CHIRONOMIDÆ FROM JAPAN (DIPTERA), IV

THE EARLY STAGES OF A MARINE MIDGE, TELMATOGETON JAPONICUS TOKUNAGA[1]

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THREE PLATES AND ONE TEXT FIGURE

There have been reported seven species of the genus *Telmatogeton* Schiner; namely, *T. sanctipauli* Schiner, *T. minor* Kieffer, *T. torrenticola* Terry, *T. abnorme* Terry, *T. trochanteratum* Edwards, *T. simplicipes* Edwards, and *T. japonicus* Tokunaga; and the majority of them, excepting the two Hawaiian species, are true marine in habitat. Studies of their biology are incomplete, and I report here more details of the structures of immature forms and some ecologic observations on the last species at Tottori, Karo.

These studies were made under the direction of Prof. Dr. Hachiro Yuasa, who has my hearty thanks. I am also deeply indebted to Prof. Dr. K. Okada for the use of equipment at the Seto Marine Biological Laboratory of the Kyoto Imperial University.

ECOLOGIC REMARKS

The size of this fly seems to vary in different localities. Specimens collected on the coast of the Pacific Ocean, at Wakayama, Seto, in June, 1930, are small, measuring 2.5 to 3 mm in length in the imaginal stage and 5 to 6 mm in the full-grown larval stage; while those obtained on the coast of the Japan Sea, at Tottori, Karo Harbor, in July, 1931, are large, being 4 to 4.5 mm in the adult form, 5.9 to 6.8 mm in the pupal stage, and 9 to 10 mm in the full-grown larval condition. These differences in size are probably due to the different conditions of the algal food rather than to the different localities themselves. The small specimens were found on the algal breeding bed composed

[1] Contribution from the entomological laboratory of Kyoto Imperial University, No. 43. Contribution from the Seto Marine Biological Laboratory of Kyoto Imperial University.

of *Monostroma* sp. on the ordinary tidal zone of a rocky shore, where this alga was very much damaged and faded, already being covered by shore sand at this season. The large specimens were taken from a breeding bed consisting of *Ulva pertusa* on stones at the estuary, and at this season the growth of this alga was still luxuriant. In the spring of 1934 I visited Seto again and obtained many vernal forms. These specimens are far larger than the summer forms of the same locality, being as large as the specimens at Karo; they were colonizing on *Monostroma* sp., which was most luxuriant in this season. The sexual difference in size is little and obscure.

Both sexes are nocturnal in habit, being most active in the evening about three hours after sunset, and imagines are usually resting in the daytime on the shaded side of a rock. Occasionally on a cloudy day, and rarely even in the direct sunshine, some individuals are actively scampering and ovipositing. When the fly is at rest, the body is closely applied to the substratum with the six long legs outstretched, as in the crane flies, supporting the body with only two distal joints of each tarsus. When the fly rests on a plain surface, either horizontal or vertical, the angles between the legs are as follows: 33° between the forelegs, 59° between the fore and middle legs, and 75° between the middle and hind legs.

The imagines rarely take flight unless molested, mating and swarming taking place only on the rock surface, and when disturbed by the on-coming waves, they adroitly fly up momentarily and resume active scampering and oviposition as soon as the waves recede. Thus they usually are found about their breeding place, but they can fly for some distance. On a calm evening, from 8 to 10.20 p. m., six female and seven male adults were obtained at a light screen set at about 600 meters from the habitat of this fly.

In size, shape, color, and structure the eggs closely resemble those of the related genus *Paraclunio* observed by Saunders. The female, soon after emergence, contains 150 to 190 mature eggs (168 mean for 20 flies), and they are almost all laid during the life of the fly. The eggs are placed singly in small crevices or pits of rock surface, as in *Paraclunio alaskensis* Coquillet, and never laid in a mass or single layer on the smooth surface as in the fresh-water species *Telmatogeton torrenticola* Terry. During oviposition, as in the marine crane fly *Limonia* (*Dicranomyia*) *trifilamentosa* Alexander, the female inserts the ovi-

positor into a crevice and flutters the wings by a rapid bobbing motion. The surface where the eggs are laid is never dry.

The adult females and males are attracted to light, and the number collected of each sex is subequal. The females collected at light had almost completed oviposition; ten flies contained mature eggs as follows: 0, 0, 0, 0, 0, 1, 1, 2, 2, 18. This is different from the observations on certain marine flies, such as *Tanytarsus boodleæ* Tokunaga and *Limonia monostromia* Tokunaga, studied at the Seto Marine Biological Laboratory by M. N. Omori and by myself.

The larval quarter of this species is never under the low tidal mark or in the rock pool but confined to the tidal zone between the upper and lower tidal lines, as already stated by Hesse and by myself. The nest cases of the immature forms are usually single and built under individual algæ. The nest is tubelike, firm, consists of sand particles and silky threads, and is not provided with special lids at both ends. The last is true even of the pupal nest. The entire larval body is inclosed within the tube, thus differing from *T. sanctipauli* and *T. minor*. Molting and pupation take place in the original larval nest case. Before pupation the nest is thickened by additional sand particles gathered by the prepupal larva. In the early stages the larvæ, in building their loose nest cases, often utilize the natural tunnellike folds in the algal fronds, and often migrate about in the wet condition of the quarter. In the later stages, after the second stadium, the position of the nests on the rock surface is limited to the bases of the algæ, contrary to the observations of Hesse, and the larva rarely creeps out of the nest case even in the wet or submerged condition. The direction of the nest tube seems to be irregular and not related to the shape of the algal base or to the inclination of the substratum (text fig. 1).

The food found in the larval stomach consists of many fragments of the living alga and a small quantity of the dead alga, mingled with sand particles and sedentary diatoms. Thus the main food item seems to be the living algæ used for their shelter, as in the African *Telmatogeton* species, which live on *Porphyra capensis* and *P. vulgaris;* and the greenish brown appearance of the living larvæ is due to these living algal fragments contained in the stomach. The tidal rhythm often affects the feeding habit of marine insects, as I have pointed out in the case of certain marine crane flies, but the larvæ of this fly seem to show no distinct rhythmic habit in feeding, due probably to the

fact that the larvæ continue to take food in the wet condition, even after the recession of the tide.

