

Description of the last instar larva of *Cordulegaster vanbrinkae* and emergence place from northern Iran (Odonata: Cordulegastridae)

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Abstract. The larva of *Cordulegaster vanbrinkae* Lohmann, 1993 is described and illustrated based on fourteen final instar larvae and 49 exuviae that were collected in Gīlān, Māzandarān and Golestān provinces, in northern Iran in July 2014, July 2017 and August 2018. Larvae of *Cordulegaster vanbrinkae* show signs of lateral spine on 8th segment missing, ratio of lateral spine on 9th segment/9th segment is 0.03–0.15 and 5 (rarely 6) long premental setae. The characters have a clear variability and there is a noticeable overlap of character values with related species—*Cordulegaster picta* and *Cordulegaster heros*. Emergence habitat are described and analysed.

Key words. Odonata, Cordulegastridae, *Cordulegaster vanbrinkae*, description, emergence place of exuviae, larva F-0, Iran

Research Article

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All relevant data are
within the paper.

Introduction

The species *Cordulegaster vanbrinkae* Lohmann, 1993 belongs to least known species in the frame of the genus *Cordulegaster*, within which many species are very poorly known, often with unclear taxonomic position or unknown distribution or ecological requirements (e.g. Boudot, 2001; Paulson et al., 2022; Schneider et al., 2021). The male adults of *C. vanbrinkae* Lohmann, 1993 are known from studies by Lohmann (1993), Ananian & Tailly (2012), Skvortsov & Snegovaya (2014), Schneider et al. (2014) and Holuša et al. (2015). Female is described recently by Holuša (2015).

Although the first description of the larva of *Cordulegaster vanbrinkae* based on three exuviae was published by Seidenbush et al. (2015). This paper presents a description of the last instar of the larva with additional biometric data on the base of studies of larvae and exuviae, collected in Northern Iran at nine localities in Gīlān, Māzandarān and Golestān provinces.

Methods

Examined material

(L – larva, E – exuviae): Gīlān province, Fūman district, Qaleh Rudkhan locality, 09-vii-2014, 16E, 17-vii-2014, 1E; Gīlān, Tālesh, Ardeh—Derān, 18-vii-2014, 1L; Gīlān, Tālesh, Poonel—Shafā Rūd, 18-vii-2014, 2E; Gīlān, Sowme'eh Sara, Ālīān, 16-vii-2014, 2E; Guilan province—Siahkal—valley of Espili deglam—Lournak waterfall, 21-viii-2018, 4L+6E; Māzandarān, Chālūs—Shoorab, Veysar—Talī Chāl Stream, 13-vii-2014, 3L+1E; Māzandarān, Chālūs—Jamand, Veysar—Lāroosar Stream, 13-vii-2014, 2L; Māzandarān, Chālūs, Koshkesara—Khātir

Table 1. Biometric data of larvae of *Cordulegaster vanbrinkae* (instar F-0). (L – prementum length, W+ – maximal width, W- – minimal width).

Feature		Range (mean, replicate)
Total length	♂ larvae	34.0–35.6 mm (\bar{x} =34.9, n=6)
	♀ larvae	33.9–39.3 mm (\bar{x} =36.5, n=8)
	♂ exuviae	37.1–43.2 mm (\bar{x} =40.7, n=12)
	♀ exuviae	40.2–45.9 mm (\bar{x} =43.8, n=13)
Head/prothorax	larvae	1.14–1.18 (\bar{x} =1.16, n=14)
Antennae segment 1/4+5	larvae+exuviae	0.9–1.1 (\bar{x} =0.96, n=25)
Premetum L/W+	larvae+exuviae	0.96–1.14 (\bar{x} =1.08, n=36)
Premetum W+/W-	larvae+exuviae	2.25–3.36 (\bar{x} =2.82, n=36)
Anal pyramid L/W	larvae+exuviae	0.91–1.27 (\bar{x} =1.08, n=36)

bon stream, 14-vii-2014, 2L; Māzandarān, Tonekabon district, Karatchal—valley of Shirud river—Abshar waterfall, 17-viii-2018, 2L; Golestan province, Tangrah—valley up to Aghsu waterfall, 14-vii-2017, 1E; Golestan, Tuskestan, 15-vii-2017, 3L+3E; All photo by Otakar Holuša.

