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**AN ILLUSTRATED KEY TO THE PUPAE OF SIX SPECIES OF
HYDROPSYCHE (TRICHOPTERA: HYDROPSYCHIDAE) COMMON
IN SOUTHERN ONTARIO STREAMS**

Jane E. Rutherford¹

ABSTRACT

I present a key for the identification of pupae and pupal exuviae of six species of *Hydropsyche* that are widely distributed throughout northeastern North America and that are particularly abundant in the streams of southern Ontario. Use of the pupal key requires less manipulation of a specimen than either removing larval sclerites from the pupal case or attempting to discern the adult genitalia through the pupal integument.

Net-spinning caddisflies of the family Hydropsychidae are among the most abundant of the aquatic insects in the streams and rivers of southern Ontario. Two genera, *Cheumatopsyche* Wallengren and *Hydropsyche* Pictet, occur throughout many drainage systems, from headwater streams to river mouths, and often assemblages of several species of both genera are found together on the same rock. In the Credit and Humber rivers, the longitudinal distributions of the common species of *Hydropsyche* overlap, so that at upstream stations (orders 3-4), *Hydropsyche slossonae* Banks and *Hydropsyche sparna* Ross co-occur, whereas at downstream stations (orders 5-6), *H. sparna* is found with *Hydropsyche morosa* Hagen and *Hydropsyche bronta* Ross. At some downstream stations, *Hydropsyche betteni* Ross, *Hydropsyche dicantha* Ross, and *Hydropsyche scalaris* Hagen are present as well (Mackay 1979). *Hydropsyche betteni* has also been collected from fourth-order Humber River stations (Mackay 1979, Rutherford 1984), and is particularly abundant below dams (Mackay 1979). Collection of hydropsychid pupae, with particular emphasis on the timing of pupation, the relative densities of pupae, and the incidence of pupal mortality, has contributed to a better understanding of the life history patterns of *H. slossonae*, *H. sparna*, *H. bronta*, and *H. morosa*.

Hydropsychid pupae are more abundant on the undersides of large rocks, and on the underlying stones and gravel, than on the uppermost surfaces of the streambed substrates where larvae are most abundant. Because considerable effort is required to collect representative samples of pupae it is important to be able to identify every specimen. Often pupae may be identified by characteristics of the larval sclerites remaining within the pupal case, or, when mature, by the adult genitalia visible through the pupal integument. However, in many instances, it is desirable to identify the insect by pupal characteristics. Unless metamorphosis is nearly complete, the genitalia are not well enough developed for identification. The larval sclerites may not be present within the pupal case, as sometimes happens naturally (Scott 1983, and personal observation). Pupal cases that have been infested by either inquiline or predatory chironomid larvae (Parker and Voshell 1979, Vinikour and Anderson 1981, Rutherford 1984) may no longer retain the larval sclerites. Similarly, the activities of the invading chironomid larvae can damage the tissues (including the genitalia) of the developing hydropsychid pupae beyond recognition, although the pupal integument usually remains almost intact.

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Accordingly, I have developed a key for the identification of the pupae of six species of *Hydropsyche* common in southern Ontario. To my knowledge, this is the first published key for the identification of hydropsychid pupae at the species level. My object was to produce a guide for the rapid identification of hydropsychid pupae which did not require excessive manipulation of specimens, or the clearing and mounting of any portion of the insect. I have used features of the dorsum of the pupal abdomen that are easily discerned under a dissecting microscope. Intact specimens are not required for positive identification; consequently, damaged insects or even empty pupal exuviae may be identified using this key. The ability to identify almost every pupa collected, no matter what its condition, allowed me to undertake two studies of pupal mortality in hydropsychids (Rutherford 1984). It is my hope that the features of the pupal integument used here will be examined in other species found in southern Ontario, so that a more comprehensive key can be developed. The species common in southern Ontario are widely distributed throughout northeastern North America (Wiggins 1977), so that a key based on Ontario species would be more than locally useful.

