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Comparison of the Gear-Efficiency of Two Types of Trawl Net

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Abstract

To obtain some fundamental suggestions on the gear-efficiency of the two different types of trawl net, the authors carried out the model experiment, and compared them with each other, basing on the physical characters of the net. The one is a six-seam net used on board of the 'Keiten Maru" (854.55 GT) for catching the demersal fishes: and here the otter board was rigged between the hand rope and the warp. The other one is shrimp trawl net used on board of the "Satsunan" (116.57 GT): and the otter board was directly rigged to the wing-tip in a traditional type. The results obtained in this study are summarized as follows.

(1) In ordinary towing condition, the height of the net mouth of the six-seam net and the shrimp trawl net, marked 3.5 m and 1 m, respectively. In six-seam net the height of the net mouth (h) can be expressed in the following formula,

$$h=(0.15-0.053\ V)l$$

where l is maximum breadth of the net mouth without shrinkage in (m), and V is towing speed in (m/sec) when the distance between both wing-tips is about 30 m. In shrimp trawl net, the maximum height of the net mouth is limited by the otter board height.

(2) The bag net and net shape of the six-seam net look like cigar-shaped and in shrimp trawl net it is conical shaped but short. These are concerned with the planning of the net design.

(3) The net resistance of six-seam net is larger than that of shrimp trawl net. At ordinary towing condition the net resistance of six-seam net, marked in 3.1～7.0 ton. In shrimp trawl net it marked about 105～275 kg. This difference of the net resistance depends on the scale of each net.

Considering from the net shape and other characteristics of net, the six-seam net with V–D type otter board seems to be suitable for catching the demersal fishes, and the shrimp trawl net with one directly rigged to the wing-tip seems to be suitable for shrimps.

Introduction

In otter trawl fishing, there are two types of method to attach the otter-board between the net and the ship. The one is of the traditional type, whose otter board is directly rigged to the wing tip. The other is of the Vigneron Dalh type, whose otter board is rigged between the hand-rope and the warp. The traditional type is usually used in small scale trawler, and recently it is widely used in shrimps trawler. The Vigneron Dalh type is usually used to catch demersal fishes.

The rigging position of the otter-board and the shape of it vary from net to net, affecting the fishing efficiency and the gear efficiency of the net. And nowadays,

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the rigging position of the otter-board and the shape of it are decided according to the fish species caught and the scale of the net used.

In this paper the authors carried out model net experiments and compared the gear efficiency of the net between two kinds of otter trawl net, i.e. trawl net with Vigneron Dalh type otter board and that with otter-board attached at the wing tip.

The data obtained here are supposed to give us some fundamental informations about the planning of the trawl nets.

Materials and Methods

The trawl nets used in this experiment are shown in Fig. (1) and Fig. (2). The one is V. D. typed six-seam net, used on board of the "Keiten-Maru"*, the other

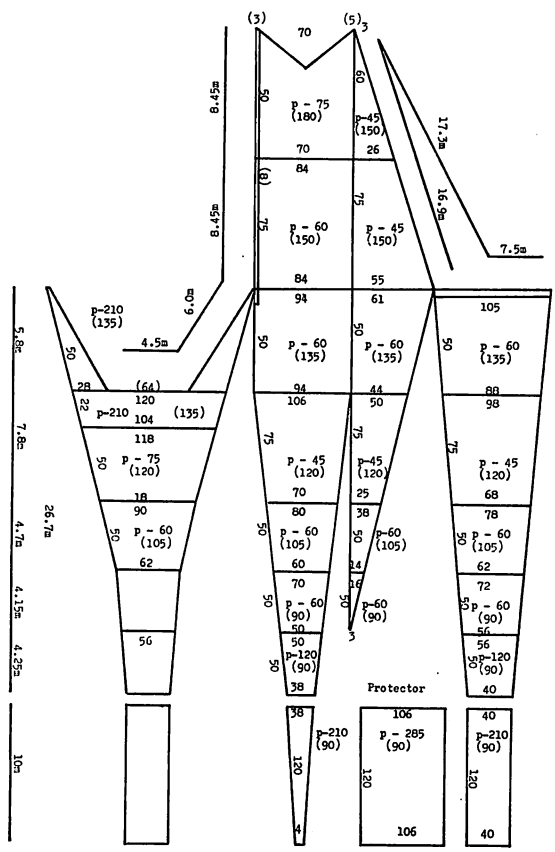

Fig. 1. Net plan of the six-seam net used in the experiment. Numbers in the figure show the mesh number, bracked numbers showing the mesh size (mm).