Sampling

Exuviae were collected in the riparian parts of the sites studied. There was sought up to about 8 m from the shoreline and up to 5 m on tree trunks. The distance from the shoreline (vertical projection of the emergence place) and the height above the ground (vertical distance from the place where the shoreline ends) were measured. The total distance to the emergence place is the sum of the height and the distance from the shore the total distance travelled by the larvae from the shoreline to the place where the imago was hatched. As a position of exuvia, there was used the position its thorax. Distances measured from this point. The positions of female and male exuviae were evaluated separately. The type of emergence place was evaluated according to place, where exuvia was attached—stones, leaves or stems of vegetation and tree trunks. Localities and habitats of *Cordulegaster vanbrinkae* are described in detail Holuša et al. (2015). The material used in this study is deposited in the authors' collection.

Measurement. All larvae and exuviae of *C. vanbrinkae* measured with an ocular micrometer in the laboratory. The following characters based on the measurements of larvae and exuviae were quantified and analysed (according to Verschuren, 1989): Total length, head width, length of antennae segment S1 and S4+5, prothorax width, length of hind femur, width of prementum (in places of articulation and labial palps), length of prementum, number of palpal setae, number of short and long premental setae, length of cerci, width of anal pyramid base, length of spine on S8 (spine visible after removal of spiny setae) and S9, length of S9 and S10, length of female gynapophyses.

Description of the last instar larva of *Cordulegaster vanbrinkae*

Measurement section

Total length of larvae 34.0–39.3 mm (see Table 1), head width 7.20–8.10 mm, length of hind femur 4.2–5.85 mm.

General. Color basically brown, head and prothorax dark brown without any paler spots (Figs 1–3), two indistinct darker longitudinal stripes on the dorsal part of sternites (Fig. 3). Body surface without gloss, rather rough with fine pale brown hairs, longer hairs at posterior edge of thorax, also on side of sternites and legs.

Head. Squarish, anteclypeus and postclypeus brown in color, anterior margin of frons with row of short hairs, interior parts of compound eyes dark brown. Antennae filiform, 7-segmented, length 7.7–8.5 mm, ratio antennae segments (S1/S1+S5)0.96. Base of antennae with small pale spots. Prementum: length 5.8–7.3 mm (\bar{x} = 6.3 mm ♂, 6.9 mm ♀), maximal width (W+) 5.9–6.8 mm (\bar{x} = 5.8 mm ♂, 6.3 mm ♀), minimal width (W-) 1.7–2.6 mm (\bar{x} = 2.1 mm ♂, 2.2 mm ♀), with ratio length/maximal width of prementum 0.96–1.14. Anterior margin of ligula (median lobe of prementum) with usual pair of V-shaped apical black outgrowths (Fig. 4C). Interior margins of palpal lobes with irregularly dentation: 3 large teeth at left lobe, 2 large at right lobe, every tooth with additional small 2–4 small teeth (Fig. 4B). Apex of all teeth black-brown. Movable hooks long and rather stout, with black apex. Lobes with 5 palpal setae. Prementum on each side at the centre with 5 long premental setae, and one to three shorter setae situated more medially (Fig. 4A).

Thorax. Prothorax broad with broadly rounded edges, only slightly narrower than head, ratio head/prothorax width 1.14–1.18 (see Table 1). Synthorax as wide as head. Wing sheaths parallel, anterior margin of forewings reach to the middle of 4th sternite, and hindwing reach to the posterior edge of 4th sternite. Edge and sides of thorax with long pale brown hair.

