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The second record of ectoparasitic Chironomidae on Trichoptera from Japan, *Polypedilum (Cerobregma) kamotertium* Sasa, 1989

(Insecta, Diptera, Chironomidae, Chironomini)

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Studies on the immature stages of *Polypedillum kamotertium* Sasa from northern Japan suggest that larvae are ectoparasitic on the prepupae/pupae of *Hydropsyche orientalis* Martynov and *Cheumatopsyche* sp.(p). A description is offered for the larva, pupa and adult female of *P. kamotertium*, with a redescription of adult male. Biology and distribution of chironomid are also given.

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Introduction

The larvae of *Polypedilum (Cerobregma) kamotertium* are found to be ectoparasitic on caddis flies, *Hydropsyche orientalis* Martynov and *Cheumatopsyche* sp.(p), in northern Japan, Aomori Prefecture. The process of the chironomid larval parasitism to the host is similar to that of *Eurycnemus nozakii* (Orthocladiinae) on *Goera japonica* Banks (T. Kobayashi 1994, 1995, 1998). It is probable that the chironomid larva invades the prepupal retreat of caddis fly, eats the host, pupates in the host case, the pupa then swims out of the case, and the adult midge emerges. The male of *P. kamotertium* was originally described by Sasa (1989) from Kyoto. One of the authors (T. K.) found the adults of the species at Todorokikyo, Nagasaki and most recently found the larvae in trichopteran pupal cases from Kogai River, Tochigi. Hirabayashi et al. (2001) reported the adults in Ueda, Nagano. The species thus is known from five places in Japan. Redescription of the male adult and the first descriptions of the female adult, pupa and larva are given together with the biology. Sæther & Sundal (1999) erected the subgenus *Cerobregma* in the genus *Polypedilum*, including *P. kamotertium* and *P. okigrandis* Sasa, 1993. The present paper describes the adults, pupa, and larva of *P. (C.) kamotertium* based on material from Tsugaru-Juniko, along with its ectoparasitic ecology on caddisflies. Type specimens from Kyoto and some material from Todorokikyo, Nagasaki, are included.

Methods

P. (C.) *kamotertium* specimens were collected from the outlet stream (40°33'35"N, 139°58'05"E) of Lake O-ike in the Tsugaru-Juniko Lakes, Aomori Prefecture on 14 August 2001. Water temperatures at the site exceed 25° in summer and fall below 1° in winter, and hydropsychid caddisflies overwhelmingly dominate the benthic