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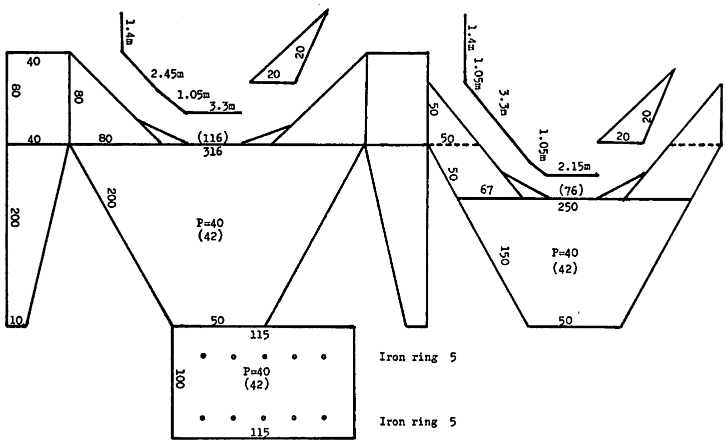

Fig. 2. Net plan of the shrimp trawl net used in the experiment. Numbers in the figure show the mesh number, bracked numbers showing the mesh size (mm).

Table 1. Summary of two experimental gears.

	Six-seam trawl net	Shrimp trawl net
Head rope length (m)	42.1	10.30
Ground rope length (m)	50.3	12.95
Float total buoyancy (kg)	350	5.88
Ground rope weight in water (kg)	400	8.6
Diameter of warp (mm)	22	18
Otter board area (m^2)	3.0×1.8	0.90×1.95

traditional typed, shrimp trawl net used on board of the "Satsunan"**.

Summary of the specification of these gears was shown in Table 1. Out of both kinds of nets, the experimental model nets were made up, basing on Dr. TAUCHI's comparative methods[1]).

The ratio between the full scale and the model scale of the two experimental nets was ascertained to be as in the following, as shown in Table 2.

(1) Reducing scale ratio λ'/λ''

(2) Ratio of twine-diameter, and that of mesh-size
$D'/D''=L'/L''=K$

(3) Ratio of velocity $V'/V''=\sqrt{D'/D''\cdot(\rho'-1)/(\rho''-1)}$

(4) Ratio of the diameter of rope
$D_1'/D_1''=\sqrt{\lambda'/\lambda''\cdot(\rho_1''-1)/(\rho_1'-1)\cdot V'^2/V''^2}$

(5) Ratio of buoyancy and that of sinker and that of the force acting on net
$F'/F''=R'/R''=(\lambda'^2/\lambda''^2)\cdot(V'^2/V''^2)$

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Table 2. The ratio between the full scale and model seale of the two experimental nets, (′) model (′′) full scale.

Ratio	Six-seam net	Shrimp trawl net
(1) λ'/λ''	1/50	1/10
(2) $D'/D''=L'/L''$	0.177	0.271
(3) V'/V''	0.420	0.521
(4) D_1'/D_1''	0.193	0.713
(5) $F'/F''=R'/R''$	0.7×10^{-4}	2.71×10^{-3}

According to the field data obtained on board of the "Keiten Maru", the interval of both wing tips fixed to be generally within the range of 50～60% of the head rope-length. In model experiment, it was fixed to be in three different intervals; 45%, 55% and 65% of the head-rope-length. The interval of six-seam net was also calculated, using Koyama's formula[2].

$$W=\frac{2I_wL_n}{L_h+I_n}\sin\frac{\theta}{2}+\frac{F\,L_n}{L_h+L_n}$$

where

W=Distance between both wing-tips
L_w=Length of the warp (m)
L_h=Length of pendant rope (m)
L_n=Length of the net measured between the wing-tips and the cod head (m)
θ =Angles subtended of a pair of warps (degree)
F =Distance between two top rollers (m)

In the recent shrimp trawl net, the intervals of both wing tips were fixed to lie in the range of 65～75% of the head-rope-length. And so, in the model experiment the intervals of both wing-tips were fixed to be 60%, 70% and 80% of the head-rope-length.

