always well developed, but not as much as in the Indian pale footed wolf. Combining present day observations with bibliographical sources from the colonial days (see bibliographical introduction to this chapter, it must be concluded that this form is chromatically polymorphic and would typically present ginger (often with white feet), black and tan, black, and white varieties; ginger morphs (sandy, yellow and red) are usually more common in non-hybridized populations.

3.2.1.6 Primitivism and other peculiarities of the dingo

A most parsimonious approach, merely based on geographic factors, would suggest that the dingo is the last in a long sequence of morphotypes whose original type can be traced to the Middle East (see chapter VI). It is however a very primitive looking dog if one can accept as signs of primitivism the external traits previously described; these can also be found among pariah populations of the Middle East, Thailand and India (see figs. 3.17, 3.18, 3.19; Menzel and Menzel 1960, Corbett 1995), but they are not always common. It could be argued that this type of conformation (that of the “dingo type” pariah as described by Menzel and Menzel) has survived better in Australia than in other parts of the world, due to isolation and strong natural selection.

The skull of the dingo is very different from those of other pariahs and show adaptations to life in the wilderness that do not appear in any other pariah populations (see above). However it has many characteristics in common with the
wolf jackal, as previous (figs. 3.4, 3.6, 3.7, 3.8, 3.9, 3.11, 3.12) and further (figs. 7.1, 7.3, 7.4) bivariate analyses demonstrate. Identified features with an almost identical degree of development in dingoes and in wolf jackals are:

Forehead width  
Cranial capacity  
Auditory bulla length  
Cranial height  
Rostral length  
Maxillary width  
Zygomatic breadth  
Upper carnassial length  
Lower carnassial length  
Ratio of the length of upper carnassial against the combined length of both upper molars  

Since these traits present a different developmental state in other pariah dog populations (see bivariate analyses in this chapter), with the exception of upper carnassial length / UM1+UM2 ratio, it must be assumed that their level of development in the dingo is due to a process of reversion to a wild ancestor (the wolf jackal, see also chapter VI).

It must be concluded then that all through the Australian continent dingo populations, although not particularly old in comparison with other pariahs (see above and chapter VI), present an external conformation that is reminiscent of the most primitive extant type of pariah which very aptly has been named as the “dingo type” (Menzel and Menzel 1960). The analysis of cranial features reveals a reversion to a more primitive morphology exemplified by one of the ancestral taxa (the wolf jackal). Other differential traits of the dingo such as mandible thickness, and the presence of a large diastema between the second and the third lower premolars, seem to be rather unique, as their level of development could not be related to any of the most probable ancestral taxa or to any of the living form of pariahs (see this chapter and also chapters VI, VII and VIII).
3.2.1.7 Summary

The Australian dingo presents characteristics of both domestic and wild canines; some of its skull features are very similar to those of the wolf jackal. The dingo, for reasons of isolation and natural selection, has also retained a primitive external morphology that is not as common among other pariah populations. Hybridization does not always overshadow dingo identity; a study case from south-western Queensland shows that the local dingo population still has a strong morphological identity despite being extensively hybridized.

3.2.2 Indian pariahs

3.2.2.1 Introduction

In India pariah dogs are a frequent sight around human habitations, from the largest cities to remote villages in tribal areas. They can also be found living in some wilderness areas, away from human contact, although this is a rare event that seems to be maintained by a periodic release “into the bush” of individual animals rather than by self-sustained populations (Khalap, pers. comm. 2009).
3.2.2.2 Pariah types

My fieldwork in India (figs. 3.17, 3.18, 3.19), together with photographs taken by Kiran Khalap, Rajashree Khalap and Aditya Panda (published in the internet by Rajashree Khalap, 2009-2010), confirms the presence in this country of a dingo-type pariah (Menzel and Menzel 1960). The basic morphology of this type coincides with previous descriptions by Studer (1901) and Zeuner (1963); it can be characterized by its medium body size, well proportioned rib cage, slightly long back and long legs; the head appears pear shaped when looked from above and the neck is strong and of a medium length, the muzzle is triangular and relatively long; eyelids are lightly slanted; the tail is often curled up, very frequently carried over the hips, sometimes in an almost closed loop, although in some cases can appear hooked or pendant, and it is usually smooth or feathered, rarely bushy; ears are of a medium size, erect, triangular and wide at the base. Coat colours are variable with ginger tones (red, yellow and sandy) dominating; specimens displaying this colour phase often have two or more white feet, a white tail tip and sometimes white chest and throat areas, and more rarely a white muzzle; sable specimens are also relatively common as well as piebalds, black and tans and blacks; light grey and full white specimens are uncommon. The largest populations of this type are usually found in remote areas, often linked to tribal communities, and usually isolated from crossbreeding with other dog types (Khalap 2009, pers. comm.).

Fig. 3.18. A male pariah from Kolkata, West Bengal. April 2004.
Using Menzel and Menzel's (1960) methodology, I have been able to identify another three different types of pariah dogs currently living in India (see box I). I based this classification on two main provisos: 1) the type had to be consistently identified in more than one geographic location; 2) the type has to be found commonly living in a "pariah state": loosely associated with humans but often ownerless. The three clearly differentiated types that I found, currently living in India, apart from the dingo type previously described, are: the village dog type, the broadhead type and the sighthound type.

The village dog (fig. 3.20) is rather similar to the dingo type but lighter, about three quarters of its size, and much more gracile, limbs are not as well muscled and the chest tends to be narrower and shallower; ears are longer, the tail is usually smooth or feathered but never bushy and is carried almost without exception high over the rump, coat colour is as variable as in the dingo type. This form seems to be more common in areas where the climate is hot and humid and is often used as a hunting aid in forested areas.
The broadhead type (fig. 3.21) is also similar to the dingo type in body shape and coat colours (with a higher predominance of brindle and piebald patterns and associated ticking); it is however more robust, although slightly smaller in size; the chest is deeper and rounder, the back shorter and stronger, the neck is also thicker to the point of presenting, at times, a bulging dorsal outline, legs are equally stouter; the head is broad giving the false impression of having a short muzzle. This type seems to dominate in many villages of south India, where it lives in a symbiotic relation with humans, for whom it exchanges its services as night-time watch dog for a more or less reliable food supply and shelter.

Fig. 3.21. Broad head type pariah from Melkote (Karnataka)

The sighthound type (fig. 3.22) presents many of the characteristics of the same type as described by Menzel and Menzel (1960), but is nonetheless stronger in conformation and has shorter legs that are also more muscled; ears are usually pricked, long and wide; head is broader, but still noticeably long, and the snout area is wider, tail is shaped as a hook and carried low; colour is often piebald, combining a white background with dark brown patches that can be bridled. In general the whole appearance of this animal could be summarized as that of a proto-greyhound (despite the relatively short legs), resembling in some ways the Egyptian and Ibizan sighthounds. In many parts of India these dogs are also considered valuable hunting aids, and are owned and managed as regular domestic dogs.

Fig. 3.22. Sighthound type pariah from Ludhiana (Punjab)
3.2.2.3 Morphology of the skull

During my work in India I very rarely had the opportunity to directly match cranial morphology to external conformation, as data on external morphology were always collected from live individuals and the studied crania were part of scientific collections, which only exceptionally held any substantial records about the original type of the specimens. Nevertheless, I have made the attempt to group the sample according to traits that could be used to define its typology. I have utilized two ratios based on those created by Harcourt (1974) and Degerbol (1961). It also needs to be stated that the specimens used in the craniology study were collected in rural areas where hybridization with modern dog breeds is either uncommon or non-existent; one can therefore expect that most specimens would belong to one of the previously described types, or otherwise will display an intermediate conformation.

A distribution of snout length indices (Harcourt 1974) seems to provide a good approach to the understanding of some basic craniometrics of the Indian population; I must mention, at this point that I gave precedence to this index over the more conventional cephalic index (Harcourt 1974, Clark 1998) as the latter is not without problems, since it involves ratios between different cranial regions which may show a large degree of non-related variability, and specimens with very different cranial conformations may yield similar values for the index, and vice versa. Following this rationale, and in order to obtain material that could be used for comparative purposes, I calculated the snout index values of two different dog types that exemplify two different manifestations of the trait in question: nine pure Australian dingoes (snout length index range = 48.51–51.21), and seven sighthounds (snout length index range = 51.83–53.93) from England, USA, Afghanistan and Nepal. As can be seen in fig. 3.23 the combined value ranges from both types overlaps the majority of the Indian sample; this implies (always assuming that the sample is large enough and unbiased) that most Indian specimens of pariah dog have a snout length index that can be identified as either dingo-like or sighthound-like, and that in consequence there is very little incidence of face reduction on the Indian pariah population.
A maxillary dental crowding index of the Indian population was calculated using a modified version of Degerbøl's index (see Appendix III), which is given priority over the mandibular overlapping index due to the overrepresentation of cranial over mandibular data in the Indian pariah sample. Figure 3.24 shows that more than 3/4 of the sample (79.48 %) is within or under the dingo range (crowding index range= 1.17-1.30), which was calculated using 8 specimens found to be pure according to Corbett's (1995) method. The resulting histogram demonstrates that most of the studied sample displays uncrowded dentitions.
Fig. 3.24. Histogram of the distribution of dental crowding indices in a sample of Indian pariahs.

Among the Indian pariahs, crowding indices are poorly correlated with snout length indices (CC= 0.047). This may be connected to a presumed low adaptive value of crowded dentitions, and to the rarity of short faced specimens in the sample. The skulls of the Indian pariah dog also share with the Indian pale footed wolf some characteristics related to the common gracility of both forms such as opisthion-akrokranian length (fig. 3.53) and mandible height (fig. 3.56), but are different in that they present wider foreheads (fig. 3.52), smaller auditory bullae (fig. 3.57) and shorter carnassials (figs. 3.54 and 3.55).
BOX II
Note on cranial types from India

Exceptionally, either by inference or through the advice of collection curators, I was able to correlate external conformation with cranial morphology. These two specimens illustrate two key types that can be found in southern Asia.

**Fig. 3.25 (IN 111, ZSI, Calcutta):** this specimen from India exemplifies many of the characteristics of a genuinely primitive pariah of the dingo type: lightly dished rostral area, medium length rostrum, no signs of frontal inflation, strong zygomata, well developed occipital process and sagittal crest and strong canines. Specimens with very similar characteristics to this one have been found in Israel; in relation to this it is significant that, in a DFA, this individual was located at the interface between the Indian and the Israeli pariah clusters.

**Fig. 3.26 (IN 100, ZSI, Calcutta):** this specimen was collected in Lalpahar (South Andaman). Although ascribable to the village dog type due to its smaller size, wider maxilla, short rostrum, dilated frontal region and prominently dished face, it also exemplifies some transitional characteristics from the dingo type like the presence of a sagittal crest, a well developed occipital process and thick zygomatic arches. This intermediate form is particularly common in southern India.
3.2.2.5 Summary

The Indian pariah population is polymorphic, presenting four clearly differentiable types, which should be nonetheless considered a part of a wider Asian pariah dog population as they present strong analogies with Israeli, Arabian and Inner Middle East pariahs. Evidence of crossbreeding with pale footed wolves is uncommon (see chapter IV), although they share a few traits with that form.

3.2.3 Israeli pariahs

3.2.3.1 Introduction

Menzel and Menzel (1960) highlighted the polymorphic nature of the Israeli pariah population. They also reported the presence of pariah packs living in wilderness areas in almost complete isolation from humans; Yom Tov (2006, pers. comm.) supported this statement. The study of live specimens confirms the presence in this country of dingo types particularly in the most remote regions.

3.2.3.2 Skull morphology

I also experienced difficulties in Israel when I attempted to match craniometrics with body conformation, and therefore I decided to apply a similar methodology to that of the previous case; albeit most of the Israeli sample can be identified as dingo type, since this is the kind of specimen that most often finds its way into the collections (Yom-Tov 2006, pers. comm.). Figs. 3.27 and 3.28 illustrate a typical Israeli pariah, very possibly of the “dingo type” (Menzel and Menzel 1960). The general appearance is that of balance between gracility and robustness. Characteristic of this type is a well rounded neurocranial dorsal outline with a slightly developed sagittal crest, the presence of a small occipital process, somewhat inflated frontal sinus, a medium length snout, an evenly dished face and a wide palate. Auditory bullae are well proportioned but not particularly voluminous. Mandibles are of a medium size with a characteristically strong angular process, and the ascending ramus is relatively wide with a well recurved coronoid apex. Obviously this skull has very little in common with that of a real dingo, since as previously commented Menzel and Menzel’s (1960) classificatory methodologies refer exclusively to external conformation and do not take into account osteological data.
Fig 3.27. Skull of an Israeli pariah (University of Tel Aviv, no serial number available). Lateral view.

Fig 3.28. Same specimen. Basal view.
3.2.3.3 Wolf analogies

A peculiarity of the Israeli population of pariah dogs is its remarkable similarity with the local pale footed wolf populations (fig. 3.29); this highlights a considerable difference from the pariah dogs of India (fig. 3.1, 4.10), the Inner Middle East (fig. 3.46) and Thailand (Corbett 1995).

Fig. 3.29. Multivariate diagram showing the statistical position of canids identified as wolf-dog hybrids relative to the range of variation of Mediterranean and desert pale footed wolves and Israeli pariahs, using 17 cranial variables. The first function accounts for 80.7% of the variance, the second for 19.3%.
A very dog-like skull (FMNH 134564; see figs. 3.31, 3.32 and comment) collected by C.A. Reed on the south side of the Sinai Peninsula, and dubiously identified as *C. l. arabs*, was studied through DFA (fig. 3.30a) and log ratio analysis (fig. 3.30b); its brain size was compared with those of Middle eastern pale footed wolves and Israeli pariahs through bivariate analysis (fig. 3.30c). The resulting graph and diagrams confirm its pariah dog identity. The fact that this specimen was initially classified as a wolf, probably in the field, seems to indicate that its external morphology was reminiscent of that taxon.

Fig. 3.30a. Multivariate diagram showing the statistical position of a canid from Sinai relative to the range of variation of Middle Eastern pale footed wolves and Israeli pariahs, using 17 cranial variables. The first function accounts for 81.4% of the variance, the second for 18.6%.
Fig. 3.30b. Log ratio diagram of the measurements of 17 cranial traits of a canid from Sinai (FMNH) 134564 compared with other canid samples. Arabian wolf data are used as standard value.
Fig. 3.30c. Graph of brain size against basion-hormion length in populations of wild and domestic canids, showing the statistical position of a doubtful canid specimen from Sinai. Slope of the regression line = 0.6.
This specimen from Sinai was initially labeled *C. l. arabs* in the Field Museum (Chicago), probably due to its external morphology (pelage, body size, etc.) at the time of collection. The cranium however presents outstanding dog characteristics: well inflated frontals, underdeveloped sagittal crest, small carnassials, contracted auditory bullae and recurved coronoid apex.
3.2.3.4 Analogies with other pariah groups

Fig. 3.33 shows that there are also consistent morphological affinities between the pariahs from India and those from Israel, and that both are, in general terms, quite different from the Australian dingo.

Fig. 3.33. Multivariate diagram showing the range of variation of three dog populations, using 17 cranial variables. The first function accounts for 89.7% of the variance, the second for 10.3%.
3.2.3.5 Bivariate analyses

The width of the forehead of the Israeli pariahs seems to follow a very similar pattern of development to the Indian pariahs, although a part of a possibly hybrid population is closer to the Israeli pale footed wolf sample (fig. 3.34).

![Graph of forehead width against basion-hormion length in populations of wild and domestic canids. Slope of the regression line = 0.463.](image)

Fig. 3.34. Graph of forehead width against basion-hormion length in populations of wild and domestic canids. Slope of the regression line = 0.463.
The cranial capacity of the Israeli pariahs is remarkably low, yielding values comparable to the lowest among dingoes (see above) and Indian pariahs; specimens identified as hybrid have values very similar to those of the Israeli pale footed wolf (fig. 3.35).

Fig. 3.35. Graph of brain size against basion-hormion length in populations of wild and domestic canids. Slope of the regression line = 0.6.
The Israeli pariahs show a similarly developed occipital crest to the rest of the groups, with the exception of the Australian dingo (see above). Two of the possible hybrid specimens have occipital crests of a size comparable to that of the latest group (fig. 3.36).

Fig. 3.36. Graph of occipital process length against basion-hormion length in populations of wild and domestic canids. Slope of the regression line = 0.45.
The length of the upper carnassial in the Israeli pariahs is comparable to that of the Indian pariahs and dingoes and noticeably smaller than that of the Israeli pale footed wolves (fig. 3.37). Five specimens out of a sample of six hybrids have very high values for this trait, comparable to that of the Israeli pale footed wolves.

Fig. 3.37. Graph of upper carnassial length against basion-hormion length in populations of wild and domestic canids. Slope of the regression line = 0.56.
The ratio between the upper carnassial and the added length of both upper molars is rather low and also very similar to that in Indian pariahs, and perceptively lower than the existing values for dingoes and Israeli pale footed wolves (fig. 3.38). Four out of five specimens identified as hybrids have also values for this trait which are similar to those of the Israeli pale footed wolves.

Fig. 3.38. Graph of upper carnassial length against the added length of both upper molars in populations of wild and domestic canids. Slope of the regression line = 0.7.
The length of the lower carnassial is very similar to that of the dingo sample; three specimens out of a sample of six identified as hybrids present values for this trait which are similar to the highest found in the Israeli pale footed wolf sample (fig. 3.39).

Fig. 3.39. Graph of lower carnassial length against basion-hormion length in populations of wild and domestic canids. Slope of the regression line= 0.53.
The height of the mandibular ramus is highly variable among the Israeli pariahs and tends to be lower than in dingoes and pale footed wolves (fig. 3.40). Three specimens out of a sample of five specimens identified as hybrids have very high values for this trait similar to the highest values found in the Israeli pale footed wolf sample.

Fig. 3.40. Graph of mandibular thickness against basion-hormion length in populations of wild and domestic canids. Slope of the regression line = 0.40.
The size of the auditory bulla of the Israeli pariahs is comparatively small, very similar to that of the Indian pariahs. Four out of a sample of five specimens identified as hybrids have values for this trait which are similar to those of dingoes and pale footed wolves (fig. 3.41).

Fig. 3.41. Graph of auditory bulla size against basion-hormion length in populations of wild and domestic canids. Slope of the regression line= 0.48.
3.2.3.6 Univariate analysis

The Bulloo Downs sample of dingoes (figs. 3.15 and 3.16; average of both sexes= 17.48 kg) is fairly similar in weight to the Israeli pariahs (average of unsexed sample= 15.43 kg, fig. 3.42). The only noticeable difference between both groups, as far as this character is concerned, is the slightly lighter conformation of the Israeli pariahs.

![Histogram of body weights of Israeli pariahs](image)

Fig. 3.42. Histogram of the distribution of body weights in a sample of Indian pariahs.
Snout length distributions show considerable similarities with those of the Indian pariahs (fig. 3.43), although this last form seems to display slightly shorter muzzles; both Indian and Israeli populations have a significant part of their respective populations included within either the dingo range or the sighthound range.

Fig. 3.43. Histogram of the distribution of snout length typologies in a sample of Israeli pariahs.
Analysis of dental overlapping (Davis and Valla 1978) evidenced a high percentage of uncrowded dentitions represented in the sample (average = 0.65, range = 0.69 – 0.61, stdv = 0.02), with only 21.87% of the sample displaying dentitions scoring a value over 0.67 (fig 3.44).

![Histogram of the distribution of teeth overlap typologies in a sample of Israeli pariahs.](image)

Fig. 3.44. Histogram of the distribution of teeth overlap typologies in a sample of Israeli pariahs.
Dental overlap shows a relatively low inverse coefficient of correlation (-0.47) with a facial length index (facial length/basion-hormion) in this case (fig. 3.45).

![Graph expressing the correlation between facial length and teeth overlapping in a sample of Israeli pariahs.](image)

**Fig. 3.45.** Graph expressing the correlation between facial length and teeth overlapping in a sample of Israeli pariahs.

3.2.3.7 Summary

While many Israeli pariahs present characteristics that are very similar to other pariah groups, a part of the sample, often individuals initially identified as "hybrids", have traits that are more closely related to the pale footed wolves inhabiting the region. The Israeli pariahs are very similar to dingoes in carnassial length, cranial capacity and body size, and evidence of the presence of crossbreeding between sheepdog pariah types and wolves has also been found.

3.2.4 Arabian pariahs

3.2.4.1 Introduction

Harrison (1973) commented on the difficulties in differentiating pariahs from wolves in the Arabian Peninsula.
3.2.4.2 Affinities

A sample of five specimens from the south side of this region in the Harrison Museum (nos. 8.7148, 7.5171, 4.4610, 2.4542, 5.4611) does not show any particularly strong similarity with wolves, and falls well in among the Indian-Inner Middle East pariah overlapping region (fig 3.46). Data from two specimens indicate a tendency towards mild teeth crowding (average= 0.67, stdv= 0.001, range= 0.66-0.67); snout length index yielded similar results to that of Indian pariahs with a distribution of values split between the dingo and the sighthound range (average= 51.35, stdv= 0.65, range= 50.74 – 52.32, n= 5); the calculated weight average for two specimens is quite similar to that found in Israeli populations (average= 15.02 kg, stdv= 1.77, range= 13.76 – 16.27 kg). It is possible, however, that Harrison (1973) had access to specimens of hybrid origin since he covered in his study a range of locations within the Arabian Peninsula.

Fig. 3.46. Multivariate diagram showing the statistical position of five Arabian pariahs relative to the range of variation of three canid populations, using 17 cranial variables. The first function accounts for 95.2% of the variance, the second for 4.8%.
3.2.4.3 Summary

A limited sample from the south of the Arabian Peninsula indicates the presence of typical pariah dogs in this region. Contrary to Harrison's (1973) supposition, no evidence of hybridization with wolves was found (but see subchapter 4.1.5).

3.2.5 Inner Middle East pariahs

3.2.5.1 Introduction

The recent populations of pariah dogs from this region have been poorly studied.

3.2.5.2 Multivariate analysis

Multivariate analysis demonstrates that all specimens included in this sample resemble the pariah dog populations from India and from Israel, and are well outside the dispersion of pale footed wolves or of Asian grey wolves (figs. 3.47, 3.48 and 3.49).

Fig. 3.47. Multivariate diagram showing the range of variation of three canid populations, using 17 cranial variables. The first function accounts for 90.0% of the variance, the second for 10.0%.
Fig. 3.48. Multivariate diagram showing the range of variation of three canid populations, using 17 cranial variables. The first function accounts for 95.1% of the variance, the second for 4.9%.
Four skulls from central Iraq in the Field Museum (nos. 44467, 46079, 44470, 44471) were originally labeled as pale footed wolves despite their evident dog characteristics (figs. 3.50 and 3.51). This inaccurate identification may perhaps have been caused by a deceptively wolf-like, external conformation; similar cases have been reported in Israel (Yom Tov 2006, pers. comm.) and the Arabian Peninsula (Harrison 1973).
Fig. 3.50. Multivariate diagram showing the statistical position of four Iraqi canids relative to the range of variation of three canid populations, using 16 cranial variables. The first function accounts for 88.4% of the variance, the second for 11.6%.

Fig. 3.51. Pariah skull (FMNH 44470) from Salman Pak (Iraq). Note outstanding dog characteristics and large angular process, note also analogies with specimen from Israel (fig. 3.27).
3.2.5.3 Bivariate analysis

This population displays, in general, a rather well developed forehead which even surpasses the maximum values found in the Indian pariah sample (fig 3.52).

Fig. 3.52. Graph of forehead width against basion-hormion length in populations of wild and domestic canids. Slope of the regression line= 0.45.
The occipital process of this group is as poorly developed as in other pariah populations (fig 3.53).

Fig. 3.53. Graph of occipital process length against basion-hormion length in populations of wild and domestic canids. Slope of the regression line= 0.54.
The upper carnassial shows also a similar degree of development to other pariah varieties and is usually much shorter than in the pale footed wolves (fig 3.54).

Fig. 3.54. Graph of upper carnassial length against basion-hormion length in populations of wild and domestic canids. Slope of the regression line= 0.55.
The development of the lower carnassial shows a very similar pattern to that of the upper carnassial, it is similar in size to that of Indian and Israeli pariahs and much smaller than those of pale footed wolves (fig 3.55).

Fig. 3.55. Graph of lower carnassial length against basion-hormion length in populations of wild and domestic canids. Slope of the regression line = 0.47.
The ratio between the length of the upper carnassial and the sum of the lengths of both upper molars is very similar to that of other pariahs and clearly different from the values found in many pale footed wolves (Fig. 3.56).

Fig. 3.56. Graph of upper carnassial length against the added length of both upper molars in populations of wild and domestic canids. Slope of the regression line = 0.73.
Cranial capacity tends to be slightly higher than in other pariah groups, but is still much lower than in the pale footed wolves (fig. 3.57).

Fig. 3.57. Graph of brain size against basion-hormion length in populations of wild and domestic canids. Slope of the regression line= 0.60.
Mandibular height appears to be as variable as in other pariah populations and shows rather extreme values (fig. 3.58).

![Graph of mandibular thickness against basion-hormion length in populations of wild and domestic canids. Slope of the regression line = 0.49.](image)

Fig. 3.58. Graph of mandibular thickness against basion-hormion length in populations of wild and domestic canids. Slope of the regression line = 0.49.
The length of the auditory bulla is also very similar to other pariah groups and considerably smaller than in pale footed wolves (fig. 3.59).

Fig. 3.59. Graph of auditory bulla size against basion-hormion length in populations of wild and domestic canids. Slope of the regression line= 0.60.
3.2.5.4 Univariate analysis

The dental series of the Inner Middle East pariah population have a slight tendency towards crowding (overlapping index = 0.66; fig. 3.60), but the degree of teeth crowding is not related to the length of the facial region (fig 3.62). As in the previous cases most of the specimens can be assigned to either the dingo type or the sighthound type in terms of snout development (fig. 3.61). The body weight is somewhat inferior to that of the Israeli pariahs and the population does not have a particularly strong representation of heavier body types (fig. 3.63).

Fig. 3.60. Histogram of the distribution of teeth overlap typologies in a sample of pariahs from the Inner Middle East.
Fig. 3.61. Histogram of the distribution of snout length typologies in a sample of pariahs from the Inner Middle East.

Fig. 3.62. Graph expressing the correlation between facial length and teeth overlapping in a sample of pariahs from the Inner Middle East.
3.2.5.5 Sheep dog types

The presence of sheep dog types in the northern part of this region has been substantiated by two specimens from Azerbaijan and northern Iraq (FMNH 98431 and 57252); both skulls are characterized by their robustness and their larger size (basicranial length = 186.62 and 198.88 mm respectively) and by displaying elevated frontal regions, broad palates and wide zygoma. Dentitions of both specimens were uncrowded (overlap indices = 0.64 in both cases), snouts were of a medium length, both within the dingo range (50.44 and 51.20) and the calculated body weights (16.93 kg and 20.64 kg) were in the top third of the frequency distribution, for the pariah sample of the Inner Middle East.

The external conformation of this type, as shown in the captive colony kept by the German organization Wolfswinkel in Birken Honigsessen, is quite robust, displaying a strong back, powerful hindquarters, a thick neck and a deep and round chest; the head is wide with a medium length muzzle, pendant ears and a well dished face; tail is usually carried curled-up, although some specimens may have crook-shaped tails similar to those of the dingoes. Coat is rough and thick, particularly during the winter,
colour is very variable, displaying many different tones, from light grey to dark brown; both uniform and piebald individuals abound.

The skull is usually rather large and thick-boned, zygomatic arches are well flared, facial region is of a medium length and deeply dished, auditory bullae are usually relatively small; mandibles are quite strong supporting comparatively small teeth. A specimen from Turkey (MCZ 51571) appears to be a hybrid between this type of dog and the local grey wolf population [fig 3.64].

Fig. 3.64. Multivariate diagram showing the statistical position of a canid from Turkey (MCZ 51571) relative to the range of variation of three canid populations, using 17 cranial variables. The first function accounts for 90.3% of the variance, the second for 9.7%.

3.2.5.6 Summary

The combined interpretation of figs. 3.47, 3.48, 3.49, 3.50 indicates that pariah dog populations from the Inner Middle East (Iran, Iraq and neighboring areas) present characteristics in common with the Israeli and Indian populations of pariah dogs. This population has smaller cranial capacity, shorter carnassial length and less voluminous auditory bulla than Indian pale footed wolves (figs. 3.55, 3.56, 3.57, 3.59), while it is similar to the Indian pale footed wolf in mandible height and opisthion–akrokranion distance (figs. 3.53, 3.58). The analyzed sample does not show evidence of hybridization with wolves except in one single case (fig. 3.64).
3.2.6 Village dogs

3.2.6.1 Introduction

The primitive dogs from the Malay Peninsula, Island Southeast Asia and Oceania have often been associated with the village dog type as depicted by Boessneck and Meyer–Lemppenau (1969), Medway (1977) and Gollan (1982); this form can be described as very similar, or in some cases identical, to the type of “village dog” whose presence I documented in India (see above). Longman (1929) regarded the New Guinea highland dogs as “true dogs, possibly not truly feral or autochthonous”; Wood-Jones (1929) considered them as a true feral variety very different from other dogs of the region; they were described as a different species by Troughton (1956), and this was supported by Koler-Matznick et al. (2003). I will discuss this variety alongside the village dog sample but will keep it in its own group.

3.2.6.2 Univariate analysis

Commonly shared characteristics among different populations of this type are a medium body weight, a relatively short snout and a non-crowded or only slightly crowded dentition, as exemplified in table 3.3. The sample of New Guinea highland dogs present values for these traits which are similar to those of typical village dogs.

<table>
<thead>
<tr>
<th></th>
<th>NBVD</th>
<th>GVD</th>
<th>NGHD</th>
</tr>
</thead>
<tbody>
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<td>0.66</td>
<td>0.64</td>
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<tr>
<td>sd</td>
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<td>0.01</td>
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<td>n</td>
<td>2</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
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<td>0.63-0.68</td>
<td>0.62-0.65</td>
</tr>
<tr>
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<td>49.59</td>
<td>47.70</td>
</tr>
<tr>
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<td>na</td>
<td>2.39</td>
<td>1.387</td>
</tr>
<tr>
<td>n</td>
<td>1</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>range</td>
<td>na</td>
<td>45.18-51.77</td>
<td>46.14-49.24</td>
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<tr>
<td><strong>Weight</strong></td>
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<td>9.60</td>
</tr>
<tr>
<td>sd</td>
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<td>0.93</td>
<td>0.33</td>
</tr>
<tr>
<td>n</td>
<td>2</td>
<td>5</td>
<td>3</td>
</tr>
</tbody>
</table>

Table 3.3. Morphometric data of village dog populations and New Guinea singing dogs. For descriptions of index and methodologies see appendix IV.

Key of abbreviations:

NBVD: New Britain village dogs.
GVD: Generic village dogs (India, Burma, Malaya, Celebes, New Guinea).
NGHD: New Guinea highland dog.
It is not uncommon for some populations of village dogs to deviate from the typical conformation by, for instance, smaller size and a broader head (Medway 1977, Gollan 1982); in addition some local varieties may display short legs, long backs and a different tail carriage (Medway 1977, Gollan 1982). This was verified by me in India (fig 3.65).

Fig. 3.65. Non typical Indian village dogs Gawdagere. Karnataka. June 2004.

3.2.6.3 Bivariate analysis

The village dog could be one of the more recent forms within the pariah group; it would be therefore of some interest to study its relationship with wild varieties in order to assess its significance within the evolutionary sequence of the domestic dogs. I will analyze below through bivariate analysis some of the more relevant traits, in the transition from the wild to the domestic, as described by Koler-Matznick (2002). I have included in the analysis four specimens from Africa in the village dog sample (see below).
Village dogs have on average relatively shorter rostrums than the wild forms and in particular than the Indian pale footed wolf (fig. 3.66).

Fig. 3.66. Graph of facial length against basion-hormion length in populations of wild and domestic canids.
The head of the village dog is relatively narrower than that of the pale footed wolf and on average very similar in width to that of the dingo and the wolf jackal (fig. 3.67).

Fig. 3.67. Graph of zygomatic breath against basion-hormion length in populations of wild and domestic canids.
The maxilla of the village dog is on average relatively as wide as that of the dingo but is not as wide as in the pale footed wolf (fig. 3.68).

Fig. 3.68. Graph of maxillary width against basion-hormion length in populations of wild and domestic canids.
The height of the skull seems to show very similar values in all groups with the exception of the pale footed wolf which has a perceptibly higher cranial vault (fig. 3.69).

Fig. 3.69. Graph of cranial height against basion-hormion length in populations of wild and domestic canids.

While following very similar patterns of development to the dingo and the wolf jackal for all the traits analyzed, the village dog samples have narrower heads and maxillas than the pale footed wolves, their cranial height is also lower; only the shorter facial length confirms the usual viewpoint about morphological transformations, in the dog, during the domestication process (Koler-Matznick et al. 2003).

