

The *verbosus* Group of the Genus *Culicoides* Latreille
(Diptera: Ceratopogonidae) in Japan, with Descriptions of
Three New Species and One Hitherto Unknown Male.

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Abstract: The *verbosus* group of the genus *Culicoides* distributed in Japan was reviewed. Three new species and one hitherto unknown male were figured and described, and a key was given to the females of all 13 species in Japan.

Key words: Ceratopogonidae, *Culicoides*, Japan, New species, Taxonomy

INTRODUCTION

Wada and Kitaoka (1977) attempted preliminarily to classify the Japanese biting midges of the genus *Culicoides* Latreille into groups. In their attempt, the subgenus *Oecacta* was broadly interpreted and the species with two spermathecae and dark R2 cell of wings were included in this subgenus, which was further classified into 13 groups. The *segnis* group and the *claggi* group had already been reviewed (Wada, 1979 and 1986). Among the remaining groups, the *kibunensis*, the *dendrophilus* and the *fascipennis* groups of Wada and Kitaoka (1977) are similar except for the wing pattern, therefore they were collectively treated in the present paper as the *verbosus* group.

Three new species and the hitherto unknown male of *C. nasuensis* were described. *C. arnaudi*, *C. kibunensis* and *C. verbosus*, which were very similar each other and sometimes confused in identification, and *C. tohokuensis*, which had not been recorded since the original description, were redescribed.

MATERIALS AND METHODS

All specimens were collected by a light trap, unless otherwise stated, and mounted with phenol-balsam for microscopic examination. Measurements were made with ocular micrometer as in the below, and values were given by means and, in parentheses, ranges.

Antennal ratio (AR) = (sum of lengths of segments 11-15) / (sum of lengths of segments 3-10).

Proboscis length = length from tip of labrum-epipharynx to tormae.

Head height = distance between tormae and interocular seta.

Proboscis / head (P/H) ratio = (proboscis length) / (head height).

Palpal ratio (PR) = (length of third segment) / (breadth of third segment).

Wing length = length from basal arculus to wing tip.

Costal length = length from basal arculus to tip of costa.

Costal ratio (CR) = (costal length) / (wing length).

The *verbosus* group

Wing. The second radial cell dark; with pale spots sometimes very faint; always with a pale spot on r-m cross vein and a poststigmatic pale spot; marginal tips of veins not pale. Halter pale or infuscated.

Female. Eyes separated. Sensilla coeloconica variously distributed on antennal segments, but always present on segment 15. Third palpal segment with a sensory pit. Cibarial armature without patch of blunt spicules. Hind tibial comb usually with 4 bristles.

Male genitalia. Ninth sternum with shallow caudomedian excavation, ventral membrane bare. Ninth tergum long and tapering, with developed apicolateral processes. Basistyle with ventral root foot-shaped, triangular or pointed. Aedeagus with slender basal arch. Parameres club-shaped, with curved and pointed tips, and usually with developed basal arm directed laterad or anterolaterad.

Some quantitative characters of females are given in Table 1, and the numbers of sensilla coeloconica on antennal segments in Table 2.

Table 1. Certain quantitative characters in the females of *Culicoides* given by mean values or ranges

	AR	PR	PH ratio	mandibular teeth	wing length (mm)	CR
<i>arnaudi</i>	1.74	2.57	0.72	13-15	1.01	0.63
<i>dendrophilus</i>	1.30	1.89	0.42	4-5	1.09	0.59
<i>dryadeus</i>	1.21	2.34	0.80	12-15	1.04	0.59
<i>fukudai</i>	0.89	2.32	0.80	6-9	1.21	0.65
<i>iriomotensis</i>	1.46	2.29	0.77	15-17	1.07	0.60
<i>kibunensis</i>	1.94	2.18	0.64	13-15	1.11	0.62
<i>nasuensis</i>	1.14	1.71	0.57	8-11	1.21	0.59
<i>okazawai</i>	1.72	2.29	0.73	12-15	1.30	0.60
<i>pictimargo</i>	1.47	2.49	0.76	13-14	1.40	0.60
<i>tohokuensis</i>	1.58	2.45	0.90	15-17	1.26	0.61
<i>toshiokai</i>	1.22	2.06	0.63	12-13	1.05	0.60
<i>tsutaensis</i>	1.24	1.75	0.72	14	1.18	0.57
<i>verbosus</i>	1.59	2.14	0.69	12-14	0.84	0.62

Table 2. Mean number of sensilla coeloconica on each of antennal segments 3–15 in the females of *Culicoides*

	<i>n</i>	3	4	5	6	7	8	9	10	11	12	13	14	15
<i>arnaudi</i>	10	3.0	0.1	0.6	0	0.8	0.1	0.8	0	1.0	1.0	1.0	2.4	1.6
<i>dendrophilus</i>	6	2.2	0	0	0	0	0	0	0	1.0	0.7	1.0	1.8	2.0
<i>dryadeus</i>	5	4.4	0	0	0	0	0	0	0	1.0	1.0	1.0	2.4	1.6
<i>fukudai</i>	8	2.0	0	0	0	0	0	0	0	0	0.4	1.3	1.9	0.6
<i>iriomotensis</i>	3	+	1.0	1.0	1.7	2.0	2.0	2.0	1.7	1.0	1.0	1.0	3.3	4.7
<i>kibunensis</i>	10	4.6	1.1	1.5	1.0	1.3	1.1	1.5	1.5	1.0	1.0	1.1	2.7	1.8
<i>nasuensis</i>	8	4.4	2.8	2.9	1.1	1.6	0.1	1.5	0	1.0	1.0	1.0	2.4	1.6
<i>okazawai</i>	10	3.2	0.8	1.0	1.0	1.0	0.8	1.0	0.4	1.0	1.0	1.0	2.7	2.0
<i>pictimargo</i>	6	6.8	2.2	2.2	2.0	2.3	2.2	2.2	2.0	0.3	0.2	0.7	3.8	3.3
<i>tohokuensis</i>	10	4.4	0.6	0.6	0.6	0.8	0.9	0.9	1.0	1.0	1.0	0.9	1.8	3.4
<i>toshiokai</i>	2	3.5	0.5	1.0	0	1.0	0	1.0	0	1.5	1.0	1.0	2.0	1.5
<i>tsutaensis</i>	1	4.0	2.0	2.0	1.0	2.0	2.0	2.0	2.0	1.0	1.0	1.0	3.0	3.0
<i>verbosus</i>	10	3.6	0.9	1.0	1.0	0.9	1.0	1.0	0.7	1.0	1.0	1.0	1.8	1.9

The *verbosus* group is characterized by spotted wings with dark R2 cell, separated eyes, sensilla coeloconica on segment 15 of antennae, and 2 developed spermathecae in the females, and the slender basal arch of aedeagus and club-shaped parameres with a curved and pointed tip in the male genitalia. This is most closely allied to the *shermani* group of Wirth and Hubert (1989).

Key to females

- (1) Antennal ratio smaller than 1; eyes broadly separated *fukudai*, n. sp.
- Antennal ratio larger than 1; eyes narrowly separated (2)
- (2) A pale spot present on middle of vein M2; cell M2 with a pale spot lying immediately in front of mediocubital fork (3)
- A pale spot absent on middle of vein M2; cell M2 with or without a pale spot lying immediately in front of mediocubital fork (4)
- (3) Proboscis short, P/H ratio 0.42; antennal sensilla pattern 3, 11–5 *dendrophilus*
- Proboscis moderately long, P/H ratio 0.77; antennal sensilla pattern 3–15 *iriomotensis*
- (4) Base of mediocubitus with a small distinct pale spot; antennal segments 4–10 without sensilla coeloconica *dryadeus*
- Base of mediocubitus without a pale spot; at least some of antennal segments 4–10 with sensilla coeloconica (5)
- (5) Third palpal segment greatly swollen, PR smaller than 1.9, with a very deep sensory pit (6)
- Third palpal segment slender or moderately swollen, PR larger than 2.0, with a shallow or moderately deep sensory pit. (7)

