A Manual for the Identification of Fish Bones

Gary L. Barnett

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A Guide to the Comparative Skeletal Collection in the
Department of Prehistory,

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Professor Jack Golson saw merit in the idea and supplied a small grant for equipment and transport of the specimens and a three-month appointment in his department to complete the manual. Most of my demands landed on Dragi Markovic for photographic work. Excellent job.

Hugh Paia and Anna Craven helped with bureaucratic hassels in the Solomon Islands. After all, no-one in their right mind collects fish skeletons.

Introduction

The task of the archaeologist is to uncover, analyze and interpret clues of past human activity. These clues are often bizarre bits and pieces. Certainly not the most bizarre, but one of the most troublesome of these bits and pieces are fish-bones. The identification of archaeological fish-bones can provide the archaeologist with information from which statements of past human activity may be deduced. The identification of fish-bones may inform the archaeologist of the species, genera or family of the fish in question. From this identification the characteristics of each family of fish can be checked. It is the unique characteristics of fish to which the fisherman must respond. Successful fishing is not a haphazard activity. In all cases one has to "fool" the fish to take it. The step from proper identification of archaeological fish-bones to statements about human activity is a very great step indeed. If one aim of archaeology is to extrapolate human activity from fish-bones, the identification of the bone is only the first step in a long and complex maze. How did the fish end up in an archaeological context? To answer this the archaeologist must be cognizant of three levels of activity: 1) fish activity 2) human activity, and, 3) human-catch-fish activity.

By fish activity I mean the totality of biological differences which separates one family of fish from another. The diversity of marine habitats and their corresponding life forms is unlimited. Each habitat, ecologic zone and niche has its specific fauna. In tropical seas there may be

some 3000 different species of fish, these are potential seafood (not to mention the invertebrates). This tremendous diversity of fish species and ecological zones requires an equal diverse set of exploitative techniques. Human populations dependent upon diverse marine resources have developed fish-or-zone-specific fishing techniques. To accomplish this they have to have a large body of knowledge on fish, fish behaviour, marine biology, ecologic zones, habitats, feeding patterns, seasonal migrations, ocean currents, and so on. The archaeologist must approximate the knowledge of his fisherman. In order to interpret human activity from fish-bones, the archaeologist should be as aware of fish activity as the man who caught the fish. That is, how does one take this particular fish? Other questions may be: How many separate fishing techniques would be required to take the total fish assemblage found in a site? What habitats are represented by the fish? Are these habitats available for local exploitation? Are all the available habitats being exploited? And so forth. This of course will vary place to place as the marine environment varies.

The ecological setting of the archaeological site, that is, the possible marine resources available for human exploitation, is necessary information for the adequate interpretation of the fish remains. A site in Arosi could not possibly have much in common with a lagoon site in North Malaita. The people are the same; the marine environment is not. The fish bones in a site will vary tremendously by virtue of its location. One area may be more dependent upon pelagic fish - another on reef fish - another with a deep entrance lagoon will have an unbelievable supply of very

diverse fish. Two sites with identical marine resources may produce entirely different fish remains. An absence of important available fish may represent fish toxicity. Or it may reflect a lack of fishing technology. One culture may have a technology lacking in another culture. The marine environment may be the same; the cultures are not. Either fish activity or human activity may determine the composition of fish species found in archaeology.

More important than understanding what fish are up to is a knowledge of what the people were up to. In areas where ethnographic populations have long since vanished, the archaeologist has a monumental task. In areas with extant ethnographic populations, the archaeologist has a gold mine. The opportunity to become proficient in both fish activity and human activity is at hand. Any archaeologist working in an area where there is "living archaeology" should rest the trowel and do ethnology. No-one can afford to dismiss expert advice. The people fishing for survival are the experts. The ground may have its secrets but without the expert's knowledge they will remain secrets. And in the Solomon Islands, as elsewhere, the death of every old man - their knowledge - their expertise - buries these secrets deeper and deeper.

The archaeologist must know what resources are available to the population; how they are exploited; what and how many fish enter the human food chain, either directly or indirectly; and lastly what happens to the remains - the fish-bones. My observations have resulted in a frightening realization: people will eat any fish they can get their hands on. In areas

such as the Solomon Islands where fish toxicity is low, the total variety of available fish is staggering. Perhaps more important for archaeology is my observatons on fish-bone disposal: people dispose of the remaining fish-bones by either burning or throwing them back into the sea. Fish bones are sharp and dangerous.

In an environment with diverse marine resources the totality of man-catch-fish activity is equally staggering. During a single day a woman may take smoked fish to the garden hut; men are fishing for pelagic fish, others for reef fish; children are fossicking the reef and beaches having a series of cook-outs; a man may eat a raw fish in his canoe; the fish may be tabu to women and children, the men cook and eat them in a tabu area; young men are spearing fish, others netting; night fishing is yet to come. Dogs and pigs are fed fish. On Tikopia only the chiefs eat fish. And so on. It is my contention that far more fish enter the human food chain than the remaining fish bones would ever indicate.

The archaeologist finds isolated and disarticulated bones of fish skeletons. Depending upon the species of fish and the actual bone found, identification has been possible through published material. However, this information may be ancillary and therefore difficult to dig out. Identification of fish skeletal material is difficult. For this reason I suggested that a comparative skeletal collection of identified fish species be made. The resulting collecting has 115 individual specimens from 28 families of important Indo-Pacific food fishes. This is probably the most complete set of species-known fish skeletons anywhere. The collection is now

part of the comparative faunal collection of the Department of Prehistory, Research School of Pacific Studies, Australian National University. This department helped support the field work and subsequent production of this manual. This manual is an attempt to aid the identification of fish-bones found in an archaeological context. More realistically the manual is a guide to the comparative collection and will prove most useful when used in conjunction with that material. Without the collection at hand, however, this manual will aid in the identification of the neurocranium, dentigerous bones and teeth. This in itself offers more than was heretofore possible. This broader application will allow those without a comparative collection to identify some of their material.

Collecting and Processing the Skeletons

The comparative collection was made while I was in the Solomon Islands in 1977. Most of the specimens were taken around the small island of Malaupina in the Three Sisters Group, north of Makira. Malaupina was the permanent base of Walter and Janice Starck. Walter is a marine biologist and owns the 65 ft research vessel *El Torito* which has been in the Pacific for the past 8 years and has been involved with a series of filming and research projects in marine biology.

The sheltered lagoon of Malaupina offered excellent protection from the great sea outside. The establishment on Malaupina included three houses, a work shed, large aquariums and a substantial dock for the *El Torito*. Several research projects were being carried out by Dr Starck and a series of visiting scientists from Australia, New Zealand and the United States. With the facilities of the *El Torito* always at hand

and a cool house in the bush in which to live, on calm days I collected fish. Fishing was done from a 28 ft canoe with outboard motor by hand line, trolling, or diving with a spear. I am skilled with the hand line, Walter with the spear. The aim of my fishing was to collect as many species from as many families as possible. This collection represents the variety of fish taken rather than the total number of fish caught.

When I was not on Malaupina, I was making a collection of language names of fish throughout the Eastern Solomons. This information is to be published by the Department of Linguistics, Research School of Pacific Studies. This project proved most interesting and much local knowledge of fish and fishing was collected.

As the purpose was to collect skeletons from known species, each specimen was either identified outright by Walter or with the aid of his extensive library. Certain families of fish are constantly undergoing taxonomic revision and even with fresh specimens identification to species level can be troublesome. Even though the fish in this collection have been identified to species, the skeletal differences between two closely related species are often minute or non-existent. For archeological purposes, however, the identification of skeletal material to the family level will prove meaningful.

After the fish were identified they were boiled until the meat could easily be separated from the bones. The specimens were cleaned with forks, foreceps, and tooth brushes. Each fish type required varying degrees of disarticulation for cleaning. The bones were set out in the sun in drying trays. The evolution of tray type resulted in compartmented

boxes covered with clear plastic. The plastic kept out rain and wind. The bottoms were open screen to allow for air movement. Wind, children, dogs and rats will rearrange bones without regard to species. The latter two will eat the bones. The drying tray was built off the dock in the direct sun. Depending on size of fish, from one to four days in the hot tropical sun will completely dry and bleach the bones. Extremely oily fish are difficult to dry. The oil permeates the bones. During storage the oily bones blossomed with various fungal growths. This causes the bones to take in moisture and become soft. Advanced cases of fungal infection were re-boiled in detergent and re-dried. When time or location prevented the rendering down of specimens they were cleaned of meat and sun dried as entire articulated fish. A remote drying tray will produce a hard fish jerky with bones in four or five days. Flies and other insects (and dogs and rats) are attracted to the rotting meat. Insects can do no harm. Again, oily fish never seem to dry properly. When the specimens were dry, they were numbered and stored for shipment. Each specimen is now in its own numbered box in the Department of Prehistory.

The Numbering System

The identification number of each specimen is in succession from 101. Each fish was numbered as processed. Each individual specimen number is preceeded by the family number. The family numbers were assigned from 1 to 412 as listed in the American Museum of Natural History's publication *Phyletic Studies of Teleosteam Fishes, with a Provisional Calssification of Living Forms*. This publication with complete numbering is available

in the Department of Prehistory. Even though there are 412 families of living teleostian fishes only about 70 of these are considered important Indo-Pacific food fishes.

This unique numbering system allows for the future inclusion of new specimens as they come to hand. Each is assigned its family number and the next higher specimen number. In each case the identification has the family number first, followed by the specimen number. Specimen 385-155 then belongs to family 385 SCOMBRIDAE and the individual number is 155. Each specimen can be identified and located by its specimen number, family number, or species identification. The following listings will identify each specimen:

1. Important Families of Food Fish.
2. Species by Specimen Number.
3. Species in Alphabetical Order.
4. Description of the Neurocranium and Dentigerous Bones by Family. (Each family lists species by name and number.)

Each specimen is in its numbered box in the collection. Box 166 is Axinurus thynnoides. The family number is 381, ACANTHURIDAE. From the description by family, the other representatives of this family are 381-167, 381-174, 381-176 and 381-197.

Identifying Your Bones

The main body of this manual is photographic plates of the neurocranium and dentigerous bones of each specimen in the comparative collection. Each specimen is also described The choice of these bones is based on the fact that they are the most diagnostic from the fish skeleton. They are also

very easy to recognise and sort from archaeological material. It does not mean that these bones are the most likely to appear in the archaeological context. However, they are robust and have a high probability of being preserved.

The neurocranium is an obvious bone (set of bones) for identification purposes. It gives a quick assessment of the size and shape of the fish. Attached to the neurocranium is the "business end" of the fish. The "business" of a fish is feeding, and the dentigerous bones are the apparatus of feeding. The mouth size and the number, size, and type of teeth are therefore the most diagnostic features of the fish skeleton. These have been described using Munro's *Fishes of New Guinea* and my observations. The photographic plates clearly illustrate the shape of the bone and tooth size, arrangement, and type. Each plate is scaled. Included in the description of each specimen is its length and weight and the method of capture.

These specimens are straight from the factory and therefo are extremely complete. The archaeologist will not be so lucky. Cooking, eating and burial mess up a good skeleton. In archaeological material the neurocranium may be disarticula and the teeth lost from the bone. Nonetheless the arrangement of tooth sockets can be compared and identification is possible.

The procedure is simply to compare your unidentified bones with the photographic plates. This comparison should yield an identification (if in the collection) or point to one or two possible families. The actual bones from the

comparative collection can be consulted for positive identifications. Once the neurocranium and/or dentigerous bones have been identified a comparison of other bones can be made. If the archaeological material has a preponderance of, say, vertebrae, they can be identified by comparing them with the material previously identified from the neurocranium. Likewise with spines, candal plates, opercular series, and so on. These other bones have a good chance of coming from the same fish as the identified bones.

Some fish families have "special" bones which are highly diagnostic. The "trigger" of the Balistidae - the pharnygeal plates of the Scaridae, the spines of the Tetraodontidae - in each case these have been photographed and described. Obviously, familiarization with fish bones will make sorting and identification processes easier. The photographic plates should offer a quick and easy method of identification.

Results from Identification

Perhaps the most significant feature of this comparative collection is its rather complete representation of pelagic fishes. This important aspect will enable the archaeologist to make strong statements about his material. By sorting into two major groups - pelagic - non-pelagic - statements of proportion and exploitation are possible. In general, the larger fish will be pelagic. Bottom dwellers and reef fish can reach incredible size, but they are easily distinguished from the fast swimming pelagic fishes. An archaeological fish assemblage represented by a majority of pelagic fishes will indicate an accompanying fishing technology.

The families of pelagic fishes in the collection are:

182 BELONIDAE

284 CARANGIDAE

285 CORYPHAENIDAE

329 SPHYRAENIDAE

385 SCOMBRIDAE

Unfortunately time limitations, mail strikes, and other evil influences have worked against the planned inclusion of a section describing the families of fish, their habitats, distribution, and methods of fishing. There are however a few excellent publications from which the archaeologist can fairly painlessly find this information. These include:

Bagnis, R., P. Mazillier, J. Bennett and E. Christian. *The Fishes of Polynesia*, Lansdowne Press, Melbourne, 1974 This is an excellent book with colour photographs of living fish, short descriptions and interesting bits of Tahitian fish lore.

Burgess, Warren, and Herbert Axelrod *Pacific Marine Fishe* 6 vols., T.F.H. Publications, Neptune City, New Jersey, 1973-1977. Excellent illustrations of a wide variety of fish. Short descriptions.

Munro, Ian S.R. *The Fishes of New Guinea*, Department of Agriculture, Stock and Fisheries, Port Moresby, New Guinea, 1967. The classic book on fish from this area. Keyed for identification of species.

Other references:

Greenwood, P.H., D.E. Rosen, S.H. Weitzman and G.S. Myers. 'Phyletic Studies of Telestean Fishes with a Provisional Classification of Living Forms', *Bulletin of the American Museum of Natural History*, vol.131, No.4, New York, 1966.

Gregory, William K. *Fish Skulls: A Study of the Evolution of Natural Mechanisms*, Eric Lundberg, Laurel, Florida, 1959.

FAMILIES OF IMPORTANT INDO-PACIFIC FOOD FISH

* Denotes families represented in the comparative collection held by the Department of Prehistory, Research School of Pacific Studies, Australian National University.