Abdomen. Brown without any paler stripes, on dorsal parts with inconspicuous dark longitudinal stripes. Hind margins of segments S1 to S9 with row of pale brown hair. Row of longer pale brown hairs also on lateral edges of sternites, especially around lateral sternite edge at S6–9. Dorsal spines absent. Lateral spines at 8th sternite absent, lateral spines at S9 sternite very small, length 0.1 to 0.3 mm (\bar{x} = 0.18 mm), normally invisible due to hairs at lateral sternite edge (Fig. 3). Epiproct approximately as long as paraprocts and slightly bent ventrally at their tips, cone shaped anal pyramid, without significant bend at ends from lateral view (Fig. 3). Ratio of length to width of base of paraprocts 0.91–1.27. Epiproct surface brown and with short pale brown hairs. Ovipositor closely S9 ter-

git reaches anterior margin of S10 (Fig. 3A). Ratio cerci /10th segment 1.35–2.08.

Comparative analysis

In the western Palaearctic the genus *Cordulegaster* includes species divided into the two species-groups, the “*boltonii*-” and “*bidentata*-”group (Verschuren, 1989; Boudot, 2001), recently also *coronata*-group (Schneider et al., 2021). *C. vanbrinkae* is morphologically similar to *C. heros* and *C. picta*, with which it forms the eastern species subgroup of the *boltonii*-group. Typical for this group is the conical end of the anal pyramid without a hooked ends of the paraprocts. The ratio of



Figure 1. Last instar of larva of *Cordulegaster vanbrinkae* Lohmann, 1993—female.



Figure 2. Last instar of larva of *Cordulegaster vanbrinkae* Lohmann, 1993—male.

the length of the cerci to the length of 10th segment is for all species 1.35–2.33, and also, the number of the long palpal setae is same (Table 2). All species of the eastern subgroup have same feature: small lateral spines at segment 9, which reaches maximal one third of sternite 9. *Cordulegaster heros* differs from *C. vanbrinkae* and *C. picta* by the presence of lateral spines on segment 8 (Table 2) which in *C. vanbrinkae* is always missing. Similarly, the lateral spine on segment 9 of *C. vanbrinkae* is very small and hardly visible be-

cause it is covered by a clump of long hairs. The ratio of the length of the lateral spine on segment 9 to the length of segment 9 is 0.05–0.15, whereas in *C. picta* this ratio is slightly higher (0.12–0.22). The prementum of *C. vanbrinkae* is slender as revealed by the ratio of length to maximal width between 0.96 and 1.14, and *C. vanbrinkae* differs clearly from *C. picta* by the low number of long premental setae—(5, rarely 6 vs 6, rarely 7) and the short premental setae (1–3 vs 3–4) (Table 2).

