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Observations on the Japanese Palolo,
Ceratocephale osawai, n. sp.

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With 2 plates.

The investigation, the results of which are embodied in the following pages, was begun in the summer of 1896 and carried on at intervals during the three following years, partly in the Laboratory of the Zoological Institute and partly in a room hired for the purpose of facilitating the collection of fresh materials.

The subject was taken up at the suggestion of Professor Ijima, who has also kindly undertaken the work of revising the manuscript. To him and also to Professor Mitsukuri I beg to express my sincere thanks for the help and advice which they have frequently extended to me in connection with my work. Further I am under deep obligation to Professor K. Osawa of the medical college, who, being himself much interested in observing the breeding and swarming habits of the worm described in this paper, has favored me with valuable information and suggestions.

The worm in question is a Lycorid Polychæte which exhibits at a certain period of the year, a most remarkable swarming habit for the purpose of breeding, which so closely resembles that of the so-called "Palolo" worms of the South Pacific (*Eunice viridis**) and of the Atlantic (*Eunice fucata*†), that it seems not altogether inappropriate to give it the title of the Japanese "Palolo." However, our Japanese "Palolo," as will soon be shown, is systematically quite distinct from both the South Pacific and the Atlantic form; it is referable to the family Lycoridæ, not to the Eunicidæ. It further shows certain differences in circumstances connected with the process of swarming.

All the three forms mentioned seem to burrow in the bottom during the immature stage. With the attainment of sexual maturity and under certain peculiar conditions, the part of the body with sexually developed segments swarms out. In the Pacific and the Atlantic "Palolo," the sexual segments are in the posterior portion of the body; this portion becomes detached from the anterior and is known to do the breeding-swarm. Contrariwise in the Japanese "Palolo," the sexual segments are confined to the anterior portion, which alone does the swarming after shedding off the posterior, shrunken, non-sexual segments.

As regards the period of the year when the swarming takes place, it is known that in the "Palolo" of both the Atlantic

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* For accounts of this worm, see: S. J. Whitmee, On the habits of Palolo viridis. Proc. Zoöl. Soc. London, 1875, P. 496-502.—W. C. McIntosh, Report on Annellida. Chall. Rep. XII., 1885, pp. 231-235 (*Staurocephalus*); pp. 257-261 (*Palolo viridis*).—A. Collin, Ueber den Palolowurm. Appendix to A. Kramer's Ueber den Bau der Korallenriffe, etc. Kiel u. Leipzig, 1897.—B. Friedlander, Ueber den sogenannten Palolowurm. Biol. Centralblatt, XVIII., 1898, pp. 337-357.—A. Agassiz, Islands and Coral Reef of the Fiji Group, Am. Jour. Sci., ser. 4, V., 1898, p. 123.—A. G. Mayer, An Atlantic Palolo, etc. Bull. Mus. Comp. Zool., XXXVI., 1900, pp. 1-14.

† For the latest account of this worm, see A. G. Mayer, The Atlantic Palolo. Science Bulletin, Mus. Brooklyn Institute of Arts and Sciences, I., 1900, pp. 93—103.

and the South Pacific the process occurs in the mornings upon or near the day of the last quarter of the moon, but the former in June-July, and the latter in the months of October and November. Whereas, in the case of the Japanese "Palolo," the swarming takes place during nights closely following the new and the full moon in October and November. Details of my observations of this phenomenon will be given further on, and as to particulars about the breeding habits of the other "Palolo" the reader is referred to the literature of the subject.

With respect to the systematic position of the Japanese "Palolo," it seems to come nearest to *Ceratocephale* MGRN., which genus has hitherto been represented by a single species from Swedish shores, *C. loveni* MGRN.* Among its points of agreement with that genus and species, are the facts that the proboscis is provided with papillæ but not with paragnathea, and that the parapodium lacks the upper ligula on the dorsal ramus and shows similarly shaped setose bristles on the inferior ramus. All these characters may serve to distinguish it from the closely related *Nereis*, although it resembles this genus, in disagreement with *Ceratocephale loveni*, in the fact that the ventral cirri are simple instead of being bifid. Taken as a whole, I have preferred, tentatively at least, to refer "the Japanese Palolo" to MALMGREN's genus *Ceratocephale* rather than to *Nereis* or to creating a new genus for its reception.

At all events it is certain that the species is a new one, and I take pleasure in naming it *Ceratocephale osawai* in honour

* A. G. MALMGREN, Annulata Polychaeta, 1867.—Possibly another species of the genus is represented by the specimens from the Gulf of St. Lawrence, noted upon by MCINTOSH (Ann. and Mag. Nat. Hist., ser. 7, X., 1902, p. 258).

of Professor K. OSAWA, whose interest in the study of the worm I have already had occasion to mention.

The characters of the species may be summarily stated as follows:

Immature worm (Pl. I., fig. 1).—Number of segments as many as 300. Præstomium subhexagonal with broad base; anteriorly concave on the sides; provided with a pair each of tentacula and subtentacula, and a pair of eyes. Peristomium with four pairs of tentacular cirri. Proboscis protrusible, with soft papillæ and a pair of jaws. Parapodia nearly similar throughout the body, being biramus; only the lower ligula of the dorsal ramus is present. Both the dorsal and the ventral cirri are simple. Pygidium with a pair of slender anal cirri.

Mature worm (Pl. I., figs. 6, A, B).—This is the head-bearing anterior portion of the original worm. The segments number 78 or less. They are distinguishable into those of the thorax and of the abdomen. Head and thoracic segments remain unchanged in character, except that the eyes are now more conspicuous than before. Abdominal segments enlarged; their bristles, originally of the ordinary form, are now replaced by paddle-shaped ones.

Ceratocephale osawai is one of the most common littoral Annelids in Tokyo and vicinity, where it is extensively used in both immature and mature phases as bait. The immature phase is locally known under the name of "Itome" and the mature phase under that of "Bachi."

The species is also known to me from Miya in the Province of Owari, from Shimizu Harbor in Suruga, from Ito in Izu, and from Matsushima and Hachinohé on the east coast of Northern Japan.

With these remarks I proceed to record the fuller details of my observations in the following order: 1) on the immature phase, 2) on the mature phase and 3) on the breeding-swarm.

1. Observations on the Immature Phase.

Habitat.—The immature worms or the atoca of the species (Pl. I., fig. 1) occur in great abundance between the tide marks along the Sumida River, on which Tokyo is situated, for a distance of about six miles from its mouth, and also in the adjoining parts of the Gulf of Tokyo. They also extend some distance into the tributaries, canals and ditches, which empty into the waters just mentioned.

At the ebb-tide they are found burrowing in the mud or sand to a depth of a foot or more. The entrance of the burrow is usually indicated by a small round hole on the surface, the margin of which is always slightly raised above the level. With the flood-tide, irrespective of the hour of the day, they leave their retirement and creep about on the bottom. They are then very active and voracious, feeding on various aquatic animals and plants. Often they are seen to dip with the head end into the bottom mud or sand in search of food.

Size and general shape.—The body is long, slender and dorso-ventrally compressed (Pl. I., figs. 1 and 2). Since we have to do with immature growing worms, it is but natural that the dimensions should be exceedingly variable. It may in general be said that they attain a length of 200–250 mm. and a breadth of 3 or 4 mm. The number of segments varies of course according to the size of the specimens; in a large one there may be as many as 300. The addition of new segments during growth takes place, one by one, invariably in front of the pygidium.

