



What is *Baetis rhodani* (Pictet, 1843) (Insecta, Ephemeroptera, Baetidae)? Designation of a neotype and redescription of the species from its original area

JEAN-LUC GATTOLLIAT¹ & MICHEL SARTORI²

Museum of Zoology, Palais de Rumine, Place Riponne 6, CH-1014 Lausanne, Switzerland.

E-mail: ¹jean-luc.gattolliat@vd.ch, ²michel.sartori@vd.ch

Summary

Baetis rhodani (Pictet, 1843) is a widespread species that occurs throughout the West Palaearctic. Recently, several sibling species of the subgenus *Rhodobaetis* have been described and compared to *B. rhodani*, clearly prompting the need to reassess the taxonomic concept of *B. rhodani*. The type material of *B. rhodani* is unfortunately lost or has been destroyed. In order to provide a necessary standard for comparison, a neotype for *B. rhodani* is designated based on material collected from the best approximation of the type locality (Geneva, Switzerland). The species is also redescribed at both larval and imaginal stages including the set of characters generally used for species identification within the subgenus *Rhodobaetis*.

Key words: *Baetis rhodani*, Switzerland, neotype, redescription, sibling species

Introduction

Baetis rhodani (Pictet, 1843) is one of the most common and most abundant species amongst western Palaearctic mayflies (Ephemeroptera). It occurs from Ireland (Kelly-Quinn & Bracken 2000) to Russia, including Baltic countries (Timm 1997; Poppels 2005; Ruginis 2006), and from North Africa (Thomas 1998) to the Near East (Dia & Thomas 2005). It is absent only from remote islands (Tuxen 1938; Brinck & Scherer 1961) where it is replaced, in some archipelagos, by sibling species, such as in the Canary Islands or Corsica (Müller-Liebenau 1971; Thomas & Soldán 1987).

The species was first described by Pictet (1843) under the name *Cloe rhodani*. The author gave a detailed description, including the nymph (Pictet 1845, plates 36–39). The species was described from the Geneva area where it was very common (Pictet 1843, p. 251). Later, the species was transferred to the genus *Baetis* Leach, 1815 (Eaton 1871), and redescribed in detail by Müller-Liebenau (1969) based on material from Sweden (Bengtsson collection), France (Thibault collection) and Germany (Müller-Liebenau collection).

This species possesses a large number of synonyms established throughout the 19th and 20th centuries. Among them are *Baetis maderensis* (Hagen, 1865) from Madeira (Eaton 1871), *Baetis bocagii* Eaton, 1885, from Portugal (Kimmins 1960), *Baetis wallengreni* Bengtsson, 1912, (Müller-Liebenau 1965; 1969), and *Baetis pusillus* Bengtsson, 1912 from Sweden (Müller-Liebenau 1969), *Baetis iberi* Navás, 1913 from Spain (Alba-Tercedor 1984) and *Baetis gemellus* Eaton, 1885 from the Alps of France, Switzerland and Italy (Kimmins 1960; Thomas 1999).

Over the years, several species closely related to *B. rhodani* have been described from the West Palaearctic region: *Baetis canariensis* and *B. pseudorhodani* Müller-Liebenau, 1971 from the Canary Islands, *B. braschi* Zimmermann, 1980 from Crimea, *B. sinespinosus* Soldán & Thomas, 1983 from Algeria, *B. bisri*

Thomas & Dia, 1983 from Lebanon, *B. ingridae* Thomas & Soldán, 1987 from Corsica and *B. gadeai* Thomas, 1999 from Southern France. All these species share enough characters at both the larval and adult stages to be recognized as belonging to the *Baetis rhodani* group sensu Müller-Liebenau, 1969, a species group that has been raised to the subgenus *Rhodobaetis* (Jacob 2003). This subgenus encompasses other species from the East Palaearctic, Caucasus, as well as one Holarctic species. More recently, several new species have been proposed from Crimea (Godunko *et al.* 2004a; Godunko *et al.* 2004b), North Africa (Soldán *et al.* 2005), or Madeira (Soldán & Godunko 2006). Godunko *et al.* (2004b) give detailed description and comparison of all known species of *Rhodobaetis* from the West Palaearctic.

A recent phylogenetic analysis of *Baetis rhodani sensu stricto* from populations across Western Europe revealed a considerable amount of variation in mitochondrial cytochrome-oxidase I (*coxI*) with several distinct lineages (Williams *et al.* 2006), strongly suggesting the presence of cryptic species throughout the geographical range.