3	Albulidae
4	Anguillidae
8	Muraenidae
15	Congridae
34	Clupeidae
35	Engraulidae
66	Synodontidae
* 91	Chanidae
*181	Exocoetidae
*182	Belonidae
193	Atherinidae
207	Anomalopidae
*208	Holocentridae
224	Aulostomidae
225	Fistulariidae
234	Scorpaenidae
238	Synancejidae
*243	Platycephalidae
*258	Serranidae
259	Grammistidae
*268	Theraponidae
270	Kuhliidae
273	Priacanthidae
274	Apogonidae
278	Branchiostegidae
282	Rachycentridae
283	Echeneidae
*284	Carangidae
*285	Coryphaenidae
288	Leiognathidae
*293	Lutjanidae
*294	Nemipteridae
295	Lobotidae
296	Gerridae
*297	Pomadasyidae
*298	Lethrinidae
*300	Sparidae
301	Sciaenidae
*302	Mullidae
303	Monodactylidae
*308	Kyphosidae
*309	Ephippidae
312	Chaetodontidae
319	Pomacentridae
321	Cirrhitidae
325	Latridae
*328	Mugilidae
*329	Sphyraenidae
*331	Labridae

*333	Scaridae
*381	Acanthuridae
*382	Siganidae
383	Gempylidae
388	Istiophoridae
*385	Scombridae
389	Centrolophidae
403	Bothidae
404	Pleuronectidae
*408	Balistidae
409	Ostraciontidae
*410	Tetraodontidae
411	Triodontidae
*412	Diodontidae

SPECIES ALPHABETICALLY ARRANGED

Trachurops crumenophthalmus	284-126
Trachurops crumenophthalmus	284-196
Tylosurus indicus	182-210
Variola louti	258-107
Variola louti	258-108

SPECIES BY SPECIMEN NUMBER

329-101	*Agrioposphyraena barracuda*
258-102	*Coryphaena hippurus*
293-103	*Lutjanus bohar*
385-104	*Gymnosarda nuda*
385-105	*Neothunnus macropterus*
385-106	*Neothunnus macropterus*
258-107	*Variola louti*
258-108	*Variola louti*
385-109	*Katsuwonus pelamis*
208-110	*Holocentrus spinifer*
258-111	*Epinephelus sp*
258-112	*Epinephelus fasciatus*
258-113	*Cephalopholis argus*
385-114	*Gymnosarda nuda*
298-115	*Lethrinus miniata*
284-116	*Caranx ignobilis*
293-117	*Pristipomoides argyrogrammicus*
408-118	*Alutera scripta*
408-119	*Alutera scripta*
408-120	*Balistapus undulatus*
258-121	*Cephalopholis urodelus*
208-122	*Holocentrus spinifer*
258-123	*Cephalopholis cyanostigma*
293-124	*Pristipomoides argyrogrammicus*
293-125	*Pristipomoides argyrogrammicus*
284-126	*Trachurops crumenophthalmus*
258-127	*Epinephelus slacksmithi*
382-128	*Siganus rostratus*
284-129	*Elegatis bipinnulatus*
284-130	*Caranx melepygus*
293-131	*Jutjanus bohar*
408-132	*Balistapus undulatus*
329-133	*Agrioposphyraena barracuda*
328-134	*Mugil cephalus*
258-135	*Epinephelus slacksmithi*
412-136	*Diodon holacanthus*
410-137	*Arothron stellatus*
284-138	*Caranx melempygus*
91-139	*Chanos chanos*
328-140	*Crenimugil labiosus*
258-141	*Anyperdon leucogrammicus*
293-142	*Lutjanus rivulatus*
302-143	*Parupeneus indicus*
302-144	*Parupeneus indicus*
302-145	*Mulloidichthys samoenis*
382-146	*Siganus vermiculatus*
298-147	*Lethrinus reticulatus*
293-148	*Aphareus rutilans*
91-149	*Chanos chanos*
308-150	*Kyphosus cinerascens*
302-151	*Parupeneus indicus*

308-152 *Kyphosus cinerascens*
182-153 *Strongylura incisa*
408-154 *Pseudobalistes flavimarginatus*
268-155 *Therapon jarbua*
331-156 *Choerodon anchorago*
298-157 *Lethrinus obsoletus*
293-158 *Lutjanus kasmira*
385-159 *Rastrelliger kanagurta*
293-160 *Lutjanus sp*
208-161 *Holocentrus spinifer*
293-162 *Pristipomoides argyrogrammicus*
294-163 *Symphorichthys spilurus*
309-164 *Platax orbicularis*
382-165 *Lo bulpinus*
381-166 *Axinurus thynnoides*
381-167 *Acanthurus gahhm*
293-168 *Macolor niger*
297-169 *Plectorhynchus chaetodontoides*
297-170 *Plectorhynchus chaetodontoides*
258-171 *Cephalopholis argus*
284-172 *Caranx ignobilis*
385-173 *Euthynnus alletteratus affinis*
381-174 *Cyphomycter vlaminga*
243-175 *Platycephalus beauforti*
381-176 *Callicanthus lituratus*
297-177 *Plectorhynchus cuvieri*
408-178 *Balistoides conspicillum*
297-179 *Spilotichthys pictus*
333-180 *Scarops rubroviolaceus*
385-181 *Scomberomorus commersoni*
293-182 *Lutjanus semicinctus*
408-183 *Canthidermis maculatus*
298-184 *Lethrinus kallopterus*
258-185 *Anyperdon leucogrammicus*
258-186 *Anyperdon leucogrammicus*
308-187 *Kyphosus cinerascens*
297-188 *Pseudopristipoma niger*
331-189 *Choerodon anchorago*
333-190 *Scarops rubroviolaceus*
385-191 *Scomeromorus commersoni*
298-192 *Lethrinus reticulatus*
258-193 *Aethaloperca rogaa*
258-194 *Cephalopholis argus*
208-195 *Myripristis pralinius*
284-196 *Trachurops crumenophthalmus*
381-197 *Acanthurus pyroferus*
294-198 *Monotaxis granoculis*
294-199 *Trachurops crumenophthalmus*
333-200 *Callyodon flavipectoralis*
293-201 *Lutjanus argentimaculatus*
284-202 *Elegatis bipinnulatus*
298-203 *Lethrinus fletus*
298-204 *Lethrinus fletus*

258-205	*Plectropoma oligacanthus*
300-206	*Acanthopagrus sp*
331-207	*Cheilinus undulatus*
385-208	*Acanthocybium solandri*
293-209	*Lutjanus gibbus*
182-210	*Tylosurus indicus*
181-211	*Hemirhamphus commersoni*
181-212	*Cyselurus opisthops*
181-213	*Cypselurus opisthops*
284-214	*Caranx lugubris*
293-215	*Aprion virescens*

Description of the Teeth and Dentigerous Bones of Species Ordered by Family

The following descriptions of the fish teeth are taken from Munro's *Fishes of New Guinea* and my own observations. Terminology can be found in the glossary of Munro.

The various adaptations of the fish skeleton to feeding, swimming and hiding are unbelievably exquisite. To explain the entire skeletal material in this collection would be fascinating but time-consuming. You can familiarize yourself with the bones by browsing through the material.

Description of the teeth and dentigerous bones of species ordered by family.

91 CHANIDAE. (Salmon-herring, Milkfish)

A single species, Chanos chanos, which is very bony and the skull is made up of many small bones which disarticulate when cooked. This species is vegetarian with a small mouth and no teeth.

91-139 Chanos chanos. No teeth. 400mm. less .5k. Netted in lagoon.

91-149 Chanos chanos. No teeth. 350mm. less .5k. Netted in lagoon.

181 EXOCOETIDAE. (Flyingfish, Half-beaks)

The flyingfish, Cypselurus opisthops, is a small plankton feeder with a small mouth. The teeth are small and villiform, sometimes finely tricuspid, present in jaws, sometimes on palatines, seldom on vomer or tongue.

These fish are small with many bones and the skull disarticulates when cooked.

The pharyngeal bones have rows of villiform teeth which easily separate from the bone. Best seen in 213.

181-212 Cypselurus opisthops. Small villiform teeth
181-213 in jaws and pharyngeal.
181-214 220mm. less .5k. Hand net at night using light.

The half-beaks are small herbivorous fish with lower jaw projecting like a beak. The lower beak is toothless. Teeth in the lower jaw restricted to basal part which fits against the triangular toothed maxilla. Teeth small and granular in jaws, absent from palate. The pharyngeal bones have rows of villiform teeth which are easily lost.

181-211 Hemirhanphus commersoni. Very small bones, teeth small villiform.
250mm. less .5k. Hand net at night with light.

182 BELONIDAE (Needlefish, Long-Toms)

Carnivorous surface feeding fast swimming fish. Jaws produced into a long beak, each ramus with one series of widely-spaced needle-like teeth. Pharyngeals toothed, lower ones united into a long slender plate.

182-153 Strongylura incisa. Both jaws with needle-like teeth. Pharyngeals toothed. 600mm. less .5k. Net lagoon.

182-210 Tylosurus indicus. Both jaws with needle-like teeth. Pharyngeals missing. 420mm. less .5k. Hand net at night using light.

208 HOLOCENTRIDAE. (Squirrelfish, Soldierfish)

Very spiny fish. The anal spine is long and strong. The skull bones have spiny margins as do the scales. Bands of villiform teeth in jaws, vomer and palatines.

208-122 Holocentrus spinifer. Spiny margins on skull. Teeth in jaws villiform, very small and easily lost from bone. 290mm. less .5k. Speared at reef.

208-110 Holocentrus spinifer. 290mm. less .5k. Speared at reef.

208-161 Holocentrus spinifer. 260mm. less .5k. Speared at reef.

208-195 Myripristis pralinus. 100mm. less .5k. Speared at reef.

243 PLATYCEPHALIDAE. (Flatheads)

Extremely depressed fishes adapted for life on the bottom where they bury themselves in sand or mud with only the eyes exposed. Head extremely depressed usually armed with exposed bony ridges, granules and sharp spines. Mouth large, with lower jaw strongly protruding. Jaws, vomer and platines with bands of villiform teeth, some of which may be enlarged and caninoid.

243-175 Platycephalus beauforti. Bands of very small villiform teeth easily lost from bone. The skull has many large and sharp spines.
540mm. 1k. Speared at reef.

258 SERRANIDAE (Gropers, Coral-cod, Coral trout)

Very large family of carnivorous fishes. Mouth large, slightly protractile. Bands of villiform or small conical teeth in jaws, vomer and palatines, inner series in jaws often depressible. Outer ones may be in part enlarged canines.

258-107 Variola louti. Several series of teeth in jaws, inner ones enlarged and depressible. Two curved canines anteriorly in both jaws and 1-2 lateral ones in lower jaw.
340mm. less .5k. Hand line.

258-108 Variola louti. Articulated specimen. Same as 107. 215mm. less .5k. Hand line.

258-121 Cephalopholis urodelus. Bands of teeth in jaws, inner depressible row in lower jaw and anterior ones of upper jaw long and slender. Pair of synphysial canines in both jaws.
170mm. less .5k. Hand line.

258-123 Cephalopholis cyanostigma. Teeth same as in 121. 240mm. less .5k. Hand line.

258-171 Cephalopholis argus. Bands of long slender teeth in jaws. Inner rows enlarged and depressible, pair of large symphysial canines in both jaws.
300mm. less .5k. Speared at reef.

258-185 Anyperdon leucogrammicus. Broad bands of villiform teeth in jaws, anterior ones depressible. Palatines without teeth.
300mm. less .5k. Speared at reef.

258-186 Anyperdon leucogrammicus.
300mm. less .5k. Speared at reef.

258-193 Aethaloperca rogga. Broad bands of sharp conical teeth in jaws, inner ones depressible, outer ones slightly enlarged. Pair of symphysial canines in both jaws.
310mm. less .5k. Speared at reef.

258-194 Plectropoma maculatum. Articulated specimen.

258-111 Epinephelus sp. Bands of sharp conical teeth in both jaws, inner ones depressible. Anterior ones largest in upper jaw. Palatine with teeth.

258-113 Cephalopholis argus. Articulated specimen.

258 SERRANIDAE (continued)

258-205 Plectropoma oligacanthus. Narrow bands of small cardiform teeth in jaws, inner ones depressible and a few outer one caninoid.

258-141 Anyperodon leucogrammicus. Articulated specimen.

258-135 Epinephelus slacksmithi. Bands of small teeth in jaws. Lower ones with three lateral rows, symphysial canines scarcely developed. Palatines with teeth.

258-112 Epinephelus fasciatus. Narrow bands of teeth in jaws, lower with 2-3 lateral series, both with pair of symphysial canines.
150mm. less .5k. Hand line.

268 THERAPONIDAE. (Therapon perch, grunters)

Carnivorous fishes with bands of villiform teeth in jaws. The outer series composed of larger ones, which may be conical, compressed or multilobed. Teeth present or absent on vomer and palatines.

268-155 Therapon jarbua. Teeth conical and arranged in several series forming villiform bands in both jaws. Palatine with teeth.
260mm. less .5k. Hand line.

284 CARANGIDAE. (Travally, Scad, Jacks)

Carnivorous but with small teeth. Dentition sometimes incomplete or obsolete, but normally there are bands of villiform teeth in jaws, vomer, and palatines, or outer row in both jaws may comprise larger conical teeth.

284-116 Caranx ignobilis. Both jaws with single row of strong conical teeth, upper with inner villiform band.
810mm. 14k. Trolling.

284-126 Trachurops (Selar) crumenophthalmus. Both jaws with single series of fine teeth. Teeth easily lost from bone. 225mm. less .5k. Speared.

284-196 Trachurops (Selar) crumenophthalmus.
284-199 Articulated specimens.

284-202 Elegatis bipinnulatus. Teeth in both jaws are very small and villiform. Teeth easily

284 CARANGIDAE (continued)

lost from bone. Trolling.

284-130 Caranx melempygus. Both jaws with single row of strong conical teeth, upper with inner villiform band.
450mm. 1k. Trolling.

284-138 Caranx melempygus.
450mm. 1k. Speared.

284-172 Caranx ignobilis.
650mm. 4.2k. Trolling.

284-214 Caranx lugubris. Both jaws with single row of strong conical teeth, upper with inner villiform band.
400mm. Hand line.

285 CORYPHAENIDAE. (Dolphinfish)

Frontal part of head developed into bony crest in males and older individuals. Bands of sharp recurved teeth in jaws, outer series more widely spaced. Two patches of villiform teeth on tongue.

285-102 Coryphaena hippurus. Teeth easily separated from bone leaving rimmed sockets. 1000mm. 5k. Trolling.

293 LUTJANIDAE. (Snapper)

Carnivorous bottom feeders. Jaws with a band of small pointed teeth of which the outer row is composed of enlarged conical ones. Anterior enlarged canines often present. Fine teeth on vomer and palatines. Pharyngeal teeth sharp pointed, illustrated in 215.

293-103 Lutjanus bohar. Teeth in jaws in narrow bands with outer series enlarged, anterior ones in upper jaw caninoid. Band of small teeth continuous in upper, interrupted in lower jaw.
610mm. 5k. Hand line.

293-117 Pristipomoides argyogrammicus. Teeth as
293-124 in 103.
293-125 285mm. less .5k. Hand line.
320mm. less .5k. Hand line.
345mm. less .5k. Hand line.

293 LUTJANIDAE (continued)

293-131 Lutjanus bohar. Same as 103.
280mm. 1k. Hand line.

293-142 Lutjanus rivulatus. Teeth as in 103.
380mm. 1k. Hand line.

293-148 Aphareus rutilans. Teeth in jaws minute, arranged in several rows anteriorly and in one row laterally. No canines.

293-158 Lutjanus kasmira. Teeth as in 103.
240mm. less .5k. Hand line.

293-160 Lutjanus sp. Articulated specimen.

293-162 Pristipomoides argyrogrammicus.
Articulated specimen.
285mm. less .5k. Hand line.

293-168 Macolor niger. Narrow bands of small teeth in jaws, outer row enlarged. Anterior teeth in upper jaw enlarged.

293-182 Lutjanus semicintus. Teeth as in 103.

293-201 Lutjanus argentimaculatus. Teeth as in 103. Skull carried off by large rat.

293-209 Lutjanus gibbus. Teeth as in 103.

293-215 Aprion virescens. Teeth in villiform bands in jaws, outer series enlarged. Pair of enlarged canines anteriorly in both jaws and some smaller ones laterally. Phayngeal teeth sharp caninoid.
400mm. 1k. Trolling.

294 NEMIPTERIDAE. (Sea-Bream)

Great variation in dentition. Carnivorous. Teeth in jaws usually small and pointed, the outer series enlarged and conical. In some genera there are molar teeth. Anterior teeth often caniniform or incisitorm. No teeth on palate.

294-163 Symphorichthys spilurus. Upper jaw with one row of submolar teeth, lower jaw with 3 rows of smaller ones, the outer row anteriorly in both jaws being short conical canines. Speared at reef.

294 NEMIPTERIDAE (continued)

294-198 Montaxis granoculis. A single row of broad molars laterally in both jaws preceded by an oval patch of very small teeth and an outer anterior row of strong canines.
130mm. less .5k. Speared at reef.

297 POMADASYIDAE (Sweetlips)

Jaws with several rows of pointed teeth anteriorly and one row posteriorly, the outer row enlarged. No canines. Strong pharyngeal bones with round submolariform teeth. Omnivorous.

297-169 Plectorhynchus chaetodontoides. Jaws with three rows of small pointed teeth and an outer row of enlarged ones.
410mm. 1.2k. Speared at reef.

297-170 Plectorhynchus chaetodontoides. Same as 169. 290mm. less .5k. Speared at reef.

297-177 Plectorhynchus cuvieri. Teeth in seven rows in upper jaw, outer row enlarged. Lower jaw with few rows of small teeth and two irregular outer rows of enlarged ones.
320mm. less .5k. Speared at reef.

