Taxonomic studies on the puffers (*Tetraodontidae, Teleostei*) from Japan and adjacent regions-VI. Variation of pectoral fin.

(With some additions to the previous reports of the present series.)

By Tokiharu ABE.- *Continued from p. 206*

β) Among *Sphoeroides* (*Torafugu*) *niphobles* (Table 3): Unlike D, d_2, A_n, $a_{n,2}$, *etc.*, P_{l+r} in the samples from northern Japan (P_{l+r}=28 to 33; modal value 32; mean value 31.02±0.071) is smaller than in those from Okinawa Island (P_{l+r}=30 to 34; modal value 32; mean value 32.55±0.061), the difference being 1.53±0.094. Likewise, P_{l+r} in the samples from southern Japan (P_{l+r}=(27), 28 to 34; modal value 30; mean value 30.89±0.064) is smaller (as in the case of D, and unlike N, A^n, $a_{n,1}$ and A) than in those from Okinawa Island, the difference being 1.66±0.088. But between the samples from northern Japan and those from southern Japan, no pronounced difference in P_{l+r} is seen (like d_1 and $a_{n,1}$, and unlike D, d_2, A_n and $a_{n,2}$). As has been stated in the previous papers (Abe, 1942, p. 481; 1944, p. 205; 1949, pp. 124–125), the local and annual variations of the meristic characters in this littoral and wide-ranging species require further investigation. The classification of the samples adopted, namely, in those from northern Japan, those from southern Japan and those from Okinawa Island, is only arbitrary. γ) Among *Legocephalus lunaris* (Table 4): Unlike N, B, D, d_2, probably Δ, A_n and $a_{n,2}$, P_{l+r} in the samples from Japan (P_{l+r}=30 to 35, modal value 32) seems not larger than in those from Borneo (P_{l+r}=32 to 35, modal value 34).

b. Number of the upper unbranched rays, and relative lengh of the uppermost ray

Unlike the number of the anteriormost unbranched fin-rays of the dorsal (d_1) and anal ($a_{n,1}$), the number of the uppermost unbranched fin-rays of the pectoral in the puffers varies only a little. It is mostly 2, and although in a few cases it is 1 (the 2nd ray from above being branched as the rays below it) and in a few other cases it is 3 (the 3rd ray from above being unbranched as the two rays above it), it seems to give no clues to the understanding of the affinity of the puffers. It is, however, remarkable that in *S. niphobles* the 2nd ray from above is oftener branched, namely, the number of the unbranched rays is oftener 1 (in 7 out of 111 specimens, and in 8 out of 222 fins), in the specimens from northern Japan (mostly from Onahama) than in the specimens of the same species from Okinawa Island (none out of 105 specimens having the 2nd ray branched, namely, the number of the uppermost unbranched rays is not less than 2) and that P_{l+r} is larger in the latter specimens than in the former (Table 3)*.

* The total length of the specimens does not differ materially between those from northern Japan and those from Okinawa I.

Turning to the relative length of the fin-ray on the top of the pectoral, it is instructive to see that, as stated above (p. 201), it is rudimentary and hidden beneath the skin in the examined members of *Lagocephalus* (with the exception of *sceleratus* for which Bleeker already gave the formulae ii/14~ii/16), *Liosaccus* and *Sphoeroides**, while it is distinct (its length being 1/3~1/7 of the length of the 2nd ray counted from above) in *Canthigaster, Chelonodon, Tetraodon* and *Dichotomycter.*