Comparing the length of six-seam net with that of the shrimp trawl net, the authors obtained the ratio between the two as in the following.

The ratio of the total length of the net

$=\frac{\text{Six-seam net}}{\text{Shrimp trawl net}}$ $\frac{53.6\text{ m}}{12.8\text{ m}}=4.2$

The ratio of the head-rope-length $\frac{38.3\text{ m}}{10.3\text{ m}}=3.7$

The ratio of length of the ground rope $\frac{42.1\text{ m}}{12.95\text{ m}}=3.3$

The ratio of maximum breadth of net-mouth $\frac{46.7\text{ m}}{29.4\text{ m}}=1.6$

The ratio of buoyancy of the net $\frac{350\text{ kg}}{5.8\text{ kg}}=59.5$

The ratio of sinker of the net $\frac{400\text{ kg}}{8.6\text{ kg}}=46.5$

Here it may be noted that among the values mentioned above, the value of the maximum breadth of the net-mouth is rather small. This shows that the ratio of the net-mouth breadth, and that of the net-mouth height, to the total-length of bag net is high, respectively.

The above model experiment were carried out in the experimental circular tank of Kagoshima University. The net resistance, the height of the net-mouth and each part of the net, were measured directly by spring balance and meter scale, as shown by Higo[3].

Results and Discussion

(A) Height of the net-mouth

The relationships between the height of the net-mouth and the towing speed are shown in Fig. (3, 4). The height of the mouth h(m), which is one of the most im-

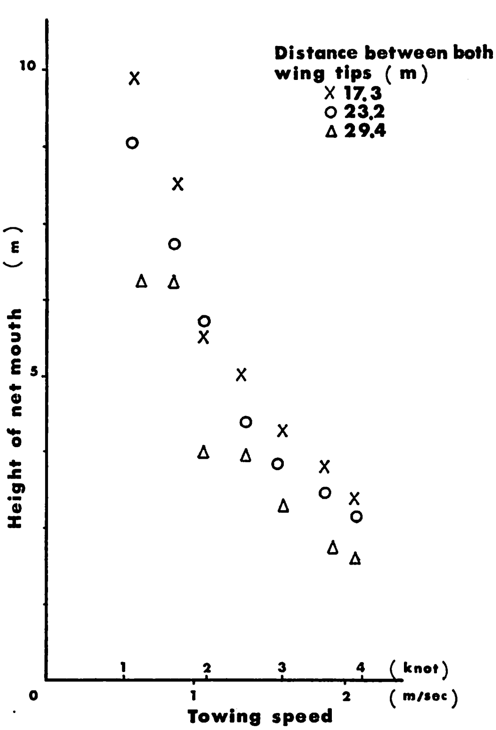

Fig. 3. Relationship between the height of the net-mouth and towing speed of six-seam net.

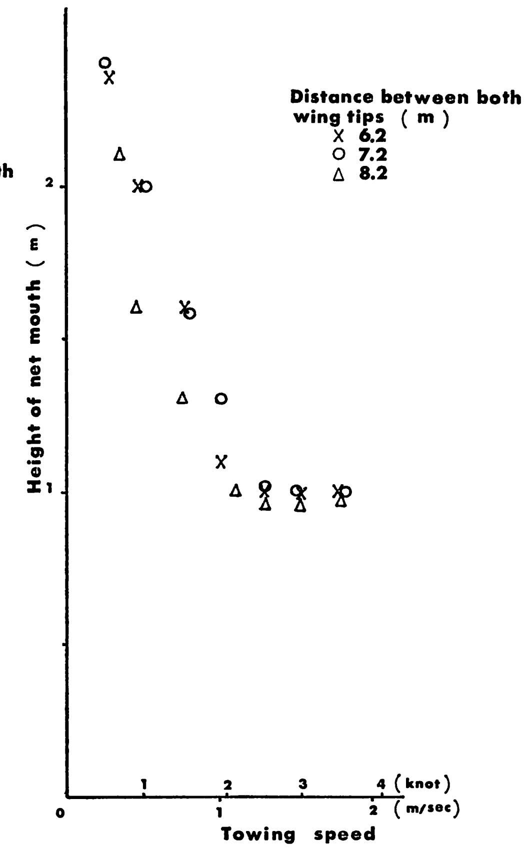

Fig. 4. Relationship between height of the net-mouth and towing speed of shrimp trawl net.

