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The peculiar winter-active midge *Diamesa starmachi* (Diptera: Chironomidae)

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ABSTRACT. Morphological variations in brachypterous and fully-winged forms of *Diamesa starmachi* KOWNACKI *et* KOWNACKA, 1970, including the first description of the female, are presented. Notes on the biology of this winter-active chironomid, based on new data from Poland, are also provided.

KEY WORDS: Diptera, Chironomidae, *Diamesa*, morphology, biology, Poland.

INTRODUCTION

KOWNACKI & KOWNACKA (1970) described the peculiar winter-emerging chironomid *Diamesa starmachi* on the basis of reared specimens and noted distinct variations in their wing length/structure. As they suggested, these variations may be the result of different conditions (temperature) in the natural habitat in winter, and in the laboratory. Unfortunately, the reared female specimens did not complete their metamorphosis, and so could not be described. *D. starmachi* was recorded from several streams in the Polish Tatra (op. cit.).

Our study, based on materials collected from nearby sites, revealed two natural forms of the species: the brachypterous one, emerging in winter, and the fully-winged, i.e. macropterous form that swarms in spring. The adult male and female of both brachypterous and macropterous forms are thus presented here. Specimens of the latter, flying form, were collected with a hanging trap.

Diamesa starmachi was suggested as a synonym (e.g. HERRMANN et al. 1987, GIŁKA 1998), but no definite evidence or formal nomenclatural corrections, except one (SPIES & SÆTHER 2004), have so far been published. In view of the questionable validity of the name and the distinct morphological variations, we present diagnostic descriptions based on detailed illustrations and measurements, which hopefully will allow the species to be defined.

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MATERIAL AND METHODS

The material consists of adult specimens taken from the surface of snow by hand or with tweezers, or collected using a triangular hanging trap containing Trypodor, the mixture commonly applied for attracting pest beetles in Poland (see Discussion). Measurements are in μm except for the total length (in mm, rounded off to the first decimal place); lengths of leg segments were rounded off to the nearest 5 μm, lengths of palpomeres to the nearest 1 μm, the antennal and leg ratios (AR, LR) were calculated to the second decimal place. The morphological terminology and abbreviations follow SÆTHER (1980). The illustrations were produced using the technique by GIŁKA (2008); the microphotographs were taken using the LAS Montage multifocus for Leica DM6000. The material is housed at the Department of Invertebrate Zoology and Parasitology, University of Gdańsk, Poland, and in the personal collection of L. Paasivirta, Salo, Finland.

RESULTS

Diamesa starmachi KOWNACKI *et* KOWNACKA, 1970

Diamesa starmachii KOWNACKI *et* KOWNACKA, 1970: 777 (male, pupa; Poland); MAKARCHENKO 1981: 104 (pupa, systematic remark).

Diamesa starmachi KOWNACKI & KOWNACKA, 1970: HERRMANN et al. 1987: 311 (systematic remark); GIŁKA 1998: 18 (remarks, Poland); SPIES & SÆTHER 2004: 4 (name correction); SÆTHER & SPIES 2013 (distribution).

Material examined

POLAND. Tatra Mts.: Białka Tatrzańska (49°23'20"N 20°06'31"E), on the River Białka, 31 December 1997, air temp.: -3°C, 2 males & 1 female (brachypterous) walking on snow, leg. A. Soszyńska-Maj; Witów (49°19'17"N 19°49'43"E) on the River Czarny Dunajec, 26 December 2012, air temp.: +1°C, 2 males & 2 females (brachypterous) walking on ice, leg. C. Bystrowski. Beskid Sądecki: Kopciowa (49°26'56"N 20°57'08"E) near Krynica Zdrój, on forest streams, 1-20 April 2012 (snow present), pheromone trap, 6 males & 15 females (macropterous), leg. M. Łuszczak.

Diagnostic descriptions

For measurements and meristic characters, see Table.

b = brachypterous form, m = macropterous form, n = number of specimens examined.

Male (n = 8) (Figs 1B, C; 2A-D, I-K; 3A, B; 4A, B)

Consistent with original description, here referred to that of female presented for the first time.