c. Shape of the visible portion of pectoral fin

Even if the change with advancing age will be left aside, the shape of the visible portion of the pectoral fin in the puffers will present some difficulties in the evaluation of its taxonomic importance, because the outline of its posterior end can hardly be expressed. But some differences in the shape and coloration** of the fin, though usually less pronounced than in the dorsal, anal and caudal fins, are discernible in certain cases, and the ratios given below will more or less show the differences. Speaking generally, they are accompanied by the differences in the shape and coloration** of the other fins. A good example of this statement seems to be provided by *Lagocephalus logocephalus oceanicus.* This form is unique in having much produced lower lobe of caudal fin in the adult, and the lower part of the pectoral fin is white in contract to the black upper part of the fin. The pectoral fin in this form is long, and its lower part is much shorter than the upper. The ratio of its height to the length of its base is much larger than in the other puffers (exceeding 2.5) as will be seen later. It is also of interest in this connection that the dorsal and anal fins are almost exclusively falcate or pointed and the caudal fin is forked or more concave in this form and the other members of the genus *Lagocephalus,* and that in the latter the ratio just mentioned tends not to be distinctly greater than in some of the other genera (although distinctly larger than in *Canthigaster, Tetraodon* and *Dichotomycter* in which the dorsal, anal and caudal fins are rounded or truncated).

i. Size of the visible portion of pectoral fin

The relative size of the pectoral fin in the puffers seems to change, on the one hand, with the increase in body size, and more especially in their early developmental stages, and, on the other hand, it varies from genus to

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* In the young of some members of *Sphoeroides*, the uppermost pectoral fin-ray is relatively longer than in the adult and not rudimentary; *e. g.*, in a specimen of 120 mm. total length of *S. stictonotus* (which attains the total length of 415 mm.), the uppermost ray is 1/6 of the next ray (namely, the 2nd from above) in length.

** The coloration will be treated of elsewhere if circumstances will permit.

genus or from subgenus to subgenus or among minor groups*. The former change has not been studied by the present writer, and for the latter also data obtained are insufficient. In the following pages mention will be made only of the ratio of the length of the base of pectoral fin to the total length of body (mostly in the adult) ($L_{b \cdot p}$) and the ratio of the height of pectoral fin to the total length of body (mostly in the adult) (H_p).

In a few forms, such as *Canthigaster margaritatus* ($L_{b \cdot p}$=0.08:1 to 0.09:1; H_p=0.12:1 to 0.13:1), *Sphoeroides* (*Liosarcus*) *chrysops* ($L_{b \cdot p}$=0.08:1; H_p=0.13:1 to 0.14:1) and *Lagocephalus laevigatus inermis* ($L_{b \cdot p}$=0.08:1; H_p=0.13:1) the both ratios are larger than in the majority of the others. In a few other forms, such as *Chelonodon firmamentum* ($L_{b \cdot p}$=0.05:1 to 0.06:1; H_p=0.09:1 to 0.11:1), *Sphoeroides* (*Shosaifugu*) *stictonotus* ($L_{b \cdot p}$=0.06:1; H_p=0.10:1 to 0.11:1) and larger individuals (total length of body 240 to 600 mm.) of *Legocephalus sceleratus* ($L_{b \cdot p}$=0.06:1; H_p=0.10:1), smaller $L_{b \cdot p}$ is coupled with smaller H_p. In the other puffers, speaking generally, larger $L_{b \cdot p}$ is accompanied by smaller H_p in *Dichotomycter, Tetraodon* (excepting for a very large individual of *stellatus* of 545 mm. total length) and *Canthigaster* (excepting for *margaritatus* mentioned above); smaller $L_{b \cdot p}$ is accompanied by larger H_p in *Lagocephalus* (excepting for *inermis* and a very small individual of *sceleratus* of 93.5 mm. total length); and there are many gradations. Further, depending on the relation between $L_{b \cdot p}$ and H_p, the pectoral fin seems elongated, short, *etc.*, but mention will be made of this later.

