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A SURVEY OF VERTEBRAL NUMBERS IN SHARKS [1]

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Introduction

This paper broadly surveys vertebral numbers in sharks. The study was prompted by our discovery that vertebral numbers are important systematic characters in those carcharinid shark genera that we have been investigating (Springer, 1964; Garrick, in ms). We, therefore, have undertaken to determine if vertebral numbers are of similar value in other genera, with the hope that some contribution might be made to shark classification as a whole.

Vertebral numbers have not been used previously as a systematic character in sharks although they have received some attention in rays (Ishiyama, 1958) and have been widely employed in teleosts (e.g., Bailey and Gosline, 1955; Schmidt, 1917). The vertebral numbers from sharks that have been recorded in the literature are given either without comment or comparison or are employed as data for studies in morphology or intraspecific variation (Punnett, 1904; Aasen, 1961).

We present here vertebral data on 1524 specimens. We personally made counts from 858 of these, mostly by X-ray methods. The

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remaining 666 counts are from the literature or were supplied by colleagues. The 1524 specimens pertain to 70 of the approximately 80 genera of sharks and to 135 of the approximately 300 species. Because our purpose has been to survey, our coverage within individual species is far from complete, but considerable attention has been paid to a few species that have presented problems.

We wish to express our gratitude to the officials of the following institutions for their assistance in providing specimens and X-ray facilities.

ANSP—Academy of Natural Sciences of Philadelphia
BMNH—British Museum (Natural History), London
CAS—California Academy of Sciences, San Francisco
CM—Canterbury Museum, Christchurch, New Zealand
CNHM—Chicago Natural History Museum
DMNZ—Dominion Museum, Wellington, New Zealand
GVF—George Vanderbilt Foundation, Stanford University, California
IRSN—Institut Royal des Sciences Naturelles de Belgique, Brussels
ISZZ—Institut für Spezielle Zoologie und Zoologisches Museum, Berlin
MCSN—Museo Civico di Storia Naturale, Genoa, Italy
MCZ—Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts
RNH—Rijksmuseum van Natuurlijke Historie, Leiden, Holland
SIO—Scripps Institution of Oceanography, La Jolla, California
SU—Division of Systematic Biology, Stanford University, California
TGFC—Texas Game and Fish Commission Marine Laboratory, Rockport
UBC—University of British Columbia, Vancouver
UMML—University of Miami Institute of Marine Sciences, Miami, Florida
UMMZ—University of Michigan Museum of Zoology, Ann Arbor
USNM—United States National Museum, Washington, D.C.
UZMK—Universitetets Zoologiske Museum, Copenhagen, Denmark

J. G. Casey, Bureau of Sport Fisheries, Sandy Hook Marine Laboratory, kindly provided some vertebral counts of *Alopias superciliosus* and *Isurus oxyrinchus*, and H. Heyamoto, Bureau of Commercial Fisheries, Seattle, Washington, sent us ten specimens of *Squalus acanthias* taken from off the coast of Washington. W. I. Follett of the California Academy of Sciences, San Francisco, generously allowed us to use his and J. D. Hopkirk's vertebral counts of *Cetorhinus maximus* and *Carcharodon carcharias*. These counts were made on vertebral columns in the CAS collections. We are grateful to Sheldon Applegate, formerly of Duke University, for providing us with counts from New Jersey and Delaware specimens of *Carcharias taurus*, and to Elvira Siccardi, Faculty of Natural Sciences of Buenos Aires, Argentina, for counts on *Isurus oxyrinchus*, *Carcharodon carcharias*, and *Lamna nasus*.

Our identifications of the species of *Sphyrna* are the result of unpublished studies by Dr. Carter R. Gilbert, to whom we extend our appreciation for allowing us to use his characterizations.

Drs. Bruce B. Collette, Carl L. Hubbs, W. Ralph Taylor, and S. J. Weitzman read the manuscript and made valuable suggestions for its improvement.

Methods

Sharks ranging in size from small embryos to specimens several feet long were used in the survey. Radiographs were made with a hard-ray machine and various industrial X-ray films. The finest-grained films gave the most desirable results, but generally grain size was a limiting factor only in making counts of the terminal vertebrae in the caudal fin. A few counts were made on skeletons. Each vertebral count was separated into two parts:

1. Precaudal vertebral count (P) includes all complete centra anterior to the forward edge of the upper precaudal pit, or, in species where a pit is absent, all complete centra anterior to the origin of the upper lobe of the caudal fin.
2. Caudal vertebral count (C) includes all centra posterior to the precaudal vertebrae.

In order to demarcate clearly the precaudal from caudal centra on a radiograph, a pin was inserted at the forward edge of the upper precaudal pit, or at the upper caudal origin, so that its point touched the vertebral column. In some sharks, notably species of *Brachaelurus*, *Halaelurus*, and *Hemiscyllium*, it is impossible to decide the point of origin of the dorsal lobe of the caudal fin; for these sharks, only total counts (T) are given.

We do not know if our two methods of separating precaudal from caudal vertebrae produce homologus (hence comparative) counts in sharks with and without precaudal pits; however, the value of the methods lies in their usefulness and for the purposes of this study we consider the results homologous. Another possible way of subdividing the vertebral column would be into monospondylous and diplospondylous centra.[2] The transition from monospondyly (anterior) to diplospondyly (posterior) usually occurs above the pelvic fin, but there are notable exceptions (*Etmopterus* and a few species of *Carcharhinus*) wherein it is much further posterior. The transition usually is evidenced by an abrupt reduction in centrum length (pl. 1A, B)[3] but in several species, e.g., *Alopias superciliosus* (pl. 1C), *Scoliodon laticaudus*, *Prionace glauca*, the reduction is so slight as to be unnoticeable on a radiograph.

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[2] Monospondyly=one centrum per myomere; diplospondyly=two centra per myomere. For detailed discussion, see Goodrich, 1930, pp. 26–27.

[3] We have not made dissections to confirm the transition points from monospondyly to diplospondyly but accept the first notably shorter centrum above or behind the pelvic region as the first diplospondylous centrum. Confirmation of this view is found in some radiographs wherein it is possible to see the apertures for nerve roots issuing: one pair for each centrum in the monospondylous region and one pair for two centra in the diplospondylous region.

Precaudal vertebral counts are subject to a maximum error of plus or minus two vertebrae. It is not always possible to decide accurately from a radiograph which is the first vertebra because, at the rear of the head, other structures, including the occipital condyles, mask the front of the vertebral column. Occasionally, owing to the angle at which our marking pin had entered, we had some doubt as to the last precaudal vertebra. Most of the counts given here were made by each of us working independently but using the same radiographs. The exceptions to these counts are the counts of the carcharhinid genera on which we are working individually. We never differed by more than one in our precaudal counts and we arbitrarily report the even count, appropriately compensating for the caudal count.

At the tip of the caudal fin the last few centra of most shark species are frequently too small to give good resolution on radiographs. Sometimes there was a difference of as much as three or four vertebrae in our counts of the caudal section. In such counts one determination or the other has been listed arbitrarily. Because of the range of variation in counts within a single species and because of the high number of vertebrae in most sharks, we believe that such an error is hardly significant. Generally, the precaudal count is more consistent than the caudal count. Caudal counts were made under magnification, usually with a low-power binocular microscope.