Gradually from the head end backwards the breadth increases slightly to about the tenth segment, then it continues nearly the same to about the 40 th or 50 th segment, beyond which the body again begins to taper very gradually towards the hindmost region, which may be said to be very slender.

The size of the segments stands in direct proportion to the breadth of the region to which they belong. In respect of their structure, both internal and external, the segments are all essentially alike so that a demarcation into thoracic and abdominal segments can not be carried out.

Color.—In the living state of average specimens, the dorsum (Pl. I., fig. 1) in the anteriormost region is dusky brown with a purplish iridescence. In the main portion of the body, this color gradually passes posteriorly into a deep red, which again gradually becomes somewhat lighter towards the hind end. On the præstomium the bluish brown pigments are developed in small irregular, sometimes eye-like, blotches. The parapodia are always of a much lighter hue than the segments to which they belong. The dorsal median blood-vessel is prominently visible as a deep red line, in which the postero-anteriorly directed peristalsis may be distinctly observed.

Seen on the ventral side, the peristomium and a few succeeding segments may be said to present a light pinkish color. For the rest the ventral surface is of a pale flesh color.

In the specimens preserved in alcohol, the coloring matter has dissolved away, leaving only a light bluish hue on the anterior dorsal surface of the body.

Præstomium (Pl. II., fig. 9).—This is small and flat, but well developed. The shape may be said to be subhexagonal, consisting of a transversely elongate, eye-bearing section attached by a broad base to the peristomium, and of an anterior section which somewhat narrows towards the bases of the tentacula at the front edge. The sides of the head at the junction of the two sections are concave. The anterior section is divided into two halves by a median groove.

The tentacula, present in a pair and situated close together on the anterior edge of the head, are small, being of a length less than half that of the entire head. Their base is slightly pigmented, the remaining part being colorless.

The subtentacula, likewise in a pair, are attached to the sides of the head at their anterior concave part as well as to the peristomium. They are thick and fleshy, with a small, round, somewhat retractile boss at the tip. Except at this end, which is colorless, they are of a brownish color.

The eyes, of which there are two pairs, are situated close to the lateral borders of the hind section of the head. In the anterior pair they are more widely separated from each other than in the posterior. Moreover, in the former they are directed forwards and outwards, while in the latter their direction is upwards and outwards. In alcoholic specimens the eyes are scarcely visible, so that with only such specimens one might be misled into assuming their absence.

Peristomium.—The peristomium or the first segment shows much longitudinal folding. On each side it is provided with four tentacular cirri, two dorsal and two ventral. The anterior ventral cirrus is the shortest, and the posterior dorsal the longest. The latter, when laid down backwards, reaches to about the the middle of the fourth segment. Each cirrus consists of a basal, more or less pigmented, section and of a colorless distal section pointed at the free end.

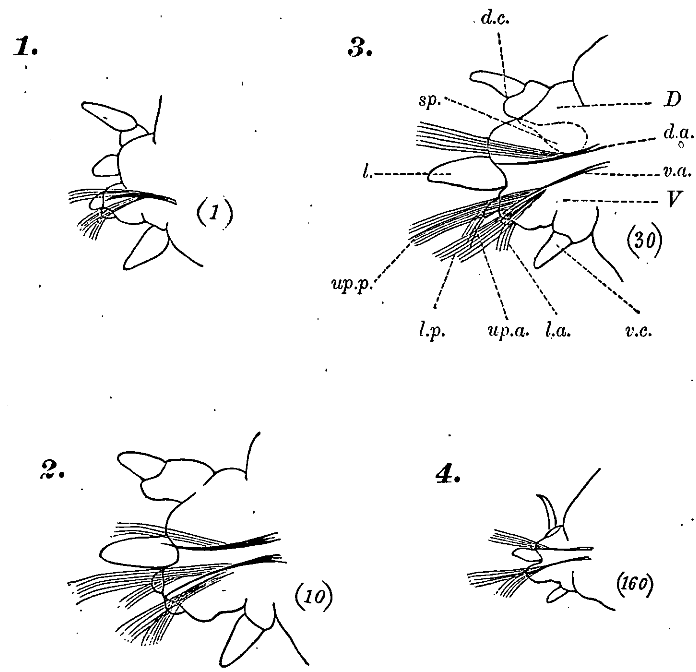
Proboscis.—Pl. II., figs. 10 and 11, show respectively the dorsal and the ventral views of the proboscis in its protruded state. It is furnished with a pair of strong chitinous jaws and a number of soft papillæ. The blackish brown but translucent jaws are slightly curved and their inner concave edge shows 7–9 teeth. Structurally, the jaws consist of a peripheral colored layer and an inner colorless mass. The latter is concentrically laminated and incloses two longitudinally running canals, which open externally on the points of the first and the second teeth. The canals contain a substance which in its staining capacity resembles the secretion of the "Spinndrüsen," a gland found in the dorsal ramus of certain parapodia. In the fully protruded state of the proboscis the points of the jaws are apart; these close and become crossed as it is withdrawn. They serve not only for capturing prey but also for burrowing into the bottom-ground.

The surface of the proboscis, when protruded, is divided by a ring-groove into a posterior and an anterior ring, both of which are again subdivided into a number of small areas by grooves which run in the main longitudinally. The posterior ring is entirely destitute of papillæ, these being confined to the anterior ring. This latter ring (Pl. II. fig. 10), seen on the dorsal side, shows in the middle a transverse row of three papillæ, situated one in each of the three areas known as the anterior median and the right and left anterior submedian. Further it shows two more papillæ of quite insignificant height, each situated near the lateral border, i. e., in the areas known as the anterior lateral. The ventral aspect of the anterior ring (Pl. II., fig. 11) bears a varying number of papillæ, arranged in irregular rows. These seem to increase in number with the growth of the individual. In the larger specimens their number varies from 17 to 27.

The paragnathea, which are of much common occurrence in the Lycoridæ and offer points of considerable systematic importance, are not found in this species as is also the case in *Ceratocephale loveni.*

Typical Parapodia.—The parapodia are best developed where the segments are largest, say in segments X. to XL. As an illustration of a typical parapodium I may take that shown in the annexed Woodcut 3, which represents the 30th parapodium belonging to the XXXI. segment.

It consists of two rami, the dorsal (*D*) and the ventral (*V*). From the upper side of the dorsal ramus arises the dorsal cirrus (*d.c.*), consisting of an elongate conical distal, and a thick basal, section. The latter, in the parapodium in question, is broad but of only about half the length of the former, and is well marked off by constrictions from this as well as from the ramus bearing it. The dorsal ramus lacks the upper ligula but possesses the lower ligula (*l.*), which arises from a point slightly ventral to its distal end and is somewhat longer than the dorsal cirrus. The ligula may be said to be conical in shape and more or less



Woodcuts 1–4. Parapodia of the atocous phase of *Ceratocephale osawai*, from the left side. All in posterior view. The figures in brackets indicate the serial number of each parapodium as counted from the first.

D, dorsal ramus ; *d.a.*, dorsal acicula ; *d.c.*, dorsal cirrus ; *l.*, ligula ; *l.a.*, lower anterior bunch of bristles ; *l.p.*, lower posterior bunch of bristles ; *sp.*, Spinndrüsen ; *up.a.*, upper anterior bunch of bristles ; *up.p.*, upper posterior bunch of bristles ; *V.*, ventral ramus ; *v.a.*, ventral acicula ; *v.c.*, ventral cirrus.

flattened in the antero-posterior direction ; it is richly supplied with a vascular network.