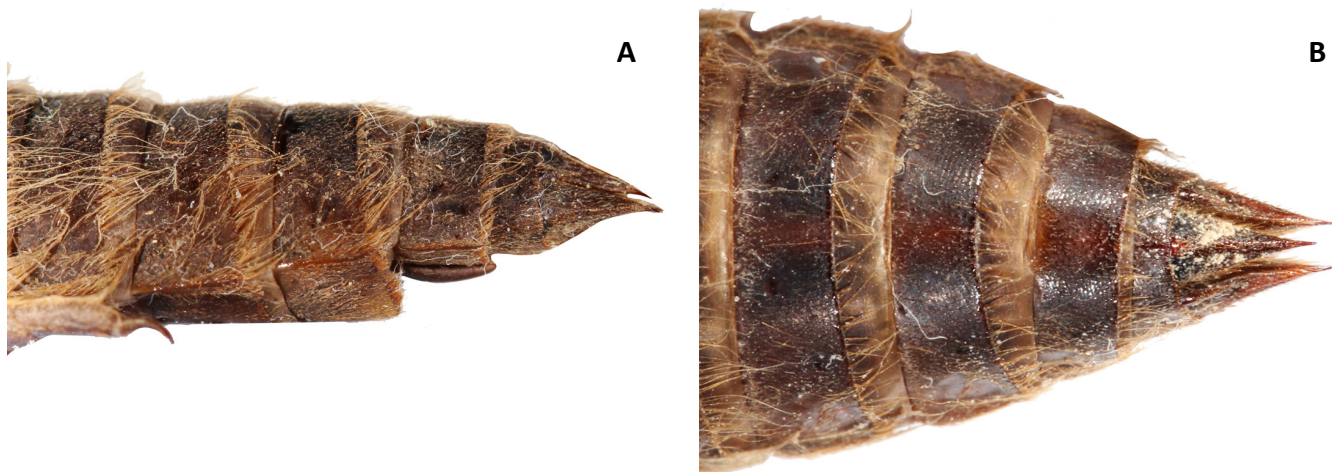


Figure 3. The top of female abdomen and anal pyramid of larva of *Cordulegaster vanbrinkae* Lohmann, 1993, A – lateral view, B – dorsal view.