The number of precaudal vertebrae is established early in embryos, but the last caudal vertebrae usually are not fully formed until late in embryonic life; hence, only late-stage embryos provide caudal counts comparable to those of adults. In those embryos in which we found calcification incomplete, we give a minimal count for the caudal vertebrae (>). We doubt that more than 25 additional vertebrae would have been formed in any of the embryos we examined, and we believe that in most of the embryos the number of yet unformed vertebrae would be much fewer.

Complete calcification of the column is recognizable on radiographs by the posterior extent reached by the column (to within a short distance of the tip of the tail) or by uniform density of the images of the last several centra.

We counted apparent fusions between centra (and also apparent monospondylous intrusions in regions of diplospondyly) as single centra, but we recorded separately the recognizable centra when the fusion was obviously incomplete.

In most sharks the monospondylous centra gradually increase in length from the cranium posteriorly, so that the centra are usually longest at, or near, the region where diplospondyly begins. The difference in the length of anterior and posterior monospondylous centra may be small or great. The difference in length between the posterior monospondylous centra and the anterior diplospondylous centra is similarly variable though reasonably constant for any one species.

Reporting these relative centrum lengths is obviously of value but offers difficulties. Because many of the specimens we used were curled or distorted, radiographs of them show oblique images of some centra. The degree of obliqueness may vary from one region of the vertebral column to another; we, therefore, see the likelihood of introducing considerable error by giving dimensions of centra that are not adjacent to, or at least very close to, each other on the radiograph. For this reason, we do not report the length of anterior relative to posterior monospondylous centra. To compare the length of a posterior monospondylous centrum with that of an anterior diplospondylous centrum (thereby indicating the relative prominence of the transition point between monospondyly and diplospondyly), we measured the length of the penultimate monospondylous centrum and the first diplospondylous centrum and then obtained a ratio, listed as "A" in the results and tables, by dividing the length of the former by the length of the latter and multiplying by 100. We chose the penultimate monospondylous centrum because it is usually more representative of the posterior monospondylous centra (the ultimate monospondylous centrum is often reduced in length even though noticeably longer than the first diplospondylous centrum). The first diplospondylous centrum was chosen because there is often a regular alternation of centrum length in the diplospondylous region. In deciding the transition point from monospondyly to diplospondyly when differences in length of the centra bordered on being imperceptible, we may be in error occasionally though we think that any error thus introduced is slight.

To give an indication of centrum shape, we have divided the length of the penultimate monospondylous centrum by its diameter (appearing as height or width on the radiograph) and have multiplied this ratio by 100 to yield the values listed as "B" in the results and tables.

Results

Our data on shark vertebrae are reported in table 1. Table 2 condenses these data so that the subordinal, familial, and generic limits, but not those of the individual species, can be more easily visualized.

We have representative samplings of six of the seven suborders of sharks and a partial sampling of the seventh. None of these suborders can be distinguished on its vertebral counts alone. In terms of total number of vertebrae we found a range of from 60 to about 419. The lowest total count is for *Squaliolus laticaudus* and the highest for

Alopias vulpinus. The species with the lowest precaudal count (44) is *Squaliolus laticaudus* and the one with the highest (149) is *Prionace glauca.* The lowest count (13) of caudal vertebrae is for *Euprotomicrus bispinatus, Squaliolus laticaudus,* and *Squaliolus sarmenti,* and the highest (>298) is for *Alopias vulpinus.*

Compared with the other suborders, the Squaloidea have low vertebral counts. In all recent systems of classification the Squaloidea are regarded as relatively advanced, so there is some justification for regarding their low counts as an advanced feature. On this basis, within the Squaloidea we could consider the generally lower counts of the dalatiids as indicating that they are more advanced than the squalids. The Notidanoidea and the Heterodontoidea, which, on other features, have some claim to being representative of the ancestral or primitive sharks, do not have more vertebrae than do many of the so-called advanced sharks in the Galeoidea. This may merely indicate that median numbers are most primitive, with both decrease and increase as specialized conditions.

Only one family, the Alopiidae, with one genus, *Alopias,* is recognizable on its vertebral numbers alone. The distinctiveness of *Alopias* is due to the high number of vertebrae in its tail, a feature that might be expected from the extreme length of its tail compared to other sharks. The diagnostic value of vertebral numbers increases in the lower taxa. Thus, in the families containing several genera, a few genera (*Lamna* in the Lamnidae, *Brachaelurus* and *Stegostoma* in the Orectolobidae, *Conoporoderma* and *Atelomycterus* in the Scyliorhinidae, *Prionace* in the Carcharhinidae, and perhaps others) are clearly recognizable on precaudal, caudal, or total count. Of the genera containing two or more species, almost half include at least one species distinguishable on vertebral counts. Because of our incomplete coverage, we believe it premature to list these species here.

The suborders Squaloidea, Pristiophoroidea, Squatinoidea, and Heterodontoidea are consistent in having fewer caudal than precaudal vertebrae. In the suborder Galeoidea, the families Scyliorhinidae, Triakidae, and most of the Orectolobidae show the same trend. It may be of significance that the sharks with fewer precaudal than caudal vertebrae are for the most part small, and usually bottom-dwelling. In *Carcharhinus* (Garrick, in ms.), the large species tend to have fewer caudal than precaudal vertebrae and the small species have more caudal than precaudal vertebrae.

In our studies, particularly of the genera *Carcharhinus, Scoliodon, Loxodon,* and *Rhizoprionodon* (Garrick, in ms.; Springer, 1964), we have noted no sexual dimorphism in vertebral numbers; however, Punnett (1904), who dissected 567 specimens of *Etmopterus spinax* from Norway, reported a statistically significant difference between males and females in numbers of monospondylous ("whole vertebrae") and diplospondylous ("half vertebrae") centra and in total number of segments (counting each whole vertebra or each two half vertebrae as one segment). Females had the higher average in each of these three categories but in none did the average difference exceed half a unit. Using Punnett's figures (for adults and embryos) we have plotted frequency distributions of total vertebrae (each whole or half vertebra of Punnett equals one vertebra in our study) and averaged them:

Total vertebrae	81	82	83	84	85	86	87	88	89	90	91	*Average*
Males	4	14	41	51	63	39	19	9	3	2	–	84. 73
Females	3	12	39	71	84	55	33	20	3	–	2	85. 02

A *t* test of these data gives the value 2.06, which is not significant at the 95 percent level; however, a *t* test of the number of monospondylous vertebrae of adults gives a value which is significant above the 99.1 percent level. Punnett did not allow for possible year-class differences and it is not possible to tell from his data if there is bias. A study of sexual differences in vertebral counts based on embryos of a single year class would offer a solution to this problem.

If the nature of sexual dimorphism in vertebral counts of sharks is generally of the magnitude shown by *E. spinax*, it is not surprising that our counts, based on small numbers of specimens, do not indicate it.

The A values $\left(\frac{\text{length penultimate monospondylous centrum}}{\text{length first diplospondylous centrum}}\times 100\right)$, like the vertebral numbers, vary widely within families and genera but within the species are relatively constant. The A values are smallest in the Lamnidae, Alopiidae, Triakidae, Carcharhinidae, and Sphyrnidae. The A values, up to about 300, are greatest in the Carcharhinidae, a family with great variation in this proportion. Families containing some species with A values of about 200 include the Scapanohynchidae, Triakidae, Sphyrnidae, Squalidae and Dalatiidae.