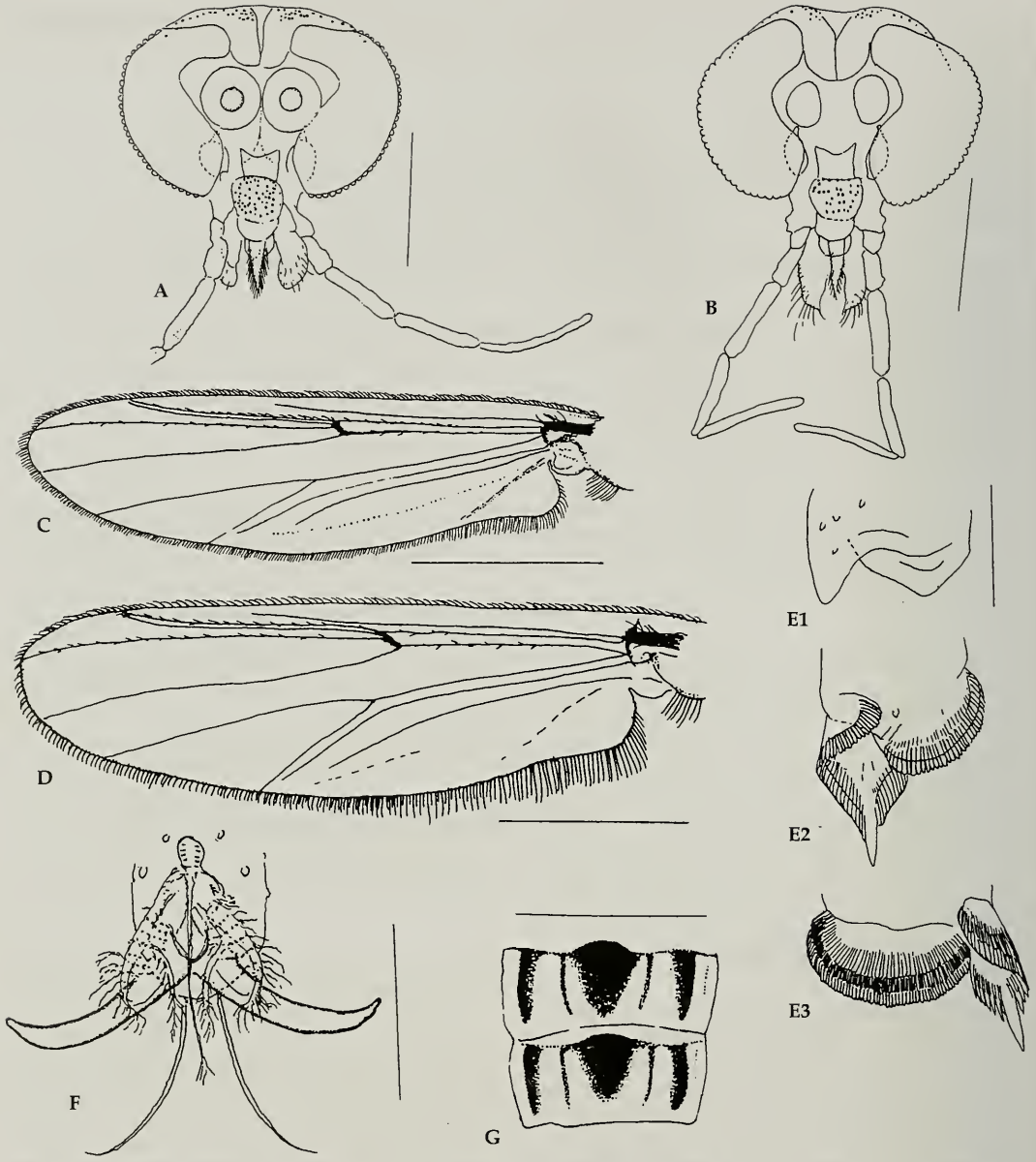

Fig. 1. *Polypedilum kamotertium* Sasa. Adult. **A.** ♂, head. **B.** ♀, head. **C.** ♂, wing. **D.** ♀, wing. **E.** ♂, tibial scale and combs 1: PI, 2: PII, 3: PIII. **F.** ♂, tip of ta5 of PI. **G.** abdominal tergites II and III. Scales (μm): A: 400. B: 400. C: 1000. D: 1000. E: 100. F: 50. G: 1000.

invertebrate assemblage of the stream (Ohtaka & Takahashi 1999). Twenty-three larvae of *P. kamotertium* were taken from hydropsychid trichopteran pupal cases and kept in small vessels. Twenty-one developed into pupae, and six male and five female adults emerged. The chironomid specimens were preserved in 70 % alcohol.

All adults with pupal exuviae and five larvae were mounted on slides in gum-chloral solution after being cleared in about 10 % hot KOH, and dissected following the method of Pinder (1989). The holotype and the paratype of *P. kamotertium* and five slide specimens of male adults from Todorokikyo, Nagasaki were also examined. All measurements, ratios and terminology are in general follows those of Sæther (1980).

To understand the parasitic ecology of *P. kamotertium* on trichopterans, a total of 569 hydropsychid pupal

cases were collected from the above-mentioned stream in August 2001. Trichopteran prepupae or pupae and *P. kamotertium* recovered from the pupal cases were examined. The trichopterans were identified after Tanida (1985) on the basis of the larval exuviae remaining within the pupal cases.

Material examined

Japan; Aomori Prefecture, outlet streams Tsugaru-Juniko Lakes, 6♂♂, 5♀♀, each with pupal exuviae, and 5 larvae, viii.2001, A. Ohtaka and T. Takahashi. Todorokikyo, Nagasaki, light trap, 5♂♂, X.2000, H. Suzuki. Kyoto, Kamo River, light trap, ♂ holotype (163: 04), ♂ paratype (163: 05), X.1988, M. Sasa.

Material from Tsugaru-Juniko deposited in the authors' collections; types and material from Todorokikyo in the Sasa collection of The National Institute for Environmental Studies.

The following descriptions are based on material from Tsugaru-Juniko Lakes. The wing length, chaetotaxy, and proportions of antennae, palpomeres and legs are compared to the type specimens (from Kyoto) and material from Todorokikyo, Nagasaki, in Tab. 1-3.