portant indicators in comparing the gear efficiency, becomes lower when the towing speed is increased[3,4,5]. This tendency can be seen remarkably in the six-seam net Fig. (3). When the distance between both wing-tips is 30 m and the towing speed was higher than 2.5 knot, the height of the net mouth of the six-seam net was estimated from the formula

$$h=(0.15-0.053v)l$$

where l is maximum breadth of net body without shrinkage (m), and v is towing speed (m/sec). And this formula shows high reducing rate of the net-mouth height at the high towing speed (higher than 3 knot).

In Fig. 3, the symbol cross (×), the circle (○) and the triangle (△) show the experimental results in the respectively distance between both wing-tips (D), and these fit well to the field data (Fig. 4).

In the shrimp trawl net, the height of the net-mouth becomes lower sharply at the towing speed 0.5∼2 knot, and it becomes steady around at 1 m height. The lowest height of the net-mouth was to be limited by the height of the otter board, (0.9 m in height), even when the net was towed at high speed. This was the most remarkable character of the shrimp trawl net compared with the otter board rigged directly to the wing tip. In the shrimp trawl net used here, the critical speed was about 2 knot.

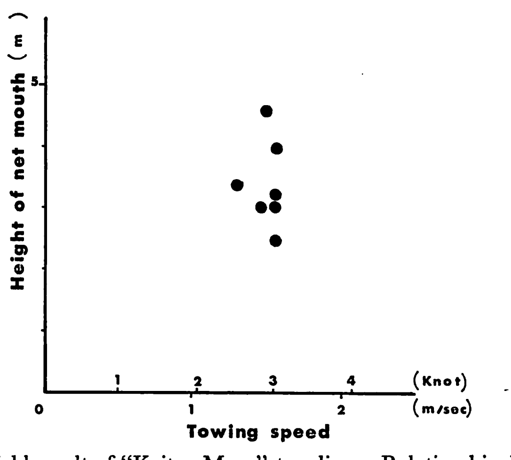

Fig. 5. Field result of "Keiten-Maru" trawling. Relationship between the height of the net-mouth and the towing speed.

(B) Net resistance

The relationships between the net resistance and the towing speed are shown in Fig. (6, 7). When the towing speed increased the net resistance increased too. The resistance of the six-seam net was higher than that of the shrimp trawl net in proportion to the scale of the net.

The relationship between the net resistance and the towing speed was explained by the formula[3),4),6)].

$$R=kV^{n},$$

where k and n are constant, R is resistance and V is towing speed, i.e.

six-seam net, $D=23.2$ m, $R=2005V^{1.76}$

shrimp trawl net, $D=6.2$ m, $R=125.3V^{1.70}$

The values of k and n are shown in Table 3, 4.

Table 3. Values of the K and n in the equation about the resistance of the six-seam net to the running water.

Item \ Distance*	17.3 m	23.2 m	29.4 m
K	2034	2005	2092
n	1.90	1.76	1.46

* Distance between both wing tips.

Table 4. Values of the K and n in the equation about the resistance of the shrimp trawl net to the running water.

Item \ Distance*	6.2 m	7.2 m	8.2 m
K	125.3	111.4	110.5
n	1.70	1.74	1.70

* Distance between both wing tips.

It is well known that the net resistance varies depending on the ratio of the projective area of net-mouth providing that the distance between both wing tips and the towing speed are constant. The net resistance is proportional to the projective area of the net-mouth which is also proportional to the net-mouth without shrinkage, (resistance of six-seam net)/(resistance of shrimp trawl net)=(maximum breadth of the net-mouth of the six-seam net)/(maximum breadth of net-mouth of shrimp trawl net)=29.4 m/46.7 m=0.68. On the other hand the ratio of the resistance of six-seam net to that shrimp trawl net obtained here, experimentally is 0.05 to 0.06. The difference between two values is to be derived from the length of the net. Strictly speaking, the value of the total resistance of a net is a function of projective area of the net-mouth and the frictional resistance of whole parts of the net related to the net length. The changes of frictional resistance related to the net length may affect the total net resistance, and this may be the reason why the value of n in the formula $R=kV^{n}$ is less than 2.

