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Differences in the Number and Position of Two Kinds of Fin-Supports of the Spinous Dorsal in the Japanese Mackerels of the Genus *Pneumatophorus**

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(2 text-figures and 4 tables)

In recent years the annual commercial fish catch by the Japanese fishermen has approached, and in 1957 exceeded, five million metric tons in weight, of which five to seven percent have been the two forms of mackerels, *Pneumatophorus japonicus japonicus* (HOULTUYN) and *P. japonicus tapeinocephalus* (BLEEKER). Whereas the annual catches of the sardine, herring, anchovy, Pacific saury and a species of squid (*Ommastrephes sloani pacificus* STEENSTRUP), all of which once exceeded the mackerels in the amount of annual catches, fluctuate considerably from year to year, the mackerels of the two forms mentioned above, if considered together, keep steadily high ranks in the order of the annual catch records. It is remarkable that, despite the disappearance of the mackerel from off the eastern coast of Hokkaido in recent years, and despite the recent unfavorable international situation regarding the fishing grounds south of Korea, their annual catch records have been more than two hundred forty thousand metric tons since 1952 (figure 1). Readers might be interested in the reasons why the two forms of the mackerels have been treated together without being distinguished from one another while the sardine, round herring and anchovy have recently been treated separately in the recording of annual catches by the Japanese governmental organizations. On the other hand, the senior author has been asked at times to point out clear-cut differences between the two forms by those workers who have started studies on the mackerels for the Japanese governmental organizations. He has been to be very careful to do this, because the differences in external characters between the two forms are subject to considerable changes with advancing age and individual variation. Speaking generally, the adult of *tapeinocephalus*

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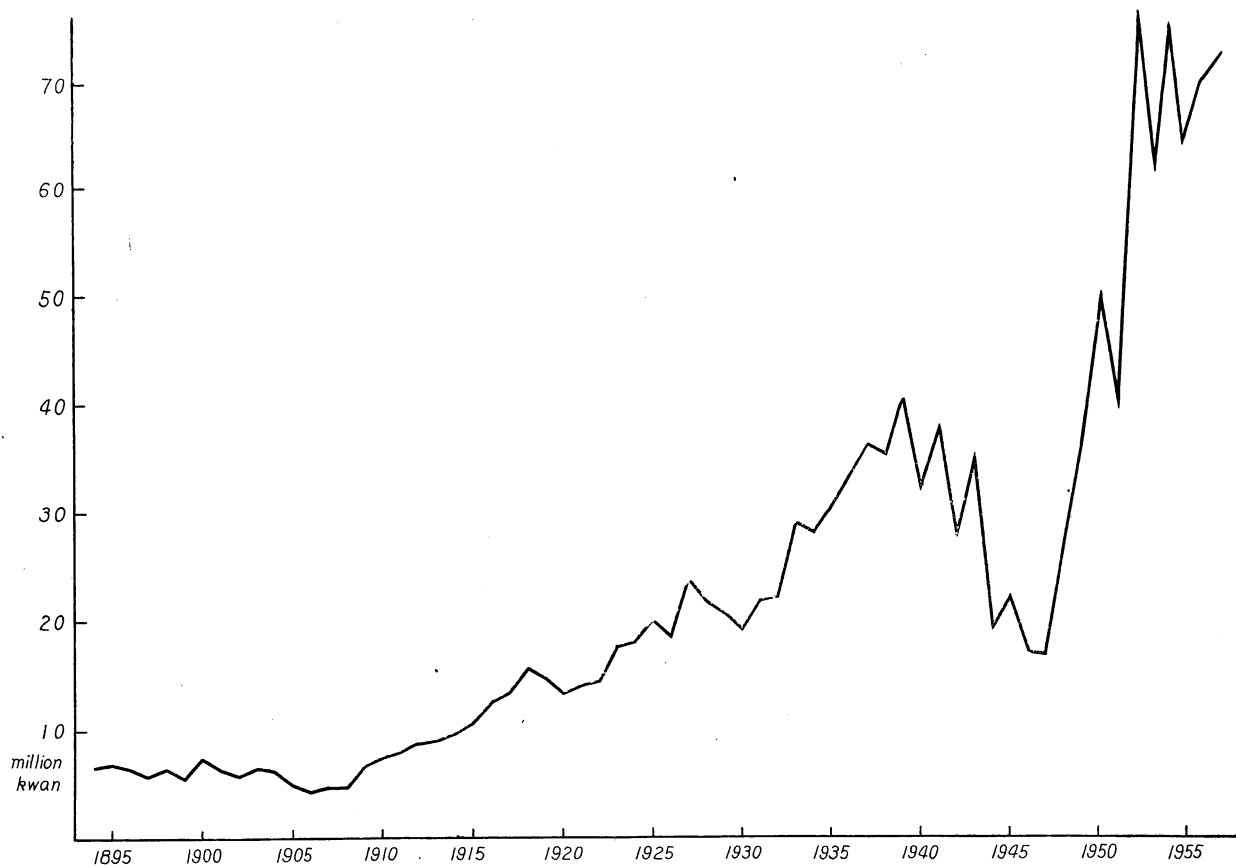