Description

Adult male.

Colour. Scutum largely brownish yellow, darker along median suture, lateral vittae dark caudally and laterally; scutellum yellow, postnotum dark brown; abdominal tergite I largely dark brown, II-VI with dark pigmentation laterally and medially (Fig. 1G), VII-hypopygium brown. Legs light brown, except femora and tibiae of mid and hind legs with dark rings at basal ¼. Wing without pigmentation. Wing length. 2570-3120 µm (Tab. 1).

Head (Fig. 1A). Dorsomedial eye extension well developed. Frontal tubercles absent. Tentorium (Fig. 1A) bottle-shaped, 140-150 µm long (148 µm, n=5), 75-100 µm wide (84 µm, n=5). Antenna (Tab. 1) with

Tab. 1. Wing length, antennal and palpal proprotions. Range (number examined) and average in µm.

Male imagines

	Wing length	Antenna		
		basal seg.	distal seg.	AR
Tsugaru-Juniko	2570-3120(5)	562-667(5)	654-745(5)	1.05-1.27(5)
	2883	**603**	**702**	**1.17**
Todorokikyo	2600-3420(5)	540-640(5)	590-780(5)	1.05-1.22(5)
	2808	**592**	**670**	**1.13**
Kyoto (types)	2560-2930(2)			
	2745	**520**	**630**	**1.21**

	Palpomere				
	1	2	3	4	5
Tsugaru-Juniko	50-70(5)	100-120(5)	205-250(5)	215-260(5)	280-380(5)
	55	**107**	**239**	**233**	**316**
Todorokikyo	50-70(3)	80-105(3)	210-260(3)	200-270(3)	260-360(3)
	57	**95**	**233**	**227**	**300**
Kyoto (types)		100-110(2)	220-250(2)	210-250(2)	260-300(2)
	70	**105**	**235**	**230**	**280**

Female imagines

	Wing length	Antennomere					
		1	2	3	4	5	6
Tsugaru-Juniko	2640-3250(5)	80-110(4)	100-125(4)	120-150(4)	110-130(5)	95-110(5)	172-225(5)
	2890	**98**	**114**	**131**	**122**	**104**	**198**

	Palpomere				
	1	2	3	4	5
Tsugaru-Juniko	60-75(5)	90-120(5)	240-260(5)	230-260(5)	330-360(5)
	68	**108**	**248**	**250**	**350**

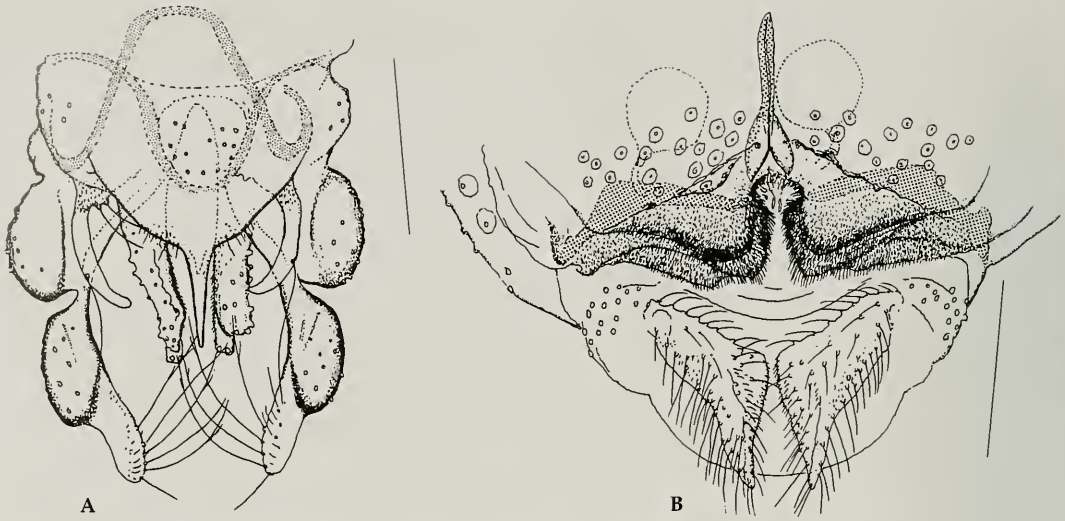

Fig. 2. *Polypedilum kamotertium* Sasa. Adult. **A.** ♂, genitalia. **B.** ♀, genitalia. Scales (μm): 400.