Colouration as in female. Antenna with 8 flagellomeres; shape of distal flagellomere in brachypterous and macropterous specimens different (Fig. 2B-C); shape of clypeus variable, but usually more slender than that in female (Fig. 2A). Proportions of palpomeres similar to that found in female, but palp usually longer; sensory pit on Pm_3 extensive, deep. Thoracic chaetotaxy similar to that in female but number of Dc, Pa and Scts proportionally lower. Legs as in female (Fig. 2I-K). Wing variable in shape (b) or similar to that of female (m) but more slender (Fig. 3A, B). Hypopygium (Fig. 4A, B).

Female (n = 18) Figs 1C; 2E-H, L-N; 3C, D; 4C-G

Colouration. Brown to black; wing membrane pale brownish/yellowish.

Head (Fig. 2E-H). Antenna with 7 flagellomeres; distal flagellomere with broadly rounded apex (b) (Fig. 2G) or tapering to slender tip (m) (Fig. 2F). Clypeus subtriangular, semicircular or trapezoid (b), or subrectangular (m), with two groups of strong but short setae in lateral or basilateral position. Pm_3/Pm_4 length ratio variable (b) or Pm_3 longer than Pm_4 (m); Pm_5/Pm_4 length ratio c. 1.35-1.75 (b) or c. 1.7-2.0 (m); sensory pit on Pm_3 large, slightly shallower than that found in male (Fig. 2E, H).

Thoracic chaetotaxy. Number of Aps, Dc and Scts lower and scutellars in 2-3 rows (b) or higher and scutellars multiserial (m).

Legs (Fig. 2L-N). Relatively short and stocky (b) or slender (m). Spurs covered with dense microtrichia in basal half, apices naked; length of spurs variable, in mid and hind leg in particular.

Wing (Fig. 3C, D). Fully developed or strongly abbreviated (intermediate morph not recorded). Variable in shape and venation (b) or variations insignificant (m) and wing similar to that found in male, but slightly broader at mid length and subcostal and anal regions more extensive. Membrane with dense punctuation (b) or covered with tiny, c. 2-3 μm long, spine-like microtrichia visible at magnification x 500 (m).