3.2.6.4 Multivariate analysis

This type of analysis demonstrates that the variety described by Medway (1977) in Malaya, exemplified by one specimen at the British Museum (BMNH 71753), shows a great similarity to a the New Guinea dog, in particular to a specimen from Mt
Wilhelm (ANU 228), and in general with a part of the Indian sample (fig 3.70). The specimen from Malaya does not show much resemblance to other village dogs from nearby regions. An analogous situation occurs between a specimen from Kerala in India (IN 238) and one from Tipone in Papua (BMNH 19861617); similarly one specimen from Tondano, Sulawesi (USNM 218568) and another from Mt Popa (Burma; BMNH 193752639) are also comparable. The analysis also demonstrates that dingoes are completely different from the other forms.

**Fig. 3.70.** Multivariate diagram showing the statistical position of four village dogs relative to the range of variation of three dog populations, using 17 cranial variables. The first function accounts for 97.2% of the variance, the second for 2.8%.

**List of village dog specimens**
A: IN 238. Kerala, India.
B: BMNH 71753. Ikan Merah, Malaya.
C: USNM 218568. Lindoe Lake, Tornado, Sulawesi.
D: BMNH 193752639. Mt Popa, Burma.
3.2.6.5 Log ratios

A log ratio diagram (fig 3.71) reinforces the idea of widespread heterogeneity within the village dog group. The line corresponding to the New Britain sample departs from the village dog sample in width of the forehead, length of the occipital process, cranial height and length of the upper carnassial.

![Log ratio diagram](image)

**Fig. 3.71.** Log ratio diagram of the measurements of 14 skull traits of village dogs and New Guinea highland dogs. Generic village dog data are used as standard value.

3.2.6.6 Qualitative analysis

A specimen from Mt Wilhelm, New Guinea (ANU 228) gives an overall impression of strong paedomorphosis; it displays wide zygomata, a bulging braincase and a deeply dished facial profile with a frontal region that is only lightly inflated; the occipital process is small and the sagittal crest is absent, the maxillary region is not particularly wide and the auditory bullae are quite small. A slightly different dog type is found on the island of New Britain, off the east coast of New Guinea; the description of its external conformation given by Gollan (1982), quoted from Studer...
(1901), has been summarized at the beginning of this chapter. Two crania from this locality, in the collection of the School of Archaeology and Anthropology at the Australian National University (M224 and M225), are strongly paedomorphic but also robust; the occipital process is well developed, and in one of the cases there is a perceptible sagittal crest; the supraorbital processes are also well developed, the frontal areas lack inflation, the facial profiles are only lightly dished and the auditory bullae are clearly ribbed; the maxillary regions are wide as well as the tip of the snout, zygomatic arches are well flared but not too thick and the body of the mandible, documented in only one specimen, is dorsoventrally relatively thin, but mediolaterally robust; the ascending ramus is wide and recurved, the coronoid apex is also backwardly projected and the angular processes are well proportioned to the size of the rest of the mandible. A photograph of a skull from the Mt Bosavi area, on the New Guinea mainland, seems to reflect a very similar kind of configuration (Boessneck and Meyer Lemppenau 1969). Photographs of two live specimens from the same area (Boessneck and Meyer Lemppenau 1969) show animals of similar conformation to those from New Britain as previously stated by Gollan (1982).

3.2.6.7 Distribution

All available accounts seem to indicate that the village dogs of Asia and Oceania could be linked, although perhaps not exclusively, to societies that traditionally practiced a mixed hunter-gatherer/agricultural economy, like the Iban and Punan from Borneo, tribes belonging to the Senoi tribal group from peninsular Malaysia, and also to many Papuan groups (Medway 1977, Gollan 1982). This may have some interesting implications since a very similar type of dog can be found in Africa amongst societies of comparable lifestyle (see below).

3.2.6.8 The New Guinea highland dog

The identity of the New Guinea highland dog has been a contentious issue since, at least, the beginning of the 20th century (De Vis 1910, Longman 1929, Wood-Jones 1929, Troughton 1957, Koler-Matznick et al 2003). The external conformation of this variety superficially resembles that of the Asian pariah dog group, although the almost vertical tail carriage and the long neck are unique traits. The development in the New Guinea highland dog of four traits considered crucial in the transition (from the wild to the domestic varieties) show very similar values to the village dog (see above). Discriminant analysis gives it an intermediate position between the dingo and the Asian pariah dog samples (fig 3.72).
Fig. 3.72. Multivariate diagram showing the statistical position of a sample of dogs from New Guinea relative to the range of variation of three dog populations, using 17 cranial variables. The first function accounts for 97.2% of the variance, the second for 2.8%.

List of New Guinea dog specimens
B: Specimen ANU 228. Village dog. Lake Koromok, Mt Wilhelm, PNG.
C: Specimen AMNH 151839. Probable hybrid (Village dog - NGHD). Bernhard Camp, Papua.
D: Specimen AMNH 151842. NGHD. Bernhard Camp.
E: Specimen QM J4083. NGHD. Mt Scratchley, Papua.
F: Specimen QM J3751. NGHD. Mt Scratchley, Papua.
G: Specimen BM 713100. NGHD. Tipone, Mimika River, Papua.
The log ratio diagram (fig. 3.71) indicates that the highland dog population has two traits developed in a fashion usually associated with wild canids namely opisthion-inion distance and auditory bulla length. A visual analysis of the skull of the New Guinea highland dog reveals a blend of both domestic and wild canid traits. Photographs taken in the Queensland Museum of the specimens (J3751, J4083) studied by De Vis (1910), Longman (1929) and Wood-Jones (1929) suggest a significant difference in the shape of the frontal area; specimen J3751 has an almost flat, and only lightly dished, frontal region (fig. 3.73) while in J4083 it is much more elevated and clearly dished, presenting in consequence a more "domestic look" (fig. 3.74). A drawing of this latter specimen included by Wood-Jones (1929) in his paper seems to represent a dingo-like form, as it displays a downwardly recurved occipital process and a depressed sagittal dorsal outline, characters that I have been unable to verify on the original specimen. All the above seem to indicate that while the New Guinea highland dog shares some cranial characteristics with other primitive dog forms from this region, but is nonetheless genuinely different in others. The only skin that I had the opportunity to study (figs. 3.75 and 3.76) belongs to J3751 and has been previously described by De Vis (1910) and Wood-Jones (1929); its colour is an obvious departure from the typical brownish coloration usually attributed to the highland dog (Troughton 1957, Koler-Matznick et al. 2003).

As noted above, there have been some doubts expressed of the genuine highland dog identity of both of the Queensland Museum specimens: "the general physical description of the single complete specimen, QM 3751, does not match the NGSD as described here and in Troughton (1957)" (Koler-Matznick et al. 2003). Morphometric comparison between the holotype of Canis hallstromi Troughton and the two specimens studied by De Vis (1910) and Wood-Jones (1929), using among others some of the traits proposed by Corbett (1995), does not seem to support this statement. Table 3.4 indicates that most values are clearly comparable; only in the case of maxillary width is there a perceptible difference. Calculated body weight values for the specimens in question are comparable to those published by Koler-Matznick et al. (2003).

<table>
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<tbody>
<tr>
<td>Head and body</td>
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<td>na</td>
</tr>
<tr>
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</tr>
<tr>
<td>Carnassial weight</td>
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<td>6.12 (4)</td>
<td>6.06 (4)</td>
</tr>
<tr>
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<td>51.07 (4)</td>
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<td>Calculated body weight</td>
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<td>9.35 (4)</td>
<td>9.98 (4)</td>
</tr>
</tbody>
</table>

Table 3.4. Morphometric data of New Guinea highland dogs.

Sources
(1) Troughton (1957), (2) De Vis (1910), (3) Corbett (pers. comm. 2005), (4) This research.
Similarly to what occurs in the case of dingoes, there is a real possibility of wild populations of highland dogs hybridizing with village dogs, particularly around remote villages, but only one probable hybrid specimen, from Bernhard Camp (AMNH 151839), has been so far identified (fig. 3.72).

Fig. 3.73. New Guinea highland dog. QM J3751. Mt Scratchley, Papua.

Fig. 3.74. New Guinea highland dog. QM J4083. Mt Scratchley, Papua.
3.2.6.9 African samples

Some authors have discussed possible similarities between African dogs (particularly basenjis) and village dogs in island South East Asia and New Guinea (Boessneck and Meyer-Lemppenau 1969, Gollan 1982, Storm 2001), most of them kept by human groups inhabiting the so called tropical hoe-culture belt (Boessneck and Meyer-Lemppenau 1969, Gollan 1982, Storm 2001). This suggestion is clearly supported by the craniometrics of some populations found within this cultural region; DFA (fig. 3.77) shows that a sample of three specimens from Garamba (northern Democratic Republic of Congo) and one from Mozambique clusters among the village dog types specifically the Indian pariahs. One of the DRC specimens (AMNH 52087) has clearly inflated auditory bullae, a long braincase and elevated
frontals, while the specimen from Mozambique (MCZ 44291) is superficially rather similar to a highland dog. Coat colour at least in one case (AMNH 52086) is like a village dog, being reddish dark ginger with an all white lower body and a white "collar" around the neck. Furthermore basenjis have been described as having black or ginger (red or yellow) coats, combined with white on the legs and lower body and around the neck (Epstein 1971). Medway (1977) finally also describes similarities between the external conformation of his Senoi dogs and the basenjis, including the presence of wrinkles on the forehead of both types.

Fig. 3.77. Multivariate diagram showing the statistical position of four African village dogs relative to the range of variation of three dog populations, using 17 cranial variables. The first function accounts for 97.2% of the variance, the second for 2.8%.

List of African village dogs
C: Specimen AMNH 52087. Village dog. Garamba, Congo.
When the sample from Garamba (AMNH 52086, 52087 52088) is compared with a sample from Egypt and with recent samples from the Inner Middle East and Israel, they are closer to the Egyptian and Middle Eastern samples, but not identical to either (fig 3.78).

Fig 3.78. Multivariate diagram showing the statistical position of four African village dogs (same sample as fig. 3.77) relative to the range of variation of three pariah populations, using 17 cranial variables. The first function accounts for 81.2% of the variance, the second for 18.8%.
3.2.6.10 Summary

The village dog type is a widespread form; populations of this type can be found in Southern and Southeastern Asia, New Guinea, Africa and very possibly the Middle East. There is a high degree of variability among populations, although a basic number of characteristics remain constant. The New Guinea highland dogs have some characteristics in common with the village dog type together with others which are particular to them and presumably relate to their adaptation to the life in the wilderness.

Four specimens collected in Africa (Congo and Mozambique) display morphologies that are consistent with that of the village dog type from Asia and New Guinea.

Both New Guinea highland dogs and village dogs tend to present lower cranial heights and narrower maxillas and zygomata than the Indian pale footed wolves. The length of their snout is however shorter; this is the only trait, of the four analyzed, which development conforms to the mainstream theories about morphological transformations in the wolf to dog transition (Koler-Matznick et al. 2003).
CHAPTER IV
WOLVES: TAXONOMICAL ISSUES AND NEW FINDINGS

4.1 Historical wolf populations from the Middle East, Southern Asia and fringe areas

4.1.1 Introduction

I will discuss in the following pages the issues around the taxonomic identity of the pale footed wolf, and of grey wolf varieties that inhabit parts of southern and central Asia and the Middle East. Initially, I will approach the topic by considering the taxonomy of the pale footed wolf, and then will discuss identities of particular geographically confined populations: the Indian, Mediterranean and desert types; I will also give some discussion of the problems of the morphological variability of some Asian populations of grey wolf.

4.1.2 Bivariate analysis

In an attempt to delineate possible differences between grey and pale footed wolves, I will investigate at first indicators of robustness, and how they may help to differentiate both groups. Carnassial size was one of the traits used by Corbett (1995) to discriminate between domestic dogs and dingoes in Australia; he found that wild varieties (dingoes and dingo hybrids) usually display larger carnassials than their domestic counterparts. This is particularly true in the case of *C. lupus* which has much larger carnassials, as shown in figs. 4.1 and 4.2; the same graphs demonstrate that pariah dogs have less developed carnassials, with pale footed wolves occupying an intermediate position between the two extremes. In the figures, the diagonal line represents the line of isometry; although carnassial size is in part related to greater absolute size, the bulk of Asian *C. lupus* specimens lie above the line of isometry, while most pariahs fall below it.
Fig. 4.1. Graph of upper carnassial alveolus length against basion-hormion length in populations of wild and domestic canids. Slope of the regression line = 0.68.
Fig. 4.2. Graph of lower carnassial length against basion-hormion length in populations of wild and domestic canids. Slope of the regression line = 0.53.
The width of the interorbital constriction is another trait directly linked to general robustness of the skull (Nowak 1995). Fig. 4.3 shows that there is a high degree of variability for this trait across the five taxa covered; specimens of *C. lupus* fall overwhelmingly above the line of isometry, and pariahs fall largely below it. *C. lupus* has on average a wider head than the rest of the taxa.

![Graph of forehead width against basion-hormion length in populations of wild and domestic canids.](image)

**Fig. 4.3.** Graph of forehead width against basion-hormion length in populations of wild and domestic canids. Slope of the regression line = 0.57.
The distance from opisthion to akrokranion is clearly associated with the development of sagittal and occipital crests, and to a protuberance at the point of intersection between both structures, usually referred to as the as the occipital process or occipital overhang (Gollan 1982); this was considered a distinctive characteristic of the dingo, and by extension of wolves, by Gollan (1982) and Corbett (1995). Fig 4.4 demonstrates that *C. lupus* stands out with a higher development of this trait, which is very similar among pale footed wolves and pariahs.

Fig. 4.4. Graph of occipital process length against basion-hormion length in populations of wild and domestic canids Slope of the regression line= 0.71.
Mandibular development is cited as another character typically associated with *C. lupus* (Scott and Fuller 1965). The next graph demonstrates that there is a wide range of variation among, and within, the different forms, with grey wolves showing the maximum degree of development (fig. 4.5).

![Graph of mandibular thickness against basion-hormion length in populations of wild and domestic canids.](image)

**Fig. 4.5.** Graph of mandibular thickness against basion-hormion length in populations of wild and domestic canids. Slope of the regression line = 0.53.
Researchers looking for a single clear difference between wolves and dogs, which could be useful when analyzing osteological materials found at archaeological sites, have referred to the ratio upper carnassial/molar series length as a most nearly diagnostic (Clutton-Brock 1963, Clark 1996); this ratio is usually formulated as the total length of the upper carnassial divided by the sum of both upper molars, which it has been suggested will always be over unity in true wolves and equal or less than unity in dogs (Clark 1996). Figure 4.6 confirms this in the case of *C. lupus*, with just a slight overlap, but shows a high degree of variability among the remaining groups. That is to say, a dog such as a pariah can generally be distinguished from *C. lupus*, but *C. pallipes* could be confused with either.

![Graph of upper carnassial length against the combined length of both upper molars in populations of wild and domestic canids.](image)

**Fig. 4.6.** Graph of upper carnassial length against the combined length of both upper molars in populations of wild and domestic canids. Slope of the regression line = 0.82.
A final character is brain size (fig. 4.7), in which the wolf group seem to depart from the rest (Groves 1989, Hemmer 1990). In this case the wild canids (pale footed wolves and Eurasian C. lupus) exhibit a very similar development, as opposed to the pariah group that in average has a comparatively small brain. Again, however, there is considerable overlap.

Fig. 4.7. Graph of brain size against basion-hormion length in populations of wild and domestic canids. Slope of the regression line= 0.76.
BOX III

Notes:

It must be said that identifying archaeological remains from either wolf or dog could be at times a challenging issue, because of both the usually fragmented nature of the sample, and the similar conformation and size of many osteological structures. The diagrams above show that there is a considerable degree of overlap among the different forms, and that in general only the most extreme values will offer a good opportunity of identifying specimens, unless a reasonable number of characters are available for analysis. Perhaps the best single measurement is the length of the lower carnassial, since the degree of overlap among the three groups (pariahs, pale footed wolves and grey wolves) is not particularly extreme although sample sizes are smaller than for other characters studied. We must not forget however that the occurrence of pale footed wolf – grey wolf – pariah hybrids is a real possibility in some parts of the world, and that these hybrid specimens have the potential to be allocated in tightly overlapping parts of the diagram, often yielding very blurred identification outcomes.

Bivariate analysis also helps to detect non-typical individuals presenting characters with values out of the usual range; the occasional existence of such individuals has been pointed out in the past by some scholars (Pocock 1941, Olsen 1985); this lack of data is possibly related to the very limited amount of research involving large samples. I have made every possible effort to verify the samples as strictly as possible and that for a specimen to be included within a certain category it needed to consistently cluster in it following a DFA, with the more closely related groups, of 17 different variables.

4.1.3 *Canis pallipes*: India

From data collected at museums and from live specimens, the Indian populations of pale footed wolves could be characterized by gracility, medium body size (calculated body weight average= 16.51 kg, range= 13.63–19.96 kg, stdv= 1.89, N= 15), large ears and long legs; the profile of the thoracic cage is rather tubular, but with some depth. These wolves usually present a pelage which is short and with very little underwool, particularly during the summer. Colour is usually a mix of grey and black with widespread reddish and sable undertones; upper parts of the body are usually darker with black and grey hair dominating; flanks have more grey and very often a profusion of buffy hair; legs are more lightly coloured displaying a mix of light grey and yellowish with some black, particularly on the hind legs; very often there is a dark grey stripe running down the front of the upper half of the forelegs; the lower third of the legs is often, but not always, paler than the rest of the body, with one or more feet also pale coloured. Undersides are lightly coloured and are usually quite yellowish or light grey. The forehead mirrors the colour patterns of the top of the back, with a central dark stripe that starts just in front of the crown and may extend, although weakened, towards the nasal region along the top of the muzzle, usually only in darker individuals; individuals with a predominance of buffy or reddish coloration do not present any differential
markings along the top of the muzzle; the sides of the snout lighten in colour towards the lips and become light grey around the mouth and towards the cheeks (fig. 4.8).

There is a degree of colour variability in this form, although it is not as pronounced as in other wolf types; the pelage of some individuals is in fact almost devoid of grey hair, except around the lips, this being replaced by a brown reddish coloration mixed with black which gives an overall sable look to the body; there seems to exist however a degree of gradation between these types as some individuals may present a varied combination of both patterns. The tail is well proportioned in length, pendant and bushy, and the hair becomes shorter in its upper quarter; it tends to get darker towards the tip. Ears tend to be relatively large and markedly triangular in shape.

Many specimens, particularly males, present a small mane and a well-developed shoulder patch with longer hair; these traits are also more apparent during the wintertime among the northern populations.

The skull conveys a general impression of gracility when compared with the grey wolf (fig. 4.9), although it has thick zygomatic arches, a well developed angular process, and a prominent occipital process; the interorbital distance is usually narrow, carnassial sizes are much closer to those of pariah dogs than to grey wolves and comparatively the sagittal crest is in most cases not very well developed. The facial region is usually slightly dished and presents non-inflated frontals. Mandibles are shallow when compared with the grey wolf; the ascending ramus is often inclined and the coronoid apex can be as much curved as in some domestic dogs, but can be completely straight in some specimens. Cranial capacity is on the other hand much closer in size to that of the grey wolf than to most of the Indian pariah dogs in the sample (fig. 4.7).

The pale-footed wolf is therefore diagnosably distinct (in the sense of the Phylogenetic Species Concept) from the grey wolf, in both external and cranial dental features. Multivariate analysis of cranialia distinguishes them absolutely (see below). Where their ranges meet they seem sharply distinct, though there is some hybridisation (see below). They will be treated as different species here, for these reasons.
Fig. 4.8. Pale footed wolves from Northeastern India. Note the well developed mane and shoulder patch as well as the predominance of grey tones in the coat. Photo courtesy Heerak Nandy (Calcutta).

Fig. 4.9. Skull from Pakistan (USNM A16147). Note the large angular and occipital processes, thick zygomatic arch and the low frontal profile.

During the development of this work, metrical analysis detected three possible Indian pariah-wolf hybrids (fig. 4.10a). Specimen IN 189 (from the collection of the Madras Veterinary College) was obtained around the Madras area (Tamil Nadu) and exhibits some characteristics reminiscent of a greyhound: the skull is very long and has a very narrow palate and non-bulging zygomatic arches; the frontal region is rather straight. Two specimens (IN 227, IN 228) from the College of Veterinary Sciences (Hebbal, Bangalore, Kerala) were identified likewise. Both crania are rather
similar (fig. 4.10b) as they have an almost straight facial region, a large occipital process, non-inflated frontals, a relatively low cranial vault and thick zygomatic arches; one of the specimens (IN 228) displays also a well developed auditory bulla.

Fig. 4.10a. Multivariate diagram showing the statistical position of three possible wolf-dog hybrids from India relative to the range of variation of three canid populations, using 16 cranial variables. The first function accounts for 86.3% of the variance, the second for 13.7%.

List of possible hybrids
A: IN 228. College of Veterinary Sciences (Bangalore).
B: IN 227. College of Veterinary Sciences (Bangalore).
D: IN 189. Madras Veterinary College.
Another source of variability is the presence of individuals of non-typical conformations, which can not be explained through crossbreeding with dogs or any other taxa (see "notes" above). Pocock (1941) studied an unusually small specimen (BMNH 858152) from Sambhar (Rajasthan) which he described as a "dwarf"; I had the opportunity to study this skull and despite the fact that it has the smallest cranium in the Indian sample (total length = 202.15 mm), its calculated body weight (14.71 kg) surpasses those of the other three specimens in the sample for which weights were available (BMNH 351181 = 14.63 kg, IN 214 - RMNHM = 13.63 kg, DCP 104 = 14.32 kg); the Sambhar specimen also fits comfortably within the Indian pale footed wolf cluster and does not stand out in Fig. 4.10. Pocock's (1941) assessment must then be supported in a sense that it refers only to an abnormally small specimen, that otherwise presents the usual characteristics of an Indian pale footed wolf. Another specimen of dubious identity was taken in Hazaribagh district (Bihar) and was labelled *Canis lupus pallipes* (BMNH 35.1.1.83); in this case DFA did not help to achieve any valuable conclusion, as the specimen nested deeply inside the wolf jackal cluster (fig. 4.13), a taxon which is not present in India (see chapter V), and could not be clearly ascribed to any other of the available groups (fig. 4.12); in a log ratio diagram the specimen shows shared characteristics with both pale footed wolves and wolf jackals (fig. 4.14). A bivariate graph, analyzing the relative size of the brain of the same groups, indicated a brain size consistent with the Indian pale footed wolf sample (fig. 4.15).
Fig. 4.12. Multivariate diagram showing the statistical position of an atypical specimen from India (BMNH 35.1.1.83) relative to the range of variation of three canid populations, using 17 cranial variables. The first function accounts for 68.0% of the variance, the second for 32.0%.
Fig. 4.13. Multivariate diagram showing the statistical position of an atypical specimen from India (BMNH 35.1.1.83) relative to the range of variation of three canid populations, using 17 cranial variables. The first function accounts for 89.9% of the variance, the second for 10.1%.
Fig. 4.14. Log ratio diagram of the measurements of 17 cranial traits of one atypical specimen from Bihar, India (BMNH 351183) compared with other canid samples. Golden jackal data is used as standard value.
The geographic distribution of the Indian pale footed wolf has been often diffusely described, and there is not much information available in regard to its exact limits (Sykes 1831; Blanford 1888 – 1891; Pocock 1935, 1941). In India it seems to have inhabited, until the 1940’s, most of the northern and central plains and some forested areas of West Bengal. Tumkur, in northern Karnataka (ASI 52), seems to be the southernmost limit documented by any specimen, while the Himalayan foothills mark the northern limits (Blanford 1888; Pocock 1935, 1941). The easternmost limit seems to be in the Puruliyya Bankura region of West Bengal (Supriya and Heerak Nandy, pers. comm.), while it is unreported in Bangladesh. In Pakistan it used to inhabit Baluchistan and Sind, but is very rare in those areas nowadays (Roberts 1977). Very little is known about its status in Afghanistan or Iran; hypothetically it should exist, or have existed, at least along the coastal lowlands of the latter country, while the grey wolf seems to be the form in the inland mountainous regions of the eastern side of the Middle East (this study). Pocock (1935b, 1941) considered that the western limit is in Mesopotamia; my analysis confirms that a specimen from Tarooma in Mesopotamia (BMNH 351141), also studied by Pocock (1935b), falls in principle into the range of variation of the
Indian populations rather than with the Israeli Mediterranean population (figs. 4.16a, 4.16b). The existence of another specimen, this time from the western seaboard of the Arabian Peninsula (HZM 31.30448, East of Umm Laj, North of Yanbu) which is also morphometrically closer to the Indian population, seem to suggest however that the morphology of both types overlap over a wide area.

Fig. 4.16a. Multivariate diagram showing the statistical position of the three specimens (blue asterisks) that best define the morphological overlapping between eastern and western populations of pale footed wolves, relative to the range of variation of three canid populations using 17 cranial variables. The first function accounts for 88.7% of the variance, the second for 11.3%.
A: HZM 31.30448. East of Umm Laj - North of Yanbu (Saudi Arabia).
B: BMNH 351141. Tarooma (Mesopotamia).
C: Specimen from the Zoological Survey of India. India (no catalogue number). Note: Although a pale footed wolf collected in India, this specimen is deeply nested inside the Mediterranean pale footed wolf cluster and must be identified as a Mediterranean pale footed wolf of Indian origin.
4.1.4 Mediterranean and desert *Canis pallipes*

The Israeli population of pale footed wolves is morphologically similar to the Indian one (Mendelssohn 1982), but not identical. Some obvious differential external traits of the Israeli wolves are their shorter legs, deeper chest and the presence of a rounder head that seems rather dog-like in some instances (fig. 4.16c). Chromatic variability is very similar to that of the Indian pale footed wolves with different individuals showing particular combinations of grey, black, red and buff; pre-eminence of reddish tones is perhaps stronger in the Israeli population than in
India; some specimens in the desert are predominantly sandy coloured, the reddish tone replaced by a light brown/yellowish one, these individuals having extensive pale grey areas from the nose to the cheeks; the presence of sandy tones in the desert populations may be due to the influence of Arabian wolves which used to inhabit that area and that very possibly were absorbed by expanding populations of pale footed wolves (see below). Another peculiarity of the Israeli wolf is the extensive light-grey areas covering feet and limbs; the inside of the legs is almost uniformly pale in most individuals. The study of museum skins, and of photographs taken in the wild by Yoram Shpirer and Thomas Krumenacker, indicates also that in desert areas the Israeli pale footed wolves develop a particularly short pelage during the summer, but a thick coat during the winter.

Fig. 4.16c. This photo of a desert pale footed wolf was taken by Thomas Krumenacker in the Arava Valley (southern Israel) during winter time. Note the length of the pelage, typical grey colour and pale coloured limbs, as well as the morphological differences from the Indian pale footed wolf (fig. 4.8).

Populations in Israel north of 400 mm isohyet were identified by Mendelssohn (1982) as Mediterranean C. l. pallipes. He characterized this variety as larger than the desert one that inhabits the lands south and east of the 400 mm isohyet, but very similar to it in terms of coloration and general body structure.

In order to develop a better understanding of the possible correlations between body size and climate, I generated a table that covers the totality of the Israeli lands from the southern desert to the Golan Heights, and that illustrates the relationship between latitude and cranial size (table 4.1, see also fig. 4.41b). The data are grouped by regions of origin which are accordingly defined by latitudinal values; it is obvious that changes in size occur along a gradient and there are no clear gaps as far as body size is concerned. These observations are consistent with
Mendelssohn and Yom-Tov's (1999) comments: they emphasized that the Galilean population shows traits which are reminiscent of *C. lupus* and that the southern populations, defined by Mendelssohn (1982) as desert *C. l. pallipes*, are also clearly smaller than the northern ones.

<table>
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<th>Latitude</th>
<th>Basicranial Length</th>
<th>sample size</th>
<th>STDEV</th>
<th>Max</th>
<th>Min</th>
</tr>
</thead>
<tbody>
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<td>33 30'</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VIII</td>
<td>196.93</td>
<td>4</td>
<td>12.06</td>
<td>212.12</td>
<td>186.56</td>
</tr>
<tr>
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<td>178.46</td>
</tr>
<tr>
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<td>1</td>
<td>0</td>
<td>183.74</td>
<td>183.74</td>
</tr>
<tr>
<td>VI</td>
<td>190.89</td>
<td>5</td>
<td>3.61</td>
<td>196.12</td>
<td>186.8</td>
</tr>
<tr>
<td>31 30'</td>
<td>191.31</td>
<td>8</td>
<td>9.96</td>
<td>209.04</td>
<td>178.55</td>
</tr>
<tr>
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<td>9</td>
<td>9.17</td>
<td>199.48</td>
<td>173.2</td>
</tr>
<tr>
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<td>187.35</td>
<td>4</td>
<td>10.22</td>
<td>197.08</td>
<td>173.03</td>
</tr>
<tr>
<td>30 30'</td>
<td>186.38</td>
<td>11</td>
<td>7.27</td>
<td>194.2</td>
<td>179.59</td>
</tr>
</tbody>
</table>

Table 4.1. Latitudinal variation of basicranial lengths in the Israeli populations of Mediterranean and desert pale footed wolves. The roman numerals, in the left column, refer to geographic regions whose limits are defined by the latitudinal values also found in the left column.

This idea is also reinforced by a histogram showing the distribution of calculated body weights from Mediterranean and the desert wolf samples (fig. 4.17). Expectedly there are no noticeable discontinuities in it.

![Histogram of body weights of desert and Mediterranean *C. pallipes*](image)

**Fig. 4.17.** Histogram of the distribution of body weights in a sample of Israeli wolves.
A trait peculiar to a part of the Israeli population of pale footed wolves is their apparent degree of similarity with the local pariah dog variety; the opposite is also true, in a sense that many of the local pariahs manifest evident wolf traits. Specimens identified as "wolf-dog hybrids" by experienced personnel (Yom Tov, pers. comm. 2006) spread in an apparent random pattern within a multivariate diagram (fig. 3.29). The next series of photographs illustrates one of such individuals (M 3978) that displays intermediate wolf–dog characteristics (figs. 4.18, 4.19, 4.20). Note the robustness and the general appearance reminiscent of a husky dog. Not unlike many types from the Polar Regions, this specimen presents a very straight sagittal crest and a large and rounded occipital process. Face profile is clearly dished; this depression abruptly accentuates in the frontal area, although the frontal bones do not show traces of inflation; zygomatic arches are well flared and thick. The auditory bullae are well developed but not inflated. The snout and palate are short and wide. Mandibles are not overly thick, in a dorsoventral aspect, and present a relatively thin ascending ramus and a recurved coronoid apex; the angular process is well developed. Dentition is not crowded, having an overlapping index of 0.64. Calculated body weight was 17.91 kg. This specimen was identified as an Israeli pale footed wolf by DFA, but was labeled as a pariah dog.

Fig. 4.18. Specimen M 3978, Hebrew University of Jerusalem. Lateral view. See text.

Fig. 4.19. Same specimen. Basal view. See text.
A specimen from Fayum in Egypt (USNM 321952) has a mix of wolf and dog traits as shown in figs. 4.21 and 4.22: the muzzle is relatively short and the palate is wide, the facial region is rather dished and the frontals are inflated, the sagittal crest and the occipital process are well developed, zygomatica are well flared and robust, auditory bullae are small; the horizontal ramus is well proportioned and the ascending ramus is recurved and presents a well rounded coronoid apex, the angular process is large, the LM1 metaconid is poorly developed (score 1) and the UM1 cingulum is incomplete; calculated body weight is 14.59 kg. The presence of genuine wolves has never been documented in Egypt and this may be only a case of a wandering specimen from the Sinai; in any case it should not be viewed as an indication of a stable wolf population inhabiting Egypt.
As mentioned before, the northern populations of Mediterranean pale footed wolf, and particularly those from Golan, were described by Mendelssohn (1982) as different from those of the rest of the country, as they seem to approach the grey wolf in their conformation. My study sample includes seven grey wolves and two reputed grey - pale footed hybrids found in Israeli territory; four of the grey wolf specimens come from the top end of the country, and two of them specifically from the Golan area. I also had access to two of the specimens which were used as baseline by Mendelssohn (1982) in proposing his hypothesis; my analysis clearly identified one of them (M 7425) as grey wolf, but the other (M 7510) as Mediterranean pale footed wolf. The remaining specimens from Golan (n=11) were identified as Mediterranean pale footed wolves, although some of them were quite large specimens (maximum calculated body weight in the sample=24.10 kg), as can be seen by looking at data referring to region VII, where the Golan is located.
A conservative estimation of the geographic distribution of the Israeli pale footed wolf could suggest northern Israel as its northern limit, although this may change in the future as the taxonomic status of Syrian and Lebanese populations are not well known. Its presence through most of Israeli territory has been substantiated, although today it may have gone extinct in the more populated areas of central Israel; it does still inhabit the Judean Desert and seems to be relatively common in the Negev (fig. 4.41b). Across the Israeli border specimens fitting the craniometrics of the Israeli pale footed wolf have been collected in Jordan, Oman, Kuwait, Aden, and India. (figs. 4.16, 4.23).

Fig. 4.23. Multivariate diagram showing the statistical position of eight specimens from the Arabian Peninsula and Jordan (blue asterisks) relative to the range of variation of three wolf populations, using 17 cranial variables. The first function accounts for 81.6% of the variance, the second for 18.4%.

