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Larval morphology of four East Palearctic species of *Ilybius* ERICHSON (Coleoptera: Dytiscidae)

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Abstract

The morphology of all three larval instars of the following four East Palearctic species of Dytiscidae is described for the first time: *Ilybius apicalis* SHARP, *I. chishimanus* KONO, *I. nakanei* NILSSON and *I. poppiusi* ZAITZEV. Leg chaetotaxy is described in detail, and the presence of secondary swimming hairs on the tibiae and meso- and metatarsi of *I. apicalis* is unique for the genus. The larvae of the allopatric *I. chishimanus* and *I. nakanei* are very similar, and possible to separate only in the first instar based on the studied material. A key is provided for the separation of the described larvae, treating *I. chishimanus* and *I. nakanei* together in the two later instars. Larval phenology suggests the same life cycle as followed by the European species of the genus, i.e. semivoltine with overwintering larvae and adults.

Key words: Coleoptera, Dytiscidae, East Palearctic, larval morphology, *Ilybius*, leg chaetotaxy

Introduction

Ilybius ERICHSON is a relatively small Holarctic genus in the tribe Agabini with about 30 species. Larvae have been described of all of the 13 species recorded from Europe except the Mediterranean *Ilybius meridionalis* AUBE (GALEWSKI 1966, NILSSON 1981, 1983). LARSON (1987) recognized 14 species in North America, of which four also occur in the Old World. The larvae of the Nearctic species remain unknown. Nothing is known of the larvae of the seven East Palearctic species, including the interesting *apicalis*-group, recognized as the sister-group to all other *Ilybius* by LARSON (1987).

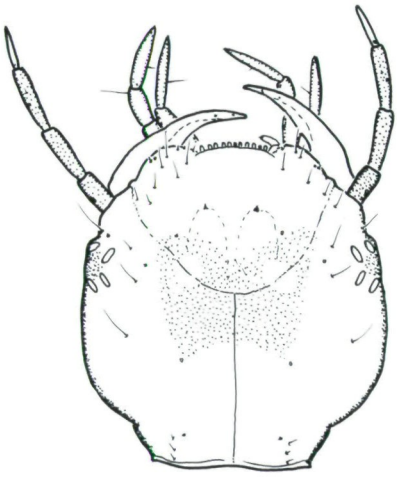
The aim of this work is to present detailed descriptions of all larval instars of four East Palearctic species, including one species of the *apicalis*-group.

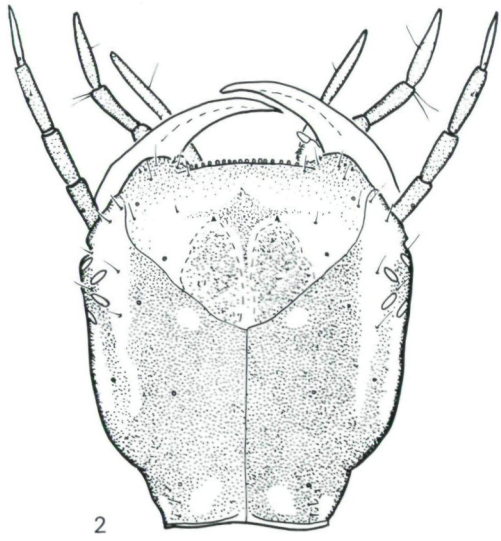
Material and methods

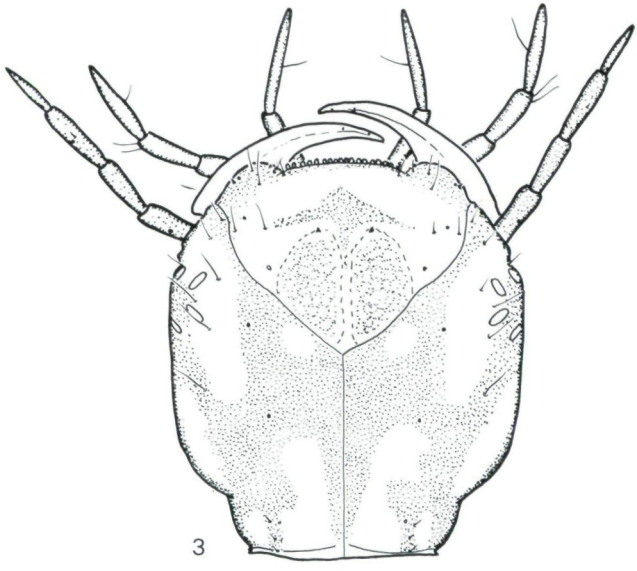
The descriptions are based on larvae collected together with adults. The association of larvae with conspecific adults was based on repeated sampling of a high number of ponds in Primorye and on the island of Sakhalin. *Ilybius apicalis* SHARP and *I. poppiusi* ZAITZEV occur in both regions, whereas *I. nakanei* NILSSON is absent from Primorye and *I. chishimanus* KONO from Sakhalin. *Ilybius apicalis* is the only species of its group on Sakhalin (NILSSON & KHOLIN 1994). Both *I. chishimanus* and *I. nakanei* are closely related to the Palearctic *I. crassus* THOMSON (NILSSON 1994), of which the larva is known (GALEWSKI 1966). Moreover, they are the largest *Ilybius* species found in their respective regions.

The following material was examined (all specimens were collected by the junior author, they are deposited in the collection of the senior author):

Ilybius apicalis SHARP. - Russia, Primorye, 17 km N Vladivostok, Sputnik Station: 28.viii.1993, 3 L1; 7.-8.x.1993, 5 (II), 2 (III). - Sakhalin, Kholmsk Reg., between Kostromskoye and Pionery, 8.ix.1993, 11 (I), 9 (II), 15.-17.viii.1994, 7 (I). In total: 21 (I), 14 (II), 2 (III).