α) *Length of the base of pectoral fin/total length of body-ratio (mostly in the adult)*: Compared with the *length of the base of dorsal fin/total length of body-ratio (mostly in the adult)* (0.04:1 to 0.13:1), *length of the base of anal fin/total length of body-ratio (mostly in the adult)* (0.03:1 to 0.11:1), and *least height of caudal peduncle/total length of body-ratio (mostly in the adult)* (0.03:1 to 0.14:1), the *length of the base of pectoral fin/total length of body-ratio (mostly in the adult)* (0.04:1 to 0.10:1) is less variable, and this alone can hardly help us in understanding the affinity of the puffers. But the combinations of these four kinds of ratios are of considerable taxonomic importance. In order to make brief the statements which will follow, the ratios will be abbreviated:

Length of the base of dorsal fin/total length of body-ratio $=L_{b \cdot d}$.
〃 anal fin/ 〃 $=L_{b \cdot a}$.
〃 pectoral fin/ 〃 $=L_{b \cdot p}$.

* There may be local variation in the relative size of the pectoral fin in *Sphoeroides pardalis* and some others. But due to the circumstances mentioned in the explanation of Table 1, this variation has not been studied, and the statements regarding the size of the pectoral fin have been based mostly on a few, mostly adult, specimens of each form.

Least height of caudal peduncle/total length of body-ratio $=L_{b\cdot c}$.

First, $L_{b\cdot p}$ is larger than the other three kinds of ratios in *Liosaccus* ($L_{b\cdot p}$ =0.07:1 to 0.08:1), *Sphoeroides maculatus* ($L_{b\cdot p}$=0.07:1), *S. tuberculiferus* ($L_{b\cdot p}$ =0.07:1) and *S. hypselogeneion* ($L_{b\cdot p}$=0.07:1 to 0.08:1). In those puffers, $L_{b\cdot c}$ is larger than $L_{b\cdot d}$ and $L_{b\cdot a}$, and $L_{b\cdot d}$ is larger than $L_{b\cdot a}$. Secondly, $L_{b\cdot c}$ is larger than the other three kinds of ratios in the genus *Canthigaster*, subgenus *Higanfugu*, subgenus *Liosarcus*, *Chelonodon patoca*, genus *Tetraodon* and genus *Dichotomycter*. In these puffers $L_{b\cdot p}$ is either mostly not smaller than $L_{b\cdot d}$ and $L_{b\cdot a}$ (as in *Canthigaster*, *Chelonodon patoca* and *Tetraodon*) or smaller than $L_{b\cdot d}$ and not smaller than $L_{b\cdot a}$ (as in *Higanfugu*, *Liosarcus* and *Dichotomycter*). Thirdly, $L_{b\cdot d}$ is not smaller than the other three kinds of ratios in the genus *Lagocephalus* and subgenera *Takifugu*, *Torafugu* and *Shosaifugu*. In the two latter $L_{b\cdot a}$ is mostly larger than $L_{b\cdot c}$ and $L_{b\cdot p}$, and $L_{b\cdot c}$ is nearly equal to $L_{b\cdot p}$. Among *Lagocephalus*, *oceanicus* alone has the same order of the four kinds of ratios as in the two subgenera just mentioned, whereas in the other three examined members of the genus $L_{b\cdot c}$ is the smallest and $L_{b\cdot a}$ is either smaller (as in *sceleratus* and *inermis*) or not smaller than $L_{b\cdot p}$ (as in *lunaris*). In *sceleratus*, in which the caudal peduncle is depressed and its width is larger than its depth, $L_{b\cdot c}$ is the smallest of all the puffers examined. Fourthly, *Chelonodon firmamentum* is again singular in that the ratios $L_{b\cdot d}$ and $L_{b\cdot a}$ are (unlike those in *Chelonodon patoca* and *Tetraodon*) larger than $L_{b\cdot c}$ and $L_{b\cdot p}$, the last being the smallest (0.05:1 to 0.06:1) of the four kinds of ratios.