A: BMNH 841312. Azraq (Jordan)
B: BMNH 46890. Kuwait
C: HZM 1.3902. Jebel Hafit, near Buraimi (Oman)
D: BMNH 9911636. Lahej (Yemen)
E: HZM 17.11819. Km 121 Mecca Bypass (Saudi Arabia)
F: HZM 129597. Wadi Khumra (Saudi Arabia)
G: BMNH 40193. 18 miles north of Jeddah (Saudi Arabia)
H: HZM 74885. Fizz (Oman)
4.1.5 On the Arabian wolf and its type specimen

This form (C. l. arabs, Pocock 1934) arguably inhabited southern Israel until recently, before being displaced and/or absorbed by the desert variety of pale footed wolf (Mendelssohn 1982). My analysis corroborates this, and also suggests that the same situation is taking place in the Arabian Peninsula, as three specimens from this area discriminated as pale footed wolves (fig. 4.23).

In consequence the Arabian wolf may only survive in the most inhospitable environments of the southern half of the Arabian Peninsula (fig. 4.23), and perhaps of the Sinai as a recently camera trap photograph, taken at the St Katherine protectorate, could indicate. The general body proportions of this variety are similar to those of the Israeli pale footed wolf, although it is smaller (average calculated body weight= 11.93 kg, range= 10.44 – 13.67 kg, stdv= 1.40, N= 4), and it has a comparable brain size (average cranial capacity index= 1.73, range= 1.56 – 1.96, stdv= 1.73, n= 4); size alone seems to differentiate it, as data from five specimens indicates an average basicranial length of 166.85 mm (range: 159.46-172.76 mm, stdv= 4.86), separated in a histogram (fig 4.45) by a clear gap from other samples of grey wolves and both desert and Mediterranean pale footed wolves, with just a small number of desert pale footed wolves being nearly as small as the Arabian wolf. Pelage colour is also comparable to that of the Israeli pale footed wolves, showing a similar degree of variability, with grey and reddish tones being predominant; this form also grows a thicker winter coat, and some individuals develop a very long and sparse mane. The shape of the head is very distinctive, almost fox-like, presenting a narrow muzzle and relatively wide zygomata. The cranium is gracile, with a slightly dished facial region, well developed sagittal and occipital crests, and a large occipital process; zygomata are both broad and thick, auditory bullae are large and the palate is quite wide (figs. 4.24, 4.25); mandibles are relatively slender, with large carnassials and a moderately sized angular process (fig. 4.26). Considering all of the above it seems likely that the Arabian wolf could be identified as a subspecies of pale footed wolf.

Caution should be however exercised as the description of the skull is based on that of the type specimen which appears to be a dog hybrid (fig. 4.27). This specimen exemplifies the difficulties that at times may arise when separating wolves and dogs in the Middle East: the general structure of the skull is wolf-like, and although gracile it has long teeth and a thick mandibular ramus; zygomatic arches are however too wide, the auditory bulla is slightly ribbed and the ascending ramus is recurved. Nothing in the description of the type specimen (Pocock 1935a) suggests the possible hybrid origin of this specimen. A sample of four specimens from the southern half of the Arabian Peninsula (fig. 4.27) also seems to evidence a degree of hybridization as they tend to group along the edge of the desert pale footed wolf cluster, facing the pariah cluster.
Fig. 4.24. Type specimen of *C. l. arabs* Pocock from Ain (Qara Mountains), Oman (BMNH 348412). Lateral view. Very possibly a dog hybrid.

Fig. 4.25. Same specimen. Basal view.

Fig. 4.26. Hemimandible of the same specimen.
Fig. 4.27. Multivariate diagram showing the statistical position of a canid sample from the Arabian Peninsula (blue asterisks) relative to the range of variation of three canid populations using 17 cranial variables. The first function accounts for 82.4% of the variance, the second for 17.6%.

The Arabian sample includes the type specimen of *arabs* from Ain (T: BMNH 348412) and also:
- BMNH 40193: 18 miles north of Jeddah (Saudi Arabia)
- HZM 17.11819: Km 121 - Mecca bypass (Saudi Arabia)
- HZM 74885: Fizh (Oman)
- HZM 129597: Wadi Khumra (Saudi Arabia)

Bivariate analysis of three characters (figs. 4.28, 4.29, 4.30a) that are usually relevant to differentiate between wolves and dogs, show that the type specimen *C. l. arabs* is within the range of variation for Arabian wolves in two of them (cranial capacity and length of the lower carnassial) and slightly under the average value for the length of the auditory bulla. However the total sample of Arabian wolves shows more affinity for the pariah than for the wolf sample in three out of four specimens, for cranial capacity and length of the lower carnassial, and for three out of five specimens in the case of the length of the auditory bulla.
Fig. 4.28. Graph of brain size against basion-hormion length in populations of wild and domestic canids.
Fig. 4.29. Graph of lower carnassial length against basion-hormion length in populations of wild and domestic canids.
Fig. 4.30a. Graph of auditory bulla size against basion-hormion length in populations of wild and domestic canids.

To counterbalance this, photographs of a captive specimen (figs. 4.30b, 4.30c) kept at the Arabian Fauna Breeding Centre (Sharjah, UAE), and others posted by the same organization in the Internet, demonstrate the existence of a distinctive external morphology, as previously described in chapter II, amongst the Arabian wolves; the individuals portrayed do not have any external indication of being hybrids and in fact reinforce the idea of a separate (from the desert and Mediterranean pale footed wolf) type of wolf inhabiting the driest regions of the Arabian Peninsula.
Fig. 4.30b. Female Arabian wolf (photo courtesy Arabian Fauna Breeding Centre, Sharjah, UAE).

Fig. 4.30c. Head detail of the previous specimen (photo courtesy Arabian Fauna Breeding Centre, Sharjah, UAE).
As previously mentioned, I lack much comparative material of typical grey wolves, and will follow Nowak (1995) in including *chanco* (plus *laniger* and *niger*) within *C. lupus lupus*, with the proviso that some Himalayan and Chinese populations present certain peculiarities. All evidence indicates that the pelage of Asian *C. lupus* presents a larger range of coloration than the pale footed and Arabian wolves; this can be particularly well documented in the Tibetan populations, where colours fluctuate from a very light grey to an almost solid black, combined with an ample inventory of individual variance, that may include black, white, grey, reddish, yellowish and buff (Hodgson 1847, Gray 1863, Sclater 1874, Blanford 1888, Allen 1938, Pocock 1935b, Pocock 1941). A winter skin from Kashmir (BMNH 3611221) presents a wide dorsal band of black and reddish hair that also extends to the outside of the extremities and the upper side of the tail, the flanks and the rest of the tail are mostly reddish with some black interspersed, and the lower regions are yellow and reddish. The winter pelage in at least a part of the Himalayan population also has a distinct appearance with wool dominating over the guard hairs. It has been stressed by some authors (Hodgson 1847, Blanford 1888, Pocock 1935, Pocock 1941) that the grey wolf is larger and more robust than most forms of pale footed and Arabian wolf. A histogram of calculated body weights, using the Hamblin-Bird method (see chapter I and appendix III), of a sample of Asian grey wolves yields results that clearly indicate the superior body size of this form, as compared with that of pale footed wolves, although there is a certain degree of overlap between both distributions (figs. 4.31, 4.45).
The skulls of Asian grey wolves appear variable in shape. The type specimen of *Canis chanco* Gray and *Canis lupus laniger* Hodgson, from Chinese Tartary (BMNH 633201 1442a; figs. 109, 110 and 111), is large (total cranial length 238.30 mm, calculated body weight= 22.99 kg), its frontal region is only slightly dished, the sagittal crest is large and expands into a sizable occipital process; auditory bullae are voluminous, the zygomatic arches are very thick but do not expand excessively, the palate region is neither wide or narrow and the mandibular body is thick, relatively straight, and presents a medium size angular process with an ascending ramus that is lightly curved (figs. 4.32, 4.33, 4.34). This specimen lacks three key measurements, and could not be analyzed through DFA.

Fig. 4.32. Type specimen of *Canis chanco* Gray and *Canis lupus laniger* Hodgson, from Chinese Tartary (BMNH 633201 1442a). Lateral view.

Fig. 4.33. Same specimen. Basal view.
The skull of a grey wolf from Gilgit (BNHS 5311, 4.35, 4.36, 4.37) seems to exemplify a different type of animal, and although it shares some characteristics with the previous specimen it is also very different in many respects. It also represents a large animal (total cranial length = 242.28 mm, calculated body weight = 26.62 kg), and has a deeply dished facial region and inflated frontals; sagittal crest and occipital process are well developed, the auditory bullae are of a medium size and the zygomatic arches are thick and well flared; the posterior palatal region is rather wide; the mandibular body is thick and recurved and has a long angular process, and the ascending ramus is upright. Many of these traits could be considered as reminiscent of a domestic dog, although the morphometrics show no association with dogs, and it is morphologically similar to the rest of the grey wolf sample as evidenced by DFA.

Fig. 4.34. Hemimandible of the same specimen.

Fig. 4.35. Grey wolf from Gilgit (BNHS 5311). Lateral view.
A cluster of specimens in Central Asia and nearby regions presents an intermediate conformation between the grey wolf and the Indian pale footed wolf (fig. 4.38). Blanford (1888) and Pocock (1935, 1941) commented also about the existence of specimens expressing characteristics from both forms, in northern India and the Himalayas. The atypical, potentially intermediate, specimens in my study come from Kashmir (USNM 198458, BMNH 3611221), Afghanistan (BMNH 818166), Sikkim (BNHS 6272), the northwest of the Indian subcontinent (BMNH 358302, BMNH 565642, BMNH 348122), Shanxi (USNM 172654, USNM 172655) and Inner Mongolia (AMNH 45602). Phenotypically all these specimens present characteristics of both forms in what appears to be a constant pattern; the statistics of calculated body weights of nine of them (average = 19.75 kg, range = 15.48 - 23.30 kg, stdv = 2.5) seems to confirm also the intermediate nature of the sample.
Fig. 4.38a. Multivariate diagram showing the statistical position of a sample of atypical wolves from Asia (blue asterisks) relative to the range of variation of three wild canid populations, using 17 cranial variables. The first function accounts for 88.1% of the variance, the second for 11.9%.

A specimen from Pakistan (USNM A16146), not included in the DFA, typifies some of the more representative characteristics of wolves of this intermediate type (fig. 4.11) such as dished facial region, wide frontal shield, short rostrum, broad palate, wide zygomatica and large angular and occipital processes; all this combined with a robust general appearance.
Another particularly interesting cranium, labelled as *C. l. laniger* (BMNH 201175), came from Gilgit (Kashmir), like BNHS 5311 described above; DFA was insufficient to identify it with any of the groups being studied. Its taxonomic status is clarified by a log ratio diagram (fig. 4.39) and a bivariate analysis of its brain size (fig. 4.40); both approaches show that the specimen in question displays an intermediate conformation between the grey wolf and the Indian pale footed wolf, without showing any signs of hybridization with dogs; its calculated body weight (19.43 kg) is consistent with this diagnosis.
Fig. 4.39. Log ratio diagram of the 17 measurements of a canid from Kashmir compared with other canids. Indian pariah data is used as standard value.
4.1.7 *Canis lupus*: Middle Eastern

Available data suggest that the grey wolf populations of the Middle East come from two main areas: 1) Israel and the coastal area from Golan to southern Anatolia, and 2) a big arc-shaped landmass that would include eastern Turkey, southern Caucasus, northeastern Iraq and all the mountainous regions of Iran (henceforth the “Inner Middle East”).

Within the Israeli sample, eight specimens were identified as grey wolves (TAU M9837, TAU M9774, TAU M10230, TAU M9258, TAU M7598, TAU M6, TAU M7425, TAU M10610; fig. 4.41a); specimen TAU M7598 was collected six km south of Giftlik, in Jordan, just across the border with Israel and is considered here, for all analytical purposes, as a part of the Israeli sample (fig. 4.41a). Four of the grey wolf specimens came from localities found above latitude 32 29" (TAU M9774, TAU M9258, TAU M6, TAU M7425); of these two were from the Golan Heights (TAU M9258, TAU M7425). This observation complements some accounts suggesting the existence of a grey wolf population in northern Israel, that may be connected with
others located farther north (Mendelssohn 1982, 1983). The directly taken weights for a sample of seven specimens averaged 28.93 kg (stdv= 4.71, range= 19.3 - 33.00 kg) the lower value of the range is given by the specimen from Elat, in the southern Negev.

![Multivariate diagram showing the ranges of variation of three wild canid populations, using 17 cranial variables. It includes a sample of eight grey wolves from Israel. The first function accounts for 85.2% of the variance, the second for 14.8%.

Four grey wolf specimens (TAU M9837, TAU M10230, TAU M7598, TAU M10610) from south of the Golan area must be considered as vagrant, as they have been found in areas typically inhabited by pale footed wolves lacking, in principle, the environmental characteristics needed to sustain the species (fig. 4.41b). Extreme cases of atypical locations for grey wolves are Mizpe Ramon (TAU M10610), an exceptionally dry and inhospitable site in southern Israel, and the area between K. Menahem and Qiryat Malakhi, north of the Gaza strip, a very densely populated region crisscrossed by roads and motorways, where TAU M10230 was obtained.
Fig. 4.41b. Geographic distribution of recent wolf samples from Israel.

- Black asterisks represent grey wolves
- Green asterisks represent Mediterranean pale footed wolves
- Red asterisks represent desert pale footed wolves
- Brown asterisks represent grey wolf – pale footed wolf hybrids
Wolf specimens in collections from the Inner Middle East are often automatically, but often erroneously, labelled as *C. l. pallipes* (fig. 4.43). Four specimens from this area (MCZ 51602, FMNH 97778, FMNH 84468, HM 86133) show the typical cranial length (average= 243.1 mm, range= 228.47 – 251.05 mm, stdv= 10.47, n= 4), calculated body weight (average= 22.76 kg, range= 19.29 – 24.89 kg, stdv= 22, n= 3) and robustness of the Asian grey wolves and have been accordingly considered as such. It is remarkable that all four specimens present some peculiarities, namely wide palates, markedly dished faces, high cranial vaults and a recurved coronoid apex, that seem to somewhat approach them to dogs of the sheepdog type. One specimen from Iran (FMNH 97778, fig. 4.42) and one from Iraq (FMNH 84468, fig. 4.43) yielded overlapping indices of 0.63 and 0.64 respectively, values which should be considered within the wolf range (Davis and Valla 1978); the specimen from Turkey (MCZ 51602) has a higher overlapping index (0.66). The specimen from Iraq (FMNH 84468) is quite remarkable as its very robust looks are combined with dog-like characteristics such as a short rostrum, inflated frontals and a recurved coronoid apex; somehow its whole appearance resembles that of a mastiff. A specimen from Borzomi (Caucasus, ZSI IN 105), labelled as *C. l. cubanensis*, presents a morphology closer to a typical grey wolf: has a lower cranial roof, a longer rostral region and a narrower zygomatic breadth; DFA clearly associates it with the grey wolf cluster (fig. 4.44).

![Wolf specimen from Lurestan, Iran (FMNH 97778). Note the elevated forehead, the lightly inflated frontals and the relatively short rostrum (see text).](image-url)
Fig. 4.43. Wolf specimen from the Iraqi Zagros (FMNH 84468). Note the “mastiff” looks, including a short rostrum and inflated rostral region.

Fig. 4.44. Multivariate diagram showing the statistical position of a wolf from the Caucasus (ZSI IN105) relative to the range of variation of three canid populations, using 17 cranial variables. The first function accounts for 84.2% of the variance, the second for 15.8%.
All the grey wolf specimens from the Inner Middle East in this study were collected in areas of relatively high altitude or in the proximity of mountain ranges, as in the case of one individual collected at Main Kaleh peninsula on the southern side of the Caspian Sea (Harr 86133). The limited size of the sample does not allow making generalizations as to geographic variation in the grey wolf in the region, or about the role of hybridization with large dogs in the morphological profile of the populations inhabiting the area.

4.1.8 Notes on the general morphometrics of Middle Eastern wolves

The antimodes in a histogram of basicranial length data of wolves from the Middle East followed the expected separations among grey wolves, pale footed wolves and Arabian wolves, with a peak also for hybrids between pale footed and Arabian wolves (fig. 4.45). The histogram also points out the possible existence of specimens with basicranial lengths outside of the expected range for their taxa.

![Histogram of basicranial lengths](image)

**Fig. 4.45. Histogram of the distribution of basicranial lengths in wolves from the Middle East. It includes specimens from Iran, Iraq, Israel, Jordan, Kuwait, Saudi Arabia and Oman. In the total sample seven specimens have been identified as grey wolves, four as Arabian wolves and two as Indian pale footed wolves. The rest of the sample consists of Mediterranean and desert pale footed wolves. The two major gaps define the samples of (from right to left): 1) Asian grey wolves 2) Mediterranean pale footed wolves 3) Desert pale footed wolves and Arabian wolves.**
When the same type of analysis was conducted for the length from basion to hormion, no substantial gaps were detected, as the whole of the histogram follows a continuum that seems to indicate that body size changes across taxa following a gradient lacking any significant discontinuities (fig. 4.46).

![Histogram of the distribution of basion hormion lengths in wolves from the Middle East. Same sample as in fig. 4.45.](image)

**Fig. 4.46.** Histogram of the distribution of basion hormion lengths in wolves from the Middle East. Same sample as in fig. 4.45.
There is however a great degree of correlation between the lengths of both traits as fig. 4.47 indicates.

![Graph relating basicranial length to basion-hormion length in a sample of wolves from the Middle East. Slope of the regression line= 0.84.](image)

**Fig. 4.47.** Graph relating basicranial length to basion-hormion length in a sample of wolves from the Middle East. Slope of the regression line= 0.84.

To summarize some of the most relevant similarities and differences among the wolf forms that inhabit the Middle East, I developed a log ratio diagram that includes a large part of the previously discussed data (fig. 4.48). This diagram again demonstrates that there are clear differences between the Arabian and the grey wolves and the rest of the Middle Eastern wolf group. The diagram also shows the great morphological similarity between the desert and the Mediterranean populations of pale footed wolves. It also reflects the general dissimilarity between dogs and wolves, although it must be emphasized that there is similarity between the shapes of the lines of the Israeli populations of pale footed wolves and the Israeli pariah dogs.
Fig. 4.48. Log ratio diagram of the measurements of 16 cranial traits of canids from the Middle East. Arabian wolf average is used as standard value.

4.1.9 Summary

The Indian pale footed wolf could arguably inhabit a wide area, from northeastern India to Mesopotamia and perhaps the west coast of the Arabian Peninsula; its presence in Afghanistan and Iran has not been yet confirmed, although it does probably exist in those countries.

Two different species of wolf have been identified in Israel: the grey wolf, from the northern regions (including the Golan) and the Israeli or Levantine pale footed wolf, which used to inhabit the rest of the country. The latter divides into Mediterranean and desert varieties. The known geographic distribution of the Levantine pale footed wolf covers a wide region, from western Israel to India, with Israel being the core area of its distribution; in fact its presence in the Arabian Peninsula has only been documented by a handful of specimens, and in India by a sole specimen sparingly labelled as such. Not much is known about its expansion into Syria, Lebanon and
farther north; occasional sightings could indicate its presence in some of these places.

Pale footed wolves often display characteristics that are closer to pariah dogs than to the grey wolf; cranial capacity is the only studied trait whose development is similar between both types of wolf.

The Israeli population of pale footed wolves seem to be very closely related to the local pariahs; specimens identified as hybrids do not manifest a constant combination of characters and are liable to occupy a variety of locations within a DFA graph.

Samples of pale footed wolves tend to have a high degree of variability, and the presence of individuals showing an abnormal development of some traits is not uncommon. An extreme case of this is exemplified by a specimen collected in Bihar that shows characteristics which are intermediate between the pale footed wolf and the wolf jackal.

The Arabian wolf, although smaller, presents physical some characteristics which are similar to the Israeli pale footed wolf, and discriminates in a totally different region of the DFA diagram from the grey wolf sample. The type specimen of *C. l. arabs* Pocock, although almost for certain a hybrid, is consistent with the range of variation of the Arabian wolf sample in two key characters, and differs a little in a third one. However, the rest of the small sample studied is also very possibly hybrid although not at the same degree than the type specimen. In contrast photographs from captive specimens taken in the UAE reflect a external conformation which in principle appears very genuine and differentiable from the Mediterranean and desert pale footed wolf.

All available evidence seems to indicate that the Arabian wolf populations have been displaced and/or absorbed by the desert pale footed wolves in Israel and in the northern half of the Arabian Peninsula; this type of wolf may be currently surviving only in the driest and more inhospitable areas of southern Arabia where is also becoming hybridized with pariahs.

A wolf-dog hybrid could have been identified in Egypt. There is no more evidence about the presence of pale footed wolves in Africa, and this specimen should be interpreted, at this time, as a vagrant individual that wandered off the Sinai perhaps with human aid.

Wolf populations from the Himalayas and central Asia need to be researched more thoroughly, as their levels of morphological variability could indicate the presence of one or more further species.
CHAPTER V
OTHER WILD CANIS

5.1 Introduction

As described in 2.11, the specific or subspecific name *lupaster* has been used in the past to define a population of medium to large canids currently inhabiting the Nile Valley and perhaps other areas. In this chapter I will try to describe in more detail the morphology of this group, comparing it with other recent canids, and will discuss the problems of its nomenclature.

5.2 The wild *Canis* from the Nile Valley and the Maghreb

5.2.1. Size

A basicranial length distribution from 57 specimens identified in museums as C. *aureus* and collected in North Africa, from Egypt to Morocco, is noticeably bimodal with an anti-mode at around 160 mm (fig. 5.1). A disproportionate number of the skulls (n= 35) measuring over 161.00 mm had the Valley of the Nile, and neighbouring areas, as their region of origin (and most of them, interestingly, were museum-labelled as C. *a. lupaster*). A diagram summarizing grouped average basicranial lengths plotted against latitude and distance from the Nile River shows that the larger specimens tend to occur much closer to the river, or at large oases (fig. 124). The average calculated body weight for this sample (n = 34) from Egypt is 12.52 kg (range= 9.26 – 15.77 kg, stdv= 1.70)
Fig. 5.1. Histogram of the distribution of basicranial lengths in Canis from North Africa. Note antimode in the 155-165 mm region.
<table>
<thead>
<tr>
<th>Latitude</th>
<th>Distance</th>
<th>Basicranial Length (mm)</th>
<th>Sample Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>14.3</td>
<td>160.81</td>
<td>179.24 (N= 1)</td>
<td></td>
</tr>
<tr>
<td>17.4</td>
<td>163.83</td>
<td>176.66 (N= 3)</td>
<td></td>
</tr>
<tr>
<td>22.2</td>
<td>166.42</td>
<td>174.1 (N= 4)</td>
<td></td>
</tr>
<tr>
<td>23.3</td>
<td>176.42</td>
<td>176.42 (N= 9)</td>
<td></td>
</tr>
<tr>
<td>25.5</td>
<td>160.81</td>
<td>179.18 (N= 1)</td>
<td></td>
</tr>
<tr>
<td>27.7</td>
<td>160.81</td>
<td>179.18 (N= 1)</td>
<td></td>
</tr>
<tr>
<td>29.9</td>
<td>160.81</td>
<td>179.18 (N= 1)</td>
<td></td>
</tr>
</tbody>
</table>

Fig. 5.2. This diagram describes the geographic relationship of basicranial length (in mm), in Egyptian wild *Canis*, with latitude on the Y axis and distance to the Nile River (in kilometres) on the X axis. The transverse dark line signifies the Nile.
It is of some interest to examine whether there are significant differences, apart from sheer size as represented by basicranial length, between Canis from the Nile and other populations ascribed to C. aureus. For the moment, I beg the question as to whether this sample exemplifies the large canid that some authors identified as C. lupaster (Hemprich and Ehrenberg 1832, Hilzheimer 1908, Anderson 1902, Flower 1932) or C. l. lupaster (Ferguson 1981), and that has been commonly known in English as the wolf-like jackal (Flower 1932), the Egyptian wolf-jackal (Bate 1937), the Egyptian jackal (Clutton-Brock 1979) and the wolf jackal (Kurten 1965). In principle this group of 35 specimens does seem to have a clearly different identity, obviously dissimilar from grey wolves, pale footed wolves, golden jackals and pariah dogs, as shown by figs. 5.3 and 5.4. For identification purposes the name wolf jackal will be used henceforth when referring to this type of canid.

Fig. 5.3. Multivariate diagram showing the ranges of variation of three taxa of wild canids using 17 cranial variables. The first function accounts for 94.9% of the total variance, the second for 5.1%.
Fig. 5.4. Multivariate diagram showing the ranges of variation of three canid populations using 17 cranial variables. The first function accounts for 90.2% of the total variance, the second for 9.8%.

The original species *C. lupaster* and *C. sacer* of Hemprich and Ehrenberg (1828-1833) were based on three specimens, now at the Zoologisches Museum (Museum für Naturkunde), Berlin. One (ZMB 834) is labelled as the type of *Canis lupaster*; a second specimen (ZMB 833) is similarly labelled, but has the word "sacer" written on the skull and was regarded as different from *lupaster* and listed as *C. sacer* by Hilzheimer (1908); the third specimen, a very young individual (ZMB 835), is labelled as the type of *Canis sacer*. In any case the basal length of ZMB 834 is only 150.7 mm, and I calculated its body weight as 7.63 kg, which places it well outside the range for the Nile Valley canids; and multivariate analysis clearly associates it with the golden jackal cluster, while ZMB 833 in the Discriminant Analysis is on the border between the Nile Valley group and *Canis aureus* (fig. 5.5) and has a calculated body weight of 9.96 kg. The cranium of ZMB 834 has a poorly developed sagittal crest and a very small occipital process, the frontal region is quite straight, zygomatic arches are thick, the palate is broad and auditory bullae are well inflated; the horizontal ramus is thin and straight with a large angular process, the ascending ramus is also rather straight presenting a slightly curved coronoid apex;
teeth are well spaced in the upper jaw and slightly more compacted in the lower one, the upper molars present well developed cingula and the lower carnassial displays a large metaconid (figs. 5.6 and 5.7). The pelage of ZMB 834 is dominated by yellowish-brown and sable tones, with a band of dark hair, mixed with yellowish brown, starting at the nape and expanding over the shoulders, and widening considerably on the flanks and the hindquarters. In the mid-section of this region there is a conspicuous band of rufous hair. Front legs and lower half of the hind legs are yellowish-brown. Chest and abdomen are covered by pale brown and grey hair.

Fig. 5.5. Diagram showing the statistical position of the two type specimens of *C. lupaster* (T1: ZMB 833 and T2: ZMB 834) compared with other wild canids, using 19 cranial variables. The first function accounts for 92.5 % of the total variance, the second for 7.5%.
Hilzheimer (1908) described *Canis doederleini* as a further new species from Egypt; the type skull of which (Zoologische Sammlung zu Strassburg 1837, currently Strasbourg Zoological Museum 1123) has a basal length of 192.8 mm and a calculated body weight of 17.48 kg; DFA shows an obvious association between this specimen and the canid group from the Nile Valley (figs. 5.8 and 5.9). The available data therefore indicate that *Canis doederleini* Hilzheimer, 1908, is the correct name for the population of large canids from the Nile Valley, despite this customarily being described as *C. lupaster* (Anderson 1902, Flower 1932), *C. l. lupaster* (Ferguson 1981) or *C. a. lupaster* (Osborn and Helmy 1980). Pending the taxonomic revisions (below), I will refer to the Nile Valley wild *Canis* simply as the wolf jackal (Kurten 1965), a name that seems to summarize well some of its most remarkable characteristics as detailed below. Four Egyptian canid specimens identified by Hilzheimer (1908) as *C. sacer* could be also best fitted within this taxon, as their basal lengths, as taken from Hilzheimer’s text (1908), exceeded 162.9 mm; this author (Hilzheimer 1908) consistently underestimated this measurement as described by von den Driesch (1976) and therefore, in any case, his specimens would be larger than he quoted (Hilzheimer 1908).
Fig. 5.8. Multivariate diagram showing the statistical position of the type specimen of *C. doederleini* (Strasbourg Zoological Museum 1123) compared with other canids, using 17 cranial variables. The first function accounts for 64.4% of the total variance, the second for 35.6%.
Egyptian pariahs (recent and archaeological) and archaeological)

Egyptian wolf jackals

Golden jackals from Asia and Africa

C. doederleini (type)

Group Centroid

Fig. 5.9. Multivariate diagram showing the statistical position of the type specimen of *C. doederleini* (Strasbourg Zoological Museum 1123) compared with other canids, using 17 cranial variables. The first function accounts for 67.3% of the total variance, the second for 32.7%.

Other specimens from Egypt housed at the Field Museum (FMNH 98921, FMNH 140121, FMNH 89966, FMNH 140122, FMNH 107226, FMNH 107224, FMNH 107225), that were initially identified as *C. a. lupaster*, and which basicranial length was under the 160 mm threshold value, or slightly over it, could not be clearly identified as wolf jackals (fig. 5.10) and ought to be identified as golden jackals. The larger specimens (FMNH 98921, FMNH 107226, FMNH 89966) could be hybrids. Localities where these canids are present seem to be spread all through the interior of the country, usually well away from the Nile.
Fig. 5.10. Multivariate diagram showing the statistical position of some Egyptian canids of uncertain identity (red asterisks), related to the range of variation of three populations of wild canids, using 17 cranial variables. The first function accounts for 87.4% of the total variance, the second for 12.67%.

List of Egyptian canids in the FMNH
A: 107224. Siwa Oasis. Basicranial length= 136.17 mm
B: 107225. Siwa Oasis. Basicranial length= 139.64 mm
C: 140121. Bir Shaqqa. Basicranial length= 142.64 mm
D: 98921. Bahig (south of Alam Shaltut). Basicranial length= 160.47 mm
E: 107226. El Gezira (southeast of Kharga Oasis). Basicranial length= 160.81 mm
F: 140122. El Afretat (southwest of El Hammam). Basicranial length= 155.93 mm
G: 89966. Abu Rawash (Imbada). Basicranial length= 158.01 mm

5.2.3. Bivariate analyses

I will next explore the identity of the wolf jackal through a series of bivariate plots against the distance from basion to hormion of variables previously used by Jolicoeur (1959), Harrison (1968), Harcourt (1974), Ferguson (1981), Hemmer
Wolves have been claimed as having broader interorbital constrictions than golden jackals (Harrison 1968); although Ferguson (1981) found that some specimens of golden jackal could have interorbital constrictions as broad as those of wolves, and claimed that the wolf jackal is similar in this feature to pale footed wolves (Ferguson 1981). A bivariate graph (fig. 5.11) illustrates that in general wolves do display a broader interorbital region, but also that there is a wide degree of individual variation which almost overpowers any difference between taxa. The wolf-jackal seems to occupy an intermediate position between wolves and golden jackals.

5.11. Graph of forehead width against basion-hormion length in populations of wild canids.
Miller (1912) defined the auditory bulla of the golden jackal as slightly more voluminous than that of the wolf; Harrison (1968) reinforced this, finding that the bulla of the pale footed wolf was distinctly smaller than that of the golden jackal. Fig. 5.12 shows that although the golden jackal has the largest bulla on average, and that the wolf jackal has on average larger bullae than desert wolves, differences among the three groups are minimal and that again individual variation in the expression of this trait is a factor to take into consideration.

![Graph of auditory bulla size against basion-hormion length in populations of wild canids.](image)

Fig. 5.12. Graph of auditory bulla size against basion-hormion length in populations of wild canids.
The relevance of studying the size of the brain, when analyzing evolutionary sequences, has been pointed out by a number of authors, and it has been argued, in accordance with domestication theory, than wild forms have larger brains than domestic ones (Groves 1989, Hemmer 1990). Little information is yet available for different species of wild canines in regard to this trait. Fig. 5.13 shows that in effect wolves very often have rather large cranial capacities, and that golden jackals and wolf jackals often display rather small ones.

Fig. 5.13. Graph of brain size against basion-hormion length in populations of wild canids.
The mandibular ramus of the golden jackal was described by Harrison (1968) as rather thin; on the contrary Scott and Fuller (1965) support the idea that grey wolves usually display quite robust mandibles (fig. 5.14). There is in fact a high degree of variability, although the wolf jackal is closer to the pale footed wolf than to the golden jackal in the development of this particular trait.

**Fig. 5.14.** Graph of mandibular thickness against basion-hormion length in populations of wild canids.
Heller (1914) highlighted the small teeth size of jackals (which he referred to the genus *Thous*); conversely Harrison (1968) commented on the robustness of the lower carnassial of the golden jackal. While again there is great variability, the golden jackal appears actually to have on average smaller carnassials than the wolf jackal (fig. 5.15). In accordance again with Heller's statement, the upper canine appears to be thinner in the golden jackal than in pale footed wolves and wolf jackals (fig. 5.16).

Fig. 5.15. Graph of lower carnassial length against basion-hormion length in populations of wild canids.
5.2.4. Other analyses

To complement the previous analyses I plotted log average values for the standard traits, studied in other canids, in a log ratio diagram (Simpson 1941, Clutton-Brock and Kitchener 2000) in which wolf jackal measurement values are used as standard (fig. 5.17). The wolf jackal yields intermediate morphometric values between the golden jackal and the pale footed wolf for all the traits.