- (6) Proboscis short, P/H ratio 0.57; antennal sensilla pattern 3-7, 9, 11-15; halter dark *nasuensis*
 — Proboscis moderately long, P/H ratio 0.72; antennal sensilla pattern 3-15; halter pale *tsutaensis*, n. sp.
- (7) Wing with two pale spots in cell M2 (8)
 — Wing with no or one pale spot in cell M2 (9)
- (8) Sensilla coeloconica present usually on antennal segments 3, 5, 7, 9, 11-15; antennal ratio 1.21-1.24 *toshiokai*
 — Sensilla coeloconica present usually on antennal segments 3-10, 13-15; antennal ratio 1.44-1.51 *pictimargo*
- (9) Proboscis long, P/H ratio 0.86-0.99; marginal pale spots in cells R5, M1 and M2 of wing distinct *tohokuensis*
 — Proboscis moderately long, P/H ratio 0.56-0.80; marginal pale spots in cells R5, M1 and M2 of wing faint or absent (10)
- (10) Sensilla coeloconica present usually on antennal segments 3, 5, 7, 9, 11-15 *arnaudi*
 — Sensilla coeloconica present usually on antennal segments 3-15 (11)
- (11) Cells R5, M1 and M2 of wing without marginal pale spots; halter pale ... *kibunensis*
 — Cells R5, M1 and M2 of wing with faint marginal pale spots; halter infuscated (12)
- (12) Small species, wing length 0.73-0.93mm; macrotrichia of wings long; distributed in Ryukyu Islands *verbosus*
 — Large species, wing length 1.18-1.43mm; macrotrichia of wings short; distributed in Hokkaido *okazawai*, n. sp.

Culicoides arnaudi Hubert and Wirth

Fig. 1, 9A, 10A

Culicoides arnaudi Hubert and Wirth, 1961 (female, male; Okinawa Is., Wakayama and Chiba). —Kitaoka, 1984b (as synonym of *kibunensis*). —Wada, 1981a (dist., Fukue Is. in Nagasaki). —Wada and Kitaoka, 1977 (list).

Culicoides kibunensis, misident., not Tokunaga, 1937. —Arnaud, 1956, in part (diagnosis, female, male). —Kitaoka, 1977, in part, (key; Nansei Islands). —Kitaoka and Suzuki, 1974 (feeding habit). —McDonald et al., 1973 (diagnosis, female; Okinawa Is.).

Female. Length of wing 1.01 (0.93-1.08, n=10) mm.

Head. —Eyes bare, very narrowly separated (Fig. 1A).

Antenna with flagellar segments in proportion (μm units) of 37: 24: 23: 24: 24: 24: 25: 61: 62: 68: 69: 99; AR 1.74 (1.63-1.84, n=10); sensilla coeloconica present usually on segments 3, 5, 7, 9, 11-15 (see Table 2 for their numbers). Third palpal segment (Fig. 1B) 65 (58-70, n=10) μm long, moderately swollen, PR 2.57 (2.18-2.80, n=10), with a shallow sensory pit. Proboscis 149 (140-158, n=10) μm long; P/H ratio 0.72 (0.67-0.76, n=10); mandible with 13-15 teeth; cibarial armature without patch of blunt spicules.

Thorax. —Legs brown; knees slightly darkened; fore and mid femora with faint subapical pale rings; tibiae with faint sub-basal pale rings; hind tibial comb with 4 bristles (n=20). Wing (Fig. 9A) with pattern as figured, pale spots faint; pale spot over r-m cross vein moderately large, extending from costal margin to posteriorly media or middle of cell M2; poststigmatic pale spot small; cell M2 with a pale streak in front of mediocubital fork; cell M4 with large pale spot broadly reaching wing margin; anal cell with one pale spot in distal portion and one near base; pale spot at base of wing very small; macrotrichia numerous, extending to base of cell M2 and anal cell; 1.01 (0.93–1.08, n=10) mm long, 0.50 (0.45–0.53, n=10) mm wide; CR 0.63 (0.62–0.64, n=10). Halter infuscated.

Abdomen. —Two developed and 1 rudimentary spermathecae as in Fig. 1C; with a ring; developed spermathecae ca. 50x37 and 46x36 μm in size, and a rudimentary one tubular, ca. 17 μm long.

In one female collected in Amami-Oshima Island, 3 developed spermathecae were present (Fig. 1D) instead of 2 developed and 1 rudimentary, and in 3 females collected in northern parts of Honshu a rudimentary spermatheca was not tubular but globular (Fig. 1E).

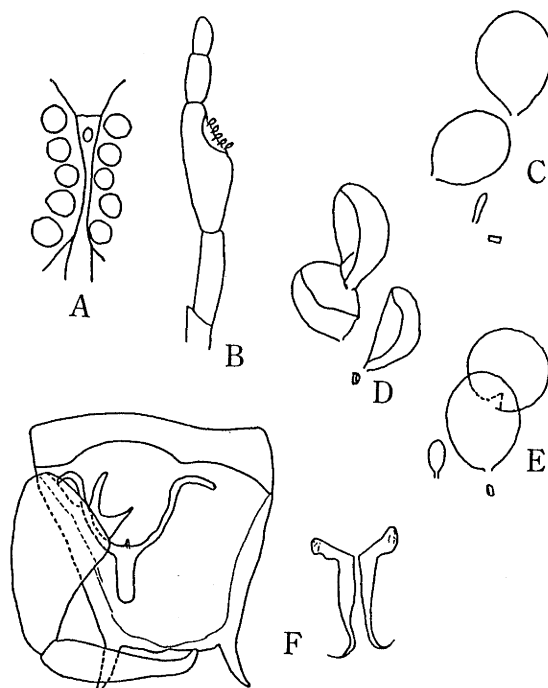


Fig. 1. *C. arnaudi* Hubert and Wirth. A–E, female; F, male. A, eyes separation; B, palpal segments; C, spermathecae; D, spermathecae, a rudimentary one developed; E, spermathecae, a rudimentary one not tubular but globular; F, genitalia, parameres separated, a basistyle of one side removed.

Male. Length of wing 0.94 (0.93–0.95, $n=2$) mm. Similar to the female with usual sexual differences (wing, Fig. 10A). Eyes bare. Third palpal segment with a shallow sensory pit. Cibarial armature without patch of blunt spicules. Halter infuscated.

Genitalia (Fig. 1F). –Ninth sternum with shallow caudomedian excavation, ventral membrane bare. Ninth tergum long and tapering, with moderately separated and long apicolateral processes. Basistyle with ventral root narrowly triangular; dististyle slender. Aedeagus with very slender basal arch, extending to 0.6 of total length; distal process short and broad. Parameres each with obliquely directed basal portion ending in a strong basal knob; mid-portion slightly swollen towards base, becoming very slender and abruptly bending laterad to end in simple pointed tip.

Distribution. Honshu, Kyushu, Goto Islands, Tokara Islands, Amami-Oshima Island, Okinawa Island.

Specimens used for redescription. KYUSHU: 1 ♀, Mt. Unzen, Nagasaki Pref., 16. viii. 1977, Y. Wada. TOKARA ISLANDS: 1 ♀, Nakanoshima Is., 29. vii. 1981, I. Miyagi; 2 ♀♀, Takarajima Is., 29. vii. 1975, A. Miyata. AMAMI-OSHIMA ISLAND: 2 ♀♀, 30. ix. 1973, Y. Wada; 2 ♀♀, 1 ♂, 3. x. 1973, Y. Wada; 2 ♂♂, 15. xi. 1973, Y. Wada; 1 ♂, 16. xi. 1973, Y. Wada. OKINAWA ISLAND: 1 ♀, 1. ix. 1976, I. Miyagi.

Other localities of specimens examined. HONSHU—Tanesashi and Tsuta (Aomori Pref.) and Shirahama (Wakayama Pref.). See the taxonomic discussions below.

Biology. This species seems to be ornithophilic in blood feeding habit (Kitaoka and Suzuki, 1974).

Taxonomic discussions. *C. arnaudi* was described by Hubert and Wirth (1961) based on specimens from Okinawa Is. and Wakayama and Chiba Prefectures, Honshu. This species is similar to *C. kibunensis* in wing pattern and antennal ratio, but they are distinct species. In *C. arnaudi* females the sensilla coeloconica are usually present on antennal segments 3, 5, 7, 9, 11–15, the third palpal segment is moderately swollen, the proboscis is longer (P/H ratio is ca. 0.72), and the halter is infuscated, while in *C. kibunensis* females the sensilla coeloconica are usually present on segments 3–15, the third palpal segment is greatly swollen, the proboscis is shorter (P/H ratio ca. 0.64), and the halter is pale. See also taxonomic discussions of *C. kibunensis*.

