Title	PRELIMINARY NOTE ON THE SO-CALLED "LOUSE-BIT" SAURY IN THE JAPAN SEA
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PRELIMINARY NOTE ON THE SO-CALLED "LOUSE-BIT" SAURY IN THE JAPAN SEA[1)]

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With 3 Text-figures and Plate XVII

Sometimes certain numbers of the saury, *Cololabis saira* (BREVOORT), are found bearing one or more small, round scars on their belly. This fact has long been noted by Japanese fishermen, and such injured individuals are generally called "louse-bit saury" or "mushi-kui samma" in Japanese, as the scars are made by the fish-louse, *Caligus macarovi* GUSSEV, 1951 (=*C. fluvipurpureus* SHIINO, 1954), of the Copepoda Caligoida. This little ectoparasite attacks the dermis and mucosa of the host, scrapes them off and ultimately buries its forebody beneath the skin; and when it changes the position on the same host or abandons the host, a round scar is left to show the site of parasitism. The fish may sometimes be so heavily infested by the parasite as to have numerous scars on the body surface; such a blemished appearance lowers the commercial value of the saury very much and is so hated by fishermen. In autumns of 1960 and 1961, such blemished fish appeared in the commercial catch yielded in the Japanese biggest saury fishing ground in the western North Pacific on an unexpectedly large scale. This outbreak attracted public attentions and induced epidemiological researches made by the staff members of the Tohoku Regional Fisheries Research Laboratory in Shiogama near Sendai, one of the main landing places of the Pacific saury (HOTTA 1962).

The "louse-bit" saury is known by fishermen of the Japan Sea, too, particularly in the region of Sado Island where the saury catch of a considerable scale is made during the northward migrating period of the fish in early summer by a very primitive but most interesting fishing method. This fishery, called "tezukami-gyogyô" in Japanese meaning a hand-grabbing fishery, is operated on board a small boat accompanied with a straw- or bamboo-mat being drifted along her side. The mat has small holes so that the fisherman may immerse his hands into water through them, and often clusters of sea-weeds are attached to the underside of the mat. While the boat and mat are drifting

1) Contributions from the Seto Marine Biological Laboratory, No. 426.

still in this way, the saury shoals may gather beneath the mat to deposit adhesive eggs to the mat, hanging sea-weeds or even to fisherman's fingers submerged in water, and it is at this moment that the saury fish are grabbed skillfully by hand*. Fig. 1 on Plate XVII shows a saury grabbed in this manner and just brought out of the water. This picture tells us how the fish is caught by fingers and at the same time it is particularly interesting in relation to our present concern because the caught fish is a "louse-bit" one, showing clearly several scars on its belly.

In the early summer of 1962, a small preliminary survey was made on the "louse-bit" saury in the northward migrating shoals in the Japan Sea to learn if any variations are to be found in the rate of occurrence according to seasons and areas, in the situation of parasitism on the body surface of the host, in the attaching posture of the parasite, etc. And it was expected that the results obtained would be interesting when they were compared with the results of observations made in the Pacific region during the southward migration phase of the same fish.

This study was done while I was a research member at the Japan Sea Regional Fisheries Research Laboratory in Niigata; I am grateful to Messrs. Hiroshi FUKATAKI and Kôsuke NAGANUMA of that laboratory for their kindness in offering me opportunities to examine the saury samples and the pertinent data. Also I want to express my hearty thanks to Prof. Huzio UTINOMI and Dr. Takasi TOKIOKA of the Seto Marine Biological Laboratory for their kind reading and criticism of the manuscript.