The B values $\left(\frac{\text{length penultimate monospondylous centrum}}{\text{diameter of penultimate monospondylous centrum}}\times 100\right)$ are in general as inconsistent within the families and genera as are the A values. The range of the B values is from about 25 (*Alopias* spp.) to 200 (*Isistius brasiliensis*).

If a B value of 75 or less is arbitrarily considered low and one of 125 or more is considered high, 13 of the 18 large sharks (attaining a size of over six feet) for which we have data are indicated as having low B values. Small species may have either high or low B values, but of the 30 species of sharks having high B values, only one, the unique *Scapanorhynchus owstoni*, attains a size greater than six feet. These facts seem to indicate that B values are functionally significant in terms of total length attained by the species.

Remarks Concerning Certain Species

In *Hexanchus* and *Notorhynchus* the vertebrae are not sufficiently calcified to produce an image on a radiograph. In *Heptranchias*, the precaudal vertebrae are poorly calcified and there is considerable spacing between the images on the radiograph, which probably indicates that only the center or the ends of each centrum are registered. The caudal vertebrae are well calcified but terminate abruptly at about the level of the subterminal caudal notch in each specimen, a condition not noted in any other species we examined.

In *Chlamydoselachus anguineus* only some of the vertebrae are calcified; hence, total counts could not be made. In one specimen the anterior 16 and posterior 3 precaudal centra and a few anterior caudal centra were apparent; in the other specimen radiographed, the anterior 18 and posterior 9 precaudal centra and the anterior 20 caudal centra were apparent. Goodey (1910) indicated the number of vertebrae in a specimen he dissected to be 112, on the basis of the number of neuromeres, which were determined by counting the ventral-root foramina of the spinal nerves perforating the basidorsals. We believe that counting in this manner yields a figure which is much too low, for it does not take into account the diplospondylous condition. It is also obvious from Goodey's plates that no nerve roots issue from large segments of the vertebral column.

Aasen (1961) reported vertebral counts of 60 specimens of *Lamna nasus* from the western North Atlantic, as follows:

Total vertebrae	150	151	152	153	154	155	156	157	158	159	160	161
Specimens	1	1	5	6	9	8	9	7	8	1	4	1

He noted that the number of precaudal vertebrae ranged from 83 to 89.

One specimen of *Paragaleus gruveli* (USNM 196158) examined (pl. 1A) had two separated groups of elongated (monospondylous) centra in the precaudal region. If each of these elongated centra were counted as two, the number of precaudal centra would be 77 and the total count 147, which would be more in accord with the other specimen examined from the same locality.

Specimens of *Sphyrna tiburo* from Florida have much lower vertebral counts than specimens from other localities. Counts from large numbers of specimens throughout the Atlantic and Pacific range of this species should be made to determine the significance of the counts shown by the Florida specimens.

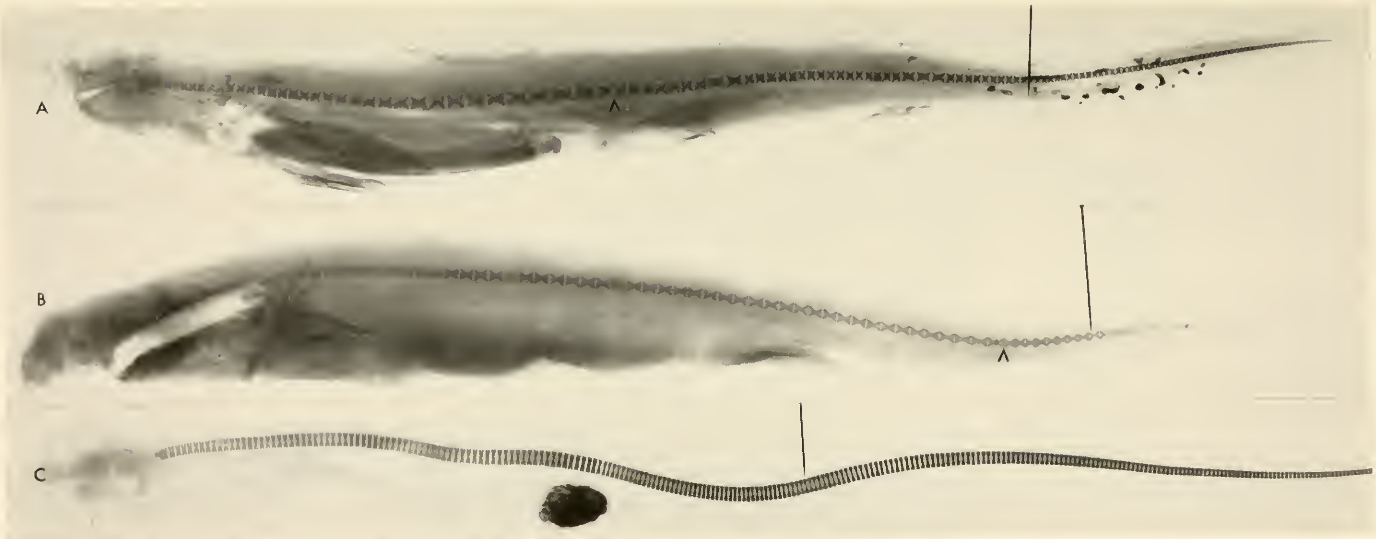

Figure a: Embryo of *Paragaleus gruveli* (USNM 196158), a species with a precaudal pit. Caret indicates point of separation of monospondylous from diplospondylous centra above anterior third of pelvic fin. This species is characterized by high A and B values (see text). Note two interpolated groups of monospondylous centra in diplospondylous region. Pin separates caudal from precaudal vertebrae. Figure b: *Etmopterus pusillus* (USNM 157835), a species without a precaudal pit. Caret indicates point of separation of monospondylous from diplospondylous centra in region far posterior to pelvic fin. This species is characterized by high A and B values (see text). Pin separates caudal from precaudal vertebrae. Figure c: Embryo of *Alopias vulpinus* (CNHM 52100), a species with a precaudal pit. This species is characterized by a low A value and a very low B value (see text). Transition point from monospondylous to diplospondylous centra occurs in region above pelvic fin but is not clear on figure. Pin separates caudal from precaudal vertebrae.

Squalus acanthias is considered a circumglobally distributed species in the temperate waters of both the northern and southern hemispheres although it is reported infrequently from subtropical areas. Our evidence (table 1) indicates that at least in the northern hemisphere the Atlantic population (with 79–85 precaudal vertebrae in 7 specimens) and the Pacific population (with 68–76 precaudal vertebrae in 21 specimens) have differentiated. Six specimens from the southern hemisphere have 75–78 precaudal vertebrae and thus are intermediate between the northern hemisphere populations. A large-scale study of vertebral numbers in this species might yield interesting information on speciation.

On the basis of the counts obtained for *Centrophorus uyato*, there is evidence that differences occur in the populations from the Gulf of Mexico and the eastern Atlantic. More counts will be necessary to verify this indication.

