MORPHOLOGICAL STUDIES OF THE SKIPPER, *Cololabis saira* (*BREVOORT*) IN THE NORTHERN WATERS OF JAPAN (1)

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Introduction

The skipper, *Cololabis saira* (*BREVOORT*) is an important species in the fisheries of Japan. The annual commercial yield had been about four million *kan* (1,000 kans=3.75 metric tons) before the end of the recent war, but the catch has been greater since with a yield during 1949 of over thirty million *kan*.

It is believed that this increase was due not to an increase in this species though there may have been some increase, but rather to a more efficient fishing method by the type of lift nets by poles using several superaqueous fish alluring-lights (see the author's prior report[1]), which have been adopted by the fishermen of Sanriku in the north-eastern district of Japan in place of the drift nets type heretofore in use. Furthermore the number of fishermen following this fishing has greatly increased of late years.

At present it is rather feared that the catch may surpass the extent of the skipper resource and a cooperative study on its protection is being carried on by members of the Japanese Fisheries Research Laboratory on a large scale.

Such a study, of course, makes necessary fundamental knowledge of the morphological and physiological characters of the groups of the skipper in various waters. However, little such information has been available hitherto. For instance, whether or not the skipper on each side of the Pacific Ocean and the Japan Sea surrounding the Japan coast are the same in morphological comparisons, and whether the male and female skipper are the same in body characters, may not yet be known with certainty.

This study was initiated in the hope that it would supplement the above large scale study with some fundamental knowledge—especially such as the morphological characters of the skipper of the various fishing grounds in the northern waters of Japan.

Methods of obtaining fish

The skipper used in the following studies were taken from commercial lift nets supported by poles using several superaqueous fish alluring-lights in the fishing grounds off the coast of Kushiro in the northern waters of Japan during the fishing season, August to October, 1950.

The about 250 fish were collected at random by tens or twenties from the lift nets through as many days as a commercial fishing boat, the Ruson-maru of the Japan Fisheries Company went out fishing. They were immediately preserved every time when collected.

One of the fish, as will be shown later, weighed too light in comparison with its body length; and for some of the others, difficulty was encountered by the author in measuring their standard lengths, as every one of them got a crook in its back while in preservation. Excepting these fish, 207 individuals were actually used in this study.

Measurements used

In the present study, the following measurements were taken:

Standard Length — the distance from the tip of the lower snout to the anterior end of the base of the caudal fin measured in centimetres.

Body weight — taken in grams.

Body depth — the maximum diameter of the vertical direction of the body section which passes through the anterior end of the base of the ventral fin.

Body breadth — the maximum diameter of the horizontal direction of the above section.

Head length — the distance from the tip of the upper snout to the anterior end of the base of the pectoral fin.

All these measurements were made in the author's laboratory after the fish had been preserved in formalin. The fish were weighed on a druggists balance. They were then laid on a ruler to determine standard length. The remaining measurements were taken with calipers.

Sex of each fish was determined from observation made on the gonad under a dissecting microscope. Age was assessed by counting the number of "the winter rings" on the scale near the upper part of the pectoral fin as proposed by Miyauti[2] (1937); but this method for the assessment of age was difficult and uncertain. It was unavoidable, therefore, that the age classification of specimens was not made in the present study.

It has been hitherto reported that hardly any significant variation is found between the two measurements taken when the fish is fresh and after preservation, therefore, in the measurements used in this study, no corrections on account of preservation were considered. Detailed studies on such subject are planned for the future by the author.

Morphological characters calculated

Frequently in the morphological studies of fish, males and females are found to differ in body characters. The usual procedure in such studies has been to divide the measurement of a body part by the standard length and compare the resulting quantities for consistent differences. Yasunari[3] (1930) has already reported on the differences between the male and female skipper as found by the same procedure. However, this has certain limitations, since the proportion of certain body parts to standard length varies with size, sex ratios and numbers of specimens.

The following procedure accordingly was adopted in the present work: first, the average

sizes of body measurements at different standard lengths were calculated for each sex (table 1). The intervals taken were centimetre classes. Second, as proposed by Huxley[4] (1932), the logarithms of the former were plotted against the logarithms of the latter in each sex(figure 1).