Material and Methods

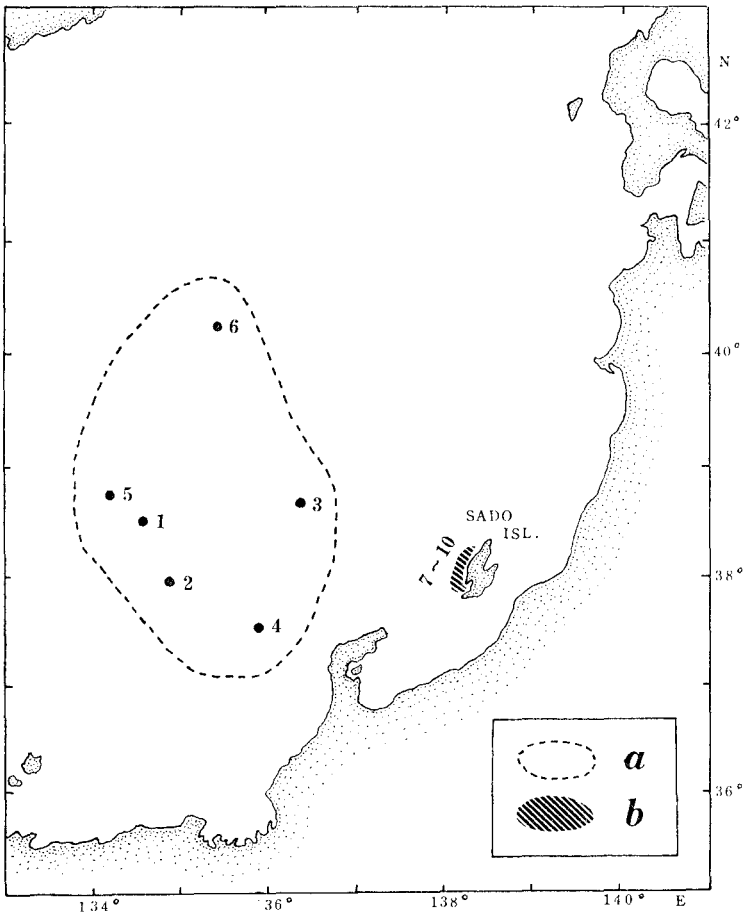
Samples of the saury for examination were collected from two areas, one in the offshore waters near the central part (*a* in Text-fig. 1) of the Japan Sea and the other in the coastal waters along the western shore of Sado Island (*b*). The samples of the former were picked up from the catch by surface drift gill-nets operated by research vessels of some prefectural fisheries experimental stations, while those of the latter came from the local commercial catch by hand-grabbing fishery. Samples were wholy composed of sexually matured adult fish ranging from 251 to 333 mm in body length**. The fish were mostly preserved in formalin immediately after they had been fished, and examinations for the louse-scars or ectoparasites themselves were made later

* For more detailed information on the hand-grabbing fishery of saury at Sado Island, see IWASAWA (1962) and KARUBE (1963).

** The body length was measured from the tip of the lower jaw to the posterior end of the lateral musculature after the standard method shown in the saury resource investigation program in Japan.

in the laboratory. Some samples were, however, instead of being immersed in formalin, chilled by ice to be quickly carried to the laboratory.

In the laboratory, the number of fish bearing the parasites or louse-bit scars were counted, and the infested site and the posture of attaching parasites were recorded. However, the level of infestation or the number of parasites and scars appearing on a single host fish could not be studied, as the *Caligus* appeared to be easily dropped or freely detached from the host surface so



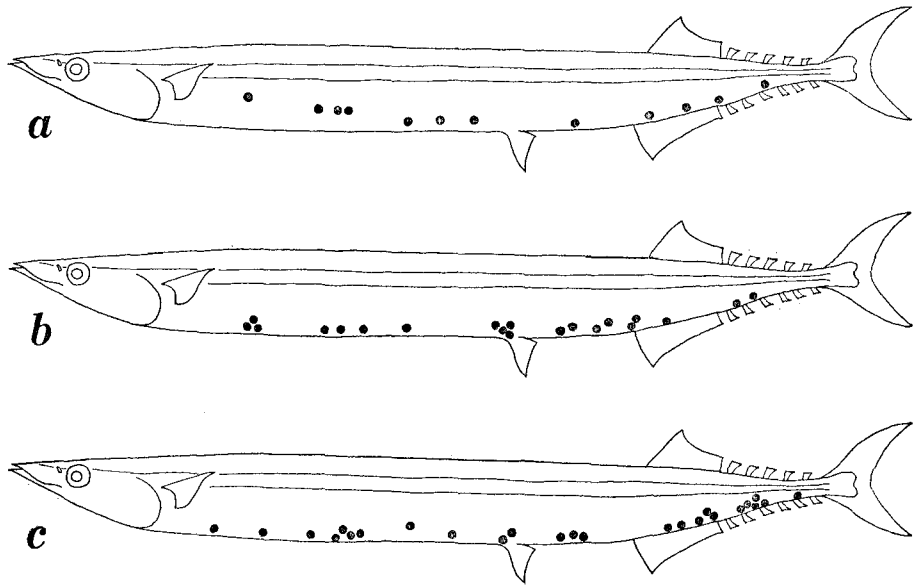
Text-fig. 1. Sampling areas in the Japan Sea. ***a.***—Offshore area near the center of the sea; ***b.***—Coastal area near Sado Island. The numerals indicate each the location of respective stations of sampling; for exact geographical situation see Table 1.