297-179 Spilotichthys pictus. Jaws with band of 4-5 rows of small teeth and an outer series of enlarged ones.
390mm. .5k. Speared at reef.

297-188 Pseudopristipoma nigra. Jaws with about three rows of small teeth.
320mm. less .5k. Netted.

298 LETHRINIDAE (Emperor)

Fairly deep bodied and moderately compressed. Head pointed. Mouth moderate, slightly protractile. Jaws with small pointed teeth and some enlarged canines anteriorly and a small row of conical or molariform teeth laterally. No teeth on palate. Carnivorous.

The two major types of dention can be seen between 115 with conical lateral teeth and 184 with molariform.

The pharyngeal teeth are sharp long curved caniniform best seen in 203. These teeth easily fall out of the bone.

298 LETHRINIDAE (continued)

298-115 Lethrinus miniata. Snout long and pointed. lateral teeth in jaws conical, anterior ones strong canines.
590mm. 3k. Hand line.

298-147 Lethrinus reticulatus. Lateral teeth in jaws submolariform, anterior ones strong canines. 220mm. less .5k. Hand line.

298-157 Lethrinus obsoletus. Lateral teeth in jaws molariform, anterior ones moderate-sized canines. 260mm. less .5k. Hand line.

298-184 Lethrinus kallopterus. Lateral teeth in jaws submolariform, anterior ones large curved canines. 320mm. less .5k. Hand line.

298-203 Lethrinus fletus. Lateral teeth in jaws molariform, anterior ones caniniform.
330mm. less .5k. Hand line.

300 SPARIDAE (Sea-Bream)

Strongly molariform dentition, carnivorous, using the pavement of teeth to crush shellfish. Several rows of large conical or rounded molar teeth in jaws, those towards the back large and more molariform. Enlarged canines or incisors in a row across front of jaw. No teeth on palate. Munro lists only two species and the following specimen checks out as a Sparid save for the dentition. This specimen was caught at a depth of over 1000 ft.

300-206 Acanthopagrus sp. Six peg like curved incisors anteriorly in both jaws. A single row of incisor like teeth posteriorly. No molars. Pharyngeal plate with long curved villiform teeth.

302 MULLIDAE (Goatfish)

Carnivorous but not voracious. Bottom dwellers. These fish are distinguished by a long pair of chin barbels which are used in probing for food. Mouth small. One or more series of small acute teeth in jaws.

302-143 Parupeneus indicus. Single series of conical teeth in jaws but vomer and palatines edentulous.
320mm. less .5k. Netted.

298 LETHRINIDAE (continued)

298-115 Lethrinus miniata. Snout long and pointed. lateral teeth in jaws conical, anterior ones strong canines.
590mm. 3k. Hand line.

298-147 Lethrinus reticulatus. Lateral teeth in jaws submolariform, anterior ones strong canines. 220mm. less .5k. Hand line.

298-157 Lethrinus obsoletus. Lateral teeth in jaws molariform, anterior ones moderate-sized canines. 260mm. less .5k. Hand line.

298-184 Lethrinus kallopterus. Lateral teeth in jaws submolariform, anterior ones large curved canines. 320mm. less .5k. Hand line.

298-203 Lethrinus fletus. Lateral teeth in jaws molariform, anterior ones caniniform.
330mm. less .5k. Hand line.

300 SPARIDAE (Sea-Bream)

Strongly molariform dentition, carnivorous, using the pavement of teeth to crush shellfish. Several rows of large conical or rounded molar teeth in jaws, those towards the back large and more molariform. Enlarged canines or incisors in a row across front of jaw. No teeth on palate. Munro lists only two species and the following specimen checks out as a Sparid save for the dentition. This specimen was caught at a depth of over 1000 ft.

300-206 Acanthopagrus sp. Six peg like curved incisors anteriorly in both jaws. A single row of incisor like teeth posteriorly. No molars. Pharyngeal plate with long curved villiform teeth.

302 MULLIDAE (Goatfish)

Carnivorous but not voracious. Bottom dwellers. These fish are distinguished by a long pair of chin barbels which are used in probing for food. Mouth small. One or more series of small acute teeth in jaws.

302-143 Parupeneus indicus. Single series of conical teeth in jaws but vomer and palatines edentulous.
320mm. less .5k. Netted.

329 SPHYRAENIDAE (Barracuda)

Carnivorous, fast swimming fish which slash their prey with sharp dog-like teeth. Teeth large and unequal, fang-like and implanted in sockets in jaws and palatines.

329-101 Agrioposphyraena barracuda. Lower jaw with single row of fang-like teeth. Anterior with large single tooth, then small teeth increasing in size posteriorly. Upper jaw with 2-3 large fangs with single row of much smaller teeth posteriorly. Upper maxillary with single row of large fang-like teeth.
1000mm. 4.7k. Trolling.

329-133 Agrioposphyraena barracuda. Same as 101.
610mm. 1.8k. Trolling.

331 LABRIDAE (Tusk-fish, Wrasses)

Partly herbivorous or carnivorous, some with dentitior modified to crush shells of molluscs. Generally singl series of teeth on cutting edges of jaws, anterior one usually caninoid and lateral ones sometimes united basally. Strong pharyngeal plates with peg-like molariform teeth.

331-156 Choerodon anchorago. Same 189.
Articulated specimen.

331-189 Choerodon anchorago. Single row of teeth in jaws more or less coalesced, 4 curved canines anteriorly in both jaws, inner ones longer in upper jaw and outer ones longer in lower jaw. 1-2 canines posteriorly in upper jaw.

331-207 Cheilinus undulatus. Both jaws with a single row of conical teeth and a pair of canines anteriorly.

333 SCARIDAE (Parrotfish)

Parrotfish feed mainly on vegetable matter and invertebrates but their strong beaks easily crush molluscs and coral. They are easily distinguished by their teeth being fused and resemble the beak of a parrot.

Teeth fully coalesced into a parrot-like beak, with median suture of each jaw, tip of the lower jaw enclosed by upper jaw. Edges of dental plate forming a continuous cutting edge in which individual teeth usually cannot be distinguished. Canines sometimes present posteriorly in both jaws. Upper pharyngeals

333 SCARIDAE (continued)

with 1-3 rows of teeth, the lower pharyngeal plate longer than broad.

333-180 Scarops rubroviolaceus. One canine posteriorly in the upper jaw. This "canine" is not on the cutting edge of the dentition but points out laterally. 230mm. less .5k. Speared at reef.

333-190 Scarops rubroviolaceus. Female of species.
330mm. .5k. Speared at reef.

333-200 Callyodon flavipectoralis. 1-2 canines posteriorly in upper jaw and sometimes others on lower jaw. This specimen has two very small canines in the upper and two more distinct ones in the lower jaw. 205mm. less .5k. Speared at reef.

381 ACANTHURIDAE (Unicornfish, Surgeonfish)

Mouth small and terminal, herbivorous, scraping algae with the fine teeth, often feeding in large schools. These fish have fixed bony plates or moveable knife-like barbs on the caudal peduncle. Teeth incisiform, setiform, or lobate. Teeth very small but numerous.

381-166 Axinurus thynnoides. Many nonserrated setiform teeth. The teeth are very small but numerous. 400mm. .5k. Speared at reef.

381-167 Acanthurus gahhm. Teeth fixed and denticulated along median and lateral margins. 30-60 teeth in upper jaw.
240mm. less .5k. Speared at reef.

381-174 Cyphomycter vlamingi. Teeth small, pointed and serrated, about 50 in each jaw.
280mm. less .5k. Speared at reef.

381-176 Callicanthus lituratus. Teeth apically rounded with entire edges. 24-28 in both jaws. 230 mm. less .5k. Speared at reef.

381-197 Acanthurus pyroferus. Teeth as in 167. Articulated specimen.
155mm. less .5k. Speared at reef.

382 SIGANIDAE (Rabbitfish)

Herbivorous nibblers. Jaws with a row of slender compressed incisors, which may be bicuspid, tricuspid or slightly serrated.

382-128 Siganus rostratus. Row of very small teeth. Teeth lost from bone leaving sockets. 210mm. less .5k. Netted.

382-146 Siganus vermiculatus. Row of small teeth. Teeth lost from bone leaving sockets. 210mm. less .5k. Netted.

382-165 Lo vulpinus. Small teeth lost from bones. 170mm. less .5k. Speared at reef.

385 SCOMBRIDAE (Mackerel, Tuna, Skipjack)

Most are large, powerful, swift-swimming, predatory fishes. Teeth sharply pointed, small and never caniniform.

385-104 Gymnosarda nuda. (Dogtooth Tuna) Teeth in jaws large and dog like. 730mm. 5.75k. Trolling.

385-105 Neothunnus macropterus. (Yellowfin tuna) Single row of small pointed teeth in jaws and smaller similar ones on vomer and palatines. 650mm. 4k. Trolling.

385-106 Neothunnus macropterus. Same as 105.

385-109 Katsuwonus pelamis. (Skipjack) Teeth small and conical. 460mm. 2k. Trolling.

385-114 Gymnosarda nuda. Same as 104. 550mm. 2.2k. Trolling.

385-155 Rastrelliger kanagurta. (Mackerel) Very small fine pointed teeth in jaws. 320mm. less .5k. Netted.

385-173 Euthynnus alletteratus affinis. (Mackerel tuna) Teeth slightly curved in jaws.

385-181 Scomberomorus commersoni. (Spanish Mackerel) Single series of pointed, compressed teeth in jaws. Largest teeth of the family. 950mm. 9k. Trolling.

385-191 Scomberomorus commersoni. Same as 181. 1050mm. 13k. Trolling.

385 SCOMBRIDAE (continued)

385-208 Acanthocybium solandri. (Wahoo) Single series of close-set, triangular, compressed, finely serrated teeth in jaws. Villiform teeth on vomer and palatines.

408 BALISTIDAE (Triggerfish, Filefish)

Characterised by a strong, erecting and locking anterior dorsal fin spine. Each jaw with a row of 6-8 incisor like teeth, upper with an inner row of 4-6 or more similar teeth.

408-118 Alutera scripta. Head long and slim. Mouth small with 6 incisor-like teeth. 310mm. less .5k. Speared at reef.

408-119 Alutera scripta. Same as 119.

408-120 Balistapus undulatus. 8 incisor-like teeth in each jaw. Teeth uneven and notched. 125mm. less .5k. Handline.

408-132 Balistapus undulatus. Same as 120. 215mm. less .5k. Handline.

408-154 Pseudobalistes flavimarginatus. 8 incisor-like teeth in each jaw. Teeth compress and larger anteriorly. Teeth notched.

408-178 Balistoides conspicillum. 8 incisor-like teeth in each jaw. Teeth uneven and notched. 240mm. less .5k. Speared at reef.

408-183 Canthidermis maculatus. 8 incisor-like teeth in each jaw. Teeth notched. 420mm. less .5k. Speared at reef.

410 TETRAODONTIDAE (Pufferfish)

Teeth in both jaws fused into 2 separate bony plates divided in front by a median suture. No internal dentigerous plates. Rather similar to the dentition of some Scarids but the teeth here look more like a solid bony structure without surface patterns of individual teeth.

410-137 Arothron stellatus. Teeth fused into bony plates forming a beak. 220mm. less .5k. Speared at reef.

412 DIODONTIDAE (porcupinefish)

Teeth in both jaws fused into a single sold bony plate without a suture in front forming a powerful parrot-like beak. Internal dentigerous plates well developed.

The numerous bony spines are characteristic of the Diodontidae.

412-136 Diodon holacanthus. Teeth in both jaws fused into single bony plate. 900mm. 5.5k. Speared at reef.

GLOSSARY

BICUSPID - having two cusps or points

CANINE - elongate conical teeth like those of a dog

CARDIFORM - coarse and sharp teeth like teeth on wool cards

CAUDAL - pertaining to the tail

COMPRESSED - flattened laterally

CRENULATE - having the edge slightly scalloped

CUNEIFORM - wedge-shaped

DENTIGEROUS - with teeth

EDENTULOUS - without teeth

INCISIFORM - shaped like incisor tooth

LANCEOLATE - broad at base and tapering to a point

MOLAR - blunt rounded tooth adopted for grinding

MOLARIFORM - form of molar teeth

OPERCULUM - pertaining to the bones

OPERCULAR forming the protective cover over the gill region

PALATINE - membrane bones on each side of the palate; teeth borne on the palative bones

PELAGIC - living in the open sea

PHARYNGEAL - pertaining to the pharynx; bones behind the gills in the gullet; teeth borne on these bones

SERRATE - bearing saw-like teeth

SERIFORM - curved like a sigma or letter S

VILIFORM - having the form or appearance of velvet; especially small slender teeth which form velvety bands