The above redescription was based on the specimens south of Kyushu, as the specimens in northern parts of Honshu may belong to a different species. The females of the northern population are larger in comparison with the typical *arnaudi* (wing length 1.05–1.30 mm vs. 0.93–1.08 mm) and have a slenderer third palpal segment (PR 2.67–3.25 vs. 2.18–2.80), but they are tentatively included in *C. arnaudi* in the present paper, because other characters are indistinguishable.

Culicoides dendrophilus Amosova

Fig. 9B

Culicoides dendrophilus Amosova, 1957 (Ussuri, USSR). Cho and Chong, 1974 (dist., Korea). –Gutchevich, 1973 (diagnosis, female, male; USSR). –Kitaoka, 1977 (key;

Nansei Islands). —Kitaoka, 1984b (key; fig., female, male). —Lee, 1988 (key; diagnosis, female, male; China). —McDonald et al., 1973 (diagnosis, female; Okinawa Is.; synonym *reesi*). —Wada, 1977a (dist., Tsushima Is.). —Wada, 1977b (dist., Chikuzen-Okinoshima Is.). —Wada, 1981a (dist., Fukue Is.). —Wada and Kitaoka, 1977 (list).

Culicoides reesi Bullock and Akiyama, 1959 (female, male; Tokyo, Kanagawa, Korea).

Distribution. Hokkaido, Honshu, Sado Island, Mikura Island, Kyushu, Chikuzen-Okinoshima Island, Tsushima Islands, Goto Islands, Okinawa Island; Korea, China, USSR.

Localities of specimens examined. All specimens were reared from larvae excepting those collected by a light trap at Tsuta and Mt. Kurotake. HONSHU—Tsuta (Aomori Pref.); MIKURA ISLAND; KYUSHU—Mt. Kurotake (Oita Pref.), Nagasaki; CHIKUZEN-OKINOSHIMA ISLAND; TSUSHIMA ISLANDS; GOTO ISLANDS—Fukue. KOREA—Hainam (Chollanam-do).

Biology. Larvae breed in tree holes, bamboo stumps, and artificial containers. Females do not feed on blood. Adults are only rarely attracted to light traps.

Taxonomic discussions. McDonald *et al.* (1973) regarded *C. reesi* Bullock and Akiyama as synonym of *C. dendrophilus*, and this treatment was followed by subsequent authors. However, the females of *C. dendrophilus* on Okinawa Is. redescribed by McDonald *et al.* (1973) have sensilla coelocnica on antennal segments 3, 7, 9, 11–15, while the females in Kyushu and north including USSR have sensilla on segments 3, 11–15 (Gutchevich, 1973; Kitaoka, 1984b; the present paper). The extremely small AR of 0.92 in McDonald *et al.* (1973) may be erroneous, otherwise the species on Okinawa Is. is very likely to be different from *C. dendrophilus*. The Okinawa specimens need further taxonomic confirmation.

C. dendrophilus is similar to *C. iriomotensis* in that there is a distinct pale spot on middle of vein M2, but in the female of *C. dendrophilus* the proboscis is short (P/H ratio 0.42) and the antennal sensilla pattern is 3, 11–15, while in *C. iriomotensis* the proboscis is moderately long (P/H ratio 0.77) and the antennal pattern 3–15. *C. dendrophilus* is also similar to *C. hainanensis* Lee in the wing pattern, but the number of manibular teeth is 3–5, occasionally indistinguishable, in the former species and 12–14 in the latter.

Culicoides dryadeus Wirth and Hubert

Fig. 9C

Culicoides dryadeus Wirth and Hubert, 1972 (female, male; India, Malaya, Sarawak, Sumatra, Thailand). —Kitaoka, 1984b (key; fig., female). —Wirth and Hubert, 1989 (diagnosis, female, male).

Culicoides sp. (MIKURA No. 2). —Wada, 1977b (dist., Chikuzen-Okinoshima Is.). —Wada, 1981b (dist., Meshima Is.). —Wada and Kitaoka, 1977 (list).

Distribution. Mikura Island, Chikuzen-Okinoshima Island, Danjo Islands, Yaeyama Islands; Thailand, Sarawak, Malaya, Sumatra, India.

Localities of specimens examined. MIKURA ISLAND; CHIKUZEN-

OKINOSHIMA ISLAND; DANJO ISLANDS—Meshima Is.; YAEYAMA ISLANDS—Iriomote Is.

Biology. Larvae breed in tree holes (Wirth and Hubert, 1972).

Taxonomic discussions. The female and male specimens agree well with the original description of Wirth and Hubert (1972).

Culicoides fukudai Wada, new species

Fig. 2, 9D

Female. Length of wing 1.21 (1.10–1.35, n=7) mm.

Head. —Eyes bare, broadly separated (Fig. 2A). Antenna with flagellar segments in proportion (μm units) of 51: 35: 33: 35: 36: 35: 36: 37: 46: 46: 50: 54: 71; AR 0.89 (0.81–0.94, n=8); sensilla coeloconica present on segments 3, 12–15 (see Table 2 for their numbers). Third palpal segment (Fig. 2C) 59 (53–63, n=6) μm long, moderately swollen, PR 2.32 (2.18–2.40, n=6) with a small shallow sensory pit, sometimes divided into 2, rarely 3, pits. Proboscis 149 (143–153, n=4) μm long; P/H ratio 0.80 (0.76–0.85, n=4); mandible with 6–9 teeth; cibarial armature without patch of blunt spicules.

Thorax. —Legs brown; knees not darkened; femora without pale rings; mid and hind tibiae with very faint sub-basal pale ring; hind tibial comb with 4 bristles (n=11). Wing (Fig. 9D) with pattern as figured, pale spots very faint; pale spot over r-m cross vein large, extending from costal margin to posteriorly middle of cell M2; poststigmatic pale spot small; large pale spot present at base of wing; marginal pale spot not present; macrotrichia sparse at basal part of wing; 1.21 (1.10–1.35, n=7) mm long, 0.56 (0.50–0.65, n=7) mm wide; CR 0.65 (0.64–0.68, n=7). Halter pale.

Abdomen. —Two developed and 1 rudimentary spermathecae as in Fig. 2B; with a ring; developed spermathecae ca. 45x34 and 37x29 μm in size, and a rudimentary one tubular, ca. 18 μm long.

Distribution. Honshu.

Types. Holotype: 1 ♀, Tanesashi, Aomori Pref., 6. viii. 1983, S. Fukuda. Paratypes: 1 ♀, the same locality and collector, 17. vii. 1983; 3 ♀♀, the same locality and collector, 7.

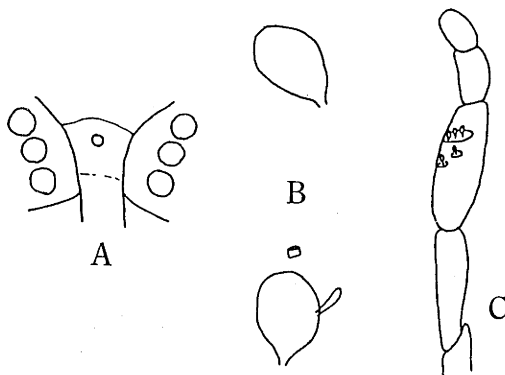


Fig. 2. *C. fukudai*, n. sp. Female. A, eyes separation; B, spermathecae; C, palpal segments.

viii. 1983; 1 ♀, the same locality and collector, 11. viii. 1984. All types will be deposited in the National Science Museum, Tokyo.

Biology. This seems to be a coastal species.

Taxonomic discussions. This species can easily be separated from other Japanese species by a combination of characters of broadly separated eyes, small AR (0.81–0.94), mandible with 6–9 teeth, and very faint pale spots of wings.

Culicoides iriomotensis Kitaoka

Fig. 9E

Culicoides iriomotensis Kitaoka, 1975 (female, male; Iriomote Is.). —Kitaoka, 1977 (key, Nansei Islands). —Kitaoka, 1984b (key; fig., female, male). —Wada and Kitaoka, 1977 (list).

Distribution. Yaeyama Islands.

Localities of specimens examined. YAEYAMA ISLANDS—Ishigaki Is. and Iriomote Is.