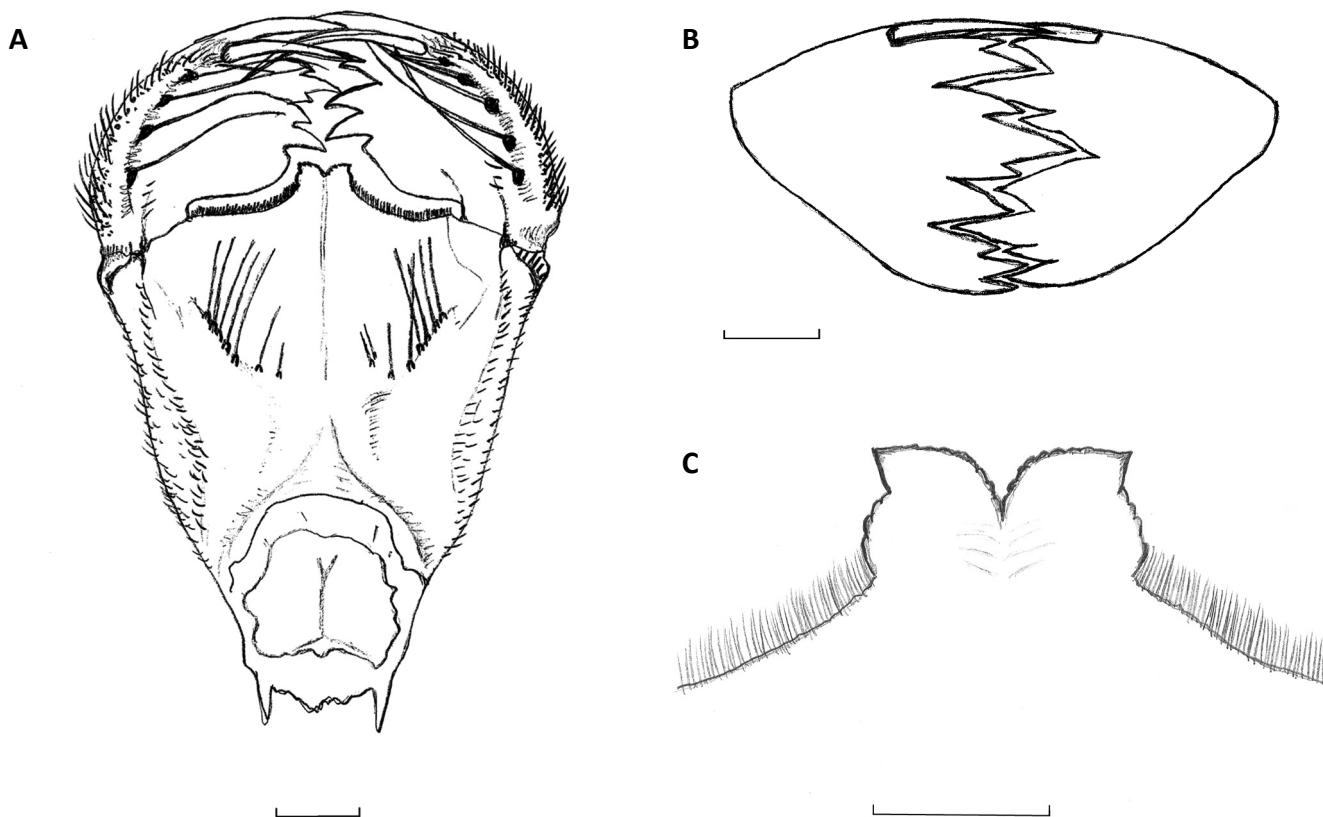


Figure 4. The labium of larva of *Cordulegaster vanbrinkae* Lohmann, 1993, A – dorsal view, B – frontal view to palpal lobes, C – anterior margin of ligula; Scale bars = 1 mm.

Table 2. Comparison of characters of known *Cordulegaster* larvae of eastern complex (instar F-0 and exuviae of *C. vanbrinkae* (n=30), *C. picta* (n=30) and *C. heros* (n=30))

	<i>Cordulegaster vanbrinkae</i>	<i>Cordulegaster picta</i>	<i>Cordulegaster heros</i>
Length of spine on segment 8	0	0–0.25	0.3–0.5
Length of spine on segment 9	0.05–0.3	0.15–0.35	0.4–0.6
Ratio lateral spine 9/segment 9	0.03–0.15	0.12–0.22	0.20–0.32
Ratio cerci/S10	1.35–2.08	1.40–2.33	1.38–2.30
Number of palpal setae	5	5	5
Number of long premental setae	5 (rarely 6)	6 (rarely 7)	5
Number of short premental setae	1–3	3–4	2–3

Emergence places—exuviae

A total of 49 exuviae were found (several exuviae were in varying degrees of damage—the abdomen or head were missing). The place of emergence was evaluated with respect to their location, i.e. it was the place where the imago was hatched: a) rock walls and boulders, b) leaves or stems of plants (e.g. *Hedera helix*, *Rubus* sp.), c) tree trunks (Fig. 5). The “offer” of these emergence places is based on the character of the habitat that species inhabits, which are watercourses shaded with rich vegetation and tree layer, riverbeds are rocky, sometimes even canyoned with rock walls and boulders (cf. Holuša et al., 2015). Rock walls and boulders dominated as a type of emergence place (57%, Figs 5, 6, 7),

then site type—plant leaves (27%, Figure 8) and last one—tree trunks (16%). Even the bases of large boulders, which formed rocky “overhangs”, were selected by larvae for emergence (Fig. 9). It is obvious that the larva at the end of its “journey” climbed as if on the ceiling of a rock niche or overhang.

Emergence places were at different distances from the shoreline and at different heights—female exuviae occurred at a distance from 0 to 310 cm (\bar{x} = 65 cm) at a height above the ground from 10–265 cm (\bar{x} = 145 cm), the total distance larval movement was from 40 to 475 cm (\bar{x} = 198 cm) (Fig. 7). Male exuviae were found at a distance from 0 to 215 cm (\bar{x} = 70 cm), at an altitude of 20–175 cm (\bar{x} = 125 cm), the total distance of the larva’s movement was from 20 to 375 cm (\bar{x} = 200 cm).