The dorsal ramus is further provided with an acicula and a bundle of bristles. The acicula (*d.a.*) is of the usual simple shape and of a blackish color. It lies imbedded in the ramus, except its pointed tip which projects outwards between the ligula base and the outer end of the ramus in question. The bristles are exclusively of the setose kind (Pl. II., fig. 12) with the blade finely serrated on one edge. They are placed in a bunch, dorsal to both the ligula and the acicula mentioned above.

The ventral ramus of the parapodium has no ligula, but is supplied with two small and rounded terminal lobes, the upper and the lower. Both are directed outwards and downwards, Further there is present on the ramus the ventral cirrus (*v.c.*). This compares well both in size and shape with the distal section of the dorsal cirrus; but the basal section, clearly distinguishable in the latter, is here only indistinctly indicated in that it shows no bounding constriction against the body proper of the ramus. The acicula (*v.a.*) is quite similar to that of the dorsal ramus, while the bristles are here of two kinds, the falcate and the setose, and are grouped in four bunches. Of these the lower-anterior bunch consists only of the falcate bristles (Pl. II., fig. 14). The upper-anterior bunch consists of setose bristles, whose blades are short and finely serrated on one edge (Pl. II., fig. 17). The lower-posterior bunch consists of setose bristles whose blades are long and rather coarsely serrated on the convex edge (Pl. II., fig. 15). This form of bristles closely resembles that from the ventral ramus of *Ceratocephale loveni.* The upper-posterior bunch is composed of setose bristles, the longest and most slender of the kind in the entire parapodium (Pl. II., fig. 16). The blade is slightly curved, with very fine serration.

Variation of the Parapodia.—The parapodia in different regions of the body are subject to certain variations as regards their size and the relative development of their parts. From the first parapodium (belonging to the second segment) backwards to about the tenth, they increase in size gradually and successively, along with the increase in breadth of the body in that region. Then they keep up approximately the same size for some distance further backwards; and in the hind region of the body, they again become gradually smaller and smaller, until the very last parapodium, occurring in the præanal segment, is represented by quite a simple and insignificant elevation. To illustrate in a way the variation above indicated, I have shown in the Woodcuts 1–4 (p. 10) respectively the 1st, 10th, 30th and 160th parapodia, taken from an average-sized individual with 178 segments.

In the first parapodium (Woodcut 1) the superior ramus is always entirely destitute of the acicula and the bristles, and is simply provided with the dorsal cirrus and the ligula. The former is well developed, being about twice as long as the latter. Its basal section, making up about one-fifth of the entire length, is marked off by constrictions from both the distal section and the ramus bearing it. The ligula is small and simple in appearance, and has a rounded tip. In the much more complicated inferior ramus the two terminal lobes are of about the same size. The upper lobe projects slightly farther out than the ligula, while the lower is directed outwards and downwards. The ventral cirrus is nearly similar in shape and size to the dorsal, but differs in having no basal section marked off. The ventral acicula present and the bunches of bristles occuring in association with it are rather weakly developed.

Generally speaking the second parapodium and sometimes even the third are essentially like the first, the dorsal ramus being characterized by the absence of both the acicula and the bristles.

The next parapodium—that is, generally the third, but sometimes the second or the fourth—is of a somewhat more complicated structure, being supplied with the acicula and the bristles in both rami. Especially the ventral ramus is more strongly developed than in the preceding parapodium. The ligula is larger, and extends a little beyond the ends of the terminal lobes of the ventral ramus. The dorsal cirrus differs from that of the first parapodium in that its basal section is longer and takes up nearly one-third of the entire length.

The series of successive parapodia beginning with the one last described and reaching down to about the 150th or thereabout, possesses essentially the same parts, which however show a very gradual variation in the following manner:

The distal portion of the dorsal cirrus grows relatively shorter posteriorly to about the 100th parapodium, from which point farther backwards it again becomes somewhat longer but more and more slender. The basal section of the cirrus increases in size posteriorly until about the 10th parapodium (Woodcut 2), where it attains its maximum size, and thence backwards it again gradually becomes shorter. The ligula continues to grow larger but flatter until about the 20th parapodium, in which it attains its greatest size. From that point backwards it gradually becomes smaller again. The setose bristles of the dorsal ramus are longest in about the 60th parapodium, in which the blade is 2½ times as long as that of the same bristle in the 30th parapodium.

The aciculæ vary in length in proportion to the general size of the parapodium to which they belong. Abnormally two or three aciculæ may occur together in either of the two rami. Such cases have been found most frequently in the first two or three parapodia.

The terminal lobes of the ventral ramus increase in size from the anteriormost parapodium to about the 20th and then begin to become smaller posteriorly until in about the 140th they become united together, finally to disappear altogether some distance still farther posteriorly.

The blades of the falcate bristles, which constitute the lower-anterior bunch of the ventral ramus, grow stronger from the anteriormost parapodium to about the 20th, in which the maximum development is reached (being about 1½ times the length of the 30th parapodium). Then they become smaller again to about the 25th or the 26th, after which they remain of nearly the same size until the posterior region of the body is reached.

The length of the setose bristles of the lower-posterior bunch is subject to much variation. It continues to increase from the front region posteriorly until the maximum length (about 1⅓ times that in the 30th parapodium) is reached in about the 60th parapodium, and then the same length is maintained to about the 100th or so, whence posteriorly it again diminishes. The variation in length of the bristles forming the upper-posterior bunch generally coincides with that of the bristles of the bunch just described.

In the upper-anterior bunch, the bristles vary not only in size but also in form. In the first 23–24 parapodia, the bunch consists exclusively of falcate bristles, just like those in the lower-anterior bunch. From about the 20th parapodium, their number in each bunch begins to decrease, while the shorter setose bristles in the bunch constantly increase in number, until in the 28th–30th the latter entirely replace the falcate variety. The setose bristles as they occur together with the falcate in the same bunch in the 20th–26th parapodia are slightly longer than the latter. Posteriorly they continue to increase in length to about the 30th parapodium, in which they reach the maximum length (the blade length being about twice that in the 30th parapodium); after that they again gradually become shorter towards the posterior end of the body.

The ventral cirrus is best developed in the anteriormost segments, gradually becoming smaller in those more posteriorly situated.

The "Spinndrüsen" of EHLERS are found in the superior ramus. This gland begins to appear in the 22nd–25th parapodium. In Woodcut 3 the outline of it is indicated by a dotted line. It is somewhat pear-shaped and occupies a great portion of the ramus. In the more posteriorly situated parapodia it may even extend into the body beyond the basal constriction of the parapodium. Externally it opens by a short duct at the base of the dorsal cirrus. It is largest in about the 35th parapodium.

Here I may state that the locomotion of the worm is effected by alternate forward and backward movements of the parapodia on both sides of the body, assisted by forcible protrusions of the chitinous appendages, which are retractile to a certain degree. It has seemed to me that in the forward motion of the worm the setose bristles come more into operation than the falcate, and *vice versa* in the backward motion, as for instance in the act of retreating into the burrow.

Pygidium.—This is about as long as it is broad, the length being about equal to that of the three preceding segments taken together. The center of the rounded hind end is occupied by the anus, which shows a radial wrinkling around it. The pygidium is devoid of parapodia but is furnished with a pair of colorless, slender and delicate anal cirri, which, arising from its ventral posterior end, are directed backwards.