Our latest studies on the Macaronesian mayfly fauna from Macaronesia give further emphasis to the need to resolve the historical confusion that hampers the taxonomic resolution of *Rhodobaetis* species in this area (Gattolliat *et al.* 2008). We show there that the continental species *Baetis rhodani* is absent from Madeira where it is replaced by *Baetis atlanticus* Soldán & Godunko, 2006. A second species of *Baetis*, *B. enigmaticus* Gattolliat and Sartori, 2008, is established in that paper for larvae presenting rheophilous adaptations similar to those of *B. pseudorhodani* Müller-Liebenau, 1971, from the Canary Islands.

These findings highlight an urgent need for the detailed and reliable characterisation of the reference species *Baetis rhodani* (Pictet, 1843), based on the criteria proposed by Godunko *et al.* (2004b).

Pictet's collection, housed in the Museum of Natural History of Geneva was already partially destroyed prior to entering the Museum in 1887, as discussed by Eaton (1871) and Meyer-Dür (1874). A catalogue of Pictet's types in Geneva and Vienna is in preparation (Sartori & Bauernfeind, in prep.). As stated by Müller-Liebenau (1969) and confirmed by us, no original material from *B. rhodani* described by Pictet is to be found in Geneva or Vienna.

F.J. Pictet lived in the Pictet family manor house in Genthod, on the shore of Lake Geneva, a few kilometres north of the city of Geneva. Approximately 500 m from the house runs the Versoix River. We chose the *Baetis rhodani* population from this stream, including reared material, for the complete redescription of the species. In this way we could obtain nymphs, winged stages, and DNA sequences.

In order to stabilize the nomenclatural concept of *B. rhodani* in the future, a neotype is designated, as there is a need to define the nominal taxon objectively (see articles 75.3, in particular 75.3.4 to 75.3.6, ICZN 1999).

We avoided using other junior synonyms as name-bearing types, since these specimens are from distant locations such as Madeira, Norway and Portugal, and there is a reasonable probability that further studies will show at least some of them to be in fact distinct species rather than synonyms.

mtDNA sequences

Genomic DNA was extracted from 3 specimens using a Wizard SV extraction kit (Promega, UK). A 357-base-pair region of mitochondrial cytochrome b (*cob*) was amplified and sequenced using primers cb3 (5'-GAG GAG CAA CTG TAA TTA CTA A) and cb4 (5'-AAA AGA AAR TAT CAT TCA GGT TGA AT) as part of a larger phylogenetic study of European Baetidae (Monaghan *et al.* unpublished). These 3 sequences have been deposited to GeneBank (accessions AM940130 - AM940132).

***Baetis rhodani* (Pictet, 1843)**

Material examined. Neotype. 1 male imago with corresponding larval and subimaginal exuviae, Suisse, Canton de Genève, Versoix River, Sauverny loc., 6°07'12.8"E, 46°18'41.3"N, Alt. 450m, 24.04.2006. Col. J.-L. Gattolliat, C. Chaussignand & T. Hupin.

Other material. Four male imagos with corresponding larval and subimaginal exuviae, 1 male imago with corresponding larval exuvia, 1 female imago with corresponding larval and subimaginal exuvia, 1 female subimago with corresponding larval exuvia, 2 male imagos, 2 male subimagos, 4 female imagos, 1 female subimago, 135 larvae, same data as neotype.

1 male imago with corresponding larval and subimaginal exuviae, 1 female imago and 52 larvae, Suisse, Canton de Genève, Versoix River, Richelien loc., 6°08'36.4"E, 46°16'50.2"N, Alt. 405m, 24.04.2006. Col. J.-L. Gattolliat, C. Chaussignand & T. Hupin.

Neotype and other specimens deposited in the Museum of Zoology of Lausanne (Switzerland) except: 1 male imago with corresponding larval and subimaginal exuviae, 1 female imago and 10 larvae in the Museum d'Histoire Naturelle of Geneva (Switzerland); 1 male imago, 1 female imago and 10 larvae in the Naturhistorische Museum in Wien (Austria); 1 male imago with corresponding larval and subimaginal exuviae and 10 larvae in the Institute of Entomology, Academy of Science of the Czech Republic, University of South Bohemia, Ceske Budejovice (Czech Republic); 1 male imago with corresponding larval and subimaginal exuviae and 10 larvae in State Museum of Natural History, L'viv, Ukraine.

Description.

Larva. Male larva length: body 7.1 – 8.2 mm; cerci 4.2 – 4.7 mm; median caudal filament 3.3 – 4.5 mm. Female larva length: body 7.8 – 10.7 mm; cerci 5.6 – 6.6 mm; median caudal filament 4.5 – 5.6 mm.