13 flagellomeres, groove beginning at flagellomere 2. Palpomere 3 with a few sensilla subapically. AR 1.0-1.2, length of palpomeres as in Tab. 1. Numbers of clypeals and temporals as in Tab. 2.

Thorax. Antepronotal lobes narrowly separated medially. Antepronotals present. Acrostichals biserial, dorsocentrals and scutellars multiserial. Scutal tubercle absent. Scutum without notch. Numbers of thoracic setae as in Tab. 2.

Wing (Fig. 1C). Membrane bare, somewhat blueish, without pattern. Brachiolum, R, RM, R_1 and R_{4+5} setose. FCu distal to RM. R_{2+3} running close to R_1.

Legs (Tab. 3). LR_1 about 1.1-1.2. Fore tibial scale oval, without spur (Fig. 1E1). Mid and hind tibiae (Figs 1E2, E3) with broad, unspurred anterior comb separated from posterior comb with elongate spur (about 80 μm long). Mid ta_1 without subapical sensilla chaetica. Pseudospurs absent. Pulvilli large and bifurcate (Fig. 1F).

Abdomen. Densely setose with elongate setae. Tergite VIII strongly tapered basally.

Hypopygium (Fig. 2A). Anal tergite bands very well developed, fused posterior to anal tergite setae. Number of anal tergite setae as in Tab. 2. Tergite IX apically rounded. Anal point well developed, slender and evenly tapering toward apex. Superior volsella bare, parallel-sided, slightly arched medially, bearing 1-4 strong subapical and/or midbasal,

Tab. 2. Numbers of setae. Range (number examined) and average.

	Cly	Temp	Aps	Ac	Dc	Pa	Scts	Anal tergite setae	Mediolateral setae on Gs	Lateral setae of SVo	Basal setae of SVo
Male imagines											
Tsugaru-Juniko	52-82(5)	19-38(6)	6-14(6)	31-51(4)	33-58(9)	12-18(9)	41-60(6)	16-31(6)	4-7(11)	1-3(11)	2-13(10)
	60	**27**	**12**	**39**	**45**	**16**	**49**	**23**	**6**	**1.7**	**7.1**
Todorokikyo	57-64(5)	22-30(5)	4-15(9)	28-40(5)	27-44(5)	12-17(5)	42-79(5)	17-27(5)	4-6(9)	1-4(10)	3-7(10)
	61	**25**	**10**	**34**	**33**	**14**	**52**	**21**	**5**	**2.8**	**5.3**
Kyoto (types)	59-67(2)	25(2)	9-14(4)	36-38(2)	28-35(2)	14-19(2)	45-47(2)	27-28(2)	5-6(4)	1(4)	2-4(3)
	63	**25**	**12**	**37**	**32**	**17**	**46**	**28**	**5**	**1.0**	**3.0**
Female imagines											
Tsugaru-Juniko	40-74(5)	23-28(4)	3-8(4)	31-52(4)	49-68(4)	17-20(4)	51-60(4)	–	–	–	–
	56	**25**	**6**	**39**	**57**	**18**	**54**	–	–	–	–

lateral setae which are 100-150 µm long (Tab. 2); number of these setae per volsella highly variable among individuals. Superior volsella also with 2-13 basomedial setae (Tab. 2) and microtrichiose basal area. Inferior volsella parallel-sided, reaching as far posterior as the anal point, divided into 2 apical lobes, dorsal lobe with much more setae than ventral lobe, some of these setae split. Gonocoxite bulbous; division between gonocoxite and gonostylus deeply constricted. Gonostylus with swelling in basolateral ⅔, abruptly narrowed at distal ⅓; bearing 4-7 extremely long (100-200 µm), uniserial subdistally, inward-directed, apically split setae.

Adult female.

Colour. As in male. Wing length 2640-3250 µm (Tab. 1).

Head (Fig. 1B). Dorsomedial eye extension weak. Frontal tubercles absent. Tentorium similar to that of male. Flagellomeres I and II occasionally appearing as single segment when boundary is indistinct. Lengths of flagellomeres and palpomeres as in Tab. 1. Numbers of clypeals and temporals as in Tab. 2.

Thorax. Dorsal area of pronotum with 1 pair of sensilla campaniformia. Numbers of thoracic setae as in Tab. 2.