VOMER - pertaining to the vomer bone; teeth borne on this bone

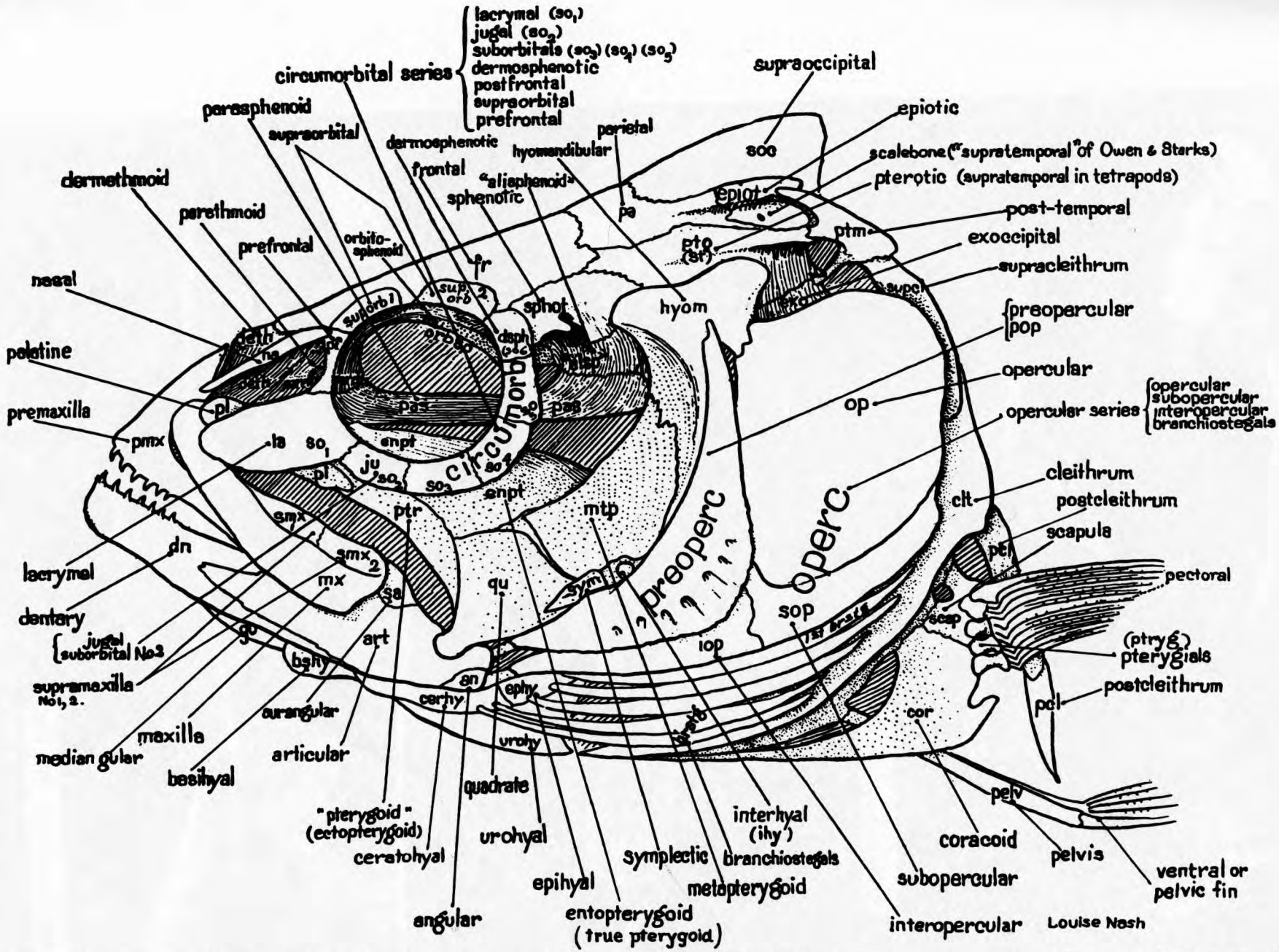
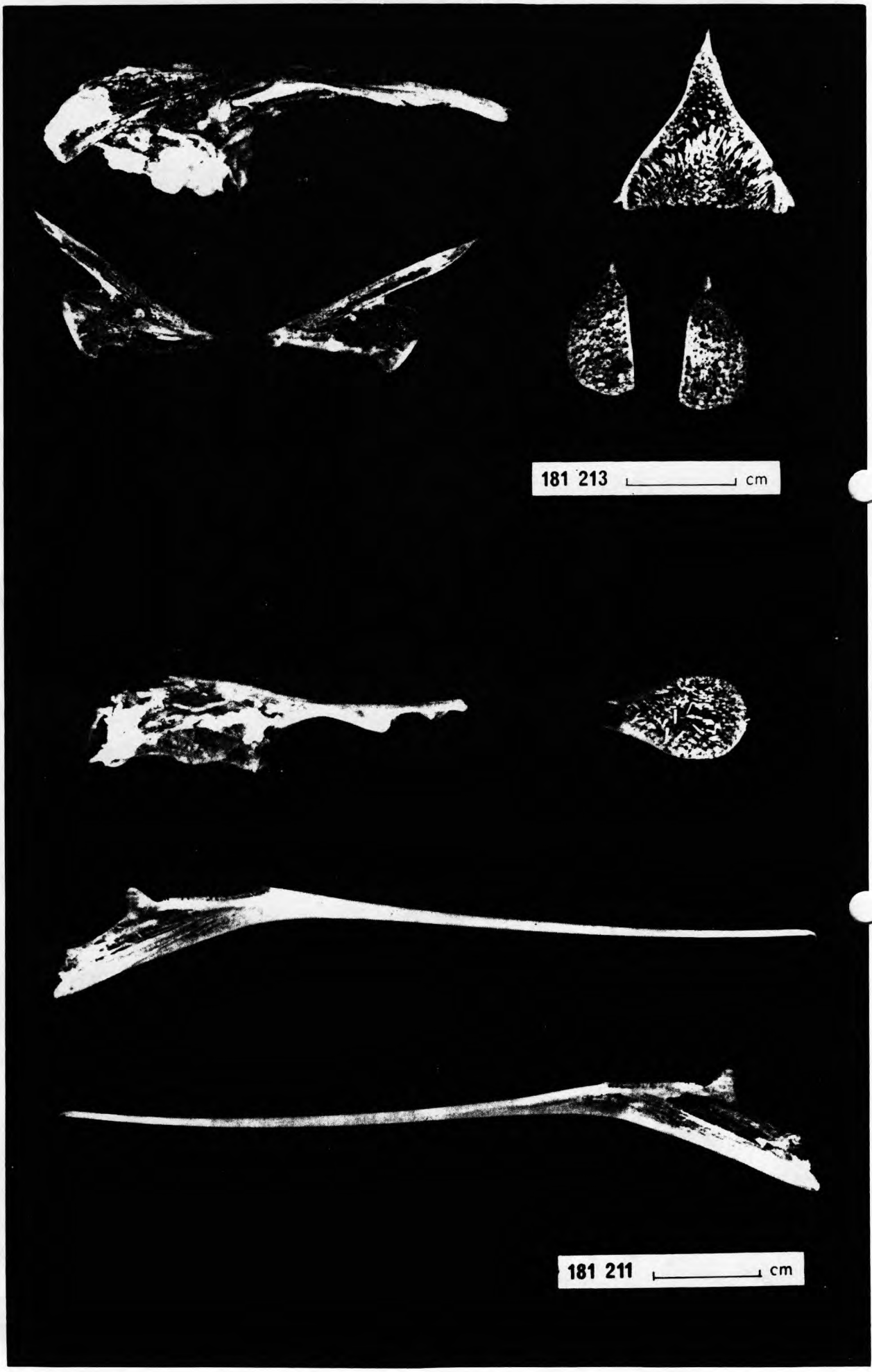


FIG. 7. The syncranium. A composite diagram based upon the study of skulls of about fifty species of teleosts, illustrating the positions of the bones and the names and abbreviations adopted in this work. Drawn by Mrs. Louise Nash, under the author's direction.