The genus *Etmopterus* is distinct from all other shark genera examined in consistently having the last monospondylous centrum at a point behind the tip of the pelvic fin (pl. 1B), usually under the anterior portion of the second dorsal fin. In all other sharks we have investigated, except a few species of *Carcharhinus* (Garrick, in ms.), the last monospondylous vertebra occurs over the pelvic fin, usually over the pelvic base.

Punnett (1904) reported the total vertebral counts of 163 free-living females of *Etmopterus spinax*. Twenty-five were gravid and were reported with the counts of their respective embryos (see our table 3). Examination of Punnett's data shows that the average number of vertebrae in a litter exceeds the maternal count in 10 of the 13 mothers with 82–85 vertebrae but is less than the maternal count in the 12 mothers with 86–88 vertebrae. Differences in counts from a single litter range from two to seven vertebrae. We have found a similar variation in the range of vertebral counts in carcharhinid sharks in the few cases in which we have mothers with embryos.

Only late-stage embryos of *Echinorhinus cookei* and *E. brucus* were radiographed; the radiographs show no evidence of calcification of the centra.

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TABLE 1.—*Vertebral characters in sharks*

P=precaudal vertebrae. C=caudal vertebrae. T=total vertebrae. A=length of penultimate monospondylous centrum divided by length of first diplospondylous centrum × 100. B=length of penultimate monospondylous centrum divided by its width ×100.

Family, genus, species, locality	P	C	T	A	B
HEXANCHIDAE					
Hexanchus					
H. griseum (Bonnaterre) (see discussion)	uncalcified				
MCSN 34580, Italy					
USNM 186120, Florida					
Notorhynchus					
N. maculatus Ayres (see discussion)	uncalcified				
USNM 27071, California					
USNM 61234, California					
USNM 38301, Peru					
USNM 87681, Uruguay					
Heptranchias					
H. perlo (Bonnaterre) (see discussion)					
MCSN 37507, Ligurian Sea, Mediterranean	ca. 85	45	ca. 130		
USNM 164167, south of Louisiana	90	56	146		
	89	52	141		
USNM 151972, off North Carolina	90	61	151		
CHLAMYDOSELACHIDAE					
Chlamydoselachus					
C. anguineus Garman (see discussion)			>112	(Goodey, 1910)	
USNM 48530, Japan					
USNM 161522, Japan					
HETERODONTIDAE					
Heterodontus					
H. francisci (Girard)					
USNM 34778, California	71	41	112	160	95
H. japonicus Dumeril					
USNM 71764, Japan	72	38	110	136	94
UMMZ 179075, Japan	74	42	116		
H. galeatus (Günther)					
USNM 59876, New South Wales, Australia	71	35	106	140	92
H. zebra (Gray)					
UMMZ 179077, locality unknown		41		133	89
CARCHARIIDAE					
Carcharias					
C. taurus Rafinesque					
USNM 143423, Louisiana, embryo	84	>70	>154		
Sandy Hook Bay, New Jersey (from Sheldon Applegate)	82	81	163		
	80	83	163		
	–	84	–		
	86	80	166		
	84	79	163		
	84	81	165		
	84	–	–		
1 mile off Lewes, Delaware (from Sheldon Applegate)	85	71	156		
	85	85	170		
	83	81	164		
	87	81	167		
SCAPANORHYNCHIDAE					
Scapanorhynchus					
S. owstoni (Jordan)					
MCZ 1279, Japan	53	69	122	189	172

Table 1.—*Vertebral characters in sharks*—Continued

Family, genus, species, locality	P	C	T	A	B
LAMNIDAE					
Isurus					
I. oxyrinchus Rafinesque					
MCZ 37994, Bahamas, embryo	110	80	190	ca. 100	
New York-New Jersey (from J. G. Casey)	110	81	191		
	110	80	190		
	109	-	-		
Puerto Quequén, Argentina (from E. Siccardi)	110	86	196		
I. glaucus					
UMMZ 177116, Japan	108	79	187	127	52
SIO 50-240, California	112	80	192	120	53
I. species (Garrick, in ms.)					
USNM 197427, Indo-Pacific	112	83	195	128	63
USNM 197429, Indo-Pacific	111	86	197	130	67
Lamna					
L. nasus (Bonnaterre)					
BMNH 1961.11.2.1, English Channel	85	68	153	ca. 100	
Puerto Quequén, Argentina (from E. Siccardi)	91	71	162		
Locality unspecified (after Günther, 1870)	-	-	155		
Western North Atlantic (after Aasen, 1961)	84-89	-	150-161	(based on 60 specimens; see text remarks)	
Carcharodon					
C. carcharias (Linnaeus)					
CAS 26245, California	-	-	178		
CAS 26361, California	104	68	172		
CAS 26363, California	105	68	173		
CAS 26366, California	104	74	178		
CAS 26367, California	107	ca. 76	ca. 183		
CAS 26678, California	107	77	184		
CAS 26680, California	105	ca. 78	ca. 183		
CAS 26376, California	106	73	179		
CAS 26378, California	106	71	177		
CAS 26694, California	104	77	181		
CAS 26695, California	104	77	181		
CAS 26781, California	108	73	181		
CAS 26793, California	103	73	176		
CAS 27013, California	107	74	181		
CAS 27014. California	105	80	185		
CAS 27015, California	104	76	180		
Puerto Quequén, Argentina (from E. Siccardi)	104	83	187		
	105	79	184		
CETORHINIDAE					
Cetorhinus					
C. maximus (Gunnerus)					
CAS 25873, California			110		
USNM (uncat.), off British Columbia	50	60	110		
ALOPIDAE					
Alopias					
A. superciliosus (Lowe)					
UMML 8861, Florida, two sibling embryos	102	180	282		
	102	187	289		
MCZ 36155, Cuba, embryo	102	181	283	ca. 100	
New York (from J. G. Casey)	102	193±3	295±3		
USNM 197700, California	100	204	304		
A. vulpinus (Bonnaterre)					
CNHM 52100, Formosa	121	>298	>419		
SIO 52-19, Galápagos, two sibling embryos	119	243	362	136	27
	119	240	359	127	25