Colouration. Head (Fig. 21) medium brown, Antennae yellowish brown, darker proximally. Prothorax medium brown with yellowish pattern; mesothorax medium brown with yellowish longitudinal stripes; metathorax medium brown. Legs: femora medium brown with a proximal and distal yellow mark, tibiae yellowish except medium brown ahead tibio-patellar suture and at apex, tarsi yellowish except proximally medium brown. Terga (Fig. 22) yellowish brown to medium brown with generally two symmetrical dark brown spots; terga II, III, VII and VIII darker. Sterna I to V yellow to light brown without pattern; sterna VI to IX medium brown to dark with two or four central ecru spots. Cerci ecru without annulations or stripes.

Head. Antenna (Fig. 10): scape with small scales and a patch of small and very thin setae. Pedicel with elongated apically rounded scales more abundant near distal margin.

Labrum (Fig. 1) rounded with the distal margin somewhat straight, width/length ratio 1.55–1.65; dorsal face of labrum (Figs. 1; 7 – 9) with an arc subparallel to distal margin formed by 1 + 8 to 10 long and stout setae, more or less arranged in 1 or 2 rows, 3 to 5 finer setae laterally, short and fine setae scattered proximally; ventral surface with about 6 short pointed setae disto-laterally; distal margins bordered with long and feathered setae.

Hypopharynx (Fig. 2) with a trilobed lingua with a broad central lobe, covered apically with minute setae, lingua with a dark H-shaped mark; superlingua as long as the lingua.

Right mandible (Fig. 3) with 7 incisors; row of thin setae on outer margin of outer of incisors absent; prosthema elongated and slender; no setae between prosthema and mola; proximal half of mandible with abundant thin setae.

Left mandible (Fig. 4) with 6 incisors; prosthema with 6 similar denticles and an elongated comb-shaped structure; no setae between prosthema and mola; proximal half of mandible with abundant thin setae.

Maxillae (Fig. 6) with 4 short teeth, none of them opposed to others; apico-laterally with one row of medium setae; 2 spine-like dentisetae and 8 to 12 long setae; palp 2-segmented longer than galea-lacinia, segment I 0.8 x length of segment II, tip of segment II (Fig. 11) with a nipple and a single stout scale apically, segments I and II almost bare except apex of segment II.

Labium (Fig. 5) with glossae clearly shorter than paraglossae; glossae triangular with broad base, inner margin and distal half of outer margin with medium setae, a few scattered setae on ventral face, no setae on dorsal face; paraglossae with three rows of long and curved setae apically, ventral face with 1 transversal row of about 7 medium setae, dorsal face with 2 long and thin setae apically; labial palp 3-segmented; segment I slightly shorter than segment II and III combined; segment II conspicuously expanded apico-laterally, with an oblique row of 5 medium setae; segment III ogival, inner margin noticeably more convex than the outer; segment III with scattered stout setae.

Thorax. Forelegs (Fig. 19). Dorsal margin of femora with medium blunt setae; abundant proximally and scarce apically; short and stout setae roughly arranged in 2 rows subparallel to dorsal margin; dorsoapical setal patch formed by several short setae; ventrally with abundant short and stout setae; upper face with abundant scales and scale bases.

Tibiae with a row of very tiny setae and a row of short and very thin setae dorsally; ventrally and laterally with tiny setae, more robust setae apico-ventrally; tibio-patellar suture present.

Tarsi dorsally with a few short and very thin setae and a few very tiny setae; ventrally with a row of short and pointed setae and a few additional short and pointed setae; lateral faces with thin and short setae; tarsal claws (Fig. 20) hooked, with 1 row of 12 to 14 acute teeth increasing in length toward the apex; subapical setae absent.

Abdomen. Terga (Figs. 12–14) with spatulate setae (spatulas sensu Godunko *et al.* 2004b), thin and long setae and scale bases, triangular broad scales rare and only present near proximal margin; posterior margin of all terga with a row of spatulate setae parallel to the distal margin; triangular spines absent on terga I to III, very rare on tergum IV (Fig. 12), present on terga V and VI (Figs. 13–14), abundant on terga VII to IX. Sterna (Fig. 15) with scales, scale bases, spatulate setae and very thin setae scattered on surface; distal margin smooth without spatulate setae and spines.

Gills (Fig. 16) on segments I to VII slightly asymmetrical; tracheation reduced but marked; stout spines and patch of very thin setae along dorsal margin (Fig. 17); ventral margin bordered with brown colouration.

Paraproct (Fig. 18) with thin setae and a few scale bases, spatulate setae mainly present near distal margin; margin with 15 to 25 spines; postero-lateral extension with a few thin setae and without scale bases, margin with short spines.