Fig 1. Annual catch record [in 1,000,000 kwan (or *ca.* $1,000,000 \times 15/4 \text{ kg} = 3,750$ metric tons)] of the Japanese mackerels [*Pneumatophorus japonicus japonicus* (HOUTTUYN) plus *P. j. tapeinocephalus* (BLEEKER)] for the years 1894–1957. The records were gathered by the Division of Statistics, Section of Economics, Ministry of Agriculture and Forestry.

第1図 日本に於けるサバ水揚量の明治27年～昭和32年間の年々の変化 (単位 100万貫).

are densely spotted ventrally, and abound warmer waters, usually not reaching beyond the Cape of Inubo (boundary between the northern and southern piscifunal areas of Japan along the Pacific coast). This form seems rather rare in Japan Sea. The other form, *japonicus*, is usually not spotted ventrally, but examples bearing blackish or bluish spots or short lines on the lower part of the flank* are not infrequently (especially in the adult) observed, which careless observers regard as *tapeinocephalus*. *P. j. japonicus* reaches north of Hokkaido, and is taken commercially in recent years off the western coast of Hokkaido in summer. In the present paper, the writers wish to give account of the fin-supports of the spinous or first dorsal fin in the two Japanese forms of mackerels leaving accounts of differences in cranial and other characters and nomenclatorial remarks for future works; two kinds of dorsal fin-supports in these fishes, namely, proximal segments of the radials often called interneural spines by taxonomists, and the middle

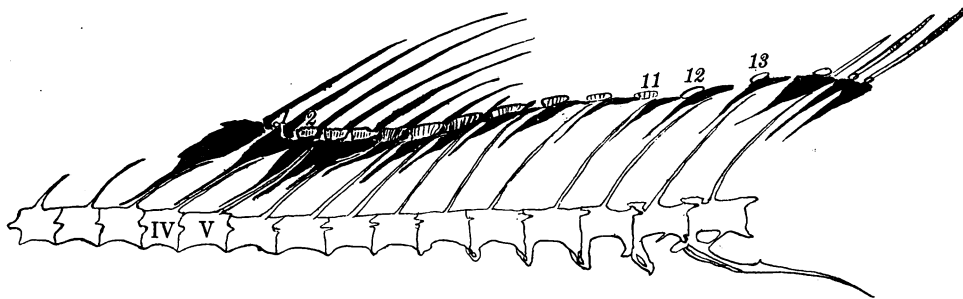


Fig. 2. *Pneumatophorus japonicus japonicus* (HOFFMANN) from off Katsu-ura, Chiba Prefecture. Cat. No. ABE, 58—231. Total length of body (including caudal fin) 418 mm, standard length (measured to hind end of vertebral column) 367 mm. Left-side view of the anterior half of the vertebral column, all of the proximal segments (or interneurals) of the radials of the spinous (or, 1st) dorsal (black), anteriormost three proximal segments of the radials of the soft (or, 2nd) dorsal (black), all of the middle (or, medial) segments of the radials of the spinous dorsal, and the anteriormost three middle segments of the radials of the soft dorsal.

