Odonatologica 30(3): 281-288 *September 1, 2001*

REDESCRIPTION OF THE LARVA OF *LEUCORRHINIA GLACIALIS* HAGEN WITH A KEY TO THE NEARCTIC *LEUCORRHINIA* SPECIES (ANISOPTERA: LIBELLULIDAE)

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Received January 26, 2001 / Revised and Accepted February 26, 2001

The final-stadium larva is redescribed from 24 authenticated larvae and exuviae. It is a medium-sized larva (total length 17.6–20.8 mm) with three ventral stripes and a dorsal pattern on the abdomen that includes large spots in the sublateral area on at least segments 4–7. The penultimate stadium is also briefly described and some natural history observations are reported. A key for the seven nearctic *Leucorrhinia* spp. is given.

INTRODUCTION

Leucorrhinia Brittinger is a holarctic genus of small to medium-sized dark dragonflies with white faces; it contains seven nearctic species. Based on larval morphology, the nearctic species can be divided into two groups: (A) those with dorsal spines on abdominal segments 3–8 and (B) those with no dorsal spines or spines restricted to, at most, abdominal segments 3–6. These groups are further distinguishable by the pattern of dark marks on the venter of the abdomen: group A species have spots or transverse bands whereas group B species have three longitudinal stripes. Group A contains three species (WALKER & CORBET, 1975): *Leucorrhinia frigida* Hagen, *L. intacta* (Hagen) and *L. proxima* Calvert. Group B contains four species (WALKER & CORBET, 1975; KENNER et al., 2000): *L. borealis* Hagen, *L. glacialis* Hagen, *L. hudsonica* (Selys) and *L. patricia* Walker.

The larva of *L. glacialis* was first described by NEEDHAM (1901). Walker collected an exuviae with its associated teneral adult near Prince Rupert, BC in 1925 and concluded that Needham's description actually referred to *L. proxima* (WALKER, 1927). Walker noted that the *L. glacialis* exuviae "closely resembles

those of *L. hudsonica* and *borealis*" (WALKER, 1927). When the full description of the *L. glacialis* larva was finally published almost 50 years later (WALKER & CORBET, 1975), the description was based on that single Prince Rupert specimen.

In a recent publication describing the larva of *L. patricia*, KENNER et al. (2000) did not include a key to the nearctic species of *Leucorrhinia* because related work showed that existing keys (WALKER & CORBET, 1975) were not reliable for *L. glacialis*. In the present work, a number of individuals of *L. glacialis* were reared to provide a series of authenticated exuviae that could be measured. The results of these measurements were combined with published information to produce a key for the larvae of the nearctic *Leucorrhinia* species. In addition, the penultimate stadium is described and several natural history observations are reported.

MATERIAL AND METHODS

The bulk of the *L. glacialis* specimens examined during this work were from the author's collection (RDK); these will be deposited in the Spencer Entomological Museum (SEM) at the University of British Columbia, Vancouver, BC. The remainder of the specimens were from the collections of the SEM and the Royal British Columbia Museum (RBCM) in Victoria, BC.

L. glacialis. – BC, Delta, Burns Bog: 01-V-1998, 1 ♀, teneral adult collected with exuviae; 1-V-1998, 1 ♂, reared; 7-V-1998, 1 ♂, teneral adult collected with exuviae; 7-V-1998, 1 ♂, 2 ♀, reared; 26-V-1998, 1 ♀, reared; 30-III-1999, 1 ♂, reared; 31-VII-1998, 1 ♂, penultimate-stadium larva, reared. All of the above were stored in 70% ethanol (EtOH) with the associated teneral adult (RDK). BC, Delta, Burns Bog: 27-IX-2000, 1♂, reared, adult and exuviae pinned (RDK). The dates given for reared specimens are the larval collection dates. The following final-stadium larvae and exuviae were identified as *L. glacialis* based on the doubled cells visible between IR3 and Rspl (see discussion): BC, Chase/Salmon Arm: 6/15-V-1933, 1 ♀, larva, EtOH (SEM); BC, Delta, Burns Bog: 1-V-1998, 1 ♀, exuviae, EtOH (SEM); 1-V-1998, 2 ♂, 2 ♀, pinned exuviae (RDK); 7-V-1998, 4 ♂, 4 ♀, pinned exuviae (RDK).

L. hudsonica and *L. patricia.* – Details of these specimens are listed in KENNER et al. (2000); one additional *L. hudsonica* specimen was obtained: BC, Delta, Burns Bog: 29-IV-1999, 1 ♂, reared (RDK).