Table 1. Average sizes of body measurements at different standard lengths of male and female skipper — taken in each centimetre class. Lengths expressed in centimetres, weights in grams.

Standard length	Males					Females				
	Number measured	Body weight	Body depth	Body breadth	Head length	Number measured	Body weight	Body depth	Body breadth	Head length
16.5	0					2	48.6	2.60	1.60	4.90
17.5	0					0				
18.5	12	64.6	2.91	1.77	5.19	4	63.3	2.93	1.78	5.08
19.5	13	80.3	3.21	1.91	5.45	11	76.9	3.15	1.87	5.35
20.5	31	91.4	3.38	2.01	5.66	35	89.9	3.32	2.01	5.63
21.5	24	100.4	3.45	2.09	5.75	37	102.7	3.52	2.14	5.79
22.5	10	113.3	3.62	2.21	5.94	24	110.9	3.56	2.17	5.94
23.5	0					4	127.3	3.83	2.30	6.08

Inspection of figure 1 shows that a single straight line can be fitted to each series of points. The equations of the best straight lines — i.e., lines such that the sum of the squares of the deviations of the various points from each line is the least possible, assuming measurements of the four body parts only are in error — have been calculated as outlined by Sato[5](1947), p.26, and are shown in table 2.

Table 2. Equations of the best straight lines through the points in figure 1.

Part \ Sex	Males	Females
Body weight	$Y = 2.744X - 1.648$	$Y = 2.697X - 1.590$
Body depth	$Y = 1.028X - 0.827$	$Y = 1.002X - 0.795$
Body breadth	$Y = 1.079X - 1.115$	$Y = 1.042X - 1.065$
Head length	$Y = 0.654X - 0.109$	$Y = 0.683X - 0.149$

By applying the antilogarithmic calculations to the formulae given in table 2, the mathematical relationships between the four body parts and the standard length have been obtained as are shown in table 3.