Wing (Fig. 1D). FCu slightly distal to RM. Bra-

Tab. 3. Leg proportions. Range (number examined) and average in µm.

PI	fe	ti	ta1	ta2	ta3	ta4	ta5	fLR
Male imagines								
Tsugaru-Juniko	1220-1420(5)	1020-1220(5)	1180-1430(5)	850-1000(5)	790-890(5)	740-890(5)	300-350(5)	1.12-1.21(5)
	1306	**1118**	**1308**	**920**	**836**	**802**	**320**	**1.17**
Todorokikyo	1100-1500(5)	1010-1300(5)	1110-1450(5)	790-980(5)	690-920(5)	650-900(5)	260-350(5)	1.07-1.15(5)
	1230	**1104**	**1220**	**840**	**762**	**722**	**290**	**1.11**
Kyoto (types)	1120-1300(2)	1000-1200(2)	1070-1320(2)	600-900(5)	500-870(2)	360-800(2)	150-320(2)	1.07-1.10
	1210	**1100**	**1195**	**750**	**685**	**58**	**235**	**1.09**
Female imagines								
Tsugaru-Juniko	1400-1700(5)	1180-1370(5)	1470-1800(4)	960-1200(4)	890-1020(4)	780-900(4)	300-370(4)	1.25-1.33(4)
	1558	**1266**	**1613**	**1068**	**960**	**850**	**345**	**1,30**
PII	fe	ti	ta1	ta2	ta3	ta4	ta5	mLR
Male imagines								
Tsugaru-Juniko	1670-1950(5)	1350-1530(5)	650-1100(5)	470-700(5)	380-610(5)	260-390(5)	140-200(5)	0.47-0.76(5)
	1792	**1428**	**842**	**568**	**464**	**320**	**172**	**0.59**
Todorokikyo	1480-1960(5)	1200-1600(5)	620-800(5)	450-500(5)	330-450(5)	230-290(5)	120-170(5)	0.49-0.52(5)
	1642	**1318**	**670**	**478**	**386**	**264**	**142**	**0.51**
Kyoto (types)			590-750(2)	440-500(2)	390-420(2)	250-270(2)	130-160(2)	
	1550	**1250**	**670**	**470**	**405**	**260**	**142**	**0.47**
Female imagines								
Tsugaru-Juniko	1700-2100(5)	1400-1690(5)	700-840(5)	500-550(5)	380-440(5)	260-300(5)	130-200(5)	0.47-0.51(5)
	1882	**1560**	**772**	**526**	**414**	**284**	**170**	**0.50**
PIII	fe	ti	ta1	ta2	ta3	ta4	ta5	hLR
Male imagines								
Tsugaru-Juniko	1690-0970(5)	1330-1590(5)	1000-1150(5)	670-720(5)	550-650(5)	400-420(5)	150-190(5)	0.70-0.75(5)
	1816	**1462**	**1066**	**698**	**606**	**406**	**178**	**0.73**
Todorokikyo	1550-2100(5)	1280-1690(5)	970-1240(5)	620-810(5)	510-700(5)	330-450(5)	140-220(5)	0.73-0.79(5)
	1728	**1392**	**1062**	**674**	**584**	**382**	**181**	**0.76**
Kyoto (types)	1580-1850(2)	1240-1500(2)						
	715	**1370**	**1080**	**700**	**600**	**420**	**180**	**0.72**
Female imagines								
Tsugaru-Juniko	1760-2200(5)	1440-1740(5)	1100-1300(5)	660-800(5)	590-690(5)	380-420(5)	200-220(5)	0.75-0.77(5)
	1940	**1576**	**1192**	**742**	**634**	**402**	**208**	**0.76**