β) *Height of pectoral fin/total length of body-ratio (mostly in the adult).* This ratio (H_p) varies within narrower range (0.09:1 to 0.14:1) than does the *height of dorsal fin/total length of body-ratio (mostly in the adult)* (H_d), *height of anal fin/total length of body-ratio (mostly in the adult)* (H_a), and *length of caudal fin/total length of body-ratio (mostly in the adult)* (H_c) which vary within 0.09:1 to 0.18:1, 0.08:1 to 0.18:1 and 0.13:1 to 0.29:1 respectively. The combinations of these ratios and the ratios relevant to the length of the base of the fins mentioned above are of importance for taxonomic purposes. First, in the subgenera *Takifugu*, *Torafugu*, *Shosaifugu*, *Higanfugu* and *Liosarcus* and in the genera *Chelonodon*, *Tetraodon* and *Dichotomycter*, H_p is not larger than H_c, H_d and H_a. Secondly, in *Sphoeroides maculatus* (H_c=0.17:1; H_d=0.13:1; H_p=0.12:1 to 0.13:1; H_a=0.10:1), *S. tuberculiferus* (H_c=0.19:1; H_d=0.13:1; H_p=0.13:1; H_a=0.10:1) and *S. hypselogeneion* (H_c=0.20:1 to 0.21:1; H_d=0.14:1 to 0.15:1; H_p=0.12:1 to 0.13:1; H_a=0.09:1 to 0.11:1) H_p, though much smaller than H_c and not larger than H_d, is larger than H_a. Thirdly, in *Canthigaster*, *Liosaccus* and *Lagocep-*

*halus**, H_p is either much smaller (in the first named) or not larger (in the two latter) than H_c as in the forms mentioned above, but not invariably smaller than H_d or H_a. Fourthly, whereas the length of the base of a fin in the puffers is smaller than its height, and whereas $L_{b\cdot c}$, $L_{b\cdot d}$, $L_{b\cdot a}$ and $L_{b\cdot p}$ are mostly smaller than H_c, H_d, H_a and H_p irrespective of the kind of the fin, $L_{b\cdot c}$ in *Canthigaster* (having the largest caudal fin) exceeds H_p, H_a and sometimes H_d of respective species. In *Tetraodon* (in which the caudal fin is also large), $L_{b\cdot c}$ is mostly not smaller than H_p of respective species. In those members of the large genus *Sphoeroides* in which the dorsal and anal fins are many-rayed**, $L_{b\cdot d}$ (or rarely $L_{b\cdot a}$) sometimes exceeds H_p. Further, some individuals of *S. pardalis* have very short pectoral fin, and their H_p is not larger than $L_{b\cdot c}$ of other individuals of the same species. Fifthly, $L_{b\cdot c}$ in *Sphoeroides* (*Liosarcus*) *chrysops*† and *Chelonodon patoca* is larger than $L_{b\cdot d}$, $L_{b\cdot a}$ and $L_{b\cdot p}$ (as in *Canthigaster, Tetraodon* and *Dichotomycter*), but smaller than H_p. Sixthly, *Chelonodon firmamentum* again differs from *Chelonodon patoca* in that H_p does not far exceed $L_{b\cdot a}$ and $L_{b\cdot d}$ which are larger than $L_{b\cdot c}$ and $L_{b\cdot p}$. In this point *firmamentum* is nearer to the subgenus *Torafugu* than to *Tetraodon* to which it was often referred.

ii. Outline of pectoral fin

Though difficult to express, the outline of the pectoral fin in the puffers more or less differs from genus to genus and between minor divisions. The differences are mainly in the contour of the postero-dorsal or postero-ventral corner of the fin, or, in the relative length of the upper rays to that of the lower ones. The expansibility of the fin seems also to differ, but this is very difficult to see in the specimens preserved in formalin (as is the case with the contour of the postero-ventral corner of the fin). Speaking very roughly, the postero-dorsal corner of the fin is angular or nearly angular in *Canthigaster, Liosaccus*†† and *Lagocephalus*, and in very large individuals of *Sphoeroides* (*Torafugu*) *xanthopterus, S.* (*T.*) *rubripes rubripes, S.* (*T.*) *rubripes chinensis* and *S.* (*T.*) *pseudommus* it approaches this shape.

* In *Lagocephalus sceleratus* H_p changes considerably with the increase in body size. In a very small specimen of 93.5 mm. total length, H_p is 0.13:1 and 0.14:1, and in a very large specimen of 600 mm. total length, H_p is 0.10:1.