One of the distinct effects of the tidal rhythm is shown in the emergence of the imagines. The emergence of this fly never occurs in the floating condition as among the Chironomidæ in general or in the submerged condition as among the Simuliidæ and the Blepharoceridæ in general, but takes place only in the exposed condition in the ebb tide. In the field, pupal exuviæ always remain in the pupal cases as in the hygropetric midges. The emergence commences immediately after the tide has receded and lasts to the next flood tide. When the mature pupæ are artificially submerged in the water at the period of emergence they all die in various states of the process of the emergence. The periodicity of the emergence is shown only in the natural condition, and not retained long but easily disturbed in the ever-exposed condition. The duration of the pupal period observed in the laboratory in summer is about 2.5 days, varying much in different individuals, from 47 to 72 hours, the mean duration for ten pupæ being 56.7 hours. This length of the pupal period is far less than that of *T. sanctipauli* obtained by Hesse, who recorded 4 to 7 days or more in the laboratory. The process of emergence of the female was observed in the laboratory, from which the following data were obtained:

Process of emergence in the laboratory at 5 p. m., July 5.

	Min.	sec.
Pupal thorax wriggled out from alga	2	00
Abdominal tip shore silvery	7	00
Entire body shone silvery	16	00
Imaginal abdomen began to move irregularly within the pupal skin	16	30
Middorsal suture split in T-shape	17	00
Complete emergence	17	55
Walked slowly and rested quietly	18	00
Meconium dropped down	18	45
Suddenly scampered about with fluttering wings	18	45
Rested quietly	19	30
Actively scampered about	19	50
Taken on the wing	20	00
Body normally tinged	35	00
Total process	33	00

In the field this process is usually completed in about thirty minutes. The pale imagines soon after emergence are also active in swarming, mating, and scampering, like the old dark flies, but oviposition is not shown by these young females. The turning of the male hypopygium is already exhibited within the pupal skin before the emergence, and occurs in the irregular movement at the shining stage of the pupal skin. The seasonal emergence of this fly is not so distinct as in the marine genus *Clunio*, imagines being found almost throughout the spring and summer seasons, and the growth of the larvæ collected from one colony in the same season is also very irregular. On this point Hesse stated that "there is reason to believe that there is more than one generation in a year," and judging from my observations there may be two generations in a year, imagines emerging twice, in the spring and summer seasons.

The duration of the imaginal life of imagines that were reared in the laboratory was about 20 hours in both sexes and the following data were obtained: 17, 22, and 22 hours in the female and 20 in the male. These flies in the laboratory did not show copulation or oviposition. Honey water was given them for food. This fly always colonizes on the hard substratum between the tide marks, and only three species of littoral green algæ are known as the host plants; namely, *Enteromorpha compressa*, *Ulva pertusa*, and *Monostroma* sp. Moreover, the rock surface where the colonization is settled always shows a sharp slope toward the water and is kept clean, as the débris, drift, and sand washed up by waves and in the ebb-tide water are not retained, as in the case of the algal bed of *Enteromorpha intestinalis*. The last-mentioned alga is one of the most prevalent plants found in a similar condition on the tidal zone to the above littoral species of algæ, and various shore chironomids and crane flies, but not *T. japonicus*, have been reported from this alga. From observations at Karo, the main animals associated with this marine midge showing a close spatial relation to the same littoral alga, *Ulva pertusa*, are one of the Janiridæ (Isopoda) and a species of *Orchestia* (Amphipoda) (text fig. 1).[2]

[2] These animals were kindly determined by Dr. K. Stephensen and Dr. K. Akatsuka, respectively.

A census of these animals on the rock surface having the largest population of *T. japonicus* is given in Table 1.

TABLE 1.—*Population of the biotic elements on the rock having the largest population of Telmatogeton japonicus Tokunaga, observed in July, 1931.*

Biotic element.	Individuals per square meter.	
		Per cent.
Telmatogeton japonicus	1,470–1,660	28.18–29.38
Pupæ	550– 560	9.51–10.99
Larvæ	920–1,100	18.39–18.68
Amphipoda	640– 650	11.04–12.78
Isopoda	1,800–1,900	32.26–35.97
Ulva pertusa	1,670–1,680	28.52–33.37

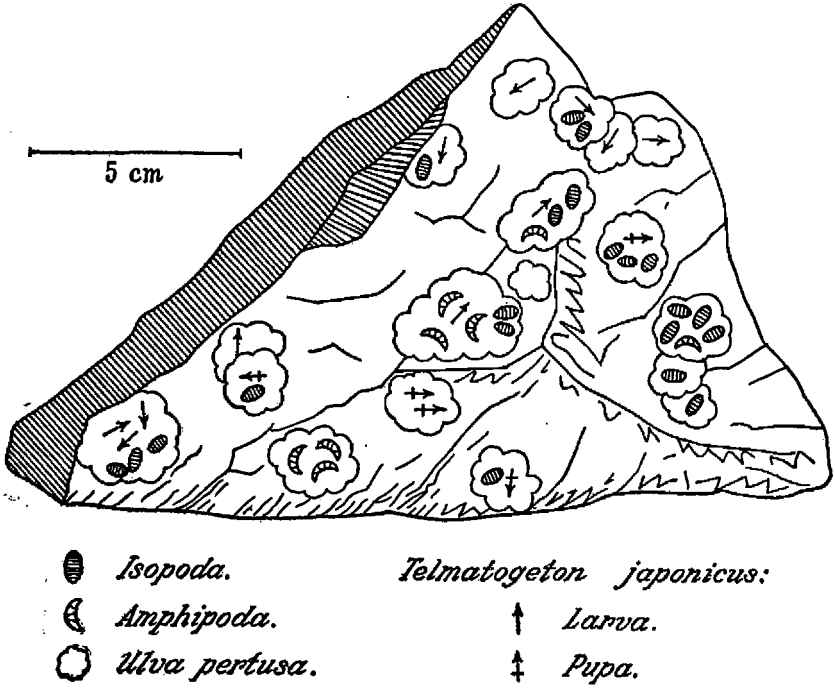

FIG. 1. Distribution of various littoral animals associated with the green alga on the surface of a piece of stone that shows a high population of the insect *Telmatogeton japonicus* Tokunaga.