that in the majority of infested fish only scars were observed but copepods were found attaching to the body surface only very rarely. It is not clear at present whether the detachment of parasites is caused by the disturbance

during preservation and transportation or during the violent struggles of the fish when they are captured, or else the scantiness of the parasite on examined samples represents actually the real relation between the saury and parasite populations in the natural environment.

Results

The rate of occurrence of the infested individuals in fish samples from various localities and of different dates is shown in Table 1. Of 386 fish examined, 32 were positive, the mean infestation rate being 8.3%. From these infested individuals 8 specimens of *Caligus macarovi* were collected, a single specimen from the offshore samples and 7 from the coastal samples. The collected copepods were all female and mostly gravid; and their body color



Text-fig. 2. Distribution of the scars made by the parasite and the sites of infestation on the body of the host. ***a***.—The distribution of the scars and infested sites in nine specimens of the infested saury taken from the offshore area in the Japan Sea in May-July, 1962; ***b***.—The distribution of the scars and infested sites in 18 infested fish taken from the coastal area near Sado on June 17 and July 1, 1962; ***c***.—The distribution of the scars and infested sites in ten of the 58 infested fish taken from the Pacific area in the autumn of 1962.

indicated a conspicuous variation ranging from yellowish or dark brown to purplish brown.

The site of infestation on the body surface of the host is diagrammatically shown in Text-figs, 2***a*** and ***b***; and these clearly indicate that *Caligus macarovi*

Table 1. Occurrence of the saury infested by *Caligus macarovi* in different areas and seasons in the Japan Sea, 1962.

Area	Sample No.	Date	Locality	Number & size range* of fish examined	Number of infested fish†	Rate of infestation as percent	Surface water temperature	Collector
Offshore	1	May 3, '62	38°30′N 134°32′E	34 ; 282–319 mm	0	0	13.9°C	R. V. Fukui Maru
	2	May 24, '62	37°58′N 134°50′E	31 ; 298–331 mm	1	3.2	15.4°C	"
	3	May 25, '62	38°42′N 136°22′E	30 ; 294–330 mm	2	6.7	15.6°C	"
	4	May 26, '62	37°26′N 135°56′E	30 ; 292–333 mm	2	6.7	18.2°C	"
	5	May 27, '62	38°44′N 134°09′E	30 ; 293–327 mm	2	6.7	14.6°C	R. V. Heian Maru
	6	July 4, '62	40°12′N 135°25′E	41 ; 251–332 mm	2	4.9	19.5°C	R. V. Koshiji Maru
Sado Isl.	7	June 7, '62	37°57′N 138°13′E	67 ; 293–328 mm	4	5.9	ca. 18°C	Commercial fishery
	8	June 17, '62	38°07′N 138°15′E	30 ; 293–323 mm	5	17	19.4°C	H. FUKATAKI
	9	June 21, '62	38°06′N 138°13′E	36 ; 283–332 mm	1	2.8	?	"
	10	July 1, '62	37°57′N 138°13′E	56 ; 299–328 mm	13	23	ca. 21°C	K. NAGANUMA

* Measured from the tip of the lower jaw to the posterior end of lateral musculature.
† Individuals bearing scars made by the parasite or parasites themselves.