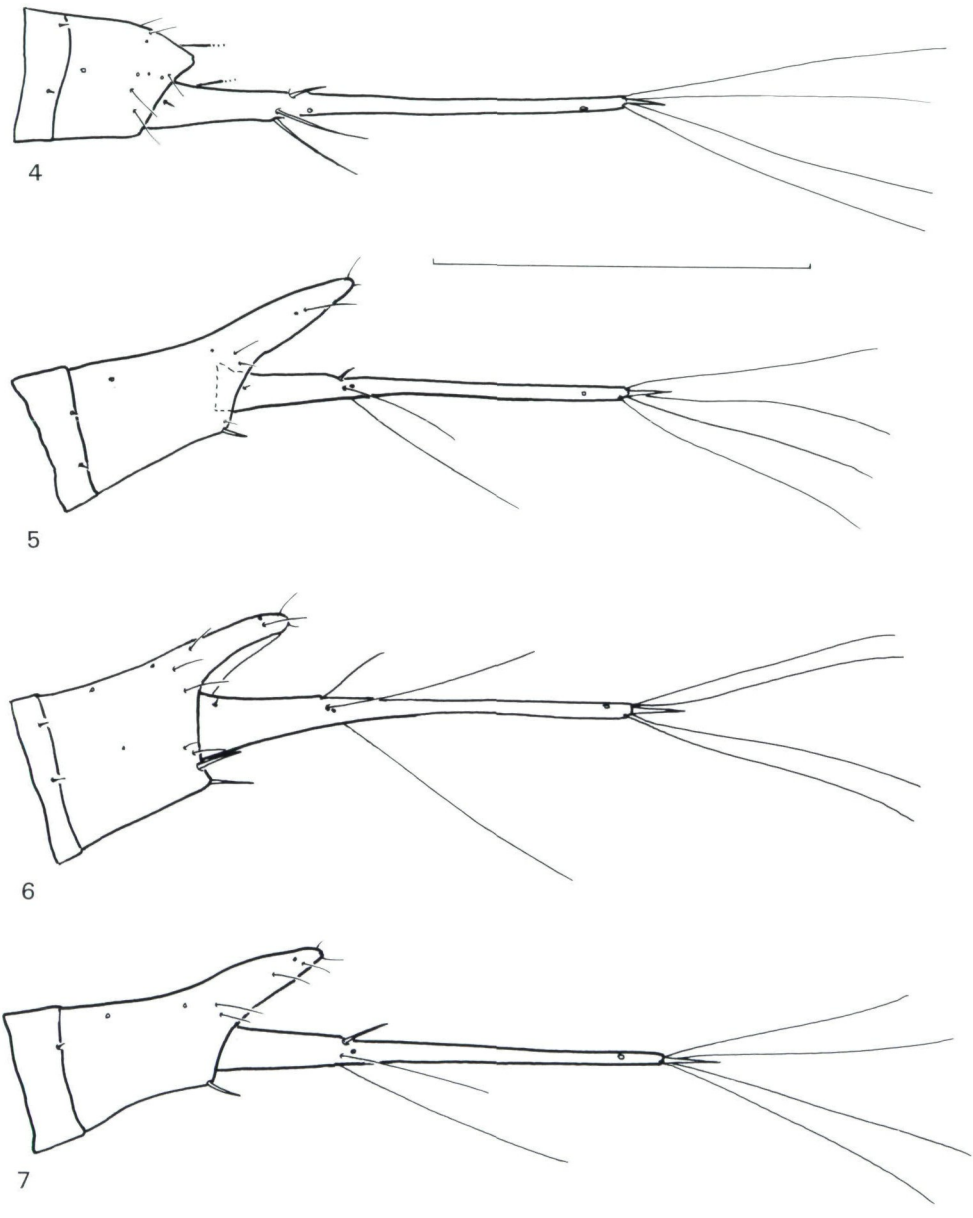




Figs 1 - 3: *Ilybius*, head of instar I larva, dorsal view. 1) *I. apicalis*; 2) *I. poppiusi*; 3) *I. nakanei*. Scale bar 1 mm.

Ilybius chishimanus KONO. - Russia, Primorye, 17 km N Vladivostok, Sputnik Station: 28.viii. - 1.ix.1993, 25 (I), 5 (II), 3 (III); 6.-8.x.1993, 6 (I), 94 (II), 47 (III); 20.v.1994, 1 (III); 31.vii.1994, 4 (I); 28.-31.viii.1994, 1 (I), 12 (II); Ussurisk Res., 30.-31.vii.1993, 7 (I). - Khabarovsk Terr., Vanino: 29.viii.1994, 1 (I). In total: 44 (I), 111 (II), 51 (III).