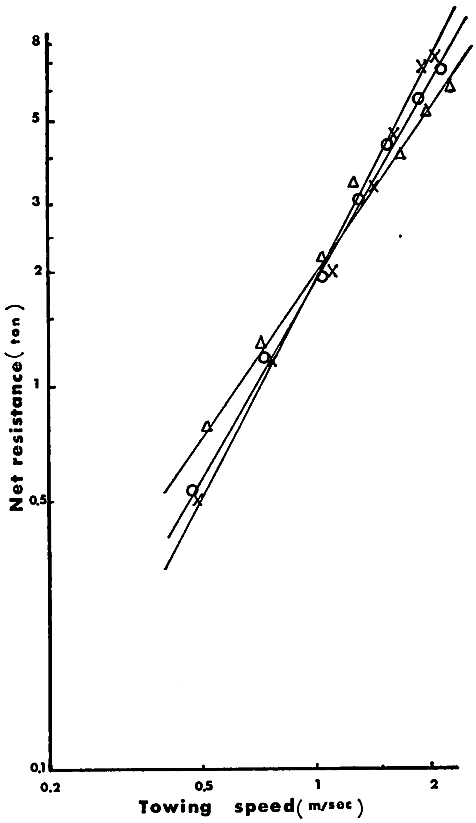

Fig. 6. Relationship between the resistance and the towing speed of six-seam net. Symbols are equal to Fig. 3.

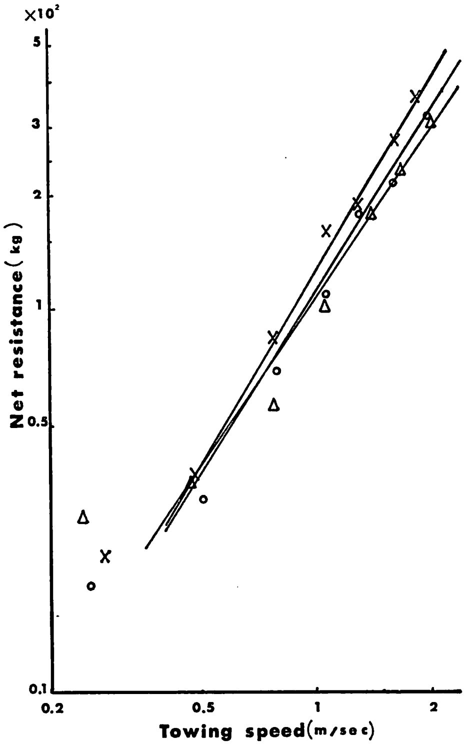

Fig. 7. Relationship between the resistance and the towing speed of shrimp trawl net. Symbols are equal to Fig. 4.

(C) Net shape

In the six-seam net comparing the net shape near the net-mouth between the two nets by h'/h shown in Fig. (8), the authors obtained the value 0.6 at 0.5 knot. When the towing speed increased the value became larger, and the value was 1.2～1.0 at about 4 knot.

The height of the net-mouth was lowered by the large tension of the head rope and so the end of square part was lifted up. This tendency in shrimp trawl net differed from that in six-seam net, where the value of h'/h was about 0.4 at 0.5 knot. It reached the maximum 0.9 at about 2.0 knot and decreased at the towing speed higher than 2.0 knot. The net shape of the net-mouth of the six-seam net was traiangular and the dorsal line of the bating showed sharp angel against the current (Fig. 9).

Only from the experimental results got here it is not possible to affirm that the net shape of the six-seam net is suitable for the entering of demersal fishes and that of shrimp trawl net is suitable for the entering of shrimp. But relying on experiences