L. borealis. – No authenticated specimens were available to the author. However, 13 specimens collected in Alaska, Yukon Territory, British Columbia and Alberta and now in the collections of the SEM and RBCM were examined and are consistent with published descriptions for this species.

Exuviae from reared specimens and/or final-stadium larvae were available for *L. frigida*, *L. intacta*, and *L. proxima* from the three collections cited above.

Measurements were made using an eyepiece graticule in a stereomicroscope and are given as a range (mean ± standard deviation, number of specimens). Abdominal segments are numbered increasing posteriorly and are labelled A1–A10. Total length was measured from the anterior of the folded labium to the apex of the paraprocts. Headwidth was measured across the widest part of the eyes; metafemur length does not include the trochanter. Lengths of the abdominal appendages were measured from the posterior edge of A10. Lengths of the lateral margins of A8 and A9 were measured from the anterior edge of the sclerotized portion of the lateral margin to the apex of the lateral spine. This avoided uncertainty in determining where the spine starts on the lateral margin. The length of the lateral spine itself was measured along its medial margin from the posterior margin of the sclerotized portion of the segment to the apex of the spine. Final and penultimate stadia are referred to as F-0 and F-1, respectively (CORBET, 1999).

DESCRIPTION

The F-0 larva of *L. glacialis* has been described previously (WALKER & CORBET, 1975); this description will not be repeated here in detail. Since no color pattern remained on the dorsal surface of the specimen upon which the original description was based, I will describe the pattern from the specimens I examined. I will then concentrate on the quantitative characters and those characters that may be useful to separate *L. glacialis* larvae from the larvae of other *Leucorrhinia* species.

Color pattern (F-0 exuviae) — Head and thorax: pale brown with various ill--defined darker patches; wingpads generally show venation pattern of collapsed wing as darker brown against pale background. Legs: tibiae and tarsi uniformly pale brown except darker on distal end of last tarsomere of each leg; femora pale brown with two darker "bands", one postbasal and one anteapical, which extend across dorsal surface and one-third of way down lateral faces. Although preapical bands are prominent on all legs, postbasal bands are less prominent than anteapical ones on profemora, are even less distinct on mesofemora and are often barely detectable on metafemora. Along dorsal surface of each femur is a somewhat irregular double row of setae that expands to a slightly denser subtriangular patch near femoral apex. Combination of setal patch with slight pigmentation gives impression of faint dorsoapical spot. Although details of dorsal pattern of abdomen vary, the pattern of large, sublateral spots with adjacent pale areas (Fig. 1) is unlike pattern on any other nearctic *Leucorrhinia* larva.

The results of measurements for 24 authenticated F-0 larvae and exuviae are summarized in column 3 of Table I. The values given in WALKER & CORBET (1975) are listed in column 4. The values in column 4 for the relative lateral spine lengths are slightly different than those in WALKER & CORBET (1975) because they were converted to include the spine in the lateral length of the segment, as is the case for the corresponding values in column 3.

None of the *L. glacialis* specimens examined has dorsal hooks on any of the abdominal segments; all specimens have lateral spines on A8 and A9. I have not found a way to adequately quantify the orientation of the lateral spines. There is certainly variation, sometimes even between the orientation of the two spines on the same segment. However, the subjective impression, which is mainly influenced by the tip and the medial margin of the spine, is that in a dorsal view, the spines on A8 are

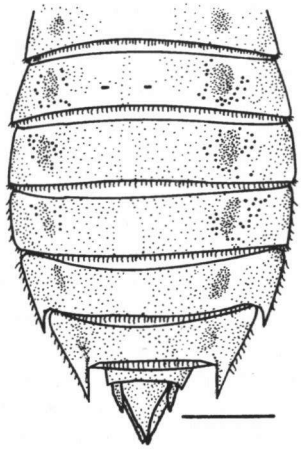

Fig. 1. Dorsal view of the abdomen of final-stadium exuviae of *Leucorrhinia glacialis* showing the color pattern. Exuviae slightly tipped to the left to show the pattern on the right side more clearly; – scale line 2 mm.