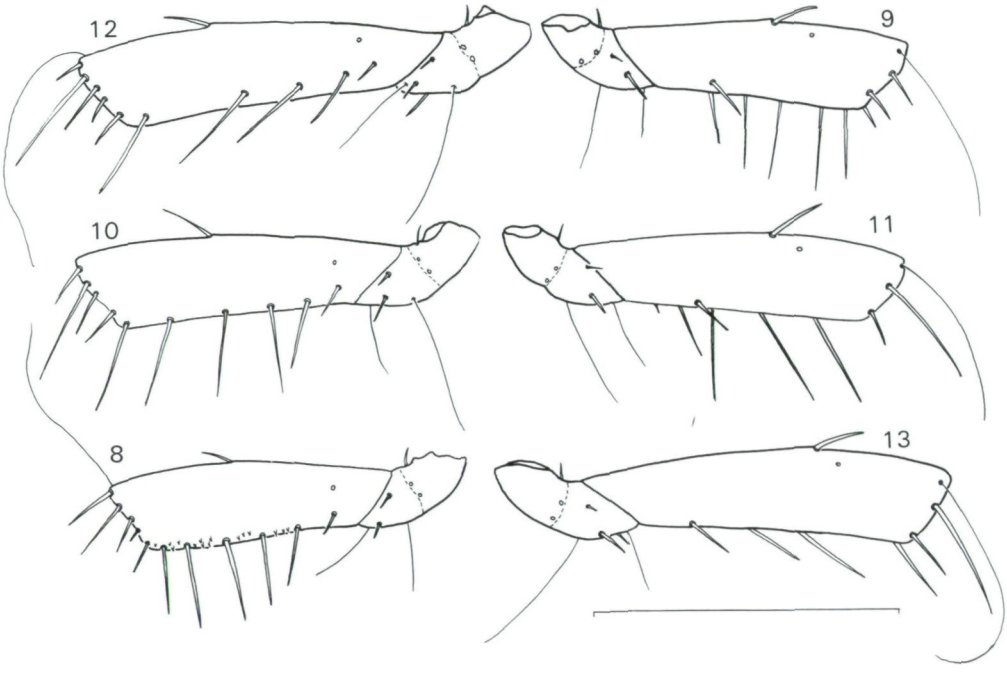
Ilybius nakanei NILSSON. - Russia, Sakhalin, Kholmsk Reg., Kholmsk: 14.ix.1993, 2 (I), 3 (II), 1 (III); 12.viii.1994, 2 (I); Pionery, 9.viii.1994, 1 (I), 1 (II). In total: 5 (I), 4 (II), 1 (III).



Figs 4 - 7: *Ilybius*, instar I larva, last abdominal segment and one urogomphus, lateral view. 4) *I. apicalis*; 5) *I. poppiusi*; 6) *I. nakanei*; 7) *I. chishimanus*. Scale bar 1 mm.

Ilybius poppiusi ZAITZEV. - Russia, Primorye, 17 km N Vladivostok, Sputnik Station: 28.viii. - 1.ix.1993, 3 (I); 7.-8.x.1993, 11 (II), 1 (III); 31.viii.1994, 1 (I), 1 (II). - Sakhalin, Kholmsk Reg., between Kostromskoye and Pionery, 8.-9.ix.1993, 4 (I), 6 (II), 4 (III); 9.-15.viii.1994, 7 (I), 1 (II).

In total: 15 (I), 19 (II), 5 (III).



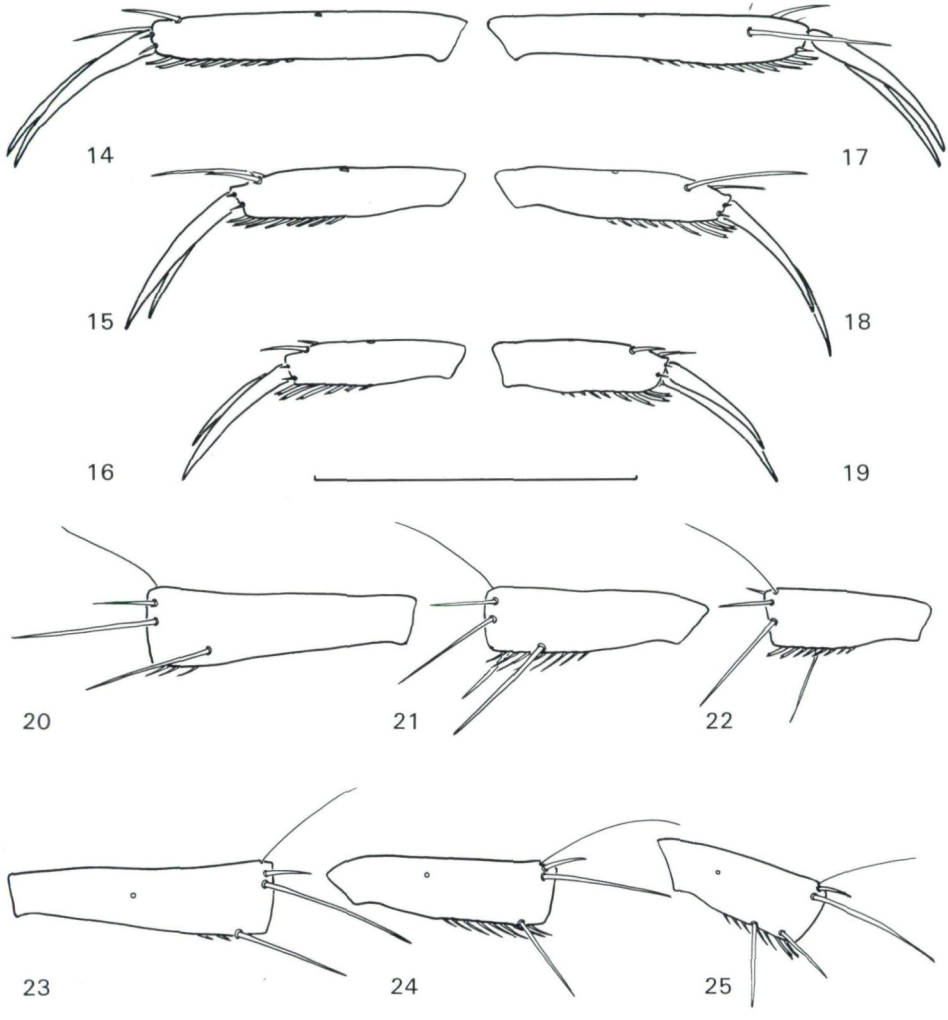
Figs 8 - 13: *Ilybius apicalis*, instar I larva, femur in anterior (8, 10, 12) and posterior view (9, 11, 13). 8 - 9) profemur; 10 - 11) mesofemur; 12 - 13) metafemur. Scale bar 0.5 mm.