Biology. Larvae breed in tree holes (Kitaoka, 1975).

Taxonomic discussions. See taxonomic discussions of *C. dendrophilus*.

Culicoides kibunensis Tokunaga

Fig. 3, 9F, 10B

Culicoides kibunensis Tokunaga, 1937 (female, male, Kibune, Kyoto Pref.). —Arnaud, 1956 (diagnosis, female, male; synonym *ponkikiri*, *sitinohensis*). —Kitaoka, 1984b (key; fig., female, male). —Kitaoka and Morii, 1964 (feeding habit). —Lee, 1978 (key; diagnosis, female, male; China). —Lee, 1988 (key; China). —Nishijima and Ono, 1964 (feeding habit). —Wada and Kitaoka, 1977 (list).

Culicoides odiatus, misident., not Austen, 1921. —Tokunaga, 1955 (diagnosis, female; Korea).

Culicoides ponkikiri Kono and Takahasi, 1940 (female; Hokkaido). —Cho and Chong, 1974 (dist.; Korea).

Culicoides sitinohensis Okada, 1941 (female; Aomori and Iwate).

Female. Length of wing 1.11 (0.99–1.24, n=10) mm.

Head. —Eyes bare, very narrowly separated (Fig. 3A). Antenna with flagellar segments in proportion (μm units) of 40: 25: 25: 24: 26: 25: 26: 27: 76: 79: 83: 80: 105; AR 1.94 (1.77–2.12, n=10); sensilla coeloconica present on segments 3–15 (see Table 2 for their numbers). Third palpal segment (Fig. 3C) 67 (63–73, n=10) μm long, greatly swollen, PR 2.18 (2.00–2.33, n=10), with a large shallow sensory pit. Proboscis 131 (113–145, n=8) μm long; P/H ratio 0.64 (0.56–0.68, n=8); mandible with 13–15 teeth; cibarial armature without patch of blunt spicules.

Thorax. —Legs brown; knees slightly darkened; fore and mid femora with faint subapical pale rings; tibiae with faint sub-basal pale rings; hind tibial comb with 4 bristles (n=20). Wing (Fig. 9F) with pattern as figured, pale spots faint; pale spot over r-m cross

vein moderately large, extending from costal margin to posteriorly media or middle of cell M2; poststigmatic pale spot small; cell M2 with a pale streak in front of mediocubital fork; cell M4 with large pale spot broadly reaching wing margin; anal cell with one pale spot in distal portion and one near base; pale spot at base of wing very small; macrotrichia numerous, extending to base of cell M2 and anal cell; 1.11 (0.99–1.24, n=10) mm long, 0.54 (0.48–0.58, n=10) mm wide; CR 0.62 (0.56–0.66, n=10). Halter pale.

Abdomen. —Two developed and 1 rudimentary spermathecae as in Fig. 3B; with a ring; developed spermathecae ca. 54x40 and 47x38 μm in size, and a rudimentary one tubular, ca. 14 μm long.

In a female collected in northern Honshu, a rudimentary spermatheca was not tubular but globular.

Male. Length of wing 0.96 (0.85–1.03, n=6) mm. Similar to the female with usual sexual differences (wing, Fig. 10B). Eyes bare. Third palpal segment with a shallow sensory pit. Cibarial armature without patch of blunt spicules. Halter pale.

Genitalia (Fig. 3D). —Ninth sternum with shallow caudomedian excavation, ventral membrane bare. Ninth tergum long and tapering, with moderately separated and long apicolateral processes. Basistyle with ventral root very narrowly triangular; dististyle slender. Aedeagus with slender basal arch, extending to 0.7 of total length; distal process

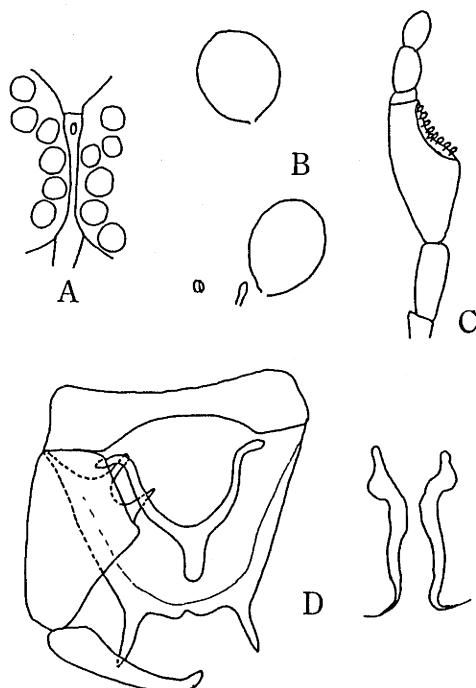


Fig. 3. *C. kibunensis* Tokunaga. A–C, female; D, male. A, eyes separation; B, spermathecae; C, palpal segments; D, genitalia, parameres separated, a basistyle of one side removed.

short and broad. Parameres each with obliquely directed basal portion ending in a strong basal knob; mid-portion slightly swollen towards base, becoming very slender and abruptly bending laterad to end in simple pointed tip.

Distribution. Hokkaido, Honshu, Shikoku, Kyushu; Korea, China.

Specimens used for redescription. HOKKAIDO: 1 ♀, Tomakomai, 27. vii. 1979, T. Okazawa; 1 ♀, 2 ♂♂, the same locality and collector, 28. vii. 1979. HONSHU: 1 ♂, Tanesashi, Aomori Pref., 27. viii. 1983, T. Fukuda; 3 ♀♀, 1 ♂ Tsuta, Aomori Pref., 17. vii. 1982, Y. Wada; 1 ♀, 1 ♂, the same locality and collector; 1 ♂, Hara, Nagano Pref., 16. vii. 1982, M. Takahashi. SHIKOKU: 1 ♀, Wajiki, Tokushima Pref., 27. ix. 1977, M. Kamei. KYUSHU: 1 ♀, Mt. Kurotake, Oita Pref., 6. vii. 1979, A. Miyata; 1 ♀, the same locality and collector, 9. vi. 1980; 2 ♀♀, Nagasaki, 17. ix. 1973, Y. Wada.

Localities of other specimens examined. Kwangnung, Korea.

Biology. This species is ornithophilic in blood feeding habit (Kitaoka and Morii, 1964; Nishijima and Ono, 1964), but attacks man also (Takahasi, 1955).

Taxonomic discussions. The characters of the types of Tokunaga (1937) in Kyushu University were invisible due to long preservation in alcohol. The present identification followed Arnaud (1956) and on this basis the discussions below were made. Arnaud (1956) redescribed this species from specimens recently named by Tokunaga and pointed out several discrepancies in the original description of Tokunaga (1937). The species of Tokunaga (1937) has a small sensory pore on the third palpal segment and a small antennal ratio of 1.3–1.4, but specimens in complete agreement with the original description are not available. *C. ponkikiri* Kono and Takahasi and *C. sitinohensis* Okada have the sensory pore of the third palpal segment and the antennal ratio that are characteristic of *C. kibunensis* of Tokunaga (1937).

The species recorded by Tokunaga (1955) from Korea as *C. odiatus* was confirmed to be *C. kibunensis*, as suggested by Campbell and Pelham-Clinton (1960), by examining specimens that were used for his record and preserved in the Faculty of Agriculture, Kyoto Prefectural University.

The species reported from Okinawa by McDonald *et al.* (1973) as *C. kibunensis* may be *C. arnaudi*. Their species has such characteristics as light brown halteres and absence of sensilla coeloconica on some segments of antennae, which indicate *C. arnaudi* rather than *C. kibunensis*. The distribution of *C. kibunensis* in Amami-Oshima Island and further south needs reconfirmation. See also taxonomic discussions of *C. arnaudi*.

Culicoides nasuensis Kitaoka

Fig. 9G, 10C

Culicoides nasuensis Kitaoka, 1984a (female; Tochigi), –Kitaoka, 1984b (key; fig., female).

Male. Length of wing 1.04 (0.95–1.13, n=2) mm. Similar to the female with usual sexual differences (wing, Fig. 10C). Eyes with very minute pubescence only near antennal scape. Third palpal segment with a shallow sensory pit. Cibarial armature without patch of blunt spicules. Halter infuscated.

