

# TRANSACTIONS OF THE SOCIETY FOR BRITISH ENTOMOLOGY

VOL. 10.

19th October, 1950

PART 3.

## DESCRIPTIONS OF SOME NYMPHS OF THE BRITISH SPECIES OF THE GENUS *BAËTIS* (EPHEM.)\*

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\* The Council of the Society desire to acknowledge, with grateful thanks, receipt of a grant of £10 from the Freshwater Biological Association in aid of the cost of printing this paper.

## I INTRODUCTION

Nine species in the genus *Baëtis* are at present known from Britain. The nymphs of five species have been described, but all the material is from continental Europe and comparative studies between the different species are meagre. It has been deemed desirable, therefore, both to examine and to describe as much British material as possible.

Adult specimens have been named by Mr. D. E. Kimmins whom I wish to thank warmly. I am further indebted to Mr. Kimmins because, during part of the war, he looked after the collections at Wray Castle with the result that the present author was able to take up the work in 1946 at almost exactly the point at which it was laid down in 1941.

In the following pages the nymphs of eight of the nine species are described. *Baëtis buceratus* has not yet been encountered. Up to the present, attention has been devoted exclusively to full-grown nymphs. The descriptions are based primarily on cast nymphal skins. This has the one paramount advantage, that there can be no doubt about the species. It also makes it possible to study the pattern of the body under constant conditions; in life the markings vary according to the age of each instar and in a nearly full-grown nymph they may be modified by the colours of the developing adult beneath. The disadvantages are two: first, it is not possible to be sure that the length of the nymphal skin is the length of the nymph when it was alive and, second, some of the delicate structures such as the palps, may shrivel slightly. The descriptions are, therefore, based to some extent on whole nymphs from the same locality, often those which died, before hatching, in the breeding dishes

## II METHODS OF BREEDING OUT ADULTS FROM NYMPHS

At Wray Castle specimens have been bred out in an apparatus originally devised by Dr. H. B. N. Hynes for the purpose of breeding out Plecoptera. It has been described by Hynes (1941) and figured by Worthington (1939). Parallel series of shallow enamel pie dishes,  $11\frac{1}{4} \times 9 \times 1\frac{3}{4}$  ins., are set one below the other on sloping shelves. Water entering the top of each series from a tap drips from each dish into the one below it. The whole is set up in the cellars of Wray Castle where the temperature is low all through the summer. Each dish is provided with a few small stones for the nymphs to cling to and is covered with a sheet of mosquito netting on a wire frame. Since the dish is tilted there is room in the upper portion for the emerged subimagines between the water surface and the mosquito netting. They are removed twice a day and kept in a glass collecting-tube until the imago emerges.

In 1939 a big collection was made from the River Avon at Fordingbridge and a preliminary note on the findings has been published by T. T. & Z. Macan (1940). No running water was available but it was possible to fetch water direct from the river and the water in the dishes was changed frequently. This technique was successful.

Elsewhere specimens have been obtained by collecting a large number of nymphs, picking out those obviously about to emerge, and then watching till subimagines come forth. Each one can be caged in a tube and kept alive, until the imago emerges, under conditions which would prove fatal to nymphs in a very short time.

### III GENERAL DESCRIPTION OF THE *BAETIS* NYMPH

#### 1. Markings and measurements

Even when quite inexperienced the author was surprisingly successful in sorting a collection of nymphs into different species on general appearance. A fairly detailed examination has, therefore, been made of the markings of the nymphs, particularly the markings on the terga where a distinct pattern is most conspicuous. The finding is that the pattern in any one species is remarkably variable, especially when specimens from widely separated localities are available. The conclusion is that no reliable specific distinctions can be based on markings until a much greater number of specimens coming from all parts of the country has been examined.

The segments of a cast skin may telescope inwards or outwards, so a length measurement may not give a true indication of the size of the living nymph. Nymphs which had been pickled whole appeared to be more expanded than in life. Figures for length in the following pages are, therefore, approximations falling well within the limits of the actual measurements obtained and probably erring on the cautious side. The range of variation is rather large in all species. Measurements of individual leg segments or gills confirm that this size variation is real; such structures may alter their size as a result of preservation but any error from this source is likely to be reasonably constant for all specimens. Length was measured from the front of the head to the tip of the last abdominal segment.

