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ON THE LIFE-HISTORY OF TWO SPECIES OF LEPTOCERID CADDIS-FLIES INJURIOUS TO THE RICE-PLANT*

BY

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[With four text-figures]

It is usual to consider that caddis-flies are beneficial insects because their larvae are not only most important food materials for fresh-water fishes, but also play a rôle in the control of aquatic weeds. As an exceptional case, the larvae of *Limnophilus flavicornis* FABRICIUS have been regarded by ORMEROD (5)¹⁾ and THEOBALD (6) as one of the most serious pests in water-cress culture in England. In Japan, however, since MATSUMURA (4) recorded *Setodes* sp. in 1899 as a pest in lowland rice-fields in the Province of Ishikari, Hokkaido, serious damages have often been caused by this and other species of Trichoptera in certain rice-fields in Hokkaido and Honshu. As the writer (2) pointed out in 1929 these injurious caddis-flies can be classified into at least four species as follows:

1. *Setodes argentata* MATSUMURA
2. *Oecetis nigropunctata* ULMER
3. *Limnophilus correptus* MACLACHLAN
4. *L. amurensis* ULMER

In this paper it is the purpose to give a preliminary note on the life-history and habits of the former two, viz. Leptocerid species. The larvae of these two insects are generally known as "Doro-tsuto-mushi" (mud-case bearing worms) by farmers in Hokkaido.

Setodes argentata MATSUMURA

Setodes argentata, MATSUMURA (as MACLACHLAN), Cat. Inj. Ins. Jap., 24 (nom. nudum) (1906); MATSUMURA, Syst. Ent., I, 194 (1907); MATSUMURA, Manual Inj. Ins. Jap., I, 146-147, Fig. 149 (1910); TAKAHASHI, Inj. Ins. Crops, 94-96 (1916); MATSUMURA, Appl. Ent., I, 478-479, Pl. XIX-Fig. 1 (1917); MATSUMURA, Manual Inj. Ins. Jap., Rev. ed., I, 416-418, Fig. 146 (1920); MURATA, Ins. inj. Cereals, 423-424, Pl. III-Fig. 1 (1927); OKAJIMA, Proc. Third Pan-Pacific Sci. Congr., II, 2064-2065 (1928);

* Contributions from the Section of Entomology, Hokkaido Agricultural Experiment Station.

1) Reference is made by italic number in parenthesis to "Literature cited."

[Trans. Sapporo Nat. Hist. Soc., Vol. XIII, Pt. 3, 1934]

KUWAYAMA (as MATSUMURA), Bul. Hok. Agr. Exp. Sta., XLVII, 5-16, Figs. 1-6 (1928); KUWAYAMA, Rep. Jap. Assoc. Advanc. Sci., V, 196, Fig. 2A. C.D (1929); MATSUMURA, Agr. Ent., 134, Pl. VI-Fig. 1 (1930); KUWAYAMA, Icon. Ies. Jap., 1510, Fig. 2987 (1932); MATSUMURA, Cons. Jap. Inj. Ins., 353-354, Fig. 146 (1932); TATEISHI, Mushi, V, 109 (1932).

Setodes sp., MATSUMURA, Jap. Ent., 81 (1893); MATSUMURA, Inj. Ins. Jap., 274-277, Fig. 120 (1893); KUWAYAMA, Bul. Hok. Agr. Exp. Sta., XLII, 43 (1926).

Setodes iris, MATSUMURA (nec HAGEN), Inj. Ins. Crops, 121-122, Pl. VI-Fig. 1 (1927); MATSUMURA, 6000 Illus. Ins. Jap.-Emp., 1130, 1 fig. (1931); MATSUMURA, Illus. Common Ins. Jap., V, 2 & (3), Pl. I-Fig. 7 (1933).

General Distribution: Hokkaido, Honshu, Kyushu.