PHOTOGRAPHIC PLATES

The bones illustrated are the neurocranium and dentigerous premaxilla and dentary. The left bones have been photographed both laterally and medially.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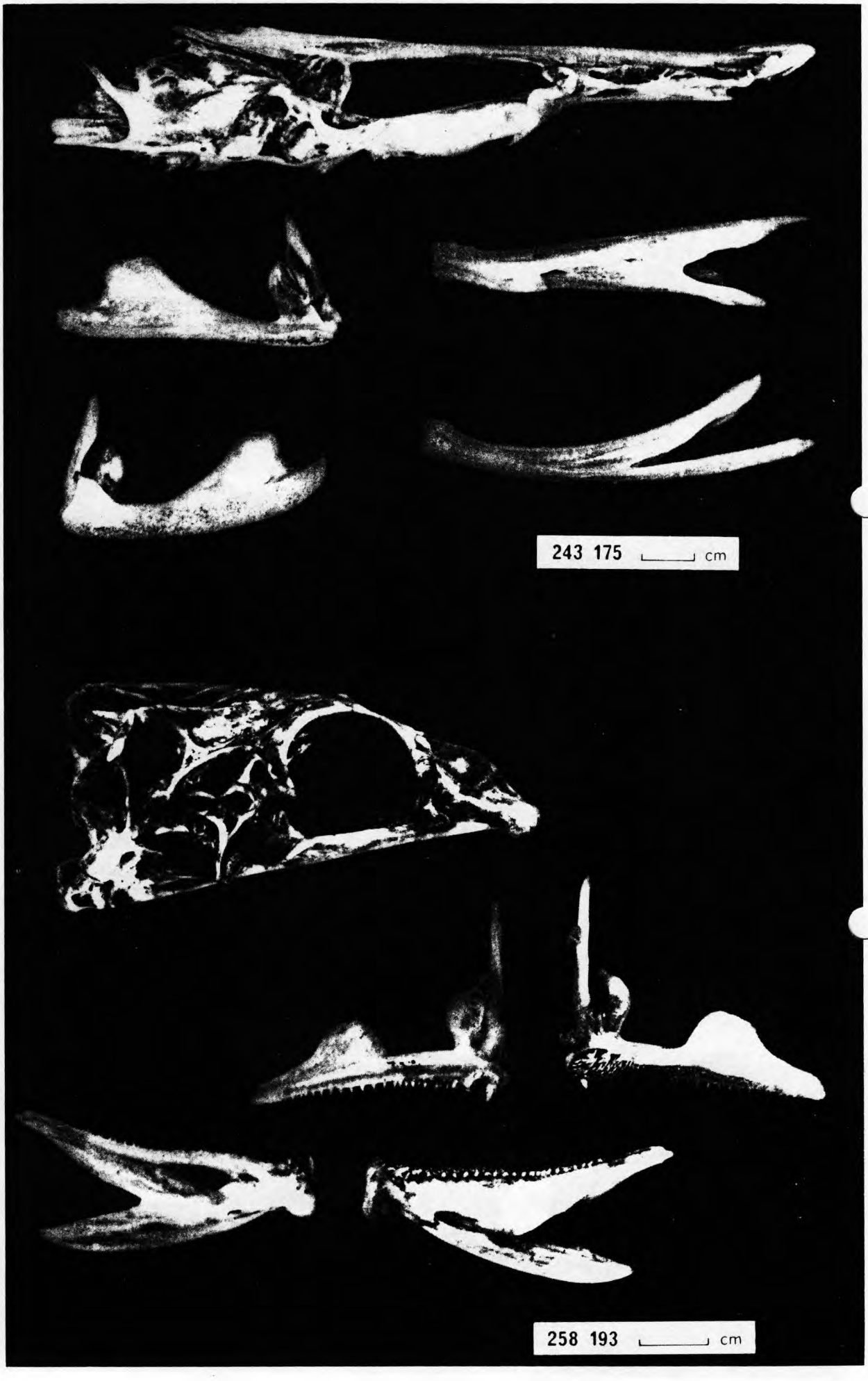
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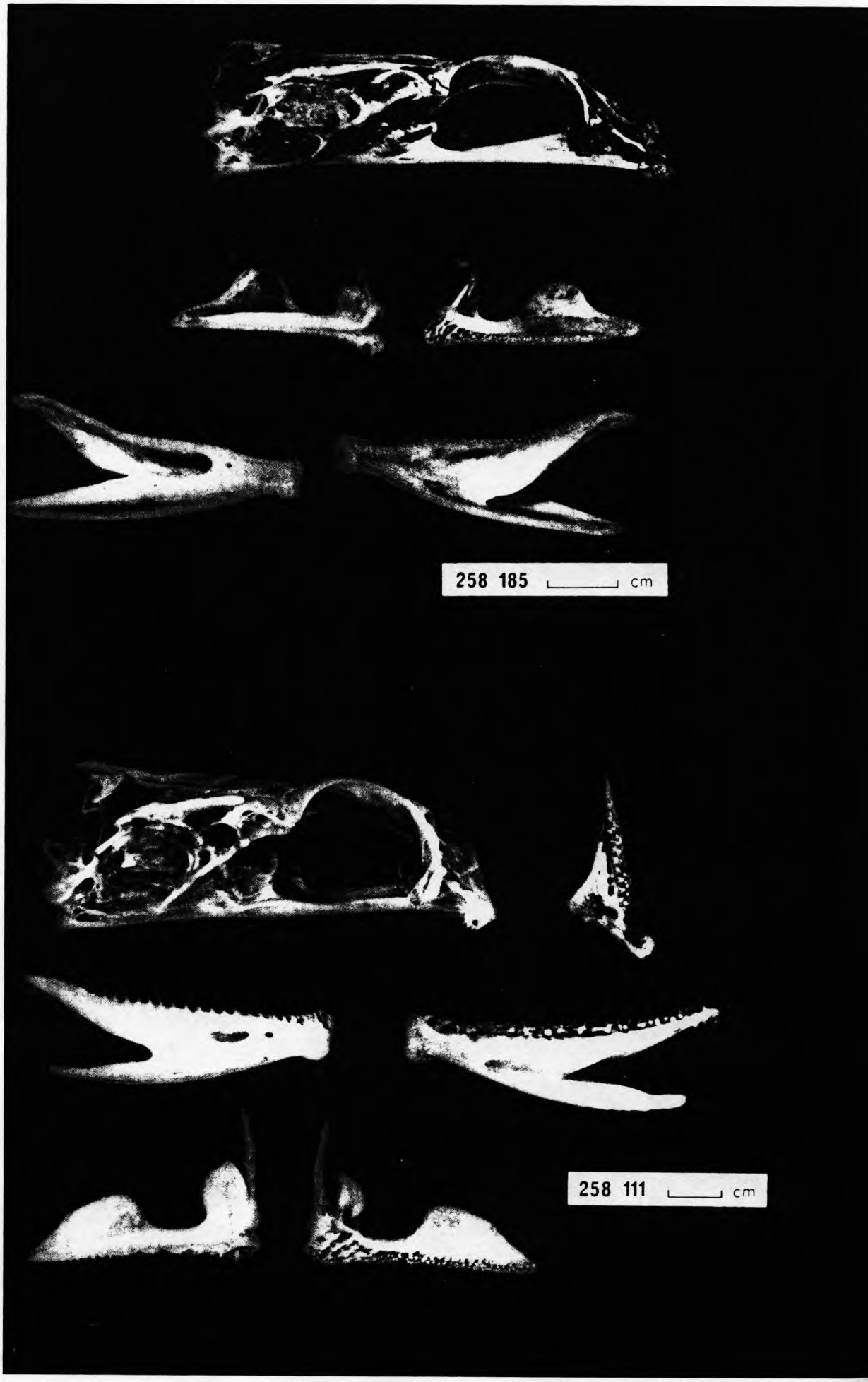
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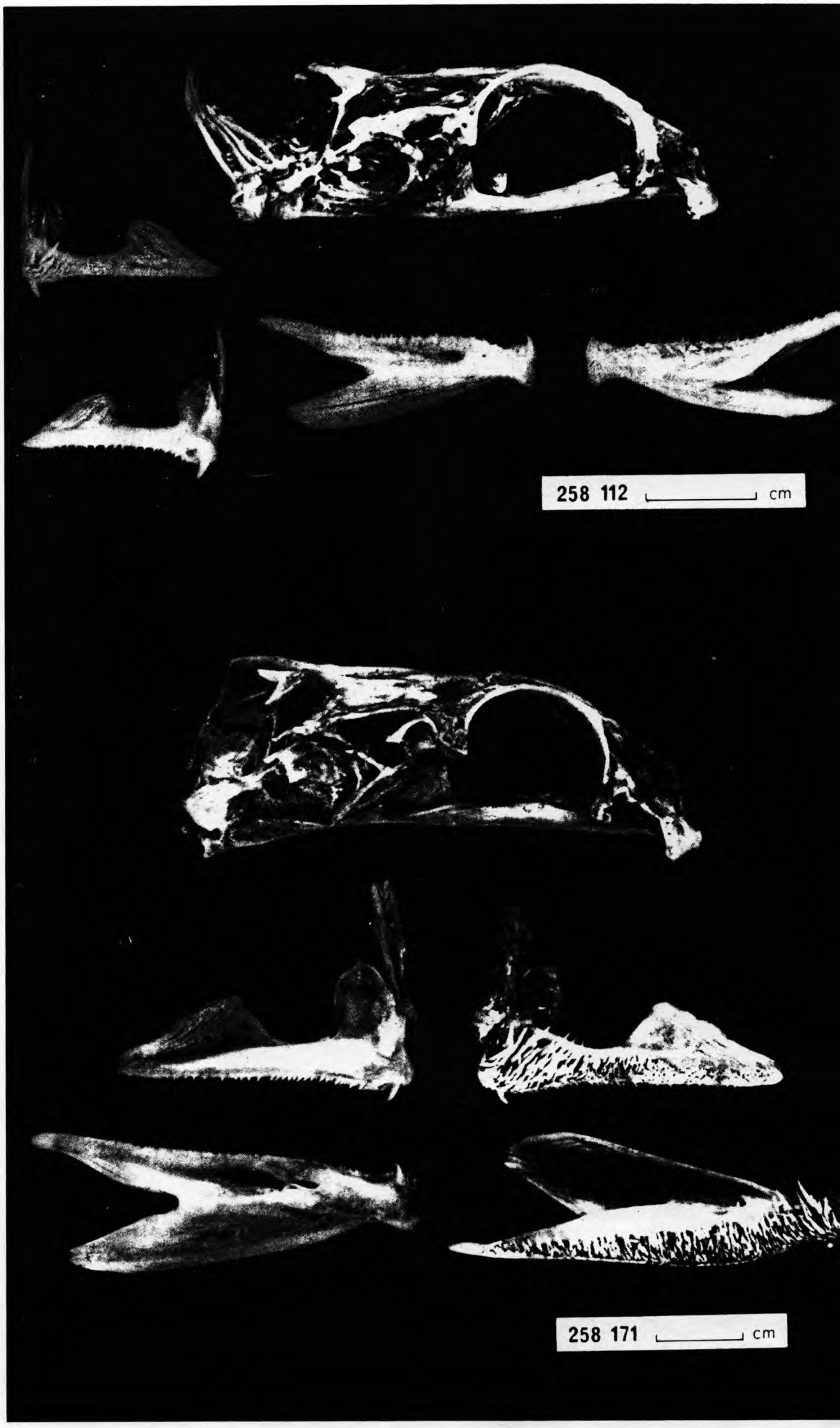
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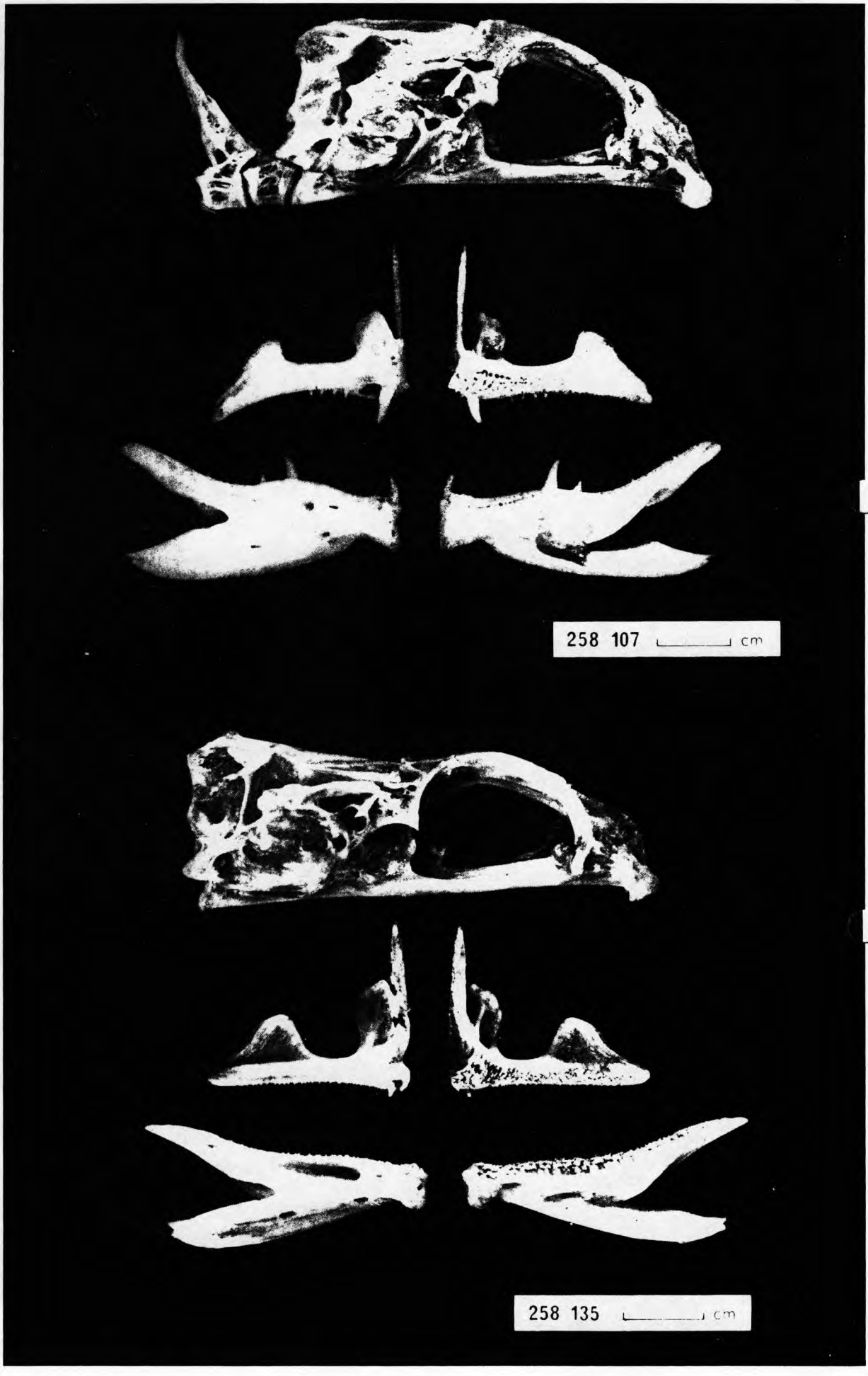
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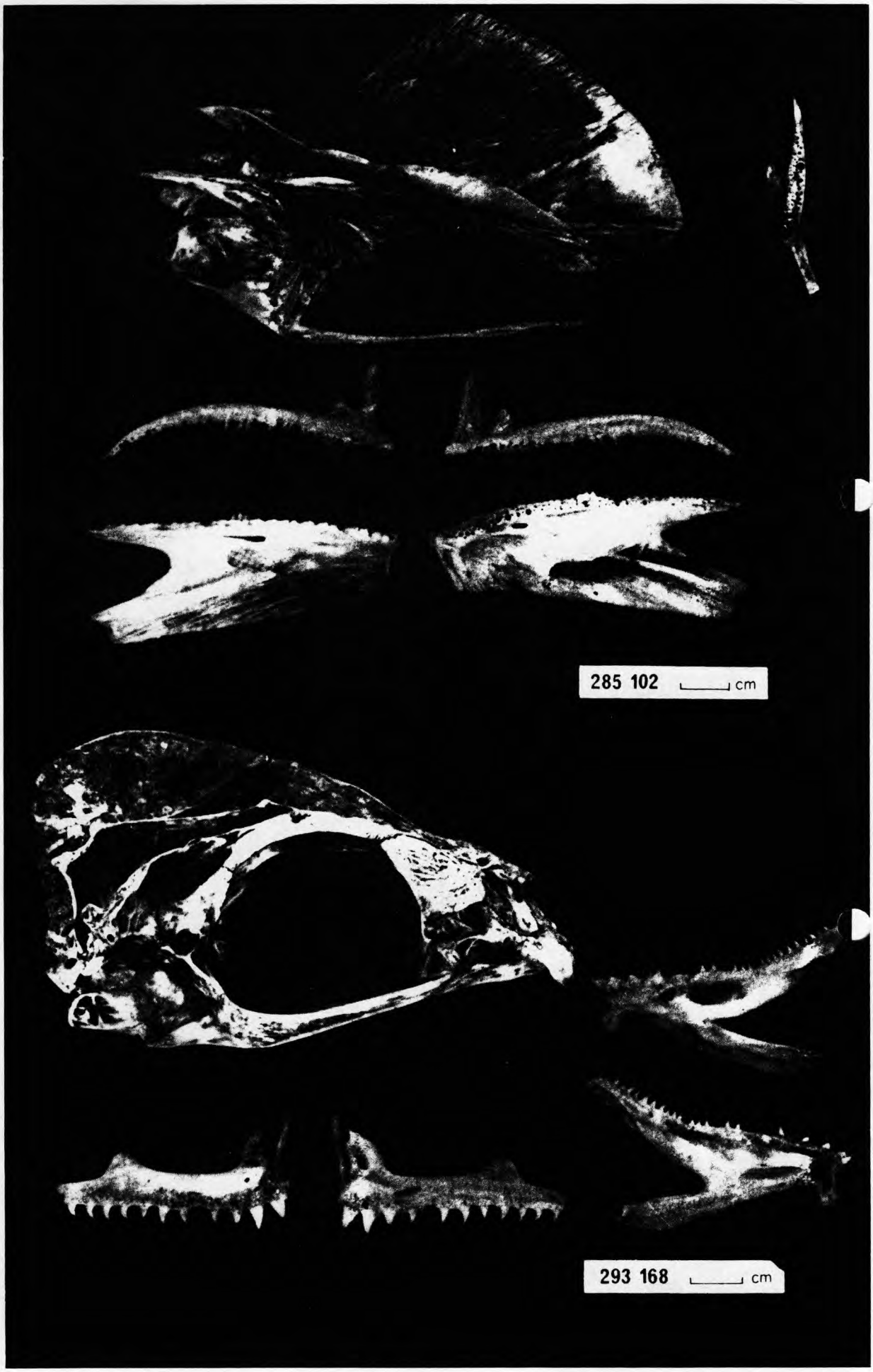