The Change of the Immature (*Atoca*) *into the Mature Phase* (*Epitoca*)—This begins to take place in the early part of September. All individuals that have passed the summer do not, however, pass nearly simultaneously into the epitoca. At the period of the year just mentioned, the worms still vary in size and it is especially the larger ones, as might be expected, which first begin to manifest symptoms of the change. These are however by no means of a uniform size. They are undoubtedly those which are destined to swarm out under the first favorable circumstances during the following month. Others which swarm later in the season undergo the change at a correspondingly retarded period. Probably some of the smallest found in the season do not become at all ready for swarming until the autumn of the following year; for throughout the winter after the last swarming has taken place in November, there are still to be found small immature worms, though in an incomparably smaller number than in the spring and summer.

The successive stages of the change into the epitocous phase are illustrated in Pl. I., figs. 1–5. To start with, fig. 1 shows a well-grown representative atoca, before the change has set in. In such specimens the sexes can not be determined by external observation. This becomes however possible as the worm grows markedly stouter, indicating the beginning of the change. The sexes then begin to present a difference in color. The worms in fig. 2,—in which figure, as also in several following figures, the letters A and B stand respectively for the male and the female, —the male (2 A) will be observed to be more dusky or more brownish than the female (2 B), which is for the most part of a bright red color, while both have grown considerably in breadth, especially in the anterior region of the body as compared with the stage (fig. 1), in which the sexual color difference could not be perceived. As before indicated, such larger worms begin to be observed from the early part of September. During the course of that month the change proceeds further and the worms acquire the appearance of those shown in figs. 3 and 4. Though the head end remains of nearly the same size as in an early stage, most of the segments in the anterior portion of the body, have undergone a considerable growth; they are now much broader and more plump-looking than before, owing to the development of sexual products within. That portion of the body, composed of approximately one-third the total number of segments, is the part which goes to make up the body of the epitoca. It is of a reddish color much lighter than before, the female being distinguished by a yellowish tint which grows deeper as the days advance. The posterior portion of the body, comprising about two-thirds of the total number of segments, is destined shortly to be cast off. It stands in contrast with the anterior part not only in that its segments have remained stationery in size and consequently are very much narrower, but also in the marked change which has taken place in the color of that part. Here the reddish color has disappeared, having given place to a dirty brown on the sides and to a pale streak in the middle. The dorsal vessel presents an interrupted appearance, preparatory to becoming sooner or later quite imperceptible. The posterior region in question is evidently undergoing a degenerating process.

For some time, this region is seen to pass gradually into the anterior epitocous region; but as the change into the epitoca nears its completion, the two regions become quite abruptly demarcated (fig. 5).

The worms represented in fig. 5 are those in which the anterior epitocous region has attained full development. So far as that region is concerned, there is observable no difference whatever from the swarming epitoca (fig. 6) either in the proportions of dimensions or in the color presented by the sexes. But the worms still drag behind them the degenerated posterior portion which has now become darker in color than before and has somewhat shrunk in thickness. It is usual that more or less of the posterior natural end of this portion is missing, it evidently having become torn off and lost.

Worms in the state above described are met with a few days—say, for a period of about a week—before the swarming is to be expected. I have found them in greatest abundance in the beginning of October, not only in the natural habitat but also in the aquarium in which only atocous worms had originally been placed. They are known to fishermen under the name of "Hori-bachi" or the "dug-out bachi," so named because the Bachi, found swimming a few days later, are in this period obtained by digging in the mud.

It seems more than probable that the degenerated posterior portion, now greatly loosened in the consistense of its tissues, becomes more and more torn off at the end, as it is being dragged along by the burrowing worm. And what may remain of of it at the time of swarming, may easily be detached by the first swimming movements. However, it sometimes happens that, among the individuals that have swarmed out, there are seen such as still possess the shrivelled tail-like appendage in varying lengths. Fishermen call these "Ya-bachi" or the "Arrow-Bachi," evidently from the remote resemblance they bear to a flying arrow.

At all events the degenerated posterior portion is destined to be sooner or later completely cast off. This leaves an open aperture to the continuous body-cavity at the hind end of the epitoca, and the genital products may find their way outwards through that aperture, assisted without doubt by the muscular exertions required for swimming. Only an insignificant quantity of genital products is extruded through the nephridial openings, as I know from direct observations. At any rate, there can be no doubt that the nephridial organs play quite an unimportant rôle as genital outlet in comparison with the rent at the posterior end or with the ruptures which subsequently occur in the general body-wall.

2. Observations on the Mature Phase.

Ceratocephale osawai, on attaining the epitocous phase (Pl. I., figs. 6, 7), i.e., the stage of sexual matruity in which it swarms out for the purpose of breeding, differs in general appearance from the immature or atocous worms so considerably that it may at first sight easily be considered as specifically distinct. But my direct observations on the life-history of the species, as also the occurrence of forms representing intermediate transitional stages, have placed the developmental relation of the two phases beyond the reach of doubt.

The best method of capturing the swimming worms is to use a hand-net. If the night be rough or rainy, the worms do not come quite to the surface of water. In such a case I have preferred to use the sort of a fine-meshed hand-net, which is commonly employed in Tokyo for the capture of *Saranx microdon* in the spring. This net, as set in frame, is triangular, with sides of about six feet length each. It is dipped into the water somewhat vertically, and by a sweeping motion the worms, as they come along with the ebbing tide, can be scooped up with convenience.

The swimming worms are attracted in numbers by the light of a lantern, which greatly facilitates the collecting. In the aquarium, a candle-light readily attracts them. Whereas, in the case of non-swimming atocous worms I have found that the same light exercised no such influence.

The epitocæ, after being captured, can be kept alive for a week or two in shallow wooden vessels placed in a shaded place and with a small quantity of the river-water taken at the time of high tide, just enough to cover the worms. The water must be changed once or twice a day, taking care to remove all the rent or otherwise injured worms as soon as possible, without which precaution the water will soon become so filled with discharged sexual products as to be detrimental to the general health. Too much water, as also much light, induces the worms to motion and thus increases the chance of receiving injuries to their body.

As might be expected, the worms are apt to fall prey to fishes while swarming. On one occasion I chanced to capture two *Leuciscus hakuensis*, which were evidently in pursuit of the swimming worms. On dissection, they were found to contain the worms in the stomach or sticking in the throat.

Size.—The dimensions of the epitoca vary considerably in different individuals, as the direct result of the fact, already mentioned, that differently sized atocæ undergo the change into epitocæ.