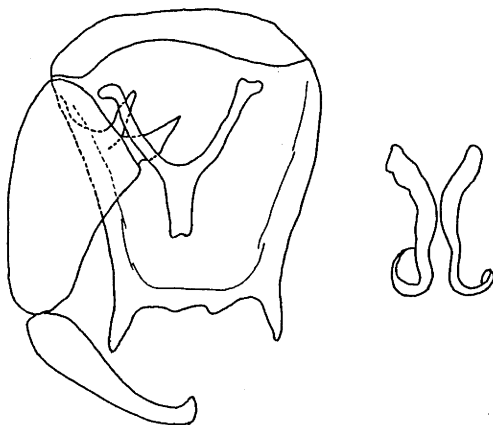


Fig. 4. *C. nasuensis* Kitaoka. Male genitalia, parameres separated, a basistyle of one side removed.

Genitalia (Fig. 4). —Ninth sternum with shallow caudomedian excavation, ventral membrane bare. Ninth tergum long and tapering, with moderately separated and long apicolateral processes. Basistyle with ventral root foot-shaped, posterior heel very poorly developed; dististyle slender. Aedeagus with slender basal arch, extending to 0.6 of total length; distal process short and broad. Parameres each with thick basal portion; mid-portion slightly swollen towards base, becoming very slender and abruptly bending ventrad and mesad to end in simple pointed tip.

Distribution. Honshu, Kyushu.

Localities of specimens examined. HONSHU—Tsuta (Aomori Pref.); KYUSHU—Mt. Kurotake (Oita Pref.).

Biology. Nothing is known.

Taxonomic discussions. The male was described for the first time. See taxonomic discussions of *C. tsutaensis*, n. sp. for characters to distinguish this species from *C. tsutaensis*.

Culicoides okazawai Wada, new species

Fig. 5, 9H, 10D

Female. Length of wing 1.30 (1.18–1.43, n=10) mm.

Head. —Eyes bare, very narrowly separated (Fig. 5A). Antenna with flagellar segments in proportion (μm units) of 46: 30: 31: 31: 32: 31: 31: 32: 81: 82: 89: 87: 113; AR 1.72 (1.62–1.83, n=10); sensilla coeloconica present usually on segments 3–9, 11–15, sometimes on segment 10 (see Table 2 for their numbers). Third palpal segment (Fig. 5C) 68 (58–78, n=10) μm long, greatly swollen, PR 2.29 (2.00–2.58, n=10), with a small shallow sensory pit. Proboscis 157 (143–173, n=10) μm long; P/H ratio 0.73 (0.68–0.78, n=10); mandible with 12–15 teeth; cibarial armature without patch of blunt spicules.

Thorax. —Legs brown; knees slightly darkened; fore and mid femora with faint subapical pale rings; tibiae with faint sub-basal pale rings; hind tibial comb with 4 bristles (n=17). Wing (Fig. 9H) with very faint pattern of pale spots as figured; a pale spot over r-m cross vein small, not reaching costal margin; poststigmatic pale spot small; small marginal pale spot on cell R5, M1 and M2 sometimes not apparent; cell M2 with a pale streak in front of mediocubital fork; cell M4 with large pale spot reaching wing margin; anal cell with one pale spot in distal portion and one near base; pale spot at base of wing small; macrotrichia sparse at basal part of wing; 1.30 (1.18–1.43, n=10) mm long, 0.60 (0.55–0.68, n=10) mm wide; CR 0.60 (0.57–0.63, n=10). Halter infuscated.

Abdomen. —Two developed and 1 rudimentary spermathecae as in Fig. 5B; with a ring; developed spermathecae ca. 52x39 and 49x37 μm in size, and a rudimentary one tubular, ca. 16 μm long.

Male. Length of wing 1.16 (1.10–1.23, n=2) mm. Similar to the female with usual sexual differences (wing, Fig. 10D). Eyes bare. Third palpal segment with a shallow sensory pit. Cibarial armature without patch of blunt spicules. Halter infuscated.

Genitalia (Fig. 5D). —Ninth sternum with shallow caudomedian excavation, ventral membrane bare. Ninth tergum long and tapering, with moderately separated and long

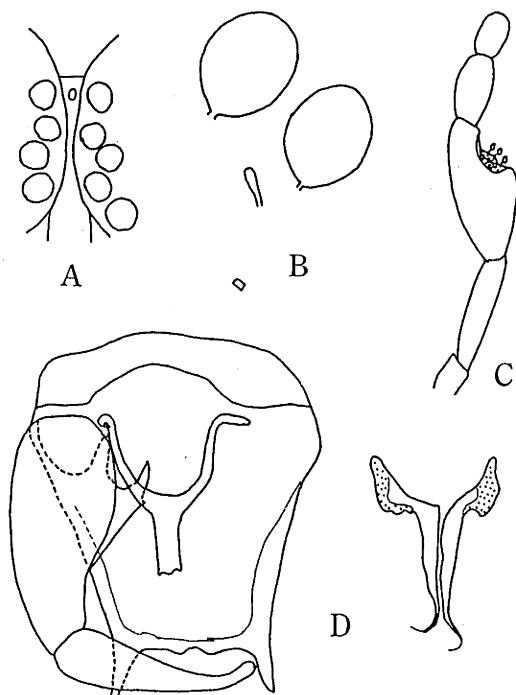


Fig. 5. *C. okazawai*, n. sp. A–C, female; D, male. A, eyes separation; B, spermathecae; C, palpal segments; D, genitalia, parameres separated, a basistyle of one side removed.

apicolateral processes. Basistyle with ventral root narrowly triangular; dististyle slender. Aedeagus with slender basal arch, extending to 0.6 of total length; distal process short, broad and square-ended. Parameres each with obliquely directed basal portion ending in a strong basal knob; mid-portion slightly swollen towards base, becoming very slender and abruptly bending laterad to end in simple pointed tip.

Distribution. Hokkaido.

Types. Holotype: 1 ♀, Tomakomai, Hokkaido, 21. vi. 1979, T. Okazawa. Paratypes: 3 ♀♀, the same data as holotype; 2 ♀♀, 1 ♂, the same locality and collector, 27. vii. 1979; 4 ♀♀, the same locality and collector, 28. vii. 1979; 1 ♂, Nukabira, Hokkaido, 2. vii. 1962, H. Ono. All types will be deposited in the National Science Museum, Tokyo.

Biology. Nothing is known.

Taxonomic discussions. The present new species is very similar to *C. verbosus*, but much larger and distributed only in Hokkaido.

Culicoides pictimargo Tokunaga and Shogaki

Fig. 9I

Culicoides pictimargo Tokunaga and Shogaki, 1953 (female; Kyoto). —Arnaud, 1956 (diagnosis, female, male; Japan, Korea). —Kitaoka, 1984b (key; fig., female, male). —Lee, 1978 (key; diagnosis, female, male; China). —Wada and Kitaoka, 1977 (list).

Culicoides odibilis, misident., not Austen, 1921. —Cho and Chong, 1974 (dist.; Korea). —Tokunaga, 1955 (Korea and Japan). —Kitaoka and Morii, 1964 (collection in poultry house; comparison with *insularis* (as *pictimargo*)). —Takahashi, 1958 (diagnosis, male; Niigata). —Takahashi, 1960 (feeding habit).

Distribution. Hokkaido, Honshu, Shikoku, Kyushu; Korea, China.

Localities of specimens examined. HOKKAIDO—Nukabira and Tomakomai; HONSHU—Tsuta (Aomori Pref.), Mt. Hagurosan (Yamagata Pref.), Mt. Funagata (Miyagi Pref.), Tokyo, Shuzenji (Shizuoka Pref.), Tadeshina (Nagano Pref.), Togakushi (Nagano Pref.) and Kyoto; SHIKOKU—Wajiki (Tokushima Pref.); KYUSHU—Mt. Kurotake (Oita Pref.) and Omura (Nagasaki Pref.). KOREA—Pusan.

Biology. This is an ornithophilic species in blood feeding habit (Kitaoka and Morii, 1964). Takahashi (1960) reported that this species rarely attacked man.

Taxonomic discussions. See taxonomic discussions of *C. tohokuensis*.

Culicoides tohokuensis Okada

Fig. 6, 9J, 10E

Culicoides tohokuensis Okada, 1941 (female; Aomori). —Arnaud, 1956 (original description of Okada cited). —Wada and Kitaoka, 1977 (list).