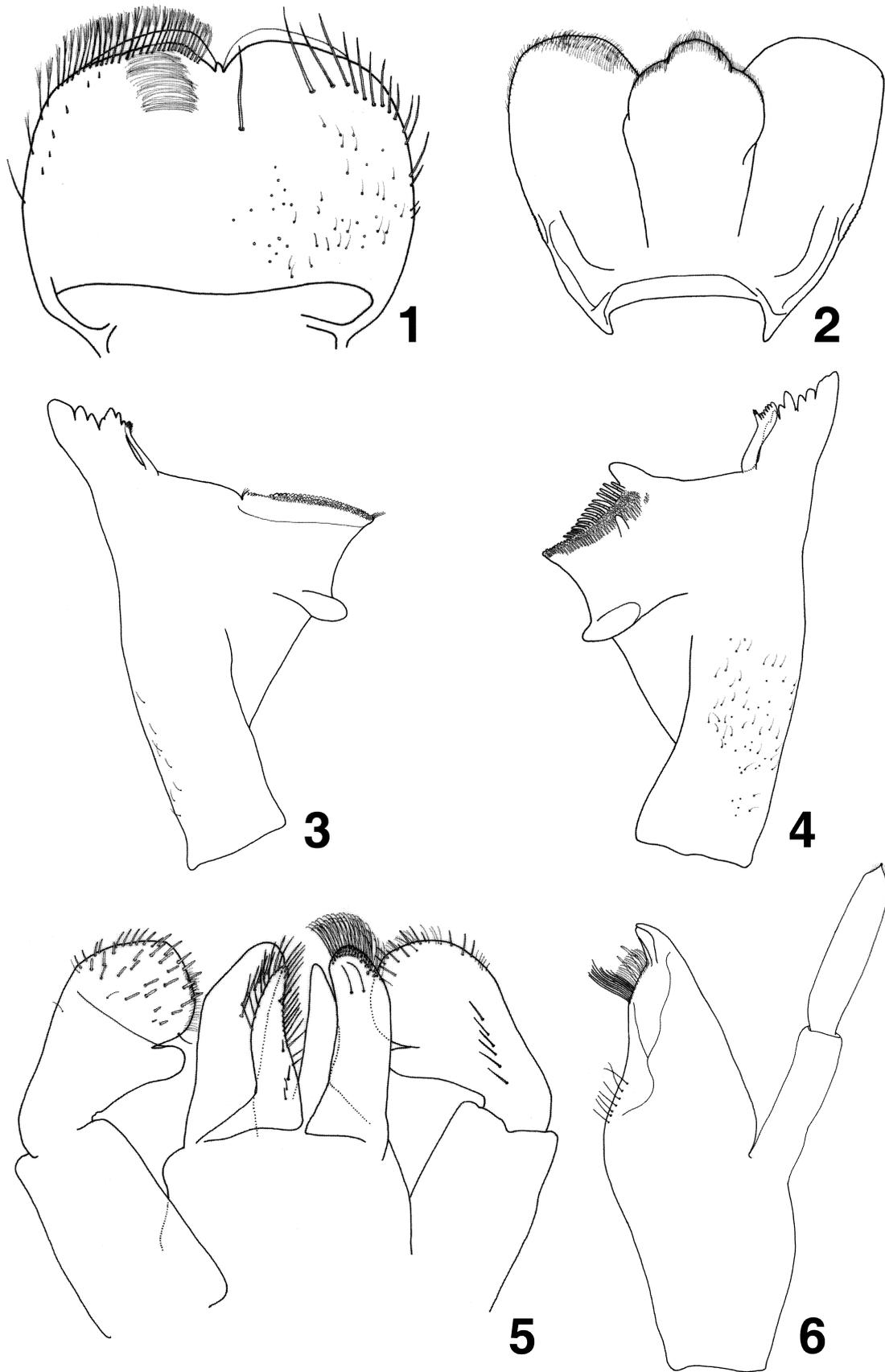
Cerci with patch of thin setae on inner margins; median caudal filament similar to cerci except patch of more abundant setae present on both sides.

Male imago. Length: body 8.1 – 8.9 mm; forewing 8.0 – 8.4 mm; hindwing 1.7 – 2.1 mm; cerci 16.5 – 18.0 mm, length of foreleg: femur 1.30 – 1.65 mm; tibia 2.00 – 2.30 mm; tarsi T1 0.85–1.10 mm; T2 0.65 – 0.85 mm; T3 0.40 – 0.50 mm; T4 0.20 – 0.25 mm.