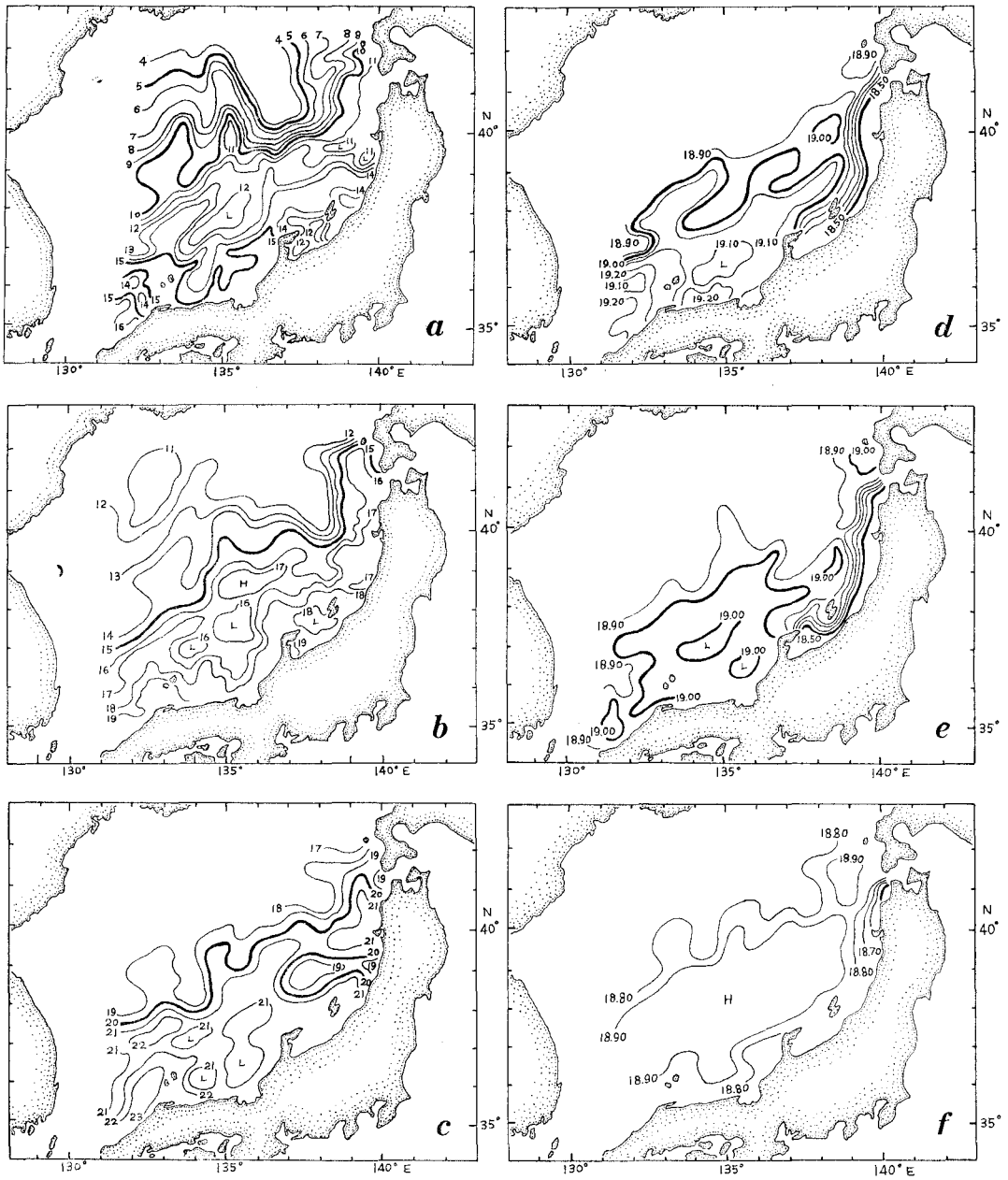
infests the fish mainly on the ventral third of the lateral side of the trunk and tail.