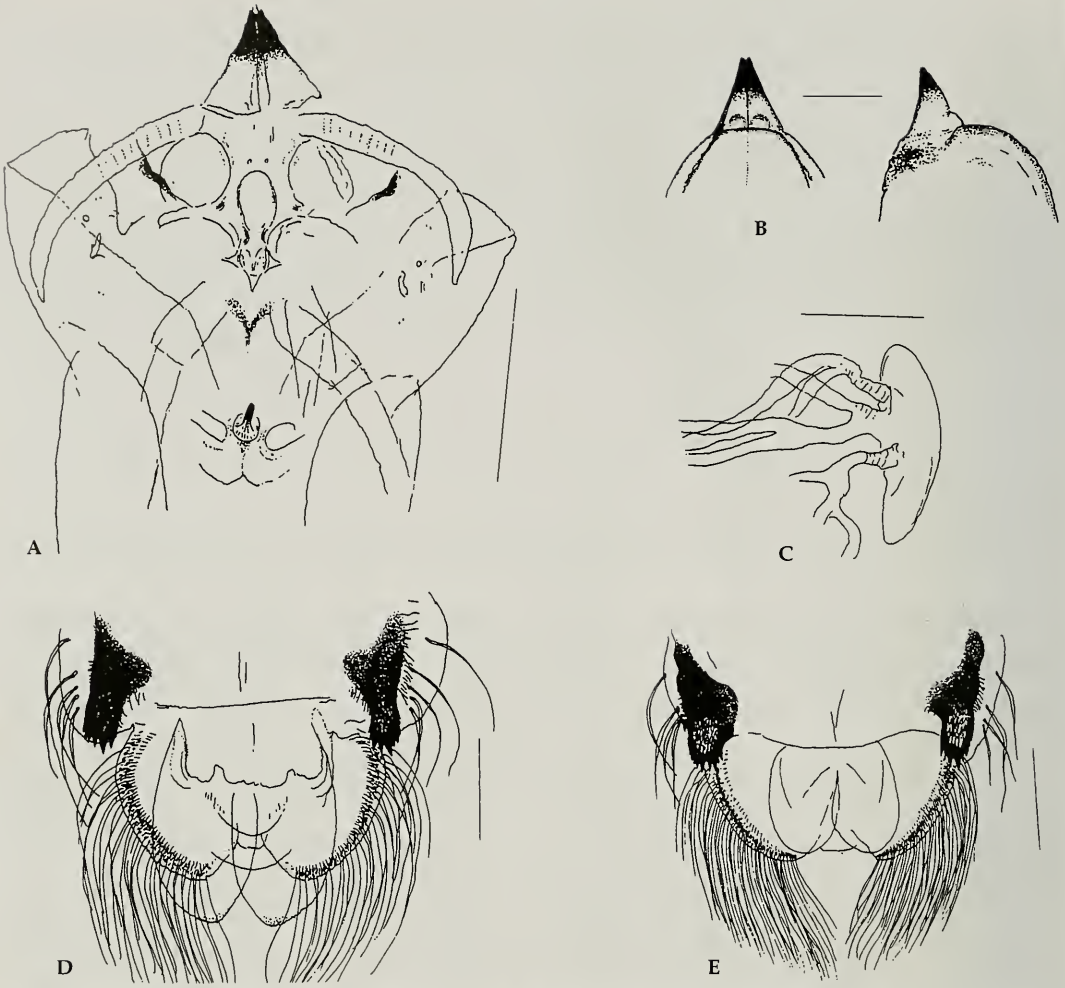

Fig. 3. *Polypedilum kamotertium* Sasa. Pupae. **A.** Exuviae, cephalothorax. **B.** Cephalic tubercle (left: dorsal, right: lateral). **C.** Exuviae, thoracic horn. **D.** ♂ exuviae, anal lobe. **E.** ♀ exuviae, anal lobe. Scales (μm): A: 1000. B: 500. C: 100. D: 400. E: 400.

chiolum, R, RM, FR, R_1, R_{2+3} and R_{4+5} setose, FR especially densely. R_{2+3} running very close to R_1. Membrane without setae, not pigmented. Squama completely fringed.

Legs. Proportions as in Tab. 3.

Genitalia (Fig. 2B). Gonapophysis VIII without ventrolateral lobe. Notum about 120 μm long, ramus 60 μm long. Postgenital plate small, not pointed at apex. Gonocoxite IX with about 20 setae. Seminal capsules about 100 μm in diameter. Spermathecal duct with sharp bend.

Pupa.