Fig. 5.16. Graph of upper canine width against basion-hormion length in populations of wild canids.
Some qualitative dental traits like the presence of a well developed cingulum on UM1 or the existence of a large metaconid on LM1 have often been quoted as a characteristic of the golden jackal, distinguishing them from wolves and dogs (Harrison 1968, Davis and Valla 1978; Ferguson 1981). I attempted to quantify these characters using a methodology previously adopted by Macintosh (Barker and Macintosh 1979). The development of LM1 metaconid was scored from 0 to three (0 signifies an absent metaconid and 3 a rather large one); the average values are given in the table. The M1 cingulum is described as complete (c), almost complete (ac) or incomplete (inc), and the frequency of each category is expressed as a percentage of the total for every group. The final results as shown in table 5.1 indicate that there is a clear gradient however from the golden jackal via the wolf-jackal to the desert pale footed wolf in the metaconid, while in the cingulum the wolf-jackal is much more like the golden jackal.
### Table 5.1. Development of the first lower molar metaconid and of the first upper molar cingulum in populations of wild canids.

<table>
<thead>
<tr>
<th>Species</th>
<th>metaconid</th>
<th>cingulum (c)</th>
<th>cingulum (ac)</th>
<th>cingulum (inc)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Golden jackal</td>
<td>av= 2.56</td>
<td>93.33%</td>
<td>Nil</td>
<td>6.66%</td>
</tr>
<tr>
<td>Wolf jackal</td>
<td>av= 2.20</td>
<td>92%</td>
<td>4%</td>
<td>4%</td>
</tr>
<tr>
<td>Desert pale footed wolf</td>
<td>av= 1.86</td>
<td>34.61%</td>
<td>30.76%</td>
<td>34.61%</td>
</tr>
</tbody>
</table>

**Sample sizes for the cingulum**
- Golden jackal n= 30
- Wolf jackal n= 25
- Desert pale n= 26

#### 5.2.5. Wolf jackals elsewhere

Three skulls at the Harrison Institute (HZM 14.9599, 11.9114, 139598) from less arid localities in the Arabian Peninsula (Wadi Khumra and the Dhofar region) fitted perfectly within the wolf jackal cluster (fig. 5.18). Another two specimens (BM 951081, BM 48367) from Aden and Buraida are intermediate between wolf jackals and either the pale footed wolf or the Arabian wolf (fig. 5.19). All these five specimens are larger than Egyptian wolf jackals; the basal length of the specimens from the Harrison Institute averaged 190.74 mm (range= 188.9 – 193.72 mm, stdev= 2.60), and the calculated body weight of one specimen (11.9114) reached 12.62 kg. The two intermediates (BM 951081, BM 48367) are 179.53 mm and 180.14 mm in basal length and 12.99 kg and 14.95 kg in calculated body weight.
Fig. 5.18. Multivariate diagram showing the statistical position of three Arabian Canis initially identified as wolves (red asterisks) relative to the ranges of variation of other wild canids, using 17 cranial variables. The first function accounts for 87.4% of the total variance, the second for 12.67%.

List of Arabian Canis in the Harrison Institute
A: 11.9114. Dhofar (Oman). Basicranial length = 188.90 mm
B: 139598. Wadi Khumra (Saudi Arabia). Basicranial length = 189.6 mm
C: 14.9599. Wadi Khumra (Saudi Arabia). Basicranial length = 193.72 mm

One of the specimens studied by Anderson (1902) (BM 461030, from Tunis) has a basal length of 161.41 mm and a relatively high calculated body weight (10.24 kg); in a DFA diagram (fig. 5.19) it seems to show a greater affinity with the golden jackal cluster. A skull from Ras el Ain (BM 98747), in the vicinity of Casablanca (Morocco), with a basal length of 161.41 mm and a calculated body weight of 9.36 kg, is intermediate between both clusters; Kowalski and Rzebik-Kowalska (1991) referred to two specimens from Es Senia and Oran (Algeria) with condylobasal lengths of 167.0 and 165.5 mm respectively. A smallish, very dog like specimen (USNM 476034), collected in Missour, near Fez (Morocco), had a basicranial length of 153.41 mm and a calculated body weight of 7.08 kg, it also has a large...
metaconid in the lower first molar (score 3) and a complete cingulum in the upper first molar (fig); Epstein (1971) reports the presence of small sized domestic dogs in the Atlas Mountains.

Fig 5.19. Multivariate diagram showing the statistical position of five specimens of questionable affinity (red asterisks) relative to the ranges of variation of three populations of wild canids, using 17 cranial variables. The first function accounts for 86.8% of the total variance, the second for 13.2%.

List of specimens of dubious identity from the Maghreb and Arabia
A: USNM 476034, Missour (Morocco)
B: BMNH 461030, Tunis
C: BMNH 98747, Ras el Ain (Morocco)
D: BMNH 951081, Aden (Yemen)
E: BMNH 48367, Buraida (Arabia)
5.2.6. Dog hybrids

The existence of wolf jackal-dog hybrids could have been documented in Egypt (fig. 5.20). These two specimens (from Al Qalyubiya, Egypt: USNM 321958, FMNH 140124) have relatively high calculated body weight values: 15.77 and 12.55 kg respectively. Specimen USNM 321958 (fig. 5.21) has a medium size LM1 metaconid (score 2) and an incomplete UM1 cingulum, the auditory bullae are relatively small, the posterior border of the palate surpasses M2, and the upper region of the neurocranium is slightly depressed like in a dingo; it has however some clear wolf jackal characteristics such as a relatively straight rostral region, well developed sagittal and occipital crest and a characteristically shaped angular process. FMNH 140124 has outstanding dog characteristics, its only detectable wolf jackal traits being the inflated auditory bullae and a very straight ascending ramus.

Fig. 5.20. Multivariate diagram showing the statistical position of two possible wolf jackal – pariah hybrids from Al Qalyubiya, Egypt (A: FMNH 140124 and B: USNM 321958) compared with other canids, using 17 cranial variables. The first function accounts for 65.3% of the total variance, the second for 34.7%.
5.2.7. External conformation and molecular data

Anderson (1902) published in his Zoology of Egypt (vol. 2: Mammalia), a detailed drawing of what he called Canis lupaster (plate XXX) based on a captive individual kept by the Zoological Society of London. The portrayed specimen has relatively short and strong legs, a well developed rib cage, short and wide ears, a bushy and pendant tail and dished face, and displays a conspicuous white spot on the throat region. This image is strikingly consistent with a photograph taken by Lajos Nemeth-Boka 20 km north of Aswan in 2007, which seems to correspond to the same type of canid (fig 5.22).

Rueness et al. (2011) proposed to change the taxonomic status of Canis aureus lupaster to that of a grey wolf. Their proposal was supported by mitochondrial DNA, from Central Ethiopia, sampled from scats "representing at least five individuals" and from one tissue sample; they also studied documented Egyptian data from another seven individuals. The external morphology of the specimens they sampled was described as "more slender" than a golden jackal. A published photograph (Tiwari and Sillero-Zubiri 2004), said to exemplify the type of animal they studied, shows a canid that has very large ears, long legs, and a very slender rib cage, and which is very different from those documented by Anderson (1902) and Nemeth-Boka (see above).

It must be concluded then that the taxon studied by Rueness et al. (2011) is not the same as the one described by Anderson (1902) and was later on documented by Nemeth-Boka (2007). Evidently, there are two different taxa of wild Canis in this general area, but before allocating scientific names to them it is necessary to return...
to the original descriptions of *Canis lupaster* and other taxa described from the region, and to the type material.

Fig. 5.22. Wild canid photographed 20 km North of Assuan in 2007. Photo courtesy Lajos Nemeth-Boka.

5.3. Summary

The cranium of the wolf jackal (figs. 5.23, 5.24) can be described as moderately gracile, the rostrum is relatively short and the facial region is slightly dished, the cranial dorsal outline presents a descending contour towards the foramen magnum, sagittal crest and occipital process are well developed, zygomatic arches are rather thick; the palatal region is not excessively broad and the tympanic bullae are very well developed; mandibles are as strongly built as in the pale footed wolf, dentition is strong, UM1 and UM2 nearly always have well developed cingula, LM1 usually presents a large metaconid (fig. 5.25); brain size is smaller than in the pale footed wolf.

Metrical analysis indicates that *lupaster* is not the correct name for the "wolf jackal" of the Nile Valley. It is very difficult to distinguish this form from either wolves or jackals, but multivariate analysis does it well; the wolf jackal is distinct from both the golden jackal and the pale-footed wolf. Its known geographic distribution covers the Nile Valley and some Arabian localities, but its presence in the Maghreb needs to be investigated more thoroughly. The name *Canis lupaster* Hemprich and Ehrenberg commonly used for it actually denotes an Egyptian golden jackal, as does *Canis sacer* Hemprich and Ehrenberg; both cranial and external
characteristics agree on this. The prior available name appears to be *Canis doederleini* Hilzheimer.

Fig. 5.23. Wolf jackal cranium (FMNH 105807) from Aswan (Egypt). Lateral view.

Fig. 5.24. Same specimen. Basal view.

Fig. 5.25. Hemimandible of the same specimen.
CHAPTER VI
PALAEONTOLOGICAL AND ARCHAEOLOGICAL REMAINS

6.1. Bibliographical introduction

Garrod and Bate (1937) described seven specimens which they ascribed to *C. lupaster*, which they called the "wolf jackal", from the Upper Acheulean (level Ea) and from the Lower Levalloiso-Mousterian layers (levels D and C) of Tabun. Their criterion to discriminate *C. lupaster* from *C. lupus* was the presence of a complete cingulum on the first upper molar of *C. lupaster*, and on the size of the upper carnassial which they described as being in *C. lupaster* shorter than the combined length of both upper premolars, while in *C. lupus* the length of the upper carnassial was supposed to exceed the length of both premolars together. They concluded that the body size of the fossil specimens was superior to the recent wolf jackal.

Kurten (1965) studied specimens attributed to *C. lupaster* from some Palestine caves (Shukbah, Zuttiyeh and Tabun), and indicated that the species seemed to have changed very little since the Eemian or Early Wurm, and that the size difference between recent and archaeological specimens was minimal.

Haas (1966) commented on the finding of some bone fragments and teeth at Ubeidiya (Lower Pleistocene, central Jordan Valley), ascribable to some type of *Canis*. The results of his research were quite inconclusive, as the body size suggested by most of the remains was intermediate between what he called *C. a. lupaster* and recent Israeli pale footed wolves; he speculated on the possibility of a still unknown species of *Canis* being represented in the assemblage.

Garrod and Bate (1937) classified a Natufian cranium of *Canis* found at Wadi el-Mughara, in the Mount Carmel region, as *Canis familiaris cf. matris optimae*; this name was originally given by Jeitteles (1877) to a Bronze Age specimen from North Germany (Epstein 1971), so Garrod and Bate (1937) were in effect saying that the origin of this form can be taken back to the Epipalaeolithic of the Middle East. They based this decision on some of the non-wolf-like characteristics of this specimen, namely the width of the palatal region and the small size of the dentition. In their analysis, they defended the argument that the specimen presented a very peculiar configuration that may perhaps indicate a transitional nature between the domestic dog and some kind of wild ancestor. Degerbøl (1961) concluded that their specimen represents "probably a prehistoric large jackal" unlikely to be domesticated; its large size inspired him to associate it with what he called *Canis aureus doederleini* Hilzheimer. Kurten (1965) studied the same specimen, as well as others of similar geographic origin and chronology such as a skull fragment from Kebarah (Natufian), a mandibular fragment from Shukbah (Natufian), an assortment of fragments of maxillae and mandibles from Ksar ‘Akil (Palaeolithic), and a LM1 from Tabun (Mousterian); he categorized all of them as wild wolf remains, and interpreted the differing sizes as a direct consequence of a dwarfing process that hypothetically took place at the end of the Wurm glacial period, and which affected several different species (Kurten 1965). Davis (1981) partly agreed with Kurten.
but also described a subsequent process of size diminution, directly related to domestication, that affected several species, the wolf among others.

Clutton-Brock (1962) restricted her analysis to materials from the Natufian. She studied the el Wad specimen, and incorporated into her sample another four of similar provenance and chronology: a skull fragment from Kebarah, a mandibular fragment from Zuttiyeh, and two mandibular fragments from Shukbah. Initially, she supported the idea of the specimens being closer to the smaller types of Asiatic wolves than to any domestic dog, although she also made the comment that the two skull fragments presented rather wide palates, which she considered a trait commonly associated with domesticity. Later on, she re-identified them as remains of “at least tamed wolves” (Clutton-Brock 1995).

Davis and Valla (1978) used data from two specimens, from Ein Mallaha and Hayonim Terrace, in their paper about prehistoric domestic dogs of the Middle East. Both individuals were described as authentic dogs, and not as wolves or jackals, due to the relatively small size of their carnassials and their scarcely developed metaconids. Dayan (1994) included all these specimens of Natufian origin in her work; she described the whole sample as of probable dog origin and characterized them by their small teeth and short rostra.

Following the discovery of two more specimens at Hayonim Terrace, Tchernov and Valla (1997) discussed the new materials plus those from el-Wad, Kebara and Shukbah. They concluded that the samples represented a type of dog of medium body size, from 11 to 16.7 kg, and agreed with Dayan (1994) that they also had relatively short snouts and smaller teeth. It had long been a widespread point of view that a noticeable reduction of the length of the rostrum occurred during the transition from the wild ancestor to the domestic state (Clutton-Brock 1962, Olsen 1985, Benecke 1987, Tchernov and Valla 1997), and the process of muzzle shortening was analyzed in some detail by Tchernov and Valla (1997); they proposed that the anterior region of the muzzle must experience the highest degree of contraction, in the whole face of the animal, should muzzle shortening effectively occur.

This thoroughly researched characteristic (Degerbol 1961, Lawrence 1967, Turnbull and Reed 1974, Davis and Valla 1978, Tchernov and Valla 1997) generated a school of thought that suggested that domestic dogs always will have noticeably more crowded teeth series than their wild counterparts (Degerbol 1961, Lawrence 1967, Turnbull and Reed 1974), although Davis and Valla (1978) found that in some cases domestic dogs and near eastern wolves could yield very similar values for the mandibular index of overlap (crown length of LM1 / alveolar length from LPM4 to LM1) and, later, Tchernov and Valla (1997) came to a similar conclusion during their comprehensive study of Natufian dogs.

Turnbull and Reed (1974) published a detailed description of a mandibular fragment found in Palegawra cave, describing it as that of a domestic dog; they based their identification on its size (LM1= 21.9), since they found that the specimen is much smaller that the type of wolf that currently inhabits the Zagros Mountains, and also on a log ratio diagram that suggested more affinities with the
dingo (n= 2) than with a Kurdish dog, with Jarmo dogs (n= 14) or with wolves from the Zagros (n= 5). This proposal was supported by Lawrence (in Turnbull and Reed 1974), Uerpmann (1982), Davis (1987) and Clutton-Brock (1995).

Olsen (1985) challenged the dominant point of view and contended that the Palegawra specimen had some wolf traits, as well as dog ones, and that as a result it could be an aberrant case. On methodological grounds the specimen was dated as Zarzian (circa 14,000 BP) by Turnbull and Reed (1974), who however expressed some concerns in regard to the integrity of the layer where the specimen was found. Uerpmann (1982) confirmed this impression, and also established that the specimen was found closer to the surface than a sample of domestic goats at the same site, and that in consequence it could not be dated as older than 8,500 BP.

Rabinovich (1998) reported on some new Natufian materials from el Wad, a mandibular fragment and some postcranial elements. Her analysis suggested that while the length of the carnassial of this specimen should be considered within the wolf range (25.98 mm), the size of the bones pointed towards a dog identity, and she proposed, using arguments previously published by Tchernov and Valla (1997), that the remains could probably be described as those of a Natufian dog, which nonetheless were notorious for presenting mixed wolf–dog characteristics (Rabinovich 1998).

Large canid remains from the Neolithic sites of the Middle East are notoriously difficult to identify because of the fragmented nature of the majority of the samples, and the obvious morphological similarity between the small wolf varieties and dogs (Lawrence 1967, Hole et al 1969, Bokonyi 1977, Clutton-Brock 1979, Lawrence 1980, Lawrence and Reed 1983). Despite all difficulties, Bokonyi (1977) claimed the presence of wolves, or wolf-dog hybrids, in the Ceramic Neolithic sites (7,000 BC) of Asiab, Sarab and Siahbid, although no particulars concerning the size of the sample, or its morphometrics, were provided.

6.2. The Kanhiapan wolf

Several decades ago the Geological Survey of India unearthed a fairly complete wolf cranium at Kanhiapan (fig. 6.2), in the Narmada valley (central India); it was broadly dated as late Pleistocene, on account of its geological context. Judging by its appearance there would not be any doubt that this is a genuine wolf on account of its considerable size (total length= 249.39 mm), degree of robusticity and a dentition that is well developed (upper carnassial length= 23.89), and spaced (maxillar crowding index= 0.81). It presents also a pronounced occipital process, a depressed neurocranial dorsal outline, a rather straight, and long, rostral region, and a relatively wide palate. Morphometrically, it occupies a space which is intermediate between the samples of Indian pale footed wolf and Asian Canis lupus in a DFA diagram (fig. 6.1).
Fig. 6.1. Multivariate diagram showing the statistical position of the Kanhiapan wolf (blue asterisk) relative to the ranges of variation of three populations of wild canids, using 15 cranial variables. The first function accounts for 87.3% of the total variance, the second for 12.7%.

Fig. 6.2. The Kanhiapan wolf (Geological Survey of India, Nagpur).
6.3. Archaeological remains of "wolf jackal"

My work with Tabun materials (three from D level and one from D-E levels), at the British Museum, yielded data on the lengths of three upper carnassials (range=21.10-20.54, av.=20.67) and two lower carnassials (range=22.39-20.08, av.=21.23 mm), that were attributed to "wolf jackals"; Garrod and Bate (1937) had provided lengths for two upper carnassials (range=21.9-21.2, av.=21.50 mm) and one lower carnassial (20.2 mm) from Tabun. When compared with a sample of 35 recent specimens from Egypt, the upper value (21.9 mm) for upper carnassial length in the fossil sample was surpassed by 6 individuals of the recent sample (average=19.66 mm, range=22.14-17.17, stdv=1.28), and the longest lower fossil carnassial (22.39 mm, this research, specimen M16096, Tabun, level D), by another 7 in the recent sample (average=21.34 mm, range=25.24-19.02, stdv=1.41). In view of this, it would be extremely difficult to conclude that the wolf jackal variety that inhabited the Levant at the time was larger than the contemporary form as maintained by Garrod and Bate. A total of four specimens from the Late Pleistocene (three of them dated as Aurignacian: 34,000 - 23,000 BP) of the Constantine Department in Algeria provided higher values than those quoted above: one upper carnassial measured 22.67 mm and a lower carnassial for a different, and fairly young, specimen, was 23.09 mm long; these figures would be, in any case, within the upper part of the range for this taxon as it is today (see chapter V). Another individual returned a calculated body weight of 10.92 kg. Two of these specimens, both adults, have the added interest of showing a high degree of teeth overlapping, though unfortunately it was only possible to calculate one maxillary crowding index, 0.90, a remarkably high value. A hemimandible (BMNH, no catalogue number) from the Bronze Age of Tell Duweir, a site located 20 k south of Jerusalem, had a very well developed metaconid (score 3), rather crowded teeth (overlapping index=0.69) and yielded a calculated body weight of 11.11 kg; all these characteristics, with the exception of the high overlapping index, seem to suggest that a typical specimen of wolf jackal is represented. An archaeological, but undated, specimen (BMNH 1911.8.14.21), which is a part of the Petrie collection, was found in Hawara associated with a large series of pariah dogs; DFA unmistakably indicates that it is a wolf jackal (fig. 6.3), a diagnosis also reinforced by the length of the upper carnassial (18.48 mm) and by its cranial capacity index (1.46).
Remains of this species, or of some kind of closely related protodog, have also been found in Sarab and Duhail (see corresponding sections).
6.4. Pre-Neolithic Dogs and protodogs - the Levant sample

6.4.1. Introduction

The term “protodog” has been used in the past to describe primitive Canis showing mixed morphological characteristics, somewhat intermediate between wild and domestic forms; materials related to this category are usually found in the transitional stages from the late Palaeolithic to the early Neolithic. Most of the specimens covered in this study were from Natufian sites. The finding of a single clear cut character that allows a definitive separation between wild and domestic forms has been for a long time an issue of interest, but has been proved often an almost futile effort.

Davis and Valla (1978) studied three Natufian specimens from Ein Mallaha and Hayonim terrace; their work revealed the limitations of this type of approach, as they established that crown length of the lower carnassial is expected to be within the range of 26-28 mm for the type of grey wolf population that inhabited the Levant during stadial periods and that, they hypothesized, would have lived in the area during the Natufian, as opposed to 19-23 mm for dogs, the wolf jackal, and the pale footed wolf; consequently, this trait alone was not reliable enough to identify specimens in the region during the Natufian period. As table 6.1 shows, my own data, collected from recent wolves, pariah dogs and wolf jackals, clearly reinforce Davis and Valla’s assertions, since overlapping in the length of the lower carnassials is a real possibility.

<table>
<thead>
<tr>
<th>Taxa</th>
<th>Mean</th>
<th>Max</th>
<th>Min</th>
<th>STDEV</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inner ME pariahs</td>
<td>20.73</td>
<td>22.48</td>
<td>18.31</td>
<td>1.19</td>
<td>18</td>
</tr>
<tr>
<td>Indian pale footed wolves</td>
<td>24.55</td>
<td>27.03</td>
<td>22.75</td>
<td>1.39</td>
<td>13</td>
</tr>
<tr>
<td>Asian grey wolves</td>
<td>26.51</td>
<td>29.4</td>
<td>23.09</td>
<td>1.69</td>
<td>15</td>
</tr>
<tr>
<td>Egyptian wolf jackals</td>
<td>21.34</td>
<td>25.24</td>
<td>19.02</td>
<td>1.41</td>
<td>35</td>
</tr>
</tbody>
</table>

Table 6.1. Lower carnassial length (in mm) in four different taxa of wild and domestic canids. Note overlapping among groups.

A second significant characteristic, the presence of a well developed metaconid on the lower carnassial, was also quoted by Davis and Valla (1978) as a characteristic to differentiate the wolf jackal from dogs and wolves. To evaluate this trait among different taxa, I developed an arbitrary score system (from 0 to 3), which is based on recent specimens of known identity (see chapter I). This analysis demonstrated that wolf jackal metaconids will usually score from 2 to 3, while wolves and dogs, in general, will attain values from 1 to 2 (table 6.2). It is evident, again, that an assessment of the metaconid on its own, may not always be enough to provide a foolproof method for species identification, as the lowest scores have the potential to overlap across taxa.
Table 6.2. Development of the lower carnassial metaconid in four different taxa of wild and domestic canids. The size of the metaconid is subjectively scored from 0 (absent) to 3 (very large).

Table 6.3. Overlapping index (Davis and Valla 1978) in three different taxa of wild and domestic canids. For a description of the index see appendix III.

Mandibular teeth overlapping has also been quoted as a procedure to separate wild from non-wild *Canis*, as it is usually assumed that dogs will experience a shortening of the face along their evolutionary process (Davis and Valla 1978, Tchernov and Valla 1997). An index measuring the expression of this character (see appendix III) was developed by Davis and Valla. Here again they found too many exceptions to this rule. My own work also supports their doubts, as values for this index, calculated from a sample of three Natufian protodogs from Hayonim Terrace, Ein Mallaha and Shukbah, can be described, following their terminology, as having only some degree of teeth crowding (overlapping index mean = 0.66, range = 0.65-0.66, stdv = 0.005), while a sample of 28 recent Mediterranean pale footed wolves shows a wider range of variability, including some relatively high values; in fact its range of variability comprises also that of the Natufian protodog sample (table 6.3). The same considerations apply to a sample of Asian grey wolves. A sample of 17 pariah dogs from the Inner Middle East exhibits the highest values of teeth overlapping, but still overlaps the other three groups for some values. Taking all the above into consideration, it can be concluded that there is no total certainty that complete discrimination between wild and domestic forms can be achieved by the analysis of teeth overlapping only.

A crowding index for maxillary teeth, based on a similar one published by Degerbøl (1961), was developed specifically for this research (see appendix III); it returned a low value (0.87) for the el Wad cranium described by Bate (in Garrod and Bate 1937), while the one from Kebara cave reached a higher figure (0.95). If we compare again these figures with samples of Indian pale footed wolves and Inner Middle Eastern pariahs, it is easy to see that both archaeological specimens fit quite well, respectively, within the lower and middle ranges of the recent samples (table 6.4), as there is not a definite separation in this trait between Indian pale footed wolves and the Middle Eastern pariah dogs.
Tchernov and Valla (1997), using data based on the correlation between body weight and lower carnassial length in recent Levantine wolves, estimated the weight of the Natufian dogs within a range from 11 to 16.7 kg. These values are consistent with my own estimates, based on the Wing (1978) and Hamblin (1984) equations, for two individuals from Shukbah and Zuttiyeh, which weigh 14.49 and 16.79 kg respectively. Then again the calculated body weights of the specimens in question could fit within the weight span of any of the three forms covered (Mediterranean pale footed wolf, Israeli pariahs and Inner Middle East pariahs) in table 6.5, regardless of their wild or domestic origin.

It appears then that a single trait would not be sufficient to separate the small wolf species from dogs. To allow myself the opportunity of examining the physical characteristics of some of the available prehistoric materials more thoroughly, I undertook a series of discriminant function analyses, as well as univariate analyses, complemented with visual evaluations of particular characters (see below). Study specimens were matched against samples of extant Canis populations of Levantine and North African origin, and comparisons conducted whenever possible on a specimen by specimen basis.
This hemimandibular specimen BMNH KC has a large carnassial (23.23 mm), a clearly recurved coronoid apex, and a moderately sized angular process; its calculated body weight reached a value of 14.5 kg and its overlapping index was high (0.68); the lower carnassial metaconid scored an intermediate value (2). The specimen clearly falls within the pariah range in a DFA diagram (fig. 6.4), and shows also some affinity with the pale footed wolf sample in a log ratio diagram (fig. 6.5).

![Multivariate diagram showing the statistical position of a specimen from Kebara C (BMNH KC) relative to the ranges of variation of three populations of canids, using five mandibular variables. The first function accounts for 84.3% of the total variance, the second for 15.7%.

Fig. 6.4. Multivariate diagram showing the statistical position of a specimen from Kebara C (BMNH KC) relative to the ranges of variation of three populations of canids, using five mandibular variables. The first function accounts for 84.3% of the total variance, the second for 15.7%.
Fig. 6.5. Log ratio diagram of the measurements of seven mandibular traits of a specimen from Kebara C (BMNH KC) compared with other canid samples. Golden jackal data are used as standard value.

6.4.3. El Wad (Level B, 11 - 11,500 BP)

This specimen (BMNH M16251; figs. 6.6, 6.7) could be perhaps considered the pivotal specimen of all the Natufian materials, presenting as it does a unique array of modern and primitive physical attributes (Rabinovich 1998). The first striking characteristic of this cranium is a general “domesticiness”: the palate is quite broad and the teeth are small enough for a domestic dog of medium size (UPM4 = 20.64 mm). Counterbalancing the presence of modern traits is the forehead which appears very flat, almost as levelled as in many wolf jackals; specially, there is no sign of inflation in the frontal region. The zygomatic arch appears as wide as in a Middle Eastern wolf of a similar size. Its teeth crowding index is not particularly high (0.87), and could be considered intermediate between that of the Kanhiapan wolf (0.81) and one extreme specimen of the Alaskan short-face wolf sample (1.04; AMNH 30431). Morphometrically, the specimen associates with the Israeli pariahs, although it is placed at the edge of the cluster, in a region where individuals with some wolf characteristics occur (fig. 6.8); conversely it does not show any obvious affinity with wolf jackals, and its affinity substantially shifts if pariahs and wolf jackals are withdrawn from the graph and replaced by dingoes and Asian grey
wolves, when it occupies an intermediate region between the Mediterranean wolves and the dingo sample while at the same time it does not resemble the sample of Asian grey wolves (fig. 6.9). Its identity is then clearly connected to both primitive dogs and pale footed wolves.

Fig. 6.6. El Wad (Level B) specimen (BMNH M16251). Lateral view. See text.

Fig. 6.7. Same specimen. Basal view. See text.
Fig. 6.8. Multivariate diagram showing the statistical position of a specimen from el Wad (BMNH M16251) relative to the ranges of variation of three populations of canids, using 12 cranial variables. The first function accounts for 61.9% of the total variance, the second for 38.1%.
Fig. 6.9. Multivariate diagram showing the statistical position of a specimen from el Wad (BMNH M16251) relative to the ranges of variation of three populations of canids, using 12 cranial variables. The first function accounts for 97.5% of the total variance, the second for 2.5%.

6.4.4. El Wad (Natufian)

The el Wad site has also yielded an intriguing hemimandibular fragment (Rabinovich 1998; fig. 6.10) with a carnassial length of 25.66 mm, a mandibular height of 24.44 mm, and a calculated body weight of 16.88 kg (Hebrew University, no catalogue number). While carnassial length seems to be excessively large for a dog and could fit within the range proposed for Israeli wolves (table 6.1), body weight value could be accommodated either in the wolf or in the dog group. The angular process, however, is unexpectedly small, and could only be compared to a dog.
6.4.5. Kebara B (Lower Natufian 12,000 BP)

This incomplete cranium (British Museum, no catalogue number), representing only the facial region, displays also a wide palate and a relatively high teeth crowding index (0.95), indicating a face shortening process (Olsen 1985, Tchernov and Valla 1997). The length of the carnassial (20.24 mm) is within the range expected for a domestic dog or a smaller wolf; its UM1 cingulum is incomplete, which would also distance it in principle from a wolf jackal. Morphometrically, however, the specimen shows clear affinity with the wolf jackal sample although it occupies a space towards the edge of the cluster, fairly close to some specimens of Israeli pariahs (fig. 6.11).
Fig. 6.11. Multivariate diagram showing the statistical position of a specimen from Kebara B (British Museum, no catalogue number) relative to the ranges of variation of three populations of canids, using 12 cranial variables. The first function accounts for 58.5% of the total variance, the second for 41.5%.

6.4.6. Zuttiiyeh (Pleistocene)

A mandibular fragment (British Museum, no catalogue number) found at this location has a medium size carnassial (22.56 mm), a medium size metaconid (score 2), a crowding index of 0.68 and a calculated body weight of 14.89 kg. Discriminant analysis places it very close to the dog group centroid, but also in an area of the diagram where some wolf jackals overlap with the pariah group (fig. 6.12).
Fig. 6.12. Multivariate diagram showing the statistical position of a specimen from Zuttiyeh (BMNH, no catalogue number) relative to the ranges of variation of three populations of canids, using seven mandibular variables. The first function accounts for 72.6% of the total variance, the second for 27.4%.

Another specimen found at this location (British Museum M13863) returned relatively low values for both carnassials (UPM4 = 17.61 mm, LM1 = 19.83 mm) and a medium value for its calculated body weight (12.38 kg). This data together with DFA, as shown in figures 6.13 and 6.14, points towards an intermediate conformation between the wolf jackal and the Israeli pariah.
Fig. 6.13. Multivariate diagram showing the statistical position of a specimen from Zuttiyeh (BMNH M13863) relative to the ranges of variation of three populations of wild canids, using 12 cranial and mandibular variables. The first function accounts for 98% of the total variance, the second for 2%.
Fig. 6.14. Multivariate diagram showing the statistical position of a specimen from Zuttiyeh (BMNH M13863) relative to the ranges of variation of three populations of canids, using 12 cranial and mandibular variables. The first function accounts for 68.1% of the total variance, the second for 31.9%.

6.4.7. Shukbah A and Shukbah B (Natufian)

Two incomplete hemimandibular specimens (British Museum M16252, British Museum SHA), from two separate individuals, have medium size carnassials (20.37 mm and 22.65 mm), relatively uncrowded teeth series (crowding indices= 0.66 and 0.67), and similar calculated body weights (13.08 and 15.58 kg) to the specimens from Zuttiyeh quoted above. It is also noticeable that both specimens have well recurved dental series, while one of them presents a very small metaconid (score 1). Both specimens must be classed as pariahs (fig. 6.15).
6.4.8. Ein Mallaha (Natufian)

Davis and Valla (1978) conducted a detailed study of this specimen (Hebrew University 4130.188; fig. 6.16), and attributed it to a dog, finding that it had some degree of teeth crowding; as my own research indeed confirms (overlapping index = 0.66). The carnassial falls into the medium size category (21.56 mm) and displays a poorly developed metaconid (score 1) as Davis and Valla also found; this obviously precludes it from being identified as a wolf jackal. The dental series presents a degree of curvature; its calculated body weight is 11.49 kg. The DFA graph (fig. 6.17) shows how this specimen falls in an intermediate position between the wolf jackal and the dog clusters.
Fig. 6.16. Ein Mallaha specimen (Natufian, Hebrew University 4130.188). See text.

Fig. 6.17. Multivariate diagram showing the statistical position of a specimen from Ein Mallaha (Hebrew University 4130.188) relative to the ranges of variation of three populations of canids, using four mandibular variables. The first function accounts for 87.6% of the total variance, the second for 12.4%.