The scars are generally of an ellipsoidal form, with a longer diameter 5 mm or less, mostly 4 to 5 mm. In the majority of cases, the longer diameter of scars is not parallel to the longitudinal axis of the host but keeping a slight inclination. Furthermore, it is found that the scars are distinctly bordered antero-dorsally but rather vaguely postero-ventrally; the skin of the host is more or less deeply scraped off at the anterior portion of the scar, frequently the underlying muscle being exposed, whilst it is only superficially damaged or already partially healed, as is suspected, near the posterior border. This suggests that the scars are caused by the parasite penetrating into and burying itself under the host skin from the postero-ventral direction. Such an attaching posture can be actually verified by observations on the parasites still clinging to the surface of the preserved fish: most of the copepods found clinging to the fish keep the cephalothorax antero-dorsad, often covered by the host integument and only the genital and abdominal segments and the egg strings being exposed (Figs. 2 and 3, Plate XVII).

Discussion

Although there is found a considerable fluctuation in the rate of *Caligus*-infestation on saury according to areas and seasons, it can be noticed that the rate may be higher in the coastal than in the offshore area and moreover that the rate may become higher with progress of season. On such possible tendencies, we may readily reach a supposition that the rate of infestation is correlated with the water temperature or the lapse of time, or with both of them. To begin with, we shall scrutinize the possible correlation with the water temperature.

In Text-fig. 3 are shown the sequences of the surface water temperature and chlorinity in the Japan Sea during the period when the samplings were made. It is obvious that the temperature is significantly higher in the coastal area than in the offshore and again so in the later season than in the earlier. A positive correlation may thus be estimated between the infestation rate and the water temperature at the surface layer which is the habitat of saury fish. This may also be corroborated to some extent by comparing the infestation rate and the actual surface temperature at respective sampling localities given in Table 1, although the latter may only indicate instantaneous value in sequence of the water temperature variation. Such a correlation is found to agree with what HOTTA (1962) mentioned about the occurrences of the Pacific "louse-bit" saury. Differences found in the chlorinity distribution and its sequence, on the other hand, are insignificant throughout the areas and periods of sampling, so that any definite correlation seems impossible between the chlorinity pattern



Text-fig. 3. Distributions and variations of the surface water temperature and chlorinity in the Japan Sea during the period from May to July, 1962. ***a.***—Surface water temperature in early May, 1962; ***b.***—The same in early June, 1962; ***c.***—The same in early July, 1962; ***d.***—Surface chlorinity in early May, 1962; ***e.***—The same in early June, 1962; ***f.***—The same in early July, 1962.

and the rate of infestation. That infestation is of higher rate in the water of higher temperature is compatible with our present knowledge; but it remains unclarified whether this is due to the denser population of the parasite achieved by accelerated ontogeny in the water mass of higher temperature within the limits for the host and parasite, or due to the enhanced activity of the parasite with increasing temperature.

On the other hand, merely the lapse of time may have been responsible for the trend of increase in infestation rate in the samples collected at progressively later dates in both the coastal and offshore waters. It is very tempting to assume that the population size of the parasite may increase with time, unless any seriously unfavorable factors for the growth and reproduction of the copepod are prevailling in the waters under consideration, contributing thereby to raise the rate of infestation in the host fish shoals.

At present we cannot tell which of the above-mentioned factors, the variation in water temperature or the lapse of time, is contributing more effectively to the change in the rate of infestation; and there are further possibilities of other factors affecting the infestation of *Caligus*, such as the degree of mixing or stagnation of the water masses in which the host population live. Anyhow, it is left for future study to clear out these problems.

A similar variation of the infestation rate was noted by SCHULMAN & SCHULMAN-ALBOVA (1953) on the related caligoid copepod, *Lepeophtheirus salmonis* (KRØYER), and its host, *Salmo salar* L., of the White Sea: the infestation was much higher in the autumn school than in the spring school of the host. These authors attributed, however, the high infestation in autumn to the formation of denser shoals of the host fish in this season.