Abbreviations. Measurements: (HL) head length incl. neck, (HW) maximum head width, (LASD) dorsal length of last abdominal segment from posterior margin of basal elevation to apex of siphon, (LASV) ventral length of last abdominal segment from posterior margin of basal elevation to ventro-posterior margin of segment, (NW) neck width subbasally, and (U1) length of segment 1 of urogomphus. Positions (often used in combination): (A) anterior, (D) dorsal, (P) posterior, and (V) ventral. Structures: (UR2 - 4) proximal setae of urgomphus; UR4 has a dorsal position (ALARIE & HARPER 1990).

See NILSSON (1988) and ALARIE (1995) for a description of primary leg chaetotaxy of Agabini larvae. Spiniform setae are referred to as spines. All drawings were prepared by the senior author.

Descriptions

Selected measurements and ratios are presented in Tables 1 - 2. Secondary leg chaetotaxy is presented in Table 3. The larvae of all four species share the following characters: (1) abdominal sternum 6 with membraneous section broad; spiracles located to tergal margins; (2) primary setae and pores on last abdominal segment as in *I. angustior* (GYLLENHAL) figured by ALARIE (1995); (3) urogomphus with 8 primary and without secondary setae; (4) urogomphus with UR4 shorter and less pigmented than UR2 - 3, especially in instar I (Figs 2 - 7); (5) legs with same number of primary setae and pores as the examined European species (e.g. *I. aenescens* THOMSON figured in NILSSON 1988, and *I. angustior* (GYLLENHAL) figured by ALARIE 1995), except the femoral D, AV and PV series that show a slight variation in the number of spines; (6) trochanter without secondary setae; (7) each coxa with secondary D spines; (8) each femur with secondary spines in D, AV and PV series only (Figs 38, 39, 46).

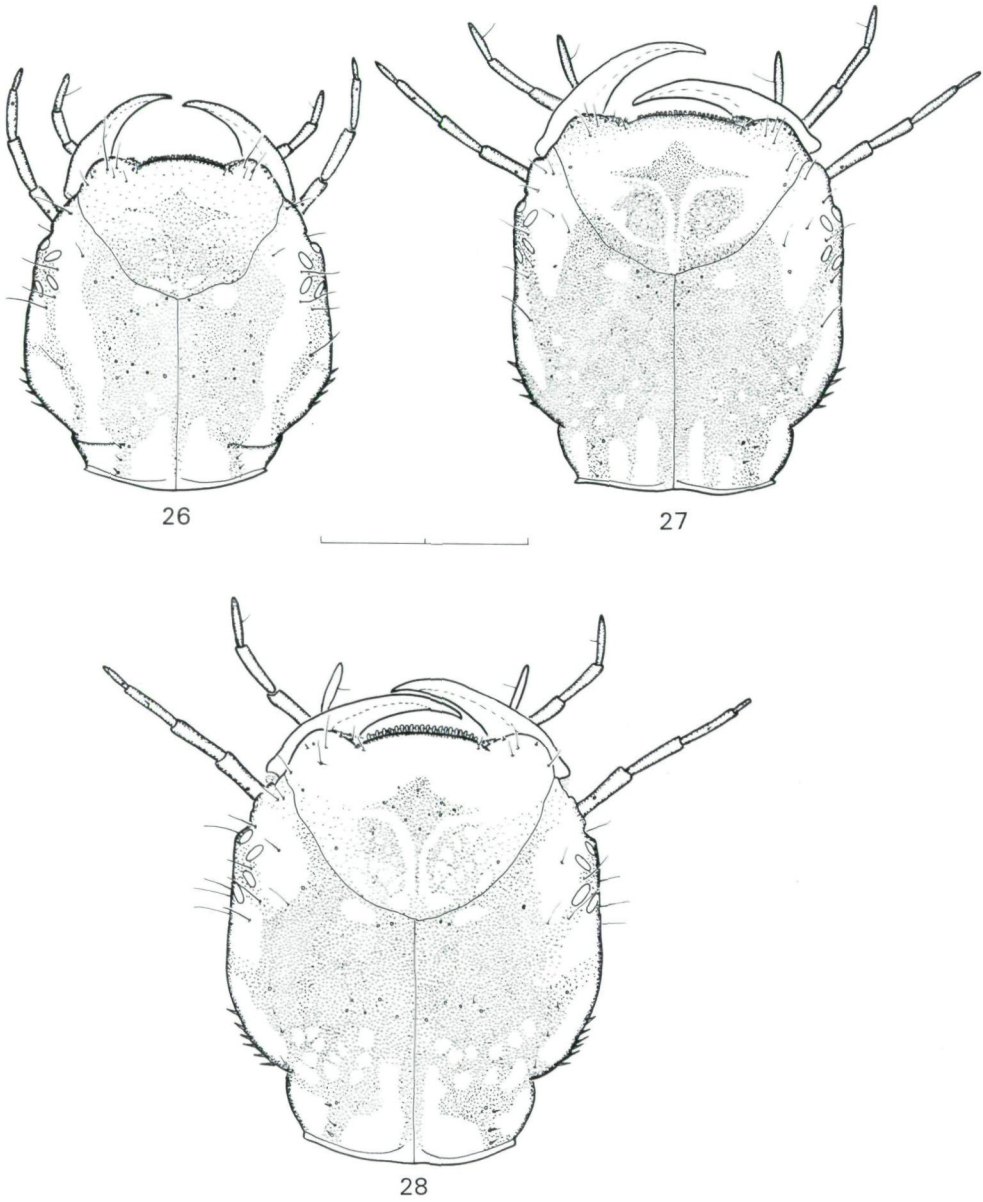


Figs 14 - 25: *Ilybius apicalis*, instar I larva, tarsus (14 - 19) and tibia (20 - 25) in anterior (14 - 16, 20 - 22) and posterior view (17 - 19, 23 - 25). 14, 17, 20, 23) hind leg. 15, 18, 21, 24) middle leg; 16, 19, 22, 25) fore leg. Scale bar 0.5 mm.