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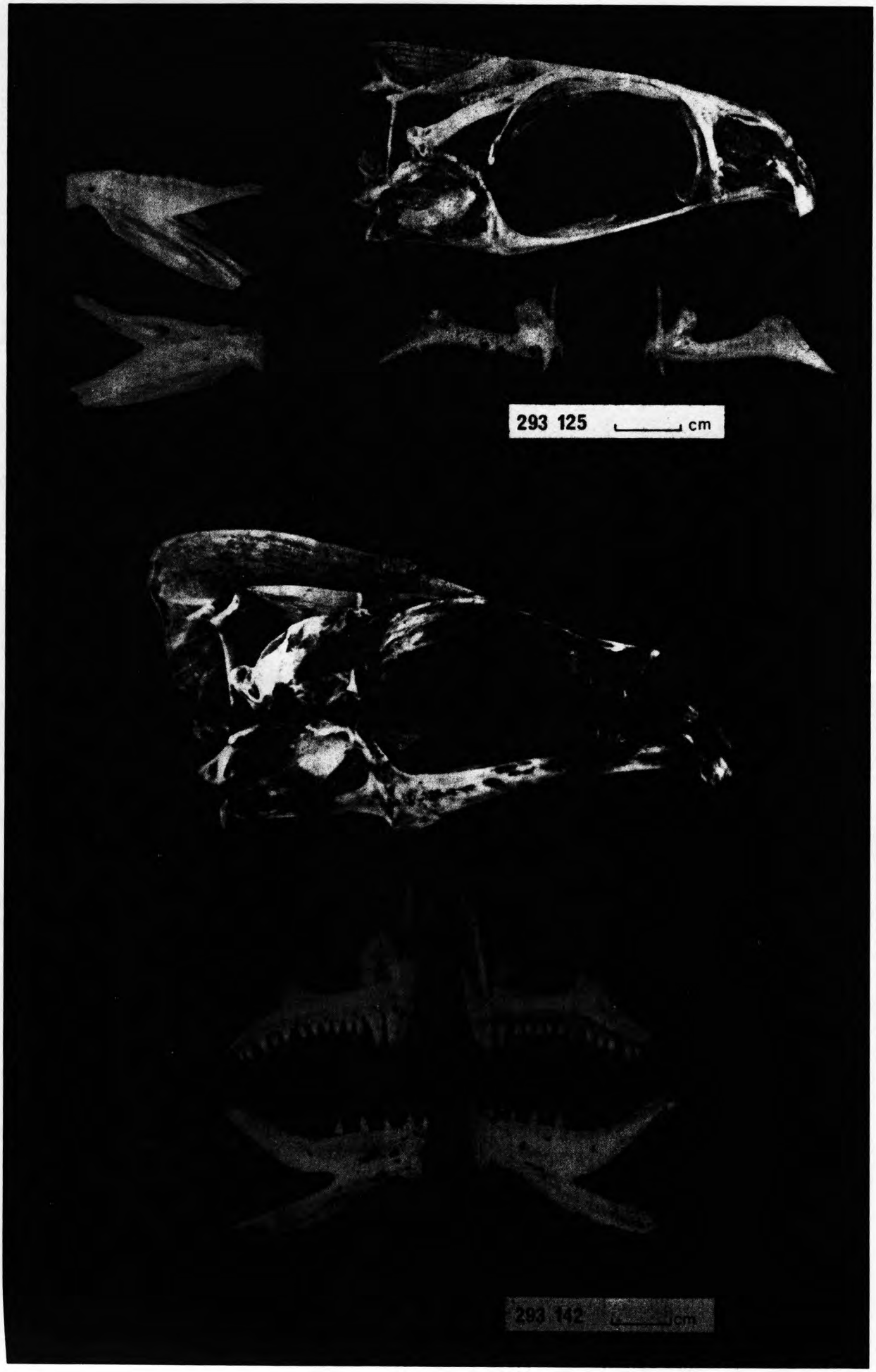
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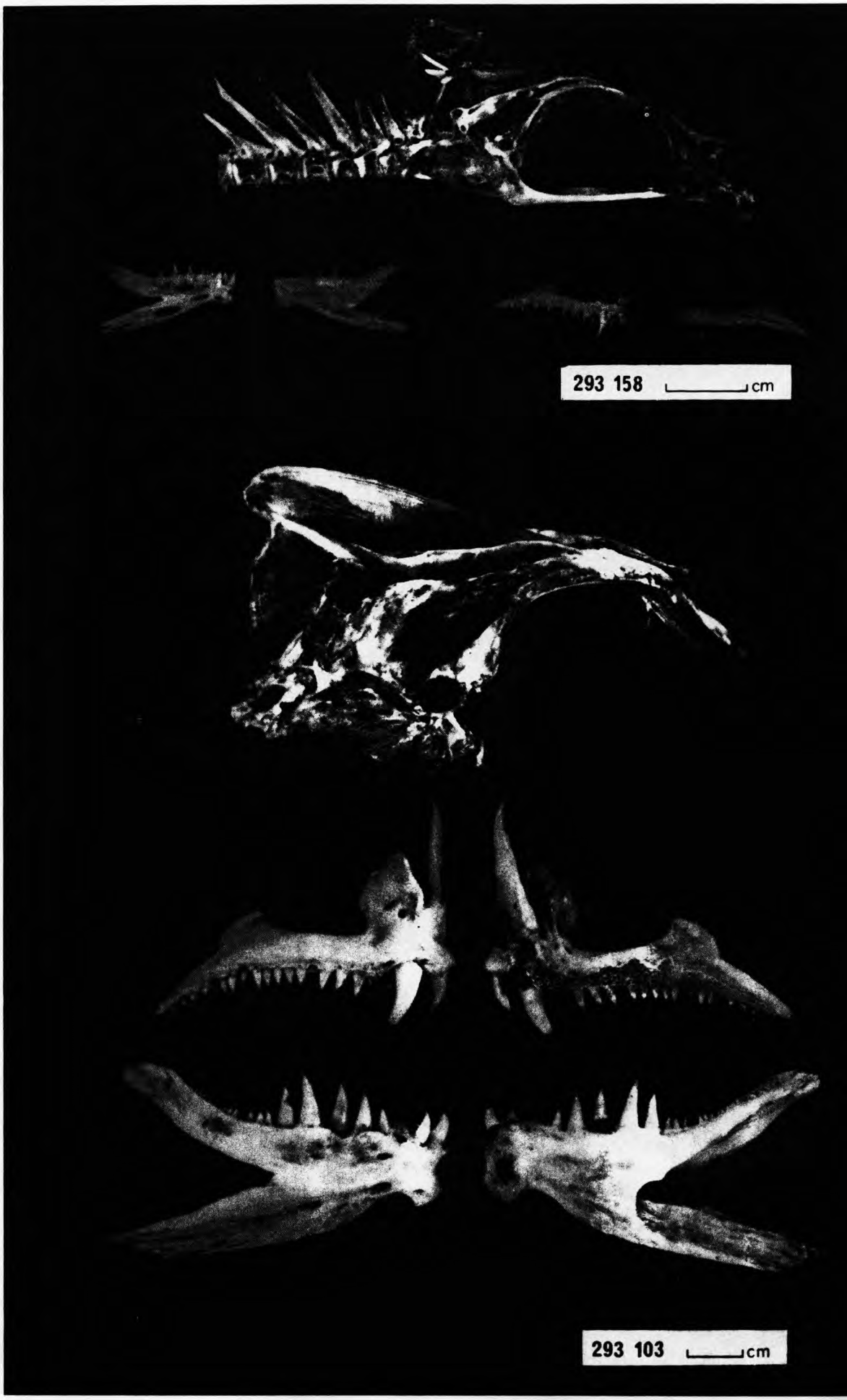
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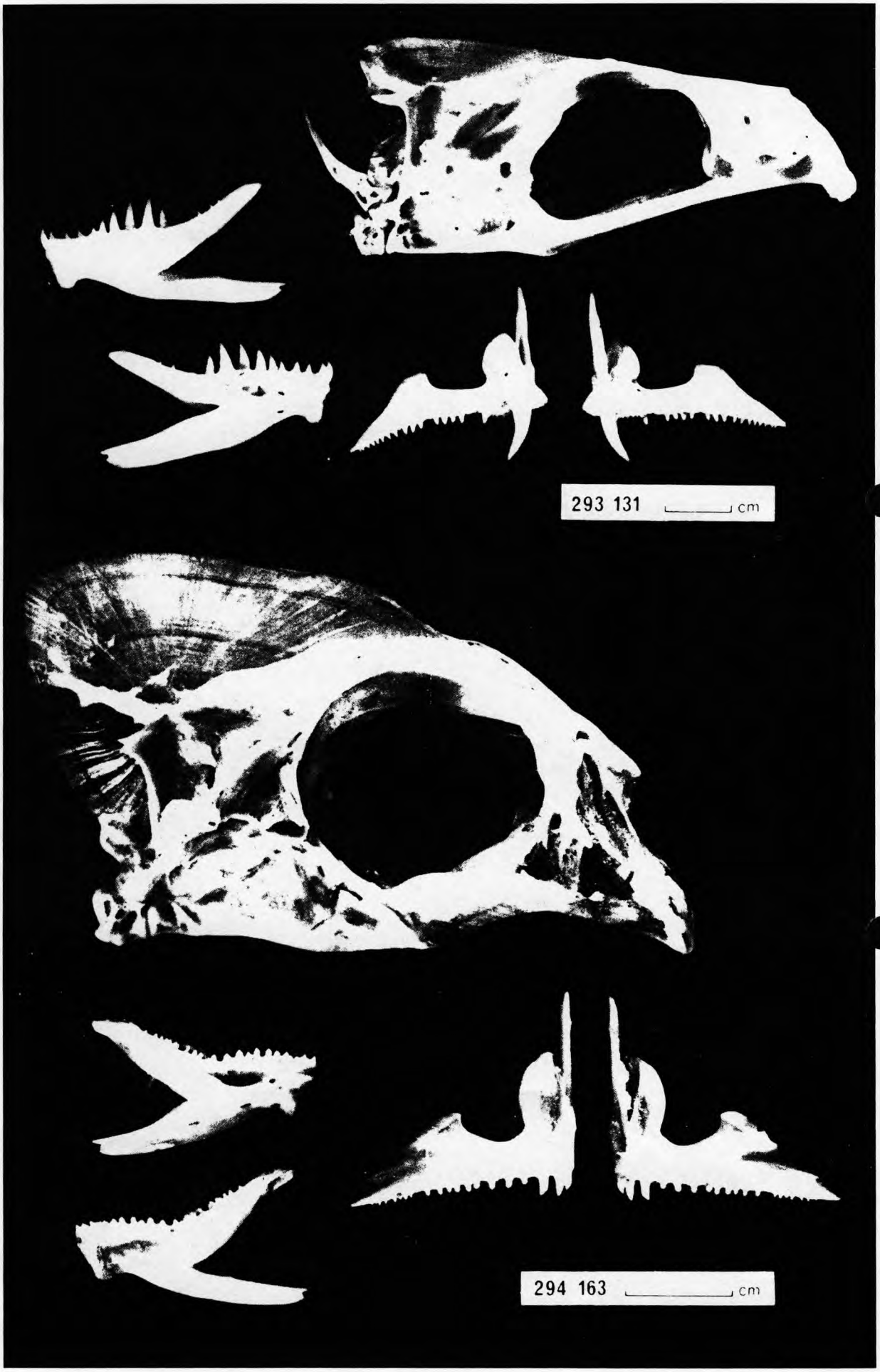
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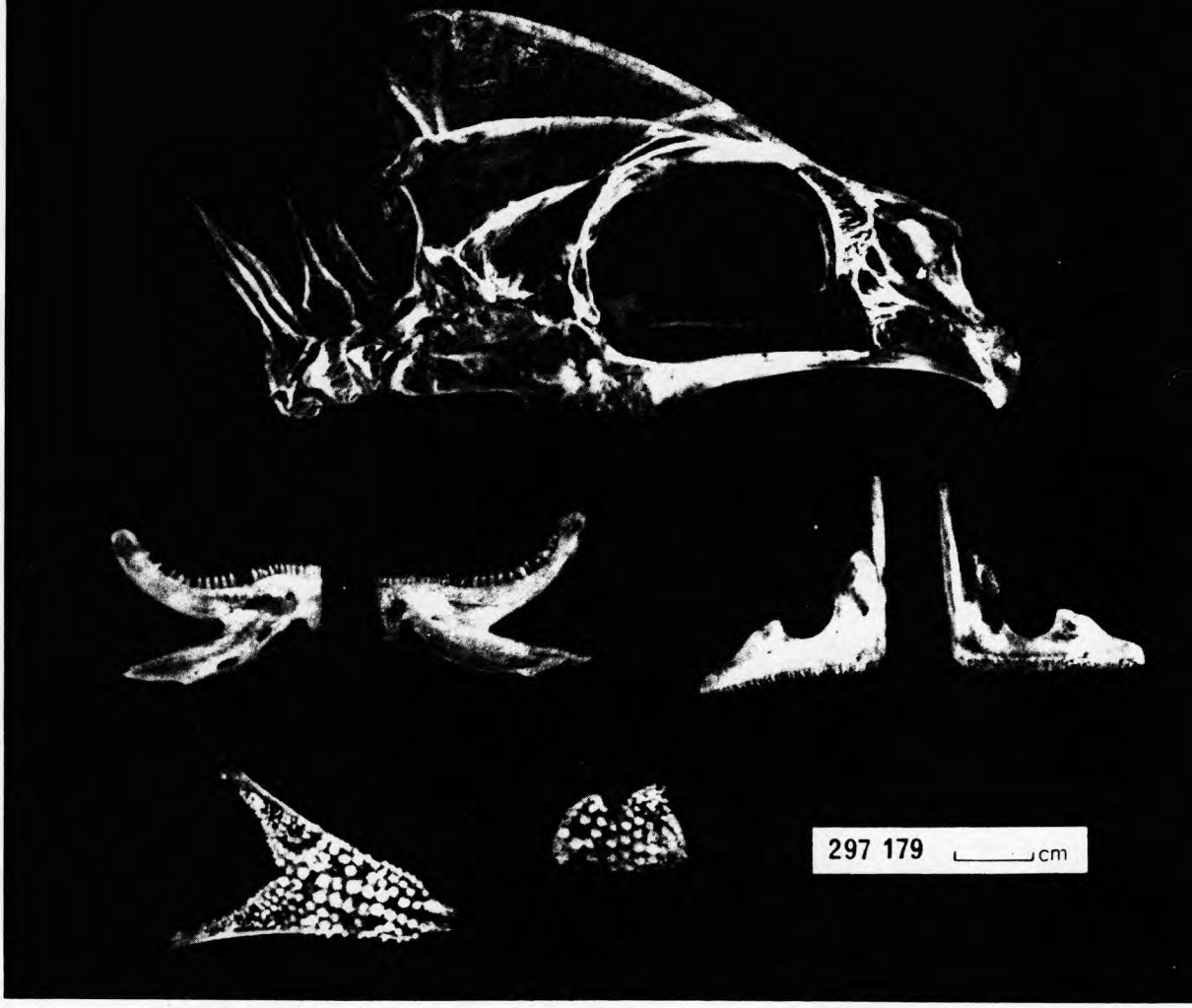
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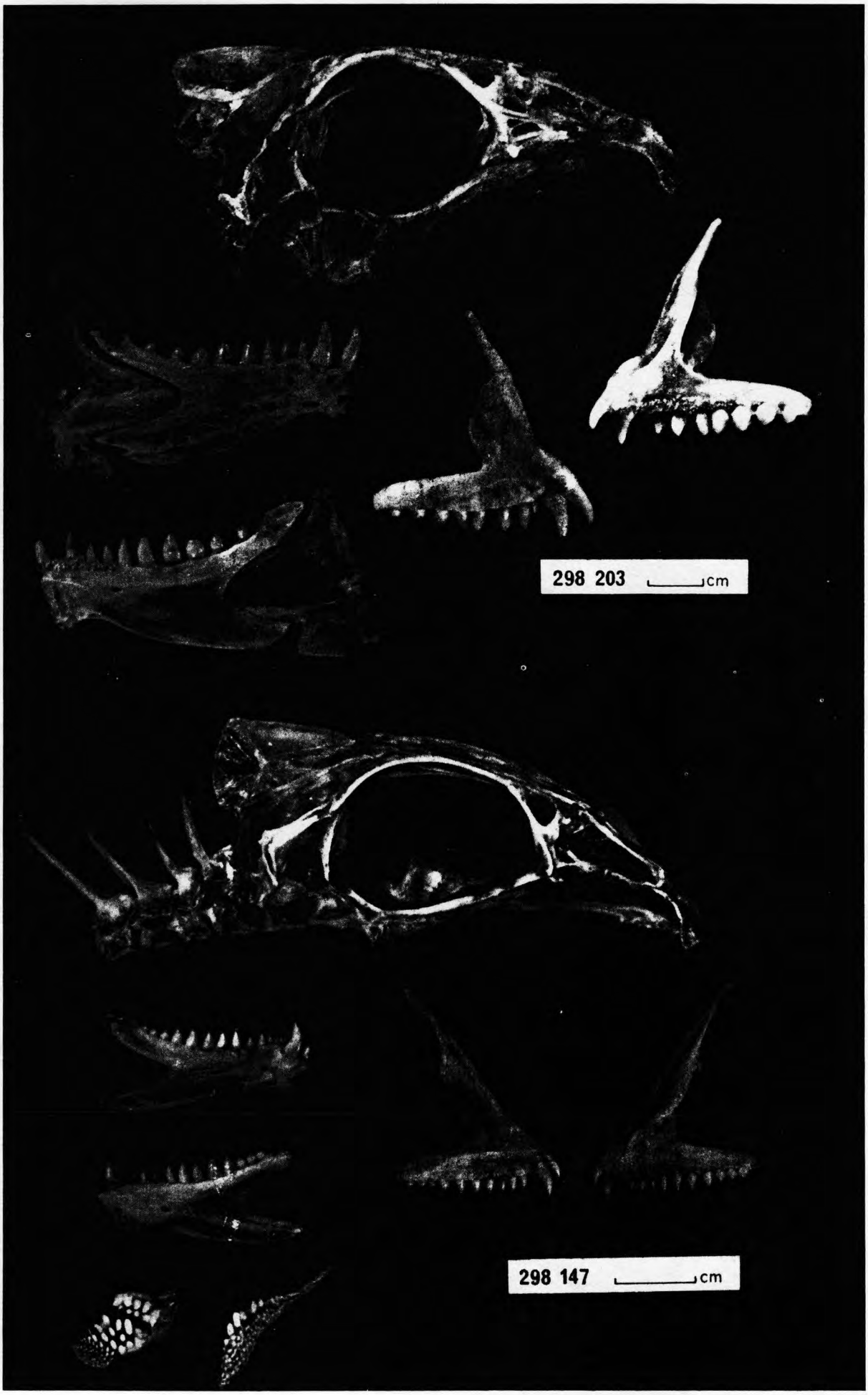
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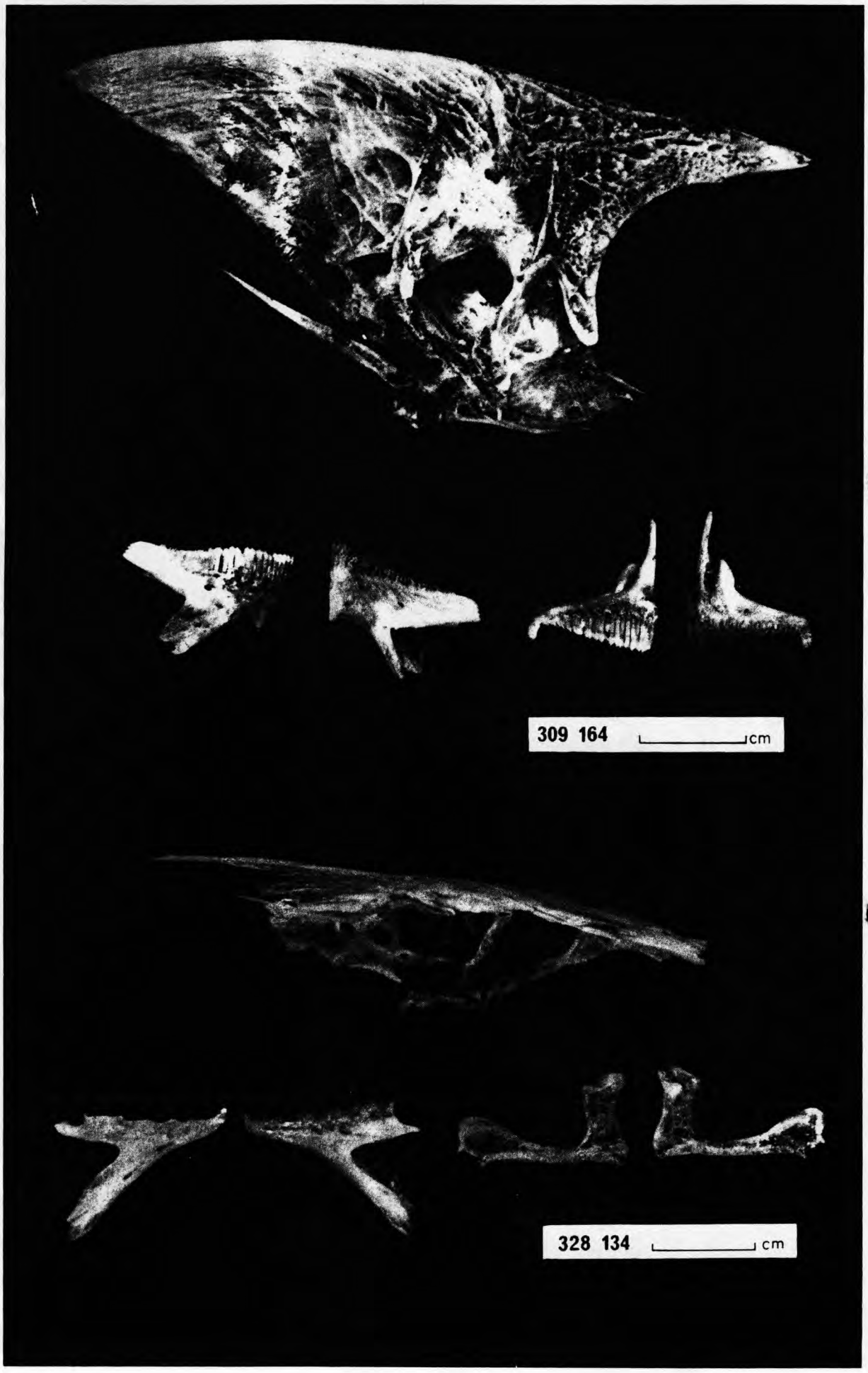
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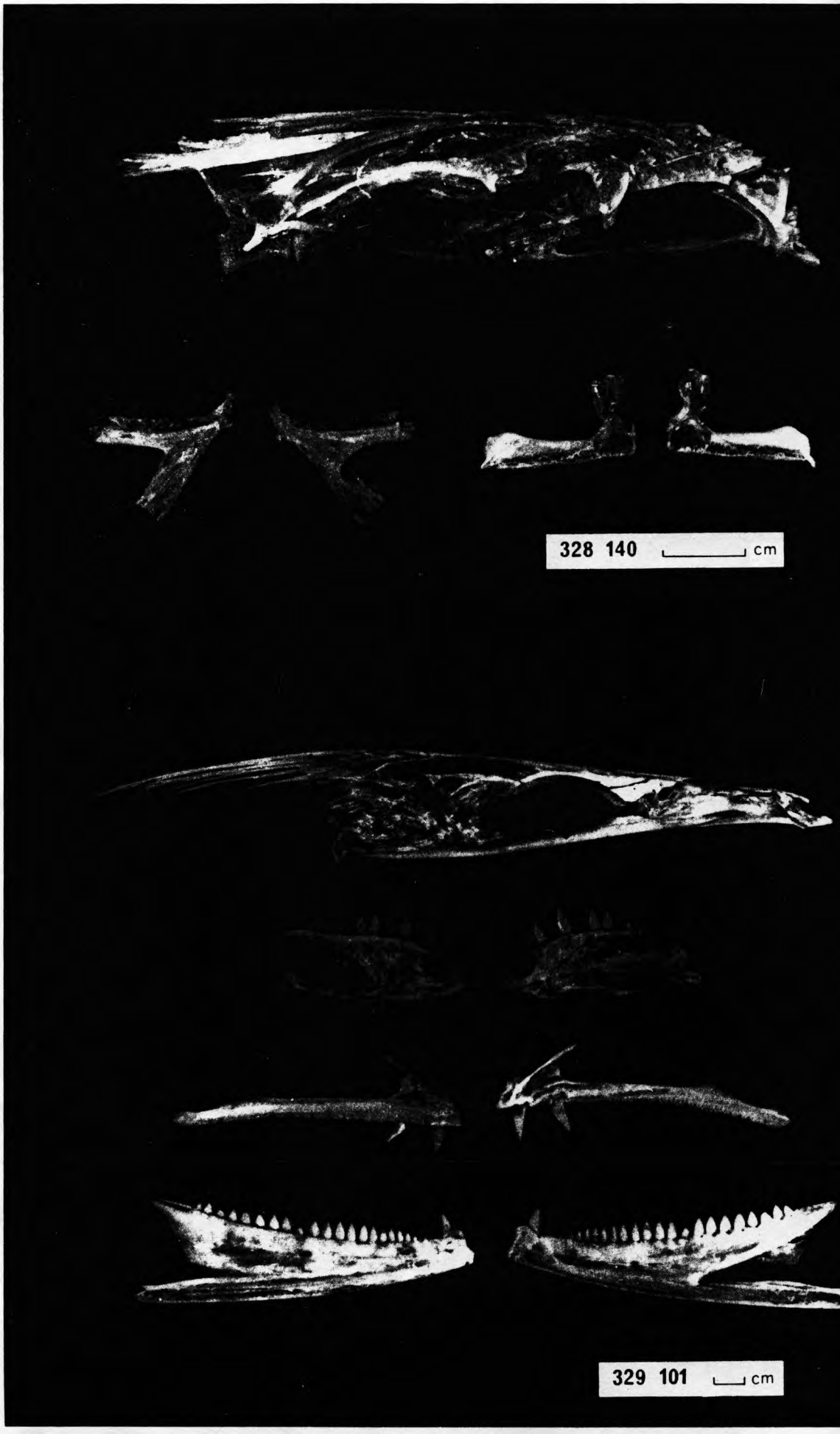
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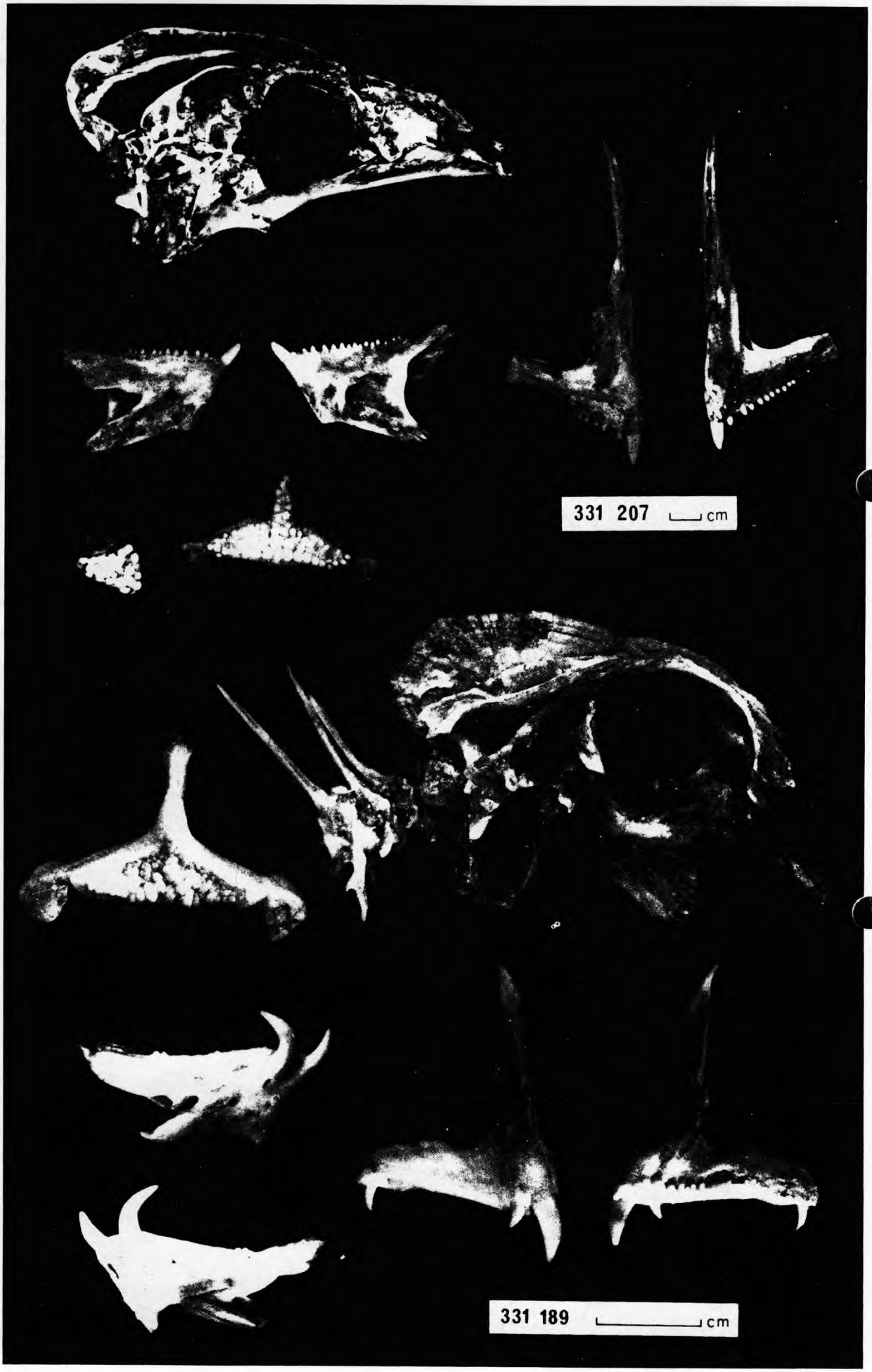