** In some of these members, H_c does not exceed H_d or H_a, while H_c is distinctly larger than H_d or H_a in the other members of *Sphoeroides*.

† In this species, H_p (0.13:1 to 0.14:1), H_a and H_d are the largest among those in the other puffers, and H_c is also large as in *Canthigaster, Tetraodon* and *Dichotomycter*

†† In *Liosaccus cutaneus* from Japan and *Sphoeroides pachygaster* (Müller et Troschel) from Barbados and from off Cape Henry (Virginia, U.S.A.) (according to Dr. Reid, 1944), the posterior margin of the pectoral fin is concave in the upper half and convex in the lower half.

The length of the lowermost ray seems to be subject to considerable bilateral variation, but this has not been studied by the present writer partly because of the difficulty in measuring the length. Apart from the bilateral variation, it may be said that the lowermost rays are only a little shorter than the upper rays (excepting for the uppermost one ray) in *Tetraodon* and *Dichotomycter* and that it is much shorter in the other genera. Further, the fin seems short or long depending on the ratio of its height to the length of its base. Some remarkable tendencies regarding this ratio will be mentioned below.

Height of pectoral fin/length of the base of pectoral fin-ratio (mostly in the adult) ($Hp/Lb.p$)*. This ratio is larger in *Lagocephalus* (1.6:1 to 2.9:1), *Sphoeroides maculatus* (1.8:1 to 1.9:1) from Woods Hole, *S. tuberculiferus* (1.8:1 to 1.9:1) from Australia, *S.* (*Takifugu*) *oblongus* (1.7:1 to 1.9:1) from Hong Kong and Borneo, subgenus *Shosaifugu* (1.6:1 to 2.0:1) and subgenus *Liosarcus* (1.6:1 to 1.7:1) than in *Canthigaster* (1.2:1 to 1.5:1), *Tetraodon* (1.0:1 to 1.5:1) and *Dichotomycter* (1.2:1 to 1.4:1). *Liosaccus* (1.5:1 to 1.8:1), *Sphoeroides* (*Shippofugu*) *hypselogeneion* (1.5:1 to 1.8:1), subgenus *Torafugu* (1.3:1 to 1.6:1, excepting for a single specimen of *pseudommus* in which the ratio is 1.8:1 and 1.9:1) and *Chelodon patoca* (1.6:1), and the singular *Chelonodon firmamentum* (1.5:1 to 1.9:1) are intermediate in this character between the two groups mentioned just above.

It might be repeated here in this connection that among *Lagocephalus*, (in which the ratio is the largest of all the genera examined) *oceanicus* has the most elongated pectoral fin, the ratio being 2.6:1 to 2.9:1.

d. Bilateral variation in pectoral fin

The present writer did not pay especial attention to the bilateral variation of the pectoral fin in the puffers prior to 1950. It was only recently that he, stimulated by Drs. C. L. Hubbs and L. C. Hubbs' paper of 1945 (kindly loaned to him by Dr. W. A. Gosline of the University of Hawaii), began to collect data concerning this kind of variation. It is regretted, however, that they have been scanty partly because of the limited time which has been

* Data concerning the change of this ratio with advancing age are scanty, but the following fragmentary statements may be of interest: $H_p/L_{b \cdot p}$ is larger in very small individuals than in very large individuals of *Lagocephalus sceleratus* (2.1:1 to 2.3:1 in a specimen of 93.5 mm. total length and 1.6:1 in a specimen of 600 mm. total length), and, contrary to this tendency, this ratio is smaller in very small individuals than in very large individuals of *Tetraodon hispidus* (1.1:1 in a specimen of 68 mm. total length and 1.3:1 to 1.5:1 in a specimen of 465 mm. total lenght) and *T. stellatus* (1.1:1 in a specimen of 103 mm. total length and 1.5:1 in a specimen of 545 mm. total length).

spared for this study*.