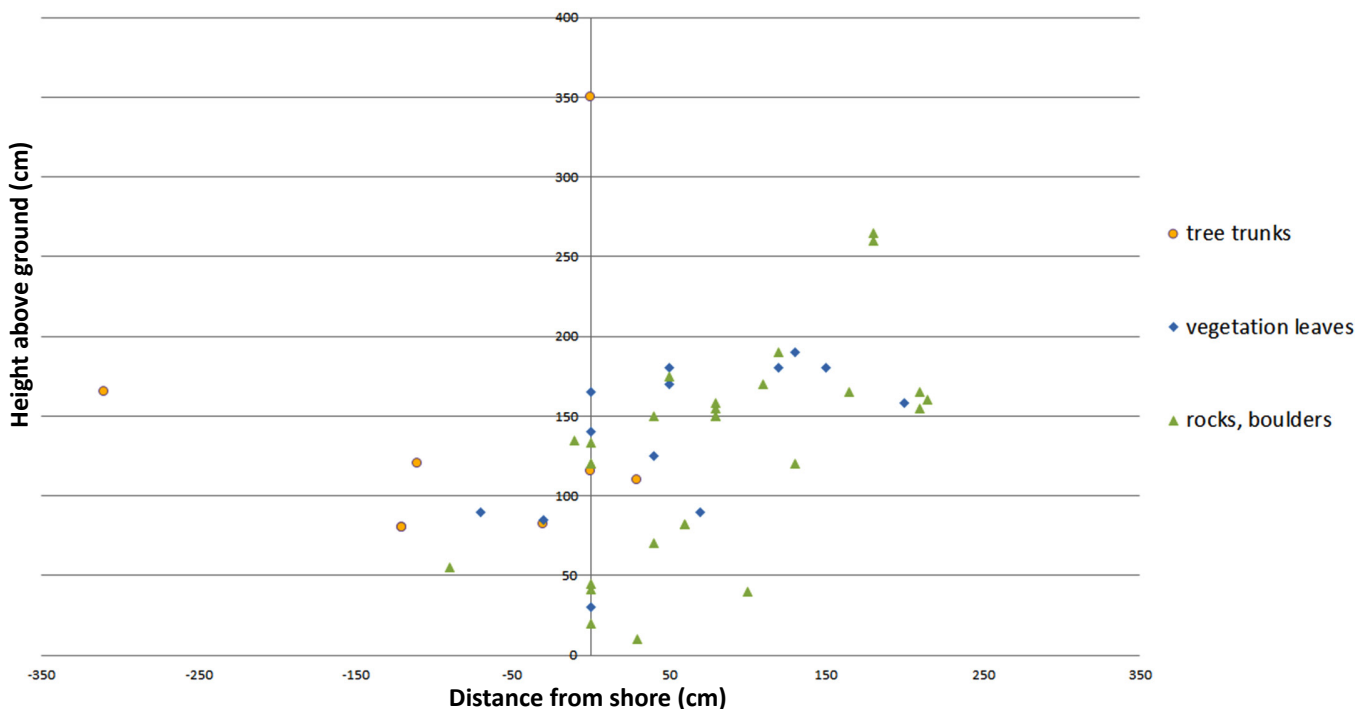


Figure 5. *Cordulegaster vanbrinkae* Lohmann, 1993—position of exuviae in riparian parts of the habitat. x-axes: (-) left bank, (+) right bank.

Discussion and conclusion

Eastern subgroup of the *boltonii*-group of *Cordulegaster* genus includes, according to the latest knowledge, four species—*C. heros*, *C. picta*, *C. vanbrinkae* and *C. kalkmani* (Schneider et al., 2021). The latter species, *C. kalkmani*, is described on the basis of two collection specimens, so there are no data on its distribution, bionomics and, of course, larvae. From previous knowledge (including the data in this paper), it is clear that larvae of species in this subgroup have characters

in general: short (or absent) lateral spines at S8, short lateral spines at S9, a very “blunt” anal pyramid with relatively short cerci, no downward hook-like curve. Larvae of *C. heros* have characters: lateral spines on 9th segment is 1/3–1/5 (i.e. 18–30%) of the length of 9th sternite, also spines on 8th segment about 1/6 of the length of 8th sternite and 5 long premental setae. Larvae of *C. picta* have characters: lateral spines on 9th segment less than 1/5 of the length of 9th sternite; spines on 8th segment very small (0.15–0.2 mm) or missing an 5–7 long premental setae. Larvae of *C. van-*