The anteriormost middle segment of the radial of the spinous dorsal (marked with italicized Arabic numeral 1) is V-shaped, its lateral wing on either side being a stout rod.

The subsequent middle segments of the radials of the spinous dorsal are concave dorsally, the lateral wing on either side being much expanded, and forming together a longitudinal groove receiving the dorsal spines. The hindmost middle segments (11th—13th) of the radials of the spinous dorsal become compressed and are reduced in size. The anteriormost middle segment of the dorsal radial placed just in front of the base of the 1st soft fin-ray of the 2nd dorsal differs greatly in shape from the preceding middle segments of the radials of the spinous dorsal, and is not counted in table 2. The 2nd and subsequent middle segments of the radials of the soft (or, 2nd) dorsal are single, rounded, semi-transparent cartilaginous balls, and are each clipped by the root of each half of each soft fin-ray.

第1図 ヒラサバの第1背鰭の2種の担鰭骨と第2背鰭の前方の2種の担鰭骨。第4、第5背椎骨の神経弓間にある神経棘間骨の数がヒラサバでは普通1個である事に注目されたい。

* It may be added here that the extent of the spotted area on the flank of the Japanese sardine, *Sardinops melanosticta* (TEMMINCK & SCHLEGEL), also varies considerably.

segments of the radials* (SCHMALHAUSEN, 1912; GOODRICH, 1930) which were called (and seemingly certainly so) distal segments of the radials by BRIDGE (1896), differ considerably in number and position between the two forms, and the differences are of great help in discriminating between them when external characters are not well exhibited.

A. Proximal segments of the radials (or, interneurals)
of the spinous dorsal fin

It is a routine practice of the senior author to count the number of the dorsal spines for corroborating the identification of the two Japanese forms of mackerels. This number is usually higher in *Pneumatophorus japonicus tapeinocephalus* than in *P. j. japonicus* (table 1.). As might be expected from this difference between the two forms, the number of the proximal segments supporting the spinous portion of the dorsal fin (or, the first dorsal fin) is higher in *tapeinocephalus* than in *japonicus* (table 2). The number of the proximal segments of the radials supporting the soft (or second) dorsal fin, anal fin and finlets seems not to differ between the two forms.

Furthermore, the position of the proximal segments of the radials supporting the spinous portion of the dorsal fin differs considerably between them (table 3). The anteriormost proximal segment of the radial is inserted between the neural spines of the 2nd and 3rd vertebrae in both forms, and the 2nd proximal segment is between the neural spines of the 3rd and 4th vertebrae in *japonicus* and the majority of the examples of *tapeinocephalus*. Then comes a remarkable difference between the two forms; in most cases the 3rd proximal segment alone is inserted between the neural spines of the 4th and 5th vertebrae in *japonicus* (fig. 2) whereas in *tapeinocephalus* there are usually 2 (in a few cases 1 or 3) proximal segments between these neural spines. One of the final routine practices of the senior author for corroborating the identification of the two forms of mackerels (when the external characters, especially the number of the dorsal spines, are not convincing) is just to cut open the left side of the anterior portion of the base of the spinous dorsal fin and to count the number of the proximal segments of the radials inserted between the neural spines of the 4th and 5th vertebrae.

The number of the proximal segments of the spinous dorsal fin between the neural spines of the 5th and 6th vertebrae is in most cases 2 (in a few cases 1; in much fewer cases 3) in both forms. The number of the proximal segments of the radials between the neural spines of the 6th and 7th vertebrae is mostly 1 in *japonicus* (in a few cases 2 or 0), and mostly 2 (in a few cases 1) in *tapeinocephalus*. The number of the proximal segments of the radials inserted between the neural spines of the 7th and 8th vertebrae

* The senior author is indebted to Prof. Alfred S. ROMER (Museum of Comparative Zoölogy, Harvard University), Dr. H. C. GODSIL, (California Department of Fish and Game, U. S. A.) and Dr. Norman J. WILLIMOWSKY (U. S. Fish and Wildlife Service, Juneau, Alaska) for the information about the name of the bones. He wishes to express here his sincere thanks for their kindness, and takes much pleasure in stating here that he has extended his studies to the comparative study of these neglected bones (cf. ABE, 1957, p. 39; *Id.*, 1958, p. 1174). He overlooked the terminology proposed by SCHMALHAUSEN prior to receipt of a letter from Prof. ROMER.