Culicoides sp. (KUROTAKE). —Kitaoka, 1984b (key; fig., female, male).

Female. Length of wing 1.26 (1.20–1.33, n=10) mm.

Head. —Eyes bare, narrowly separated (Fig. 6A). Antenna with flagellar segments in proportion (μm units) of 44: 29: 29: 29: 30: 32: 32: 34: 73: 73: 76: 77: 110; AR 1.58

(1.50–1.71, $n=10$); sensilla coeloconica present usually on segments 3–15 (see Table 2 for their numbers). Third palpal segment (Fig. 6C) 73 (65–80, $n=9$) μm long, moderately swollen, PR 2.45 (2.23–2.58 $n=9$), with a small shallow sensory pit. Proboscis 184 (170–195, $n=10$) μm long; P/H ratio 0.90 (0.86–0.99, $n=10$); mandible with 15–17 teeth; cibarial armature without patch of blunt spicules.

Thorax. —Legs dark brown; knees darkened; fore and mid femora with sub-apical pale rings; tibiae with sub-basal pale rings; hind tibial comb with 4 (rarely 5) bristles ($n=20$). Wing (Fig. 9J) with moderately distinct pattern of pale spots as figured; pale spot over r-m cross vein moderately large, extending from costal margin to media; poststigmatic pale spot moderately large, reaching vein M1; cells R5, M1, M2 and M4 with marginal pale spot usually broadly touching wing margin; cell M2 with pale spot lying immediately in front of mediocubital fork; anal cell with one pale spot in distal portion and one near base; pale spot at base of wing small; macrotrichia numerous, distributed all over wing; 1.26 (1.20–1.33, $n=10$) mm long, 0.59 (0.55–0.63, $n=10$) mm wide; CR 0.61 (0.57–0.63, $n=10$). Halter infuscated.

Abdomen. —Two developed and 1 rudimentary spermathecae as in Fig. 6B; with a ring; developed spermathecae ca. 42x37 and 38x33 μm in size, and a rudimentary one tubular, ca. 15 μm long.

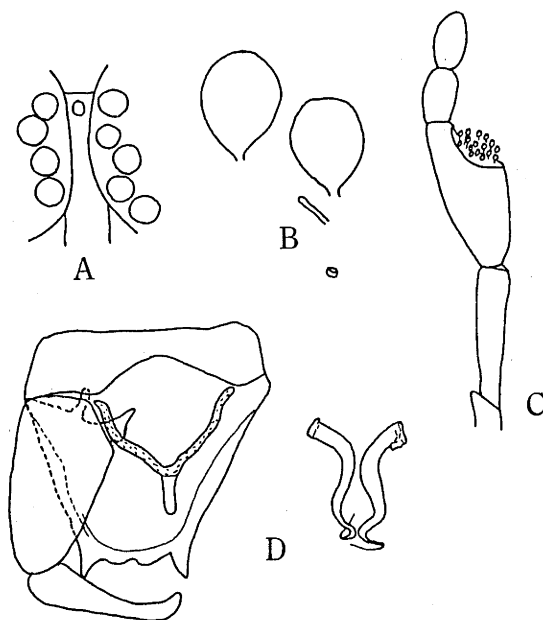


Fig. 6. *C. tohokuensis* Okada. A–C, female; D, male. A, eyes separation; B, spermathecae; C, palpal segments; D, genitalia, parameres separated, a basistyle of one side removed.

Male. Length of wing 1.07 (0.98–1.18, n=6) mm. Similar to the female with usual sexual differences (wing, Fig. 10E). Eyes bare. Third palpal segment with a shallow sensory pit. Cibarial armature without patch of blunt spicules. Halter infuscated.

Genitalia (Fig. 6D). –Ninth sternum with shallow caudomedian excavation, ventral membrane bare. Ninth tergum long and tapering, with moderately separated and rather short apicolateral processes. Basistyle with ventral root triangular; dististyle slender. Aedeagus with slender basal arch, extending to 0.7 of total length; distal process short and moderately slender. Parameres each with obliquely directed basal portion ending in a basal knob; mid-portion curved, slightly swollen towards base, becoming very slender and abruptly bending to end in simple pointed tip.

Distribution. Hokkaido, Honshu, Hyushu.

Specimens used for redescription. HOKKAIDO: 4 ♀, 2 ♂, Tomakomai, 21. vi. 1979, T. Okazawa. HONSHU: 2 ♀♀, 2 ♂♂, Tsuta, Aomori Pref., 17. vii. 1982, Y. Wada; 2 ♀♀, the same locality and collector, 18. vii. 1982; 1 ♀, the same locality and collector, 19. vi. 1983; 1 ♀, Hara, Nagano Pref., 16. vii. 1982, M. Takahashi. KYUSHU: 1 ♀, 2 ♂♂, Mt. Kurotake, Oita Pref., A. Miyata; 1 ♀, the same locality and collector, 9. vi. 1980.

Other localities of specimens examined. HONSHU—Nishitsugaru and Tanesashi (Aomori Pref.).

Biology. Nothing is known.

Taxonomic discussions. All morphological characters of females agree with the original description of Okada (1941). This species has not been recorded since the original description excepting Kitaoka (1984b) who gave the key and figured females and males with a tentative name of KUROTAKE.

The female of *C. tohokuensis* has the wing pattern similar to *C. pictimargo*, but can be separated by a longer proboscis (PH ratio 0.90), presence of sensilla coeloconica usually on antennal segments 3–15, and a pale spot broadly touching the wing margin on cells M1 and M2.

Culicoides toshiokai Kitaoka

Fig. 9K

Culicoides toshiokai Kitaoka, 1975 (female, male; Ishigaki Is.). –Kitaoka, 1977 (key; Nansei Island). –Kitaoka, 1984b (key; fig., female, male). –Lee, 1988 (key; diagnosis, female, male; China). –Wada and Kitaoka, 1977 (list).

Distribution. Tokara Islands, Yaeyama Islands; China.

Localities of specimens examined. TOKARA ISLANDS—Takarajima Is.; YAEYAMA ISLANDS—Ishigaki Is. and Iriomote Is.

Biology. Larvae breed in tree holes and bamboo stumps (Kitaoka, 1984b; Lee, 1988).

Taxonomic discussions. The specimens agree with the original description of Kitaoka (1975). Two distinct pale spots on cell M1 of wings are characteristic of *C. toshiokai*.

Culicoides tsutaensis Wada, new species

Fig. 7, 9L, 10F

Female. Length of wing 1.18 mm.

Head. —Eyes with very minute pubescence only near antennal scape, very narrowly separated (Fig. 7A). Antenna with flagellar segments in proportion (μm units) of 50: 33: 35: 38: 38: 38: 40: 38: 65: 68: 75: 75: 100; AR 1.24; sensilla coeloconica present on segments 3–15 (see Table 2 for their numbers). Third palpal segment (Fig. 7C) 68 (58–78, $n=10$) μm long, very greatly swollen, PR 1.75, with a small, very deep sensory pit. Proboscis 163 μm long; P/H ratio 0.72; mandible with 14 teeth; cibarial armature without patch of blunt spicules.