Adult¹⁾: Length of body, 4.5-5 mm. Expanse, 13-14 mm. Head and thorax deep brown, with dense, long concolorous hairs. Abdomen yellowish green to dark yellow. On the vertex three silvery-white stripes in a Λ -form. Eyes dark brown. Palpi pale brown, with concolorous hairs. Antennae very long, more than twice as long as the fore-wing, the basal half of each joint silvery-white and the apical half blackish gray; basal joint bulbous and grayish brown. On the dorsal parts of the pro- and mesothorax run two silvery-white stripe. Legs yellowish brown; spurs 0-2-2. Fore-wings slender and somewhat acute; membrane pale gray and subhyaline, densely clothed with golden-brown or somewhat fulvous pubescence, and provided with 20 to 22 black-margined silvery-white stripes, scattered over the whole surface, consisting of pubescence, the stripes on the basal half rather long and that on the apical rather short; fringes comparatively long and yellowish brown. Hind-wings acute, smoky-grayish subhyaline, with sparse pubescence, iridescent; neuration fuscous; fringes very long and smoky-gray.

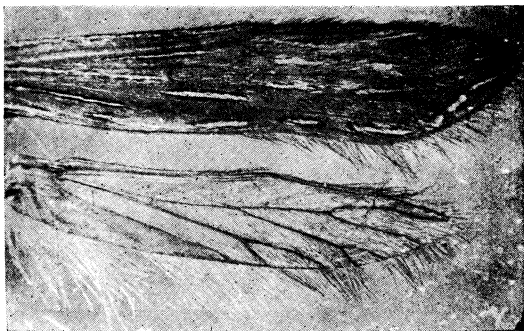


Fig. 1

Wings of *Setodes argentata*

(Ca. $\times 12$)

Egg and egg-mass: More than one hundred and fifty eggs are enclosed in a translucent but slightly dirty brownish spherical mass of jelly, 4-5 mm. in diameter. They are arranged in a spiral inside the jelly. The egg is greenish yellow and about 0.2 mm. in diameter.

Larva: Length, 7-8 mm., and maximum width of abdomen, 1.3 mm., in

1) Description of the genital organs is omitted here being not significant for the purpose of this paper.

the full-grown state. Body in life yellowish green. Head, dark brown in ground colour, with many round blackish spots scattered on it; middle and posterior parts of frons and vicinity of eyes yellowish brown. Eyes black. Antennae distinct, dark brownish. Mouth-part well defined, brownish, mandibles blackish brown in colour, stout and chisel-shaped, deeply grooved, with about five teeth on the inner margin, the middle tooth being very sharp and long. Dorsal plates of prothorax uniform dark brown, with blackish posterior margin; mesothorax with homologous but rather smaller plates; metathorax without distinct chitinous plates. Legs dark brownish, with numerous long swimming hairs; fore-leg the shortest, stout, the hind-leg the longest, slender. The first abdominal segment bearing three spacing humps, the mid-dorsal one being prominent and horn-shaped, while the lateral two are ovoidal with a thick fringe of fine hairs. Gills simple, filamentous and rather small; they occur on the second to sixth abdominal segments, as shown in the following diagram:

1	2	3	4	5	6	7	8	9
	○	○	○	○	○			
	○	○						
	○							
	○ ○	○ ○	○ ○	○				

No distinct lateral line on the abdomen. The terminal segment bears an indistinctly delimited chitinous plate on which about ten brownish spots are scattered, and which is provided with long brownish bristles along the dorso-posterior margin. A pair of fleshy large prolegs bear also several long and short hairs, and each terminates in a movable chitinous brownish drag-hook.