The femora are slightly darker along the upper and under sides, and these darker bands meet in the middle towards the apex of the segment and give rise to a chevron or transverse bar. The tip of each segment is more heavily pigmented than the rest and there may be a complete ring around the apex of the tarsus. Specimens which are heavily pigmented generally, have more definite markings on the legs, but the pattern is never

conspicuous and all the species appear to be basically similar. Neither the actual lengths, nor the relative proportions, of the leg segments have any systematic value.

The caudal appendage and cerci are marked with alternating darker and lighter bands, and the middle band in some species is very dark, and conspicuous to the naked eye. In other species it is not. This appears to be a good point of difference but it is felt that any distinction based on pattern should be regarded with suspicion until much more material has been examined, because the pattern on other parts of the body is so variable. The relative lengths of the caudal appendage and cerci have been ignored. They are easily damaged and it is not always possible to be sure whether or not the extreme tip has been broken off. It is felt, therefore, that any systematic distinction based on this character would have disadvantages from the practical point of view.

The markings and the length of every available specimen were studied. For minute detail requiring dissection and examination under the high power of the compound microscope examples of each species were selected, dissected, and mounted in Canada Balsam. At least ten examples of each species were examined if possible.

## 2. Minute detail

The mouth parts are of the mandibulate type. The labrum is a small quadrangular plate with a notch in the rounded fore-margin. The upper surface of the right half of the labrum of *B. pumilus* is illustrated in fig. 2P. Just inside the front margin there is a row of bristles, inserted close together, apparently two bristles to each insertion. They are finely and closely frayed. At the side the point of insertion is on the margin of the labrum and the bristles here are longer and sparsely feathered. Only one example of each of these two types of bristle is shown in fig. 2P and the rest have been cut off in order not to obscure the bristles lying behind, as these are of more importance in the separation of species. The upper surface is fairly closely beset with bristles, most of which are very fine and difficult to count, though those towards the anterior margin are larger and more conspicuous. In most species (e.g. fig. 2R) there is, in this region, a definite transverse row of noticeably stouter and longer bristles.

On the underside of the labrum there is a mass of long fine curving hairs which appear to delimit a central channel and, near the margin, there is a row of widely spaced robust spines.

The hypopharynx of *B. pumilus* is illustrated in fig. 1H.

The mandibles (fig. 1Md) are robust pyramidal structures, differing in detail one from the other. The effective surface is divided into an inner molar and an outer canine area, and the