Table I

Values in mm of measurements on penultimate- and final-stadium *Leucorrhinia glacialis* larvae with literature values for final-stadium larva; mean, standard deviation and number of specimens given in parentheses

Character	Penultimate stadium	Final stadium	WALKER & CORBET (1975)
Total length	16.0 (n=1)	17.6-20.7 (19.7±0.8, n=20)	20.8 (n=1)
Head width	4.5 (n=1)	4.1-5.4 (5.2±0.3, n=20)	5.2 (n=1)
Length of metafemur	3.9 (n=1)	4.5-5.4 (4.9±0.3, n=24)	5.5 (n=1)
No. of palpal setae	9, 9	9-11	10 (n=1)
No. of premental setae	12, 12	12-15	14 (n=1)
Length of epiproct	1.25 (n=1)	1.40-1.65 (1.53±0.08, n=23)	
Length of cercus	0.55 (n=1)	0.66-0.92 (0.81±0.06, n=24)	
Length of paraprocts	1.40 (n=1)	1.51-1.89 (1.72±0.09, n=22)	
Length of lateral spine on A8	0.50, 0.50	0.39-0.66 (0.52±0.06, n=24)	
Ratio of lateral spine to lateral margin of A8	0.31, 0.32	0.24-0.34 (0.28±0.02, n=23)	0.28 (n=1)
Length of lateral spine on A9	0.80, 0.80	0.65-1.07 (0.86±0.10, n=24)	
Ratio of lateral spine to lateral margin of A9	0.40, 0.42	0.32-0.44 (0.38±0.03, n=23)	0.33 (n=1)

generally parallel to slightly divergent and those on A9 are generally convergent.

One of the *L. glacialis* specimens was collected in its penultimate stadium and was subsequently reared to adulthood. Results of measurements on the F-1 exuviae are given in column 2 of Table I. Unfortunately, damage to the associated F-0 exuviae made it impossible to get a full set of measurements on that exuviae; in particular, total length and headwidth are missing. The value of many characters increase from the F-1 exuviae to the associated F-0 exuviae — metafemur: 3.9 mm to 4.9 mm; epiproct: 1.4 mm to 1.58 mm; number of palpal setae: 9 to 10; number of premental setae: 12 to 13 or 14. However, the lengths of the lateral spines on A8 and A9 do not change. Thus the lateral spines are relatively larger in the F-1 stadium compared to the F-0 stadium; this makes the former look more like *L. hudsonica.*

The color pattern on the F-1 exuviae is similar to that on F-0 larvae. The venter of the abdomen has three dark-brown stripes. The bands on the legs are somewhat darker in the F-1 exuviae but are not otherwise different. The details of the pattern on the dorsum of the abdomen are slightly different from those shown in Figure 1 but there are still large spots in the sublateral areas of A4–A7.

DISCUSSION

The specimens upon which this description is based were identified either by association with an adult or by wing venation. Adult *L. glacialis* may be separated

from the other nearctic *Leucorrhinia* species by the doubled cells between IR3 and Rspl (CANNINGS & STUART, 1977). In sufficiently mature F-0 larvae and in many F-0 exuviae, one can see these doubled cells or their imprint. In the venational pattern visible on the interior of the wingpads of the exuviae, the doubled cells often show as nodes with short transverse extensions near the middle of the crossveins; only rarely does the full bisecting vein show. If the doubled cells can be detected, this appears to be an unequivocal way to confirm the identity of *L. glacialis* larvae and exuviae.

Comparing the values for F-0 larvae in Table I, one sees that the agreement between the results of this work and the literature values is quite good. However, the specimen collected by Walker appears to be particularly large as the values for both total length and length of the metafemur are outside the range of the specimens examined in this work. WALKER & CORBET (1975) give the number of palpal and premental setae as 10 and 14, respectively. These values are in good agreement with the findings of this work, where the usual number of palpal setae is 10, rarely 9 or 11 and the number of premental setae is 13 or 14, rarely 12 or 15. WALKER & CORBET (1975) do not give lengths for the anal appendages, only ratios — epiproct : cercus : paraproct = 1.8 : 1 : 2. These values are also in good agreement with this work as the same ratios (using the mean values) are 1.9 : 1 : 2.1.

The large size of Walker's specimen suggests that there is a clear size difference between the F-0 larvae of *L. glacialis* and *L. hudsonica*; this apparent size difference was used to help separate these two species (WALKER & CORBET, 1975; NEEDHAM et al., 2000). In fact, *L. glacialis* and *L. hudsonica* overlap in total length: *L. glacialis* 17.6–20.8; *L. hudsonica* 16–18 mm (WALKER & CORBET, 1975), 17–18 mm (NEEDHAM & WESTFALL, 1955), 15.3–17.5 mm (KENNER et al., 2000).