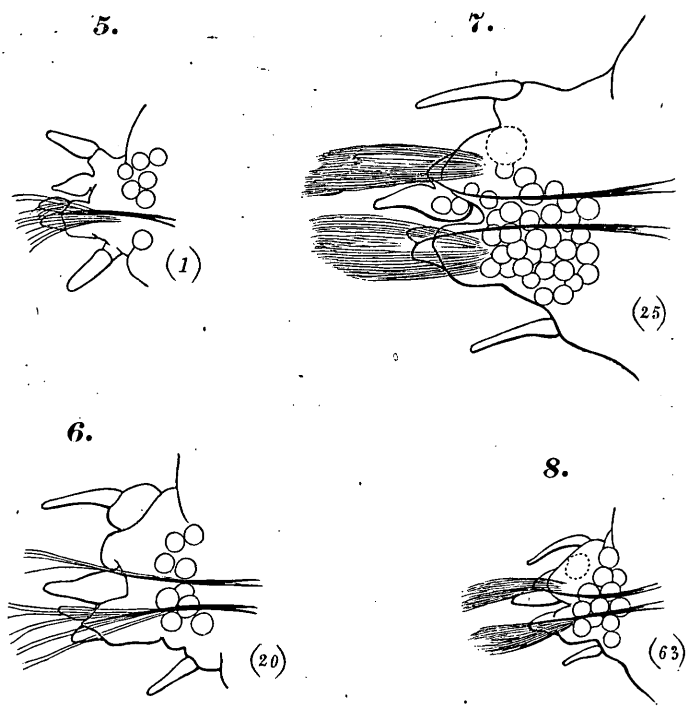
I have found males measuring between 40 mm. and 130 mm.

in length, and 3–11 mm. in breadth at the broadest part, while the number of segments varied from 60 to 78. In the females, the length varied from 35 mm. to 120 mm., and the breadth within nearly the same range as in the males; the number of segments was 60–74. In general it may be said that the atoca in developing into the epitoca increases about three-fold in greatest breadth, but decreases by nearly one-half in length, while the number of segments is reduced by approximately two-thirds as already indicated. The segments, taken singly, have grown not only in breadth but also considerably in length, and consequently have become more distinct than before.

Color.—In the epitocous phase, the sexes are as before mentioned easily distinguishable in color. In the females the body is at first of a yellowish color (Pl. I., figs. 6 B and 6b), but after swimming about for a while in exposure to light, the color changes to a light greenish (Pl. I., fig. 7). The males are pinkish white blending into a deep pink at the bases of the parapodia (Pl. I., figs. 6 A and 6 a).

Cephalic Region.—There exists no remarkable difference in the cephalic region in the two phases, except in regard to the eyes. It will therefore not be amiss here to give first a short description of an eye in the atocous phase. It consists of the three chief parts: retina, lens and cornea. The retina is composed of pigmented cells, each being in possession of a clear refractive end, the rod. The retinal cells collectively make up a pigmented single-layered epithelium, forming the wall of a deep cup, the aperture of which represents the pupil. This is not conspicuously discernible from the outside, being covered over by the cuticula and the thick epidermis. The nuclei of the retinal cells are situated close to the outer end of the cells, forming a zone. The dark blue pigment is especially densely developed at the inner end, along the line demarcating the rods from the cell-bodies proper. The peripheral end of each cell tapers out into a process continuous with a nerve fibre, which can be traced uninterruptedly for some distance into the opic nerve. The clear refractive rods form, as indicated, an inner lining to the pigmented retina; on the internal aspect they are indistinctly marked off from a clear central mass, the lens. They are longest in the fundus, and become shorter towards the rim, of the retinal cup. The lens not only fills up the entire cavity of the cup, but even projects slightly out of it at the pupil, thus coming here in direct contact with the epidermis. The name of cornea is given to that portion of the epidermal layer which intervenes between the lens and the cuticula. The latter is directly contiunous with that over the entire head and is in no way modified over the eyes.

In adult worms the eyes have grown considerably in size; the retinal cup is now about twice as large in diameter as in immature worms, while the diameter of the pupil has increased about four times. The lens now projects outwards to a much greater degree than before, pressing against and reducing the thickness of both the cornea and the cuticula. The former may sometimes become even entirely pressed aside, thus becoming perforate in the center and bringing the lens into direct contact with the cuticula. The result of these changes is that the eyes are now very conspicuously visible in surface view (Pl. II., fig. 18), in both the living and the preserved state of specimens. They are especially distinct in specimens killed with picrosulphulic acid, in which they appear as whitish spots surrounded by a black ring, the margin of the



Woodcuts 5–8. Posterior views of the left side parapodia of epitocous. *Ceratocephale osawai*. Small circles in the figures indicate the outlines of eggs contained in the paradodia. The figures in brackets show the serial position of each parapodium as counted from the anteriormost. Magnified 20 ×.

pigmented retinal cup. The greater development of the eyes in the epitoca evidently stands in relation with the free-swimming habit.

Thoracic and Abdominal Regions.—In the epitocous worm we may speak of the thoracic and the abdominal regions of the body. The boundary between the two regions varies somewhat in different individuals. It lies between the 22nd and the 25th segments in females, and between the 24th and the 27th in males, In both sexes, the segments of the thoracic region gradually enlarge antero-posteriorly to about the 10th segment and then remain nearly the same in size down to the abdominal region. The parapodia of that region are essentially similar to those in the corresponding body-part of immature worms (Woodcuts 5–6), except in this respect that the dorsal and the ventral cirri are generally much more slender and longer. The aciculæ as well as both the falcate and the setose bristles remain, in the thoracic parapodia, in much the same condition as before.

In the abdominal region, the segments begin again to gradually broaden and continue to do so to about the 40th in the female, and to about the 45th in the male; then they narrow backwards to the posterior end. The parapodia in this region show a somewhat sudden enlargement within the anterior two or three segments; and after that they are seen to increase posteriorly gradually in size until the 40th (female) or the 45th (male) segment is reached. Beyond this they again become gradually smaller towards the hind end of the body.

In all the abdominal parapodia (Woodcuts 7–8), the distinction between the dorsal and the ventral rami is more pronounced than in the atocous stage; the cirri are more elongated, and their basal portion much shorter, being sometimes scarcely distinguishable as such. The ligula has become somewhat more slender. The "Spinndrüsen" now show a rounded outline. The extension of the body-cavity into the parapodium is full of mature eggs or spermatozoa according to the sex. Sometimes the sexual products are found even in the interior of the ligula. The aciculæ present simply a larger size in correspondence to the general growth undergone by the parapodia themselves.

In the anterior two or three abdominal segments, the paddle-shaped bristles are found together with the ordinary bristles, but in the more posterior segments, the latter disappear altogether. Only exceptionally are a few ordinary or setose bristles again found in both the dorsal and the ventral rami in the last one or two abdominal segments.

The paddle-shaped bristle (Pl. II., figs. 19 and 20) consists of a shaft, which shows regular transverse striations, and of a blade, which is very finely serrated on one edge. It remains the same in form throughout the same individual but differs somewhat according to sexes. The body-region in which the above mentioned transition in the character of bristles, from the setose to the paddle-shaped, occurs,—that is, approximately the boundary between the thoracic and the abdominal parts,—nearly coincides with that region of atocous worms in which the falcate bristles become replaced by the setose.

The Hindmost Segment.—In external appearance the hindmost segment of the epitocous worm is just like any of those which precede it. Its parapodia are directed postero-laterally, and of course no anal cirri are present. Examined in longitudinal sections, the hypodermis of this segment is seen to be greatly thickened, especially in the dorsal part. At the posterior end of the segment it is four times or more as thick as at the anterior end or in any other segment. Further, the hypodermis can be distinctly made out as being discontinuous with the wall of the intestine, in contrast to the condition in the hind end of atocous worms, in which the hypodermis cells pass gradually and continuously into the cells of the intestinal wall at the anus. The epithelial cells of the intestine in the hind end of epitocous worms present some signs of atrophy, in that the cell-outlines are indistinct. Elongation of the hypodermis cells and a consequent thickening of the layer they compose also occur close to an artificial cut by which the hind part of a worm has been removed, but in this case, the cells of the intestinal wall do not show any sign of atrophy.