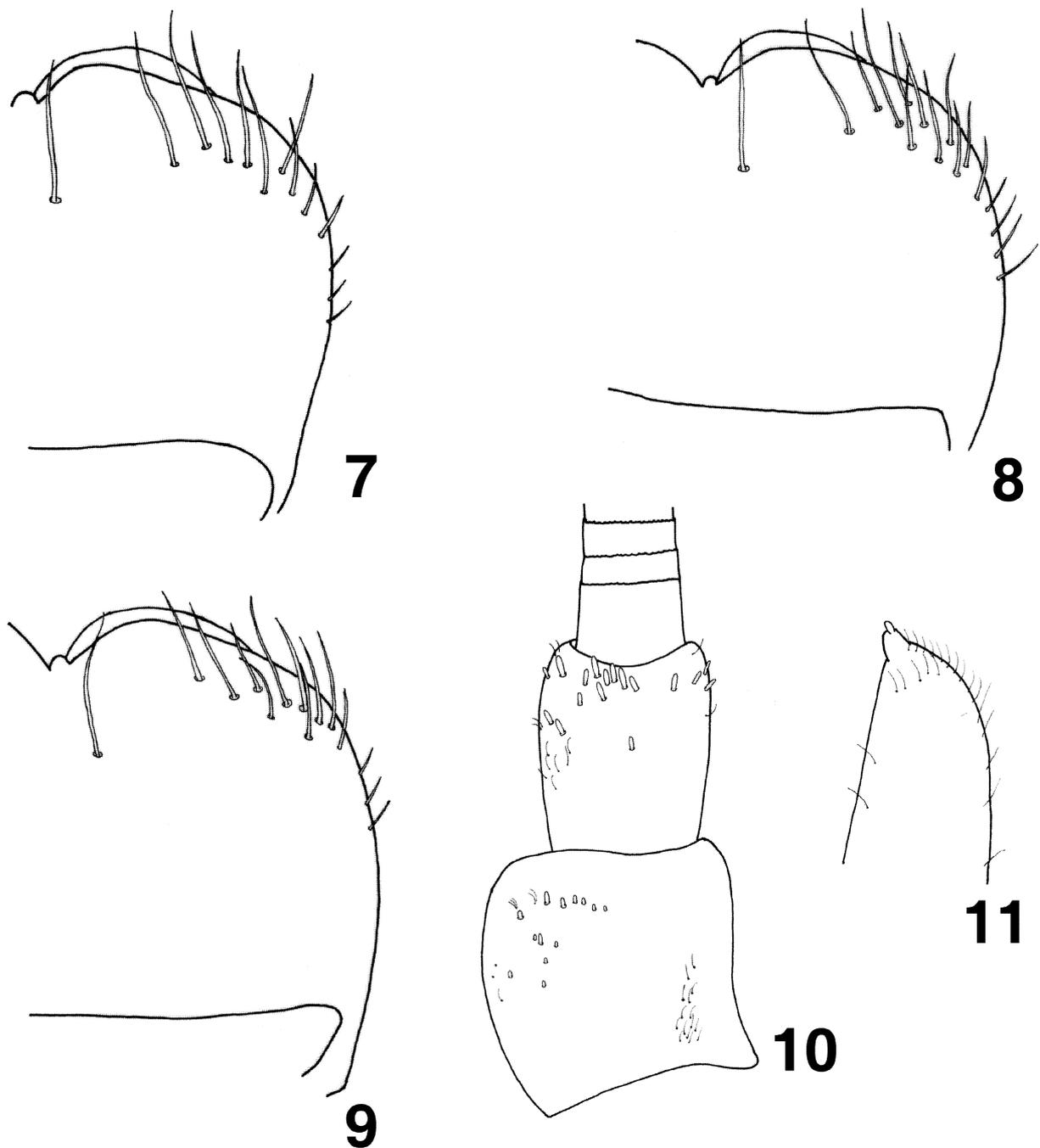
Colouration. Head medium brown to dark brown; scape and pedicel medium brown, darker proximally, flagellum ecru. Facetted surface of compound eyes orange, lateral face darker with a brown ring at base. Thorax medium to dark brown. Legs ecru except forelegs ventral and partially dorsal margins of femora, apex of tibiae medium brown. Wings hyaline with dark brown venations. Abdomen: tergum I medium brown; terga II to VI ecru with a symmetrical coma shaped medium brown mark and medium brown laterally and apically; terga VII to IX medium brown with dark stripes. Sterna uniformly ecru except sternum I medium brown and sterna VII to IX with longitudinal medium brown stripes. Cerci and median caudal filament ecru except proximal segments with dark brown joints. Genitalia yellow except base of the basal segment dark brown.

Forewing (Fig. 23). Pterostigma with about 10 cross-veins, most of them not reaching the radial vein, horizontal veinlets joining different cross-veins; double intercalary veins shorter than distance between corresponding main veins in proximal part of wing and longer than distance between corresponding main veins in distal part of wing

Hindwing (Fig. 24) with an erected costal spur at $\frac{1}{4}$ of the length of wing; three longitudinal veins reaching margin, incomplete veinlets between main longitudinal veins.