It may be worth noting that the colonization of the Japanese species is found in various conditions of salinity, such as about 3.2 per cent salt (NaCl) on the Pacific coast and about 1 to 3.1 per cent on the coast of the Japan Sea, as I have already re-

ported (1933). Experimentally a dozen or more normal imagines were obtained, which were reared with fresh water alone from young second and third instars (1932 and 1933). Hesse also reported that "immersion in fresh water or sea water does not appear to affect them in any way and one specimen was left in fresh water for several days without showing any signs of being uncomfortable." Judging from these biologic observations, together with those on the Hawaiian fresh-water species, the genus *Telmatogeton* is thought to suggest a transitional mode of life between land and sea, both in habitat on the intermediate shore zone and in physiologic resistance to the salinity of sea water, differing from the other genera of the marine subfamily Clunioninæ in the latter point.

MORPHOLOGY OF THE LARVA

GENERAL REMARKS

The larva is elongated and cylindrical, of the usual chironomid type, and closely resembles that of *Paraclunio*. The body is semihyaline and pale green or greenish brown according to the algal color of the stomach contents. The development of the setæ of the body is very poor. The head is brown, darker along the occipital foramen, cephalic margin, lateral margins of the front, and at the base of the mentum. Distinct paired eyespots are present on the cephalolateral side of the vertex and each eyespot consists of closely situated masses of pigment; namely, a large posterior mass and two or three small anterior pigment masses. Terry states that these eyespots are wanting in *T. torrenticola*. The mandibles are provided with seven teeth, while in *T. torrenticola, T. sanctipauli, T. minor,* and *Paraclunio alaskensis* they are provided with five teeth, and the setæ of the brustia also differ in number from those of *T. japonicus*. The general shape of the mentum is related to that of *P. alaskensis,* and the number of teeth is nearly the same as in *T. sanctipauli,* but the shapes of the teeth are quite characteristic for the species. In the present larva there are eleven teeth, and the median tooth is comparatively small and sharply pointed, while in *T. sanctipauli* the number of the teeth varies between nine and eleven, and the middle tooth is very large; in *T. minor* it varies between eleven and thirteen, and the middle tooth is not sharp; in *T. torrenticola* there are fifteen. Both the pre- and postclypeus are well developed and the frontoclypeal suture

is straight in the present insect, while in *P. alaskensis* this suture is U-shaped, judging from Saunders's figure. The details of the antennæ, maxillæ, and epipharynx are quite characteristic for this species. The salivary glands are asymmetrical as pointed out by Saunders in the case of *P. alaskensis*, the left being divided into two equal, long, tubular glands and the right being single with a round basal lobe. Moreover, each caudal tuft of the terminal segment of the Japanese species is represented only by two single setæ arising directly from the skin, while in the African species these setæ arise from a common base.

THE HEAD CAPSULE

The head capsule is broad, compact, highly chitinized, and nonretractile. The entire surface of the head is finely sculptured. This sculpture is the structure of the ental surface of the cuticular layer, and the external surface is quite smooth. The reticulation on the ventral side is more compact and complete than on the dorsal side. Along the thickened occipital foramen there are large, hyaline, mussel-shaped, paired ental lamellæ, which serve as the attachments of the strong cervical muscles. The head capsule is divisible into paired lateral halves of the vertex and the unpaired sclerite of the front by the distinct epicranial suture and the midventral suture. The former suture is split in the process of molting and pupation.

The vertex (Plate 2, figs. 7 and 8) is provided with two pairs of small sensory pores on the dorsocaudal surface, a pair on the lateral side, a pair on the dorsal side near the basis of the mentum, and a pair on the dorsocephalic part near the front. Simple setæ are also found on the vertex; a pair on the dorsal part near the front, a pair on the laterocephalic part, and a pair on the ventrocephalic region near the bases of the postcoilæ. The ventrocephalic margin of the vertex is strongly projected cephalad, forming a distinct postcoila, and on the dorsal side the cephalic margin is also projected ventrocephalad, forming a blunt precoila for the articulation of the mandible.

The front (Plate 2, fig. 7) is broad, shield-shaped, and somewhat oval. Two pairs of simple setæ are found on the laterocephalic margins along the epicranial arms.

The antennæ (Plate 2, fig. 9) are located close to the clypeus. The antennaria is well developed, subtriangular, and thickly chitinized, but not developed externally. The major part of the antennaria is displaced caudad under the vertex along the

epicranial arm. Thus the vertex on this region appears to be of a dark color due to the thick chitinization of the antennaria, and the external distal region of the antennaria is shown as a tubercle between the clypealia and precoila in the dorsal aspect. The antenna (Plate 2, fig. 7) is articulated to the cephalic end of the antennaria by means of the intermediation of the large socketlike antacoria. The antenna is very small for the size of the head capsule and 4-segmented. The proximal segment is comparatively large, not cylindrical but somewhat barrel-shaped, its length about twice its width or the length of the remaining three segments taken together, provided with a sensory pore on the dorsoproximal region, and membranous on its distal end. In some cases it appears that there is a very delicate hyaline seta on the base of this segment, but this is not determined yet to be constantly present. The second antennal segment is cylindrical and twice as long as wide. On the distal membrane of the proximal segment, in a parallel position with the second segment, there is a membranous trichoid sensilla, Lauterborn's organ, which is as long as the distal three segments taken together and biramous on its distal region as in *T. torrenticola*. The distal two segments are very minute and brown. Besides these segments, on the distal membrane of the second segment there are a chitinized sensory peg and two tricoid hyaline sensillæ, which are all as long as the distal two segments taken together. The segments of the antenna are often incorrectly counted as three owing to the extremely delicate structures of the distal region of the antenna and to the presence of the comparatively large sensory peg, which is brown and as long as the two distal segments of the antenna proper taken together.

THE MOUTH PARTS

The mouth opening is large and provided with a well-developed labrum, epipharynx, mandibles, mentum, and hypopharynx. The maxillæ are small, and the labial appendages are all atrophied.