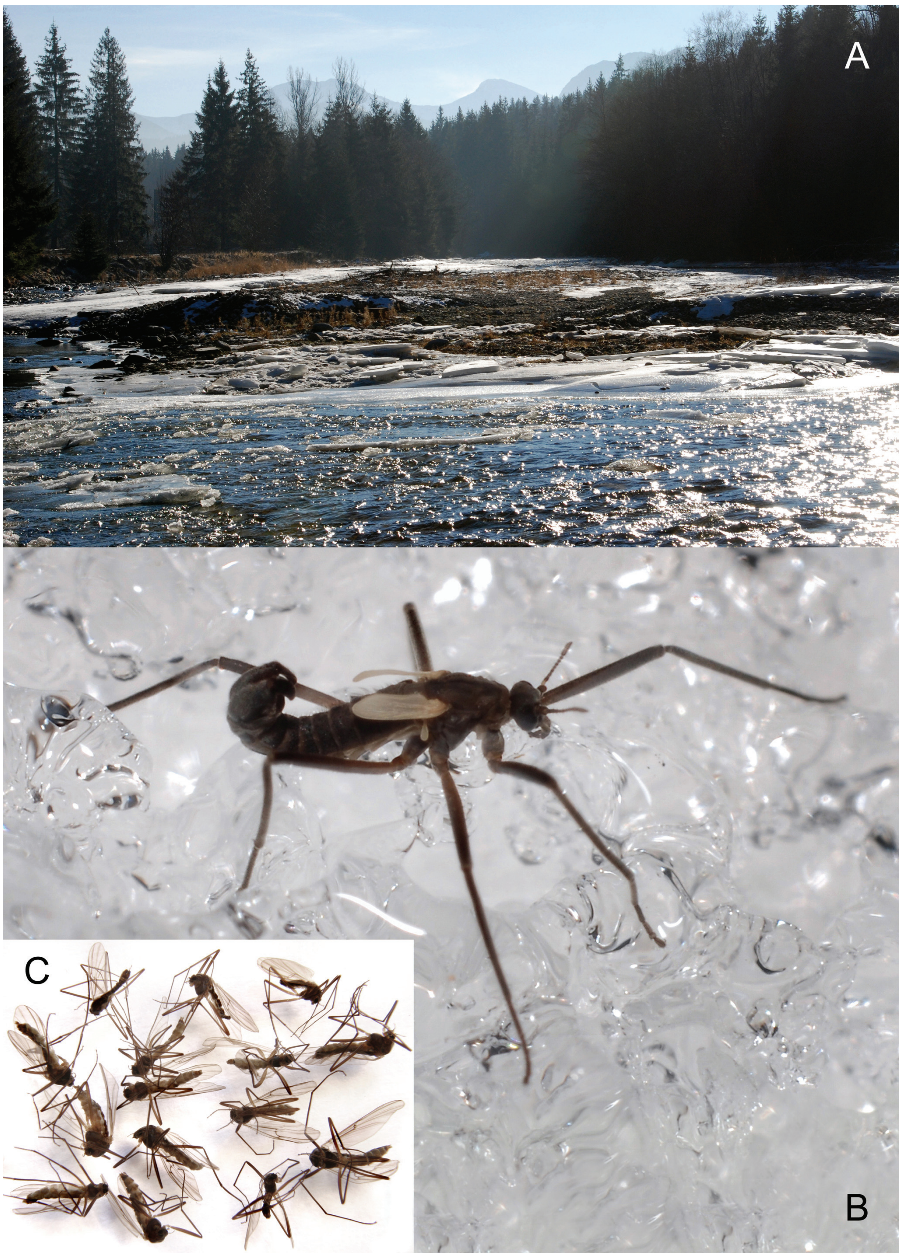

Fig. 1. *Diamesa starmachi* KOWNACKI *et* KOWNACKA. A – site at Witów during sampling on 26th December 2012, B – brachypterous male walking on ice (site and date as in A), C – macropterous specimens collected at Kopciowa using the hanging trap in April (diminished x 5 relative to the specimen shown in B). Photographs A and B by C. Bystrowski.