The circular muscle of the dermal musculature is strongly developed in the last segment, especially in its posterior part. The longitudinal muscles end abruptly in this segment; so likewise the ventral nerve cord, its fibres showing some signs of degeneration. There is found no ring vessel connecting the ventral longitudinal vessel with the dorsal, which ring-vessel is one of the points characteristic of the anal segment in atocous worms; both the dorsal and the ventral blood vessels terminate freely and apparently blindly. From what has been said it clearly follows that the hindmost segment of the epitocous worm is not the anal segment of the atocous. On the contrary there can be no doubt whatever of its being an ordinary body segment, which has undergone some change, as the result of the shedding away of the more posterior segments.

Some Other Points of Anatomical Differences between the Atoca and the Epitoca.—The integument becomes thinner as the worm passes into the epitocous phase. The cuticula measures 1–1½ μ in thickness in the epitoca, while in the atoca it is 2–3 μ hick. The hypodermis is 10–13 μ thick in the epitoca, but 20–25 μ in the atoca. The thinning is evidently due to the expansion of the general body cavity, in consequence of the development of reproductive elements.

Apparently for the same reason, both the dorsal and the ventral longitudinal muscles in the epitoca are greatly thinned out and are pressed against the inner side of the body-wall; while in the atoca these muscles are much thicker and occupy a more internal position in the body. The circular muscle layer is also much reduced in thickness.

The communicating apertures between consecutive segments become larger as the worm approaches sexual maturity, and admit of a free movement of the genital element from one segment into another. As before indicated, the general body cavity, more or less filled up with either eggs or spermatozoa, extends into the parapodia and sometimes even into the ligula. The main body of the nephridium is pushed into the parapodial cavity by the mass of the genital product.

The alimentary canal, caudad from the transitional region between the proboscis and the intestine, is much reduced in caliber. The intestinal wall is now much poorer in capillary vessels than before.

Sexual Products.—The eggs or the spermatozoa are discharged while the epitocous worms are actively swimming near the surface of the water. The eggs then sink down gradually to the bottom. They are each surrounded by a thick and transparent gelatiuous envelope, so that when found in masses, they are separated from one another by a considerable space. They are spherical in shape, with a diameter of 120–150 μ. In color they vary from yellow to greenish blue.

The vitellus, surrounded by a delicate membrane at first in direct contact with it, is finely granular and consists of the protoplasm inclosing at least three distinguishable kinds of matter, viz., large oil-drops, small oil-drops and deutoplasmic spheres (Pl. II., fig. 22). The large oil-drops, of which approximately from twenty to thirty are present in each egg, vary much in size and are situated in the vegetative half of the vitelline mass. This pole of the egg is therefore lighter than the opposite and is thus always turned upwards in the natural position of the egg in water. The second kind of oil-drops are minute and highly refractive spheres, found scattered throughout the entire vitellus. I am unable to say whether they are chemically of exactly the same nature as the larger kind. There exist no intermediate sizes linking together these two kinds of drops. The deutoplasmic spheres may be said to stand in point of size intermediate between the two forms of the oil-drops. They are at first uniformly distributed in the vitellus together with the smaller oil-drops.

The spermatozoa, soon after expulsion from the body, are found adhering in large numbers to the gelatinous envelope of the ovum. Each consists of an ellipsoidal head and of a long slender filiform tail. The head is 3 μ long and 1.7 μ broad. The tail measures 35–45 μ in length; it gradually tapers towards the hind end.

Artificial fertilization by bringing together the eggs and spermatozoa taken from mature worms can easily be effected, provided the precaution be taken to keep the water at the same temperature and the same degree of salinity as that at high tide in the river during the swarming period. Forty to fifty minutes after fertilization, the vitellus contracts and aquires an irregular surface, which is separated here and there from the vitelline membrane by vacant spaces. Sometime afterwards, the vitellus again assumes a perfectly spherical shape, and is then separated throughout from the membrane by a narrow perivitelline space.

Meanwhile certain changes, preparatory to the formation of polar bodies, take place in the animal pole. The deutoplasmic spheres migrate away from the animal pole, leaving there a clear protoplasmic area, which henceforth slowly enlarges. The oil-drops mostly press themsleves into the vegetative half of the egg, but a few small oil-drops may still be seen scattered in the hyaline animal pole. The greenish blue color of the egg is now most intense in the vegetative pole; it gradually fades away towards the animal pole.

About an hour after fertilization, the first polar body is extruded; the second follows fifteen or twenty minutes later. In this stage (Pl. II., fig. 22) the vitellus appears somewhat flattened at the upper pole and is separated from the membrane by a considerably wider space than before. The main axis, connecting the animal and the vegetative poles, measures 110–140 μ in length. So far as I have been able to follow the cleavage process in the living ova, it shows a general agreement with that described by WILSON* for *Nereis limbata;* only it proceeds much more slowly than in that species.

The larva of the species I have not been able to observe.

3. OBSERVATIONS ON THE SWARMING.

With respect to the swarming habit of the "Bachi" or the mature *Ceratocephale osawai,* it has long been known from the experience of fishermen in the locality that the swarming occurs during the months of October and November, usually in four different periods, each lasting a few days; that the period falls on nights close to the days of the new and the full moon; that it invariably takes place in the evening just after the flood-tide;

* WILSON, E. B.—The Cell-lineage of *Nereis.* Jour. of Morph. Vol. VI. 1892.

and further, that in some years it occurs in two or three, instead of four periods and rarely only once during the months mentioned.

In order to make observations for myself, I spent many evenings on the river, and it was not long before I became convinced of the general accuracy of the fishermen's predictions as to when the swarming was to be expected. On October 8th 1896, I had the satisfaction of observing the swarming for the first time. It was the first swarming of that year. On that day the worms that swarmed out were not numerous, but on the following day the swarm proved to be one of the largest I have ever known.

As an illustration I may describe my experience on that particular day (Oct. 9th, 1896). In good time to see the beginning of the swarming, I was on the river in a boat manned by two fishermen and provided with a lantern, nets of various kinds and such other utensils as might be required for observing, capturing and preserving the worms. About half past six in the evening, the place was reached which was considered likely to be favorable for the accomplishment of my purpose. The flood was to occur at 6.54 p.m. While we were waiting for the beginning of the swarming, a crowd of other boats, each provided with a light to attract the worms, assembled near mine. They had come to catch the "Bachi," which, as I have said, are much used as bait in fishing and therefore are a marketable commodity. About 7 o'clock or a little later, the first swimming worms were observed. It was only individuals of small size, measuring 30–40 mm. in length, that were seen in the first part of the swarming; about 15 minutes later, larger ones began to join the swarm, in which a few individuals were noticed still trailing the shrivelled posterior portion of the body, such as are shown in fig. 5, Pl. I. ("Ya-bachi"). About half an hour from the beginning, the swarm was thickest; full-sized individuals were now seen in abundance together with smaller ones. All swam about rapidly, somewhat after the manner of eels, darting in all directions. I ascertained that the swarm reached to a depth of three or four feet from the surface of the water. Within that extent, the worms in the height of the swarming, were so plentiful that one could not dip his hand into the water without touching some. About an hour and a half from the beginning, the larger worms first began to gradually disappear and as the end of the swarming approached, it was only the smaller specimens that could be found swimming. Two hours after the beginning of the swarming (at 9 p.m.), there were none to be found swimming.

The above account, except as it concerns the hours of the day, may in general be considered to hold good for all observed cases in which the swarming took place in large numbers.

Possibly a part of the worms after the swarming sink to the river-bottom in an exhausted condition. At the same time it seems certain that a large number of them are carried down stream and some distance out into the sea by the ebbing tide. On more than one occasion I have followed the shifting swarm to a distance of two or three miles from the river-mouth—to the neighborhood of the old forts off Shinagawa,—but always to lose sight of it gradually and altogether at the end.