Table 1

Frequency distributions of the number of the dorsal spines (Roman numerals), dorsal soft-rays (Arabic numerals) and dorsal finlets (bold-faced Arabic numerals) in the two Japanese forms of mackerels, *Pneumatophorus japonicus japonicus* (HOUTTUYN) (ordinary figures) and *P. j. tapeinocephalus* (BLEEKER) (bold-faced figures). The material used is :

P. j. japonicus.

66 examples from Manazuru (Sagami Bay). Total length 180~330 mm. Taken by trap net during January, 1955~January, 1956.

166 examples from off south-eastern coast of Bōsō Peninsula. Total length 270~385mm. Taken by hook and line ("hanezuri") in the night of June 15~16, 1955, and July 9, 1955.

15 examples from Toyoura-machi, Yamaguchi Prefecture. Total length 65~115 mm. Collected by trap net on April 2, 1955.

13 examples from Okino-shima, Fukuoka Prefecture. Total length 250~345 mm. Taken in the night of February 10~11, 1955.

P. j. tapeinocephalus.

65 examples from Manazuru (Sagami Bay). Total length 195~285 mm. Taken by trap net on January 14, 1955, March 13~14, 1955, and January 18, 1956.

1 example from off south-eastern coast of Bōsō Peninsula. Total length 340 mm. Collected on May 11, 1956, at the Central Wholesale Market of Tokyo.

9 examples from Maese (Suruga Bay). Total length 330~350 mm. Taken on June 25, 1956.

8 examples from Nishiki, Mie Prefecture. Total length 105~115 mm. Taken by trapnet on April 22, 1954.

9 examples from near the Bonin Islands. Total length 425~450 mm. Taken by hook and line, on January 20, 1956, and early in March, 1956.

3 examples from Formosa. Total length 340~380 mm. Collected on February 25, 1956, at the market in Keelung.

第 1 表 ホンサバとゴマサバの背鰭棘数、背鰭軟条数及び背部離鰭数

Number of dorsal spines, dorsal soft-rays, and dorsal finlets	IX•12 (=ii+10)•5	IX•11 (=ii+9)•6	X•11 (=ii+9)•5	X•12 (=ii+10)•5	X•I•12 (=ii+10)•5	X•13 (=ii+11)•5	XI•11 (=ii+10)•5	XI•12 (=ii+10)•5	XII•11 (=ii+9)•5	XII•12 (=ii+10)•5	XIII•12 (=ii+10)•5	XIV•12 (=ii+10)•5
Number of examples	18	1	8	179+5* +2† 1***	1	1+1*	1	36+3* +1**+1† 22	3	34+2** +1†	19+3** +1†+1††	3

* : Number of anteriormost unbranched soft fin-rays 3 or uncertain.

** : 12=i+11

*** : Number of proximal segments of radii of spinous dorsal 10. Number of middle segments of radii of spinous dorsal 18. Number of proximal segments between the neurel spines of 3rd and 4th vertebrae 2.

† : 12=iii+9

†† : Or, XIII•11(=i+10)•6

††† : XI•12(ii+10)•6

Table 2

Frequency distributions of the number of the proximal segments of the dorsal radials (often called interneurals) (D') in the two Japanese forms of mackerels, *Pneumatophorus japonicus japonicus* (HOUTTUYN) (ordinary figures) and *P. j. tapeinocephalus* (BLEEKER) (bold-faced figures). The left figures represent numbers of D' supporting dorsal spines; the middle figures, numbers of D' supporting soft dorsal fin-rays; the right figures, numbers of D' supporting dorsal finlets. The material used is the same as in table 1.

第2表 ホンサバとゴマサバに於ける神経棘間骨の数

Number of D'	13+ 12+5	13+ 14+5	14+ 11+5	14+ 12+5	14+ 13+4	15+ 11+6	15+ 12+5	15+ 13+5	16+ 12+5	17+ 12+5	18+ 11+5	18+ 12+5	18+ 12+5	18+ 12+6	19+ 11+6	19+ 12+5	20+ 12+5	21+ 11+5	21+ 12+5	22+ 12+5
Number of exampls	13	1	1	101+ 1+1*	3	1	87	1	4	1***										
										1	1	1	10	1	1	31+1††	24	1	14	1

* 1st and 2nd D' dorsally fused with one another ; counted as 2.