Ilybius apicalis SHARP

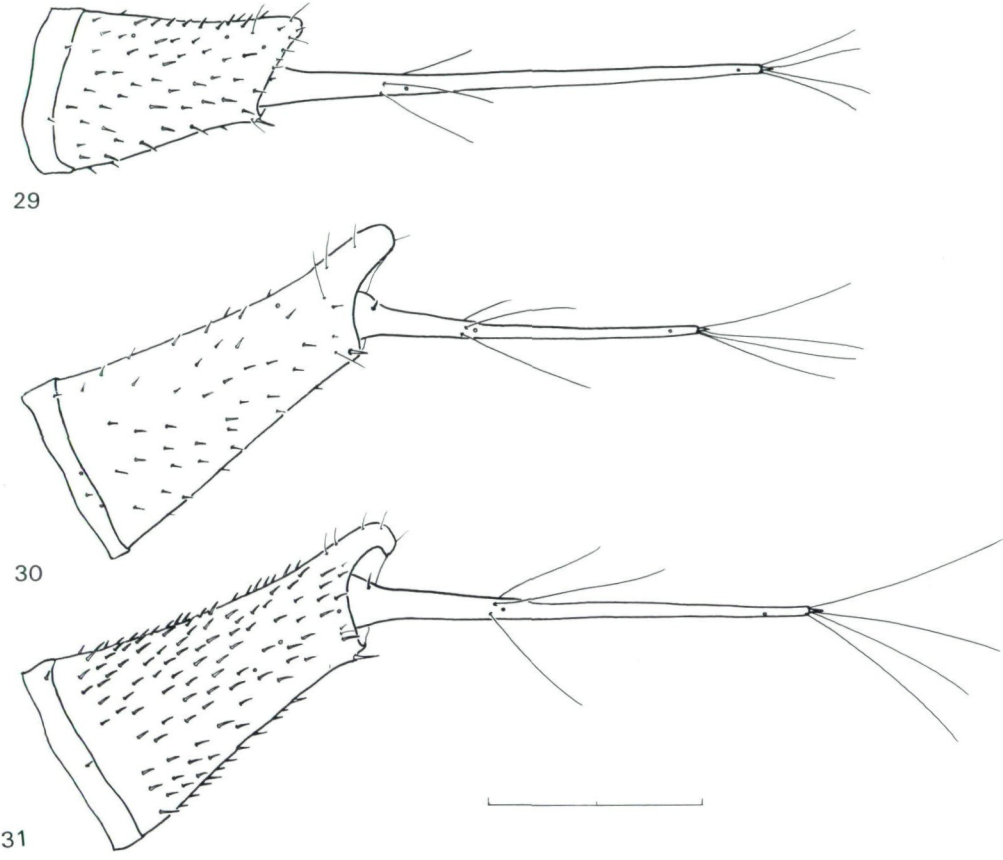
Colour. Head in instar I dorsally yellowish with more or less pigmented dark central marking (Fig. 1); in instars II - III with more extensive brown pattern (Fig. 26). Antenna with segments 1 - 3 and palpi with weak infuscation in instar I. Body yellowish white; terga with pattern of brownish spots and stripes. Setal sockets strongly pigmented in instars II - III. Anterior tergal margins strongly pigmented sublaterally.

Head. Lateral outline subparallel in instar I (Fig. 1), slightly converging anteriorad in instars II - III (Fig. 26). With 4 - 6 secondary temporal spines. Neck separated from head by secondary bead, absent medially (Fig. 26). Clypeal margin narrow, with 11 lamelliform setae in instar I, and with 16 large and about 30 small lamelliform setae in instars II - III.



Figs 26 - 28: *Ilybius*, head of instar III larva, dorsal view. 26) *I. apicalis*; 27) *I. poppiusi*; 28) *I. chishimanus*. Scale bar 2 mm.

Body. Tergal setation strong. Last abdominal segment short with short siphon (Figs 4, 29). Urogomphus very long; more than twice as long as last abdominal segment in instar III, and almost four times as long as last abdominal segment in instar I; with relatively short setae (Figs 4, 29).