Thorax. —Legs light brown; knees not darkened; fore and mid femora with faint subapical pale rings; tibiae with faint sub-basal pale rings; hind tibial comb with 4 bristles ($n=17$). Wing (Fig. 9L) with pattern of pale spots as figured; a pale spot over r-m cross vein small, not reaching costal margin; poststigmatic pale spot small; cell M2 with small

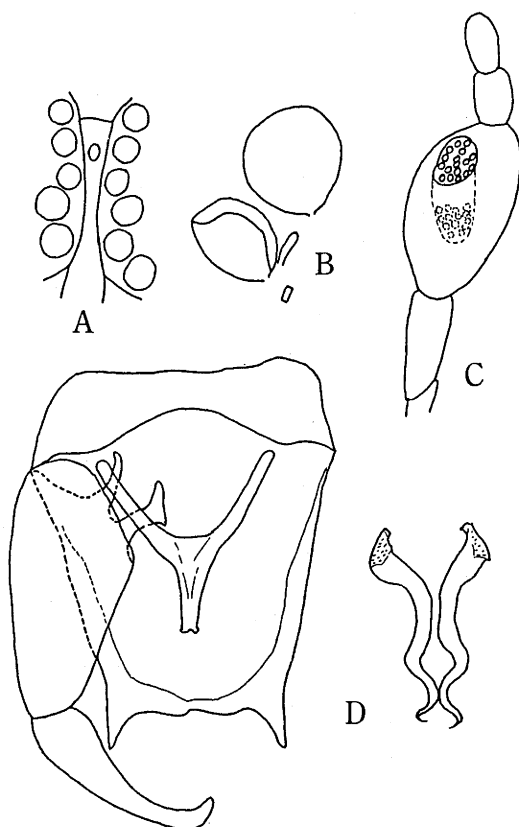


Fig. 7. *C. tsutaensis*, n. sp. A–C, female; D, male. A, eyes separation; B, spermathecae; C, palpal segments; D, genitalia, parameres separated, a basistyle of one side removed.

pale spot posteriorly to r-m pale spot; small faint marginal pale spot present on cell R5, M1 and M2; cell M4 with large faint pale spot reaching wing margin; anal cell with one pale spot in distal portion and one near base; pale spot at base of wing very small; macrotrichia long, numerous, extending to M2 and anal cell; 1.18 mm long, 0.55 mm wide; CR 0.57. Halter pale.

Abdomen. —Two developed and 1 rudimentary spermathecae as in Fig. 7B; with a ring; developed spermathecae 55x45 and 48x65 μm in size, and a rudimentary one tubular, 20 μm long.

Male. Length of wing 1.60 (0.98–1.20, n=6) mm. Similar to the female with usual sexual differences (wing, Fig. 10F). Eyes with very minute pubescence only near antennal scape. Third palpal segment with a deep sensory pit. Cibarial armature without patch of blunt spicules. Halter pale.

Genitalia (Fig. 7D). —Ninth sternum with shallow caudomedian excavation, ventral membrane bare. Ninth tergum long and tapering, with moderately separated and rather short apicolateral processes. Basistyle with ventral root foot-shaped, posterior heel poorly developed; dististyle slender. Aedeagus with slender basal arch, extending to 0.5 of total length; distal process short and broad. Parameres each with obliquely directed basal portion ending in a basal knob; mid-portion curved, slightly swollen towards base, becoming very slender and abruptly bending to end in simple pointed tip.

Distribution. Honshu.

Types. Holotype: 1 ♀, Tsuta, Aomori Pref., 17. vii. 1982, Y. Wada. Paratypes: 5 ♂♂, the same data as holotype; 1 ♂, the same locality and collector, 31. viii. 1984. All types will be deposited in the National Science Museum, Tokyo.

Biology. Nothing is known.

Taxonomic discussions. The female of the present new species is similar to that of *C. nasuensis* in the wing pattern and the greatly swollen third palpal segment, but can be separated by the pale color of halteres and the presence of sensilla coeloconica on the antennal segment 10.

Culicoides verbosus Tokunaga

Fig. 8, 9M, 10G

Culicoides verbosus Tokunaga, 1937 (female; Taiwan). —Kitaoka, 1977 (key; Nansei Islands; synonym *yaeyamensis*). —Kitaoka, 1984b (key; fig., female, male; synonym *kadenensis*). —McDonald and Lu, 1972 (diagnosis, female; Taiwan). —Tokunaga, 1962 (diagnosis, female; Iriomote Is.). —Wada and Kitaoka, 1977 (list). —Wirth and Hubert, 1961 (key; diagnosis, female; Taiwan).

Culicoides yaeyamensis Kitaoka, 1975 (female, male; Yaeyama Islands).

Female. Length of wing 0.84 (0.73–0.93, n=10) mm.

Head. —Eyes bare, very narrowly separated (Fig. 8A). Antenna with flagellar segments in proportion (μm units) of 30: 23: 23: 24: 23: 23: 23: 24: 53: 54: 58: 59: 83; AR 1.59 (1.36–1.77, n=10); sensilla coeloconica present usually on segments 3–15 (see

Table 2 for their numbers). Third palpal segment (Fig. 8C) 62 (45–70, $n=10$) μm long, greatly swollen, PR 2.14 (2.00–2.33, $n=10$), with a large shallow sensory pit. Proboscis 122 (95–138, $n=10$) μm long; P/H ratio 0.69 (0.61–0.72, $n=10$); mandible with 12–14 teeth; cibarial armature without patch of blunt spicules.

Thorax. –Legs brown; knees slightly darkened; fore and mid femora with faint subapical pale rings; tibiae with faint sub-basal pale rings; hind tibial comb with 4 bristles ($n=19$). Wing (Fig. 9M) with pattern as figured; pale spot over r-m cross vein moderately large, continuing to large pale area of cell M2; poststigmatic pale spot moderately large; cell R5, M1, M2 and M4 with moderately large marginal pale spot reaching wing margin; cell M2 with a pale streak in front of mediocubital fork; anal cell with one large pale spot in distal portion and one near base; pale spot at base of wing small; macrotrichia long, numerous, extending to cell M2 and anal cell; 0.84 (0.73–0.93, $n=10$) mm long, 0.41 (0.35–0.45, $n=10$) mm wide; CR 0.62 (0.60–0.64, $n=10$). Halter infuscated.

Abdomen. –Two developed and 1 rudimentary spermathecae as in Fig. 8B; with a ring; developed spermathecae ca. 47x34 and 43x33 μm in size, and a rudimentary one tubular, ca. 12 μm long.

Male. Length of wing 0.74 (0.70–0.75, $n=5$) mm. Similar to the female with usual sexual differences (wing, Fig. 10G). Eyes bare. Third palpal segment with a shallow sensory pit. Cibarial armature without patch of blunt spicules. Halter infuscated.

Genitalia (Fig. 8D). –Ninth sternum with shallow caudomedian excavation, ventral

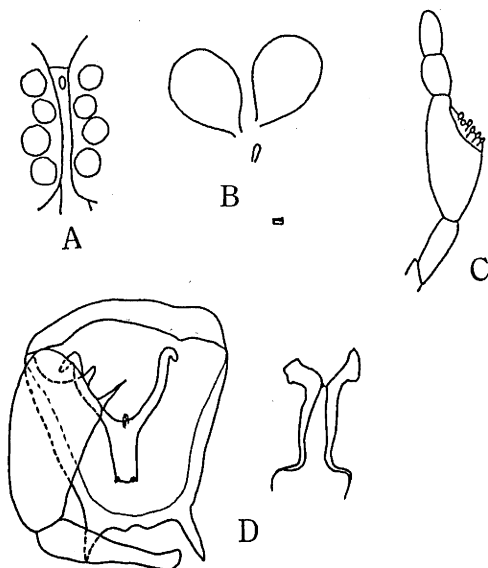


Fig. 8. *C. verbosus* Tokunaga. A–C, female; D, male. A. eyes separation; B, spermathecae; C, palpal segments; D, genitalia, parameres separated, a basistyle of one side removed.