In the aquarium, in which I had kept a number of large atocæ and in which the natural conditions were imitated as far as possible, the worms changed, into the epitocous phase and began to swim almost simultaneously with those at large. The ebb and the flood of each day were imitated in the aquarium at proper hours, the former by gradually drawing off the water so as to almost expose the mud at the bottom and the latter by slowly adding fresh water to a depth of about two feet. In the river, the bottom-temperature was found to rise 1–2°C. higher during the flood than at the ebb, the surface maintaining the same temperature all the time. This periodical change in bottom-temperature could not very well be introduced into the aquarium, but this seemed to excercise no influence upon the swarming process. I regret that I omitted to ascertain by experiment whether or not the worms, when left in standing water that showed nothing like the ebb or the flood, would have swarmed out at the right time.

The epitocæ that have swarmed out in the aquarium continue to swim about for a longer or shorter period, sometimes for several hours, though the swimming may at times be interrupted by pauses in which they sink to the bottom and remain motionless. In many cases the distended body-wall becomes rent during the exertions of swimming; this soon puts an end to the swarming career. In other cases, they may remain for a considerable while uninjured save at the posterior torn end. Such individuals become gradually less energetic in their movements, finally to rise no more from the bottom, but soon to become ruptured in the body-wall. It may fairly be said that in twenty-four hours at the longest the energy of the worms becomes completely exhausted in all cases, unless, as before mentioned, their movements be restricted by denying them enough water to swim in, so that it seems exceedingly probable that the worms which have once swarmed out in the river never join in the swarm of the day following. I see no ground to doubt that the fate which I have observed to be fall the swarming epitocæ in captivity, is in general the same as that which happens to those under natural conditions.

Since taking up this subject of research, I have made a series of observations on the time and periods of the swarming, on the Sumida River in Tokyo. In both the years 1896 and 1897, the swarming occurred in four periods in the months of October and November. The following tables record my observations for these years:

Table I.

1896.

Periods.	Date and phase of moon.	Time of flood in the evening.	Hour and duration of swarming.	Size of swarm.
I.	Oct. 7th, New Moon.	5.25, P.M.	———	None.
	„ 8th.	6.08, „	6.30–8., P.M.	Few.
	„ 9th.	6.54, „	7.–9., „	Very abundant.
	„ 10th.	7.41, „	7.40–9.20, „	Abundant.
	„ 11th.	8.31, „	8.40–9., „	Very few.
	„ 12th.	9.25, „	———	None.
II.	Oct. 21st.	4.53, P.M.	———	None.
	„ 22nd, Full Moon.*	5.26, „	About 6., P.M.	Very few.
	„ 23rd.	5.56, „	6.30–8.40, „	Abundant.
	„ 24th.	6.29, „	7.20–8.40, „	Few.
	„ 25th.	7.05, „	———	None.
III.	Nov. 5th, New Moon.	5.05, P.M.	———	None.
	„ 6th.	5.54, „	6.30–8.30, P.M.	Abundant.
	„ 7th.	6.42, „	7.–8.40, „	Abundant.
	„ 8th.	7.30, „	About 8., „	Very few.
	„ 9th.	8.18, „	———	None.
IV.	Nov. 20th, Full Moon.†	5.05, P.M.	———	None.
	„ 21st.	5.40, „	———	None.
	„ 22nd.	6.17, „	About 6.40, P.M.	Very few.
	„ 23rd.	6.55, „	———	None.

* Moonrise at 4.53 P.M.

† Moonrise at 4.02 P.M.

Table II.

1897.

Periods.	Date and phase of Moon.	Time of flood in the evening.	Hour and duration of swarming.	Size of swarm.
I.	Oct. 11th, Full Moon.*	5.27, P.M.	———	None.
	„ 12th.	5.57, „	6.20–7., P.M.	Few.
	„ 13th.	6.29, „	6.50–7.20, „	Few.
	„ 14th.	7.03, „	———	None.
II.	Oct. 25th.	4.35, P.M.	———	None.
	„ 26th, New Moon.	5.19, „	6.–6.10, P.M.	Very few.
	„ 27th.	6.07, „	6.10–8.20, „	Very abundant.
	„ 28th.	6.56, „	7.05–9.20, „	Very abundant.
	„ 29th.	7.45, „	8.–8.40, „	Abundant.
	„ 30th.	8.39, „	———	None.
III.	Nov. 9th, Full Moon.†	5.03, P.M.	———	None.
	„ 10th.	5.36, „	6.–7.20, P.M.	Abundant.
	„ 11th.	6.11, „	6.40–7.10, „	Few.
	„ 12th.	6.45, „	———	None.
IV.	Nov. 24th, New Moon.	5.07, P.M.	———	None.
	„ 25th.	5.59, „	6.25–8., P.M.	Abundant.
	„ 26th.	6.49, „	About 7.20, „	Very few.
	„ 27th.	7.39, „	———	None.

The watch for the swarming was kept on several other days than on those mentioned in the above tables, but with negative results; so it may be confidently stated that no other swarms occured in the years 1896 and 1897. In both these years, from July to October I examined every week the atocous worms, freshly dug out of the mud. By the immature condition they presented it could be foretold that the swarming was not close at hand.

* Moonrise at 5.6 P.M.

† Moonrise at 4.11 P.M.

As before mentioned, forms transitional to the epitoca appeared at the end of September and became very numerous in the beginning of October. After that a sharp look-out for the swarming was of course daily maintianed on the river, at the same time continuing the examination of fresh specimens obtained every other day. In this way, I could approximately foresee the approach of the swarming, quite independently of the forecast made by the fishermen as there sult of the experience of many years.

After each swarming period the transitional half-epitocous forms, such as are shown in Pl. I., fig. 5, totally disappear for a time from among the worms collected from the river-bottom. However, in about ten days,—that is to say, a few days before the next swarming period,—a plenty of the half-epitocous worms are again met with in the mud; it is needless to say that these are to take part in the next swarming. After the last swarming at the end of November, there are to be found in the river-bottom only small atocous worms, which probably attain sexual maturity in the autumn of the following year.

In the years 1898 and 1899, I made only occasional observations on the swarming so that my records for those years are not so complete as for the two preceding years. Nevertheless, it can be confidently stated that the swarming in the years mentioned took place quite in accordance with our previous observations,—that is to say, it occurred at periods and hours, which could be foretold. The number of swarming worms was variable as before, and sometimes very small.

To give in general terms the results derived from my observations:

1.—The epitocous worms swim out four times a year, in the months of October and November.

2.—Each swarming period extends from one to four consecutive days, immediately following the days of the new and the full moon.

3.—The largest swarms occur within three days after the day of the new and the full moon.

4.—The swarming is greater after the new moon than after the full moon.

5.—The swarming invariably takes place just after the flood in the evening.

6.—The swarming continues generally from one to two hours.

7.—On warm cloudy nights, the swarming seems to be generally larger than on clear chilly nights.

As to the tidal conditions in the mouth of the Sumida River during the two months of October and November, it is known: 1) that spring-tides occur in the evening within three days following the day of the new and the full moons; and 2) that the spring-tide following the new moon is higher than that after the full moon. There is then noticeable a parallelism between the occurrence of the densest swarm and the highest spring-tide during the months concerned. Noteworthy seems also the fact that in the present species the time of swarming closely follows both the new and the full moon.

Postscript.