The systematics of the Hydropsychidae have received considerable attention recently. Several workers have proposed the splitting the genus *Hydropsyche* into as many as three genera: *Hydropsyche*, *Symphitopsyche* Ulmer, and *Ceratopsyche* Ross and Unzicker (Schuster and Etnier 1978, Schuster 1984, Morse and Holzenthal 1984). By this scheme, two of the species represented in this pupal key, *betteni* and *dicantha*, would remain in the genus *Hydropsyche*, while the remaining four species, all members of the *bifida* group, would belong to the genus *Ceratopsyche*. Other workers who recognize the taxonomic complexities of the *bifida-morosa* complex do not favour the splitting of *Hydropsyche* into separate genera (Scheffer 1982, Scheffer and Unzicker 1984). Until this matter is resolved, I prefer to retain the use of the name *Hydropsyche* for all the species considered in this paper.

MATERIALS AND METHODS

Four sampling stations were established on each of the Credit and Humber rivers (Fig. 1); these have been described in detail elsewhere (Mackay 1979, Rutherford 1984). Weekly collections of hydropsychid pupal cases were made from 15 May to 9 September, 1980, to obtain pupae for rearing in the laboratory. Pupae were maintained in small rearing pots at 18°C under a 12:12 h light-dark photoregime (details are described in Rutherford 1984). The pots were checked daily for newly emerged adults and cast exuviae. Adults were removed to holding jars for a few days to allow hardening of their sclerotized tissues, then preserved in Kahle's solution in individual vials in which the associated pupal exuviae were already preserved. Exuviae were easy to associate with individual adults despite the fact that pupae were reared in small groups (up to 30 per pot). Adults emerged sporadically; my records show that for those days on which adults were collected, the rate of emergence was 1.71 ± 0.049 ($\bar{x} \pm 1$ SE, $n = 555$) adults per pot. Not all collected pupae gave rise to adults (emergence success was about 33%) (Rutherford 1984); however, all specimens were identified using adult characters where possible (Ross 1944), or setal lengths and colour patterns of larval sclerites retained within the pupal case (Mackay 1978, 1984a). These identifications were used to confirm identifications based on characteristics of the hook plates and hairs of the pupal abdomen. Some pupal exuviae were mounted in PermountTM on microscope slides to facilitate measurement of the dimensions of the abdomen and hook plates. In total, 2332 specimens were examined (Table 1) to develop the key to six species of *Hydropsyche*. Mounted specimens of *H. morosa* and *H. bronta* were measured at 12 X magnification using a dissecting microscope equipped with an ocular micrometer. Abdominal length was measured along a dorsal midline extending from the thoracic-abdominal suture to the distal end of segment VIII. Width was measured at a perpendicular to the midline, across the 4p hook plates. Hook plate widths were measured at 50X. Drawings of mounted specimens were rendered using both a dissecting microscope and a compound microscope fitted with drawing tubes.