Pupa: Length, 6-7 mm. Width, 1 mm. In life the body bright green, except the head and thorax which are brownish yellow with slight greenish tinge. Eyes reddish brown. Antennae whitish with dark grayish annulations, very long and coiled about the posterior end of the body. Labrum very small, not protruded at the anterior margin which is provided with a few long bristles. Mandibles reddish brown, very long and slender, with small teeth along the curved inner margin. Palpi very long. Both anterior and posterior wing-sheaths similar in shape, very acute at apex, being extended to the middle of the sixth abdominal segment. Legs light yellow, the hind tarsus being very long. Near the anterior margin of each tergum of the third to sixth segments occur two yellowish brown chitinous knobs studded with a few blunt spines, and near the posterior margin of the fifth tergum two additional elliptical homologous knobs are situated. A double line of dark brownish chitin run on both

dorsal and ventral sides of the abdomen. Lateral line of soft yellowish hairs begins on the third segment and forms a loop under the eighth segment. Gills simple as in the larva. The ninth segment is long and slender, and the genitalia of the adult may be seen on the ventral side; this segment terminates with a pair of long spiniform reddish brown processes, which taper suddenly at the middle and are studded with brownish bristles on the distal half.

Case: Length, 9-11 mm. Width, 1-1.2 mm. at the anterior end, 0.7-0.9 mm. at the posterior end. Cylindrical, straight or slightly curved, composed of very fine sand grains and much silk, forming a smooth and very tough case. The anterior edge crosses the long axis of the case at a right angle.



Fig. 2

Case of *Setodes argentata*
(Ca. $\times 4$)

Seasonal history and habits: According to the observations in Hokkaido, this caddis-fly produces only one generation per year. It passes the winter as larva in case hidden beneath the roots of rice-plants and weeds, or not very deep under the ground of the bank of the foot-paths between rice-fields. The larvae leave their hibernating places as early as the middle of May, and commence to feed on the young shoots of rice-plants, especially on roots, being most active in calm and warm daytime. They may continue to injure as late as early July. However, early matured larvae begin to pupate in the middle of June. At the time of pupation, the case is attached to the submerged stem of a rice-plant by silk. The pupal case is closed at both ends with discoid membranes consisting of sand. The anterior closing membrane is provided with a central perforation and the posterior one is located a short distance from the end. After seven to ten days of pupal stage, the adults commence to emerge at the end of June and continue to do so until early September, especially abundantly during July. During this season hordes of adults may be seen among the bushes and trees along the infested rice-fields, literally by thousands. The adult is easily attracted to artificial light in evening. The Kamikawa Branch of the Hokkaido Agricultural Experiment Station at Nagayama, Kamikawa district, Province of Ishikari, attempted to ascertain the time of appearance of the adult by light traps. The following table shows the total number attracted to light during the season from 1925 to 1929 inclusive. Two light trap apparatuses used consisted of an electric lamp of 10 candle power each and additional one used in 1925 consisted of a kerosene lamp of 2 candle power. These lights were placed at the center of the experimental field.

Date Number of adults	June		July						1-5
	21-25	26-30	1-5	6-10	11-15	16-20	21-25	26-31	
Total number attracted	—	502	3,860	10,101	7,767	4,427	1,534	1,008	6
Percentage of ditto	—	1.66	12.79	33.48	25.75	14.67	5.09	3.34	0.02

August					September			
6-10	11-15	16-20	21-25	26-31	1-5	6-10	11-15	16-20
—	—	277	253	388	33	11	—	—
—	—	0.92	0.84	1.29	0.11	0.04	—	—

The eggs are laid in a mass, surrounded by jelly; as many as over one hundred eggs may occur in one mass. These egg-masses are laid on the surface of the water, and as the jelly becomes swollen they deposit on the mud ground. The eggs hatch in about two weeks, and as soon as the larvae develop they commence to form around themselves a case made of minute sand grains mixed with silk. The young larvae in this season do not injure rice-plants, but the hibernated larvae are sometimes very ravenous feeders on rice-plants in the next spring. Usually these caddis-worms injure the rice-plants directly sown in the lowland fields, while the young shoots of rice-plants in the seed beds as well as the plants transplanted from the seed beds are entirely free from this pest.

Oecetis nigropunctata ULMER

Oecetis nigropunctata, ULMER, Deutsch. Ent. Zeitschr., 1908, 345-346, Figs. 4-7 (1908); MATSUMURA, 6000 Illus. Ins. Jap.-Emp., 1130, 1 fig. (1931); KUWAYAMA, Icon. Ins. Jap., 1509, Fig. 2986 (1932); MATSUMURA, Illus. Common Ins. Jap., V, 2 & (3), Pl. I-Fig. 8 (1933).