TABLE 1.—*Vertebral characters in sharks*—Continued

Family, genus, species, locality	P	C	T	A	B
ORECTOLOBIDAE					
Orectolobus					
O. maculatus (Bonnaterre)					
USNM 176695, near Brisbane, Australia	106	50	156	133	78
Stegostoma					
S. tigrinum (Bonnaterre)					
RNH skeleton no. 429, Java	81	145	226		
S. fasciatum (Hermann)					
USNM 138547, Macassar market, Celebes	95	122	217	150	55
USNM 138548, Macassar market, Celebes	101	121	222	140	58
Chiloscyllium					
C. indicum (Gmelin)					
UMMZ 179022, Japan	114	61	175	143	62
C. griseum Müller and Henle					
UMMZ 179034, Java			170	118	72
C. species					
USNM 6449, Hong Kong	111	61	172	115	71
C. species					
USNM 148107, Persian Gulf	104	65	169	117	74
USNM 148108, Persian Gulf	107	60	167	117	80
Eucrossorhinus					
E. dasypogon (Bleeker)					
BMNH 1867.11.28.209, Aru Islands, syntype of *Crossorhinus dasypogon* Bleeker	100	62	162		
Ginglymostoma					
G. cirratum (Bonnaterre)					
USNM 196159, Senegal, sibling embryos	97	77	174	125	80
	97	73	170	118	74
USNM 37741, Jamaica (sibling embryos?)	98	73	171	116	71
	95	75	170	121	74
USNM 181312, Sonora, Mexico	92	83	175	125	66
Hemiscyllium					
H. ocellatum (Bonnaterre)					
USNM 176863, Great Barrier Reef,			191	120	71
Queensland, Australia			190	150	75
H. species					
USNM 123025, no locality			192		
Brachaelurus					
B. waddi (Bloch and Schneider)					
USNM 197619, Sydney, Australia			142	125	68
RHINCODONTIDAE					
Rhincodon					
R. typus Smith					
TGFC, off Texas, embryo	81	>72	>153		
SCYLIORHINIDAE					
Cephaloscyllium					
C. uter (Jordan and Gilbert)					
USNM 196142, California	74	35	109	141	94
Galeus					
G. arae (Nichols)					
USNM 185602, off Nicaragua (Atlantic)	75	60	135	158	143
	76	>51	>127	173	124
USNM 159233, off Florida	74	55	129	141	124
USNM 158101, southwest of Grand Bahama Island	81	59	140	147	133
Haploblepharus					
H. edwardsi (Voigt)					
MCZ 1028, Cape St. Blaize, South Africa	94	43	137	140	107

TABLE 1.—*Vertebral characters in sharks*—Continued

Family, genus, species, locality	P	C	T	A	B
SCYLIORHINIDAE—Continued					
Halaelurus					
H. vincenti (Zietz)					
UBC 56-406, Adelaide, South Australia			130	133	114
Parmaturus					
P. xaniurus (Gilbert)					
MCZ 1002, off California	70	60	130	145	115
Apristurus					
A. herklotsi (Fowler)					
USNM 93134, Philippines, holotype of *Pentanchus herklotsi* Fowler	69	>50	>119	155	122
A. verweyi (Fowler)					
USNM 93135, Borneo, holotype of *Pentanchus verweyi* Fowler	70	46	116	139	133
Scyliorhinus					
S. torazame (Tanaka)					
UMMZ 179029, Fusan Market, Korea	74	38	112	167	105
S. garmani (Fowler)					
USNM 43749, East Indies, holotype of *Halaelurus garmani* Fowler	92	40	132	162	105
Pentanchus					
P. profundicolus Fowler					
USNM 70260, Mindanao Sea, holotype (several centra missing, counts estimated)	79	54	133	135	113
Conoporoderma					
C. marleyi (Fowler)					
ANSP 53427, Natal, South Africa, holotype of *Poroderma marleyi* Fowler	76	28	104	172	100
Atelomycterus					
A. marmoratus (Bennett)					
UMMZ 179603, Java	110	54	164		
Undescribed genus and species (S. Springer, in ms.)					
USNM 185557, Caribbean Sea	105	40	145	125	125
PSEUDOTRIAKIDAE					
Pseudotriakis					
P. microdon Capello					
Cape Verde Is. (from Jaquet, 1905)			ca. 186		
TRIAKIDAE					
Scylliogaleus					
S. quecketti Boulenger					
BMNH 1903.2.6.21, off Natal, South Africa, holotype	88	>52	>140	114	103
Triakis					
T. semifasciata Girard					
UMMZ 61065, California	84	52	136	142	117
T. scyllia Müller and Henle					
UMMZ 179099, Fusan Bay, Korea	93	60	153	200	93
	93	60	153	200	95
T. venustum (Tanaka)					
UMMZ 179065, Okinawa, Japan	107	51	158	144	100
T. henlei (Gill)					
UMMZ 61051, California	109	51	160	117	83
SU 34283, California	103	49	152	112	88
Eridacnis					
E. radcliffei Smith					
USNM 74604, Philippines, holotype	77	47	124	125	105

TABLE 1.—*Vertebral characters in sharks*—Continued

Family, genus, species, locality	P	C	T	A	B
TRIAKIDAE—Continued					
Mustelus					
M. manazo Bleeker					
UMMZ 178990, Japan	90	52	142	136	120
UMMZ 178993, Japan	90	51	141	123	112
M. kanekonis (Tanaka)					
UMMZ 179097, locality unknown	81	49	130	153	104
M. canis (Mitchill)					
USNM 73091, New Jersey	90	56	146	137	111
M. canis or *M. schmitti* Springer					
USNM 86724, Uruguay	89	48	137	169	122
	90	46	136	144	121
M. norrisi Springer					
USNM 116444, Florida	93	52	145	137	100
M. higmani Springer and Lowe					
USNM 156930, off Surinam, holotype	88	49	137	132	102
USNM uncataloged, off British Guiana	89	50	139	131	100
USNM uncataloged, off Surinam	87	49	136	132	100
	90	51	141	154	105
	89	50	139	142	92
	91	53	144		
Triaenodon					
T. obesus (Rüppell)					
ANSP 71738, Pearl and Hermes Reef, embryo	129	85	214	ca. 100	
Leptocharias					
L. smithi Müller and Henle					
USNM 164435, Liberia	137	76	213	112	68
MCZ 39691, off Banana, West Africa	136	75	211	ca. 100	
CARCHARHINIDAE					
Carcharhinus					
C. sorrah (Valenciennes)					
9 specimens from China, Thailand, and Red Sea	66–73	85–93	153–166	142–167	88–107
C. limbatus (Valenciennes)					
5 specimens from Florida, Brazil, Virgin Islands, and Liberia	96–100	98–101	194–198	110–138	62–89
C. falciformis (Bibron)					
14 specimens from western north Atlantic and eastern North Pacific Oceans	98–105	98–110	199–215	112–123	68–78
C. leucas (Valenciennes)					
7 specimens from Florida, Lake Nicaragua, Guatemala, Tampico (Mexico), and Panama	110–114	95–104	208–218	110–130	60–72
C. melanopterus (Quoy and Gaimard)					
14 specimens from Gilbert, Caroline, and Philippine Islands and Thailand and Red Sea	115–122	86–92	202–214	112–136	64–74
Aprionodon					
A. isodon (Müller and Henle)					
USNM 118457, Texas	79	86	165	206	102
Negaprion					
N. brevirostris (Poey)					
CNHM 32743, Florida	117	84	201	125	76
Hypoprion					
H. macloti Müller and Henle					
ISZZ 5799, Hong Kong	70	84	154	222	154
SU 12988, Hong Kong	68	82	150	191	150
SU 14488, Burma	70	82	152	162	124
H. signatus Poey					
USNM 133827, Florida, embryo	104	80	184	120	67