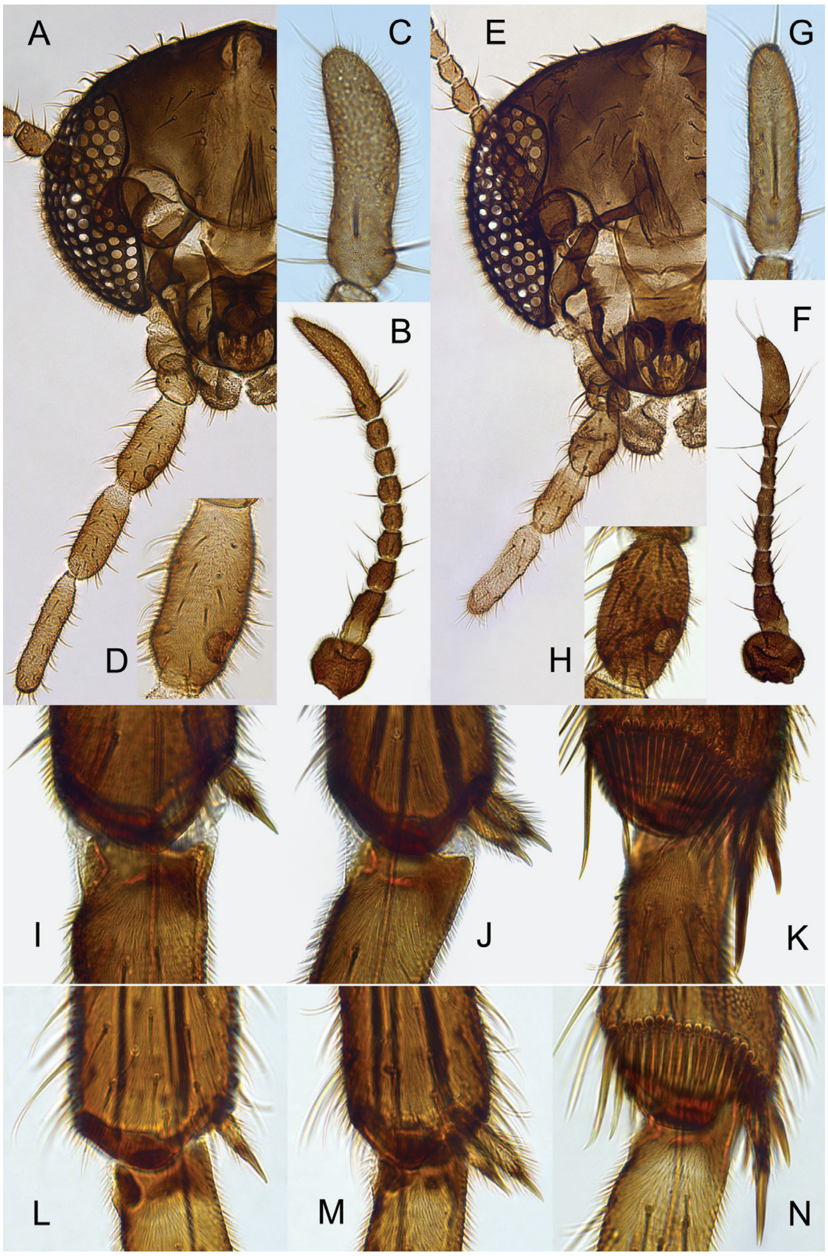

Fig. 2. *Diamesa starmachi* KOWNACKI *et* KOWNACKA. Male (A-D, I-K). Female (E-H, L-N). A, E – head; B, F – antenna (macropterous form); C, G – ultimate flagellomere (brachypterous form, magnified c. 3 x relative to B and F respectively); D, H – 3rd palpomere; I-N – tibial apices of fore (I, L), mid (J, M) and hind leg (K, N).

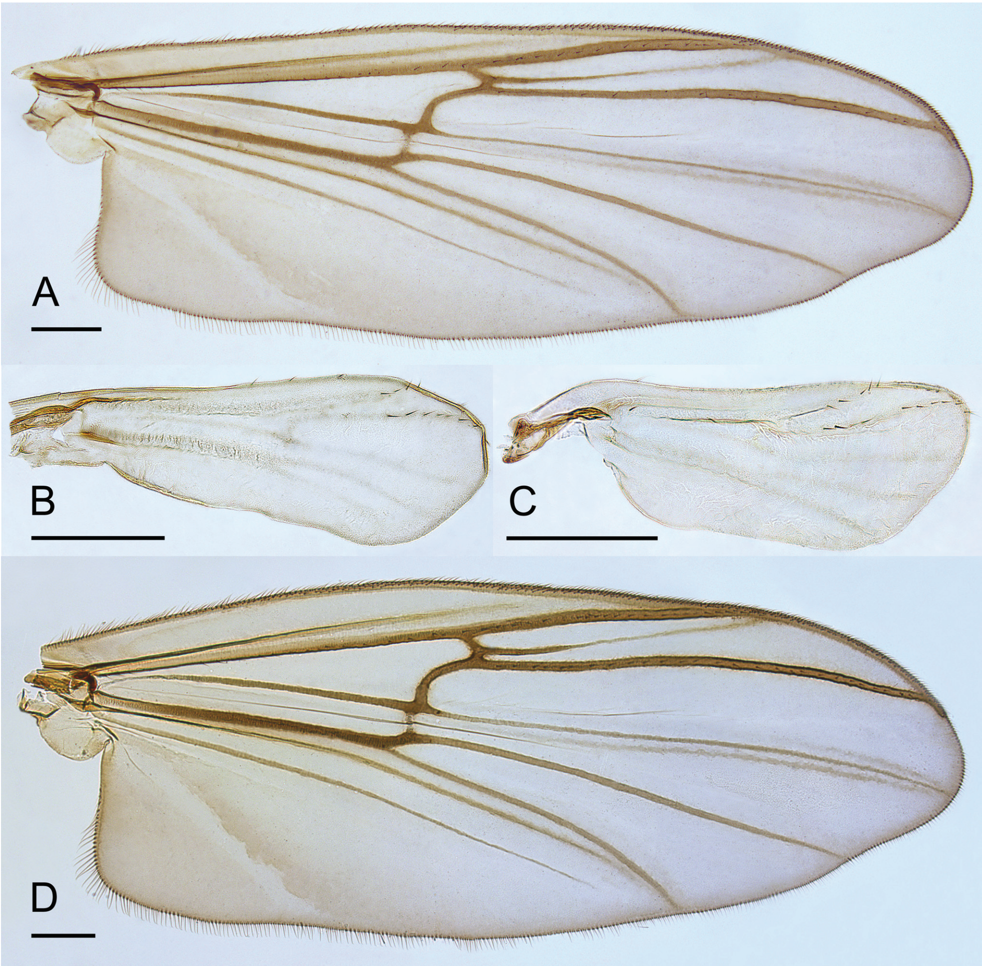

Fig. 3. *Diamesa starmachi* KOWNACKI *et* KOWNACKA. Wing of male (A, B) and female (C, D), fully developed (A, D) and shortened (B, C). Scale bar: 250 µm.