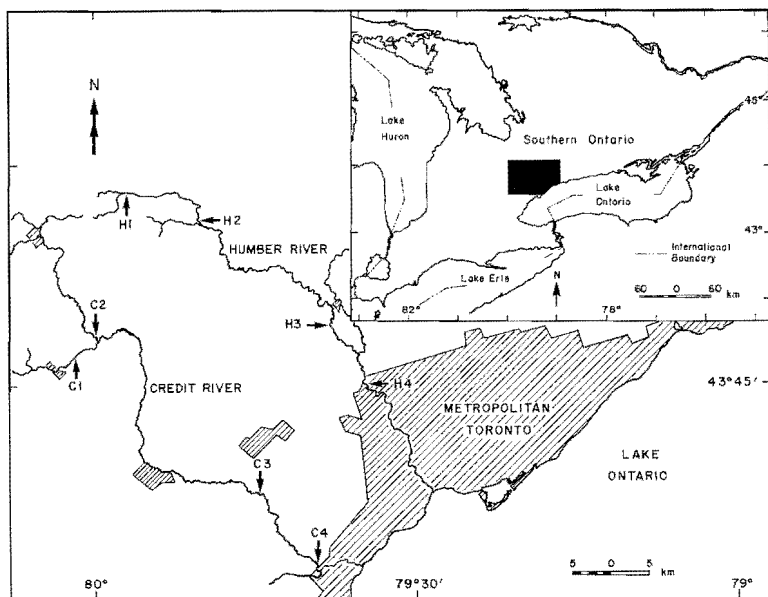


Fig. 1. Location of sampling-stations on the Credit and Humber rivers, southern Ontario.

Table 1. Specimens examined for development of the key to six species of *Hydropsyche*.

Taxon	Identified	Exuviae mounted
<i>Cheumatopsyche</i>	247	13
<i>H. slossonae</i>	677	51
<i>H. sparna</i>	453	49
<i>H. betteni</i>	5	4
<i>H. dicantha</i>	1	1
<i>H. bronta</i>	374	33
<i>H. morosa</i>	575	63
Total	2332	214

RESULTS AND DISCUSSION

Trichopteran pupae may be identified to family using the keys of Ross (1944). The hydropsychid pupal abdomen lacks a lateral fringe of setae, but has lateral gills; the mandibles have several conspicuous sub-apical teeth in addition to a prominent apical point; the dorsum of segment III bears two pairs of hook plates. In many streams of southern Ontario, the two genera *Hydropsyche* and *Cheumatopsyche* co-exist in abundance. *Cheumatopsyche* pupae may be distinguished from *Hydropsyche* by the shape of the 3p hook plates, which in *Cheumatopsyche* are ovoid to round and in *Hydropsyche* are elongated ovals (Ross 1944). Certain features of the dorsum of the pupal abdomen of *Hydropsyche* are important to note (Fig. 2): segment I is moderately hairy but does not have a spined ridge (as in Limnephilidae); segments II to VIII (in some species, III to VIII) bear paired hook plates with an anterior and posterior pair on each of segments III and IV.

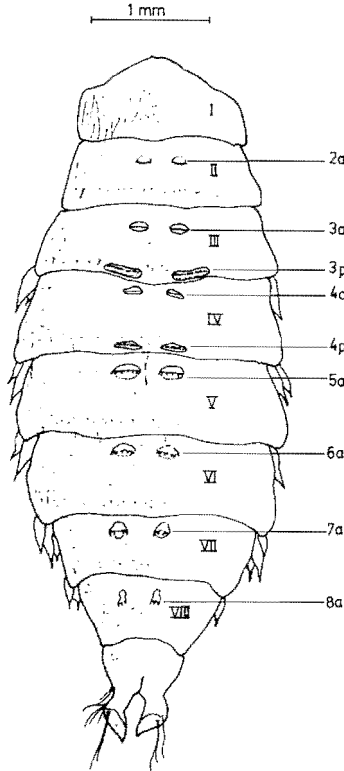


Fig. 2. Generalized drawing of a hydropsychid pupal abdomen showing segments I to VIII, lateral gills, terminal anal processes, and location of paired hook plates (a = anterior, p = posterior); rows of hairs (shown here on the left side of the drawing only) extending across dorsum of each segment are usually well-developed on segments IV to VI, less well-defined on other segments.

On the other segments the hook plates are in the anterior position. Hairs are scattered over the dorsal surface; on some segments (particularly IV to VI) there is a well developed row of hairs on the posterior third of the segment. The presence or absence of the 2a hook plates, the relative size, shape and spacing of the other hook plates, and the stoutness of hairs on the dorsal surface are the main characters used to separate six species of *Hydropsyche* in the following key.