6.4.9. Hayonim Terrace (Natufian)

One of the specimens (Hebrew University, HT 89. 3243-52) is represented by one maxillary and two hemimandibular fragments (figs. 6.18, 6.19). The lower
carnassial length is within the pariah dog range (22.16 mm) and displays a very small metaconid; the lower dental series are noticeably curved, and show a certain degree of teeth crowding (overlapping index= 0.65); the calculated body weight is 15.33 kg. The mandibular ramus is recurved, as is the coronoid apex, and the angular process is of an intermediate size. Discriminant analysis places the specimen inside the dog cluster; it does not show any close associations to any other group (fig. 6.22). Not many reliable measurements could be obtained from the remaining specimen found at this site (HT89. 3243-50) since the fragmented condition of the sample only allowed a rather crude reconstruction of it (figs. 6.20, 6.21); a visual analysis reveals, however, that this is a very typical dog specimen: both the angular process and the metaconid (score 1) are rather small, the palate is wide, one of the hemimandibular fragments is quite shallow while the other is relatively thick (which may indicate a different origin for each fragment), and the lower carnassial is clearly within dog-size range (20.96 mm). The only trait manifesting some primitiveness is the ascending ramus that is quite straight (fig. 6.21).

Fig. 6.18. Hayonim Terrace specimen (Natufian, Hebrew University HT 89. 3243-52). See text.

Fig. 6.19. Hayonim Terrace specimen (Natufian, Hebrew University HT 89. 3243-52). See text.
Fig. 6.20. Hayonim Terrace specimen (Natufian, Hebrew University HT 89. 3243-50). See text.

Fig. 6.21. Hayonim Terrace specimen (Natufian, Hebrew University HT 89. 3243-50). See text.
Fig. 6.22. Multivariate diagram showing the statistical position of a specimen from Hayonim (Hebrew University HT 89. 3243-52) relative to the ranges of variation of three populations of canids, using 16 mandibular and cranial variables. The first function accounts for 62.8% of the total variance, the second for 37.24%.

6.5. Neolithic materials

6.5.1. Introduction

Following a similar framework to the previous section, I will try in the following lines to describe, and analyze, some materials found in a number of Neolithic sites of the Middle East and India; most of them have also been previously studied to some extent by other authors. I will arrange this section following a site by site description, and I will complement the published arguments with my own data and interpretations.
6.5.2. Jericho Tell

This site is on the northern shore of the Dead Sea, only a few miles from the Jordan Valley; it shows patterns of almost continuous occupation from the Natufian to the Late Bronze Age (Bahn 2001). Zeuner (1958) and Clutton-Brock (1979) described a dog sample unearthed from the Neolithic strata of this site. Clutton-Brock studied remains representing a total of seven individuals, and found them to be within the size range of contemporary pariah dogs. I had the opportunity to study the same seven specimens: four mandibular fragments, a maxillary piece, a lower carnassial and a tibia. The total sample ranges from the Protoneolithic right through to the Early Bronze Age.

This collection represents a medium size type of dog, of an average calculated body weight of 12.38 kg (range= 11.95 - 12.65 kg, stdv= 0.37, n= 3), an average overlapping index of 0.64 (range= 0.62-0.66, stdv= 0.02, n= 3) and an average lower carnassial length of 20.87 mm (range= 20.31-21.39 mm, stdv= 0.45, n=4). The only maxillary fragment available (ARC 1974 5976; Prepottery Neolithic A) displays a medium size carnassial (UPM4= 19.59 mm). A value of 516 mm was calculated for the height at the shoulders of a single specimen (British Museum ARC 1974 5977; Early Bronze Age), using Harcourt’s (1974) index, which is based on the length of the tibia; this value seem to indicate the presence of a large dog, or a wolf, in the sample. This would be consistent with current data supporting the occurrence of both pariah dogs and pale footed wolves in the area (see corresponding chapters, this work). Discriminant function analysis of two mandibular specimens (ARC 1974 5961 and ARC 1974 5936; both from the Prepottery Neolithic A) indicates, in agreement with Clutton-Brock (1979), that they are morphometrically consistent with the current pariah dog populations from the region (fig. 6.23).
Fig. 6.23. Multivariate diagram showing the statistical position of two specimens from Jericho Tell (specimen A: BMNH ARC 1974 5961; specimen B: BMNH ARC 1974 5936) relative to the ranges of variation of three populations of canids, using seven mandibular variables. The first function accounts for 72.6% of the total variance, the second for 27.4%.

6.5.3. Suberde (c. 8,500 BC; Peabody Museum)

This is a small Aceramic Neolithic site in southern Turkey, near Lake Sugla (Bahn 2001), from where 19 mandibular fragments and two maxillary pieces were recovered (Lawrence 1980). Lawrence (1980) described them as representing a robust type of dog, with a short face and crowded teeth series. She described a part of the teeth sample as unusual, particularly in that some carnassials have a rounded and thick appearance with blunt cusps. I had access to a somewhat reduced sample of 15 mandibular fragments and one maxillary fragment. Overlapping indices range from 0.66 to 0.71 (Av= 0.67, stand dev= 0.01, n= 7), which reflects a relatively high incidence of teeth crowding in this population. All available carnassial teeth fit perfectly within the pariah dog range (range= 19.55 - 21.46 mm, average= 20.71 mm, stdv= 0.67, n= 8); there is evidence however (Lawrence 1980) of larger specimens which could not be incorporated into a more
formal analysis due to lack of key morphological elements. Some of the hemimandibles exhibit a peculiar shape which can be described as thick in a lateromedial aspect, and triangularly shaped from a lateral perspective; the base of this imaginary triangle will follow a line perpendicular to the alveolar row, from top to bottom of the mandibular ramus, the vertex placed just below the posterior border of the alveolus of the first incisor tooth. The calculated body weight, for a sample of six specimens, has a relatively wide range of variation (av.= 11.22 kg, range= 6.65 - 16.39 kg, stdv= 3.28) due to the presence in the sample of two specimens under 9 kg in weight (Peabody Museum 346: 6.65 kg, Peabody Museum 28: 8.97 kg); the lighter specimen has the highest overlapping index of the whole sample (0.71). Two other specimens (Peabody Museum 24 and 293) clearly associated with the Israeli pariah cluster (figs. 6.24, 6.25).

Fig. 6.24. Multivariate diagram showing the statistical position of two specimens from Suberde (A: Peabody Museum 24; B: Peabody Museum 293) relative to the ranges of variation of three populations of canids, using seven mandibular variables. The first function accounts for 81.1% of the total variance, the second for 18.9%.
Fig. 6.25. Multivariate diagram showing the statistical position of two specimens from Suberde (A: Peabody Museum 293; B: Peabody Museum 24) relative to the ranges of variation of three populations of canids, using seven mandibular variables. The first function accounts for 72.6% of the total variance, the second for 27.4%.

6.5.4. Jarmo (Aceramic Neolithic to Ceramic Neolithic 7,000 – 6,500 BC)

This is a small archaeological village site, in the foothills of the Zagros Mountains in Northwestern Iraq. The canid sample is characterized by its robustness (Lawrence and Reed 1983), and by what seems to be an interesting admixture of large and medium sized specimens. The average body weight in the sample (n= 9) was 20.22 kg, with a maximum value of 26.86 kg and a minimum of 14.07 kg (stdv= 4.80); four individuals had calculated body weights over 21 kg. The length of the lower carnassial seems to suggest also the presence of a large type of Canis in the sample, perhaps in an even more compelling manner, as its average size is 24.16 mm (n= 9), which ranges from 22.04 to 25.5 mm (stdv= 1.20); furthermore seven specimens exhibit values over 23.5 mm. The average index of overlapping is 0.67 (range= 0.65 -0.68, stdv= 0.01, n= 4) which can be also described as relatively high. In the light of the large sizes of some of the specimens Lawrence and Reed (1983)
proposed that there was enough evidence, in the sample, to support the presence of grey wolf genes within the population. Following this argument, I studied a collection of grey wolves obtained in an assortment of localities, from the Middle East, Central Asia, China and Mongolia, and found a phenotype characterized by average values of 25.17 kg of calculated body weight (range= 20.98 - 31.75 kg, stdv= 2.48, n= 15), 26.51 mm for the length of the lower carnassial (range= 23.09 - 29.40 mm, stdv= 1.69, n= 15) and 0.64 for the index of overlapping (range= 0.61 - 0.68, stdv= 0.02, n= 15). Taking both sets of data into account, it is obvious that there is a degree of overlap between the two groups in the distribution of the frequencies of values for the three key traits.

Complementarily, a sample of pariah dogs from Iran and Iraq showed a range from 18.31 to 22.48 mm (stdv= 1.19, n= 18) for the length of the lower carnassial, and of 7.58 Kg to 20.64 kg (stdv= 3.26, n= 17) for the calculated body weight; taking these values as a reference it can be concluded that, of the Jarmo specimens, 22.22 % of the lower carnassial length sample fell within the dog range, as well as 55.55% of the body weight sample. Following a more detailed approach, a histogram based on the length of the lower carnassials shows an antimode in the 23.00 - 24.00 mm critical region, which suggests that two different populations could be represented in the sample (fig. 6.27).

![Histogram of the distribution of length of the lower first molar in canids from Jarmo.](image)

The only mandibular specimen (Chicago Field Museum PMO 30079) complete enough to allow it to be placed in a discriminant analysis (figs. 6.28, 6.29) clearly associates with the dog cluster and does not show any affinity with the grey wolf
group, hypothetically representative of the type of wolf that still inhabits that area. This particular individual has a lower carnassial length of 22.04 mm, an overlapping index of 0.65 and a calculated body weight of 19.86 kg.

Fig. 6.28. Multivariate diagram showing the statistical position of a specimen from Jarmo (FMNH PMO 30079) relative to the ranges of variation of three populations of canids, using eight mandibular variables. The first function accounts for 93% of the total variance, the second for 7%.
Another interesting specimen (Chicago Field Museum PMO 30033) displays a subtriangular mandibular structure reminiscent of the type found in Suberde. It has a calculated body weight of 26.30 kg and an alveolar carnassial length of 24.93 mm; these data seem to indicate the presence of a rather large canid, substantially bigger than the pariah dog previously described.

6.5.5. Catal Hüyük (c. 7,000-5,600 BC)

This site is located on the Konya Plain in southern central Anatolia. Lawrence (1980) described a small mandibular sample (2 specimens) from this locality, which revealed a gracile type of dog. I had the opportunity to study her sample (their provenience was mostly level III (c.6, 200 BC)), plus another two hemimandibles from level VI (c.7, 000 - 6, 200 BC), and also a relatively well preserved cranium.
from level III. The lower carnassials are similar in size to current populations of pariah dogs (LM1 av= 20.44 mm, range= 18.55-21.37 mm, stdv= 1.29, n= 4), and the average overlapping index is relatively high (av= 0.67, range= 0.67-0.68, stdv= 0.003, n= 3); calculated body weight averages 12.85 kg (range= 9.31-14.23 kg, stdv= 2.37, n= 4). The shape of the mandibular rami shows a degree of variation, from triangular, such as those from Suberde, to very straight in one specimen, and to well balanced and uniformly curved in another specimen. One of these mandibular rami (Peabody Museum, no catalogue number), from level III, yielded a calculated body weight of 9.31 kg and has a carnassial length of 18.55 mm, and displays a relatively crowded dentition (overlapping index= 0.67). Its morphology is clearly doglike although perhaps not very closely related to that of the pariahs from the Inner Middle East (fig. 6.30).

Fig. 6.30. Multivariate diagram showing the statistical position of a specimen from Çatal Hüyük (A: Peabody Museum, no catalogue number) relative to the ranges of variation of three populations of canids, using eight mandibular variables. The first function accounts for 93% of the total variance, the second for 7%.
The only cranium (Peabody Museum, EVI) in the sample seems to represent a typical pariah dog, with a carnassial length of 20.56, a rather straight forehead, and uncrowded teeth (Crowding index = 0.60). Its basic morphology is very similar to that of the Inner Middle East pariahs (fig. 6.31).

Fig. 6.31. Multivariate diagram showing the statistical position of a specimen from Çatal Hüyük (Peabody Museum, EVI) relative to the ranges of variation of three populations of canids, using 17 cranial variables. The first function accounts for 59.8% of the total variance, the second for 40.2%.

6.5.6. Sarab (Ceramic Neolithic - 7th millennium BC)

This site is located in the Kermanshah Valley, on the Iranian side of the Zagros Mountains. In his work on the zooarchaeology of the site, Bökőnyi (1977) identified both wolf and dog as being a part of its faunal assemblage, although he also acknowledged the intricacies inherent in undertaking this kind of identification. His set of measurements reflects a rather heterogeneous canid population which oscillates from typical dog specimens to others, much larger, displaying uncontrovertibly wolf morphologies, as well as intermediate cases, where both dog
and wolf traits appear to be mixed. He contended that the only wolf type found in
the sample is C. l. pallipes, which he characterizes as exhibiting lower carnassials
that range, in length, from 20.0 to 25.5 mm (average= 22.63 mm), as opposed to C.
l. lupus with lower carnassials from 24.6 to 32.0 mm (average= 28.55 mm);
paradoxically he cites, as a part of his sample, two lower carnassials measuring a
total length of 27 mm, which following his argument ought to be identified as C. l.
lupus. The presence of "signs of domestication", and therefore of authentic dogs
presumably derived from C. l. pallipes, is also recognized, as he described
specimens having slender mandibles and crowded teeth (Bökönyi 1977).

The lower carnassial sample from Sarab that I had the opportunity to study
(average length= 25.67 mm, range= 26.71 - 24.44 mm, stdv= 1.03, n= 4) does not
exhibit the same degree of variability as in Bokonyi (1977); this may be due to the
comparatively limited size of my sample. The analysis of the length of the lower
carnassial alveoli offers a different perspective, as I was able to collect data from
nine different specimens (average= 23.73 mm, range= 21.21 - 26.2 mm, stdv= 1.58,
n= 9). Records for the four different taxa relevant to this study have been
summarized in table 6.6. In this light it becomes evident that the Sarab sample
presents a noticeable range of variation for this character that covers the variability
range of the four series. The same situation is evident in two other relevant traits,
calculated body weight and overlapping index (tables 6.7, 6.8). Obviously the
overlaps of the more significant traits between taxonomic categories make the
identification of some of the specimens rather difficult, particularly when only a
very limited amount of variables per specimen are to hand. Nonetheless, the
relatively great length of some of the carnassial alveoli, combined with data for body
weights, suggests the presence, in the sample, of a large proportion (57.1%) of
specimens with characteristics attributable to large wolves (table 6.9).

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<td>21.21</td>
<td>1.58</td>
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Table 6.6. Alveolar length of the lower carnassial (in mm) of five different groups of recent and
archaeological samples of canids.

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<td>21.21</td>
<td>1.58</td>
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</table>

Table 6.7. Calculated body weight (in kg, after Wing 1978 and Hamblin 1984) of five different
groups of recent and archaeological samples of canids. For a description of the methodology see
appendix III.
Table 6.8. Overlapping index (Davis and Valla 1978) in five different groups of wild and domestic canids. For a description of the index see appendix III.

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<th>Min</th>
<th>STDEV</th>
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<td>Egyptian wolf jackals</td>
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<td>0.69</td>
<td>0.62</td>
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<td>Sarab sample</td>
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<td>0.68</td>
<td>0.65</td>
<td>0.01</td>
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</table>

Table 6.9. Morphometric data of 10 specimens from Sarab. For descriptions of index and methodologies see appendix III.

The heaviest specimen (Field Museum AG9) has a calculated body weight of 27.27 kg, which is heavier than any of the Indian pale footed wolves in the sample. Its alveolar carnassial length is also rather large (26.2 mm), which fits well within the Asian grey wolf range, and is only half a millimetre shorter than the uppermost value found in the Indian pale footed wolf sample. In a more qualitative sense the general aspect of the specimen conveys a general impression of robustness, reinforced by the appearance of the lower margin of the mandibular body, which in the distal quarter presents a noticeable depression; this is a characteristic often found in grey wolves. It must be concluded, then, using the most parsimonious approach, that these remains indicate the presence of grey wolves in the population.

Starting at the opposite end of the spectrum was not as productive, as the minimum body weight value available (14.17 kg, Chicago Field Museum specimen AG6c) is within the range of values of wolf jackals, pale footed wolves and pariah dogs alike. I conducted a sequence of discriminant analyses of those mandibular specimens that were particularly complete. The first two (Field Museum, no catalogue numbers) present an alveolar lower carnassial length of 24.64 and 22.94 mm, coupled with calculated body weights of 24.64 and 22.94 kg respectively; consistent with these data, discriminant analysis shows the pronounced affiliation of both specimens with the Indian C. pallipes cluster (fig. 6.32). Both specimens exhibit nonetheless very different indices of overlap: 0.65 and 0.68 respectively. A third specimen (Field Museum AG8) displays a gracile conformation and a dental
series not particularly crowded, its calculated body weight reaches 14.77 kg and it has an alveolar carnassial length of 22.23 mm; its position within a discriminant analysis diagram suggests equally wolf jackal and Inner Middle East pariah affinities (fig. 6.33).

Fig. 6.32. Multivariate diagram showing the statistical position of two specimens from Sarab (Field Museum, no catalogue numbers) relative to the ranges of variation of three populations of canids, using eight mandibular variables. The first function accounts for 95.1% of the total variance, the second for 4.92%.
Identification of some other mandibular elements faced further difficulties as they presented a very limited amount of measurable traits. Specimen AG6c had a calculated body weight of 14.17 kg, a shallow mandible and alveolar carnassial length of 23.63 mm; its teeth series appear crowded. Obviously, its small body weight precludes these remains from being a grey wolf, and the large carnassial size, as shown by the length of the alveolus, ruled out identification as a pariah dog; it must be thus identified as a pale footed wolf or a wolf jackal. AG11a has a noticeably large carnassial (26.31 mm) that could only belong to a wolf, either a grey or a pale footed wolf, more likely the former. A robust but not overly large mandibular specimen (AG1) has an alveolar carnassial length of 23.40 mm which ought to be attributed to a wild *Canis*, or to one in the process of becoming domestic; its borderline value prevents it from being identified more precisely. A gracile mandibular ramus (AG2), exhibiting a degree of teeth crowding, has an alveolar carnassial length of 21.21 mm; it would be impossible to classify this specimen with absolute certainty, although the evidence of a small carnassial
coupled with a gracile appearance, and the indication of teeth crowding, seem to denote a dog.

Two cranial specimens (AG6a and AG10), with upper carnassial lengths of 18.41 and 19.45 mm respectively, and high crowding indices 0.87 (AG6a) and 0.92 (AG10), did not yield the necessary amount of morphometric information to conduct an acceptably accurate discriminant function analysis. I opted then for a log ratio diagram, to investigate some of their possible relationships. The results seem to indicate that both specimens are dogs (fig. 6.34).

![Log ratio diagram](image)

**Fig. 6.34.** Log ratio diagram of the measurements of seven cranial traits of two specimens from Sarab (AG6a and AG10) compared with other canid samples. Inner ME pariah data is used as standard value.

Visual examination of a gracile cranial specimen (AG6b) suggests the presence of another domestic dog. The only relevant available measurement (upper carnassial length= 20.22 mm) is not enough to corroborate this, as this value could equally be attributed to pale footed wolves, wolf jackals or pariah dogs (table 6.10).
Asian grey wolves | 24.74 | 26.59 | 22.6 | 1.09 | 16
Indian pale footed wolves | 22.56 | 24.75 | 18.84 | 1.48 | 16
Inner ME pariahs | 18.45 | 20.94 | 16.02 | 1.16 | 18
Egyptian wolf jackals | 19.66 | 22.14 | 17.17 | 1.28 | 35
Domestic dog Sarab sample | 19.29 | 20.22 | 18.41 | 0.90 | 3

Table 6.10. Length of the upper carnassial (in mm) of five different groups of recent and archaeological samples of canids.

There seems therefore to be enough evidence to confirm the presence of grey wolves, pale footed wolves and pariah dogs in the Sarab sample; the existence of the wolf jackal or of some type of protodog connected to it is also possible.

6.5.7. Palegawra (c. 8500 BP)

This cave site is located on the southwestern side of the Zagros; its artefact assemblage was identified as Zarzian (Turnbull and Reed 1974). The widely discussed canid specimen found at that location consists of a relatively well preserved fragment of mandibular ramus (fig. 6.35). It has a relatively robust body, combined with a medium sized metaconid (score 2), a medium length carnassial (22.05 mm), a lightly crowded dentition (overlapping index= 0.65) and a calculated body weight of 15.08 kg. All these measurements confirm it, in principle, as a medium size Canis specimen, but do not provide any indication of its taxonomy at the species level. A log ratio diagram (fig. 6.36) suggests a high degree of similarity with dingoes, pariah dogs and wolf jackals for four relevant traits, and much weaker similarity with pale footed wolves; it also represents a complete departure from any other groups for the length of LP2-LP3 diastema which is extremely short (0.17 mm). There is however a rather reduced expression of this trait, smaller in fact than the Palegawra value of 0.17 mm, in some closely related groups such as Indian pariahs (27.27% < 0.17 mm, n= 11), Israeli pariahs (5.88% < 0.17 mm, n= 34) and Indian pale footed wolves (6.66% < 0.17 mm, n=15). Consequently, and as previously suggested by Olsen (1985), this could be an aberrant specimen, but not a wolf since its morphometrics tend to point more towards a protodog, with wolf jackal affinities. The chronology of this specimen was debated by Uerpmann (1982) who proposed the “late 8th millennium BC” as its “earliest possible date”; he based his comment on the presence of domestic goat remains in deeper layers than that of the canid mandible.
Fig. 6.35. Specimen from Palegawra cave (Field Museum PM 11265). See text.

Fig. 6.36. Log ratio diagram of the measurements of five mandibular traits of the Palegawra specimen (PM 11265) compared with other canid samples. Inner ME pariah data is used as standard value.
6.5.8. Kfar-Galim (c. 7,100-6,300 BP)

This is a submerged Ceramic Neolithic site off the coast of Mount Carmel (Dayan and Galili 2000). The only available specimen is a well preserved cranium, which obviously belonged to a domestic dog (figs. 6.37, 6.38); the tympanic bullae are small and flattened, the frontal region is not excessively inflated, the neurocranium is well vaulted, teeth are crowded and the upper carnassial was relatively small (upper carnassial alveolus= 19.10 mm); the specimen also presents a small sagittal crest and a well developed occipital process. In general, it can be described as showing signs of paedomorphosis given its combination of a short and broad rostrum, dished face and a rounded neurocranial dorsal outline. There is no suggestion that it might be a hybrid. Its proximity to the Indian pariah centroid in a DFA graph is somewhat surprising (fig. 6.41), but does at any rate confirm it as a dog.

Fig. 6.37. Kfar-Galim specimen (Hebrew University, no catalogue number). Lateral view. See text.

Fig. 6.38. Same specimen. Basal view. See text.
A fairly well preserved cranium (30/93/11/1) and an incomplete skull (30/93/6/32) were found at a second submerged Ceramic Neolithic site off Mount Carmel (Dayan and Galili 2000). Both crania have similar characteristics to the previous one from Kfar-Galim; i.e. they present clear symptoms of paedomorphosis, and both of them display crowded teeth, wide palate, short rostrum and relatively small carnassials (UP4 alveolus = 19.28 mm, specimen 30/93/11/1 and 17.37 mm, specimen 30/93/6/32). The former specimen appears to be a subadult, judging by the open cranial sutures, and even more diagnostically by the presence of a clearly defined suture between the presphenoid and the basisphenoid; it also presents a rather straight facial region, perhaps a consequence of its age, a ribbed auditory bulla, an incipient sagittal crest, a relatively well developed occipital crest, and a not excessively rounded neurocranium (figs. 6.39, 6.40). Morphometrically it presents some similarity with Israeli pariahs as well as with the Indian pariahs (fig. 6.41).
Fig. 6.41. Multivariate diagram showing the statistical position of specimens from Tel Hreiz (A: Hebrew University 30/93/11/1) and Kfar Galim (B: Hebrew University, no catalogue number) relative to the ranges of variation of three populations of canids, using 16 cranial variables. The first function accounts for 83.6% of the total variance, the second for 16.4%.

The other specimen from Tel Hreiz (30/93/6/32) appears to be an adult (figs. 6.42, 6.43). Apart from the characters shared with the previous individual, it has a dished facial region, lightly inflated frontals, a thin mandibular ramus and relatively small carnassial alveoli (upper carnassial alveolus= 17.37 mm, lower carnassial alveolus= 21.17). Its calculated body weight is 11.42 kg. As with the previous specimen, DFA demonstrated similarities with the Indian pariahs, but also with those from the inner Middle East (fig. 6.44).
Fig. 6.42. Tel Hreiz specimen (Hebrew University 30/93/6/32). Lateral view. See text.

Fig. 6.43. Same specimen. Basal view. See text.
6.5.10. Burzahom

This site is located in Kashmir 1,800 m above sea level (Bahn 2001). Four different occupational periods have been described: Pit Dwelling, Late Neolithic, Megalithic and Early Historic (Gosh 1995, Bahn 2001). Its chronology is somewhat uncertain but it can be approximately defined as covering the 3rd and the early 2nd millennia BC.

Gosh (1995) considered that dogs inhabited the site since the late Neolithic and identified two different types, which he named types I and II (Gosh 1995). He described the former as smaller but more robust than the present day type of pariah; and the latter as taller and more slender than type I. He also mentioned that the cephalic index of his sample was between 50 and 60, which he described as "dolicocephalic"; otherwise he did not advise of any substantial cranial difference.
between the two types. He also pointed out the presence of wolves at this site, which he described as similar to the present day ones and to those from Harappa.

I studied, at least in part, the sample described by Gosh (1995). Initially I opted for analyzing calculated body weights, followed by multivariate analysis of as many specimens as possible, since it was my intention to develop a better idea about the presence of different dog types, and of wolves, in the sample. A calculated body weight histogram (fig. 6.45) of all individuals within the total sample for which this character could be calculated (18 specimens) shows that there seem to exist two different groups, separated by an antimode in the histogram from 15 to 17.5 kg. The most parsimonious explanation for this scenario would be that all specimens included in the histogram which weighed more than 17.5 kg ought to be considered as wolves, while those which weighed less than 17.5 kg would be identified as dogs. This explanation would be consistent with data from recent Asian grey wolves which calculated body weights covered a range from 18 to 32 kg, in a sample of 20 adult specimens (this work, chapter IV). This is not, however, without its problems since four archaeological mandibular specimens from the collections of the Zoological Survey of India in Calcutta (3280, 3036, 3293, 3294), which on this criterion should be identified as wolves (calculated body weights 18.17 to 21.09 kg), were more strongly associated to the pariah cluster than to the clusters of either pale footed wolves or Asian grey wolves (figs. 6.51, 6.52). A more detailed analysis shows that the length of the lower carnassial in three of the specimens is much closer to that of a dog (range= 21.49 - 22.36 mm); there is only one exception (ZSI 3293), whose carnassial length seems unusually large for a dog (23.45 mm), although only marginally larger than that of the Harappa specimen (23.19 mm) that was identified as closer to the dog than to the wolf group. The rest of the specimens, which on a body weight basis could have been identified as wolves, were represented only by long bones, mostly femora. The interpretation of their remains is hence open to debate; the fact however that only long bones were found could suggest that they may correspond to body parts collected in the field, by hunting parties, that quartered the bodies to facilitate transport.
Continuing now with the analysis of the four DFA diagrams generated during the study of this case: in the first set of four crania (fig. 6.46), three specimens clustered with the pariah group for North West India, one of them being identified as "type I" and two specimens as "type II" by Gosh (1995), and remarkably the specimens representing either type were located in different sections of the pariah cluster. One of the specimens identified as a type II (ZSI 3135) yielded a cephalic index of 59.9 which identified it as a broad head type; unfortunately it was not feasible to calculate the value of this index for the rest of the sample, as they had seriously damaged zygomatic arches. Similarly, it was possible to calculate the body weight of only one of the specimens ([N 78], yielding a value of 13.07 kg; this individual also had an index of overlap of 0.64, and a medium value cranial capacity index (1.68). All three specimens included in the pariah dog cluster (ZSI 3135 & 3135, 3139 & 3136) have medium length upper carnassials (average= 18.98, range= 19.77-17.85, stdv= 1.00). It was possible to calculate the body weight of only one of the Burzahom specimens included in this table (3139 & 3136); it yielded a value of 13.07 kg, and its mandible had an index of overlap of 0.64. This individual, together with another one from the same site (3135) presented a combination of characteristics that can only be described as paedomorphic, such as a broad head, a short snout and a well vaulted neurocranium; this gives both specimens a very similar look to that of the village dogs previously described. The previously quoted estimated body weight for one of the specimens (3139 & 3136) may seem excessive (13.07 kg) for a village dog, and the same could apply to the
other individual (3135), that judging by the total length of its skull (175.46 mm) could have had a very similar body size. In spite of this, both specimens clustered into an almost identical region, within a DFA diagram, as two typical Asian village dogs (figs. 6.46, 6.47).

Another specimen (ZSI 3288; figs. 6.46, 6.48) occupied an intermediate position between pale footed wolves and grey wolves (fig. 204); this individual, collection-labelled as C. l. ssp., displays a robust appearance, and has an inflated frontal region, a short rostrum, a large tympanic bullae (26.39 mm) and medium size carnassials (21.52 mm); its crowding index is 0.89 and the estimated shoulder height, calculated from the greatest length of the atlas (Clark 1997), is 636.41 mm.

Fig. 6.46. Multivariate diagram showing the statistical position of four archaeological specimens from Burzahom relative to the ranges of variation of three populations of canids, using 14 cranial variables. The first function accounts for 91.8% of the total variance, the second for 8.2%.

**List of specimens from Burzahom**
A: ZSI 3288. Possible hybrid.
B: ZSI 3135&. Type I specimen (Gosh 1995).
D: ZSI 3135. Type II specimen (Gosh 1995).
Fig. 6.47. Multivariate diagram showing the statistical position of four recent village dogs from Asia relative to the ranges of variation of three populations of canids, using 14 cranial variables. The first function accounts for 91.8% of the total variance, the second for 8.2%. This analysis replicates the one above, excluding the Burzahom sample and incorporating the village dog sample.

**List of village dog specimens**
A: IN 238. Kerala, India.
B: BMNH 71753. Ikan Merah, Malaya.
C: BMNH 193752639. Mt Popa, Burma.
D: USNM 218568. Lindoe Lake, Tornado, Sulawesi.
A second group, of relatively complete crania (3 specimens) of unidentified type, clearly associated with the pariah cluster (fig. 6.50), forming a relatively tight pattern; one of the specimens (ZSI 3136) had a calculated body weight of 13.91 kg, a lower carnassial length of 20.73 mm and an index of overlap of 0.66, all of them characteristic values of the Indian pariah dog population.
Fig. 6.50. Multivariate diagram showing the statistical position of three archaeological specimens from Burzahom relative to the ranges of variation of three populations of canids, using eight cranial variables. The first function accounts for 91.6% of the total variance, the second for 8.4%.

List of specimens from Burzahom
A: Specimen ZSI 4014.
B: Specimen ZSI 3136 (13.91 kg).
C: Specimen ZSI 4013.

The study of mandibular material found at this site provides a slightly different perspective. Multivariate analysis of well preserved materials (fig. 6.51) suggests the presence of two non-typical individuals, which despite their relatively high body weight (ZSI 3294: 19.43 kg and ZSI 3293: 21 kg) do not show a strong wolf affinity, although both specimens were labelled as *Canis lupus ssp.* One of them (ZSI 3293) has an index of overlapping of 0.66 and a lower carnassial length of 23.45 mm, which can be considered somewhat excessive for a dog of this size. The other individual (ZSI 3294) has an overlapping index of 0.66 as well, and a lower carnassial length of 22.36 mm; both values falling within the range of variation for the Indian pariah dog population. A third, lighter individual (ZSI 4014; 16.87 kg) shows a closer association with the pariah dog cluster; it had an overlapping index of 0.65 and a lower carnassial length of 22.44 mm.
Fig. 6.51. Multivariate diagram showing the statistical position of three archaeological specimens from Burzahom relative to the ranges of variation of three populations of canids, using nine mandibular variables. The first function accounts for 93.1% of the total variance, the second for 6.9%.

List of specimens from Burzahom
A: Specimen ZSI 4014 (16.87 kg).
B: Specimen ZSI 3293 (21 kg).
C: Specimen ZSI 3294 (19.43 kg).

A second set of three mandibles provides also an interesting insight into canine typology (fig. 6.52). One specimen (ZSI 3036), identified by curatorial personnel as a dog, has a body weight (18.87 kg) slightly high, accordingly to preliminary analysis, for a dog from this population, a rather low index of overlapping (0.62), and a relatively small carnassial (21.49 mm); its position within the DFA graphs indicates intermediacy identity between dogs and grey wolves. Another specimen (ZSI 3280), also labelled as dog, occupies a similar position within the graph as ZSI 3294 (see previous graph); it does not appear to be very close to the dog cluster, but does not show much resemblance with any of the wolf groups either; it presents a certainly high overlapping index (0.70) and a medium size carnassial 22.42 mm. The last specimen in the graph (ZSI 3139), identified also as *C. familiaris* by the curators, is
unmistakably included within the pariah cluster; his body weight (13.44 kg), overlapping index (0.66) and carnassial length (21.14 mm) are typical of the Indian pariah dog population. Another specimen (ZSI, 4044, 4040, 4043), represented only by some long bones, was identified by collection personnel as either a wolf or a dog; its calculated body weight was 25.09 kg and its shoulder height 565 mm, both values seem to suggest a wolf identity.