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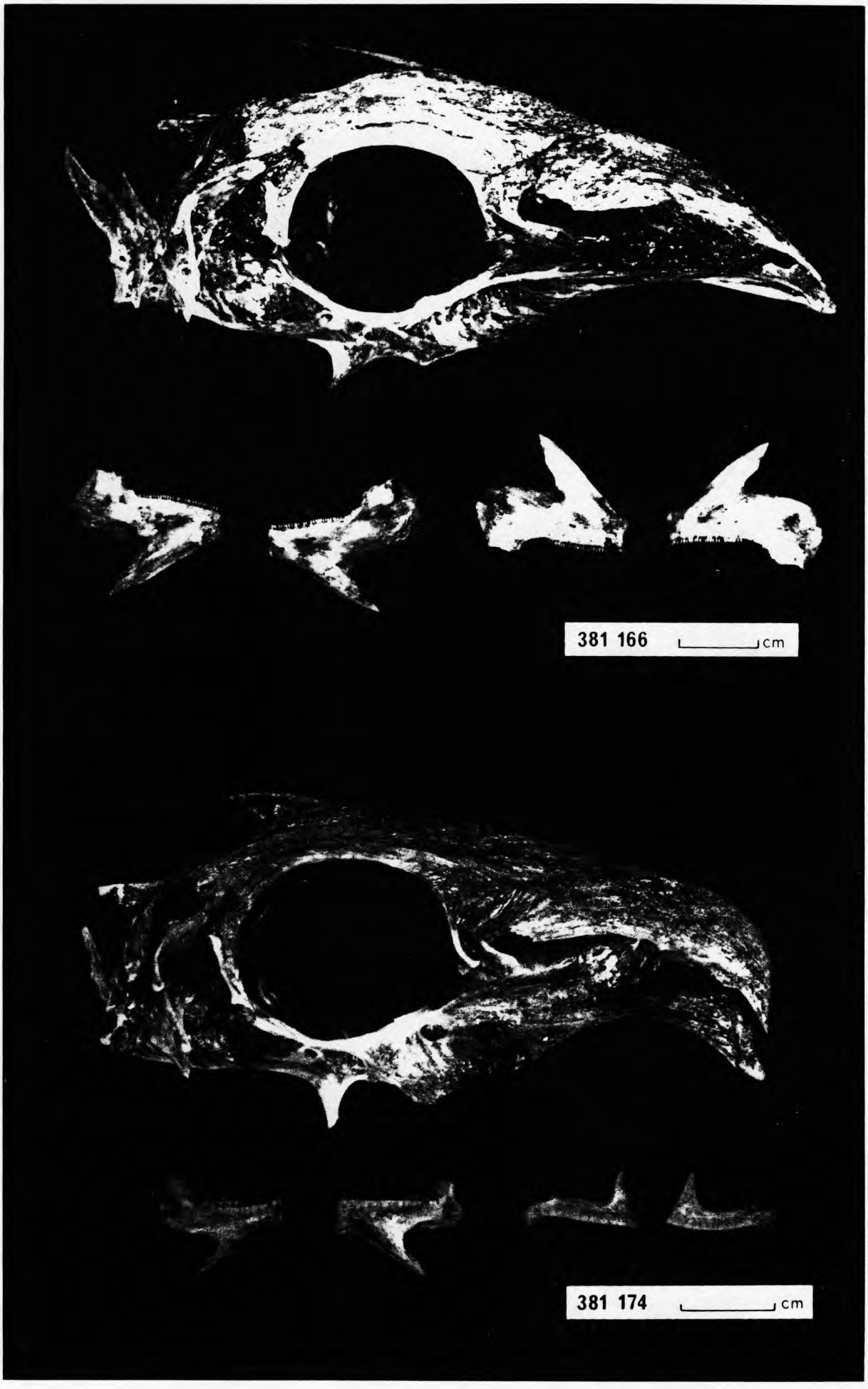
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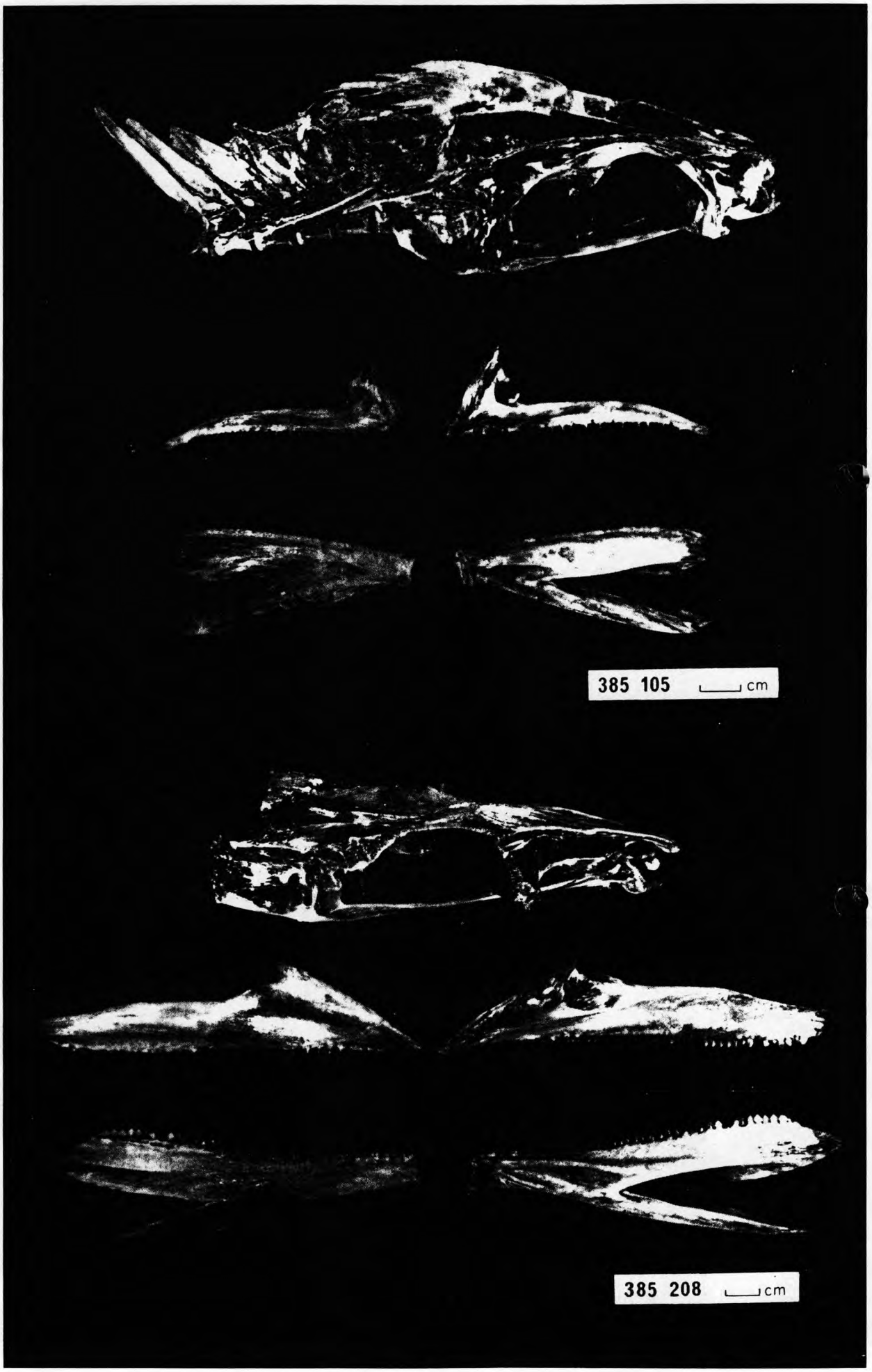
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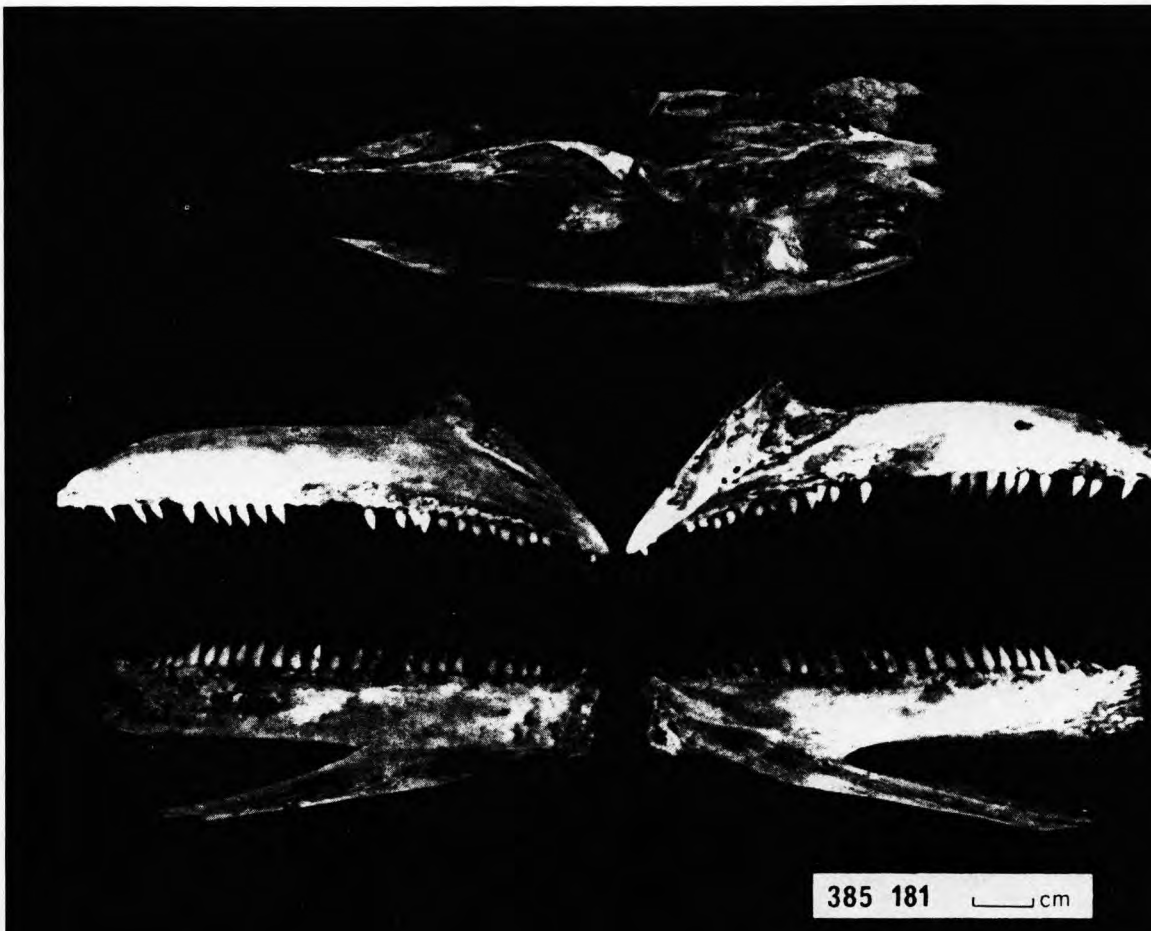
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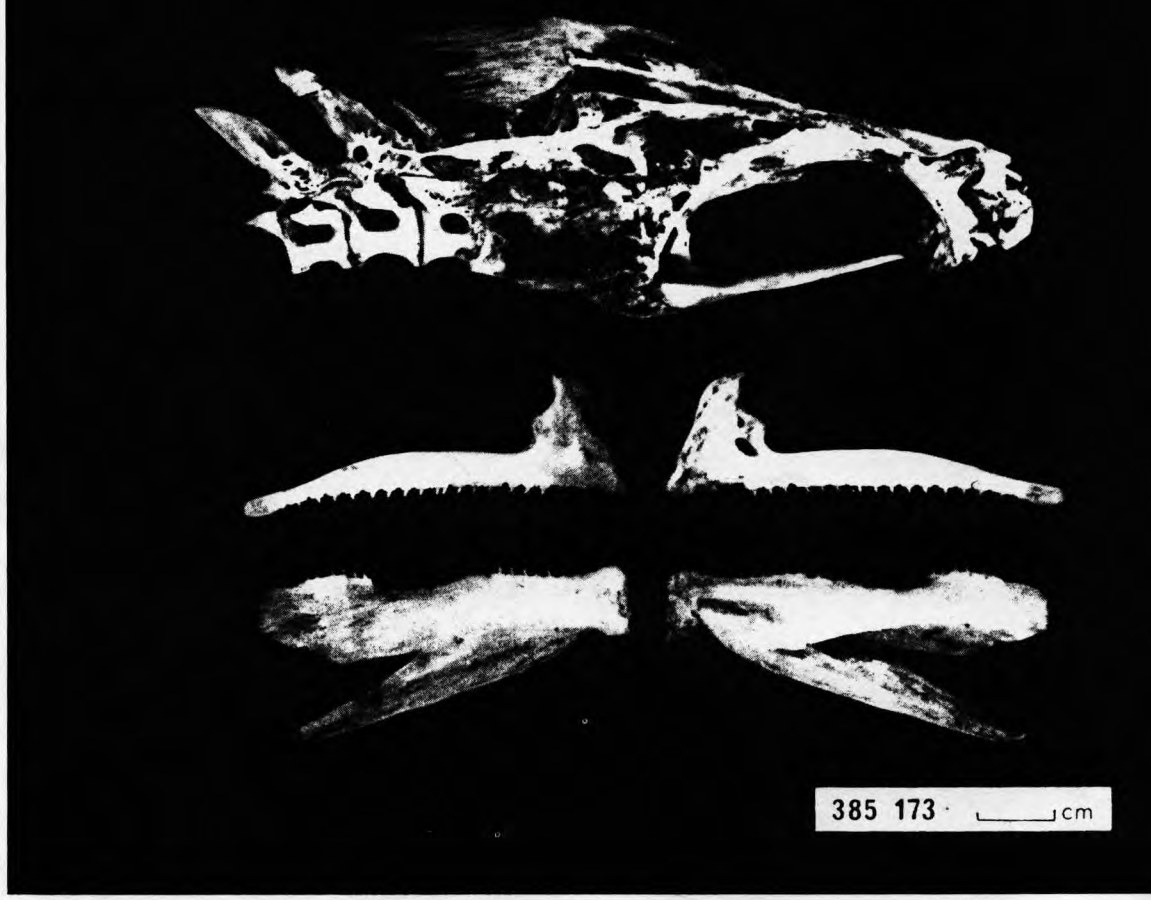
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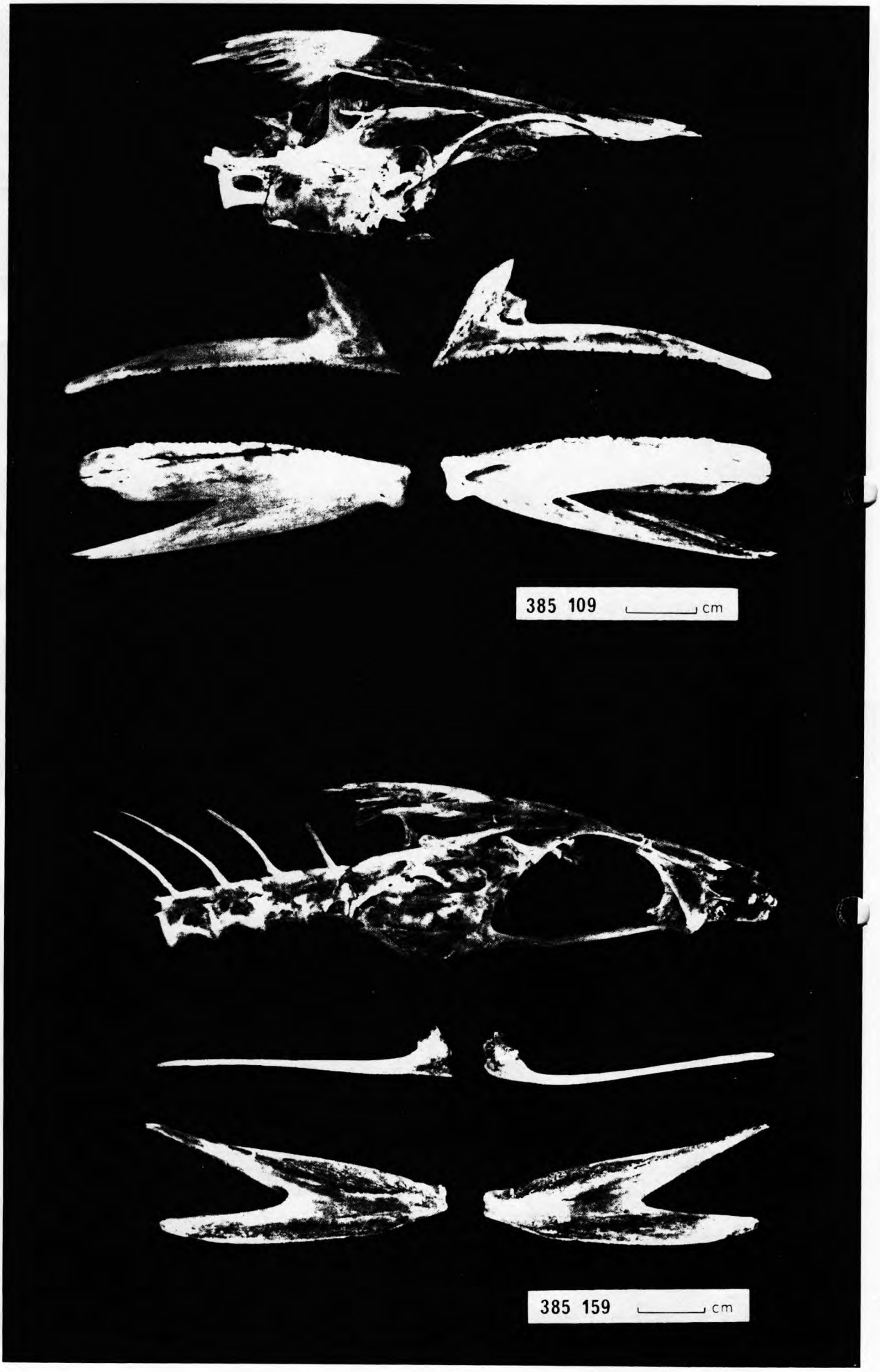
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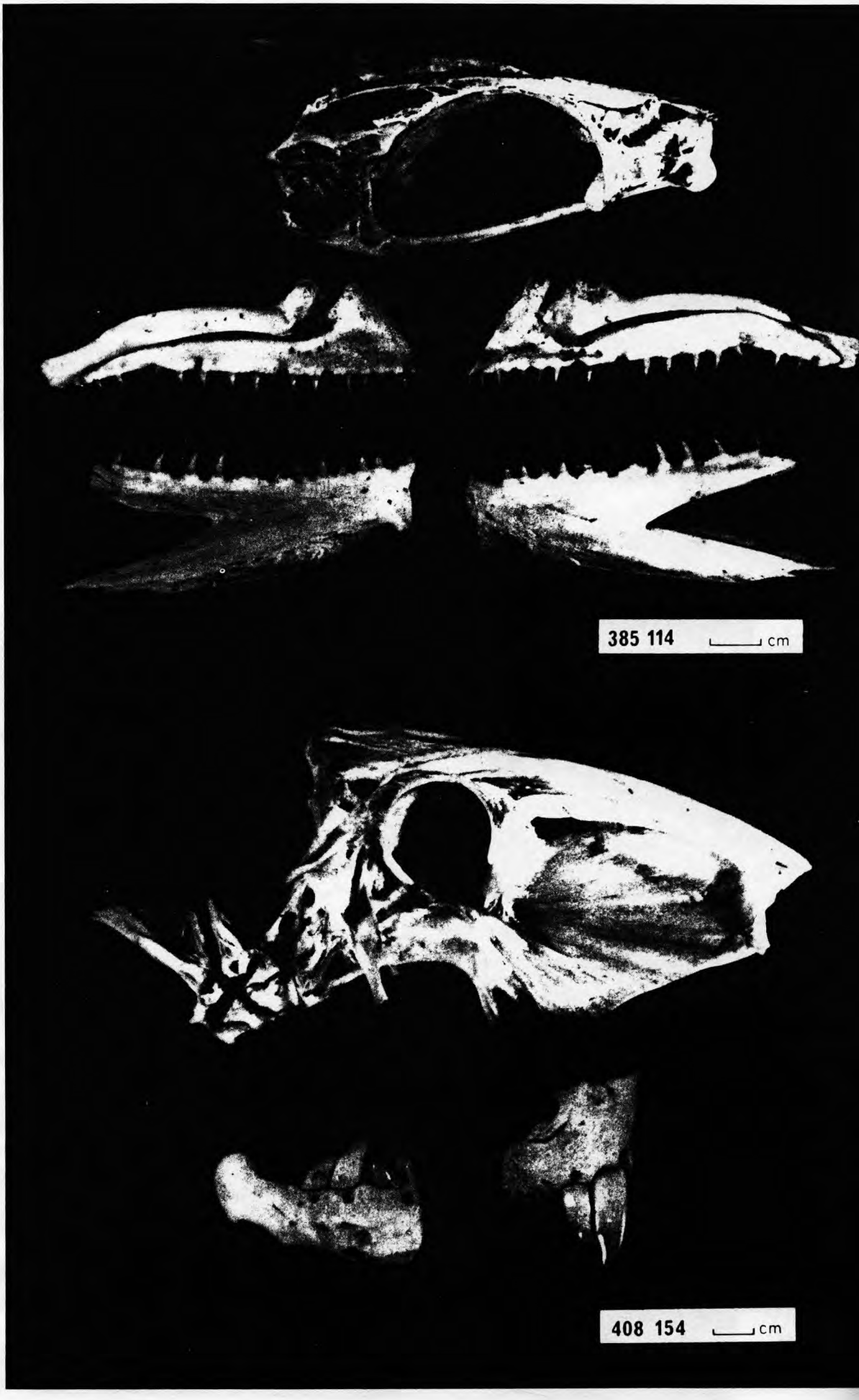
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cm
408 154
cm