KEY TO PUPAE

- 1. 3p hook plates ovoid to round *Cheumatopsyche*
- 1'. 3p hook plates elongated ovals (*Hydropsyche*) 2
- 2(1'). 2a hook plates absent 3
- 2'. 2a hook plates present (Fig. 2), but may be reduced to as little as a single hook (Fig. 5b) 5
- 3(2). Hairs at lateral margins of dorsum of segments VI to VIII short and coarse, twice as thick at base but only 1/3 to 1/2 as long as hairs of postero-lateral margin of

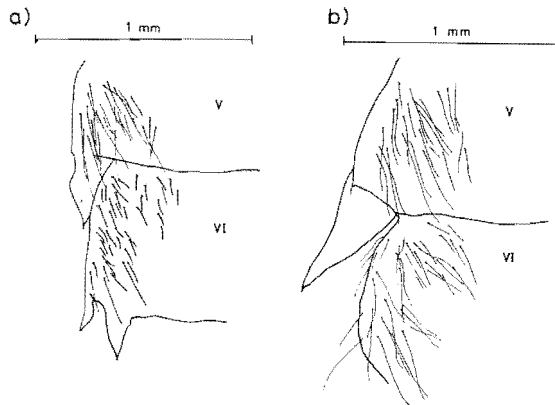


Fig. 3. (a) detail of lateral margin of dorsal surface of *H. bronta* with fine hairs on segment V, coarse hairs on segment VI; (b) lateral margin on *H. sparna* with fine hairs on segments V and VI.

- segment V (Fig. 3a) (short coarse hairs 0.007–0.01 mm long, slender hairs of segment V 0.02–0.03 mm long) *H. bronta* (in part)
- 3'. Hairs at lateral margins of dorsum of segments VI to VIII slender, similar in length and thickness to hairs found on lateral margins of segments III to V (Fig. 2 and Fig. 3b) 4
- 4(3'). 4a hook plates small, 0.10–0.12 mm wide, with 4 short hooks, each about as long as they are broad at the base (Fig. 4a); 3a hook plates 0.08–0.10 mm wide, with number of hooks variable (4–8) (Fig. 4c); hook plates on segments V to VII (i.e. pairs 5a, 6a and 7a) 0.10–0.14 mm wide with 4–6 hooks (Fig. 4e, g and i) *H. dicantha*
- 4'. 4a hook plates wider, range 0.16–0.18 mm, with more than 4 hooks (number variable, usually 7–9), each about twice as long as they are broad at the base (Fig. 4b); 3a hook plates 0.16–0.18 mm wide, with 7–11 hooks (Fig. 4d); hook plates on segments V to VII (i.e. pairs 5a, 6a and 7a) 0.15–0.19 mm wide with 4–7 hooks (Fig. 4f, h and i) *H. betteni*
- 5(2'). Hairs at lateral margins of dorsum of segments VI to VIII short and coarse, twice as thick at base but 1/3 to 1/2 as long as hairs at lateral margins of segment V (Fig. 3a); 3p hook plates wider than other hook plates, with 4a hook plates 1/2 to 2/3 as wide as 3p hook plates (Fig. 2) 6
- 5'. Hairs at lateral margins of dorsum of segments VI to VII slender not coarse, similar to hairs at lateral margins of segments I to V (Fig. 3b); 3p, 4a, 4p and 5a hook plates approximately equal in width, with 4a plates at least 2/3 as wide as the 3p plates, and the 4p and 5a hook plates both slightly wider than the 3p plates (Fig. 6a) 7
- 6(5). 2a hook plates present, clearly visible at 50X, each with well-developed hooks, number variable (2–13) but usually 6 or 7 (Fig. 5a); complete row of short hairs present on the anterior portion of dorsum of segments III and IV with some arising at the anterior margins of hook plates 3a and 4a (Fig. 5c); 6a hook plates with sturdy hooks, intermediate hooks generally as long and as heavily-sclerotized as lateral hooks (Fig. 5e) *H. morosa*
- 6'. 2a hook plates usually present but can be difficult to see clearly at 50X, often reduced in size with few hooks (range 0–8, but usually 3) (Fig. 5b); some short hairs may be present on anterior portions of segments III and IV, but do not form a well-defined row and none arise at the anterior margins of hook plates 3a and