Genitalia (Fig. 4C-G). Tergite IX broadly semicircular, with pair of large lobes, each with nipple-like apical process. Gonapophysis VIII single-lobed, extensive, caudomedian margins broadly rounded, tapering to wide floor covering about one-third of anterior part of vagina, margins splayed (Fig. 4C, E). Rami lightly coloured, covered by vagina (poorly observable), tapering to strong notum. Labia wide, triangular, with parallel posteromedian margins extending far beyond posterior margin of SVIII. Seminal capsules ovoid, unequal in size, each with long neck posteriorly directed; spermathecal ducts curved but never looping (Fig. 4C, D). Postgenital plate subtriangular. Coxosternapodeme strong, as shown in Fig. 4C. Cercus triangular, rarely subrectangular, with dorsomedian lobe extending slightly beyond ventromedian margin at most (Fig. 4C, F, G).

Pupa. KOWNACKI & KOWNACKA (1970); resembling that of *Diamesa leona* ROBACK, 1957 (MAKARCHENKO 1981).

Larva. Not described.

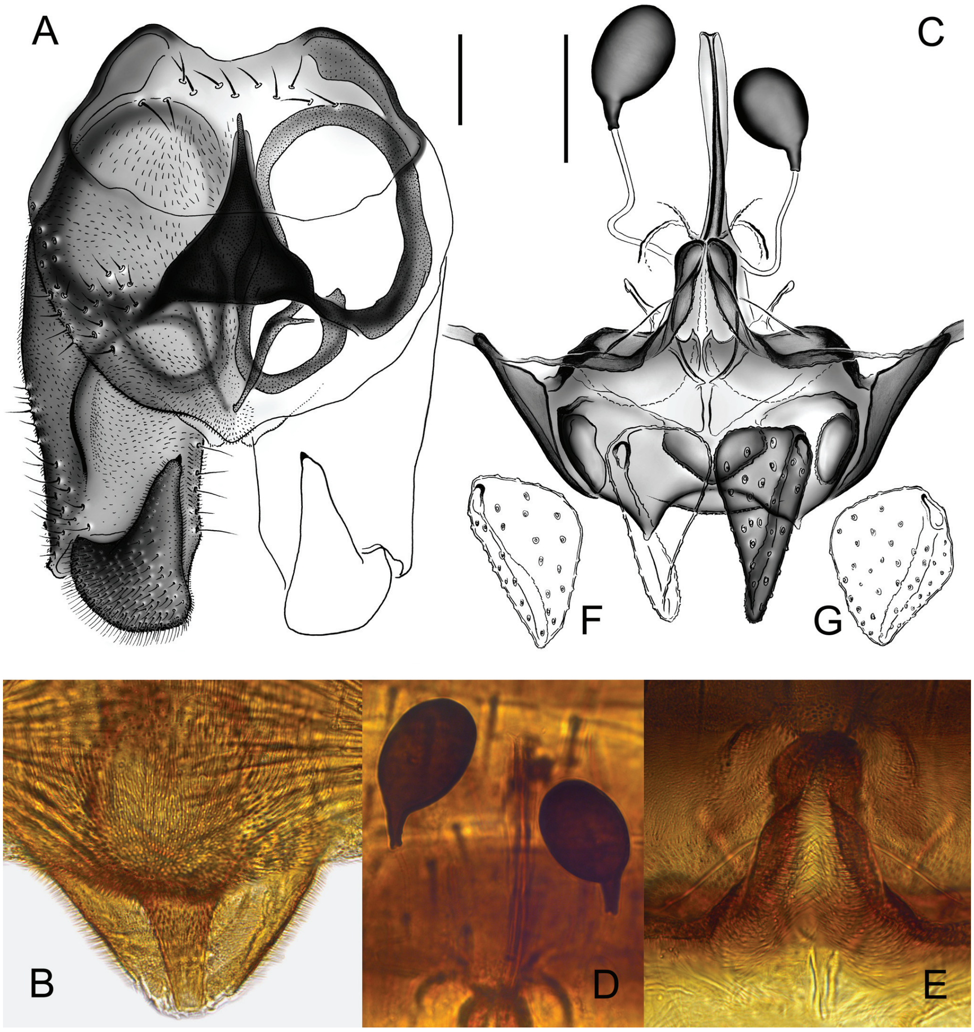

Fig. 4. *Diamesa starmachi* KOWNACKI *et* KOWNACKA. Genitalia in male (A, B) and female (C-G). A – hypopygium; B – anal point (bent out on slide); C – genital apparatus, ventral (setae and trichia omitted); D – seminal capsules and notum; E – gonapophysis VIII and labia; F, G: cercus (variation). Scale bar: 100 µm.