TABLE 1.—*Vertebral characters in sharks*—Continued

Family, genus, species, locality	P	C	T	A	B
CARCHARHINIDAE—Continued					
Rhizoprionodon (see Springer, 1964)					
Subgenus *Rhizoprionodon*					
R. acutus (Rüppell)					
121 specimens from the eastern Atlantic and Indo-Pacific; counts vary according to locality.	55–79	64–83	121–162		
R. terraenovae (Richardson)					
Counts based on 74 specimens from the western Atlantic from Nova Scotia to Yucatan. A and B values based on 6 specimens.	58–66	67–81	126–144	151–174	118–145
R. porosus (Poey)					
Counts based on 58 specimens from the western Atlantic from the Bahamas to Uruguay. A and B values based on 5 specimens.	66–75	69–85	136–159	125–141	108–114
R. longurio (Jordan and Gilbert)					
Counts based on 39 specimens from the eastern Pacific.	68–86	73–85	146–167		
Subgenus *Protozygaena*					
R. lalandei (Valenciennes)					
Counts based on 45 specimens from the western Atlantic from Panama to Brazil. A and B values based on two specimens.	79–90	67–79	153–168	126–138	96–103
R. oligolinx Springer					
Counts based on 57 specimens from the Indo-Pacific.	84–91	64–75	151–162	ca. 100	
R. taylori (Ogilby)					
Counts based on 10 specimens from Australia.	73–80	62–70	135–149	ca. 100	
Loxodon (see Springer, 1964)					
L. macrorhinus Müller and Henle					
Counts based on 20 specimens, vary with locality; A and B values based on 4 specimens	77–106	71–86	148–191	112–208	84–110
Scoliodon (see Springer, 1964)					
S. laticaudus Müller and Henle					
Counts based on 98 specimens; A value based on 4 specimens	97–112	50–62	148–171	ca. 100	
Prionace					
P. glauca (Linnaeus)					
BMNH 1961.11.2.2. English Channel	149	98	247	ca. 100	
USNM 48317, Italy	143	96	239		
USNM 125766, off northern (eastern?) United States	142	101	243		
USNM 164621-23, Hawaii, sibling embryos	146	106	252	110	38
	146	102	248		
	145	102	247		
UMMZ (field no. H29-15), Japan	147	>90	>237		
USNM 197687, Capetown, South Africa	143	101	244		
Galeorhinus					
G. galeus (Linnaeus)					
UZMK 463, locality unknown	83	53	136		
G. japonicus (Müller and Henle)					
UMMZ 179061, Fukuoka market, Japan	106	54	160	114	82
Hemipristis					
H. elongatus (Klunzinger)					
GVF 2385-1, Gulf of Thailand	104	86	190		
	104	90	194	122	80
	103	89	192	132	64
Galeocerdo					
G. cuvieri (Peron and LeSueur)					
GVF 2357-1, Gulf of Thailand	105	126	231	113	55
USNM 196524, Florida, sibling embryos	106	>117	>223	133	62
	108	>114	>222		

TABLE 1.—*Vertebral characters in sharks*—Continued

Family, genus, species, locality	P	C	T	A	B
CARCHARHINIDAE—Continued					
Negogaleus					
N. macrostoma (Bleeker)					
BMNH 1867.11.28.197, Java, holotype of *Hemigaleus macrostoma* Bleeker	74	63	137	139	141
N. microstoma (Bleeker)					
BMNH 1867.11.28.173, Java, holotype of *Hemigaleus microstoma* Bleeker	81	69	150	148	108
UMMZ 179017, Java	78	65	143		
Paragaleus					
P. gruveli Budker					
USNM 196158, Senegal, embryo (see discussion)	72	70	142	180	140
USNM 196163, Senegal, embryo (see discussion)	79	70	149	192	144
P. pectoralis (Garman)					
MCZ 847, off New England (?), holotype of *Hemigaleus pectoralis* Garman	78	70	148	174	119
SPHYRNIDAE					
Sphyrna					
S. tiburo (Linnaeus)					
USNM 88677, Guayaquil, Equador	81	82	163	158	106
USNM 190591, Panama Bay, Panama			165	145	111
ANSP 86208, San Miguel Bay, Panama	86	87	173	125	89
ANSP 581, Rhode Island	88	82	170	127	93
USNM 125763, Appalachicola Bay, Florida	72	70	142	165	132
USNM 116888, Tortugas, Florida	72	71	143	153	124
USNM 104318, Recife, Brazil	80	78	158	143	111
S. media Springer					
USNM 196140, Gulf of Nicoya, Costa Rica	103	92	195	136	72
	100	93	193	120	69
	103	89	192		
	102	88	190	111	80
	101	92	193	113	65
	102	92	194	150	72
USNM 190593, Panama Bay, Panama	102	94	196	112	63
	102	91	193		
	101	92	193	116	73
	101	91	192	105	72
S. mokarran (Rüppell)					
USNM 29645, Mazatlan, Mexico	98	108	206	137	69
USNM 40026, New South Wales, Australia, embyro	97	108	205	122	78
S. lewini (Griffith)					
USNM 72476, Java, embyro	92	105	196	156	91
USNM 130604, Foochow, China	92	100	192	148	83
USNM 29999, Jamaica	96	108	204		
USNM 25180, South Carolina	89	85	174	155	99
S. zygaena (Linnaeus)					
UMMZ 179078, Japan	99	103	202	121	82
USNM 119699, Virginia	102	104	206	ca. 100	
S. tudes (Valenciennes)					
USNM 195957, Mississippi	107	95	202	ca. 100	
S. blochi (Cuvier)					
RNH skeleton no. 343, Java	52	64	116		
CNHM 21836, North Borneo	54	70	124	178	128
USNM 195846, Bombay, India	52	66	118	160	133

TABLE 1.—*Vertebral characters in sharks*—Continued

Family, genus, species, locality	P	C	T	A	B
SQUALIDAE					
Squalus					
S. acanthias					
USNM 17495, Norway	83	26	109	179	86
	83	26	109	191	75
CNHM 35495-7, Scotland	81	30	111	169	93
	85	30	115	233	97
	84	29	113	173	104
USNM 75665, Virginia	85	32	117	140	104
USNM 121955, Virginia	79	29	108	118	114
USNM 197692, Capetown, South Africa	75	27	102		
USNM 104828, Alaska	70	29	99	135	108
	73	30	103	162	96
USNM 52852, Alaska	71	29	100	141	108
USNM 27305, Puget Sound, Washington	70	30	100	155	124
USNM 50989, Puget Sound, Washington	69	28	97	141	110
USNM 197796, Washington	73	30	103		
	70	29	99		
	71	26	97		
	72	27	99		
	70	30	100		
	75	29	104		
	72	29	101		
	73	31	104		
	76	30	106		
	72	28	100		
USNM 71835, Japan	68	28	96	181	97
	69	29	98	167	100
	72	28	100	135	100
CNHM 59847, Japan	70	28	98	130	107
UMMZ 179056, Korea	69	29	98	148	107
	71	28	99	172	108
USNM 164430, Chile	78	31	109	175	131
	77	30	107	150	126
USNM 164431, Chile	76	26	102	170	131
USNM 77306, Straits of Magellan	76	29	105	148	137
	75	31	106	151	160
S. blainvillei (Risso)					
USNM 130611, Ningapo, Chekiang, China	86	28	114	128	80
UMMZ 179055, Japan	89	29	118	156	80
USNM 196545, Taiwan	89	27	116	156	86
CNHM 55618, Korea	89	27	116	166	81
USNM 197393, Hawaiian Islands	84	29	113	129	117
USNM 157864, Florida	87	28	115	152	98
	85	30	115	155	95
USNM 160831, Florida	86	29	115	140	96
USNM 157748, Florida	86	30	116	150	81
USNM 158478, Louisiana	86	31	117	143	83
USNM 197691, Capetown, South Africa	82	32	117		
MCSN 34458, Italy	80	26	106	160	100
USNM 28473 (presumably Italy)	78	28	106	155	102
	79	29	108	165	94
S. megalops (Macleay)					
GVF HK95 south China Sea	80	25	105		
	78	26	104		
	78				
USNM 191180, Taiwan	81	26	107	160	100
	82	26	108	136	94
	81	27	108	165	93
UMMZ 179033, Japan	80	26	106	136	97
UMMZ, 179053, Japan	79	27	106	144	82