The clypeolabrum (Plate 2, figs. 7, 8, and 10) is somewhat trapezoid and composed of the thickly chitinized marginal structures and two chitinized plates, pre- and postclypeus, on the membrane. The region of the postclypeus is demarcated from the front by the straight frontoclypeal suture and from the preclypeus by the shallow fold of the membrane and consists

of a trapezoid plate, postclypeus proper, and the lateral membrane. The chitinized plate is not provided with setæ, but on the lateral membrane there is a very large seta, which grows on the conspicuous tubercle. The preclypeus is obscurely demarcated from the labrum by a pair of incomplete furrows on the lateral membrane of the clypeolabrum and provided with a subtriangular plate, preclypeus proper, on its meson and a pair of ordinary setæ on its lateral membrane. The labrum is membranous, provided with a pair of simple setæ on its dorsal side, and various cuticular appendages on its cephalic smooth membrane, which is somewhat dilated ventrad. On this swollen area, as shown in Plate 2, fig. 10, giving the cephalic aspect of the labrum, there are paired brushlike setal groups on the lateral sides, three pairs of hyaline trichoid sensillæ, which are curved ventrocaudad on the meson, two pairs of sensory pegs on the dorsomeson, and two pairs of minute hyaline trichoid sensillæ, which are extended mesad and located near the sensory pegs. On the entire dorsal membrane of the clypeolabrum minute round dots of chitinization are densely arranged. Each dot represents the external surface of the conical tuberclelike chitinization of the cuticular layer, which is internally thickened.

The lateral chitinization of the clypeolabrum consists of three different sclerites in the typical specimen, two of which are homologous with the clypealia and torma. The remaining one is apt to be overlooked, but this chitinization is widely shown in Nematocera, and the origin is considered as the secondary chitinization of the lateral margins of the labrum, for which I propose the term "labralia." In the present case the clypealiæ are well developed and found on the lateroproximal margins of the clypeolabrum. The tormæ are firmly fused with the labraliæ and represented by the blunt ventral projections. The labraliæ are fused with each other at the cephalic extremity, forming a framework to support the labral membrane, and on the ventral side these marginal sclerites bluntly project mesad for the articulation of the premandibles.

Although the ventral side of the clypeolabrum (Plate 2, figs. 8 and 10) is not definitely divided into the epipharynx and epigusta, the region of the epigusta is quite smooth and membranous, while the region of the epipharynx is provided with various appendages that are characteristic for the chironomid larvæ. Of these appendages the most conspicuous organs are

the paired premandibles, which are articulated to the special projections of the labraliæ, each provided with a set of antagonistic muscles at its basal projections. The distal half of the premandibles is thin, somewhat concave on the mesal aspect, and dentated into three blunt teeth on its edge, as in Plate 2, fig. 12. The membrane mesad of the premandibles is swollen and spinous. On the cephalic region of the epipharynx there is a U-shaped chitinization, which is formed by the fusion of originally paired secondary chitinization of the membrane. Along the arms of this U-shaped structure there are paired groups of minute hooklets. These hooklets (Plate 2, fig. 11) are hyaline and flat, and those of the mesal side are finely serrated, while those of the lateral side are simple and slender. On the cephalic margin of the epipharynx there are three minute, hyaline, scalelike combs, which are finely and irregularly serrated on the distal margin. Besides these cuticular structures there is a pair of brown thickened patches on the meson caudad of the U-shaped sclerite or mesad of the premandibles.

The mandibles (Plate 2, figs. 8, 13, and 14) are symmetrical in structure, comparatively slender, and each has two long setæ on the ventrolateral surface. There are seven mandibular teeth. The distadentis is somewhat slenderer than the proxadentes, but there is no distinct differentiation between them. At the base of the dental row is a strong hyaline seta. The brustia is represented only by a proximal group of simple setæ, which are on the membranous area at the attachment of the retractotendon, and the number of setæ is usually six. The extensotendon is slender, but the retractotendon is very large, thickly chitinized, and oval.

The maxilla (Plate 2, fig. 8; Plate 3, figs. 16 and 17) is membranous, connected with the ventrocephalic margin of the vertex by the broad maxacoria, and consists of two chitinized plates and two blunt distal membranous lobes. These two sclerites are the cardo and the stipes. The stipes is reduced into a small elongated sclerite on the dorsal side of the maxilla at the base of the lateral membranous lobe, and the ventral part of the stipes is reduced completely. The cardo is large, located on the ventral side, and its mesal part is bent dorsolaterad. Thus, as the result of the reduction of the stipes, the inner membranous lobe is directly supported by the semicircular cardo at its base.

The inner lobe is the lacinia. This membranous projection is subtriangular, thickly fringed with special setæ; the setæ on the cephalic margin are delicate and slender (Plate 3, fig. 16, *c*), and those on the mesal margin are long, stiff, semihyaline, and somewhat swollen at the base (Plate 3, fig. 16, *d*). On the ventral surface there are two long ordinary sensory setæ, and on the dorsal surface there is a group of sensory pegs (Plate 3, fig. 16, *b*).

The lateral lobe is the palpifer. The ventral surface of the palpifer is thinly membranous, very finely pubescent, provided with two long ordinary setæ on the basal region, which are located on the common basal chitinization, and with two sensory setæ on the meson, which are flat, somewhat blade-shaped, and each is attached to the individual tubercle (Plate 3, fig. 16, *e*). The dorsal surface is covered with the small pale brown scale-like structure that is shown in Plate 3, fig. 16, *a*. The maxillary palpus (Plate 3, figs. 17 and 18) is small and nonsegmented, located in the socketlike membranous concavity on the distal region of the palpifer. On the distal membrane of the maxillary palpus are usually eight minute sensillæ, as shown in Plate 3, fig. 18.

The labium is represented only by the dentated mentum, completely losing its palpi and membranous structures as is generally the case in the Chironomidæ. The mentum (Plate 2, fig. 8) is broad, thickly chitinized, with eleven teeth, including the large median and a pair of the most-lateral minute teeth. The setæ are wanting. The submentum, which is usually known as the fanlike lobe, is completely atrophied.