Table. Comparison of metric and meristic characters of brachypterous and macropterous forms of adult male and female *Diamesa starmachi*. Lengths in µm, except for total length (mm). Ranges complemented with values by KOWNACKI & KOWNACKA (1970) wherever possible (in parentheses).

Character		Male		Female	
		brachypterous	macropterous	brachypterous	macropterous
Total length		3.2-5.0	3.2-3.4	3.7-5.5	3.6-4.9
Wing length		788-994	3170-3200 (2100)	554-615	3046-4128
Total length / wing length ratio		4.0-6.2	1.0-1.1	6.5-8.9	1.1-1.2
AR		0.40-0.54 (0.68)	0.45-0.57	0.32-0.36	0.26-0.39
Antennal flagellum, length		414-577	525-583	405-437	386-457
Ultimate flagellomere, length		151-199	179-205	115-119	115-139
Frontal tubercle, length		c. 3-4 or absent	absent	c. 2-4 or absent	absent
Pm_1		44-60	54-60	40-48	48-56
Pm_2		68-90	63-80	56-71	56-76
Pm_3		119-183	147-160	87-111	119-155
Pm_4		103-151	119-163	87-107	111-139
Pm_5		139-187	183-235	127-155	218-239
Clypeals		4-12	10-15	6-13	12-17
Aps		11-14	13-18	10-15	13-19
Ac		absent	absent	absent	absent
Dc		7-12	15-17	8-15	16-23
Pa		3-4	4-5	4-6	6-7
Scts		9-18	21-22	20-29	48-53
p_1	fe	1405-1755	1935-1950	1075-1340	1455-1840
	ti	1330-1680	2040-2050	1000-1340	1545-2120
	ta_1	605-720	1250-1270	525-615	975-1235
	ta_2	265-310	585-605	230-245	450-570
	ta_3	155-185	350-355	125-155	265-325
	ta_4	95-125	120-125	75-90	110-125
	ta_5	125-170	170-185	140-170	185-215
p_2	fe	1360-1770	1935-2010	1045-1310	1470-2010
	ti	1190-1515	1730-1840	925-1185	1440-1965
	ta_1	415-495	835-880	355-415	680-820
	ta_2	185-230	400-450	155-200	340-430
	ta_3	125-160	265-280	110-125	215-280
	ta_4	95-115	120-125	75-90	110-125
	ta_5	125-160	155-170	125-155	170-200
p_3	fe	1545-2000	2070-2165	1170-1460	1575-2120
	ti	1530-1860	2135-2275	1155-1460	1745-2255
	ta_1	680-850	1250-1260	600-690	1100-1330
	ta_2	370-445	635-695	340-385	620-755
	ta_3	170-220	340-370	170-185	325-370
	ta_4	95-125	140-155	75-110	110-170
	ta_5	125-160	185-195	125-155	185-230
LR_1		0.43-0.49 (0.54)	0.61-0.62	0.46-0.54	0.58-0.64
LR_2		0.31-0.38	0.47-0.49	0.35-0.40	0.42-0.50
LR_3		0.43-0.48	0.55-0.59	0.47-0.56	0.59-0.63
p_1 spur, length		40-54	48-65	40-44	48-64
p_2 spurs, length		44-54 & 44-56	48-65 & 60-67	40-44 & 44-52	44-60 & 48-64
p_3 spurs, length		44-60 & 76-87	64-88 & 100-115	48-52 & 71-79	64-80 & 84-107
p_3 comb, length & number of setae		24-80 18-21 setae	28-84 19-23 setae	28-83 16-20 setae	32-88 18-21 setae
Gonostylus, length		280	290		
Tooth of gonostylus, length		c. 15	c. 15		
Notum, length				160-170	170-175
Seminal capsule smaller, length (without neck) & width				60-87 & 50-52	75-88 & 52-54
Seminal capsule larger, length (without neck) & width				75-79 & 52-60	77-79 & 55-60
Necks, length				20-24 & 24-26	20-25 & 24-28
Spermathecal duct, length				160-180	200-210
Cercus, length				155-200	170-260