FIGURES 1–6. Larval structures of *Baetis rhodani*: 1 : labrum (left : ventral; right : dorsal). 2 : hypopharynx. 3 : right mandible. 4 : left mandible. 5 : left maxilla. 6 : labium.



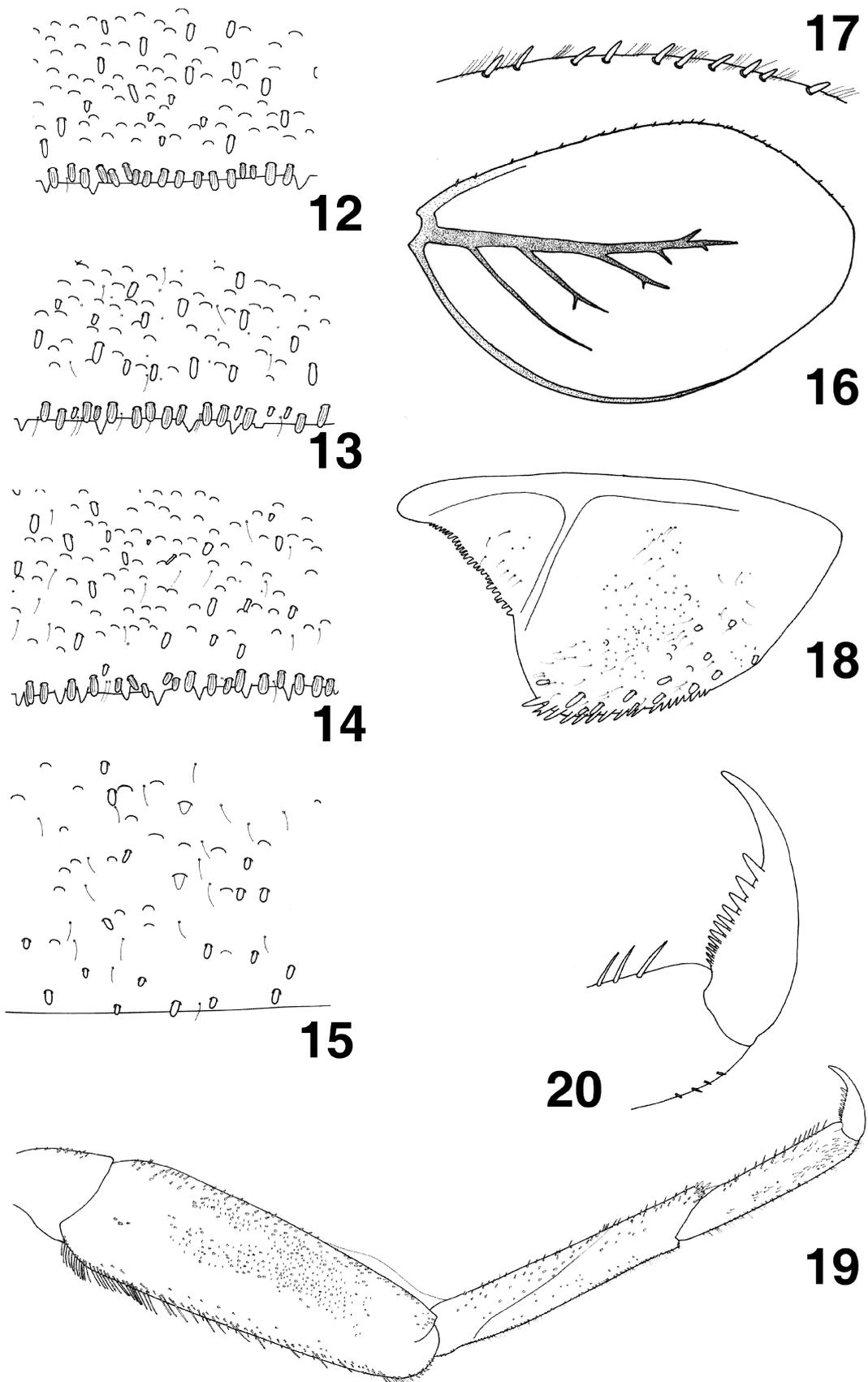
FIGURES 7–11. Larval structures of *Baetis rhodani*: 7 – 9 : labrum of different specimens. 10 : detail of antenna (scape and pedicel). 11 : tip of maxillary palp.

Genitalia (Fig. 25): basal segment of forceps longer than broad; segment I and II almost fused; segment I with a rounded inner projection apically; segment II with parallel margins; segment III rounded as long as broad.

Female imago. Length: body 7.1 – 8.7 mm; forewing 8.3 – 9.1 mm; hindwing 1.8 – 2.1 mm; cerci 12.0 – 14.0 mm.