i. Bilateral variation in the total number of pectoral fin-rays

The number of the rays of the pectoral fins (P_l and P_r) in the puffers often differs on the two sides (Table 1). The specimens examined seem to be quite insufficient in number to state for certain how frequently the asymmetry occurs, but the data obtained regarding the following five forms may give readers some idea about the frequency with which this variation in these forms occurs:

	$\frac{L^{**}+R^{**}}{\text{Total number of specimens}}$	$\frac{L}{L+R}$	$\frac{R}{L+R}$
Lagocephalus lunaris	$\frac{12}{80}=0.15$	0.58	0.42
Sphoeroides niphobles	$\frac{98}{368}=0.27$	0.54	0.46
S. vermicularis vermicularis	$\frac{34}{124}=0.28$	0.47	0.53
S. vermicularis porphyreus	$\frac{35}{150}=0.23$	0.51	0.49
S. pardalis	$\frac{74}{306}=0.24$	0.64	0.36

If the specimens of *S. pardalis* are classified into two categories, namely, into the specimens from northern Japan and those from southern Japan (Table 2†), $\frac{L}{L+R}$ becomes much larger than $\frac{R}{L+R}$ in the latter:

Locality	$\frac{L+R}{\text{Total number of specimens}}$	$\frac{L}{L+R}$	$\frac{R}{L+R}$
Northern Japan	$\frac{43}{182}=0.24$	0.56	0.44
Souhtern Japan	$\frac{29}{120}=0.24$	0.72	0.28

Such local variation in the degree of preponderance of P_l over P_r, or that of P_r over P_l, together with the local variation in the frequency with which this kind of asymmetry ($P_l \neq P_r$) occurs, is to be seen among *S. niphobles* (Table 3††) (a'so see below):

* In addition to the bilateral variation which will be touched upon in the following pages, the asymmetry in the size of the pectoral fin and in the relative length of the lowermost pectral fin-ray may be of interest even for taxonomists.

** L indicates the number of the specimens in which $P_l > P_r$. R indicates the number of the specimens in which $P_r > P_l$. (Following Drs. Hubbs and Hubbs, 1945.)

† In Table 1, specimens from unknown localities of Japan are included.

†† In Table 1, specimens from unknown localities of Japan are included.

Locality	$\frac{L+R}{\text{Total number of specimens}}$	$\frac{L}{L+R}$	$\frac{R}{L+R}$
Northern Japan	$\frac{31}{111}=0.28$	0.42	0.58
Southern Japan	$\frac{40}{143}=0.28$	0.48	0.53
Okinawa Island	$\frac{19}{105}=0.18$	0.58	0.42

ii. Bilateral variation in the number of the uppermost unbranched fin-rays of the pectoral

As stated previously, the number of the uppermost unbranched fin-rays is 1 or 3 (or more) in a few cases, the normal number being 2. Data concerning the bilateral variation in this number is especially scanty (Tables 1-4). Here mention will be made only of one case, namely, again of *S. pardalis*. Among the specimens of this species, some of those with P_{l+r} 33 seem to be subject to the bilateral variationin in the number of the uppermost unbranched rays (Table 2). It is 1 exclusively in those specimens in which $P_l > P_r$, and it is smaller (1) exclusively on the right side than on the left (2), namely, the 2nd ray from above is branched exclusively on the right side whereas it is unbranched in the left fin which has more rays than does the right fin.

iii. Bilateral variation in the number of the lowermost unbranched fin-rays of the pectoral

With only the scanty data obtained by the present writer, it seems almost impossible to see whether the number of the lowermost unbranched rays of the pectoral fin in the puffers is correlated with the total number of the pectoral fin-rays, or, with the relative length of the lowermost rays of the

Table 5

Correlation between the bilateral variation of the total number of the pectoral fin-rays and the bilateral variation of the number of the lowermost unbranched rays of the fin in *Sphoeroides pardalis.*

Number of the lowermost unbranched rays \ Pl / Pr	i+14 / i+14	i+15 / i+14	i+15 / i+15	i+16 / i+15	i+15 / i+16	i+16 / i+16	i+17 / i+17
Left 1, Right 1			2	1		4	
Left 1, Right 0			2	1		1	
Left 0, Right 1			1				
Left 0, Right 0	1	1	10	2	1	11	1

fin. It was stated above that the bilateral variation in the number of the uppermost unbranched rays seems to be correlated with that in the total number of the rays of the pectoral fin in *Sphoeroides pardalis*, and this leads the writer to present here the fragmentary results of the counting.