According to HOTTA (1962), the rate of occurrence of the "louse-bit" individuals in the Pacific saury samples ranged from 14.0% to 92.8%, mostly more than 50% and with an average of 53.2%, during the fishing season in the autumn (September to December) of 1961. Compared with the results of the present study on the Japan Sea saury, the Pacific saury seems to show a surprisingly high infestation by *Caligus macarovi*. Such high infestation rates in the Pacific saury cannot be unusual, since HOTTA (1962) stated that a comparably high rate of occurrence of the "louse-bit" individuals was shown in the saury caught from that region in 1960, too. I myself tried to examine some saury samples taken from the Pacific side in the same year as the samples were collected in the Japan Sea; and fortunately I could get a single sample through a commercial route, neither exact locality nor date of which is therefore known, and check the rate of *Caligus*-infestation. Of 82 fish examined, 58 individuals, or 71% of the examined fish were infested. The level of infestation, as indicated by the number of scars or parasites themselves per host, was found to be much higher, too. The scars were located almost exclusively

on the ventral third of the lateral side of the host body (Text-fig. 2*c*), as in the case of the Japan Sea samples. Four specimens of *Caligus macarovi*, all female and gravid, were obtained from this Pacific sample. The color variation was also conspicuous in these specimens.

Thus, it may be concluded that the Pacific shoals of the saury in their southward migration during autumn to winter show consistently much higher infestation of *Caligus* than the Japan Sea shoals which are caught during spring to early summer in their northward migration phase. It is, however, very danger to bring the above-mentioned conclusion directly into the discussion regarding the problem of subpopulations or migration patterns of this fish, although efforts have been made, for the practical purpose, by fisheries biologists to get any clues available to clarify the relationship between the Pacific and the Japan Sea saury shoals. To avail the infestation rate for this purpose, further studies on the life history of *Caligus macarovi* and the duration time of the louse-bit scars, etc. must be pursued.

As to the constant posture of attaching parasites, it is supposed, without any experimental evidence, that the direction of penetration of the copepod into the host skin may be chiefly determined by water flow over the surface of the host body. It is quite strange, however, that the situation of the parasite is not exactly paralleled to the longitudinal axis of the host body; might the deviation be induced by the response of the parasite to the gravitational pull or to the micro-structural difference of the host scales? Moreover, it is beyond our grasp that the site of infestation is limited to the ventral part of lateral sides of the host body; might some differences in the physical or chemical nature of the integument between dorsal and ventral parts, e.g. the ground color, softness, elasticity, mucus-secretion, etc. be influential in such selective attachment, or might it be shown by the parasite avoiding the incidental rays of sunlight (direct exposure to the sunlight, especially to its ultraviolet rays, may be deleterious for the parasite, and particularly for its embryos developing within the egg strings, attaching to this quite surface-swimming and frequently air-jumping teleostean host)? SCHULMAN & SCHULMAN-ALBOVA (1953) found a similar distribution of *Lepeophtheirus salmonis* on the host body; they noted this copepod clinging mainly on the skin of the ventral side especially around the anus and on the anal fin of the host salmon.

Summary

1. Small round scars found on the skin of the saury, *Cololabis saira* (BREVOORT), taken from the Japan Sea are due to infestation by the fish-louse, *Caligus macarovi* GUSSEV (Copepoda : Caligoida).

2. Occurrences of such "louse-bit" saury were studied on the material

collected from the offshore and coastal areas of the Japan Sea in the spring of 1962. It was found that the rate of occurrence was generally greater in the coastal areas than in the offshore area and that there is a trend toward increase of the rate with season within the period studied (May through July). And the rate of occurrence seemed, first of all, to be positively correlated with the surface water temperature of the fishing ground.

3. The rate of occurrence is much lower in the Japan Sea shoals of saury than in the Pacific shoals.

4. Positions of louse-bit scars on the surface of the host body were almost confined to the ventral third of the lateral side of the body.

5. The *Caligus* seems to keep a posture with its head roughly toward the anterior end of the host, scrape off the dermis and bury itself beneath the host integument in the antero-dorsal direction, as such a posture can be observed on some specimens found still clinging on the body surface of quickly preserved fish.