Total length about 7.0 mm. Exuviae pale brown. Cephalothorax (Fig. 3A). Cephalic tubercles (Fig. 3B) fused, forming long, conical, chitinized process, hollow, weakly curved ventrally, darkly pigmented in apical ½, dorsally and ventrally with median, longitudinal suture, a pair of short (about 50 μm), rigid frontal setae apically, but occasionally missing; rounded and closely adjacent weak frontal wart present (Fig. 3B), but invisible in exuviae. Thoracic horn (Fig. 3C) consisting of several branches. Basal ring long elliptical. Prealar tubercle absent. 1-2 antepronotals, 2 precorneals, and 3 dorsocentrals present. Abdomen. Segments slender, about 2½ times as long as wide. Tergite I bare; II-VI with broad, rectangular field of very fine, dense, uniform shagreen; without anterior, transverse band of stronger shagreen; VII without shagreen; VIII and anal segment

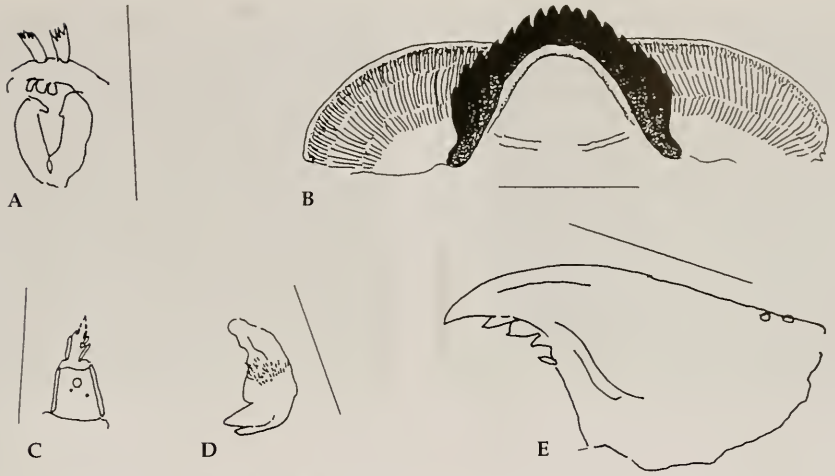

Fig. 4. *Polypedilum kamotertium* Sasa. Larvae. **A.** SI and pecten epipharyngis. **B.** Mentum and ventromental plate. **C.** Antenna. **D.** Premandible. **E.** Mandible. Scales (μm): A: 20. B: 50. C: 20. D: 20. E: 50.

bare. Hook row continuous, occupying scarcely ½ width of segment. All conjunctives bare. Pedes spurii A and B absent. Anterolateral and anteromedian tubercles absent. Anal comb (Figs 3D, E) dark brown, with elongate stem bearing crown of about 12 strong teeth and with scale-like covering of small toothlets. Abdominal setation. Segment I without L setae; II-VI with 1-2 L setae; VII with 4 taeniae; VIII with 5 taeniae. O setae absent. Anal lobe with fringe of about 250 taeniae in multiple row; without dorsal setae. Genital sac of male broad and rounded, extending only slightly beyond anal lobe, apically beset with small warts; genital sac of female not reaching beyond anal lobe, without small warts.

Larva.

Total length about 8 mm, head relatively small, 0.3 mm in length, with 2 pairs of separate eyes. Body color deep by red.

Head. Anterior margin of frontoclypeal apotome almost straight. Labral sclerite 1 absent; sclerite 2 present. Antenna (Fig. 4C) with 5 segments, very short (total length about 40 μm), AR 0.82; ring organ just in above middle of segment 1; blade as long as segments 2-5; Lauterborn organs indistinct. SI of labrum (Fig. 4A) narrow, leaf-like and plumose on tip; SII simple. Seta premandibularis very short and simple. Pecten epipharyngis (Fig. 4A) consisting of 3 separate, non-serrate platelets. Premandible (Fig. 4D) with 2 teeth, without brush. Mandible (Fig. 4E) without dorsal tooth; apical tooth followed by 3 inner teeth; seta subdentalis simple. All teeth of mentum (Fig. 4B) dark, about equally high, with 4 median teeth and 6 lateral pairs of which 5 pairs somewhat larger than median teeth and outermost pair smaller. Ventromental plates (Fig. 4B) broad, width about 5 times distance between plates; the latter about equal to width of 4 median teeth; striae fine but distinct; median ends of ventromental plates pointing towards each other. Seta submenti simple. Abdomen. Procercus absent, 7-8 anal setae; anal tubules normal; posterior parapod with about 16 simple claws.

Remarks

Morphology. The genus *Polypedilum* has been divided into five subgenera (Sæther & Sundal 1999): *Polypedilum* s. str., *Pentapedilum* Kieffer, *Tripodura* Townes, *Uresipedilum* Oyewo & Sæther, and *Cerobregma* Sæther & Sundal. The last one was erected most recently, in 1999, and includes *P. kamotertium*, *P. okigrandis*, and related species. The species described here has the characteristics typical of the subgenus not only in the male imago but also in the female and the immature stages.