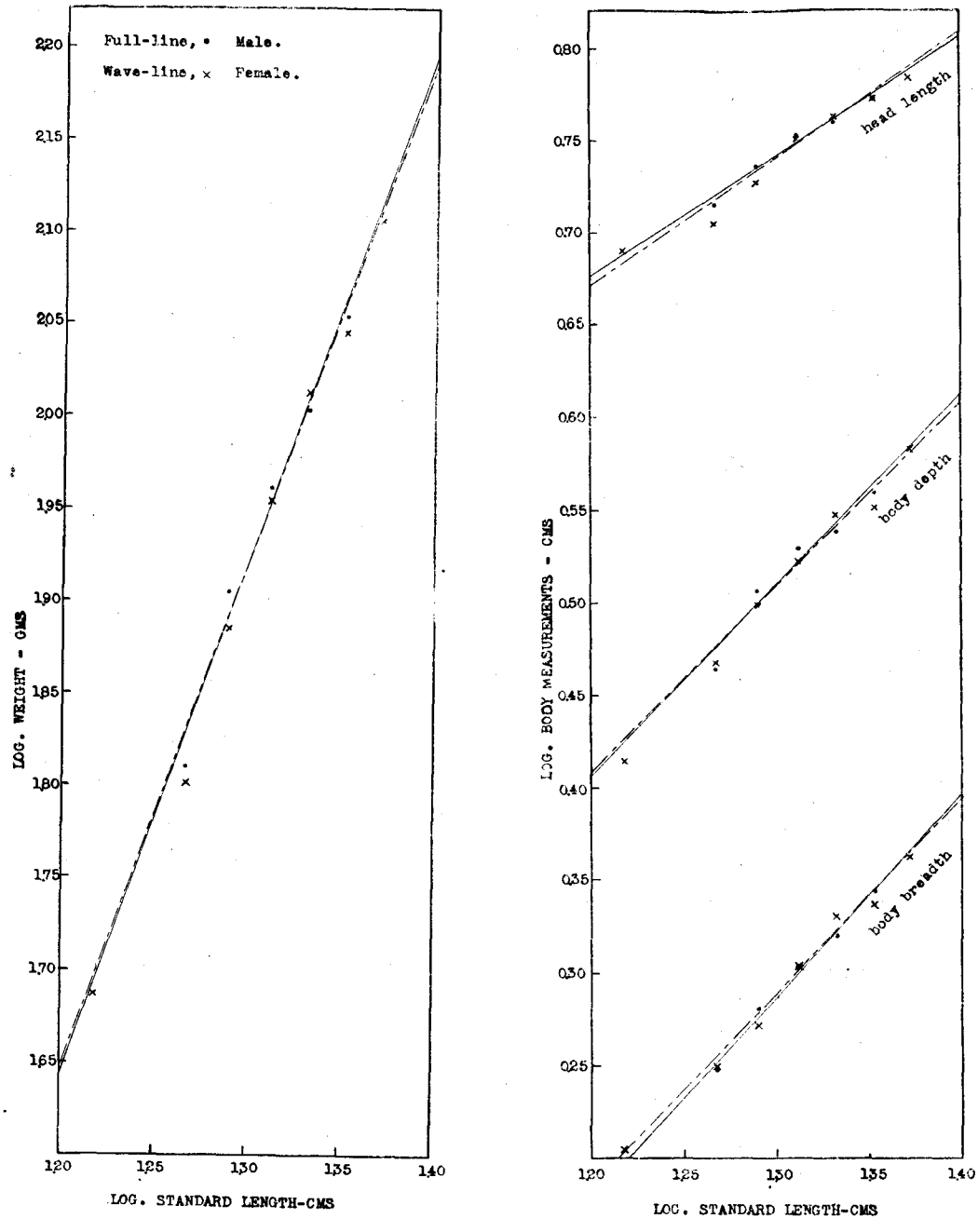

Figure 1. Logarithms of body measurements plotted against logarithms of standard lengths. The lines are fitted from the formulae given in table 2.

Table 3. Mathematical relationships between the four body parts — weight(W), depth(D), breadth(B) and head length(H) — and the standard length(L) for each population of the male and female skipper collected for this study. Lengths are given in centimetres, weights in grams.

Item \ Sex	Males	Females
W and L	$W = 0.0225L^{2.744}$	$W = 0.0258L^{2.697}$
D 〃 〃	$D = 0.149L^{1.028}$	$D = 0.160L^{1.002}$
B 〃 〃	$B = 0.0768L^{1.079}$	$B = 0.0861L^{1.042}$
H 〃 〃	$H = 0.779L^{0.654}$	$H = 0.710L^{0.683}$

A critical test to determine whether the exponents of L in the formulae given in table 3 corresponding to males versus females are significantly different from each other, may be made by "student's t test". Such a test—as outlined by Sato[5], p.429 or Statistical tables 1[6] (1943), p.95 — has been made by the procedure comparing the confidence intervals associated with "true" means of the regression coefficients of the lines shown in figure 1, since the above exponents of L are all the same as the latter, and these confidence intervals at the 99 and 95 percent confidence are shown in table 4. These values were obtained by substituting the actual values on the formula for finding the confidence interval associated with "true" mean of a regression coefficient, such as (3), p.332 in Sato[7] (1950).

Table 4. Confidence intervals at the 99 and 95 percent confidence associated with "true" means of the exponents of L in the formulae representing males and females given in table 3. The calculations are based on the truth that such exponents are the same as the regression coefficients of the lines shown in figure 1.

Confidence	Regression coefficient \ Sex	Males	Females
99%	W to L	2.621 — 2.867	2.613 — 2.782
	D 〃 〃	0.946 — 1.111	0.950 — 1.055
	B 〃 〃	1.046 — 1.113	0.989 — 1.095
	H 〃 〃	0.617 — 0.691	0.654 — 0.713
95%	W 〃 〃	2.651 — 2.837	2.637 — 2.757
	D 〃 〃	0.966 — 1.090	0.963 — 1.042
	B 〃 〃	1.054 — 1.104	1.002 — 1.082
	H 〃 〃	0.626 — 0.682	0.661 — 0.706

A glance at table 4 shows that the confidence intervals corresponding to males versus females have some regions in common with each other at the case of the 95 percent confidence as well as at the 99 percent. It may safely be said that, therefore, there is no

significant difference between the exponents of L in the four body parts — standard length relationships of males and of females.