The hypopharyngeal structures (Plate 3, fig. 15) are comparatively well developed. The dorsal surface of the hypopharynx is membranous and provided with numerous spines, which are directed backwards. The lateral sides of the hypopharynx are supported by a pair of elongated sclerites, pharyngea-lingulæ, which are provided with two tendons on each caudal end that may be homologous with the linguacuta and paralingua tendon, being the pharyngea tendon atrophied. The salivos is found between the cephalic ends of the pharyngea-lingulæ and supported by the salivia. The salivia consists of two thinly chitinized plates; the dorsal plate is broad, while the ventral is narrow, and the two plates are directly connected with the cephalic ends of the pharyngea-lingulæ on their lateral corners.

The common salivary duct is comparatively short and distinctly dilated before the aperture. The ventral side of the hypopharynx is represented by the ventral plate of the salivia, which is connected with the dorsal side of the mentum by a narrow, delicate, membranous oscula. The special structure composed of the setæ is connected with the ventral plate of the salivia. The setæ of this structure are featherlike, stiff, pale brown, finely serrated on the lateral sides, more or less curved dorsad (Plate 3, fig. 15, *f*), and arranged in five or six rows. The small setæ are arranged on the dorsocaudal region, and the majority of the long setæ are located on the membranous areas near the lateral sides of the ventral plate of the salivia.

THE THORAX AND THE ABDOMEN

Of the three thoracic segments the prothorax is large and the remaining two segments are very small, being smaller than those of the abdomen except for the ultimate one. The setæ are very poorly developed and the great majority of them are very delicate and slender. The distribution of the setæ on the prothorax is somewhat different from that of the following two segments. On the prothorax three pairs of minute setæ are found on the anterior region of the tergum near the cervacoria and two pairs on the sternum near the base of the pseudopods. Of the lateral pairs one pair is long and comparatively distinct, and each consists of two ordinary setæ. On each of the remaining thoracic segments one minute seta is found on the anterior region of the lateral fold and three pairs on the sternum, and often some of these setæ consist of double setæ. The anterior pseudopods are quite contiguous, being incompletely separated by the shallow furrow and provided with numerous, simple, small brown hooklets on the distal region, but on the median furrow the hooklets are quite wanting. These hooklets are arranged on the oval area on each pseudopod, and the majority of them are very minute, but those of the anterior margin are long and slender.

The setæ on the abdomen are also very poorly developed and their distribution is subequal to each of the abdominal segments except for the two posterior ones. Generally, on the abdominal segment, there are two pairs on the tergum of which the anterior is large, a long single seta on the posterior region of the lateral fold, two pairs on the sternum of which the posterior is distinct,

and two simple setæ on the lateral side of the sternum close to the lateral fold. On the ninth abdominal segment there are two pairs of conspicuous setal groups on the posterior region of the tergum. Each setal group consists of two long stiff ordinary setæ growing from a common basal ring not provided with a common basal tubercle, differing in this from most species of the Chironomidæ. These caudal setæ are thought to be inconspicuous in certain related species, judging from the figures given by Johannsen and Saunders. The sternum of the ninth segment usually is not provided with setæ, but in the male on the meson of the sternum there is a slight furrow, which indicates the rudiment of the genital aperture, and in the female the genital rudiment is found between the eighth and ninth sterna. The ultimate segment is very small; there is one pair of ordinary setæ on the posterior region of the tergum and a single seta on the lateral side. The posterior pseudopods are comparatively short, but strong, deeply separated from each other, and each is provided with nineteen chitinized hooks on its distal region. These hooks are various in size, not serrated but all simple, arranged into about three circular rows on the distal end, and those of the peripheral rows are smaller and more sharply curved than those of the inner rows. The anal and caudolateral gills are all wanting as in the marine forms in general.

MORPHOLOGY OF THE PUPA

GENERAL REMARKS

The pupa is cylindrical, and both ends are obliquely truncated and more or less flattened. These oblique surfaces of the extremities are more thickened than in the other parts. In all probability these structures mainly serve for the protection of the quiescent pupa in the open cylindrical nest case. Especially, the peculiar abdominal termination is thought to serve partially to avert the danger of the pupa being washed away from the unclosed nest by waves, together with the small paired hooks provided on the ventral side of the caudal extremity, besides serving as a piston in the tube to force the pupa out to the surface when it is ready to emerge, as suggested by Saunders. Terry described this terminal structure as a suckerlike structure, but Saunders said that no such function can be ascribed to it.

Although neither Terry nor Saunders has mentioned it, in both sexes of the present species there is a pair of small but distinct hooks on the ventrocaudal side of the anal disc, as in *T. sanctipauli* and *T. minor*. This chitinized anal disc is thought to be an obvious character for the group including *Telmatogeton* and *Paraclunio*, differing from the group including *Clunio*, although the immature forms of the other genera of the Clunioninæ are little known.

The coloration of the pupa differs with the stage of development; in the early stage it is pale yellowish and semihyaline, darkening gradually on the anal disc, head, thorax, wings, and legs, and before the emergence the entire body appears dark brown. The pupal exuvia is pale brown on the head, thorax, anal disc, and sheaths of wings and legs and quite hyaline on the abdomen. The sexual difference is shown only on the genital sheaths; on the other structures it is very obscure.

In comparison with the other known pupal forms of *Telmatogeton*, the following structures of *T. japonicus* may be pointed out as the distinct differences: Head not distinctly bilobate apically, abdominal segments not provided with the anterior transverse shagreened bands, first abdominal segment without the paired lateral lobelike prominences, differing in this character from *T. sanctipauli*, anal disc of the female not distinctly elongated, differing in this from *T. minor* and *T. sanctipauli*, and prothoracic respiratory organ characteristic in shape for the species.

THE HEAD

The head (Plate 1, figs. 1 to 3) is comparatively broad, flattened and rugous on its surface, and situated on the ventrocephalic end of the body.

The sheaths of the antennæ are small, arising from the cephalic margin of the head, extending along the cephalic margin of the head but not far beyond the middle of the lateral margin of the vertex, and the sheaths are shallowly constricted according to the segmentation of the adult antennæ. On the dorsal side at the base of the antennal sheaths is a pair of conspicuous setæ, and there is a pair of minute papilliform projections on the dorsomeson of the head.