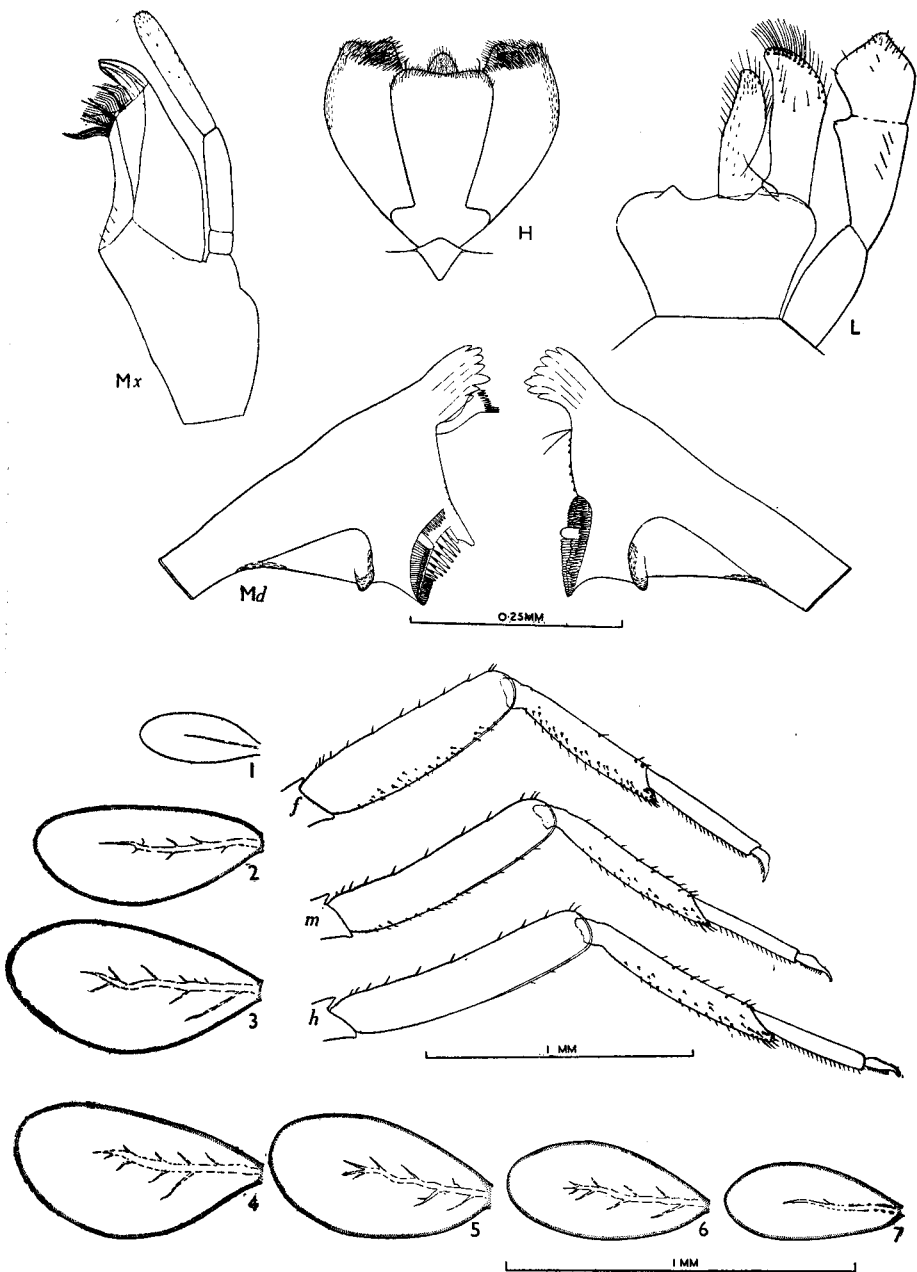


FIG. 1.—*Baëtis pumilus*; Mx, maxilla; H, hypopharynx; L, labium; Md, mandibles; 1—7, gills numbered from the front; f, m, h, fore, mid, and hind legs.

canine area is at the top in fig. 1 Md. In most species it bears 7 teeth, with often a minute extra one interposed between the fourth and fifth, counting from the outside. The shape of the teeth varies in the different species (fig. 4) and this is a good way of telling some of them apart; it must be noted that the canine area is curved, so that the middle teeth in the figures are nearer to the observer than the teeth at either end and the exact appearance will, therefore, vary according to the angle from which the organ is viewed.

Below the canine area there is a small appendage of obscure significance known as the lacinia mobilis, mandibular palp or prosthema; the last of these terms is used in this paper. The prosthema of the left mandible bears on its outer margin a series of teeth of which the upper are short and the lower long; that of the right mandible is a smaller structure, armed at its outer end with a few bristles. In *B. pumilus* (fig. 1 and fig. 4P) it is represented by two long bristles. The prosthema is of high value in distinguishing species.

The galea and lacinia of the maxilla (fig. 1 Mx) are fused. The palp is 3-jointed. It is beset with extremely fine hairs which are numerous at the tip and scattered sparsely over the rest of the organ. In some species the palp extends beyond the tip of the galea-lacinia and in others it only just reaches or does not quite reach this point, but otherwise the maxillae of all the species are similar.

The labium is shown in fig. 1L. Glossae and paraglossae are distinct. The inner margin and the distal part of the outer margin of the glossae are beset with long bristles, and there are minute bristles on the rest of the surface; details of the insertion of these bristles are shown in fig. 2g. The outer margin of the paraglossae is closely beset with long bristles, which are arranged in two (fig. 2p), three, or more rows according to the species. Near the inner margin there is a well-spaced row of 4-7 long bristles, and there may be a few fair-sized bristles near the centre of the organ. The number and arrangement of these bristles is rather irregular and of no value in distinguishing species.

The labial palp has three segments and the inner distal corner of the middle one is produced into a process which varies in size and shape in the different species. The terminal segment, particularly towards its tip, bears numerous fine hairs of various lengths and a number of more robust spines. The spines are quite distinct from the hairs and their number differs in the different species.