The second character used to separate *L. glacialis* (and *L. borealis*) from *L. hudsonica* is the orientation of the lateral spines. WALKER & CORBET (1975) describe the former as having "lateral spines on segs. 8 and 9 with outer margins not divergent, but following the curved outline of the abdomen" and the latter as having "lateral spines on segs. 8 and 9 with outer margins slightly divergent". NEEDHAM et al. (2000) describe the difference as "lateral spines of abdominal segment 9 distinctly convergent" for *L. glacialis* (and *L. borealis*) and "lateral spines of abdominal segment 9 parallel with body axis" for *L. hudsonica* (and *L. patricia*). As discussed above, the orientation of the spines on A8 and A9 of *L. glacialis* is not consistent from one specimen to another but, in general, those on A9 are slightly convergent to the body axis. Unfortunately, the lateral spines on A9 of *L. hudsonica* can also be slightly to strongly convergent. Based on the specimens I have examined, I find this character unreliable and difficult to use.

The four species in group B form a continuum with respect to size, with *L. borealis* at the upper end and *L. patricia* at the lower end; many other characters are correlated with size. Although it is difficult to use in a key, size remains a helpful character.

The only really definitive character I found is the presence of dorsal hooks on some specimens of *L. hudsonica*. Other useful characters are color pattern of the abdominal dorsum, length of the epiproct and length of the lateral spines on A8.

Combining my observations and the results in Table I with the published descriptions of *L. borealis* larvae (WALKER, 1916; WALKER & CORBET, 1975) and the information in KENNER et al. (2000), I produced a key for the species in group B. Adding this key to existing keys for the species in group A (WALKER & CORBET, 1975; NEEDHAM et al., 2000) yields the key given here for F-0 larvae of all seven nearctic *Leucorrhinia* species.

In this key, the ratio of the length of the lateral spine on A8 to the length of the epiproct has been used instead of the more usual ratio of the lateral spine on A8 to the lateral margin of A8 because the former ratio seems to yield fewer outliers than the latter. In the few cases I have seen in which the ratio of the lateral spine to the length of the epiproct did not fall within the defined limits of couplet 5, only one of the two lateral spines was too long or too short. Checking the other characters should resolve most such cases.

In practice, one quickly learns to recognize *L. borealis* by its large size, small lateral spines on A8 and relatively plain dorsal pattern (WALKER, 1916). *L. patricia* stands out by its small size (but watch for very small *L. hudsonica* KENNER et al., 2000). Those *L. hudsonica* lacking dorsal hooks are best separated from *L. glacialis* using the dorsal pattern, with the relative length of the lateral spines on A9 serving as a check. It may also prove useful to look for the doubled cells in suspected *L. glacialis* specimens.

Based on the F-1 exuviae examined in this work, *L. glacialis* larvae in that stadium should key out correctly with the above key; they have three ventral stripes, lack dorsal hooks, have a dorsal pattern on the abdomen that is similar to that shown in Figure 1 and, with their relatively longer lateral spines, the requirement of couplet 5 is easily met.

F-0 larvae of *L. glacialis* (and *L. hudsonica*) can be found in the pools in Burns Bog in late August (KENNER & NEEDHAM, 1999); I do not know how much earlier they may be present. One *L. glacialis* larva, collected 27 September and kept at room temperature, emerged 8 November. Another, collected in its penultimate stadium on 31 July, molted to F-0 around 21 October and emerged on 12 February. These examples suggest that no particular winter diapause is required before emergence. The bulk of the population appears to emerge over a relatively short period in early spring but the dates can change by at least a month from one year to the next. This suggests that temperature may be the controlling factor in determining the emergence timing.

Before this study, the earliest known flight date for *L. glacialis* in British Columbia was 7 June (CANNINGS & STUART, 1977). The corresponding date for Canada was "last week in May" (WALKER & CORBET, 1975) and for North America "May 17 (NJ) / June 4 (QC)" (NEEDHAM et al., 2000). During the collection of specimens

for this study, *L. glacialis* were observed emerging on 1 May; by 7 May mature individuals were observed. The few exuviae found on 27 April that year were all *L. hudsonica* and on 1 May, mature *L. hudsonica* were seen. This suggests that *L. hudsonica* begins to emerge one to two weeks earlier than *L. glacialis* in southern British Columbia.