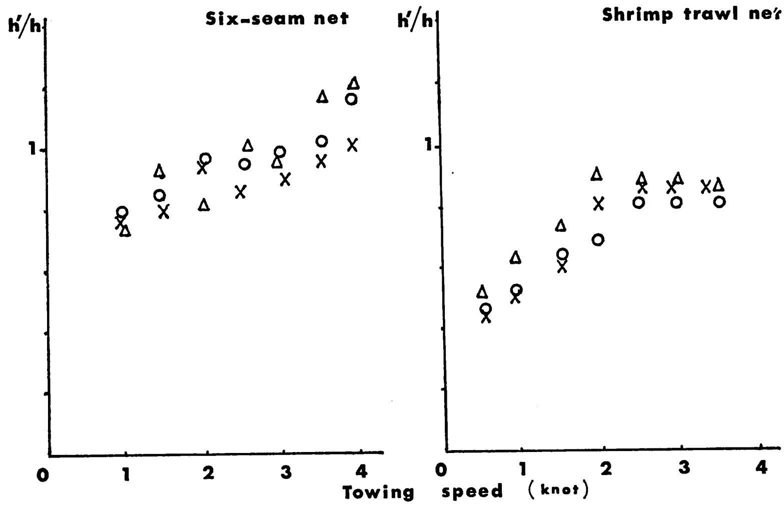

Fig. 8. Comparative figure about the value of h'/h and towing speed of the two types of net.

in the field it may be possible to say that both net shapes are reasonably used in practical point of view. And the shapes of the net from net-mouth to the cod-end are shown in Fig. (9). The shape is cigar shape in six-seam net and it is cone-shaped in shrimp trawl net.

It can be estimated that the shape of the net and its opening have great effects on the entering of fishes and shrimps. From the Fig. (9), it was cleared that in ordinary towing condition, the height of the net-mouth of six-seam net was about 3.5 m and that of shrimp trawl net was about 1 m.

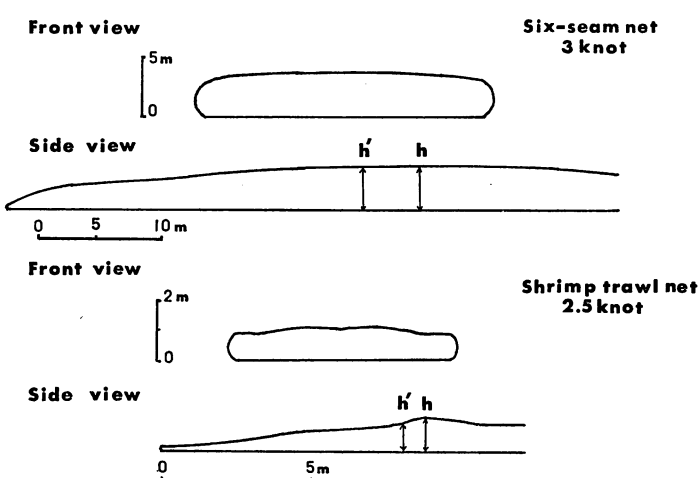

Fig. 9. Comparative figure about the net shape, front view and side view of it at ordinary towing speed.

Each trawl net has characteristic gear efficiency which is decided for the net design and the otter board attach. And the gear efficiency and the fishing efficiency are not subjected to the behaviour of fishes. In the six-seam net, fishes must be prevented from escaping out of the net-mouth, and must be lied smoothly to the cod-end. In the shrimp trawl net, only the jumping of the sluggish shrimps out of the net must be controlled.

Accordingly the cigar shaped six-seam net supposed to be fit for catching the demersal fishes, and the short cone-shaped shrimp trawl net is supposed to be effective for catching the shrimps.

Those results mentioned above, were estimated from the experimental informations obtained in this study, but those two nets were not designed depending on the precise informations on the responsive to the gears.

Further study is to be carried out in consideration of the view points clarified in these experiments by the authors.

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References

1. TAUCHI. M. (1934): *Bull. Jap. Soc. Sci., Fish.*, **3** (1), 1–4.
2. KOYAMA, T. (1965): *Bull. Tokai Reg. Fish. Res., Lab.*, **43**, 14–71. (in Japanese).
3. HIGO, N (1971): *This Mem.*, **20** (2), 1–137, (in Japanese).
4. HONDA, K. (1958): *Bull. Jap. Soc. Sci. Fish.*, **23** (10), 608–611, (in Japanese).
5. TAKAYAMA, S., T. KOYAMA, H. TAKETOMI. (1959): *Bull. Tokai Reg. Fish. Res. Lab.*, **24**, 7–19 (in Japanese).
6. KOYAMA, T., M. IWAI, T. YOKOCHI, O. MAEKAWA. (1968): *Ibid.*, **38**, 125–143, (in Japanese).