Colouration. Head and thorax medium to dark brown. Legs ecru. Terga uniformly dark brown, Sterna ecru except sterna VII to IX medium brown.

Male and female subimagos. Similar to imagos except pattern faded.



FIGURES 12–19. Larval structures of *Baetis rhodani*: 12 : distal margin of abdominal tergum IV. 13 : distal margin of abdominal tergum V. 14 : distal margin of abdominal tergum VI. 15 : distal margin of abdominal sternum IV. 16 : gill IV. 17 : dorsal margin of gill IV. 18 : paraproct. 19 : foreleg. 20 : tarsal claw.



Figures 21– 22. Larval structures of *Baetis rhodani*: 21 : head and thorax. 22 : abdomen.

Discussion

Godunko *et al.* (2004b) compiled a list of 26 characters useful to the identification of the West Palearctic species of *Rhodobaetis* (see table 1). As most species only differ by minute characters, it is absolutely necessary to have a very accurate description of each sibling, in particular that of *Baetis rhodani* which constitutes a critical reference. The present examination of the larvae and imagoes of *B. rhodani* from the type locality reveals that Godunko's concept of *B. rhodani* slightly differs from the material described here (see table 1). Notable differences include the presence of triangular spines at the distal margin of at least terga V and VI (Figs 13 and 14), the paraproct plate with 15 to 25 teeth (Fig. 18), the faceted surface of turbinate eyes orange rather than brown or dark brown and the segment I of the gonopods with an apical inner projection (Fig. 25).

Müller-Liebenau's concept (1969) of *B. rhodani* is based on observations of populations from Sweden, Germany and south-western France, and it is possible that different species were in fact inadvertently included by her under the name *B. rhodani*. Therefore, her description of *B. rhodani* is broad enough to encompass variations of the different populations or species likely to exist based on molecular evidence (Williams *et al.* 2006). There exist importance differences in the tergal pattern and in gill tracheation between the figures 54 and 56 in Müller-Liebenau (1969); the labial palp (degree of development of apico-lateral expansion of segment II, shape of segment III) noticeably differs between our figure 5 and figure 57e in Müller-Liebenau (1969). Other important characters, such as labrum or legs, are not illustrated or described in enough detail by

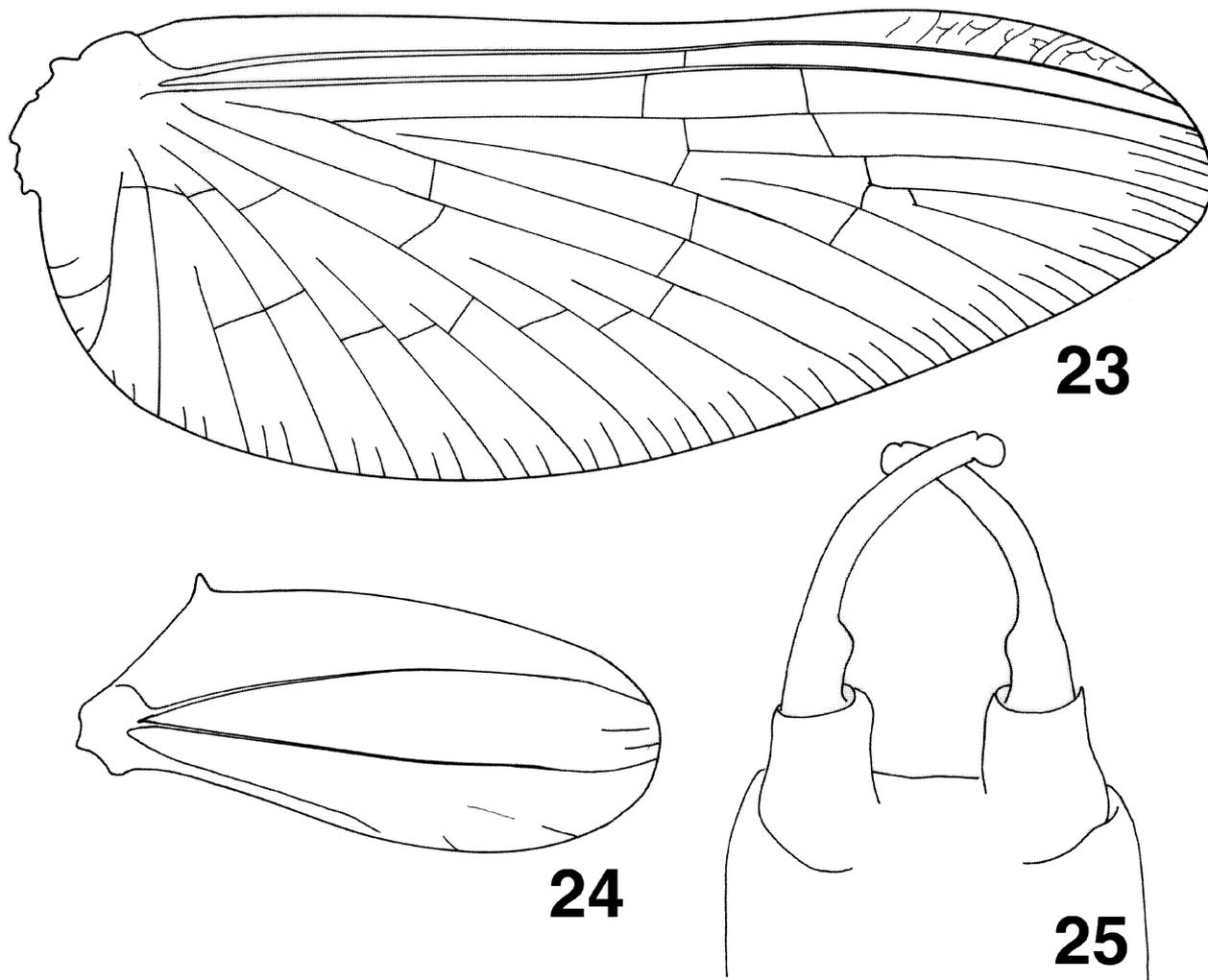
Müller-Liebenau (1969), meaning that they can effectively correspond to most of the species encompassed presently in the subgenus *Rhodobaetis*.