** 12th and 13th D' dorsally fused with one another ; counted as 2.

*** Number of middle segments of radials of spinous dorsal (D'') 15. Number of D' inserted between the neural spines of 4th and 5th vertebrae 1. Ridges on the right half of the skull is suggestive of *tapeinocephalus*.

† Number of D'' 16. Number of D' inserted between the neural spines of 4th and 5th vertebrae 2.

†† Hindmost 2 D' dorsally fused with one another ; counted as 2.

Table 3

Variation in the position of the anterior proximal segments of the radials (or internuials) of the spinous (or first) dorsal fin (D') in the two Japanese forms of mackerels, *Pneumatophorus japonicus japonicus* (HOUTTUYN) (ordinary figures) and *P. j. tapeinocephalus* (BLEEKER) (bold-faced figures). The uppermost Arabic numeral in the uppermost column is the number of the anteriormost proximal segment (D') of the dorsal radial which is invariably inserted between the neural spines of the 2nd and 3rd vertebrae. The successive Arabic numerals in the same column are the numbers of D' inserted between the successive pairs of neural spines of the successive pairs of vertebrae. The material used is the same as in tables 1 and 2.

第3表 ホンサバとゴマサバの神経棘間骨の位置

上端のアラビア数字は第2脊椎骨の神経棘と第3脊椎骨の神経棘間にある神経棘間骨 (D') の数を示し、
以下相続く2個宛の脊椎骨の神経棘の間にある神経棘間骨の数を示す。

Number of D' inserted between the neural spines of 2nd and 3rd vertebrae, and those between the successive pairs of neural spines of the successive pairs of vertebrae	1	232	9	4	1	1	3**	1†	11	26	38	1	1	1	1	2	1	1	2
Number of examples	1			1*															

* The specimen was in alcohol since November 28, 1950, and examined in 1956. Because of the bad state of preservation, the positions of D' were somewhat uncertain. The number of D' is 18. The number of dorsal spines and fin-rays is XI-12-5. The skull is somewhat suggestive of that of *japonicus* on the left side.

** In 1 specimen number of D' 14. In 2 specimens number of dorsal spines 9 and 10, respectively; number of D' 15.

† Number of D' 14.

is 1 in *japonicus* and 2 or 1 in *tapeinocephalus*. Then, usually 1 proximal segment of the radial is inserted between each 2 neural spines of each two successive vertebrae till the one supporting the anteriormost fin-ray of the soft (or second) dorsal fin (and usually 2 proximal segments between each 2 neural spines of each two successive vertebrae below the soft dorsal fin) in *japonicus*. In *tapeinocephalus* the number of the proximal segments inserted between each two vertebrae beginning with the pair of the 8th and 9th vertebrae is either 1 or 2 (and the position of the proximal segments of the radials supporting the soft dorsal fin, anal fin and finlets seems not to differ from that of *japonicus*).

B. Middle segments of the radials of the spinous dorsal fin

In so far as the present writers are aware, little attention has been paid by ichthyologists to the number and shape of the middle segments of the radials of the dorsal and anal fins in fishes. GILL (1885, p. 211) stated that "Teuthioidea are fishes distinguished by the development of transversely expanded, buckler-like, subcutaneous plates on the back, intervening between the spines, and limiting their erection forwards." His Teuthioides included *Teuthidae* (*Acanthuridae* or *Hepatidae*) and *Siganidae*. MATSUBARA (1955, pp. 964 and 965) mentioned that these plates are slightly larger than in many members of Scombroidea and that they are not distinctly larger than in certain berycoid fishes. Soon after the commencement of the present study by the senior author in 1950, he noticed the remarkable variation in the number and shape of the middle segments of the radials of the spinous dorsal fin in the Japanese mackerels. But it was not until 1956 that he extended his study to the comparison of the middle segments of the radials of dorsal and anal fins of varied fishes in order to understand the significance of these bones for the taxonomic study of the mackerels.