The exponents of L like the above are considered to indicate the characteristics of populations of fish. On the contrary, the coefficients of L are considered to have slight relation to the very morphological characters, so that the above test has not been applied in them, but it can be seen that these for each of the males and females are not sufficiently different to justify separate consideration. Thus, it may be sure that there is no significant difference between males and females as regards the four body parts — standard length relationships, so that these relationships, of all others, can be represented by the same formulae.

There have been tried again the calculations without distinction of sexes by the same procedure as above; the results are shown in table 5, with the confidence intervals (β) at the 95 percent confidence associated with "true" means of the exponents of L.

Table 5. Mathematical relationships between the four body parts and the standard length for the population of skipper collected for this study (207 specimens), and confidence intervals (β) at the 95 percent confidence associated with "true" means of the exponents of L. Expressed in centimetres, in grams.

Item	Relationship	β
W and L	$W = 0.0253L^{2.704}$	2.659 — 2.749
D 〃 〃	$D = 0.160L^{1.003}$	0.977 — 1.029
B 〃 〃	$B = 0.0807L^{1.063}$	1.037 — 1.089
H 〃 〃	$H = 0.742L^{0.669}$	0.651 — 0.687

As shown in table 5, the weight increases approximately as the 2.704 power of the standard length. This value may be called "the fatness-index of the group" — defined by Kimura[8] (1935) — of the skipper. It should seem that "the fatness-index of the group" for the skipper from the northern waters of Japan has not been found yet in the ichthyological studies hitherto published. Though Fukuhara et al.[9] (1951) have already reported as to the value of such, yet their conception differs from that of Kimura.

Now, as stated above, no significant difference is found between males and females as regards the relative size to the standard length of the four measurements taken, but there may be significant differences between the two as to the other morphological comparisons. This problem the author intends to deal with in the near future.

It should be noticed that one certain fish out of the specimens collected, mentioned above, was not used in the present study. The fish was interpreted as age V male, and had the standard length of 28.2 centimetres with the weight of 61.4 grams. Comparing these values with those in table 1, it is apparent that the fish must be distinguished from the others. It is likewise to be ascertained in future studies whether the said fish belongs to some other population of the skipper than the one of the Pacific extraction, or whether it only has got lean on account of the infirmity of old age.

Summary

Some morphological characters of a population of the skipper, *Cololabis saira* (*BREVOORT*) collected from commercial lift nets by poles using several superaqueous fish alluring-lights off the coast of Kushiro in the northern waters of Japan during the fishing season from August to October of 1950, were investigated. At the same time a comparison was made between males and females over the whole size range to see whether or not the two are the same in body characters.

There was found no significant difference between males and females as regards the relative size to the standard length of any of the four body parts measured — body weight, body depth, body breadth and head length.

In the case of the population of the skipper collected for this study(207 specimens taking both sexes together), the mathematical relationships between each of the four body parts and the standard length could be expressed respectively by the following formulas:

$W = 0.0253L^{2.704}$, $D = 0.160L^{1.003}$, $B = 0.0807L^{1.063}$, and $H = 0.742L^{0.669}$,

where L is standard length, W body weight, D body depth, B body breadth and H head length, and lengths are given in centimetres, weights in grams. Since the exponents of L are considered to indicate the characteristics of this population, the author furthermore made calculation of the errors at the 95 percent confidence associated with "true" means of them respectively as follows:

± 0.045, ± 0.026, ± 0.026 and ± 0.018

The coefficients of L are considered to have little relation to the very morphological characters, so these were not calculated with allowance for errors like the above. Of the above exponents of L, 2.704($\pm$0.045, errors, 95 % confidence) may be called "the fatness-index of the group" of the above population.

The author takes this occasion to say that since both sexes were about equally collected in the above takings, there seems no difference between males and females in the physiological character of being allured by the light.

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