Among species of the subgenus the Nearctic *P. ontario* (Walley) probably is the closest related, showing many similarities. The male imagines, however, differ in many characters. The tentorium of *P. kamotertium* is 120-150, 139 μm long (n=11) and 70-100, 80 μm wide (n=11) with a width to length ratio of 0.50-0.67, 0.58 (n=11), whereas in *P. ontario* the corresponding values are 169 μm, 68 μm, and 0.40 (Sæther et Sundal 1999). There is no correlation of body length with width to length ratio of tentorium as far as concerning the specimens available (r=0.27). The shape of the tentorium of *P. kamotertium* is more oval than that of *P. ontario*, the anal point

Fig. 5. Larva and trichopteran pupa.

Fig. 6. Larval gut contents.

is evenly tapered rather than broader in the middle as in *P. ontario*, and the gonostylus is more abruptly constricted distally. The front leg ratio of *P. kamotertium* is much lower than that of *P. ontario* (1.12-1.21 as compared to 1.81-2.04). There is no correlation of wing length with LR_1 (r=0.26).

The front tibial scale is oval in *P. kamotertium*, narrowly triangular in *P. ontario*.

The pupa of *P. (C.) kamotertium* is very similar to *P. (C.) ontario* (see Pinder & Reiss 1986 sub Chironomini Genus C, Bolton 1991, Sæther & Sundal 1999). The other known Japanese species in the subgenus, *P. okigrandis*, apparently lacks the long inner marginal setae of the gonostylus which separate the species from all other known members of the subgenus, the gonostylus is less strongly constricted in the distal ⅓, and the front tibial scale forms a broad triangle (oval in *P. kamotertium*). Sasa reported that the number of flagellomeres was 11, but the authors found 13 flagellomeres as usual on the holotype.

Distribution and biology. Japan, Aomori Pref., Tsugaru-Juniko Lakes; Tochigi Pref., Kogai River; Kyoto Pref., Kamo River; Nagasaki Pref., Todorokikyo; Nagano Pref., Ueda City. Additional records: Far East Russia, Ussuri River basin (Primorye region) and Amur River basin (Khabarovsk region), (pers. comm. E. A. Makarchenko).

Larvae of *Polypedilum ontario*, the probably closely related species from the Nearctic, were collected from pupal retreats of *Cheumatopsyche* caddisflies, which they 'coinhabit' (Bolton 1991: 125). No previous author, however, has mentioned ectoparasitism for species of the subgenus *Cerobregma*. Ashe et al. (2000: 271) summarized known chironomid/trichopteran associations, listing 9 species of chironomids as ectoparasitic, including *Polypedilum fallax* on *Potamophylax cingulatus* (Limnephilidae) from Sweden. However *P. fallax* does not belong to the subgenus *Cerobregma* but to the subgenus *Polypedilum* (Maschwitz & Cook 2000).

In the streams from Tsugaru-Juniko Lakes surveyed in the present study, 93 larvae of *P. kamotertium* were found in the 569 hydropsychid pupal cases examined, yielding a parasitization rate of 13.5 %. The host hydropsychids consisted of two taxa, *Hydropsyche orientalis* Martynov (26 %) and *Cheumatopsyche* sp.(p) (72 %). Every hydropsychid pupal case invaded contained a single *P. kamotertium* larva. The head of the chironomid was oriented in the same direction as that of the host (Fig. 5). The smallest larva of *P. kamotertium* observed in a pupal case was 6 mm in length. All hydropsychids invaded by *P. kamotertium* were intact without any wounds in the prepupal stage (n=8). After the hydropsychids became pupae, chitinous fragments of the host were observed in the guts of the chironomid larvae (Fig. 6). In the early stage of the predation by *P. kamotertium* larvae, a single hole was detected on the ventral side of the host prothorax. After *P. kamotertium* pupated, only a small amount of fragments, for example, integuments or wings, remained in the pupal cases of *Cheumatopsyche* sp(p). (n=18), whereas some posterior pupal segments remained of *Hydropsyche orientalis* (n=6). It is possible that other species of the subgenus *Cerobregma* are also ectoparasitic.

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