Professor K. OSAWA presented before the V. International Zoologists' Congress (Berlin, 1901) a paper entitled "Ueber die japanischen Palolo," in which he, as I am told by him, dealt principally with the swarming habit, leaving the worm undescribed. The paper should have already appeared, in the "Verhandlungen," accompanied with a plate. Unfortunately the said "Verhandlungen" had not arrived in Japan before the time when I had to send my manuscript to the press; so that much to my regret, I could neither refer to nor benefit by his paper. It is more than probable that some facts already known through him have been unnecessarily redescribed by me in this contribution, for which repetition I herewith beg to offer my apology.

Tokyo, May 27th, 1903.

A. IZUKA.

OBSERVATION ON THE JAPANESE PALOLO, CERATOCEPHALE OSAWAI, N. SP.

PLATE I.

Plate I.

Fig. 1. *Ceratocephale osawai* in the atocous or immature phase, commonly known under the name of "Itomé." (Nat Size).

Figs. 2–5. Immature specimens in different stages of transition into maturity or the epitocous phase. *A*, males. *B*, females. (Nat. size). In figs. 2*A* and 2*B*, it will be seen that the sexes differ slightly in color of the body, which is now considerably stouter than in the stage of growth represented in fig. 1. In figs. 3*A* and 3*B*, the anterior portion of the body has undergone much more enlargement, while the posterior portion remains nearly the same; the sexes are easily distinguishable on account of their different colors. Figs. 4*A* and 4*B* represent worms somewhat advanced in the change into the epitocous phase. Figs. 5*A* and 5*B* represent nearly full-grown worms, in which the anterior portion of the body, that is the epitoca about ready to swim out, is abruptly marked off from the shrivelled and discolored posterior portion. Some posteriormost segments have already been torn off and lost.

Fig. 6. Epitocous phase, or the so-called "Bachi." Figs. 6*A* and 6*B* represent respectively a male and a female epitoca of representative dimensions. Fig. 6*a* and 6*b* represent a male and a female of unusually small size.

Fig. 7. An epitocous female, showing the change of color into the greenish, after swimming about for a while in exposure to light. (Nat. size).

Fig. 8. Dorsal view of that part of the body, in which the anterior epitocous portion of the worm passes over into the posterior portion which is eventually shed off.

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PLATE II.

Plate II.

Fig. 9. Dorsal view of the anterior end of an atocous worm. 10 ×.

Fig. 10. Dorsal view of same, with protruded proboscis. 15 ×.

Fig. 11. Ventral view of same. 15 ×.

Fig. 12. A bristle from the dorsal ramus of 30th parapodium, from an atocous worm. 390 ×.

Fig. 13. A bristle from the upper-anterior bunch of the ventral ramus, from the same. 390 ×.

Fig. 14. A bristle from the lower-anterior bunch from the same. 390 ×.

Fig. 15. A bristle from the lower-posterior bunch from the same. 390 ×.

Fig. 16. A bristle from the upper-posterior bunch from the same. 390 ×.

Fig. 17. A bristle from the upper-anterior bunch of the ventral ramus of the 35th parapodium, from the same. 390 ×.

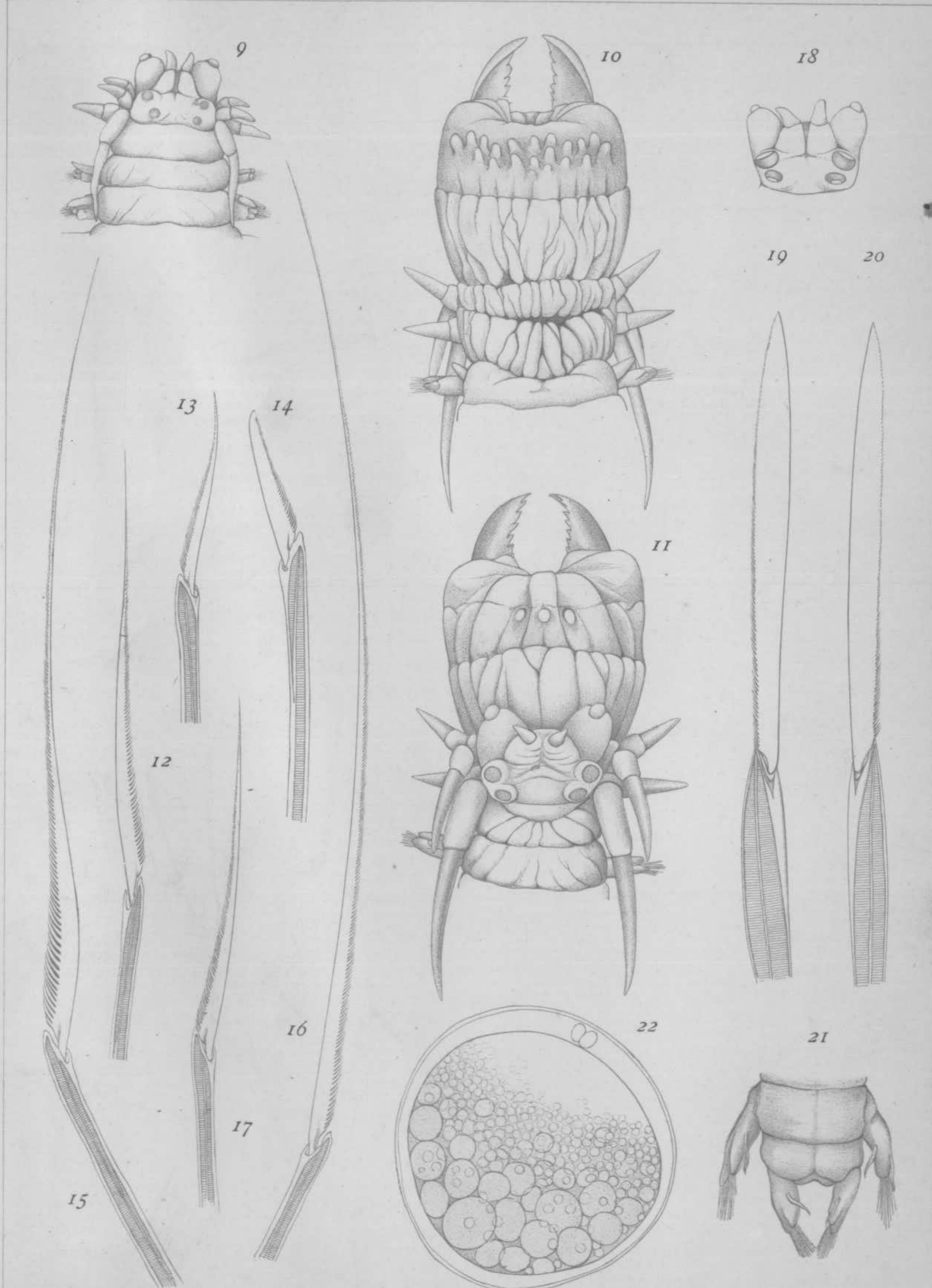
Fig. 18. Dorsal view of the head of an epitocous worm. 10 ×.

Fig. 19. A paddle-shaped bristle of the 30th parapodium, from a female epitoca. 390 ×.

Fig. 20. A paddle-shaped bristle of the 30th parapodium, from a male epitoca. 390 ×.

Fig. 21. Last two segments of an epitocous worm. 10 ×.

Fig. 22. Lateral view of a fertilized egg, just after the extrusion of the second polar body. Drawn from a living specimen. 390 ×.



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