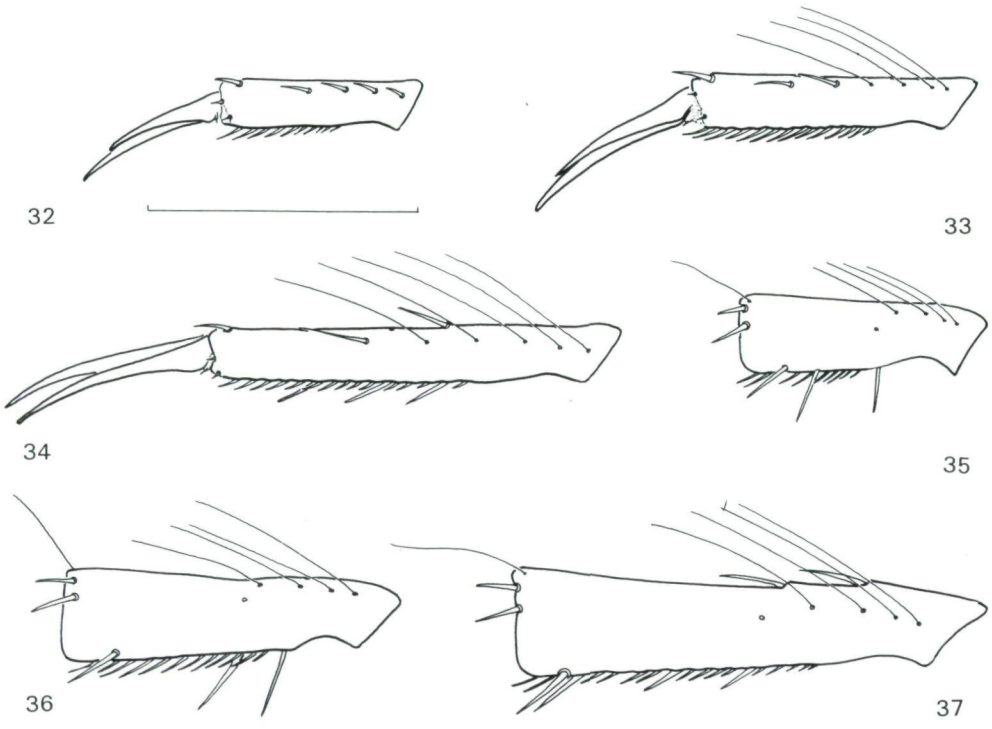
Figs 29 - 31: *Ilybius*, instar III larva, last abdominal segment and one urogomphus, lateral view. 29) *I. apicalis*; 30) *I. poppiusi*; 31) *I. chishimanus*. Scale bar 2 mm.

Legs. With very long spines in instar I (Figs 8 - 25). Profemur with one primary D spine in distal half. Pro-, meso- and metafemora each with 4, 4 - 5 and 4 secondary D spines, respectively. Each tibia with one or more secondary spines plus a PD series of long hair-like setae in proximal half (Figs 35 - 37). Each tarsus with a proximal PD series of secondary setae, spiniform on fore leg and hair-like on mid and hind legs (Figs 35 - 37).

Ilybius chishimanus KONO and *I. nakanei* NILSSON

These two species belong to the *crassus*-complex and they are very similar as adults (**NILSSON** 1994) and as larvae. The significance of the quantitative differences (Tabs 1 - 2) is difficult to judge until more specimens have been measured.

Colour. Body of instars II - III dorsally brown with pale yellowish spots; prothorax with lateral, sublateral and median spots; other terga without median spots, weaker towards end of abdomen. Head dorsally with contrastive pattern (Figs 3, 28).



Figs 32 - 37: *Ilybius apicalis*, instar III larva, tarsus (32 - 34) and tibia (35 - 37) in posterior view. 32, 35) fore leg; 33, 36) middle leg; 34, 37) hind leg. Scale bar 1 mm.

Head. Sides subparallel (Figs 3, 28). Neck with distinct bead in lateral third in instar III (Fig. 28). Temporal spines of medium length, 5 - 6 and 5 - 7 in instar II and III, respectively. Clypeal margin with 17 - 18 lamelliform setae in instar I, and with 21 - 22 large and more than 20 small lamelliform setae in instars II - III.

Body. Tergal setation not reduced. Last abdominal segment relatively long with long siphon (Figs 6, 7, 31). Urogomphus about 1.2 times as long as last abdominal segment in instar I (Figs 6, 7), and about 1.5 times as long as in instar II - III (Fig. 31). Urogomphus with UR4 much shorter and paler than UR2 - 3 in instar I, less so in instar II, and of same length in instar III (Fig. 31).

Legs. Profemur with one primary D spine in distal half in *I. chishimanus* and with two D spines in *I. nakanei*. Pro-, meso- and metafemora each with 4, 4 and 5 secondary D spines, respectively (Figs 38, 39, 46); if these numbers are constant, the additional primary D spine in *I. nakanei* is diagnostic also in the two later instars. Without swimming hairs. Protibia with secondary AV and D spines (Figs 40, 41); meso- and metatibiae also with secondary AD and PD spines (Fig. 45; Tab. 3). Protarsus with one secondary D and 2 PV spines; meso- and metatarsus also with 1 - 4 AV spines (Tab. 3).

Ilybius poppiusi Zaitzev

Colour. Body of relatively dark uniform colour. Head dorsally brown with paired yellowish neck, central and ocular spots; number of spots higher in instars II - III than in instar I (Figs 2,

27). Thoracal and abdominal terga brown with relatively few and small yellowish spots, most distinct in instar III.

Head. Sides slightly diverging anteriorad in instars I - II (Fig. 2), subparallel in instar III (Fig. 27). Neck with distinct bead in lateral third in instar III (Fig. 27). Temporal spines weak, 3 - 4 and 4 - 5 in instars II and III, respectively. Clypeal margin with 17 lamelliform setae in instar I, and with 22 large and 20 small lamelliform setae in instars II - III.

Body. Tergal setation reduced, especially in instar III. Last abdominal segment relatively long with long siphon (Figs 5, 30). Urogomphus slightly longer than last abdominal segment in instars I - II (Fig. 5), and slightly shorter in instar III (Fig. 30). Urogomphus with UR4 much shorter and paler than UR2 - 3; length of UR4 not exceeding diameter of urogomphus in instars I - II (Fig. 5).

Legs. Profemur with one primary D spine in distal half. Pro-, meso- and metafemora each with 3 - 4, 5 and 5 - 6 secondary D spines, respectively. Without swimming hairs. Protibia with a single PD secondary spine; meso- and metatibia each with 4 secondary spines (Tab. 3). Each tarsus with secondary D and PV spines, plus AV spine(s) on meso- and metatibiae (Tab. 3).