Table 6

Correlation between the bilateral variation of the total number of the pectoral fin-rays and the bilateral variation of the number of the lowermost unbranched rays of the fin in *Sphoeroides cyrysops*.

Number of the lowermost unbranched rays \ Pl / Pr	i+14 / i+14	i+15 / i+14	i+14 / i+15	i+15 / i+15
Left 1, Right 1	2	1	1	
Left 1, Right 0	5	1		
Left 0, Right 1	2			
Left 0, Right 0	6		1	1

In Tables 5 and 6, the specimens examined are mostly the adult, and the counting of the lowermost unbranched rays was made exactly. Furhter, a few specimens of almost each of the other members of the puffers* listed in Table 1 have been examined with special reference to the correlation between the bilateral variation of the total number of the pectoral fin-rays (P) and that of the number of the lowermost unbranched rays of the fin (p). As might be expected**, p seems to be oftener larger on the side on which P is higher than on the other side. But, contrary to expectation†, p of the left side seems not to be oftener smaller than that of the right side (namely, the lowermost ray of the left fin seems not to be oftener branched than in the right fin) in those specimens of *S. pardalis* in which P_l is equal to P_r.

* In four specimens of *Lagocephalus lagocephalus oceanicus*, which has the most elongated pectoral fins among the puffers examined, the lowermost ray was invariable unbranched.

** The present writer is now examining the bilateral variation in the number of the lowermost unbranched rays of pectoral fin in some other fishes, and the general impression he gets from such studies is that the lowermost ray is shorter on the side with more-rayed fin and that the number of the lowermost unbranched rays is higher on this side.

† In *S. pardalis* P_l oftener exceeds P_r than P_r does P_l. If this be interpreted as left-handedness (in the sense that the left fin is more powerful or effective for swimming than the right fin), and if a branched fin-ray be assumed as more effective for swimming than an unbranched fin-ray, one would expect that the lowermost fin-ray of the left pectoral is oftener branched than in the right fin in those specimens of *S. pardalis* in which P_l is equal to P_r.

SUMMARY OF THE STUDIES ON THE VARIATION OF THE VISIBLE PORTION OF PECTORAL FIN

The variation of the following characetrs of the pectoral fin in the puffers from Japan and adjacent regions (and one species from the Atlantic coast of U. S. A. and another from Australia) have been studied from taxonomic standpoint:

a. Sum (P_{l+r}) of the number of the fin-rays of the left pectoral (P_l) and that of the right pectoral (P_r).
b. Number of the upper unbranched rays, and relative length of the uppermost ray.
c. Shape of the visible portion of pectoral fin.
   i. Size of the visible portion of pectoral fin.
   ii. Outline of the pectoral fin.
d. Bilateral variation in pectoral fin.
   i. Bilateral variation in the total number of pectoral fin-rays.
   ii. Bilateral variation in the number of the uppermost unbranched fin-rays of the pectoral.
   iii. Bilateral variation in the number of the lowermost unbranched fin-rays of the pectoral.