Fig. 6.52. Multivariate diagram showing the statistical position of three archaeological specimens from Burzahom relative to the ranges of variation of three populations of canids, using six mandibular variables. The first function accounts for 94.7% of the total variance, the second for 5.3%.

List of specimens from Burzahom
A: Specimen ZSI 3280 (18.82 kg).
B: Specimen ZSI 3036 (18.87 kg). Possible hybrid.
C: Specimen ZSI 3139 (13.44 kg).

It is therefore apparent that in Burzahom we can identify at least four different types of canid, whose main morphometrics are summarized in table 6.11. The more common type of dog found here conforms to the basic pariah morphotype; they are characterized by a medium body size, a broad head, lightly dished forehead, a medium sized sagittal crest, and average sized lightly crowded, dentitions. A visual examination of the skull of this type reveals some peculiarities such as a high degree of cranial robustness, and the fact that the lower edge of the mandibular
ramus is often strongly curved and tends to be quite thick, both in lateromedial and dorsoventral aspects; molars are often thick, as well, not very different from those found in some Middle Eastern sites. A paedomorphic type, very similar in cranial proportions to the modern village dog, has also been documented; the two specimens identified as such were however heavier than what is usual in other village dog populations; for practical reasons I have included the village dog type within the general pariah dog population, as it occurs as such in many parts of the world. Discriminant analysis has identified the presence of some kind of non-typical dog in the sample, which does not seem to show any traces of hybridization with wolves; considering the available data, this type is heavier and taller than the pariah type, but data are of necessity limited since mandibles were the only remains available. The probable presence of a medium size wolf type has been suggested by the study of some postcranial elements, but it would be premature, at this stage, to make any classification attempts at the species level, as this is an area where three different forms, which may present body sizes similar to those identified, can overlap; the lack of cranial and mandibular material may suggest that the specimens were killed away from the settlement, as a result of which their presence could be more logically attributed to hunting. Remains of two probable wolf-dog hybrids have also been found; the calculated body size of one specimen was within the expected range of the local wolf population, although the size of the dentition of the other specimen appears to be closer to that of a dog. There is no significant morphological variability, along chronological lines, among the different canid types found in the sample, from the Megalithic to the Early Historic period.

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Table 6.11. Morphometric data of four groups of canids from Burzahom. For descriptions of index and methodologies see appendix III.
6.5.11. Thailand

Higham et al. (1980) studied materials (mostly mandibles) from four different sites of north and central Thailand. The exact age of the materials has not yet been determined. Chronologically speaking, Ban Chiang, the reference site, extends from c. 3,500 BC to very recent times. The other three sites are Non Nok Tha (2,500 C – 1st millennium AD), Ban Phak Top (3rd millennium BC) and Ban Tong (Iron Age). Morphometrics (length of the upper carnassial and body weight) are very similar across all four sites (figs), and seem to support the presence of a typical pariah dog, not very different from what has been found in India (tables 6.12, 6.13). Complementarily the visual analysis of the drawings of the mandibles studied by Higham et al. present in most cases a typical pariah dog conformation: strong and curved horizontal rami coupled with arched ascending rami and rounded coronoid processes. Higham et al. (1980) highlighted the jackal-like appearance of an almost complete hemimandible displaying a very straight ascending ramus, a rather shallow corpus and uncrowded dentition; this specimen, however, has a calculated body weight of 11.68 kg, which would set it apart from the golden jackal subspecies described for the region (C. a. cruvessemani), which although insufficiently studied does not appear to be as large as this; one specimen from Chaiyaphum, at the Smithsonian Institution (USNM 297170), had a calculated body weight of only 4.93 kg. Moreover, specimens of C. aureus exceeding 9 kg have been documented only in non tropical regions such as Afghanistan and Morocco. Another interesting case (Higham et al. 1980) is a rather complete skull from Bang Chiang (burial 13) whose body weight is comparatively smaller (8.86 kg) although the length of its lower molar (19 mm) is longer than other specimens of greater body weight; Higham et al. (1980) published a drawing of this specimen and compared it to a similar contemporary specimen also from Bang Chiang: the archaeological specimen.
presents many of the traits of the village dog such as a broad head, small sagittal crest, reduced tympanic bulla, bulging neurocranial region and slender mandibles.

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Table 6.12. Calculated body weight (in kg, after Wing 1978 and Hamblin 1984) of probable pariahs from four archaeological sites in Thailand. For a description of the methodology see appendix III.

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Table 6.13. Length of the lower carnassial (in mm) of probable pariahs from four archaeological sites in Thailand.

**Key of abbreviations:**

NNT: Non Nok Tha
BC: Ban Chiang
BT: Ban Tong
BPT: Ban Phak Top

Dr Helmut Loofs-Wissowa, of the Australian National University, collected an extensive zooarchaeological sample at Khok Charoen, a prehistoric cemetery in the upper Pa Sak Valley in central Thailand (Bahn 2001). Amongst the abundant osteological evidence of deer, wild cattle and pigs were found the very fragmented remains of three dogs; of these only one specimen was suitable for morphometric analysis. The individual in question had a calculated body weight of 13.15 kg and a lower molar length of 20.38 mm, both measurements making it comparable with the general prehistoric Thai population previously described.

6.5.12. West Timor

In 2001 an archaeological team from the Australian National University found in Matja Kuru (West Timor) the skeletal remains of a medium size dog; it was dated 2,967 ± 58 BP (fig. 6.55). It has a lower carnassial length of 17.78 mm, an index of overlap of 0.67, a calculated body weight of 9.1 kg and a calculated height at the shoulders of 39.30 mm. All these data seem to suggest identification as a village dog, which is also reinforced by a log ratio diagram (fig. 6.54). It only departs from this general pattern when the length of the diastema between 2\textsuperscript{nd} and 3\textsuperscript{rd} premolar is taken into consideration; like the Palegawra specimen this apparently aberrant
value is still larger than two other measurements, documented for this character in two village dogs (0.47 mm, 1.07 mm) of a similar size collected in India (IN 238) and Burma (BMNH 193752639).

Fig. 6.54. Log ratio diagram of the measurements of 10 skull traits of the Timor dog compared with other canid samples. Asian village dog data is used as standard value.

Fig. 6.55. Some well preserved skeletal elements of the Timor dog.
6.6. Post-Neolithic and materials of uncertain chronology

6.6.1. Harappa

The Harappan civilization was one of the most technologically developed of the time. Located in the Indus valley, the majority of the sites are found in what is today Pakistan; its chronology covers mainly the 3rd millennium BC (Bahn 2001). Prashad (1936) described the form as *Canis tenggeranus* race *harappensis* – that is to say, as a local form of the Javanese Tengger dog - and discussed in detail a number of skulls that he ascribed to it. His type specimen (from the Zoological Survey of India, Calcutta; fig. 6.56) is a medium size incomplete skull of gracile appearance with noticeably inflated frontals, reduced tympanic bullae, a small sagittal crest and a scantily developed occipital crest; the teeth are of a medium size (upper carnassial = 17.17 mm) and are relatively crowded (crowding index = 0.84), and its cranial capacity index is certainly high (1.94), closer to that of a wolf. DFA shows a similarity with the pariah dogs that today inhabit the area (fig. 6.57).

![Fig. 6.56a. Type specimen of *Canis tenggeranus* race *harappensis* (ZSI HP106). Lateral view. See text.](image1)

![Fig. 6.56b. Same specimen as above. Basal view. See text.](image2)
Fig. 6.57. Multivariate diagram showing the statistical position of an archaeological specimen from Harappa (ZSI HP106) relative to the ranges of variation of three populations of canids, using 12 cranial variables. The first function accounts for 63% of the total variance, the second for 37%.

Another interesting specimen (ZSI HP 103; fig. 6.58), also ascribed to this “local race” by Prasad (1936), was studied by Gollan (1985), who identified it as a domestic dog. It displays a well domed neurocranium, small auditory bullae, elevated frontals, dished rostral area, wide palate and relatively small teeth (upper carnassial length= 18.81 mm); its crowding index (0.94) is quite high, the cranial capacity index is low (1.56), of a value usually found in pariah dog populations. A multivariate graph clearly shows on the edge of the dog cluster (fig. 6.59). A different conformation seems to be signified by another specimen (Peabody Museum 422060-1) with a wider cranium (cephalic index= 57.85), also of a medium size (total length= 186.67 mm) and exhibiting a crowded dentition (crowding index= 0.94); this individual also has a medium size upper carnassial (18.77 mm) and a very low cranial capacity index (1.24); it should still be considered as a part of the local pariah population, as DFA demonstrates (fig. 6.59).
Fig. 6.58. Harappa specimen (ZSI HP103). See text.

Fig. 6.59. Multivariate diagram showing the statistical position of two archaeological specimens from Harappa (A: Specimen 422060-1, Peabody Museum; B: Specimen HP103 Zoological Survey of India, Calcutta) relative to the ranges of variation of three populations of canids, using 14 cranial variables. The first function accounts for 66.3% of the total variance, the second for 33.7%.
A gracile rostral fragment (ZSI HP 107) presents a carnassial whose length (P4 = 18.27 mm) is consistent with that of this pariah population. DFA shows a clear association with the pariah cluster (fig. 6.60).

Fig. 6.60. Multivariate diagram showing the statistical position of an archaeological specimen from Harappa (ZSI HP107) relative to the ranges of variation of three populations of canids, using 10 cranial variables. The first function accounts for 63.5% of the total variance, the second for 36.5%.

A gracile incomplete skull with an associated mandibular ramus (ZSI HP 73) was initially labelled as belonging to a pale footed wolf; it has a maxillary crowding index value of 0.83, which is only slightly higher than the one for the Kanhiapan wolf. The ramus fragment presents a large carnassial (L = 23.19 mm), and a relatively low mandibular crowding index value (0.66). The estimated body weight based on the height of the mandibular ramus yielded a value of 15.53 kg. Discriminant function analysis identifies it as a typical Indian pariah (figs. 6.61, 6.62). It is particularly noteworthy however that this specimen exhibits such a long lower carnassial and also a rather long auditory bulla (26.07 mm), which are closer in value to those of a wolf; taking this into account it would be more accurate to identify it as a protodog.
Fig. 6.61. Multivariate diagram showing the statistical position of an archaeological specimen from Harappa (ZSI HP73) relative to the ranges of variation of three populations of canids, using 14 cranial variables. The first function accounts for 85.5% of the total variance, the second for 14.5%.
I describe as "broad headed" the only specimen (Peabody Museum 422060-1) in the archaeological sample for which a cephalic index calculation was feasible; this value (57.85) was closer to that of a rotweiler (62.6; Clark 1998), a typical modern broad headed breed, than to that of the most wide-headed specimen in a sample of recent sighthounds (average = 49.16, range = 47.23-51.06, stdv = 1.56, n = 5). A sample of recent pariah dog skulls collected in the same locality gave a very diversified set of values for this index (average = 53.41, range = 58.19 - 50.00, stdv = 2.56, n = 8).

All the above mentioned data seem to point to the existence in Harappa of a non-uniform dog population, some of them presenting rather archaic characteristics possibly related to a wolf descent. There is not enough evidence, at this time, to suggest the presence of pale footed wolves as such, or their hybrids, in the Harappa sample; albeit some of the specimens less well documented could be perhaps
attributed to this species, or to its hybrids, as a clear dog identification could not always be made with complete certainty.

6.6.2. Archaeological remains from Egypt

Churcher (1993) studied a sample of eight skulls, plus some postcranial elements, from a rather disturbed tomb site in the Ein Tirghi Cemetery, in the Western Desert of Egypt. He found the dating of these materials a highly subjective matter; tentatively they were assigned a broad chronology from 800 or 1000 AD to the 17th and 19th Centuries. He identified all these specimens as representatives of the robust, broad headed pariah dog. He compared his sample with others collected by Petrie at four other Egyptian Archaeological sites (Dendereh, Hawara, Gizeh and Qau), also of undetermined chronology. Although I was unable to study the materials from Ein Tirghi, I was fortunate enough to have access to a part of the Flinders Petrie collection which is kept at the British Museum, including specimens from Abydos, Lahun, Hawara, Abadiyeh, Dendereh and Gizeh, and to five specimens from Lahun, in the UCL collections, also at the British Museum; their chronology is unknown. I also had the opportunity to study, at the Smithsonian Institution, three more archaeological specimens from Upper Listh (1 specimen) and "Egypt" (2 specimens), all three of them also of unknown chronology. All those materials will be treated in this study as a single sample, since it would be impossible to attempt any stratification of them along a time scale. I will also analyze, but this time in a separate group, individuals from the Petrie collection labelled as "recent"; this much smaller sample includes materials from Abydos, Dendereh and "Egypt".

DFA demonstrated a perfect discrimination between the Egyptian pariahs and samples of Mediterranean pale footed wolves and Egyptian wolf jackals but very little difference between the archaeological and recent samples (fig. 6.63). A second analysis shows that the Egyptian pariahs are rather similar to the recent pariah population, from Israel and the Inner Middle East, although each one of the three groups preserves a certain degree of homogeneity (fig. 6.64).
Fig. 6.63. Multivariate diagram showing the statistical position of a sample of recent pariahs from Egypt relative to the ranges of variation of three populations of canids, using 17 cranial variables. The first function accounts for 57.6% of the total variance, the second for 42.4%.
Fig. 6.64. Multivariate diagram showing the statistical position of a sample of recent pariahs from Egypt relative to the ranges of variation of three populations of canids, using 17 cranial variables. The first function accounts for 80.2% of the total variance, the second for 19.8%.

In general the Egyptian pariah dog sample is very dog-like, and does not present any traces of hybridization with any wild species, as data referring to particular morphological characteristics also confirm. The archaeological sample yielded an average value of 0.68 for the overlap index (stdv= 0.01, range= 0.63-0.70, n= 22), which can be considered relatively high, an average of 20.11 mm (stdv= 1.32, range= 16.68-22.44 mm, n= 23) for the length of the lower carnassials, and an average calculated body weight of 11.04 kg (stdv= 2.85, range= 6.25-19.46 kg, n= 37). Dogs of a smaller type, from 6 to 10 kg, are abundant in the samples, which seems to confirm the presence of village dog types (fig. 6.65).
Fig. 6.65. Histogram of the distribution of calculated body weights of archaeological Egyptian pariahs.
Further analysis (fig. 6.66) showed that a sample of four village dogs from Garamba (Congo) and Tete (Mozambique) show surprising similarities to a part of the Egyptian sample, which confirms previous impressions about the occurrence of village dogs in the latter.

Fig. 6.66. Multivariate diagram showing the statistical position of a sample of recent African village dogs relative to the ranges of variation of three populations of canids, using 17 cranial variables. The first function accounts for 80.2% of the total variance, the second for 19.8%.

List of village dog specimens
A: MCZ 44291. Tete, Mozambique.
B: AMNH 52088. Garamba, Congo.
C: AMNH 52086. Garamba, Congo.
D: AMNH 52087. Garamba, Congo.

Churcher (1993) commented on the presence in Egypt of two basic forms of pariah dog: a broad head type ("shenzi") and a sighthound type ("tesem"), although he was able to identify only shenzi types at Ein Tirghi. To test for the presence of both types in my sample, I compared the sample of Egyptian pariahs with samples of pariahs from the Inner Middle East and Israel, and with a collection of four English
greyhounds and one Afghan sighthound. The result indicated that, as Churcher had maintained, there is very little similarity between the Egyptian and the sighthound sample; moreover the specimen from Afghanistan also shows a clear departure from the conformation of the English greyhounds, as well as from the rest of the samples (fig. 6.67).

![Multivariate diagram](image)

**Fig. 6.67. Multivariate diagram showing the statistical position of a sample of recent sighthounds relative to the ranges of variation of three populations of canids, using 17 cranial variables; the greyhound sample includes one Afghan sighthound (specimen A: AMNH 189373). The first function accounts for 80.2% of the total variance, the second for 19.8%.

6.6.3. Haditha

Lawrence (1956) studied a collection of heterogeneous undated osteological remains found in a sink-hole located three miles south of this Iraqi city, in the vicinity of the Euphrates, together with a large collection of ungulate remains, and speculated on the possibility of four different types of wolf being represented in the sample. My analysis has been necessarily limited by the fact that, within the whole sample, only one cranial and two mandibular specimens were complete enough to allow
discriminant analysis. The cranial specimen (MCZ 47464) discriminates as a pariah dog (fig. 6.68) and has an appearance consistent with this, as it presents a downhill neurocranial profile, inflated frontals and crowded premolars (crowding index = 0.85), and it also has a cranial capacity index whose value (1.77) would be consistent with a pariah dog; following a visual analysis the specimen could be perhaps associated to the broad head type, but disappointingly the zygomatic could not be measured due to its incompleteness. The two mandibles (MCZ 47452 and 47453) that could be analyzed through DFA (fig. 6.69) also suggest the presence of pariahs in the sample; both specimens show a certain degree of teeth crowding (overlapping indices = 0.65 and 0.66) and mid-range body sizes (body weights = 13.43 and 14.92 kg), and the length of the lower carnassial fits also in both cases within the value range expected for a pariah dog population (20.09 and 20.92 mm). One of the specimens (MCZ 47453) is particularly worth mentioning since the lower border of the mandibular ramus is remarkably straight, a characteristic often found in grey wolves, with which the specimen does not show any traces of hybridization as per its DFA. The rest of the specimens (n = 13) had to be studied through univariate analysis (table 6.14), since not many traits were available for measurement; of these one individual (MCZ 47448) clearly outsized the rest of the sample, with a large carnassial (25.76 mm), and, although it has a relatively high overlapping index (0.66), it would be accurate to label it as a wolf, particularly when the dimensions from the rest of the sample are taken into account. Another specimen (MCZ 47461) has a relatively high calculated body weight (16.51 kg) and a low overlapping index (0.63); its lower carnassial is however of a medium length (21.38 mm), and the most parsimonious decision would be also to consider it as a wolf. The remaining specimens (n = 11) could correspond to a pariah dog population since all morphometric values fit within this category, as shown by the average values of the traits listed in table 6.14.

<table>
<thead>
<tr>
<th>Trait</th>
<th>MEAN</th>
<th>STDEV</th>
<th>MAX</th>
<th>MIN</th>
<th>N</th>
</tr>
</thead>
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<tr>
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<td>1.152</td>
<td>18.22</td>
<td>16.59</td>
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<tr>
<td>Lower carnassial length</td>
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<td>0.90</td>
<td>21.71</td>
<td>19.24</td>
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<tr>
<td>Index of overlap</td>
<td>0.66</td>
<td>0.02</td>
<td>0.69</td>
<td>0.63</td>
<td>5</td>
</tr>
<tr>
<td>Weight</td>
<td>12.15</td>
<td>1.17</td>
<td>13.63</td>
<td>10.98</td>
<td>6</td>
</tr>
</tbody>
</table>

Table 6.14. Morphometric data of probable pariahs from Haditha. For descriptions of index and methodologies see appendix III.

### 6.6.4. Duhail

In analogy to the previous case, Lawrence (1956) described an osteological series found in another sink-hole, this time located in the surroundings of Duhail, in the eastern-central part of the Qatar Peninsula. As in Haditha herbivore remains (mostly of domestic varieties) clearly outnumber those of *Canis*.

A cranium (MCZ 47465) presents superficially an appearance which is reminiscent of a pariah dog, perhaps of an intermediate type between the short face and the sighthound types; carnassial length is clearly within the pariah range (18.28 mm), and also has a low crowding index value (0.81). Multivariate analysis shows that it belongs to the pariah cluster, although it is quite far from the centroid (fig. 6.68).
Another specimen represented by a gracile cranium (MCZ 47466) exhibits an almost straight face, and has lightly inflated frontals and a downhill neurocranial top line; its cranial capacity index is low (1.56), as its crowding index (0.81); it has a medium size upper carnassial (length= 17.79). Its position inside the pariah dog cluster, very close to the centroid, confirms its identity as a dog.

A very shallow pair of hemimandibles (MCZ 47469) represent a medium weight animal (11.28 kg), with a medium length carnassial (20.35), a low index of overlap (0.62), and a well developed metaconid (score 2); this specimen occupies a peculiar position in the DFA diagram, as it is remarkably close to the wolf jackal centroid (fig. 6.69a); all characteristics seem to suggest the presence of this species, or of a closely related type of protodog, in the sample.

Fig 6.68. Multivariate diagram showing the statistical position of archaeological specimens from Duhail (A: MCZ 47465 and C: MCZ 47466) and from Haditha (B: MCZ 47464) relative to the ranges of variation of three populations of canids, using 18 cranial variables. The first function accounts for 65.4% of the total variance, the second for 34.6%.

A very shallow pair of hemimandibles (MCZ 47469) represent a medium weight animal (11.28 kg), with a medium length carnassial (20.35), a low index of overlap (0.62), and a well developed metaconid (score 2); this specimen occupies a peculiar position in the DFA diagram, as it is remarkably close to the wolf jackal centroid (fig. 6.69a); all characteristics seem to suggest the presence of this species, or of a closely related type of protodog, in the sample.
One specimen (MCZ 47467) represented by a hemimandible displays characteristics in common with MCZ 47469, as it has a medium calculated body weight (11.08 kg), and also a medium length carnassial (20.16 mm); its index of overlapping is however higher (0.66); the metaconid was missing. All these increase the complexity of identifying this specimen as either a dog or a wolf jackal, as all of these values overlap between both forms. The largest Canis remains, in this site, are represented by a rather lateromedially thick hemi-mandible (MCZ 47468) that corresponds to an individual with a calculated body weight of 17.20 kg; this relatively high value strongly contrasts with the short length of the lower carnassial alveolus (19.13 mm); no more crucial values are available for this specimen which on account of its short carnassial suggests it to be a relatively large bodied dog.
6.7. Summary

A wolf skull found in Kanhiapan is, to this date, the earliest evidence of the presence of modern wolves in south Asia; its robust conformation is intermediate between the grey wolf and the pale footed wolf. Wolf jackal remains have been found in the Aurignacian of Algeria and later on in the Natufian of Israel; wolf jackals seem to have survived in Israel at least until the Bronze Age, as a specimen from Tell Duweir exemplifies.

The earliest remains of protodogs in the Middle East have been found in the Levant; these are specimens whose morphology is a mix of primitive and modern characteristics and which eventually evolved into the pariah dog. Genuine dogs consistent with this type are found for the first time in Hayonim Terrace, a Natufian site, and afterwards in a plurality of Neolithic sites from the Middle East to India; as this expansion occurred, new forms of domestic dogs appeared. The earliest dog remains from the Indian subcontinent are dated from the 3rd millennium BC; roughly of a similar age to the remains from East Timor (2,967 +/- 58 BP). A wolf-like protodog from Harappa could indicate the presence of a separate domestication centre in south Asia.

The extreme variability of the Sarab and Jarmo samples seems to suggest a degree of interest among the local population in experimenting with the breeding of dogs. The very probable presence of pale footed wolves, and even of a wolf jackal, in Sarab, well away from their original areas of distribution, reinforces this idea.

The following tables list all the sites I have studied to document this chapter. I have generated separate tabulations for: 1) The Middle East and Asia Minor (table 6.15) 2) North Africa (table 6.16) and 3) other Asian sites (table 6.17). Two maps detailing the location of Middle Eastern and Asia Minor sites are also included (figs. 6.69b, 6.69c).
<table>
<thead>
<tr>
<th>SITE</th>
<th>LOCATION</th>
<th>CHRONOLOGY</th>
<th>TAXA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tabun</td>
<td>Mount Carmel</td>
<td>Palaeolithic</td>
<td>wolf jackal</td>
</tr>
<tr>
<td>Zutiyyeh</td>
<td>North of Sea of Galilee</td>
<td>Pleistocene</td>
<td>protodogs</td>
</tr>
<tr>
<td>Kebara C</td>
<td>Mount Carmel</td>
<td>24 - 14,000 BP</td>
<td>protodog</td>
</tr>
<tr>
<td>el Wad (level B)</td>
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<td>11 - 11,500 BP</td>
<td>protodog</td>
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<tr>
<td>el Wad</td>
<td>Mount Carmel</td>
<td>12,000 BP</td>
<td>protodog</td>
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<tr>
<td>Kebara B</td>
<td>Mount Carmel</td>
<td>Natufian</td>
<td>protodog</td>
</tr>
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<td>Judean desert</td>
<td>Natufian</td>
<td>protodog</td>
</tr>
<tr>
<td>Shukbah B</td>
<td>Judean desert</td>
<td>Natufian</td>
<td>protodog</td>
</tr>
<tr>
<td>Ein Mallaha</td>
<td>Jordan Valley</td>
<td>Natufian</td>
<td>protodog</td>
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<tr>
<td>Hayonim Terrace</td>
<td>Western Galilee</td>
<td>Neolithic</td>
<td>dogs</td>
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<td>North shore Dead Sea</td>
<td>c. 8,500 BC</td>
<td>dogs</td>
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<td>Palegawra</td>
<td>southern Turkey</td>
<td>7,000 - 6,500 BC</td>
<td>dogs</td>
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<td>Suberde</td>
<td>Zagros</td>
<td>c. 7,000-5,600 BC</td>
<td>dogs</td>
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<td>Jarmo</td>
<td>south central Anatolia</td>
<td>7th millennium BC</td>
<td>grey wolves, pale footed</td>
</tr>
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<td>Catal Huyuk</td>
<td>Zagros</td>
<td></td>
<td>wolves and dogs</td>
</tr>
<tr>
<td>Sarab</td>
<td>Zagros</td>
<td></td>
<td>dog</td>
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<tr>
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<td>Mount Carmel coast</td>
<td>c. 7,100-6,300 BP</td>
<td>dog</td>
</tr>
<tr>
<td>Tel Hreiz</td>
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<td>c. 7,100-6,300 BP</td>
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<td>20 k S. of Jerusalem</td>
<td>Bronze Age</td>
<td>wolf jackal</td>
</tr>
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<td>Haditha</td>
<td>Iraq</td>
<td>NA</td>
<td>dogs and pale footed wolves</td>
</tr>
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<td>Duhail</td>
<td>Qatar Peninsula</td>
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<td>dogs</td>
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Table 6.15. Chronology and identity of canid remains found in archaeological sites of the Middle East and Asia Minor.

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<th>CHRONOLOGY</th>
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</thead>
<tbody>
<tr>
<td>Aioun Berich, Ain Beida</td>
<td>Constantine Department (Algeria)</td>
<td>Late Pleistocene</td>
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<td>Abydos</td>
<td>Northeastern Egypt</td>
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<td>dogs</td>
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<td>dogs</td>
</tr>
<tr>
<td>Hawara</td>
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<td>dogs and wolf jackal</td>
</tr>
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<td>Abadiyeh</td>
<td>Northeastern Egypt</td>
<td>NA</td>
<td>dogs</td>
</tr>
<tr>
<td>Dendereh</td>
<td>Northeastern Egypt</td>
<td>NA</td>
<td>dogs</td>
</tr>
<tr>
<td>Gizeh</td>
<td>Northeastern Egypt</td>
<td>NA</td>
<td>dogs</td>
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Table 6.16. Chronology and identity of canid remains found in archaeological sites of North Africa.

<table>
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</thead>
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<td>wolf</td>
</tr>
<tr>
<td>Harappa</td>
<td>Indus Valley</td>
<td>3rd millennium BC</td>
<td>dogs and protodog</td>
</tr>
<tr>
<td>Burzahom</td>
<td>Kashmir</td>
<td>3rd - early 2nd millennia BC</td>
<td>dogs, wolf-dog hybrids and wolves</td>
</tr>
<tr>
<td>Khok Charoen</td>
<td>central Thailand</td>
<td>c 1000 BC</td>
<td>dog</td>
</tr>
<tr>
<td>Matja Kuru</td>
<td>East Timor</td>
<td>2,967 +/- 58 BP</td>
<td>dog</td>
</tr>
</tbody>
</table>

Table 6.17. Chronology and identity of canid remains found in archaeological sites of Asia and East Timor.
Fig. 6.69b. Map of the Middle East and Asia Minor showing the location of archaeological sites mentioned in the text. For details about Levantine sites see fig. 6.69c.
Fig. 6.69c. Map of The Levant showing the location of archaeological sites mentioned in the text.
7.1. The origin of the pale footed wolf

The Kanihiapan wolf has a closer affiliation with the Indian pale footed wolf than with any other form covered by this study. The specimen belongs to a faunal assemblage that inhabited the cool and dry savannas of central India during the late Pleistocene (Frenzel et al. 1992), typified by the presence of, amongst other genera, *Cervus, Boselaphus, Bubalus, Rhinoceros* and *Acinonyx* (Dassarma and Biswas 1977, Frenzel et al. 1992). It may well be that, in agreement with Bergmann’s rule, smaller varieties of pale footed wolf might have lived in the drier and warmer areas of south India (Frenzel et al. 1992) inhabited by *Antilope, Equus, Hyaena, Gazella*, and *Panthera* (Patnaik et al. 2008).

Sotnikova (2001) examined the strong similarities between *Canis mosbachensis* and *C. pallipes*, and found the two putative taxa to be almost identical in many cranial, mandibular and dental characteristics. My own data, when compared with Sotnikova’s documented data, support a strong likeness between them (table 7.1).

<table>
<thead>
<tr>
<th>body weight</th>
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<tbody>
<tr>
<td>Pale footed wolf</td>
<td>16.51 kg (n= 15)</td>
</tr>
<tr>
<td><em>C. mosbachensis</em></td>
<td>15.30 kg (n= 12)</td>
</tr>
</tbody>
</table>

Table 7.1. Comparison of two key morphological traits between the pale footed wolf and its possible ancestor, *C. mosbachensis*.

Note: the pale footed wolf sample consists of specimens from India and Pakistan, the sample of *C. mosbachensis* of specimens from Untermassfeld (Southern Thuringia, Germany).

It would be conceivable then that *C. mosbachensis* was the direct ancestor of the Indian pale footed wolf, and may therefore have survived without undergoing many changes in south India during the late Pleistocene, and expanded through most of the subcontinent at the end of the last glaciation. A larger type of pale footed wolf, probably closely related to the Kanihiapan wolf, may have dispersed, during the late Pleistocene, from central and northwestern India towards the west, eventually colonizing most of the Middle East, including the Levant. Warmer weather patterns during the Holocene may have caused a generalized decrease in size of the Middle Eastern populations.

Sharma et al. (2003) proposed that all wolf types may have their origin in South Asia but only the wolf-dog clade (essentially grey wolves sensu stricto) expanded out of this region; the remaining lineages, including the Indian pale footed, became isolated during the glaciations of the Pleistocene in the Indian Peninsula and stayed there afterwards. Aggarwal et al. (2007) along similar lines suggested that the Indian pale footed wolf derived from a post-jackal pre-wolf lineage that migrated to India during the early Pleistocene and evolved there in isolation into a different species, which they named (unnecessarily) *C. indica*, while the rest of the world was inhabited by the grey wolf lineage. Both hypotheses, particularly the second one, have a degree of consistency with the morphological evidence so far discussed, but
do not explain the strong physical resemblance between Middle Eastern and Indian pale footed wolves.

7.2. Characterization of the pale footed wolf

All populations of pale footed wolves so far discussed have been characterized by showing dog-like features, and are in this respect quite different from the grey wolf. Bivariate analysis of most traits, with the exception of brain size, length of the carnassials and length of the auditory bulla, place pale footed wolves closer to dogs than to the grey wolf; multivariate analysis also supports this. The differences between the pale footed wolf and the grey wolf are absolute – they are diagnostically different, as is required under the Phylogenetic Species Concept.

In the light of this the pale footed wolf must be regarded as a different species. I propose to restore *Canis pallipes* Sykes, 1831 to species rank, to include the pale footed wolf populations from South Asia and the Middle East. It is evident that there is geographic variation in the species; the former is characterized by having long ears, long legs and a narrow chest; the latter is a much stockier animal with shorter legs and ears, a broader chest and a more doglike head that becomes more apparent in summer pelage; reddish tones tend to be more common and more intense in the pelage of *C. p. pallipes*. Both variants seem to overlap over a wide area, from the west coast of the Arabian Peninsula to the Indian subcontinent, and therefore can not be regarded as different subspecies.

7.3. The problematic Levantine pale footed wolf

The Israeli population of pale footed wolves shares many characteristics with the local pariahs: width of the forehead, occipital process and mandible height are almost equally developed in both. The pale footed wolves have larger brains, carnassials and auditory bullae.

Identified “hybrids” do not cluster together in any particular region of the DFA diagrams as would be expected, but they spread over the three main clusters (pariahs and Mediterranean and desert pale footed wolves), indicating how widespread the mixture of wolf-dog traits, in an apparently patternless manner, is within the studied populations.