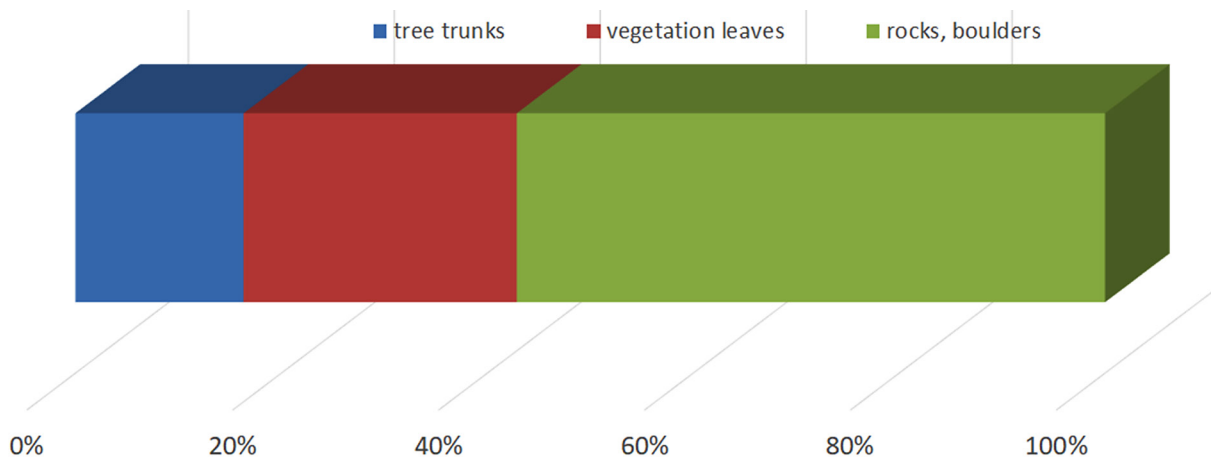


Figure 6. Proportion of different types of emergence place of *Cordulegaster vanbrinkae* Lohmann, 1993.