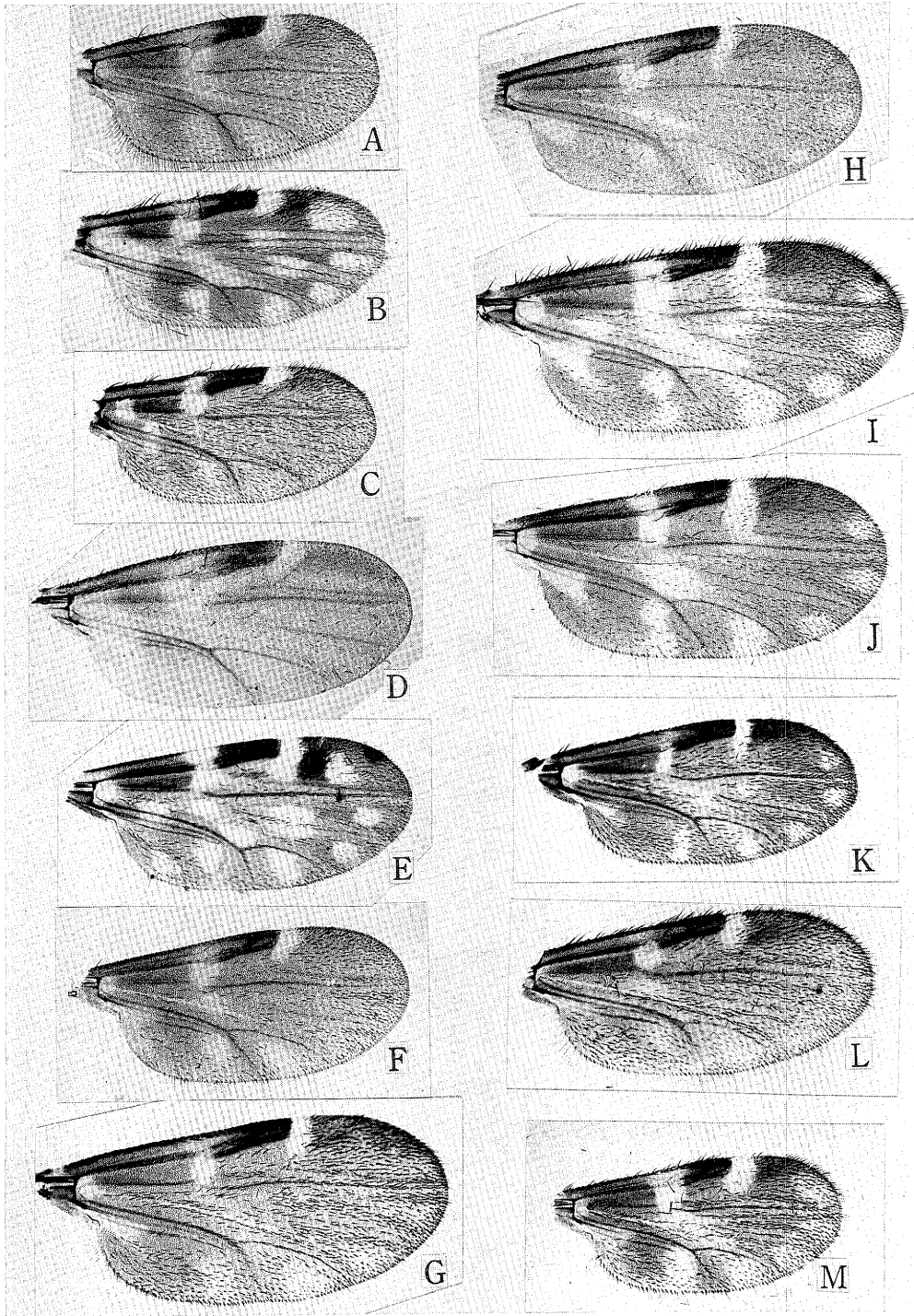


Fig. 9. Female wings. A, *C. arnaudi*; B, *C. dendrophilus*; C, *C. dryadeus*; D, *C. fukudai*, n. sp.; E, *C. iriomotensis*; F, *C. kibunensis*; G, *C. nasuensis*; H, *C. okazawai*, n. sp.; I, *C. pictimargo*; J, *C. tohokuensis*; K, *C. toshiokai*; L, *C. tsutaensis*, n. sp.; M, *C. verbosus*.

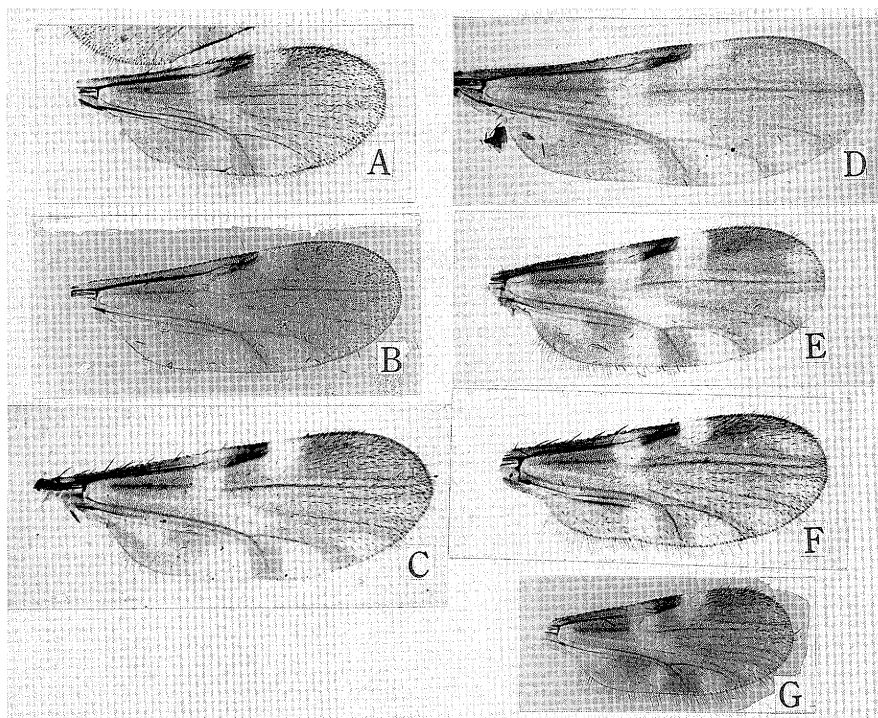


Fig. 10. Male wings. A, *C. arnaudi*; B, *C. kibunensis*; C, *C. nasuensis*; D, *C. okazawai*, n. sp.; E, *C. tohokuensis*; F, *C. tsutaensis*, n. sp.; G, *C. verbosus*.

membrane bare. Ninth tergum long and tapering, with moderately separated and long apicolateral processes. Basistyle with ventral root slender and pointed; dististyle slender. Aedeagus with slender basal arch, extending to 0.6 of total length; distal process short, broad and square-ended. Parameres each with obliquely directed basal portion ending in a strong basal knob; mid-portion slightly swollen towards base, becoming very slender and abruptly bending laterad to end in simple pointed tip.

Distribution. Okinawa Island, Yaeyama Islands; Taiwan.

Specimens used for redescription. OKINAWA ISLAND: 1 ♀, 1. ix. 1976, I. Miyagi. YAEYAMA ISLANDS: 1 ♂, Ishigaki Is., 10. iv. 1976, I. Miyagi; 2 ♀♀, the same, 24. vii. 1976, I. Miyagi; 1 ♀, Iriomote Is., 28. vii. 1976, I. Miyagi; 3 ♀♀, 3 ♂♂, the same, 3. vii. 1977, I. Miyagi; 1 ♂, the same, 6. x. 1978, I. Miyagi; 3 ♀♀, the same, 14. v. 1979, I. Miyagi.

Localities of other specimens examined. Hsitau, Pintung and Taipei, Taiwan.

Biology. Nothing is known.

Taxonomic discussions. Okada (1945) recorded *C. verbosus* from North China and described the male, but his species seems to be *C. morisitai* Tokunaga.

McDonald *et al.* (1973) described *C. kadenensis* from Okinawa Island, which has three developed spermathecae and the wing pattern similar to *C. kibunensis*. Kitaoka (1983)

mentioned the abnormal presence of three spermathecae in some species of *Culicoides* including *C. verbosus* that normally have two spermathecae, and based on this fact, Kitaoka (1984b) regarded *C. kadenensis* as a synonym of *C. verbosus*. However, because of the similar wing pattern, *C. kadenensis* may be a synonym of *C. arnaudi* (*C. kibunensis* of Okinawa is probably *C. arnaudi*; see taxonomic discussions of *C. arnaudi*).

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I wish to express my thanks to Dr. S. Kitaoka of Niigata-Sangyo University for critical comments, to Dr. W. W. Wirth of Florida Department of Agriculture and Consumer Services for encouragements, Dr. M. Sasakawa of Kyoto Prefectural University for loan of some specimens from Tokunaga's collection, Dr. R. V. Peterson of U. S. National Museum for loan of type series of *C. arnaudi*, and Dr. T. Okada for information of *C. tohokuensis*. I am also very grateful to Dr. C. S. Chen (Taiwan), Mr. A. Fukuda, Ms. S. Fukuda, Mr. T. Fukuda, Dr. H. K. Hong (Korea), Dr. H. Kurahashi, Dr. I. Miyagi, Dr. A. Miyata, Dr. M. Mogi, Dr. A. Mori, Mr. T. Ogasawara, Dr. T. Okazawa, Dr. H. Ono, Dr. H. Suzuki, Dr. M. Takahashi, and Dr. K. Yasutomi for providing with specimens or helping field collections.

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