In southwestern British Columbia, the emergence season for *L. glacialis* is quite long as two exuviae were collected on 9 July. They appeared to be relatively fresh as the pattern on the dorsum of the abdomen, which bleaches easily in the sun, was still visible. This long emergence season is perhaps to be expected as the adults are known to fly until at least 22 August (CANNINGS & STUART, 1977).

KEY TO THE FINAL-STADIUM LARVAE OF NEARCTIC *LEUCORRHINIA* SPECIES

1 Dorsal hooks on A3-A8; venter of abdomen without 3 continuous longitudinal dark stripes 2
— Dorsal hooks absent on A7 and A8; venter of abdomen with 3 continuous longitudinal dark stripes ... 4
2 Lateral spines on A9 extending as far as tips of paraprocts; usually not more than 16 mm total length ..... ***frigida***
— Lateral spines on A9 not extending as far as tips of paraprocts; usually at least 17 mm total length 3
3 Dorsal hook on A8 extending well over base of A9; dorsal hook on A7 at least as long as mid-dorsal length of A7; lateral spines on A9 extending beyond the tips of the cerci ..... ***intacta***
— Dorsal hook on A8 extending barely over the base of A9; dorsal hook on A7 shorter than the mid-dorsal length of A7; lateral spines on A9 not extending beyond tips of cerci ..... ***proxima***
4 Dorsal hooks present on any of A3-A6 (hooks may be very small) ..... ***hudsonica*** (in part)
— Dorsal hooks completely absent from all abdominal segments 5
5 Length of epiproct more than 3.7 times length of lateral spines on A8 and/or length of epiproct less than 1.12 mm; sublateral area of abdominal dorsum without strong pattern 6
— Length of epiproct less than 3.5 times length of lateral spines on A8; sublateral area on dorsum of abdomen may have strong pattern 7
6 Large, total length greater than 18.5 mm ..... ***borealis***
— Small, total length less than 16 mm ..... ***patricia***
7 Dorsal pattern of abdomen with large sublateral spots (Fig. 1); lateral spines on A9 extending not quite to tips of cerci ..... ***glacialis***
— Dorsal pattern of abdomen without large sublateral spots; lateral spines on A9 extending to or beyond tips of cerci ..... ***hudsonica*** (in part)

ACKNOWLEDGEMENTS

I thank K. NEEDHAM and I. LANE for help with the fieldwork, K. Needham and G.G.E. SCUDDER for use of the facilities and access to the collections and references of the Spencer Entomological Museum at the University of British Columbia. R.A. CANNINGS made an extended loan of specimens from the collection of the Royal B.C. Museum in Victoria, B.C. and commented on a draft of the manuscript.

REFERENCES

CANNINGS, R.A. & K.M. STUART, 1977. *The dragonflies of British Columbia.* Brit. Columb. Prov. Mus., [Handbook 35], Victoria, BC.

CORBET, P.S., 1999. *Dragonflies: behavior and ecology of Odonata.* Cornell Univ. Press, Ithaca, N.Y.

KENNER, R.D., R.A. CANNINGS & S.G. CANNINGS, 2000. The larva of Leucorrhinia patricia Walker (Odonata: Libellulidae). *Int. J. Odonatol.* 3: 1-10.

KENNER, R.D. & K. NEEDHAM, 1999. *Burns Bog ecosystem review: invertebrate component.* Tech. Rep. for R.P.A. Associates.

NEEDHAM, J.G., 1901. Aquatic insects in the Adirondacks. Order Odonata. *Bull. N. Y. St. Mus.* 47: 429-540.

NEEDHAM, J.G. & M.J. WESTFALL, Jr., 1955. *A manual of the dragonflies of North America (Anisoptera), including the Greater Antilles and the provinces of the Mexican border.* Univ. California Press, Berkeley.

NEEDHAM, J.G., M.J. WESTFALL, Jr. & M.L. MAY, 2000. *Dragonflies of North America* [revised edn]. Scient. Publishers, Gainesville, FL.

WALKER, E.M., 1916. The nymphs of N. American species of Leucorrhinia. *Can. Ent.* 48: 414–422.

WALKER, E.M., 1927. *The Odonata of the Canadian Cordillera.* Prov. Mus. Nat. Hist., Victoria, BC.

WALKER, E.M. & P.S. CORBET, 1975. *The Odonata of Canada and Alaska*, Vol. 3. Univ. Toronto Press, Toronto, ON.