Oecetis nigropunctatus, KUWAYAMA, Rep. Jap. Assoc. Advanc. Sci., V, 197, Fig. 2B (1929).

General Distribution: Hokkaido, Honshu, Shikoku, Korea.

Adult¹⁾: Length of body, 5-6 mm. Expanse, 16-19 mm. Head and thorax brown, clothed with grayish brown hairs mostly; abdomen bright green in life and yellowish brown in older specimen. Eyes dark brown. Palpi brown, with grayish brown hairs. Antennae long, twice as long as the fore-wing, grayish yellow with narrow fuscous annulations which are less distinct toward the terminal joints; basal joint bulbous. Legs grayish yellow; spurs 0-2-2. Fore-wings slender and subacute, brownish subhyalin, but rather sparsely clothed with pale brownish pubescence; round dark brownish spots on all anastomoses of veins, terminals of veins at the outer margin and also on greater parts of

¹⁾ Description of the genital organs is also omitted here for the reason mentioned before.

transverse veins; these spots are bordered with light coloured portions. In older individuals, the neuration is distinctly brownish, and as the pubescence is entirely lost the wings appear lustrous. The fringes on the outer and posterior margins are dense and dark brown. Hind-wings narrow and much shorter than the fore-wings, grayish hyaline, iridescent, sparsely pubescent with gray, and with dark brownish fringes which are long on the inner margin; neuration yellowish brown.

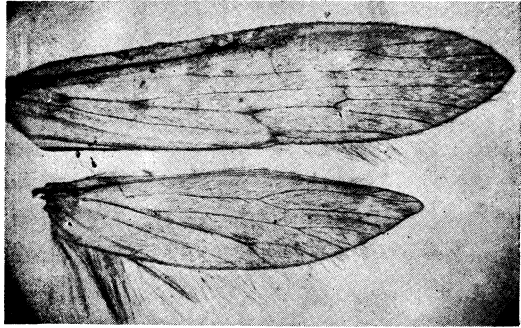


Fig. 3

Wings of *Oecetis nigropunctata*
(Ca. $\times 8$)

Egg and egg-mass: The egg-mass consists of a spherical mass of grayish translucent jelly 5-6 mm. in diameter, in which about 300 eggs are imbedded. The egg is also spherical and about 0.2 mm. in diameter, greenish yellow in colour.

Larva: Length, 8-9 mm.; width 1.3 mm. Head large as compared with the width of the abdomen. Body in life light green. Ground colour of the head pale straw-yellow with dark brownish spots on the dorsal surface, except brownish frons. Eyes black. Antennae rather long, yellowish brown. Labrum comparatively large, trapezoidal in shape, with a deep cleft at the middle of the anterior margin, on this cleft four notches are engraved making three dentations. Mandibles reddish brown, broad at base, sharply pointed, and curved inward, with two large pointed teeth at the middle of the inner margin, and many small denticles in the portion from the base to the first tooth. Prothoracal shield very large, transverse, and straw-yellow mottled with oval brownish spots on the posterior half. Dorsal plates of mesothorax straw-yellow, with dark oval spots; metathorax without chitinous plates. Legs light yellow, the apex of each segment blackish. Fore-leg somewhat broad and flat; the middle longer and less stout; the hind the longest of all and slender; both the latter two provided with numerous long swimming hairs. First abdominal segment has a prominent conical dorsal spacing hump and two ovoidal lateral humps provided with a thick fringe of fine hairs pointed forward. Lateral fringe present, but rather thin. Terminal segment provided with a few long bristles along the posterior margin, but without chitinous dots. Large and long colourless gills arise singly on each of the second to eighth abdominal segments inclusive; arrangement as shown in the following diagram:

1	2	3	4	5	6	7	8	9
	o	o	o	o	o	o	o	
	o							
	o	o	o	o	o	o	o	

Prolegs not chitinized, bearing many microscopic hairs at the base, and provided with a few long dark brownish bristles; drag-hooks reddish brown, stout, acutely curved and sharply pointed.