Probably correlated with the available space for the base of the fin and its position, (1) the total number of the fin-rays, (2) number of the uppermost unbranched fin-rays and (3) size of the pectoral fin vary within narrower range than in (1) the total number of dorsal and anal fin-rays, (2) number of the anteriormust unbranched fin-rays of the dorsal and anal and (3) size of the dorsal, anal and caudal fins, respectively. With respect to the genera, subgenera or widely separated-species, the total number of the pectoral fin-rays* does not vary together with the total number of vertebrae (N), total number of dorsal fin-rays (D), total number of anal fin-rays (A_n) and total number of caudal fin-rays (C). Among the closely-related species or forms belonging to the subgenus *Shosaifugu*, P_{l+r} does not vary together with D, A_n and the size of the body attained by the adult. Between the samples from colder seas and those of the same species from warmer seas, P_{l+r} is either higher (like N, D, A_n, *etc.*) in the former than in the latter

* In order to facilitate the evaluation of the toxonomic importance of the total number of the pectoral fin-rays, the sum (P_{l+r}) of the number of the fin-rays of the left pectoral (P_l) and that of the fin-rays of the right pectoral (P_r) has been compared (instead of the comparison of P_l or P_r), the bilateral variation in the number of pectoral fin-rays having been dealt with separately.

(as in *Sphoeroides pardalis*), or, (unlike N, D, A_n, *etc.*) not higher in the former samples than in the latter (as in *Lagocephalus lunaris*).

The uppermost unbranched ray (though divided as in the other rays) is rudimentary and hidden beneath the skin in *Liosaccus, Lagocephalus* (excepting for *sceleratus*) and *Sphoeroides*, but it is longer and easily seen without dissecting the skin in the other puffers examined. Usually the 1st and 2nd rays from above are unbranched, but in a few cases the 2nd ray from above is branched, or in a few others, the 1st to 3rd rays from above are unbranched. The variation of the number of the upper unbranched rays gives no clue to the understanding of the affinity of the puffers.

The shape of the pectoral fin, the relative length of its base and its relative height, together with the corresponding characters of the dorsal, anal and caudal fins, reveal the affinity of the puffers fairly well. The inadequacy of referring *Tetraodon firmamentum* TEMMINCK et SCHLEGEL to *Chelonodon* or to *Tetraodon* has become clear, and the distinctions of the subgenera of the large genus *Shoeroides* provisionally adoptea here have become evident. The nomenclatural corrections will be made in future when further specimens and publications will be gathered from abroad.

The study of the bilateral variation in the characters listed above seems to suggest that this kind of study will be profitable for taxonomy and other branches of biology.

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The majority of the publications referred to in the previous papers of the present series and those listed on pp. 200 and 201 of this paper will be omitted.

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ADDITIONS AND CORRECTIONS

P. 199, line 5. For subgenera read subgenera†.
〃 〃 7. For 1938 read 1939.
〃 〃 10. 〃 〃

P. 200. Add the following papers:

BRUUN, F. A. 1941: Observations on North Atlantic fishes. 1. *Acanthocottus lilljeborgi.* Ammodytes lancea group. Vidensk. Medd. fra Dansk naturh. Foren, civ, pp. 323–340, pl. 2.

DANNEVIG, A. 1933: The number of vertebrae in *Gadus virens* L. from the Norwegian Skagerak coast. Journ. Cons. Perm. Intern. l' Explor. Mer, viii, pp. 355–356.

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DANNEVIG, G. 1951: Sprat from Norwegian waters. An analysis of vertebrae counts. Fiskeridirektoratets Skrifter, ser. Havunders. (Rep. on Norwegian Fishery and Marine Investigations), ix, no. 12, 22 pp.

SCHMIDT, J. 1921: John. Schmidt: Race-Undersøgelser, viii, Den numeriske betydning af sammenvoksede hvirvler. Meddelelser fra Carlsberg Laboratoriet udgivne ved Laboratoriets Bestyrelse. Fjortende Bind, nr. 16, 5 pp.

Table 1, top of the 2nd column from the right end. For $P_l + P_r$ read $P_l = P_r$.

P. 202, line 13. For Roman read Arabic.

P. 203, line 13. For members *Shosaifugu* read members of *Shosaifugu.*

P. 205, lower part of Table 3, 4th column from the right end, 3rd row from bottom. For 30.88 read 30.89.