The ventral surface of the head is divided by the shallowly depressed epicranial suture into the lateral halves of the vertex

and the median frontoclypeus. This epicranial suture is never split in the process of emergence, and the imaginal head comes out through the cervical opening in this species. The area of the compound eye is very large, somewhat reniform, and hyaline in the exuvia. There is a pair of small setæ on the caudal side of the vertex. The frontoclypeus is large, somewhat triangular, and devoid of sensory and ordinary setæ.

The labral sheath is small; the labial sheaths are minute and separated from each other. The sheaths of the maxillary palpi are comparatively large for the small adult palpi, closely extended along the caudal margin of the vertex, and reach as far as the lateral margin of the head.

THE THORAX

The cephalic half of the thorax in height suddenly decreases forwards. The middorsal suture is distinctly marked throughout the prothorax, præscutum, scutum, and scutellum. This suture and a transversal suture of the cervacoria, which is shown by a chained line in Plate 1, fig. 2, are split in the process of emergence. The thoracic appendages are tightly held close to the ventral side of the body. The lateral margin of the thorax, cephalad of the wing base, is distinctly folded ventrad, forming a thickly chitinized ridge.

The prothorax is not distinctly demarcated from the mesopræscutum, and on its meson it seems to be separated into triangular lateral halves by the prolonged præscutum in the dorsal aspect. On the lateral margin of the pronotum is a pair of broad, flattened, ax-shaped, respiratory horns. The horns are closely similar in shape and structure to those of *P. alaskensis* described by Saunders. The tracheal trunk within a horn is dark brown, distinctly dilated, cylindrical, and slightly constricted before the opening. The opening is cuplike, provided with a dark ring and fringed processes of the lip, which are radially arranged. On the dorsal side near the base of the prothoracic respiratory horn there is usually an isolated seta and two closely arranged setæ.

The dorsum of the mesothorax consists of the scutopræscutum, scutellum, and postscutellum. The former two regions are rugous and indistinctly separated from each other by an incomplete shallow depression, but the last region is distinctly demarcated by a deep transversal furrow and quite smooth.

On the posterior part of the scutopræscutum there are two pairs of minute and a pair of distinct setæ, which are arranged transversally before the scutellum. A single distinct seta is found in the position corresponding with the adult prealar setæ. The scutellum and postscutellum are devoid of setæ. Between the postscutellum and the base of the wing the parascutella is partially visible in the dorsal aspect. The dorsum of the metathorax is not visible externally, being deeply hidden within the invagination between the thorax and abdomen.

The sheaths of the wings are extended ventrocaudad close along the body, ending before the caudal margin of the second abdominal sternum, and the distance between the tips of the wing sheaths is comparatively short. The anal angle of the wing sheath is well developed and the tip of the sheath comparatively sharp.

The sheaths of the legs do not extend caudad beyond the caudal margin of the second abdominal sternum as in the wing sheaths. The major parts of the paired sheaths of the fore and middle legs, including the tibiæ and tarsi, are extended caudomesad, forming a V, but not closely contiguous on their distal regions. Moreover, the sheaths of the fore and middle legs on one side are arranged in parallel position. The foreleg sheath is extended along the cephalic margin of the wing sheath and entirely visible in the ventral aspect, while the tarsal region of the middle-leg sheath is hidden under the wing sheath and ended before the tip of the foreleg sheath. The major part of the hind-leg sheath is not visible externally, being hidden under the preceding legs and wing. Under the wing sheath the hind leg is turned thrice, ending near the tip of the wing sheath, and the distal three tarsal joints of the hind leg are arranged along the caudal margin of the wing sheath and externally visible.

THE ABDOMEN

The cephalic seven segments are normal in type and subequal in shape and structure to each other, while the remaining terminal segments are highly modified for the genital sheaths and anal disc.

Generally an abdominal segment is provided with a U-shaped marginal chitinization each on the tergum and sternum, paired pale brown spinous patches on the lateral sides near the ends of the arms of the U-shaped chitinization, and several delicate

minute setæ. The arrangement of the setæ is as follows: Two pairs on the dorsocephalic region, one pair on the dorsocaudal, one pair on the ventrocephalic, two pairs on the ventrocaudal region, and on the lateral side two setæ on the cephalic region and a single seta on the caudal region. The first, second, third, and seventh segments are somewhat different in these cuticular structures. The ventral U-shaped chitinization is not present on the cephalic two sterna; the dorsal U-shaped chitinization is widely interrupted on the meson of the first tergum by the intruding postscutellum, being represented by a pair of separate lateral arms; the ventral chitinization of the third segment is also interrupted slightly by the special large, brown, oval, spinous patch; the setæ on the dorsocaudal region are usually wanting on the first and seventh segments, and the small, spinous, lateral patches are wanting on the first, second, and seventh abdominal segments.

The anal disc (Plate 1, fig. 5) is oval, more pointed on its caudal region in the female than in the male, thickly chitinized, composed of roughened chitin corrugated along the margin, and divisible into two parts by a deep furrow. These two parts are slightly movable along this furrow, and they are held at a different angle to the body axis, the upper part being almost perpendicular and the lower distinctly oblique (Plate 1, fig. 3). The upper part is lunate. The convex margin is heavily thickened, irregularly dentated into strong spines, and usually provided with two pairs of strong setæ. The surface of this region is distinctly roughened by numerous minute depressed dots and provided with two small setæ along its margin. The lower part is large and fringed with a row of slender setæ on its thickened margin. The dorsal surface of this part is very slightly elevated caudad on the meson, entirely covered with minute spines, and provided with small, strong, scattered spines, U-shaped brown markings on the meson, and two pairs of large and small setæ on the depressed areas. On the ventral side there are many large setæ, which are attached to the tubercles on the marginal area, and a pair of strong hooks on the caudal end, curved cephaloventrad.