DISCUSSION

The subfamily Diamesinae includes cold-stenothermal and extremely cold-tolerant species, which are known for their reduced wings. Brachyptery, the phenomenon defined as one of several levels of a multi-step wing reduction (e.g. HERRMANN et al. 1987), is an adaptation to cold and snow/ice environmental conditions and ground mating, and involves secondary morphological adaptations (DOWNES 1969). Brachypterous morphs of the Diamesinae, like those known from the *Diamesa steinboecki* or *D. davisi* groups, were found at high altitudes (LODS-CROZET et al. 2001), including a Himalayan glacier, where a wingless *Diamesa* was reported as active even at an altitude of 5100-5600 m and -16°C, probably the lowest temperature recorded for any active insect (KOSHIMA 1985). HERRMANN *et al.* (1987) reported the brachypterous morph of *Diamesa leona* emerging at an altitude of 2100 to 3000 m, i.e. higher than the macropterous one.

Diamesa starmachi has so far been recorded in Poland only from the Tatra Mountains (KOWNACKI & KOWNACKA 1970); the species is also known from Austria, Germany, Italy, Luxembourg and Slovakia (SÆTHER & SPIES 2013). In this work, brachypterous adults of *D. starmachi* were observed twice in large numbers on snow surrounding the banks of the River Białka (alt. 700-800 m). Macropterous specimens of *D. starmachi*, presented here for the first time, have never yet been observed on snow (SOSZYŃSKA-MAJ pers. observ.), but have been collected in traps on the snowbound banks of streams and springs in the Beskid Sądecki Mountains. Interestingly, the macropterous specimens were taken using a hanging trap containing the aggregation pheromone Trypodor intended to attract the striped ambrosia beetle (*Trypodendron lineatum*). This suggests that the chironomid specimens were swarming in large numbers at that time (April) and/or that the effectiveness of the substance is wide-ranging.

Adult dipterans known for their brachyptery have much stronger legs, enabling them to disperse by walking and search for a mate. ARMITAGE (1995) pointed out that brachypterous adults of *Belgica antarctica* Jacobs (Chironomidae: Orthocladiinae) disperse by walking a few metres. *Diamesa starmachi*, as recorded in this work (SOSZYŃSKA-MAJ pers. observ.), is capable of covering much greater distances. The brachypterous specimens of *D. starmachi* were observed walking and mating at a temperature of -3°C.

Diamesa leona, the species/name suggested as a probable senior synonym of *D. starmachi*, is also known from mid-winter emergence in the central Colorado Mountains, where both brachypterous and macropterous forms occur synchronously and sympatrically (HERRMANN *et al.* 1987). The two forms were also recorded from several distant sites in the Baikal Region and the Far East by MAKARCHENKO (1981) and LINEVICH & MAKARCHENKO (1989), whereas HANSEN & COOK (1976) described a morph having wings of intermediate length. HERRMANN et al. (l.c.) indicated temperature as the prime selection factor for both forms of *D. leona*. They pointed out that the median surface water temperature at the time of emergence was 2°C for brachypterous and 3.7°C for the fully-winged form of this species; wind stress and high altitude were also thought to be determining factors. Both forms were recorded together in 30% of collected samples; although cross-copulation never took place. It was therefore suggested that spatial and behavioural isolation factors as well as temperature led to molecular diversity. The correlation between temperature and the occurrence of different forms was also presumed for *Diamesa starmachi* (KOWNACKI & KOWNACKA 1970); however, the brachypterous and macropterous forms of *D. starmachi* have not yet been observed either synchronously or sympatrically.

The peculiar biology of *Diamesa starmachi* obviously results in morphological variations. Apart from the wing modifications, there is a distinct variability of several diagnostic structures in this species. The brachypterous and macropterous specimens of both sexes clearly differ in the shape and proportions of the palpomeres (the ultimate flagellomere in particular), in the number and arrangement of thoracic setae (the scutellars in particular), as well as in the total length of legs, leg ratios and length of tibial spurs. Spermathecal ducts and cerci in macropterous specimens are longer than those found in brachypterous females, despite the proportionally smaller overall size. In contrast, the female and male genitalia in the two forms show only slight variations in the size of the seminal capsules, length of notum and gonostylus (Table).

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