Pupa: Length, 8-9 mm. Width, 1.8 mm. Body in life bright cobalt green. On the eve of emergence the head and thorax become brownish and the wing-sheaths are tinged with black, and legs reddish brown. Eyes dark brown. The long antennae are coiled about the posterior end of the body, passing about twice around. Labrum comparatively large, quadrate, rounded at the anterior angle, with a triangular protuberance at the middle of the anterior margin, and with a few long hairs. Mandibles reddish brown on the apical half, longer than the labrum, broadly based and sharply pointed, curved inward, with fine denticles along the inner margin, the basal four or five being comparatively large and pointed. Palpi very long. The anterior and posterior wing-sheaths similar in shape, sharply pointed. Legs yellowish brown. A pair of dorsal chitinous knobs studded with two curved brownish spines are arranged on the anterior part of the third to seventh abdominal segments respectively. Two additional transverse chitinous knobs which are provided with six curved brownish spines appear along the posterior margin of the fifth segment. Two dark brownish chitinous lines extend down on both the dorsal and ventral sides of the abdomen. Lateral line of soft yellowish hairs begins on the third, and forms a loop under the eighth segment. The gills simple and filamentous as in the larva, and the gill formula is almost identical. Two small groups of bristles on the dorso-lateral sides of the ninth segment, pointed forward, evidently holding the coil of the antennae in place. The genitalia of the adult may be seen on the ventral side. The posterior end of the body is terminated with two chitinous spiniform light brownish appendages which are very long measuring about 1.5 mm.



Fig. 4

Case of *Oecetis nigropunctata*

(Ca. $\times 4$)

Case: Length, 10 mm. Width, anterior, 2 mm., posterior, 0.8-1 mm. An elongate conical case of rather fine sand, smooth as in *Setodes argentata*, neatly fitted; the posterior half often curved. The anterior edge crosses the long axis of the case at an angle of about 60° .

Seasonal history and habits: The life-history of this species is very similar to that of *S. argentata*, and the larvae of both always live in the same rice-field. There is only one generation in a year, and it overwinters in the larval stage in its case as does the preceding species. The larvae leave their winter-quarters early in the spring, and commence to feed ravenously on the young shoots of rice-plants, and may continue to do so as late as early July. On the other hand, the pupation begins to occur during the middle of June. The adults begin to appear during a period from the end of June to August; they are especially abundant during the middle part of August, and disappear by the middle of September. Using the same light trap apparatus as in the survey of *S. argentata* during 1925 to 1929, the Kamikawa Branch of the Hokkaido Agricultural Experiment Station examined the number of adults attracted during the above-mentioned period. The data are summarized in the following table:

Date Number of adults	June		July						I-5
	21-25	26-30	I-5	6-10	11-15	16-20	21-25	26-31	
Total number attracted	260	752	6.009	9.947	12,515	6.650	6,644	4,938	4,708
Percentage of ditto	0.10	0.28	2.23	3.69	4.65	2.47	2.47	1.83	1.75

August					September			
6-10	11-15	16-20	21-25	26-31	I-5	6-10	11-15	16-20
23,049	48,514	137,918	5,321	1,567	390	177	40	5
8.56	18.07	51.19	1.97	0.58	0.18	0.06	0.01	0.00

Eggs are deposited in a mass on the surface of water from early July to late August. The egg-mass is spherical in shape and consists of jelly. About three hundred eggs are imbedded in a mass and sink down to the bottom of the water by swelling of the jelly. Eggs hatch in from one to two weeks, and the larvae live in the water, feeding on weeds or decayed plant debris, attaining nearly a half length of the full-grown state. The injuries done by this insect are also restricted to the rice-plants directly sown in the lowland fields.

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