408 178
cm
408 119
cm


408 183
cm
408 132
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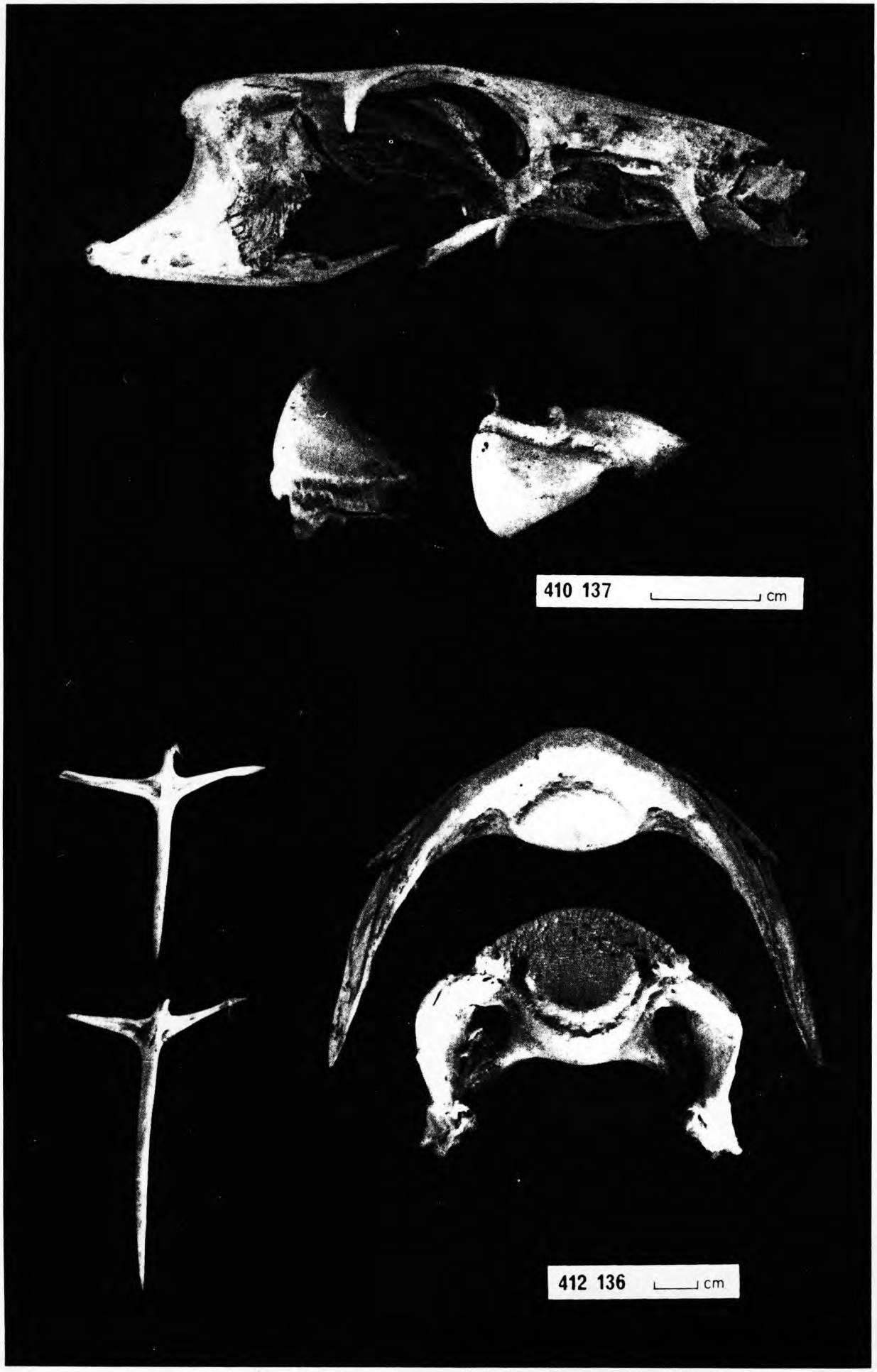
410 137
cm
412 136
cm