The terminal segment just before the anal disc is very narrow, especially on the tergum, and provided with several slender setæ on the ventrocaudal margin, and in the male pupal exuvia there is a brown marking on the ventrocephalic area, as shown

in Plate 1, fig. 4. The sheaths of the genital structures are on the ventral side of the anal disc. In the female the genital sheaths are pointed (Plate 1, fig. 1) and in the male blunt (Plate 1, fig. 4). In the female the sheaths of the ovipositor are very small, provided with about four small setæ on the base, and the paired sheaths are contiguous, forming a double-headed papilliform projection at the caudal end. The sheaths of the cerci are also quite contiguous with each other, forming a large common lobe, which is devoid of setæ. In the male the sheaths of the claspers are comparatively large, forming a pentagonal common lobe, which is deeply depressed on the meson and devoid of setæ.

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ILLUSTRATIONS

[Drawings by M. Tokunaga.]

TELMATOGETON JAPONICUS TOKUNAGA

PLATE 1

FIG. 1. Female pupa, ventral aspect.
2. Female pupa, dorsal aspect.
3. Female pupa, lateral aspect.
4. Male pupa, genital sheath, ventral aspect.
5. Male pupa, anal disc, caudal aspect.

PLATE 2

FIG. 6. Full-grown larva, lateral aspect.
7. Larval head capsule, dorsal aspect.
8. Larval head capsule, ventral aspect.
9. Larval antenna, lateral aspect.
10. Larval labrum-epipharynx, cephalic aspect.
11. Various hooklets of larval epipharynx.
12. Premandible, mesal aspect.

PLATE 3

FIG. 13. Sinistral larval mandible, dorsal aspect.
14. Sinistral larval mandible, ventral aspect.
15. Larval hypopharynx, dorsal aspect; *f*, featherlike setæ of hypopharynx.
16. Sinistral larval maxilla, dorsal aspect.
17. Sinistral larval maxilla, ventral aspect; *a* to *e*, various cuticular structures.
18. Larval maxillary palpus.

TEXT FIGURE

FIG. 1. Distribution of various littoral animals associated with the green alga on the surface of a piece of stone that shows a high population of the insect *Telmatogeton japonicus* Tokunaga.

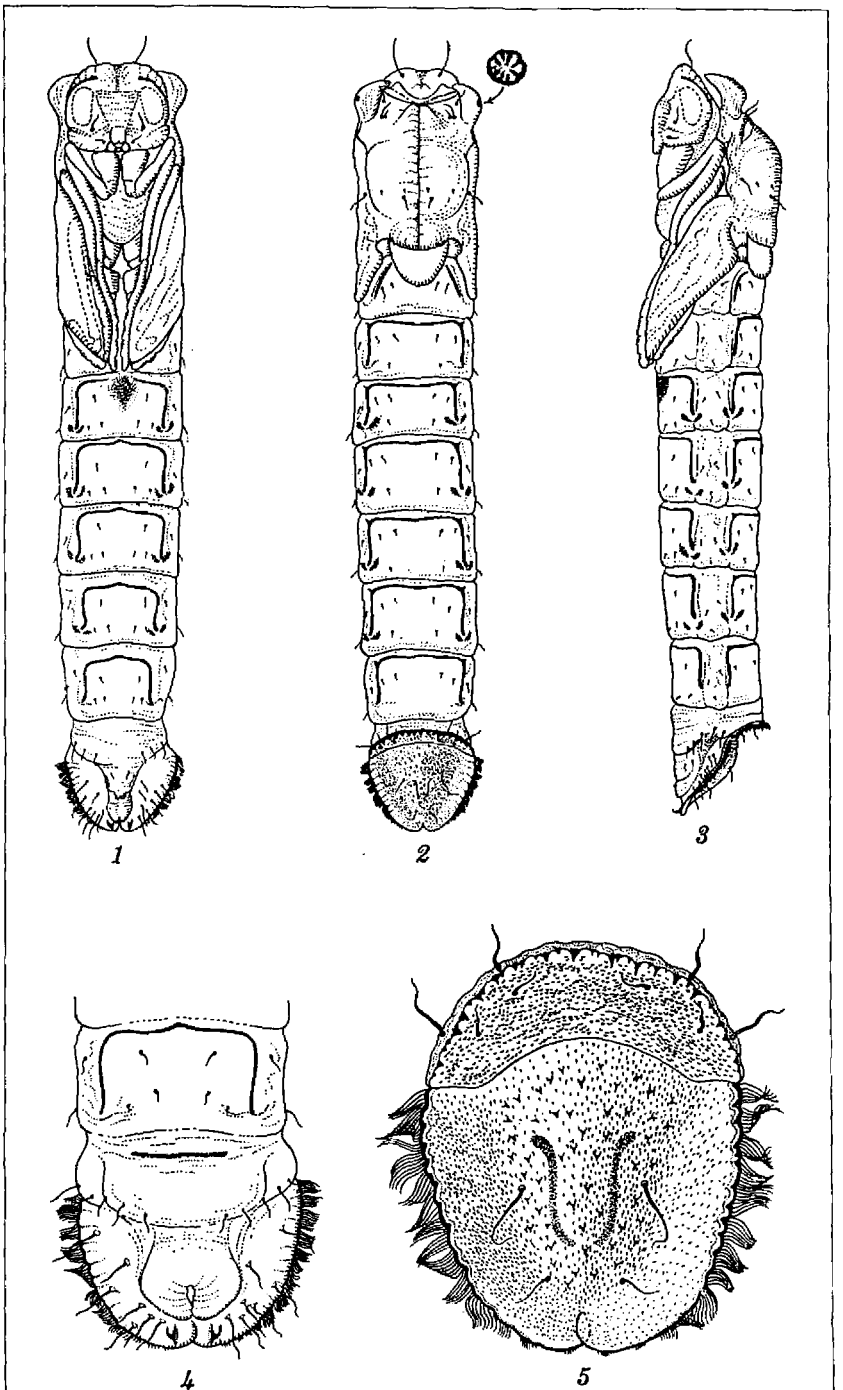
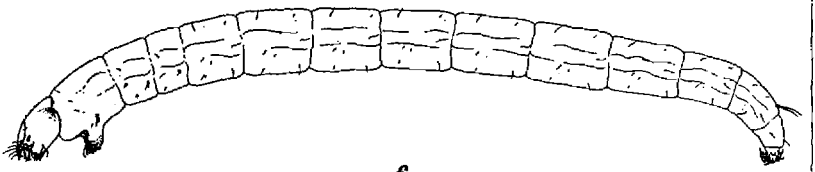


PLATE 1.