Key to the larvae described herein

1 Head without temporal spines (Figs 1 - 3). Frontoclypeus with pair of hatching tubercles (Figs 1 - 3) (instar I) 2

\- Head with temporal spines (Figs 26 - 28). Frontoclypeus without hatching tubercles (Figs 26 - 28) (instars II - III) 5

2 Last abdominal segment short with short siphon (Fig. 4). Urogomphus almost four times as long as last abdominal segment (Fig. 4) ..... *apicalis*

\- Last abdominal segment long with long siphon (Figs 5 - 7). Urogomphus less than twice as long as last abdominal segment (Figs 5 - 7) 3

3 Head dorsally dark brown with few paler spots (Fig. 2). Urogomphus 1.2 - 1.3 times as long as last abdominal segment (Fig. 5) ..... *poppiusi*

\- Head dorsally with dark colour more restricted (Fig. 3). Urogomphus 1.6 - 1.7 times as long as last abdominal segment (Figs 6, 7) 4

4 Each femur with one D spine ..... *chishimanus*

\- Each femur with two D spines ..... *nakanei*

5 Each tibia and tarsus with three or more PD setae, of which most are long and hair-like, except on protarsus (Figs 32 - 37). Each tarsus without PV spines. Urogomphus at least 2.2 times as long as last abdominal segment (Fig. 29) ..... *apicalis*

\- Tibiae and tarsi without or with 1 - 2 spiniform PD setae (Figs 41, 43). Each tarsus with 1 - 2 PV spines (Fig. 43). Urogomphus at most 1.6 times as long as last abdominal segment (Figs 30 - 31) 6

6 Abdominal terga 1 - 7 without pair of lateral spiracles (instar II) 7

\- Abdominal terga 1 - 7 each with pair of lateral spiracles (instar III) 8

7 Head with sides slightly diverging anteriorad. Urogomphus 1.1 - 1.3 times as long as last abdominal segment ..... *poppiusi*

\- Head with sides subparallel. Urogomphus 1.4 - 1.6 times as long as last abdominal segment ..... *chishimanus & nakanei*

8 Abdominal segment 7 - 8 with few and short spines (Fig. 30). Urogomphus slightly shorter than last abdominal segment (Fig. 30) ..... *poppiusi*

\- Abdominal segments 7 - 8 densely covered with relatively long spines (Fig. 31). Urogomphus slightly longer than last abdominal segment (Fig. 31) ..... *chishimanus & nakanei*

Species	Instar	n	HL	HW	NW	LASD	LASV	UI	TL
apicalis	I	5	1.69 ± .05	1.52 ± .08	.94 ± .05	.66 ± .04	.49 ± .02	2.50 ± .07	2.9 ± .6
	II	5	2.46 ± .05	2.30 ± .02	1.46 ± .02	1.34 ± .05	1.07 ± .04	3.67 ± .17	7.0 ± 1.6
	III	2	3.40 ± .06	3.16 ± .06	2.16 ± 0	2.26 ± .08	1.96 ± 0	4.96 ± .11	10.0 ± 2.4
chishimanus	I	5	2.12 ± .03	1.85 ± .07	1.10 ± .05	1.41 ± .02	.74 ± .02	2.33 ± .03	5.0 ± .3
	II	5	2.95 ± .07	2.62 ± .05	1.76 ± .05	2.18 ± .11	1.61 ± .06	3.37 ± .19	8.8 ± .5
	III	5	4.32 ± .03	3.82 ± .05	2.52 ± .06	3.53 ± .10	2.86 ± .12	4.33 ± .23	11.8 ± 1.3
nakanei	I	5	2.14 ± .02	1.86 ± .02	1.15 ± .02	1.36 ± .04	.77 ± .03	2.26 ± .07	5.3 ± 1.2
	II	4	3.06 ± .02	2.70 ± .08	1.76 ± .03	2.17 ± .09	1.52 ± .09	3.08 ± .09	8.8 ± .9
	III	1	4.36	3.88	2.60	3.24	2.76	3.92	11.3
poppiusi	I	5	1.89 ± .02	1.75 ± .03	1.07 ± .03	1.51 ± .09	.80 ± .04	1.92 ± .09	4.4 ± .7
	II	5	2.71 ± .05	2.43 ± .07	1.62 ± .04	2.38 ± .08	1.70 ± .06	2.98 ± .19	6.3 ± 1.0
	III	5	3.86 ± .08	3.48 ± .06	2.48 ± .07	3.60 ± .07	2.98 ± .13	3.23 ± .20	11.3 ± 1.9

Table 1: Selected measures (mm) of larvae of four East Palearctic *Ilybius* species. Values given as mean ± SD; n gives number of specimens. See text for explanation of abbreviations.

Species	Instar	HL/HW	HW/NW	LASD/LASV	UI/LAS
apicalis	I	1.11 ± .04	1.61 ± .03	1.35 ± .07	3.82 ± .15
	II	1.07 ± .03	1.58 ± .03	1.26 ± .07	2.74 ± .19
	III	1.08 ± .01	1.46 ± .03	1.15 ± .04	2.20 ± .03
chishimanus	I	1.15 ± .03	1.67 ± .01	1.91 ± .05	1.65 ± .02
	II	1.13 ± .02	1.49 ± .06	1.36 ± .03	1.54 ± .09
	III	1.13 ± .01	1.52 ± .05	1.23 ± .02	1.23 ± .04
nakanei	I	1.15 ± .02	1.62 ± .02	1.77 ± .06	1.67 ± .08
	II	1.13 ± .03	1.53 ± .04	1.43 ± .04	1.42 ± .04
	III	1.12	1.49	1.17	1.21
poppiusi	I	1.08 ± .02	1.64 ± .04	1.89 ± .03	1.27 ± .04
	II	1.12 ± .02	1.51 ± .03	1.40 ± .03	1.22 ± .10
	III	1.11 ± .01	1.40 ± .02	1.21 ± .03	.90 ± .06

Table 2: Selected ratios of larvae of four East Palearctic *Ilybius* species. Values given as mean ± SD; see Table 1 for number of specimens. See text for explanation of abbreviations.