TABLE 1.—*Vertebral characters in sharks*—Continued

Family, genus, species, locality	P	C	T	A	B
SQUALIDAE—Continued					
Squalus—Continued					
S. cubensis Howell-Rivero					
USNM 157853, north of Cuba	84	30	114	150	80
USNM 157846, north of Cuba	86	30	116	141	100
USNM 196544, north of Cuba	87	29	116	144	92
USNM 164247, Dominican Republic	82	30	112		
Centrophorus					
C. uyato (Rafinesque)					
USNM 196160, Senegal	90	32	122	136	95
USNM 157862, south of Alabama	82	31	113		
	83	30	113		
C. squamosus (Bonnaterre)					
USNM 161517-18, Japan	82	24	106		
	83	24	107	125	78
MCZ 40769, New Zealand	86	28	114	122	100
Centroscymnus					
C. owstoni Garman					
UMMZ 142885, Japan	74	28	102	125	69
C. crepidater Bocage and Capello					
USNM 196151, Senegal	77	29	106	137	128
MCZ 40768, New Zealand, embryo, uncalcified					
C. coelolepis Bocage and Capello					
USNM 38072, off New Jersey	78	27	105	133	80
MCZ 37420, east of New York	79	26	105	126	67
MCZ 37424, east of New York	79	29	108	122	65
USNM 94522, Madeira	75	34	109	125	118
Centroscyllium					
C. fabricii (Reinhardt)					
USNM 131383, off Newfoundland	66	29	95	162	130
USNM 38110, off New York	67	30	97	200	122
C. ritteri Jordan and Fowler					
UMMZ 179024, off Japan	62	28	90	141	124
USNM 161521, Japan	61	27	88	181	106
	64	27	91	161	119
	64	26	90	160	121
Deania					
D. elegans Springer					
USNM 159603, off North Carolina, holotype	85	34	19	133	80
D. calcea (Lowe)					
UMMZ 142884, Japan	90	36	126		
Etmopterus					
E. polli Bigelow, Schroeder, and Springer					
USNM 163370, off Angola	54	24	78	144	163
E. spinax (Linnaeus)					
USNM 195848, Italy	55	29	84	130	118
Counts based on 567 specimens from Norway (after Punnett, 1904; see our discussion)			81–91		
E. virens Bigelow, Schroeder, and Springer					
USNM 158406, Gulf of Campeche, Mexico	56	27	83	173	173
USNM 185600, Nicaragua (Atlantic)	57	24	81	144	144
	57	24	81	140	140
	58	26	84	150	150
E. schultzi Bigelow, Schroeder, and Springer					
USNM 158144, south of Alabama	56	26	82	160	120
	57	25	82	153	153
	56	26	82	143	133
	58	24	82	147	147
	56	27	83	143	165

TABLE 1.—*Vertebral characters in sharks*—Continued

Family, genus, species, locality	P	C	T	A	B
SQUALIDAE—Continued					
Etmopterus—Continued					
E. princeps Collett					
USNM 163365, off New Jersey	58	23	81	211	136
E. lucifer Jordan and Snyder					
USNM 51282, Japan	59	26	85	154	176
	62	27	89	152	173
USNM 161515, Japan	63	27	90		
E. bullisi Bigelow and Schroeder					
USNM 185597, northeast of Honduras	60	24	84	175	131
	61	24	85	178	114
USNM 185603, North Carolina	60	24	84	150	150
E. baxteri Garrick					
MCZ 40688, New Zealand	61	27	88	141	135
E. pusillus Lowe					
USNM 157835, off northwest Florida	64	24	88	154	180
E. frontimaculatus Pietschmann					
USNM 196521, Japan	66	22	88	127	136
UNMZ 179025, Japan	61				
OXYNOTIDAE					
Oxynotus					
O. centrina (Linnaeus)					
ANSP 575–76 Italy	61	30	91	143	95
	64	30	94		
DALATIIDAE					
Dalatias					
D. licha (Bonnaterre)					
MCSN 34631, Italy	51	27	78	140	156
MCZ 910, Italy	51	28	79	143	152
USNM 157844, south of Alabama	50	28	78	153	149
Scymnodalatias					
S. sherwoodi (Archey)					
CM no number, New Zealand, holotype of *Scymnodon sherwoodi* Archey	58	23	81	130	152
Euprotomicrus					
E. bispinatus (Quoy and Gaimard)					
USNM 190031, near Midway Island	51	13	64	182	190
USNM 164176, west of Johnston Island	47	14	61	173	161
USNM 190032, south Pacific Ocean	46	15	61	130	144
CAS 20431, off California (after Hubbs and McHugh, 1951)	48				
Heteroscymnoides					
H. marleyi Fowler					
ANSP 53046, South Africa, holotype	52	18	70	160	145
Isistius					
I. brasilensis (Quoy and Gaimard)					
USNM 164174, west of Christmas Island	61	24	85	157	147
USNM 164175, northwest of Fanning Island	61	25	86	150	161
USNM 190039, near Fanning Island	60	24	84	166	200
USNM uncataloged, off Mississippi (Oregon 2507)	62	20	82	172	172
USNM uncataloged, off Mississippi (Oregon 2945)	61	20	81	159	189
	66	23	89	162	179
I. species (Garrick and S. Springer, in ms.)					
USNM uncataloged, off Mississippi (Oregon 3102)	65	27	92	167	180

TABLE 1.—*Vertebral characters in sharks*—Continued

Family, genus, species, locality	P	C	T	A	B
DALATHDAE—Continued					
Squaliolus					
S. sarmenti Noronja					
ANSP 2454, Madeira	48	13	61	139	178
S. laticaudus Smith and Radcliffe					
USNM 70259, Luzon, Philippines, holotype	47	13	60	173	173
USNM 76679, Luzon, Philippines, paratype	44			150	150
Somniosus					
S. rostratus Capello					
IRSN 1399c, Mediterranean	58	20	78		
ECHINORHINIDAE					
Echinorhinus (see discussion)					
E. cookei Pietschmann					
USNM 179805, Hawaii, embryos					
E. brucus (Bonnaterre)					
BMNH 1891.7.2.3.1, Nice, embryo					
PRISTIOPHORIDAE					
Pristiophorus					
P. schroederi Springer and Bullis					
UMMZ 178848, off Cuba	100	55	155	144	100
P. oweni Günther					
BMNH 1859.9.11.1, locality unknown, holotype	103	48	151	150	78
P. japonicus Günther					
BMNH 1862.11.1.37, Japan, syntype	109	40	149	114	83
BMNH no number, Japan, syntype	104	53	157		
UMMZ 176819, Japan	108	48	156	143	75
P. nudipinnis Günther					
BMNH 1869.2.24.2, Tasmania, syntype	103	50	153	117	99
Pliotrema					
P. warreni Regan					
BMNH 1905.6.8.9, Natal, South Africa, holotype	106	49	155	121	83
SQUATINIDAE					
Squatina					
S. japonica Bleeker					
UMMZ 179041, Nagasaki market, Japan	92	34	126	133	70
S. squatina (Linnaeus)					
IRSN 1401B, Mediterranean	93	28	121		
RNH skeleton no. 492, Holland	96				
RNH skeleton no. 428, no locality	93				
S. californica Ayres					
UBC 59-237, Cape San Lucas, Baja	108	33	141	135	56
California, Mexico	108	32	140	135	53