7.4. Hybrids

The retreat of the permafrost line, at the end of the last glaciation, would have facilitated the expansion of pale footed wolves towards the north and of grey wolves towards the south, until they came into contact in the south-western slopes of the Himalayas. The finding of apparently intermediate forms between the two species in Afghanistan and northwestern India and along the Himalayas would be therefore consistent with a process of hybridization. It would be now difficult to accept the argument that there is no point of contact between the pale footed wolves of the
plains and the Himalayan wolves, and that the Himalayan foothills are devoid of any wolf population (Hodgson 1847, Sharma et al. 2003). The identity of the three specimens of intermediate conformation from north-central China cannot be explained in this manner, as the area is far distant from any known populations of pale footed wolves. For the moment, this must remain problematic.

In the northeastern corner of the USA and in adjacent parts of Canada populations of grey wolves, timber wolves and coyotes regularly hybridize with each other and form successful biotypes such as the "tweed wolf", a coyote – timber wolf hybrid; these new varieties seem to be particularly well adapted to the anthropogenic environments that have been developing in the region during the last 100 years.

Wolf and pariahs in Israel are often difficult to separate, and DFA shows a continuum between both populations in some parts of the diagram; supposed hybrid specimens spread all through it in an apparent random way, even in one case a she-wolf was observed raising what seem to be a litter of dog puppies in a wilderness area of the Judean Desert. The situation as a whole would be difficult to explain until more research is conducted; widespread hybridization could explain the issue in part, although this would be somehow an incomplete explanation only, as the morphology of the so-called hybrids does not seem to follow a homogeneous pattern.

Australian dingoes often show signs of genetic introgression from domestic dogs. Interestingly in many areas this is not superficially apparent and most individuals, hybrid or not, still show many of the characteristics of the pure dingoes, even if hybridization is widespread. DFA shows that dingoes, hybrid or not, still retain a strong identity when compared with closely related varieties such as the Indian pariahs.

Despite the cases I have mentioned above hybridization in the wild is not a common event, and most canid populations covered in this study do not seem to be strongly affected by it.

7.5. The wolf jackal

I have detailed in chapter V the arguments supporting the specific status of the large canids collected along the valley of the Nile, and the presence of the species in new localities of the Arabian Peninsula. A recent work by Rueness et al. (2011) supports a change in the taxonomic status of this population, suggesting that the name *Canis lupaster* is applicable, and expands its geographic distribution to two Ethiopian localities. As shown above, however, the type specimen of Hemprich & Ehrenberg's *Canis lupaster* is a golden jackal, and the available name for the Nile Valley canid is *Canis doederlinii*. The external conformation of this species can be exemplified by a drawing captioned "C. lupaster" published by Anderson (1902), and by a photograph of a wild specimen taken in Lower Egypt by Nemeth-Boka (2007).
7.6. Evolution of the pariah dog

The available literature reflects a considerable amount of dissension among scholars involved in the archaeozoology of the Pleistocene – Holocene transition in the Levant. The faunal assemblages of this period usually contain species ascribable to a transitional Oceanic - Mediterranean climate. It is within this context that the first potential ancestors of the pariah dog are found: the Natufian protodogs. Identifying the wild species that may have given rise to this population can be challenging, as no wolf remains have ever been found in Natufian sites; Dayan (1994) assumed, when she took into consideration climatic data, that the wolf inhabiting the Levant during the Natufian must have been as large as those found in Geometric Kebaran sites (LM1= c. 28 mm). Tchernov and Valla (1997) supported this; they also hypothesized that this type of wolf would make an unlikely candidate for an ancestor of the Natufian dog, because such a severe size reduction must have caused a noticeable shortening of the muzzle and therefore a conspicuous crowding of the teeth, and they were unable to identify anything like this in their sample. My analysis does not always confirm this, and I have found one specimen from the early Natufian (Kebara B, BMNH no catalogue number) displaying a relatively high maxillary crowding index (0.95), of the type found among the short faced wolves of Alaska (see Chapter II), as well as a protodog from Zuttiyeh (BMNH no catalogue number), dated only as “Pleistocene”, which has an overlapping index of 0.68. Furthermore another Natufian protodog from Shukbah A (BMNH SHA) has an overlapping index of 0.67, a value which has been described by Davis and Valla (1978) as evidencing “some degree of overlap”.

Multivariate analysis suggests a possible connection between one Natufian protodog (El Wad – level B, BMNH M16251) and the pale footed wolf. A hemimandibular fragment from a protodog from Shukbah B (BMNH M16252) has an association with both pale footed wolves and wolf jackals in a DFA graph. A mandibular fragment from El Wad (Hebrew University, no catalogue number) has rather large carnassials (25.66 mm) and yielded a calculated body weight of 16.88 kg, its angular process was on the other hand as small as that of a dog. The most parsimonious approach would suggest an intermediate wolf-dog identity.

In any case, multivariate analysis within the Natufian sample indicates that more individuals are associated to the wolf jackal than to the pale footed wolf (Zuttiyeh, BMNH no catalogue number; Shukbah A, BMNH SHA; Shukbah B, BMNH M16252; Ein Mallaha, HU 4130.188, Kebara B BMNH no catalogue number). In relation to this, wolf jackals and pariah dogs are very similar in two slow changing traits: brain size and the length of the lower carnassials. They also have comparable body sizes (table 7.2).
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<th>BRAIN SIZE</th>
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Table 7.2. Comparison of three key morphological traits among the pariah dog and its probable ancestors: the wolf jackal and the pale footed wolf.

Note: the pale footed wolf sample consists of specimens from India and Pakistan.

Available data appear to indicate a mixed origin for the Natufian dogs. It seems likely that the type of wolf jackal that contributed to this hybrid form was very similar to that currently existing in Egypt; the pale footed wolf inhabiting the Levant at the time would be exemplified by the specimen found at Kanhiapan (see below), as Bergmann's rule and the data on teeth crowding in protodogs may suggest; it was much larger than any of the contemporary forms of pale footed wolf.

An overview of most of the dog-like specimens found so far in the Levant (table 7.3) suggests that two different basic morphologies can be identified within the protodog sample, pale footed wolf-like and wolf jackal-like, while one individual, from Kebara B, can only be described as intermediate between the two forms. The evolutionary pathway from wild species into domestic or semi-domestic varieties is represented by transitional forms; these can be characterized as displaying relatively large carnassials, small or moderately sized angular processes, and a body weight approaching that of the protodogs.

The chronology of the Middle Eastern dog-like canids needs to be reconsidered as a specimen (BMNH KC) from the Kebaran period (24 – 14,000 BP) is a clear protodog, also intermediate between the pale footed wolf and the wolf jackal.

The first genuine dogs come from the Late Natufian deposits of Hayonim Terrace; they are remarkably similar to pariah dogs.
Table 7.3. Chronological and morphological data from Natufian and Kebaran samples.

Data discussed above seem to support a dual origin (wolf jackal – Levantine pale footed wolf) for the pariah. This hypothesis agrees, at least in part, with Koler-Matznick’s (2002) views on the origin of the dog, which she saw as independent from any grey wolf lineage.

**7.7. Neolithic dogs from the Middle East and Asia Minor**

I have documented above the presence of pariah-like dogs in seven different Neolithic sites, spread over a large area from the Levant to the Zagros in the east and the Anatolian Peninsula in the north; at least by the end of this period, dogs were dispersed over this region. The basic conformation of the specimens covered by this study is that of a medium sized animal with uncrowded or lightly crowded dentition and no particularly exaggerated morphological traits; most of the specimens, from all sites, which have been analyzed through DFA are strongly connected to modern pariah populations. A village dog type was also identified in one site. The population found at Suberde has a rather unusual conformation, characterized by a short facial region, teeth crowding, recurved mandibles and an overall robust appearance; DFA still identifies it as akin to the Israeli pariah. Most of the specimens analyzed show a stronger connection with the wolf jackal than with the pale footed wolf. Wolf remains, and a limited amount of wolf-hybrids, have been found in two of the sites.

**7.8. Neolithic dogs from South Asia**

The sample from this region is substantially diversified: Harappan dogs are, with only one exception, of the same type that can be currently found in India,
particularly in the northwestern region, and this applies also to the specimen that was described by Prashad (1936) as *Canis tenggeranus* (although it has nothing to do with that putative species). Burzahom canids are of varied type; the most common are broad headed pariahs of a particularly robust type, there is also a large village dog with a highly paedomorphic skull, and the third type is a larger dog that does not show any particular association with the pariah type but nor does it seem to be a wolf hybrid, although two specimens from this site were identified as wolf-dog hybrids. One specimen from Harappa (Zoological Survey of India HP 73) had been labelled as a pale footed wolf, although DFA identified it as a pariah dog; it has abnormally large carnassials and auditory bullae, an assortment of characters that may identify it as a protodog. Large long bones seem to reveal the presence of wolves in Burzahom, although the specific adscription of the remains could not be investigated due to the lack of cranial or mandibular elements.

7.9. Neolithic dogs from Southeastern Asia

The type of dog found in five different archaeological sites of north and central Thailand corresponds to the typical pariah and to a lesser extent to the village dog (Higham et al. 1980, this work). No evidence of hybridization with any wild variety has been found.

7.10. The Timor dog

This Neolithic specimen (2,967 +/- 58 BP) represents a village dog and is probably closely related to similar village dog populations currently inhabiting New Guinea and Island Southeast Asia.

7.11. Dog remains of undetermined chronology

Some archaeological remains from Egypt of inconclusive chronology, found at eight different sites, represent a sample which is very similar to the contemporary Egyptian pariah, and also has characteristics in common with the Israeli and the Inner Middle East populations (see chapter III). We can detect the presence of a larger pariah type as well as of village dogs, none of them showing any signs of hybridization with wild varieties.

Two undated sink holes in Haditha (Iraq) and Trucial Oman (Qatar) have also provided a significant amount of pariah dog remains.

7.12. The expansion of the pariah

All data discussed above points out towards a Middle Eastern origin for the pariah dog and the rapid expansion of this type within Neolithic cultures, from the Middle East through Southern Asia towards Southeastern Asia.
7.13. Modern pariahs

Current populations of pariahs have been documented in the Middle East, South Asia and Southwestern Asia. The basic morph is the dingo type, and its presence in some isolated and remote parts of the world, far removed from contact with other dog types or even other pariah morphotypes, as well as the unspecialized conformation, suggests a primitive status within the pariah dog lineage; it seems to retain characteristics attributable to the early dogs that evolved in the Middle East during the Natufian period. This type shows no exaggerated features of any kind: it has a medium body weight, well proportioned head size and leg length, a medium length hooked tail, a relatively long snout and pricked ears. Ginger coloration dominates in the pelage of this type.

Menzel and Menzel (1960) recognized four different morphotypes in Israel, and I have found another four in India, two of which are different from those described by them and the other two correspond to morphotypes that they described. Multivariate analysis indicates that all pariah dog populations covered in this study are rather similar, despite some local differences as noted above, which seems to suggest a common origin. The village dog type is of particular interest since it appears to be the most common type found over Island Southeast Asia, as well as in Africa, the Middle East, South Asia and continental Southeastern Asia.

Current populations of pariahs have been documented in the Middle East, South Asia and Southeastern Asia.

7.14. Domesticity of the pariah

Koler-Matznick (2002) defined “reduced rostrum, elevated frontals, wider palates, broader craniums and smaller teeth” as key characteristics to separate domestic dogs from grey wolves. The following graphs give only partial support to her statement (figs. 7.1, 7.3, 7.4; see also figs. 4.35, 4.36, 4.42, 4.43).
The length of the rostrum (fig. 7.1) is on average longer in wolves (both grey and pale footed), but specimens from all analyzed taxa can be found above and below the line of isometry.

Fig. 7.1. Graph of rostral length against basion-hormion length in populations of wild and domestic canids.
Fig. 7.2 shows that the grey wolf sample has remarkably high cranial vaults, which tend to be much lower in pale footed wolves. The Indian pariah sample also has rather high vaults, although some specimens fall below the line of isometry.

Fig. 7.2. Graph of cranial height against basion-hormion length in populations of wild and domestic canids.
Grey wolves and pale footed wolves tend to have rather wide palates, which are almost matched in terms of relative size by the Indian pariahs (fig. 7.3).

Fig. 7.3. Graph of palate width against basion-hormion length in populations of wild and domestic canids.
Zygomatica are noticeably wider in the grey wolf sample, while the rest of the groups show a very similar development for this trait (fig. 7.4).

Fig. 7.4. Graph of head width against basion-hormion length in populations of wild and domestic canids.
The length of the auditory bulla, relative to body size (fig. 7.5), seems to be an acceptable divider between wolves and Indian pariahs, and in the case of the Israeli pariahs even its absolute length could be helpful to discriminate between pariahs and wolves. There are however some overlaps between all the clusters. Nonetheless this is one of the few traits where grey wolves and pale footed show a high degree of similarity.

![Fig. 7.5. Graph of auditory bulla length against basion-hormion length in populations of wild and domestic canids.](image)

Tooth size was analysed through bivariate analysis in chapter III. Results indicate that grey wolves usually have larger teeth than the other groups; pale footed wolves occupy an intermediate position between grey wolves and pariahs, but overlaps between both groups abound.

To this list Stockhaus (1965) and Hemmer (1990) added a smaller cranial capacity; although Hemmer warned that this is not directly applicable to pale footed wolves which may have much smaller brains than grey wolves, very often similar in size to those of dogs. My own analyses confirmed Hemmer’s ideas (see chapter III).

Taking into consideration average values, results from this research seem to confirm that grey wolves have larger brains and teeth than pariahs; surprisingly they also have larger cranial heights and broader heads and maxillae. The case of the pale footed wolf needs to be treated more carefully as it presents a wide range of...
variability; it is usually closer to the pariah group than to the grey wolves in all traits except in the case of brain and teeth size, where it seems to fill in an intermediate position between the two extremes. Wolves seem to have on average longer snouts than the rest of the groups, although the differences are not outstanding, and again overlaps are common.

In 1959 Dmitry Belyaev, a Russian scientist, started to select silver foxes exclusively for tameness, from an original population of fur farmed animals (Belyaev and Trut 1975, Trut 1999, Trut et al. 2009). Today after more than 50 years the experiment continues. Perhaps one of its more remarkable aspects is the surge of novel, not selected for, morphological traits within the experimental population. Characters usually considered typical of domestic dogs, such as piebald coats, shorter rostrums, floppy ears and curled up tails, seem to appear more often as the selection process progresses and the foxes become more friendly towards their human caretakers. This has been attributed to a complex genetic process by which the selection process favours those specimens with lower levels of corticosteroids; it is argued that the genes that control the formation of these compounds are also connected to the expression of other genes, such as those that regulate the expression of the characteristics previously listed. My field work in India has detected such traits among pariah dog populations, with the exception perhaps of shortening of the rostrum (fig. 221); this would be in agreement with the previously cited observations on captive foxes if we accept that even unregulated populations of domestic animals could be selected for tameness.
Fig. 7.6. Broad head and sighthound type pariahs from Melkote (Karnataka). Both together exemplify some of the morphological characteristics that commonly appear during the domestication process, such as piebald colours, floppy ears and curled up tails. The rope around the neck of the black and white dog signifies its status as a privately owned hunting dog.

Tchernov (1984) defined commensalism as a type of symbiosis, characterized by the fact that only one of the organisms (the commensal) of the two involved benefits from the relationship. He also proposed that the other element (the host) would neither profit nor receive any harm. The point of the host being only a passive element within the relationship could however be a contentious issue. Detailed discussion of this would be out of the scope of this work; it would suffice to say at this time that these relationships are hardly ever neutral for the host and that examples of this abound: mice, rats, pigeons and dogs to cite just a few. It would be perhaps more accurate to say that the commensal moves into the host’s environment and clearly benefits from the relationship, while the host could receive harm or benefit (or both) or, more rarely, neither. Nonetheless it was suggested that before its domestication the dog could have been a commensal species (Tchernov 1984, Tchernov and Horwitz 1991, Tchernov and Valla 1997). Adding to this argument Tchernov and Horwitz (1991) and Tchernov and Valla (1997) contemplated the possibility of wolves moving into the new, and secluded, anthropogenic environments created around the Natufian settlements; the morphological changes that followed were just a consequence of the adaptation to novel conditions, but unrelated to artificial selection (Tchernov and Horwitz 1991). In connection to this they described a generalized decrease in body size for most would-be domestic species, but only as an adaptive strategy not linked to any conscious effort by humans. However, as commented before, there is not a large
difference between the average body weight of the Natufian dogs and protodogs (14.54 kg, range= 11.49 – 16.88 kg, stdv= 1.94, n= 6) and that of their ancestors, the wolf jackal (12.52 kg, range= 9.26 – 15.77 kg, stdv= 1.7, n= 35) or the pale footed wolf (16.51 kg, range= 13.63 – 19.96 kg, stdv= 1.89, n= 15).

Following, in part at least, the previously discussed hypotheses, it would be agreeable with my data to develop now a vision of a scenario where changes, brought about by humans during the Natufian, attracted wild canids such as wolf jackals and pale footed wolves to the surroundings of these first semi-permanent settlements, by an abundance of rodents and the availability of food refuse; from here a commensal relationship between humans and canids may have developed (it must be highlighted that since the initial stages this relationship must have been beneficial for all species involved). This situation could have evolved into a closer one, in some cases, as humans realized the potential of the canids as wardens, hunters and companions, this could have lead to domestication and eventually to the development of breeds; in other places the dogs may have remained as purely commensal animals, domestic but not domesticated, until today. It is also very likely that in the early phase of semi-domesticity pale footed wolves and wolf jackals hybridized; this may explain the presence in the sample of specimens of an intermediate nature (although wolf jackal morphology seems to predominate).

The Neolithic saw a rapid expansion of dogs all through the Middle East, and from there to South Asia and Indochina, places that still host sizable populations of pariahs often living as commensals that never underwent domestication; they are good examples of the morphological transformations that took place during the transition from the wild to the domestic stages.

7.15. The Australian dingo

The external morphology of the dingo is very similar to that of the pariahs and particularly to the “dingo type”. The skull, and principally the cranium, is however very different as shown by multivariate analysis; even dingo hybrids still cluster separately from other pariah dog populations. Some of the peculiar characteristics of the dingo skull, when compared with pariah dogs, are: a low cranial height, a well marked depression on top of the cranial roof, well developed sagittal and nuchal crests, a conspicuous occipital process, large auditory bullae, and thick mandibles. These are characteristics which are peculiar to the dingo and not common in any pariah population, but can be found among wolves and are presumably associated with a predatory lifestyle.

The dingo sample follows almost identical clustering patterns to the wolf jackal in nine out of 12 traits studied through bivariate analysis, but have thicker mandibles and better developed occipital processes than wolf jackals. Dingoes and wolf jackals show equal development of two slow changing traits: length of the carnassials and brain size. DFA also confirms the proximity between both groups.

Dingo hybridization is a contentious issue. My work shows that even dingo hybrids are in most cases very “dingo like” and are perfectly differentiable from other
canids, including closely related varieties such as the pariah dogs (see subchapter on hybridization). Efforts to clarify the question of what is and what is not a pure dingo have not always been successful: Elledge et al.'s (2006, 2008) attempts to correlate morphology with genetics led to inconclusive results.

A more constructive approach was followed by Daniels and Corbett (2003) when they acknowledged the existence of hybrids living in the wild. They emphasise that the dingo still exists, although in some cases it may have experienced changes that could be attributed to hybridization; nonetheless these hybrids still have the same basic appearance and the same ecological function as pure dingoes. Jones (2009) reached very similar conclusions when working with wild Canis from the Victorian highlands.

7.16. Origin of the dingo

Storm (2001) provided evidence of the presence at the present time of medium sized pariahs in Java (lower carnassial length average= 18.32, range= 19.4 - 17.3, n= 4). Two of these specimens were identified as "hybrid dingo" after the application of Corbett's (1995) canonical equation (Storm 2001). Regrettably not much more information seems to be available, at the moment, about this population. Gollan (1982) referred to an archaeological specimen found in Timor that was “dingo size”, but he objected that the chronology was too recent and that it could not be considered in principle as ancestral to the dingo. I myself have seen some privately owned photographs of village dogs taken in Borneo, Cebu and Palau whose external morphology is certainly dingo-like.

Savolainen et al. (2004), using molecular methods, traced the origin of the dingo to >3,500 BP. Only a small number of animals seem to have been the founders of the Australian population, for which they proposed an East Asian origin. Their findings are largely consistent with archaeological data, the oldest known dingo materials (those from Madura cave) being dated at 3,450 +/- 95 BP (Milham and Thomson 1976).
Chapter VIII
Conclusions

The analysis of the samples covered in this study confirmed some of my initial hypotheses, but also brought up some unexpected findings, and opened the door to completely new issues of great interest. As a consequence the topics covered by this thesis surprisingly expanded as the data analysis developed. This is particularly true in all matters related to the wild canids that may have had a role in the ancestry of the domestic dog. It has become now obvious that our knowledge of the taxonomy and zoogeography of the wolves, and closely related canid forms, from India and the Middle East, was deficient and that there was a need to resurrect some of the old ideas on the classification of the taxa, elaborated during the last century. These concepts now appear, with the benefit of hindsight and more specimens available for study, more thought provoking than ever before. This approach has also proved invaluable to develop a better understanding of the more significant themes involved in the origin and evolution of dog types. With the objective of facilitating a quick comprehension of the findings of this work, I have summarized in the next paragraphs some of the significant aspects that I have identified and discussed.

1) The taxon *pallipes* is substantially different from *Canis lupus*; it also lacks homogeneity, as there are conspicuous morphological divergence between the Middle Eastern and the Indian populations. All available data support the view that the pale footed wolf is morphologically closer to the pariah dog than to the grey wolf for most of the traits analyzed through bivariate analysis; there are only a few of them such as auditory bulla length, brain size and teeth size that may be of some assistance to differentiate remains of pariahs and pale footed wolves. Even whole skulls may be difficult to identify unless DFA is conducted. In comparison, grey wolf remains tend to be much more diagnostic due to their size and robusticity. Although identifiable as a part of the same taxon as the Indian population, the Israeli pale footed wolf has some very dog-like characteristics; equally the Israeli pariah population is very wolf-like. It could be conjectured that this is due to a close phylogenetic relationship still being clearly perceptible. Explanations based on the hypothetical existence of a widespread hybridization process in Israel do not seem to be an acceptable option since those specimens identifiable as hybrids do not show their traits combined along any particular pattern; on the contrary, statistics demonstrate apparent random manifestations of both dog and wolf characters in both groups.

2) This work confirms the presence in Israel of Mediterranean and desert varieties of pale footed wolf. The latter has expanded into the Negev and probably over at least the northern half of the Arabian Peninsula, absorbing or displacing the Arabian wolf in the process. The Arabian wolf, still identifiable by some specimens displaying a diagnostic external conformation, seem to be surviving only in the southern half of the Arabian Peninsula, where hybrid specimens with pariahs have been also recorded.
3) The Indian wolf could inhabit a wide region from the west of the Arabian Peninsula and Mesopotamia to West Bengal. The northwestern limits of its distribution are not known; equally its presence in Iran and Afghanistan needs to be confirmed. Specimens identifiable as Middle Eastern pale footed wolves have been collected mostly around the west side of the Middle East, although an isolated specimen was found in India. There seems to exist therefore a wide area of overlapping between the eastern (Indian) and western (Middle Eastern or Levantine) morphotypes of pale footed wolves, gravitating around two main core areas: the Indian subcontinent and the Levant.

4) The taxonomy of the grey wolves from southern and central Asia is complex. Hybrids with pale footed wolves seem to be tolerably common in the eastern and central Himalayas and in adjacent areas of central Asia. Also, the sample initially identified as *C. l. chanco* is perceptively very heterogeneous and could represent more than one taxon. More data need to be collected to clarify these issues. This work has confirmed the presence of grey wolves in northern Israel; furthermore three vagrant individuals have been documented in the southern half of the country, in areas that were typically inhabited by pale footed wolves. Archaeological remains of the grey wolf tend to be much more easily recognizable than those of pale footed wolf, due to their size and robusticity.

5) Multivariate analysis has demonstrated that the often overlooked wolf jackal of the Nile Valley can be now considered significantly different from wolves and jackals, and constitutes a clearly differentiable taxon, for which the correct name is *Canis doederleini*. Its current geographic distribution covers also the Arabian Peninsula and perhaps North Africa. There are some interesting similarities between the Indian pale footed wolf and the wolf jackal, which are very possibly plesiomorphic, that is to say connected to the primitive status of both forms, and this needs further study. Likewise the possible subspecific identity of the Arabian populations of wolf jackal requires to be explored.

6) The pariahs are primitive dogs which origin goes back to the Natufian dogs of the Levant (see below). They are characterized by displaying a characteristic morphotype that is not always homogeneous but always identifiable, and which typologies are constant within certain geographies (see below), and also by mostly living a commensal lifestyle around human settlements. Conceivably these populations are a part of a biological continuum that developed during the Mesolithic in the Levant, as dog populations expanded (as the archaeological record demonstrates) following humans during their travels and migrations. As the process unraveled some dog groups, due to cultural circumstances (beyond the scope of this work), must have kept their original niche – as domestic animals - without becoming domesticated in the strict sense of the word. Today we refer to them as “pariahs” and they can still be found, largely unchanged in morphology and lifestyle, living as commensals in some parts of the world such as India and the Middle East.

7) Pariah dog populations from Egypt, Israel and India are perceptibly alike. The Israeli sample shows more wolf-like characteristics than the others; this
circumstance is difficult to elucidate, as widespread hybridization does not suffice as an explanation (see above).

The most morphologically primitive type of pariah dog that I have been able to identify displays an external morphology that is similar to that of the Australian dingo, although its cranial features are noticeably different; this form has been identified in Israel, India and Thailand. It tends to diversify into two basic morphs: a gracile one usually called the "sighthound type" and another much more robust, the "broad head pariah". This separation can be documented in India and the Middle East as early as 5,000 BP, and clearly announces the origin of sighthounds and of heavier forms such as hounds and mastiffs, from which many other types and ultimately breeds originated.

The widely cited village dog has now been identified as a genuine subtype of the pariah dog; it inhabits a wide spread of terrain from the African continent through India and southeastern Asia to New Guinea; its presence has been documented in archaeological sites of Egypt, Israel and India.

8) The external morphology of the dingo clearly resembles that of a pariah of the dingo type and in this regard the evidence is so compelling (including chronological and geographical factors) that the Asian pariah dog must be considered as the ancestor of the Australian dingo. Paradoxically dingo craniometrics is rather original, and in fact the dingo skull has traits which can only be found in a wild species and that are combined in a pattern that is uniquely dingo-like. Some of the most significant peculiarities of the dingo skull are:

A highly developed depression on the cranial roof.
The great size of sagittal and occipital crests as well as the development of a large occipital process.
An increase in size of the auditory bulla.
A lowering of the height of the skull
An increase in mandible thickness.
A pronounced increase in the length of the diastema between the second and the third lower premolars.

9) Data collected during this research indicate the great similarity of the dingo skull with that of the wolf jackal, to the point that the bivariate distributions, relative to basion – hormion length, for 10 characters are almost identical for both groups. DFA also shows a high degree of similarity between both. It could be hypothesized then that the dingo has followed a process of reversion to one of the wild ancestors of the pariah dog (see below); this process may have been triggered by the need to adapt to a wild environment far removed from the commensal lifestyle of the pariah dog (dingoes associated with Aboriginal camps being probably only a fraction of the total population). In all likelihood the process is still ongoing and hybridization, at least in many localities, does not seem to be stopping it, as the phenotypic contribution of domestic dogs to dingo populations is actually absorbed and re-shaped into dingo-like canids.

10) Despite an abundance of mostly anecdotal evidence claiming the contrary, many dingo populations still keep a significant degree of morphological identity, irrespective of relatively high levels of hybridization The review of written sources,
from the early days of the colony, are also drawing attention to the possibility of the "original" dingo having a less homogeneous phenotype than previously thought.

11) The point of origin and the access route of the ancestor of the dingo to Australia are still unknown. The simplest approach, at this stage, could be to assume that it was brought to Australia by earlier Austronesians, as its time of arrival seem to correspond to the time of the Austronesian expansion.

12) Hybrids are present among wild and domestic populations of Canis. Some dog and wolf populations from South Asia, the Middle East and North America appear to be inextricably linked, by a long chain of hybridization events, which may have contributed greatly to the current biological identity of both groups. This could imply that hybridization, at least in these cases, has adaptive value and ought to be understood as a process contributing towards the ecological success of the wolf/dog clade.

13) Natufian faunal assemblages seem to suggest a climate of a humid continental type, interspersed with warm and cold breaks such as the Bolling-Allerod (circa 15 – 13,000 BP), and the Younger Dryas (circa 12.7 – 11,500 BP). These circumstances would allow, at least in theory, for two different types of wolf to inhabit the area during the period, and perhaps occasionally at the same time, as happens currently in northern Israel or in the foothills of the Himalayas.

14) The origins of the Natufian dogs, almost for certain predecessors of the pariah dogs from the Middle East, seem to be linked to the pale footed wolf (not to the grey wolf) and to the wolf jackal. Specimens from a sample of Natufian protodogs kept at the British Museum exhibit clear similarity with one or the other or with both at the same time. The similarities with the wolf jackal are particularly striking, and perhaps unexpected, since they concern key morphological aspects such as body size and slow changing traits like cranial capacity and teeth size. Individuals showing similarity with the pale footed wolf tend to look more primitive, and have characteristics usually associated with the wild canids together with others that can only be related to domestication. The presence of pale footed wolves in Israel during the Natufian, as explained before, can not be ruled out and in fact it seems very likely that a wolf of the "Kanhiapan type", or even smaller, inhabited the area during the warmer periods of the Natufian, as this was a larger type of pale footed wolf that lived in the temperate regions of Central India during the Pleistocene.

15) A specimen from Kebara (dated 24,000-14,000 BP) could be the oldest evidence of the presence of protodogs in the Middle East.

16) The intermediary characteristics of a skull from Harappa seem to suggest a (wolf-dog) protodog. This could imply the existence of an independent domestication centre in the region. A second specimen has obvious dog characteristics, although its brain size is closer to a wolf; its identity is therefore in question.

17) Three Asian Neolithic sites located in mountainous regions show a high degree of variability in their canid sample. At least two different types of dog can be clearly identified in Burzahom, as well as wolf-dog hybrids and grey wolf remains. The
fragmentary nature of the samples from Sarab and Jarmo do not allow the identification of dog types, although the variability of the sample seems to suggest the existence of more than one type. Gray wolves, and their hybrids with dogs, have been identified in both sites. The probable presence of pale footed wolves and of one specimen of wolf jackal in Sarab, in both cases far away from their original areas of distribution, could signify a high degree of interest amongst the local population in the breeding of canids.

18) My analyses do not support a separate specific identity for the New Guinea Highland Dog, although it has a very peculiar conformation intermediate between the village dogs and the dingo. It has some traits such as large auditory bullae, well developed occipital process, a relatively low cranium and in some individuals well developed sagittal crests and rather flat facial regions, such as are usually found in wild forms and particularly in the dingo. It is also evident that the frequent ginger coloration with white socks seems to suggest a similarity to the dingo. Other traits like head and maxillary widths and facial length seem to reveal the influence of a domesticated strain. More data are obviously needed, but considering the available information, the New Guinea highland dog seems to be a relatively stabilized hybrid between the dingo and some of the local types of village dogs.

19) It would be difficult to support a separate specific identity for the Harappan dog, as described by Prashad (1936); its morphology is consistent with that of the Indian sample of pariahs.

20) Pocock (1941) and Olsen (1985) identified the presence of aberrant canid specimens in their samples. This study confirms and reinforces their observations, as a significant number of individuals with non-typical manifestations for some traits, or a combination of traits, was found through all the types of analysis used. An extreme case of this was identified in sample from Bihar; the specimen in question presenting intermediate characteristics between the pale footed wolf and the wolf jackal. It could presumed that this might be due to the retention of primitive traits in some wolf populations which are closer to the original centre of dispersion of the pale footed wolf in southern India (the wolf jackal arguably being the ancestor of *C. mosbachensis* the most probable predecessor of the pale footed wolf).

21) Morphological changes from the wild ancestors (the pale footed wolf and the wolf jackal) to the domestic form (the pariah dog) can be numerically subtle or virtually non-existent; very often it is not possible to visually ascribe, with any certainty, incomplete remains to any of the varieties previously mentioned. Nevertheless, throughout this work I have been able to identify some morphological traits that, on average, are affected by change during this transition; please note that I refer to changes in a proportional sense of the size of the skeletal element in question as related to total body size of the specimens (as expressed by the distance from basion to hornion).

*The transition from the pale footed wolf to the pariah is characterized by:*
A decrease in teeth size
A decrease in brain size
An increase in the width of the forehead
A decrease in facial length
An increase in cranial height
A decrease in the size of the auditory bulla

The transition from the wolf jackal to the pariah is characterized by:
An increase in cranial height
An increase in the height of the mandible
A decrease in the size of the auditory bulla
A decrease in the size of the LM1 metaconid
A decrease in the development of the cingulum on UM1, which becomes incomplete in most cases.

Brain and teeth size as well as body weight do not seem to experience any significant change in the transition from the wolf jackal to the pariah. Also contrary to the general opinion maxillary width and zygomatic breadth do not seem to experience any substantial changes; the same applies to teeth crowding. These are processes that will take place later as domestication follows its course, as samples from the Neolithic exemplify.