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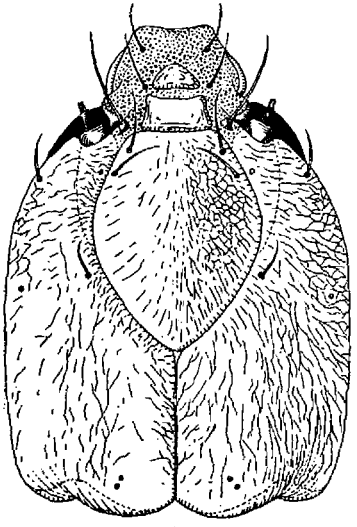

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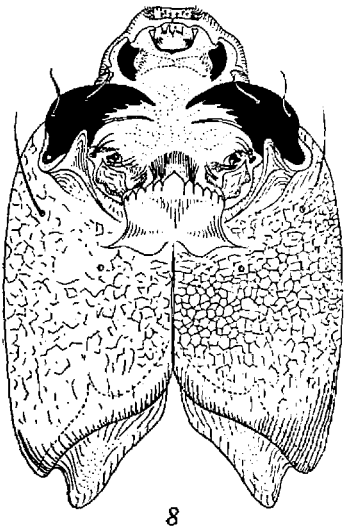

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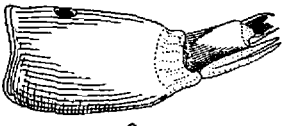

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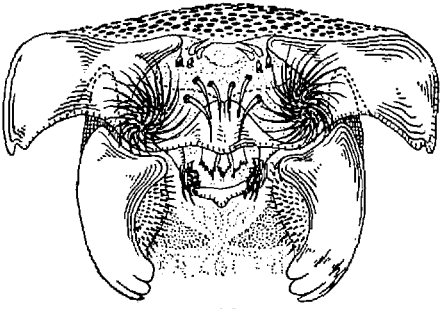

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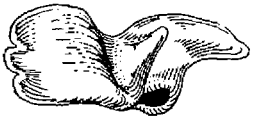

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PLATE 2.

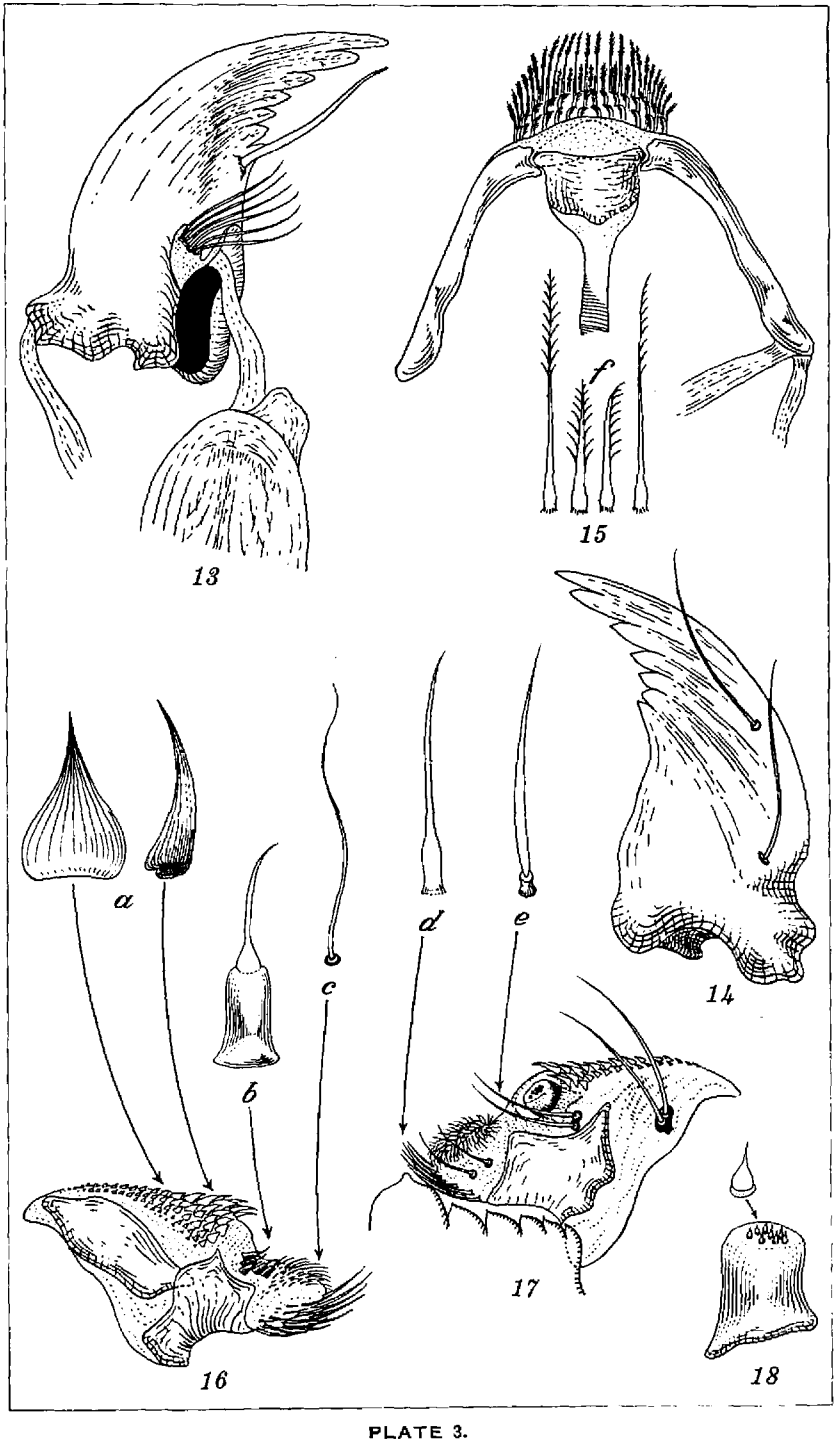

PLATE 3.