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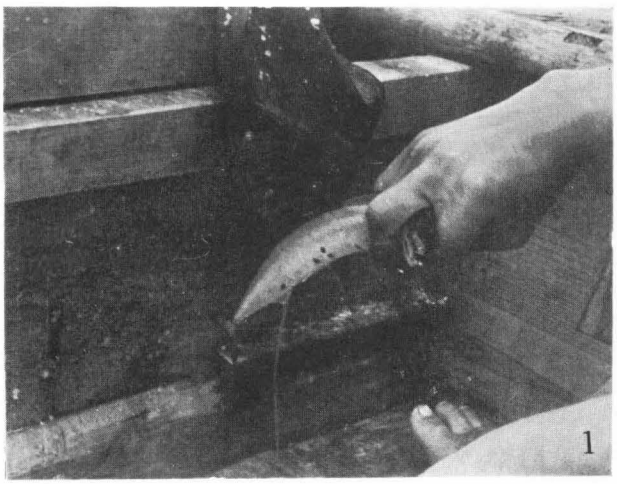
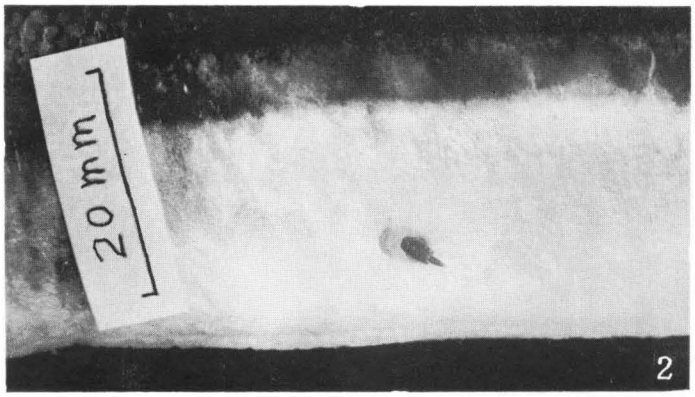
EXPLANATION OF PLATE XVII

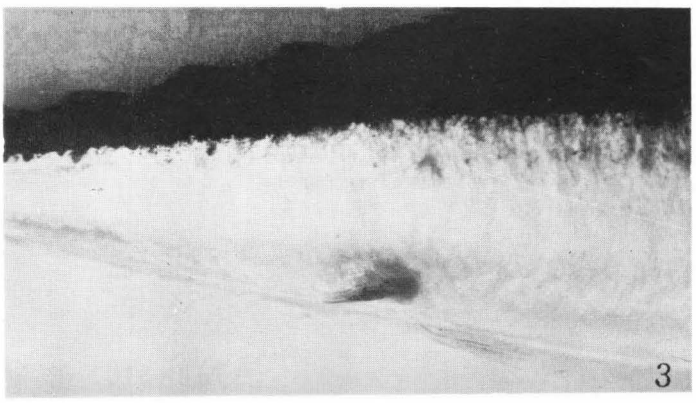
Fig. 1. The picture showing a saury caught and just brought out of water in the hand-grabbing fishery at Sado Island. Note that five scars made by *Caligus macarovi* are clearly seen in the ventral part of its lateral side. Further it may be noted that all of the copepods had already been detached from the host when the fish was brought out of water. The photograph was taken in June, 1955, off Tassha on the western coast of the island. By courtesy of Mr. I. OKACHI, Japan Sea Regional Fisheries Research Laboratory, Niigata.

Fig. 2. Attaching posture of *Caligus macarovi* on the host body. A parasite is seen attaching in the ventral third of the lateral side of the trunk region of the fish. The fish is placed with the head to the left. The parasite is buried beneath the host integument with the carapace pointing toward the antero-dorsal of the fish, only its abdomen being exposed.

Fig. 3. A parasite attaching near the base of the anal fin of the host, pointing towards the anterior end of the fish. The body axis of the parasite is slightly inclined to that of the host, and the cephalothorax is concealed under the host integument, only the abdomen and egg strings being seen exposed.







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