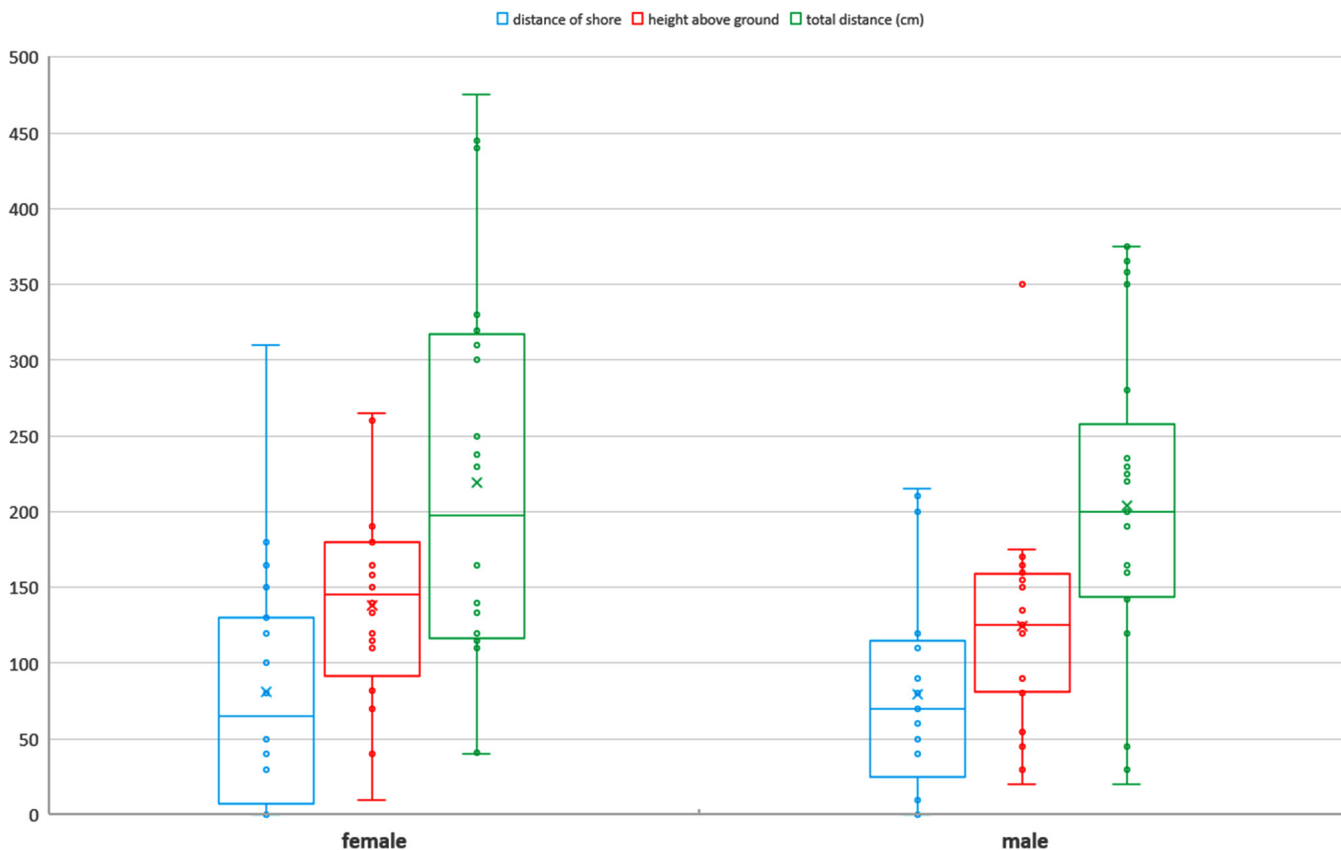


Figure 7. Variability of position of exuviae by sex of *Cordulegaster vanbrinkae* Lohmann, 1993 (distance from shore, height above ground, total distance; all in cm).



Figures 8. Exuviae of *Cordulegaster vanbrinkae* Lohmann, 1993 on vegetation in forest undergrowth (1st exuvia at the left edge of picture, 2nd in middle part), locality in Northern Iran, Gīlān province, Fouman—Qaleh Rudkhan, 9.VII.2014 (photo by Otakar Holuša).



Figure 9. Exuvia of *Cordulegaster vanbrinkae* Lohmann, 1993 on large boulder, locality in Northern Iran, Gīlān province, Fouman—Qaleh Rudkhan, 17.VII.2014 (photo by Otakar Holuša).

brinkae have characters: lateral spine on 8th segment always missing, ratio of lateral spine on 9th segment/9th segment is 0.03–0.15 and 5 (rarely 6) long premental setae. From the data so far, there is a clear variability and overlap in the values of individual traits for each species. Based on the analysed material, it is interesting to note that no individual of *C. vanbrinkae* larvae had lateral spines at S8. Seidenbush et al. (2015), but on the material of three exuviae, he describes these spines. It is possible that the occurrence of a cluster of spinous setae at the site of the lateral spine may have been confused with a spine. To detect the presence of lateral spine, it is advisable to remove these spiny setae and always determine in laboratory with binocular loupe.

There is an assumption that the species *C. kalkmani* will have larvae with the characters of *C. vanbrinkae* and *C. picta*, making future determination even more difficult. Current knowledge indicates that 100% discrimination among the larvae of eastern subgroup of *boltonii*-group of *Cordulegaster* may be problematic. Essentially without knowledge of the geographic origin, 100% identification of larvae may be impossible. The whole issue is further complicated by the possible occurrence of hybrids, which happens in contact zones

of adjacent species—e.g. *Cordulegaster vanbrinkae* × *C. picta* (Schneider et al., 2021), or in the adjacent western subgroup *Cordulegaster trinacria* × *C. boltonii* (Solano et al., 2018).

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