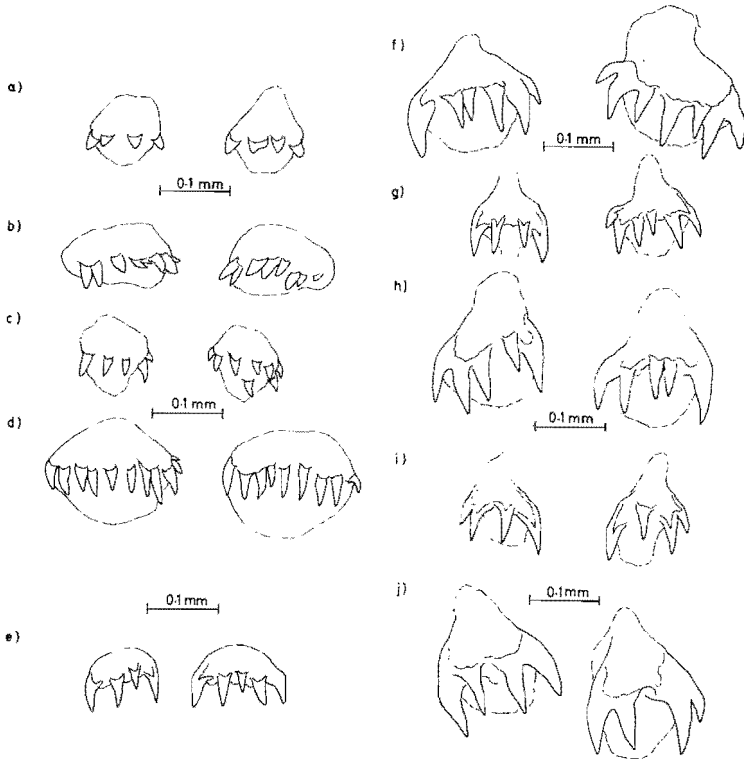


Fig. 4. Comparison of hook plates of *H. dicantha* and *H. betteni* (two examples of each): 4a hook plates, (a) *H. dicantha*, (b) *H. betteni*; 3a hook plates, (c) *H. dicantha*, (d) *H. betteni*; 5a hook plates, (e) *H. dicantha*, (f) *H. betteni*; 6a hook plates, (g) *H. dicantha*, (h) *H. betteni*; 7a hook plates, (i) *H. dicantha*, (j) *H. betteni*.

- 4a (Fig. 5d); lateral hooks on 6a hook plates heavily sclerotized, about twice as long and sturdy as intermediate hooks (Fig. 5f) *H. bronta* (in part)
 7(5'). Pupa small, abdominal length 5.8–7.3 mm ($\bar{x} = 6.5 \pm 0.58$ mm, $n = 37$), does not have a dense patch of fine hairs on dorsum of segment IV, but has well-developed posterior row of hairs across dorsum of segments IV, V and VI (Fig. 6a); left and right plates of each pair on segment III close together, sometimes almost touching, with maximum distance between paired plates less than a single plate-width (Fig. 6a) *H. sparna*
 7'. Pupa large, abdominal length 6.9–9.0 mm ($\bar{x} = 7.8 \pm 1.00$ mm, $n = 43$) with a dense patch of fine hairs present on dorsum of segment IV but the rest of the dorsal surface relatively hairless (Fig. 6b); left and right plates of each pair on segment III well-separated by at least 1 hook-plate width (Fig. 6b) *H. slossonae*

At upstream stations *H. slossonae* and *H. sparna* are often equally abundant. *H. slossonae* pupae may be recognized immediately by the dense patch of fine hairs on the