In the two Japanese forms of mackerels, the anteriormost middle segment of the dorsal radial is placed between the roots of the 1st and 2nd dorsal spines. Its shape is

Table 4

Frequency distribution of the number of the middle segments of the radials of the spinous dorsal (D'') in the two Japanese forms of mackerels *Pneumatophorus japonicus japonicus* (HOUTTUYN) (ordinary figures) and *P. j. tapeincephalus* (BLEEKER) (bold-faced figures). The middle segment of the radial just in front of the base of the 1st dorsal soft fin-ray is usually larger than, and different in shape from, preceding ones, and not included in the following counting. The material used is the same as in tables 1-3.

第4表 ホンサバとゴマサバの背部担鰭骨中節の数

Number of D''	9	10	11	12	13	14	15	16	17	18	19	20
Number of examples	1	17	52 + * 2→	46 + 3** →	56	29	3 5	10	24 + 1†→	26	14	4

* or 12. ** or 13. † or 18.

unique among all the middle segments of the radials of the two dorsal fins and anal fin; it is an attenuated, but stiff, V-shaped bone, and its lateral wings are much narrower than in the subsequent middle segments of the dorsal radials each of which is placed just in front of a dorsal spine and concave dorsally. The size of the middle segments of the dorsal radials (hereafter abbreviated to D'') decreases from the largest 2nd one backwards, and their shape changes gradually backwards. The hinder middle segments of the dorsal radials placed between the hindmost dorsal spine and the anteriormost soft fin-ray of the 2nd dorsal are usually compressed, and devoid of lateral wings, the hindmost being at times extremely thin and small in size. As expected from the difference in the number of the dorsal spines between the two Japanese forms of mackerels, the number (table 4) and position of D'' differ between them. The number of D'' is 15 or more (up to 20) in *tapeinocephalus*, and 15 or less (down to 9) in *japonicus*. The difference in the position of D'' has not been used in the present study as a key to distinguish the two forms from one another.

Appendix

• Hints to the discrimination at sea of the two forms of mackerels

1) Difference in shape of anal spine. The difference in the shape (or, strength) of the anal spine between the two Japanese forms of mackerel was first suggested* by Mr. Shoichiro TODA who helped the writers during 1953—1955. On the sea, and more especially in tagging experiment, the senior author often suffered from the injury caused by the strong spine of the anal fin of *Pneumatophorus japonicus japonicus*. The spine is not infrequently damaged and at times shows signs of regeneration. The writers have not yet studied the change with advancing age and local variation in the shape (or, strength) of this spine, but it may be said that it is thicker, stronger and longer in *P. japonicus japonicus* than in *P. japonicus tapeinocephalus*. Tentatively, its relative length has been measured. In the former, the length of the anal spine is mostly more than 1.6% (ranging up to 2.6) of the standard length, while it is usually less than 1.5% (ranging up to 1.9% of the standard length). The measurements have been made mostly of examples more than 200 mm in total length.

2) Distance between the anterior dorsal spines. In the adult, the distance between each two spines of the anterior portion of the dorsal is smaller in *tapeinocephalus* than in *japonicus*,** and the contour of this fin also differs.

3) Color of the anterior portion of the spinous dorsal fin. In the adult, the membranes of the anterior portion of the spinous dorsal is blackish in *tapeinocephalus* and whitish in *japonicus*.

4) Groove behind the visible hindmost dorsal spine. Whenever there is a distinct groove behind the visible last dorsal spine, the senior author has dissected this part of body, and often found an extremely small spine clipped by the pair of hind projections of the middle segment

* In the key to the Indo-Australian species of *Scomber*, Dr. L. F. DE BEAUFORT (in DE BEAUFORT & CHAPMAN's "The fishes of the Indo-Australian Archipelago," ix, p. 206, 1951) states that the anal spine is very feeble in *S. australis* and that it is short but strong in *S. janesaba*.