TABLE 1. Morphological characters to distinguish *Baetis rhodani* of the type locality from *B. rhodani* concept proposed by Godunko *et al.* (2004b). Characters are identical to those proposed for the diagnoses of West Palaearctic species of the subgenus *Rhodobaetis* (according to Godunko *et al.* 2004b).

N°	Characters	Baetis rhodani	BRR (coding according to Godunko <i>et al.</i> 2004b)
Larva			
1	Pedicel : shape of scales	Elongated and blunt	Elongated pointed and bluntly pointed apically
2	Scape : shape of scales	Small and wide	Small and wide
3	Labrum : mean width/length ratio	1.55–1.65	1.32
4	Labrum : number of long submarginal setae	1 + 8–10	1 + 7 – 12
5	Maxillary palps : apical part of distal segment	With one pointed scale	With one pointed scale
6	Paraglossae : number of regular row of bristles	3	3
7	Labial palp	Asymmetrical and wide	Slightly asymmetrical and relatively wide
8	External margin of femora : shape of bristles	Long and blunt	Long and bluntly pointed apically
9	Tarsal claw : number of strong teeth	12 – 14	8 – 14
10	Tarsal claw : presence of apical setae	Absent	Absent
11	Surface of terga : shape of scales	Mainly absent. When present wide, triangular and blunt apically	Wide and rounded apically
12	Posterior margin of terga III–VI: presence of triangular spines	Present	Absent
13	Shape of gills III–V	Slightly asymmetrical	Slightly asymmetrical
14	Spines of external margin of gills	Present	Present
15	Paraproct plate : number of marginal teeth	15 – 25	At least 15
16	Paraproct plate : shape of scale (=spatulas)	Elongated, rounded apically	Rounded apically
17	Terminal filament length : relative to cerci length	> 3/4	2/3 – 3/4
Male imago			
18	Turbinate eyes : faceted surface	Orange	Brown to dark brown
19	Shaft of turbinate eyes	Dark orange with a basal brown ring	Yellowish brown with brown rings
20	Coloration of thorax	Medium to dark brown	Dark brown
21	Hindwing : number of veins	3	3
22	Basal segment of forceps	Elongated	Slightly elongated
23	Segment I of forceps	With inner projection apically	With subparallel margins
24	Segment II of forceps : widened part	Almost not widened	2/3 segment length
25	Segment II of forceps : inner margin	Concave	Concave
26	Segment III of forceps	Rounded, as long as broad	Mainly quadrangular or oval

We suggest that any further comparison of populations and specific attribution to *B. rhodani* should be made based on the above description, rather than with those proposed by Müller-Liebenau (1969) or Godunko *et al.* (2004b), in order to avoid further confusion.

The aim of the present study is not to provide a global revision of the species included in *Rhodobaetis*, although such a revision is highly necessary, and must include the careful re-examination of different species that takes into account the present redescription of *B. rhodani*. The status of the different synonyms of *B. rhodani* must be reconsidered again since it seems likely that old, sometimes poorly described species in fact represent valid species.



FIGURES 23–25. Male imaginal structures of *Baetis rhodani*: 23 : forewing. 24 : hindwing. 25 : genitalia.

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