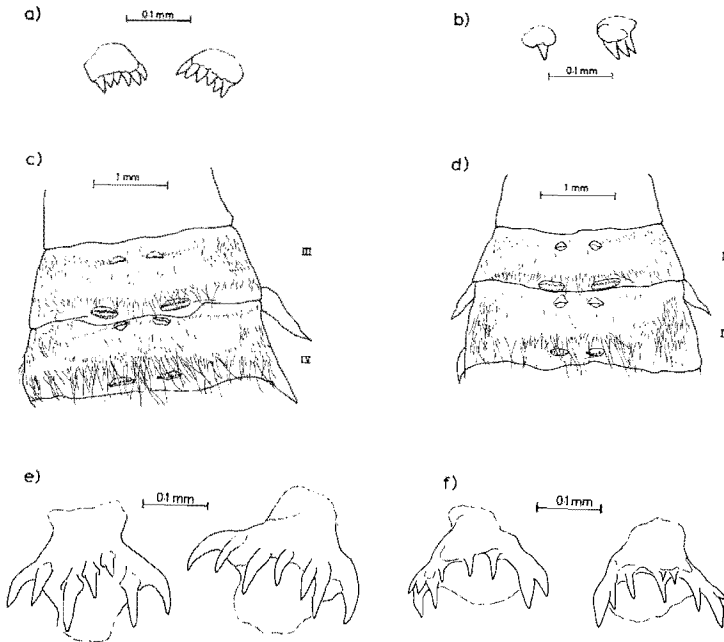


Fig. 5. (a) 2a hook plates of *H. morosa*; (b) 2a hook plates of *H. bronta*; (c) *H. morosa*: detail of dorsum of segments III and IV. Note row of short hairs at anterior of segments, extending to the 3a and 4a hook plates; bases of some hairs arise from anterior margin of hook plates. (d) *H. bronta*: detail of dorsum of segments III and IV. Anterior row of short hairs on each segment not as well-defined as on *H. morosa* (compare to Fig. 5c); no hairs arise from anterior margin of 3a or 4a hook plates. (e) 6a hook plates of *H. morosa*; (f) 6a hook plates of *H. bronta*.

dorsum of segment IV, which contrasts with the rather hairless appearance of the rest of the dorsal surface (Fig. 6b). On *H. sparna*, the hook plates of segment IV are wide, about as wide as the 3p hook plates, but are set very close together (Fig. 6a); the dorsum of segment IV is not markedly hairier than the rest of the abdomen. Both these species are easily distinguished from *H. bronta* and *H. morosa* which are chiefly confined to downstream stations. These latter species have distinctly coarser hairs on the edges of segments VI to VIII than on segments I to V (Fig. 3a); the lateral hairs of *H. slossonae*, *H. sparna*, as well as *H. dicantha* and *H. betteni*, do not become coarser on the three terminal segments (Fig. 3b and Fig. 6a and 6b). *H. dicantha* and *H. betteni* co-occur with *H. bronta*, *H. morosa* and *H. sparna* at some downstream stations. *H. dicantha* and *H. betteni* lack the 2a hook plates, whereas they are well-developed in *H. sparna* and *H. morosa* and usually present (although often reduced in size) in *H. bronta*. Details of the hook plates of segments III to VII may be used to separate *H. dicantha* from *H. betteni* (Fig. 4). *H. morosa* and *H. bronta* are the most difficult to distinguish in the pupal stage, as they are in the larval stage (Mackay 1978, 1984a). In general *H. morosa* pupae are larger and relatively hairier than *H. bronta* pupae (Fig. 5c and d) but because of sexual dimorphism as well as seasonal differences in size attained (Mackay 1984b), length and width alone are not adequate for separation of the two species (Table 2). Close attention must be paid to the size of the 2a hook plates, and the presence of short hairs on the anterior dorsum of segments III and IV for reliable separation of the species (Fig. 5).