** This might be expected from the difference between the two forms in the number of the proximal segments of radials inserted between the neural spines of pairs of vertebrae. Further, the dorsal spines in the adult of *japonicus* are thicker and stronger than in *tapeinocephalus*.

of dorsal radial, in front of which is the last visible dorsal spine. In counting the dorsal spine, the presence of the distinct groove behind the hindmost dorsal spine may be regarded as a sign of the presence of an additional small spine.

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日本近海産サバの二型間に見られる二種の背部担鰭骨の相異に就いて*

阿部宗明・高島百合子

近年我が国のサバの産額が著しく増加し、此の数年は年産数千万貫を下らない(第1図)。然し従来の漁獲統計では、我が国に分布している2型のサバ、即ちホンサバ(別名ヒラサバ)とゴマサバ(別名マルサバ)の両者を区別しなかつた為に、此の産額の増加が両者の産額の増加に依るものか、又はその一方だけの増加に依るものかは明らかでない。サバの資源生物学的研究の第1歩は此の両者の類縁関係、分布を明らかにし、又簡単な識別法を見出して、漁獲統計をホンサバ、ゴマサバに分けて行うことにあると考えられる。著者は1953年4月以来、主として関東地方の水域の材料を基とし、サバの漁況調査と平行してその魚体調査を行つて来たが、ホンサバとゴマサバの識別法に関しては漸くその研究結果の一部を公表する段階に達したと思われるに至つた。産業的に最も重要な全長30 cm以上のサバ類の魚体に就いては、その斑紋に依つてかなりの程度二型を識別することが出来ることは先人達の既に繰返し指摘している所であるが、之は必ずしも常に確実な範疇ではない。ホンサバにも腹部に黒斑又は黒紋があるものがあり、又ゴマサバでも腹部の斑点又は斑程明瞭でない事がある。体形に就いても、ヒラサバ、マルサバともいわれるようにホンサバはやゝ紋が左側扁し、ゴマサバは横断面が円形に近いが、之にも例外が少なくなく、特に済州島方面で漁獲されたものに就いては、体形では全く区別し難いもののある事を見た。

次に背鰭棘の数の相異も従来屢々指摘された所で、之は確かに實際上便利な形質である。即ち背鰭棘数が10個又はそれ以下のゴマサバは先づ無いし、12個又はそれ以上のホンサバは先づ無い。只問題は11個のもので、之では両型を区別出来ない。而かも後方の棘は甚だ低小である事が多く、ホルマリンで固定したものでは屢々甚だ見難い。次に近年になつて言われて来た事であるが、背部担鰭骨(詳しく見ると2列ある)中、その背椎骨の神経棘間にあるもの(之を分類学者は棘間骨又は神経棘間骨といつている)の数はホンサバではゴマサバに於けるよりも概して少いが、此の場合も西日本では区別出来ぬ事があるという。著者はその数のみでなく相隣る2個の神経棘間にある神経棘間骨の数を調べたが、第4脊椎骨と第5脊椎骨の間にある神経棘間骨の数がゴマサバで2個又は3個、ホンサバでは1個であるのが普通である。そうでない場合は神経棘間骨の総数、又は他の列の背鰭担鰭骨(之の名称に就いては混乱があるが、middle segments of the dorsal radialsとするのが妥当と思われる。背部担鰭骨中節と訳す)の数の違い、背鰭棘の数、体側下方の斑紋の様子、其他を総合して査定する事が出来る。

最後にホンサバとゴマサバの区別法を簡単に述べると、先づ①背鰭棘が10個又はそれ以下ならホンサバ、12個又はそれ以上ならゴマサバ、②11個の時は便宜上体の左側の背鰭の前部の根元を切開いて、第4脊椎骨と第5脊椎骨の間にある神経棘間骨が1個ならホンサバ、2個ならゴマサバ、③斑紋や臀鰭の棘や頭骨がゴマサバの特徴を備えていないのに上記の数が2個なら、その時はじめて背部を充分開いて神経棘間骨の総数を調べてホンサバかゴマサバかを定める。之でも決定出来ない場合は極めて稀で、通常の魚体調査に於いては斑紋、体形、臀鰭棘の形と大きさ、及び上記の①位で大抵区別が出来るのである。臀鰭棘は破損している事や再生したと思われる場合が少くないが、概してホンサバでは強大で、ゴマサバでは弱い。

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