TABLE 2.—*Summary of vertebral characters in suborders, families, and genera of sharks*

For explanation of symbols, see table 1

	P	C	T	A	B
NOTIDANOIDEA					
Hexanchidae					
Hexanchus			uncalcified		
Notorhynchus			uncalcified		
Heptranchias	85–90	45–61	ca. 130–151		
CHLAMYDOSELACHOIDEA					
Chlamydoselachidae					
Chlamydoselachus			>112		
HETERODONTOIDEA					
Heterodontidae					
Heterodontus	71–74	35–42	106–116	133–160	89–95
GALEOIDEA	50–149	28->298	104->419	ca. 100-328	25–172
Carchariidae					
Carcharias	80–87	71–85	156–170		
Scapanorhynchidae					
Scapanorhynchus	53	69	122	189	172
Lamnidae	84–112	68–86	150–197	ca. 100–130	52–67
Isurus	108–112	79–86	187–197	100–130	52–67
Lamna	84–91	68–71	150–162	ca. 100	
Carcharodon	103-108	68–83	172–187		
Cetorhinidae					
Cetorhinus	50	60	110		
Alopiidae					
Alopias	100–121	180–>298	282–>419	ca. 100–136	25–27
Orectolobidae	81–114	50–145	142–226	115–150	55–80
Orectolobus	106	50	156	133	78
Stegostoma	81–101	121–145	217–226	140–150	55–58
Chiloscyllium	104–114	60–65	167–175	115–143	62–80
Eucrossorhinus	100	62	162		
Ginglymostoma	92–98	73–83	170–175	116–125	66–80
Hemiscyllium			190–192	120–150	71–75
Brachaelurus			142	125	68
Rhincodontidae					
Rhincodon	81	>72	>153		
Scyliorhinidae	69–110	28–60	104–164	133–173	94–143
Cephaloscyllium	74	35	109	141	94
Galeus	74–81	>51–60	>127–140	141–173	124–143
Haploblepharus	94	43	137	140	107
Halaelurus			130	133	114
Parmaturus	70	60	130	145	115
Apristurus	69–70	46–>50	116–>119	139–155	122–133
Scyliorhinus	74–92	38–40	112–132	162–167	105
Pentanchus	79	54	133	135	113
Conoporoderma	76	28	104	172	100
Atelomycterus	110	54	164		
Undescribed genus (S. Springer, in ms.)	105	40	145	125	125
Pseudotriakidae					
Pseudotriakis (from Jaquet, 1905)			ca 186		
Triakidae	77–137	46–85	124–214	ca. 100–200	68–122
Scylliogaleus	88	>52	>140	114	103
Triakis	84–109	49–60	136–160	112–200	83–117
Eridacnis	77	47	124	125	105
Mustelus	81–93	46–56	130–146	123–169	92–122
Triaenodon	129	85	214	ca. 100	
Leptocharia	136–137	75–76	211–213	ca. 100–112	68

TABLE 2.—*Summary of vetebral characters in suborders, families, and genera of sharks*—Continued

For explanation of symbols, see table 1

	P	C	T	A	B
GALEOIDEA—Continued					
Carcharhinidae	54–149	50–126	110–252	ca. 100–328	38–154
Carcharhinus (Garrick, in ms.)*	54–125	53–110	110–235	110–328	60–107
Aprionodon	79	86	165	206	150
Negaprion	117	84	201	125	76
Hypoprion	70–104	80–86	152–184	120–222	67–154
Rhizoprionodon					
subgenus *Rhizoprionodon*	55–86	64–85	121–167	125–174	108–145
subgenus *Protozygaena*	73–91	62–79	135–168	ca. 100–138	96–103
Loxodon	77–106	71–86	148–191	112–208	84–113
Scoliodon	97–112	50–62	148–171	ca. 100	
Prionace	142–149	>90–106	>237–252	110	38
Galeorhinus	83–106	53–54	136–160	114	82
Hemipristis	103–104	86–90	190–194	122–132	64–80
Galeocerdo	105–108	>114–126	>222–231	113–133	55–62
Negogaleus	74–81	63–69	137–150	139–148	108–141
Paragaleus	72–79	70	142–149	174–192	119–144
Sphyrnidae					
Sphyrna	52–107	64–108	116–206	ca. 100–178	63–133
SQUALOIDEA	44–90	13–36	60–126	118–233	65–200
Squalidae	54–90	22–36	78–126	118–233	65–180
Squalus	68–89	26–32	96–118	118–233	75–160
Centrophorus	82–90	24–32	106–122	122–136	78–100
Centroscymnus	74–79	26–34	102–109	122–137	65–128
Centroscyllium	61–67	26–30	88–97	141–200	106–130
Deania	85–90	34–36	119–126	133	80
Etmopterus	54–66	22–29	78–91	127–211	114–180
Oxynotidae					
Oxynotus	61–64	30	91–94	143	95
Dalatiidae	44–66	13–28	60–92	130–182	141–200
Dalatias	50–51	27–28	78–79	140–153	149–156
Scymnodalatias	58	23	81	130	152
Euprotomicrus	46–51	13–15	61–64	130–182	144–190
Heteroscymnoides	52	18	70	160	145
Isistius	60–66	20–27	81–92	150–172	147–200
Squaliolus	44–48	13	60–61	139–173	150–178
Somniosus	58	20	78		
Echinorhinidae					
Echinorhinus	uncalcified				
PRISTIOPHOROIDEA					
Pristiophoridae	100–109	40–55	149–157	114–150	75–100
Pristiophorus	100–109	40–55	149–157	114–150	75–100
Pliotrema	106	49	155	121	83
SQUATINOIDEA					
Squatinidae					
Squatina	92–108	28–34	121–141	133–135	53–70

*Includes data not in table 1.

TABLE 3.—Etmopterus spinax: *total vertebral numbers in females with litters (based on data in Punnett, 1904)*

Total vertebral count			Number of sibling embryos
Mother	Average of sibling embryos	Range of sibling embryos	
82	84.7	83-87	6
82	84.7	83-87	7
83	83.5	81-86	12
83	84.2	82-86	9
84	83.3	82-85	7
84	83.9	83-85	10
84	84.3	83-86	6
84	84.5	82-87	12
84	85.5	84-88	6
85	83.8	82-85	8
85	85.2	84-88	13
85	85.3	85-87	6
85	85.5	85-86	2
86	83.7	82-87	10
86	83.9	82-86	9
86	84.5	82-87	11
86	84.7	84-87	9
86	84.8	84-86	9
86	84.9	83-87	8
86	85.2	84-87	13
86	85.5	85-87	14
87	84.2	83-85	8
87	86.8	85-88	12
88	86.0	84-88	8
88	87.2	84-90	9

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