Table 2. Comparison of length and width of pupal abdomens (mounted pupal exuviae) in females and males of *H. morosa* and *H. bronta*.^a

Dimension		<i>H. morosa</i>			<i>H. bronta</i>		
		F	M	Both	F	M	Both
Length (mm)	Mean	6.91 ^A	6.27 ^{A,B}	6.67	6.10 ^{A,B}	5.30 ^B	5.64
	S.E.	0.078	0.093	0.085	0.195	0.098	0.130
	n	17	10	27	11	15	26
Width (mm)	Mean	3.09 ^C	2.74 ^C	2.96	2.76 ^C	2.33 ^C	2.50
	S.E.	0.037	0.070	0.047	0.131	0.055	0.075
	n	17	10	27	11	15	26

^aLengths and widths of females and males of the species were compared by two separate *a posteriori* tests (using the Student-Newman-Keuls test): (1) lengths, letters denote means that are significantly different, $P < 0.05$; (2) widths, no significant differences were found.

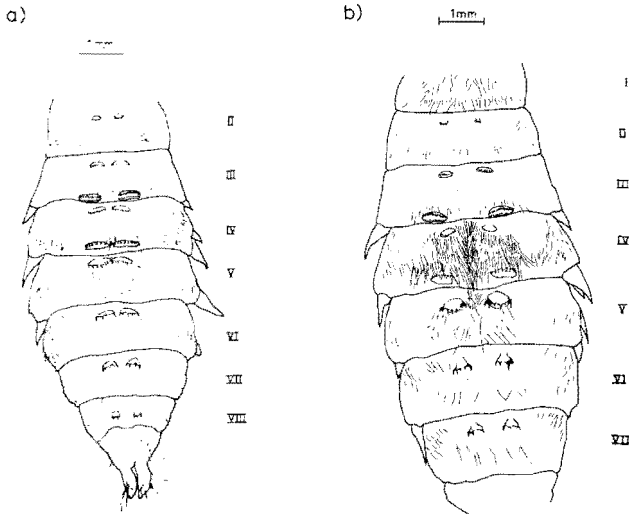


Fig. 6. (a) Dorsal view of *H. sparna* pupal abdomen: hook plates 4a, 4p and 5a approximately the same width as 3p hook plates; plates of each pair separated by less than 1 plate-width; (b) dorsal view of *H. slossonae* pupal abdomen: note dense patch of fine hairs on segment IV; other segments bear relatively few hairs.

Other species of *Hydropsyche* are known to occur at stations on the Credit and Humber rivers. *H. walkeri* is rare at C3 and C4, and *H. scalaris* is moderately abundant at H3 and C3 (Mackay 1979). However, in this study no specimens of these species were successfully reared to adulthood, so that adults and pupal exuviae could not be associated.

Perhaps the most difficult feature to use confidently is the detection of the 2a hook plates on some specimens. This leads us once again to the nomenclatural and systematic problem of the recognition of one, two, or three generic names, as opposed to my use of the single name *Hydropsyche*. The 16 Afrotropical species of the proposed *Symphitopsyche*, and the members of the larger proposed genus *Ceratopsyche*, all possess dorsal hook plates on segment II whereas the members of *Hydropsyche (sensu stricto)* do not (Scott 1983, Shuster 1984). By this scheme, *sparna*, *slossonae*, *morosa*, and *bronta* all belong to *Ceratopsyche*. However, the 2a hook plates on pupae of *bronta* are often very difficult to distinguish and, in my experience, are sometimes completely missing. For this reason, two distinct pathways lead to the identification of *bronta* in my key. For these problematic specimens, the choice of either alternative in couplet 2 will lead to the correct identification.

The pupal key presented here was tested in 1981 in a study of pupal mortality in which 4721 pupal cases were collected and preserved immediately in Kahle's solution (Rutherford 1984). Frequently these insects had just pupated so that the genitalia were not developed. In 1–2% of the cases, the larval sclerites were not present. For these specimens, the pupal key provided the only means of identification. Even when larval sclerites were retained in the pupal case, they were tedious to extract, and often the characteristic pronotal setae were broken. Identification of these specimens using pupal characters was easier and more efficient than relying on the colour pattern of the larval head capsule sclerites, and required less handling of the insects.

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