Species	Leg	Tibia AD	AV	D	PD	PV	Tarsus AD	AV	D	PD	PV
apicalis	F		1		3-4					4-5	
	M		2	1	4					4-6	
	H	2	2-3	3	5-6			3	1-2	7-8	
chishimanus	F		1	1	1				1		2
	M	2	2	1-2	2			1-2	1-2		2
	H	2	2	2	2			3-4	2-3		2-3
nakanei	F		1-2	1					1		2
	M	1	2	2	2			2	2		2
	H	2	3	2-3	2			3	2		3
poppiusi	F				1				1		1-2
	M	1	1		1	1		1	1		2
	H	1		1	1	1		2-3	1		2-3

Table 3: Number of secondary setae and spines in different series on tibia and tarsus on fore (F), mid (M), and hind (H) legs of instar III larvae of four East Palearctic *Ilybius* species.

Discussion

Finding morphological characters that will admit a clearcut separation of the European *Ilybius* larvae from those of *Agabus* LEACH is problematic (NILSSON 1983, GALEWSKI 1987). These difficulties probably reflect the paraphyletic character of *Agabus* without *Ilybius* (FERY & NILSSON 1993). Problems will probably become even increased as soon as larvae of other non-European species are described. GALEWSKI (1987) noted that secondary urogomphal setae occur in some *Ilybius* species, but not in *Agabus*. Later, NILSSON (1992) documented the presence of secondary setae in some Ethiopian *Agabus* species. Likewise, legs with natatorial setae were previously thought to be restricted to the *Agabus aeruginosus*-, *A. labiatus*- and *A. clavicornis*-groups within the Agabini (NILSSON 1979, MATTA 1986). The swimming hairs here reported in *Ilybius apicalis* have the same position as those in *Agabus* larvae, although they are fewer in numbers and spiniform on the protarsus. As the larvae of the other species of the *A. apicalis*-group have not been described, it is not known if the presence of swimming hairs is unique for *I. apicalis* or represents a synapomorphy of all species of this group.

The study of larvae will no doubt provide many additional characters for the study of *Ilybius* phylogeny. Besides the above-mentioned swimming-hairs, the presence of an additional primary D spine on each femur is an interesting character, earlier described in the three European species *I. guttiger* (GYLLENHAL), *I. quadriguttatus* (LACORDAIRE), and *I. similis* THOMSON (GALEWSKI 1966). These three species way well form a clade within the genus, whereas the presence of this spine in *I. nakanei* is probably homoplastic.

The larval phenology of the four described species suggests that they all have the life-cycle type recognized for the genus by NILSSON (1986), i.e. a semivoltine life cycle with overwintering larvae and adults. Only one instar III larva of *I. chishimanus* was found in the spring samples. All other larvae were collected between 30 July and 8 October, with instar I dominating in August and instars II - III in later samples.

Acknowledgement

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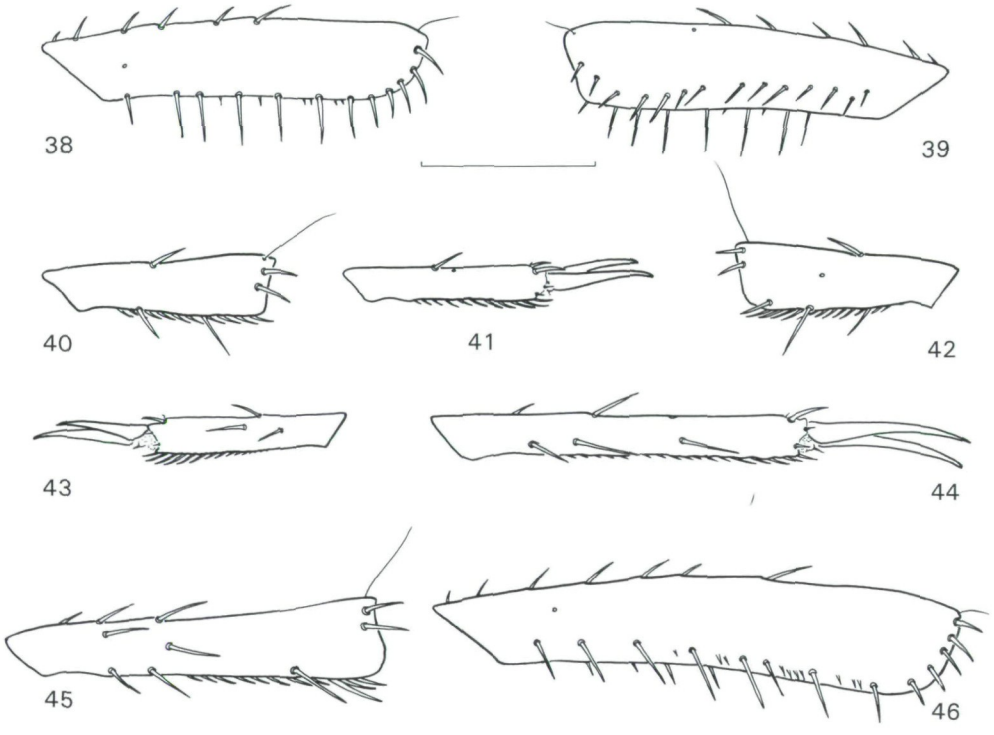

Figs 38 - 46: *Ilybius chishimanus*, instar III larva, parts of fore (38 - 43) and hind leg (44 - 46). 38, 39, 46) femur in anterior (38, 46) and posterior view (39); 40, 42, 45) tibia in anterior (40, 45) and posterior (42) view; 41, 43, 44) tarsus in anterior (41, 44) and posterior (43) view. Scale bar 1 mm.

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