The external morphology of the pariah clearly shows the effects of domestication as described by Belyaev and Trut (1975), Trut (1999) and Trut et al. (2009). Some of these characteristics are curled up tails, piebald colouring and floppy ears. In agreement with the work of Menzel and Menzel (1960) in Israel, four different types of pariah were identified during my fieldwork in India. The development of different morphotypes, perhaps not directly related to artificial selection, has also been documented in the archaeological record of the Neolithic.

22) The only available fossil wolf from the Indian subcontinent (dated 10,000 BP+) is large and robust, somewhat different from the rather gracile modern Indian wolf. Its peculiar morphology may help to understand a type of wolf that could have inhabited the Mount Carmel region during the Natufian period.

23) Much work is still needed in many subjects connected to the identity of primitive domestic dogs and wolves, such as clear definitions of the geographic limits of the wolf jackal in North Africa and the Middle East and of the pale footed wolf in the Middle East and central Asia. Our knowledge of the current pale footed wolf and pariah populations from Israel could also benefit from a detailed study correlating external conformation and craniometrics.

It would be as well of great interest to collect more data on the New Guinea highland dog to ascertain whether this is beyond doubt a stabilized dingo-village dog hybrid.

It is also becoming apparent that scientists and government agencies need to approach the subject of dingo hybridization in a less casual manner, as it is becoming apparent that hybrid populations have the potential to retain a very high degree of dingo identity, and in consequence they may have a significant biological value far from the usual description as “wild dogs”.

307
APPENDIX I
COLLECTIONS


Bombay Natural History Society (BNHS). Bombay.

Department of Anatomy. Madras Veterinary College (MVC). Madras.

Regional Museum of Natural History (RMNH). Mysore.


Anthropological Survey of India (ASI). Mysore.

Mysore Zoological Gardens (MZG). Mysore.


Department of Anatomy and Histology. Veterinary College. Karnataka Veterinary Animal and Fisheries Sciences University (KVAFSU). Bangalore

Department of Veterinary Anatomy. Bombay Veterinary College (BVC). Bombay.

Deccan College (DCP). Pune.


University of Tel Aviv (UT). Tel Aviv.

Hebrew University (HU). Jerusalem.


Peabody Museum (PM). Harvard University.

Museum of Comparative Zoology (MCZ). Harvard University.


Field Museum of Natural History (FMNH). Chicago.
Natural History Museum, formerly British Museum (Natural History) (BMNH). London.

Harrison Institute (HZM). Sevenoaks.

Senckenberg Museum (SMF). Frankfurt.


Musée Zoologique de la Ville de Strasbourg (MZS). Strasbourg.

Queensland Museum (QM). Brisbane.

School of Pacific Studies. Australian National University (ANU). Canberra.

School of Archaeology and Anthropology. Australian National University (ANU). Canberra.

APPENDIX II
MEASUREMENTS

Most of the osteological measurements used in this work were sourced from von den Driesch (1976). A smaller amount was obtained from Corbett (1995) and Davis and Valla (1978), or was specifically developed for this research by myself. Extended descriptions of certain measures have been added when deemed necessary. All subjective estimates were developed by me.

CRANIAL

I) Total length (von den Driesch 1976): from akrokranion to prosthion.
II) Basicranial length (von den Driesch 1976): from basion to prosthion.
III) Zygomatic breath (von den Driesch 1976): from zygion to zygion.
IV) Upper neurocranium length (von den Driesch 1976): from akrokranion to frontal midpoint.
V) Greatest neurocranium breath (von den Driesch 1976): greatest breath of the braincase, from euryon to euryon.
VI) Least breath between the orbits (von den Driesch 1976): from entorbitale to entorbitale.
VIII) Length of auditory bulla (greatest diameter of the auditory bulla, von den Driesch 1976): from the most aboral point of the bulla on the suture with the paraoccipital process up to the external carotid foramen.
IX) Maximum maxillary width (Corbett 1995): Is the greatest palatal breadth (von den Driesch 1976) but measured across the outer borders of the alveolar junction of the 4th upper premolar and 1st upper molar.
X) Opisthion to akrokranion (Corbett 1995): measured from the upper border of the opisthion (excluding the notch if present) to the midpoint of the akrokranion. 2nd
XII) Viscerocranium length (von den Driesch 1976): from nasion to prosthion.
XIII) Snout width across the outer margins of the alveoli of the canines (breath at the canine alveoli, von den Driesch 1976): distance across the snout between the external borders of the canine alveoli.
XIV) Cranial height (Corbett 1995): from the upper point of the external auditory meatus to the bregma, including the sagittal crest if present.
XV) Palate length (median palatal length, von den Driesch 1976): from staphylion to prosthion.
XVI) Length of the upper dental series (this research): from the posterior alveolar rim of UM2 to prosthion.
XVII) Basion – hormion (hirnstambasis, Albert Heim foundation website)
XVIII) Mid crown length of the upper carnassial (von den Driesch 1976)
XIX) Mid crown width of the upper carnassial (greatest breath of the carnassial, von den Driesch 1976): measured through the highest cusp in a lateral direction.
XX) Length of the upper carnassial alveolus (von den Driesch 1976)
XXI) Basal length of UC1 (Corbett 1995): basal crown length of the upper canine, measured along the tooth row.
XXII) Distance from the posterior alveolar rim of the upper canine to the posterior alveolar rim of the carnassial (Corbett 1995).
XXIII) **Length of cheektooth row** (von den Driesch 1976): from the anterior alveolar rim of the upper 1st premolar to the posterior alveolar rim of the 2nd upper molar; measured along the alveoli on the buccal side.

XXIV) **Alveolar length of the upper molar row** (von den Driesch 1976): measured along the alveoli on the buccal side.

XXV) **Length of the upper molar row** (this research): measured from the anterior edge of the cingulum of the 1st upper molar to the posterior edge of the cingulum of the 2nd upper molar.

XXVI) **Length from the anterior alveolar border of the 1st upper premolar to the posterior alveolar border of the 3rd upper premolar** (this research).

XXVII) **Cranial capacity** (Groves, pers. comm. 2004): total volume of the cranial cavity.

**MANDIBULAR**

XXVIII) **Total length** (Different from total length, von den Driesch 1976): from the angular process to the infradentale (von den Driesch 1976).

XXIX) **Length from the indentation between the condyle process and the angular process to infradentale** (von den Driesch 1976).

XXX) **Height of the mandible behind the carnassial** (von den Driesch 1976): measured on the lingual side and at right angles to the basal border.

XXXI) **Height of the mandible at front of LM1** (this research): measured on the lingual side and at right angles to the basal border.

XXXII) **Length of the lower cheektooth row** (von den Driesch 1976): distance from the anterior alveolar border of 1st lower premolar to the posterior alveolar border of the 3rd lower molar.

XXXIII) **Length of the lower molar row** (von den Driesch 1976): distance from the anterior alveolar border of the carnassial to the posterior alveolar border of the 3rd lower molar.

XXXIV) **Mid-crown length of the lower carnassial** (von den Driesch 1976)

XXXV) **Length of the lower carnassial alveolus** (von den Driesch 1976)

XXXVI) **LP2 – LP3 diastema** (this research): distance from the posterior alveolar border of the 2nd lower premolar to the anterior alveolar border of the 3rd lower premolar.

XXXVII) **Alveolar length from the anterior alveolar rim of the 4th lower premolar to the posterior alveolar rim of the 1st lower molar** (Davis and Valla 1978).

**POST CRANIAL**

XXXVIII) **Greatest length of the atlas** (von den Driesch 1976): taken from the facies articularis cranialis to the facies articularis caudalis.

XXXIX) **Greatest length of the humerus** (von den Driesch 1976)

XL) **Greatest length of the radius** (von den Driesch 1976)

XLI) **Length of ulna** (von den Driesch 1976)

XLII) **Length of tibia** (von den Driesch 1976)

XLIII) **Length of femur** (von den Driesch 1976)

XLIV) **Femur circumference** (von den Driesch 1976): smallest circumference of the diaphysis.
SUBJECTIVE STIMULATIONS (CRANIUM AND MANDIBLES)

A) Convexity of the lower border of the horizontal ramus: scored from -3 (clearly concave) to 3 (very convex).
B) Curvature of the lower dental series: scored from 0 (dental series following a straight line) to 3 (dental series following a much curved line).
C) Metaconid development at LM1: scored from 0 to 3; 0 signifies an absent metaconid and 3 a rather large one.

D) Cingulum development at UM1: Described as incomplete, almost complete or complete.
E) Coronoid apex curvature: scored from 0, if the coronoid apex lacks a backward process, to 3 when the process is well developed.

F) Face dishing: scored from -3, when facial profile is extremely convex to 3, when is very concave.
G) Sagittal crest dishing: estimated along the edge, from -3 (if a very convex upper border is present) to 3 (if a very concave upper border is present).
Appendix III
Indices and Calculated Values

In this work I have used some indices and calculated values that I detail below. All of them, with one exception, have been sourced from the available literature; a few indices have been slightly modified to fit better the objectives of the research.

**Humerus length** (Clark 1996)
It is generated in mm and its calculation is based on the greatest length of the atlas (taken in mm).
Humerus Total Length= (atlas Greatest Length x 4.57) -11.5

**Shoulder Height** (Harcourt 1974)
It is generated in mm and its calculation is based on the length of long bones (taken in mm):
Shoulder Height= (3.43 x humerus Total Length)-26.54
Shoulder Height= (3.18 x radius Total Length)+19.51
Shoulder Height= (2.78 x ulna Total Length)+6.21
Shoulder Height= (3.14 x femur Total Length)-12.96
Shoulder Height= (2.92 x tibia Total Length)+9.41

**Body Weight**
It is given in grams and its calculation is based on the height of the mandible at front of the LM1 (taken in mm). To improve accuracy I averaged values generated by two different published formulas (Wing 1978 and Hamblin 1984).
log body Weight= 2.2574 (log mandible Height) + 1.1164 (Wing 1978)
log body Weight= 2.1122 (log mandible Height) + 1.2722 (Hamblin 1984)

**Crowding Index**
This is a modified version of Degerbol’s Overlapping Index (1961):
Alveolar lengths (UPM1+UPM2+UPM3)/total distance from the anterior border of the alveolus of UPM1 to the posterior border of the alveolus of UPM3.

**Index of Overlap** (Davis and Valla 1978)
As proposed by the authors:
LM1 Length/ total distance from the anterior border of the alveolus of LPM4 to the posterior border of the alveolus of LM1.

**Cephalic Index** (Harcourt 1974)
As proposed by the author:
Zygomatic width of the cranium x 100 / total length of the cranium.

**Snout length index** (Harcourt 1974)
As proposed by the author:
Length of the viscerocranium x 100 / total length of the cranium.

**Cranial Capacity Index** (Gonzalez, this study)
Cranial capacity / basion-hormion.
Facial length index (Gonzalez, this study)
Facial length / basion-hormion.
APPENDIX IV
SPECIMENS LIST

When possible specimens are cited using the original labelling. Unlabelled specimens were given a “study number” (in boldface type hereby), by the author, and were identified accordingly to information provided by the curators of the collection. Underlined collection numbers represent type specimens.

Eventually, some specimens included in the list were re-classified following the findings of this work, and are named differently in the main text.

RECENT SPECIMENS

**Indian pariahs (including Pakistani pariahs)**

**INDIA**
ZSI: IN 106; IN 111; 17510; 17511; 15742.
DCP: 13; 68.
AMNH: 244434.
BMNH 488149.

**BALOCHISTAN**
ZSI: 17507 (Quetta).

**PUNJAB**
PAU: IN 1; IN 2; IN 3; IN 4; IN 5; IN 6; IN 7; IN 8; IN 9; IN 10; IN 11; IN 12; IN 14; IN 15; IN 16; IN 17; IN 18; IN 19; IN 20; IN 21; IN 22; IN 23; IN 24; IN 25; IN 26; IN 27; IN 28; IN 29; IN 30; IN 31; IN 32; IN 33; IN 34; IN 35; IN 36; IN 37; IN 38; IN 39; IN 40; IN 41; IN 42; IN 43; IN 44; IN 45; IN 46; IN 47; IN 48; IN 49; IN 50; IN 51; IN 52; IN 53; IN 54; IN 55; IN 56; IN 57; IN 58; IN 59; IN 60; IN 61.

**KARNATAKA**
ZSI: 2739 (Bramagiri).
RMNH: IN 215.
UOM: IN 218; IN 219; IN 220; IN 221; IN 222; IN 223; IN 224; IN 225.
KVASU: IN 227; IN 228; IN 229; IN 230; IN 231; IN 232.
BMNH: 72861 (Mysore).

**KERALA**
ZSI: 18285 (Trivandrum).
KVASU: IN 233; IN 234; IN 235; IN 236; IN 237.
GC: IN 238.
ORISSA
ZSI: **IN 139** (Ganjam District).

MADHYA PRADESH
ZSI: 18271, 18281, 17508, 18272 (Jubbulpore Cantonment).

MAHARASTHRA
ZSI: 18273, 17550 (Nagpur).
BVC: **IN 240; IN 241; IN 242**.
DCP: 1; 67 (Pune).
GSI: **IN 255**.

WEST BENGAL
ZSI: **IN 101, IN 102, IN 103** (Bankura District: Susunia Hill).
MCZ: 332; 52804, 52808 (Hoogly District: Singur); 52809 (Hoogly District: Junction Nasibpur-Chandinagar).

BENGAL
BMNH: 565645 166EEE.

SOUTH ANDAMAN
ZSI: **IN 100** (Lalpahar).

TAMIL NADU
MVC: **IN 189; IN 190; IN 191; IN 192; IN 193; IN 194; IN 195; IN 196; IN 197; IN 198; IN 199; IN 200; IN 201; IN 202; IN 203; IN 204; IN 205; IN 206; IN 207; IN 208; IN 209; IN 210; IN 211; IN 212; IN 213**.

ORISSA
ZSI: **IN 100** (Bhitarkanika).

HARAPPA

**Egyptian pariahs**

EGYPT
USNM: 219907; 219906; 219907 (Upper Lisht).
FMNH: 77745 (Minya Province: Jebel el Teir); 101999 (Giza Governorate).
BMNH: 84351.
**Inner Middle East pariahs**

**IRAN**
FMNH: 112377; 112374 (Fars: Chah Moslem); 92895, 92896 (Khuzistan: Awaz); 98431 (Azerbaijan: Mianeh); 112373 (Maku); 112381, 112380 (Kermanshahan: Ravansar); AG7 (Tepe Sarab).

**IRAQ**
FMNH: 86833; 57252 (Erbil Liwa: Harir); 86840 (Rutani Farm); 86842, 86839, 86836, 86841, 86834, 86835 (Baghdad); 44473 (Diyala: Diyala Zor); 86838, 86837 (Diyala); 129747; 121642 (Kish); 121541 (Rayy: Bibi-Shar-Bam).

**Israeli pariahs**

UT: M7513 (Hisdai Sharon); M7668 (Hazeva); M7746 (Yotvata); M9803 (Palmahin); M8308 (Bet-Guvrin experimental zoo); M8831 (Elat Mountains); M9701 (Givat Ada); M9021 (Ramat Hagolan Coor); M8603 (Mishor Yemin); M8426 (Ramat Hagolan); M7250 (Abu-Kabi Physiology lab); M6858 (Tel-Asad); M6148 (Nashon Road); M7354; M10026 (Moledet); M4115; [IS 57]; [IS 58]; [IS 59].

HU: M4051, M4068, M3972, M3976, M3975, M3974, (Suez); M4059 (Sinai: Gebel Meghara); M4057 ( Lahav Region); M4064 (Galilee); M7039 (Ramat Hasharon); M4054, M4053, M4050, M3977, (Jerusalem: Hebrew University); M6596 (Jerusalem); M3981 (Judean Hills: Givat Yeshayahu); M3979 (Judean Hills: Bet Nir); M6965 (Golan: Yaar Massada); M7391 (Biqat Uvda: Shizafon); M3978; M4001 (Negev: Kibbutz Lahav); M7930; M7708; M7703; M4066 (Negev: Beersheba to Revivin).

**Arabian pariahs**

**OMAN**
HZM: 2.4542, 4.4610, 5.4611 (Batinah: Sohar; Salan); 7.5171.

**TRUCIAL OMAN**
HZM 8.7148 (Asimah Village).

**New Guinea and New Britain village dogs**

**DUTCH NEW GUINEA**
AMNH: 151839 (Bernhard Camp).

**PAPUA**
BMNH: 19861617 (Tipone).
PAPUA NEW GUINEA
ANU: M459 (Mount Wilhem).

NEW BRITAIN
ANU: M223, M224, M225 (village inland from Kandrian).

New Guinea highland dogs (NGHD)

DUTCH NEW GUINEA
AMNH: 151842 (Bernhard Camp).

PAPUA
BMNH: 713100 (Tipone)
QM: J3751, J4083 (Mount Scratchley).

African village dogs

CONGO
AMNH: 52087, 52086, 52088 (Garamba).

MOZAMBIQUE
MCZ: 44291 Tete.

SE Asia village dogs

CELEBES
USNM: 218568 (Lindoe Lake).

BURMA
BMNH: 193752639 (Mount Popa).

MALAYA
BMNH: 71753.

Sledge dogs

UNKNOWN LOCALITY
AMNH: 408; 35271; 90299; 35314; 669 C.A.
BMNH: 166a; BMNH 166t.

SIBERIA
AMNH: 18224, 18220, 18222, 18221, 18219, 18225, 18227, 18228,
18236, 18232, 18231, 18233, 18230, 18234, 18235, 18229 (Marcova:
Anadyr).
GREENLAND
AMNH: 13681; 12724; 12725; 14896; 73309; 245089 (Disko Island: Skansen); 14445; 14051; 14046; 14049; 14048; 14045; 14047; 14050. BMNH: D32.

NEW YORK
AMNH: 11155 (Highland Falls).

BAFFIN ISLAND
AMNH: 1555; 147177 (Cape Dorset).

BERING ISLANDS
AMNH: 135578.

ALASKA
AMNH: 245024, 245025, 245026, 245027, 245011, 245012 (St. Lawrence Island); 245034 (Upper Ester Creek).

Sighthounds

AFGHANISTAN
AMNH: 189373.

NEPAL
BMNH: 166H.

ENGLAND
BMNH: 5612 10685 166CCC, D53 802522, 166i.

EIRE
BMNH: 1995212.

Turkish dogs

MCZ: 51571 (Malatya); 51602 (Hazar Dagi). BMNH: D9672877 (Constantinople).

Canis pallipes

DECCAN
(BMNH: 434660).

Canis lupus pallipes

INDIA
ZSI: 15734; 18276.
BNHS: 6276.
GM: IN 239.
DCP: 105.

PAKISTAN
USNM: A 16147; A 16146.

CENTRAL PROVINCE
BNHS: 6273 (Hudra); 6274.

BALOCHISTAN
ZSI: 17507, 17512, 18279 (Quetta).

KARNATAKA
RMNH: IN 214); IN 216.
ASI: S2 (Tumkur).

KERALA
ZSI: 18282 (Trivandrum Beach).

NORTHWESTERN PROVINCE
ZSI: 6597 (Shiurajpur); 15733 (Barda).

MAHARASTHRA
DCP: 103, 104, 105 (Rehekuri Forest).

PUNJAB
BNHS: 5302 (Jullunder).

UTTAR PRADESH
ZSI: 18284 (Dehradum: New Forest).
BNHS: 6275, 6271, 5308, 5303 Etwah; 6277 (Fategavi).
BMNH: 61455 (Mirzapur District).

BIHAR
BMNH: 351181, 351182, 351183 (Hazaribagh District).

RAJASTHAN
BMNH: 358302, 358304 (Bikanir District).

RAJPUTANA
BMNH: 858152 (Sambhar).

CUTCH
BMNH: 351186 (Bajana).
PESHAWA
BMNH: 351102 (Chitral).
SIND
BMNH: 86211 (Harnal).

KUWAIT
BMNH: 46890; 39895.

MESOPOTAMIA
BMNH: 351141 (Tarooma).

IRAN
FMNH: 47778, 112379 (Kermanshahan); 99028 (Teheran).
HZM: 8.6133 (Main Kaleh Peninsula).

IRAQ
FMNH: 84468 (Zagros Mountains); 44467, 46079, 44471 (Diyala);
44470 (Salman Pak); 44468 (Rowandiz District: Seri-Hassan-Beg
Mountains); 154643) (Erbil Liwa); 84469 (Jebel).

*Canis lupus*

INNER MONGOLIA
Kalgan (AMNH 45602).

CHINA
AMNH: 85272 (Yen-Chung-Kow).

ISRAEL
UT: M9181 (Kefar Sold); M9182, M9775, M9104, M9226, M10621,
M10681, M10338, M10402 (Golan Heights: Nahal Son); M7510 (Golan Heights: Buque’ata); M7425 (Golan Heights: Yaar Massada); M9161, M9637 M9293, M2918, M2799 (Yotvata);
M9837, M9838, M7738 (Elat); M9774 (Prazon: Bet Shean); M10230 (K. Menahem to Qiryat Malakh); M10231, M8291, M8290, M8602
(HaZe’va); M9292 (Haarava Road: Faran); M9386, M5454 (Haarava Road: Zofar); M9339 (Moshav Paran); M9443 (South Negev: Neot Semadar);
M9417 (Judean Desert); M9258 (Merom Golan Sur: Tel-Marti); M7598
(Giftlik); M7699, M6320, M10610 (Mizpe Ramon); M7669, M10615
(Nahal Mishmar); M8577 (Arava: Samar Sands); M8271, M6051, M2965
(Sede Borger); M8601 (Nahal Urea); M5123 (Be’er Ora); M5725 (Shoval);
M4346, M11044, M10393 (Shamir); M4296 (Tel el Safi); M6839
(Amaza); M6840 (Nahal Suanith); M7041 (Yahav to Zofar); M3392,
M3391 (Kefar Zekharya: Tel-Aseka); M6 (Alonim); M669 (Ein Gev);
M6898 (Ein Fesha); M10607 (Tel Yosef); M10580 (Ramot Yissakhar);
M11041 (Lahavot Habashan); M10685 (Nahal Kanaf); M10689
(Yahudia); M10686 (Tel Hispin); M7364 (Sinai: Bir Tahal); M10341.
HU: M6598 (Jerusalem).
AFGHANISTAN
BMNH: 818166 (Kandahar).

NEPAL
BMNH: 5862461; 59670a.

BALUCHISTAN
BMNH: 348122 (Chotair).

*Canis lupus* hybrids

ISRAEL
UT: M10337 (Gazit Ramot Yissakhar); 9331 (Ramat Hagolan); M9329 M9330 (Ramat Hagolan: Moshav Nov); M6248 (En-Harod); M9638 (Yotvata).

*Canis lupus cubanensis*

CAUCASUS: Borzomi (ZSI IN 105).

*Canis chanco*

CHINESE TARTARY
BMNH: 6332011442a.

*Canis lupus chanco*

UNKNOWN LOCALITY
MCZ: 24873.

PESHAWA
BNHS: 5312 (Chitral).

KASHMIR
USNM: 198457 (Ladak Leh); 198458 (Nubra Valley).
BNHS: 5311 (Gilgit).

SHANXI
USNM: 172654, 172655 (Nin Wu Fu).

MONGOLIA
MCZ: 24870.
**Canis lupus laniger**

SIKKIM
BMNH: 6272 (Gangtok).

MONGOLIA
AMNH: 57328 (Loh).

CHINA
BMNH: 91112 (Shensi: Yen-An-Fu).

KASHMIR
BMNH: 3611221 (Ladakh); 201175 (Gilgit), 996232 (Braldu).

PUNJAB
BMNH: 565642 (Salt Range).

CHINESE TARTARY
BMNH: 6332011442a.

**Canis lupus arabs**

SINAI
FMNH: 134564.

ADEN
BMNH: 951081; 9911635 (Lahej).

ARABIA
BMNH: 40193 (Jeddah); 48367 (Buraida); 348412 Ain.

JORDAN
Azraq (BMNH 841312).

SAUDI ARABIA
HZM: 14.9599, 13.9598, 12.9597 (Wadi Khumra); 31.30448 (East of Umm Laj and North of Yanbu); 17.11819 (Mecca Bypass).

OMAN
HZM: 4.3957 (West of Mahab); 11.9114 (Dhofar); 1.3902 (Buraimi);
74885 (Fizz).
**Canis aureus**

**INDIA**
ZSI: C. au 22; 15738.
BNHS: 6278.

**BIHAR**
ZSI: 7245 Gya District.

**KARNATAKA**
MZG: IN 226.

**MAHARASThra**
DCP: 77 (Raisen District: Bhimbetka).

**RAJASTHAN**
DCP: 217 (Balathal).

**SIND**
BNHS: 6279.

**ETHIOPIA**
AMNH: 81040, 54033 (Abyssinia: Billata).

**KENYA**
AMNH: 27727; 114175 (Mt Longonot).

**BRITISH EAST AFRICA**
AMNH: 27733, 27735, 27732, 27739 (Guasinirock); 27726 (Elmenteita).

**MOROCCO**
USNM: 399432, 399434, 399431, 399436, 339435 (Ouarzazate);
399433 (Ksar es Souk);
BMNH: 98747 (Ras el Ain).

**AFGANISTAN**
USNM: 399445.

**ISRAEL**
HU: M8097); M8076); M8052.

**TUNIS**
BMNH: 461030.

**Canis aureus indicus**

**KASHMIR**
USNM: 173280, 173281 (Woolar Lake).
NEPAL
USNM: 290135 (Ruxaul-Birganj).

**Canis aureus lanka**

SRI LANKA
USNM: 257654 (Kumbukkan).

**Canis aureus cruessemanni**

THAILAND
USNM: 297170 (Chaiyaphum).

**Canis aureus lupaster**

EGYPT
FMNH: 140124 (Al Qalyubiya); 89967, 89966 (Giza); 105743, 105741, 105744, 106722, 106724, 106723, 105742 (Faiyum Governorate); 107228, 105807, 107229, 107234, 107232, 107 230, 107231, 107340, 107236, 107336, 107337, 121349, 107338, 140115, 140117, 140119, 140118 (Aswan Governorate); 106720 (Qena Governorate); 108364 (Dakhla Oasis); 98921, 140121, 140122, 107224, 107223, 107225 (Matruh Governorate); 107226 (Wadi Gedeed Governorate); Cairo (BMNH 19773490); Bedrasheen (BMNH **BM39**).
USNM: 321958 (Qalyubiya); 321954, 321956 (Giza); 321951 (Western Desert); 321952 (Faiyum Governorate).
BMNH: 7434, 48214, 33131, 986533 (Giza); 19773490 (Cairo); **BM39** (Bedrasheen).

LIBYA
USNM: 322833 (Fezzan: el Barcat); 322834 (el G atrum).

**Canis aureus maroccanus**

MOROCCO
USNM: 476031 (Agadir: Tafraoute); 486165, 486167 (Goulimine); 476030 (Aquinet Tarkoz).

MAURITANIA
USNM: 410910 (Kiffa); 410911 (Kaedi).
Canis aureus moreoticus

TURKEY
USNM: 327729 (Surmene).

Canis aureus algeriensis

MOROCCO
USNM: 476034 (Missour).

Canis lupaster

EGYPT
ZMB: 833 (Fayum).

Canis sacer

EGYPT
ZMB: 835 (Fayum).

Canis doederleini

EGYPT
MZS: 1123.

Dingoes

AUSTRALIA
BMNH: 1952492.

CENTRAL AUSTRALIA
ZSI: IN 107.

QUEENSLAND
ZSI: IN 108 (Central Queensland).
AMNH: 65845 (Atherton Tableland: Ravenshoe); 18077 (Dawson River); 153663, 153664 (Cape York: Wenlock), 154465 (Lockerbie).
BMNH: 58820 (Jukerman).
GC: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39 (Shoalwater Bay Training Area); 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50(a) (Mount Owen); 50(b), 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79 80, 81, 82, 83, 84 (Bulloo Downs); 85, 86 (Upper Kedron); 87, 88 (Mountville);
89 (Maroochydore); 90, 92, 93, 96, 97 (Tuan State Forest); 98, 99, 120 (Avocet); 101 (Springsure); 102 (Vandyke); 103, 104 (Bribie Island); 105, 106 (Fernvale); 107 (Noosa Valley); 108 (Jericho); 125, 126, 127, 128, 129, 138, 139, 140, 141 (Roseberth); 130, 131, 132, 133, 134, 135 (Durrie); 136 (Highfields).

NORTHERN TERRITORY
BMNH: 61193, 61195, 61196 (Alexandria); 413104 (Arhem Land).

WESTERN AUSTRALIA
AMNH: 183434 (Domagee Mission); 197746 (Woodstock Station); 197748 (Darradup); 197747 (Windich Spring).
BMNH: 79156 (Margaret River).

ARCHAEOLOGICAL AND PALAEONTOLOGICAL SPECIMENS

HARAPPA
PM: 422060-1; 433156-90; 433156-70; 433156-69.
HARAPPA: HP 106; HP 103; HP 104; HP 105; HP 107; IN 67; HP 91; HP 73; HP 98; HP 67; HP 66; HP 69, HP 68, HP 71; HP 100, HP 101; HP 44, HP 13619; 422060-1.

BURZAHOM
ZSI: 3135; 3136; 3139 & 3136; 3135 &; 3139; 3134; 3122; 3126; 3125; 3117A; 3112 & 3112A; 3280; 3036; 3293; 3288; 3294; 3291; 3298; 3202; 3247-3248; 3208; 3301; 2870; 4013; 4014; 4014; 4031; 4030; IN 121; 4025; 3986; 3985; 3983; 4044, 4040?, 4043; 3466 & 3463; 3349; 3348; 3344; 3345; 3458; 4011; 4000; 3997; 3041; 4057.

KANHIAPAN
GSI: IN 254.

ALASKA
AMNH: 67160 (El Dorado Creek Goldstream); 30430, 67155 (Little El Dorado Creek); 67170, 67163 (Ester Creek); 30433, 30431, 70932 (Fairbanks); 30457, 30434, 30435 (Clearly Creek); 30450, 67157 (Lower Goldstream); 67166 (Upper Clearly); 30473.

HADITHA
MCZ: 47464; 47452; 47463; 47461; 47462; 47453; 47460; 47454; 47457; 47455; 47458; 47459; 47456; 47448; 47451; 47449; 47450; 47470.

TRUCIAL OMAN
MCZ: 47466; 47465; 47467; 47468; 47469.
CATAL HÜYÜK

SUBERDE
PM: 379; 24; 293; 49; 168; 293; 28; 72; 26; 379; 49; US 280; US 281; 346; 294; 49.

JARMO
FMNH: PMO 30060; PMO 30086; PMO 30093; PMO 30097; PMO 30102; PMO 30106; PMO 30107; PMO 30109; PMO 30057; PMO 30059; PMO 30014; PMO 30076; PMO 30099; PMO 30110; PMO 30050; PMO 30112; PMO 30087; PMO 30029; PMO 30033; PMO 30113; PMO 30079; PMO 30068; PMO 30035; No?; PMO 30075.

SARAB
FMNH: AG4; AG5; AG6(a); AG6(b); AG6(c); PM 30617; PM 30616; AG8; AG9; AG10; AG11(a); AG11(b); AG12; AG12(c); AG12(d); AG1(a); AG1(b); AG2.

PALEGAWRA
FMNH: PM 11265.

AIOUN BERICH
FMNH: UM 1677; UM 1674.

CONSTANTINE DEPARTMENT
FMNH: UM 1686; UM 1652.

HAYONIM
HU: HT89; pit89.

EIN MALLAHA
HU: 4130.188.

EL WAD
HU: IS 124).
BMNH: M16251; WC.

KFAR GALIM
HU: IS 125.

TEL HREIZ
HU: IS 126, IS 127.

ABYDOS
BMNH: BM 57; BM 58; BM 59; BM 60; BM 61; BM 62.
LAHUN
BMNH: ZD197549; ZD197548; ZD197550; ZD197552; ZD197553.

HAWARA
BMNH: 19118146; 19118145; 19118144; 19118143; 4118141; 19118146; 19118145; 19118144; 19118143; 19118142; 19118140; 19118149; 19118148; 191181425; 191181423; 191181421; 191181422; 191181420; 191181417; BM 111; BM 112; BM 113; BM 114; BM 115; BM 116; BM 117; BM 118; BM 119; BM 120; BM 121; BM 122; BM 123.

DENDEREH
BMNH: BM 86; BM 87; BM 88; D4; D3); BM 94; D10; BM 99; D12.

EGYPT
BMNH: D6; D5; D11; D7; D13.

ABADIYEH
BMNH: D8.

GIZEH
BMNH: 783159; 783158.

LACHISH
BMNH: BM 104; BM 105; BM 106; BM 107; BM 108; BM 109.

QAU
BMNH: 19715235.

JERICHO TELL

TELL DUWEIR
BMNH: BM 164.

KEBARA
BMNH: KC; B 183; KE.

TABUN
BMNH: M16096; M16096(1); M15844; 16249; TB.

ZUTTIYEH
BMNH: M13863; B 179.

SHUKBAH
BMNH: M16252; SH AB; SH A.
KHOK CHAROEN
ANU: 2083; 2236; 1010.

TIMOR
ANU: MK2.
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