The legs consist of femur, tibia, single tarsal segment, and claw. It will be convenient to use the terms upper and lower to refer to the surfaces shown in those positions in fig. 1 f.m.h.

The armature on the under surface of all the segments does not differ significantly in any of the species, though *B. atrebatinus* has a greater number of spines on the claw. In strong contrast, the armature of the upper surface is of the utmost value in the taxonomy of the nymphs and, according to the nature and

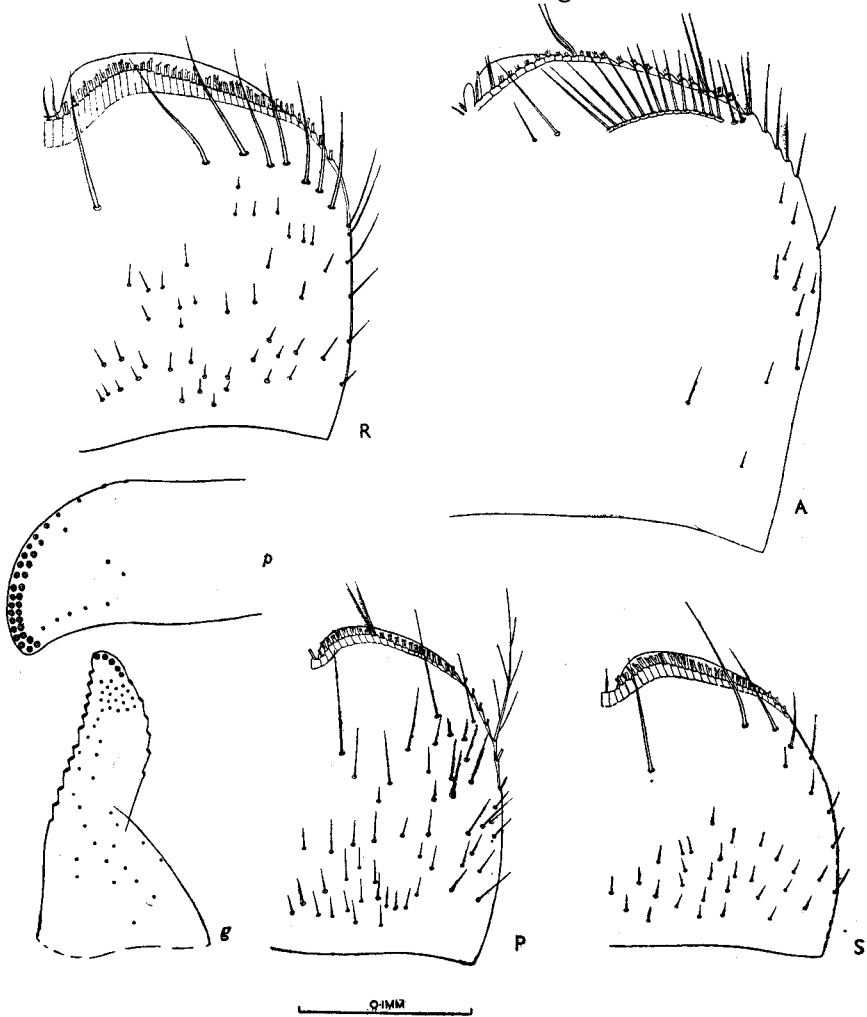


FIG. 2.—R, A, S, P, labrum of *B. rhodani*, *atrebatinus*, *scambus*, and *pumilus*; g, p, glossa and tip of paraglossa of *B. niger*.

arrangement of the spines present, the 8 species examined fall clearly into 4 groups. Along the femur, in addition to fine hairs, there is a row of moderately long spines, usually in a single row except at the base and the apex. These spines vary in shape and in one of the groups they are interspersed with short spines. *B. pumilus* (fig. 1) and *B. niger* are the only species with large spines on the upper surface of any segment but the femur.

The gills are simple lamellae attached to abdominal segments 1-7. A set from a specimen of *B. pumilus* is illustrated in fig. 1. Those of *B. niger* are similar, but on all the other species, except *B. atrebatinus*, the first gill is of about the same size as the last and all are relatively shorter and broader. The margin, except for the basal third or so on either side, is finely denticulate and there is a minute hair between each tooth (fig. 6p).

#### IV COMPARATIVE DESCRIPTIONS OF THE SPECIES

The following descriptions of the species, one by one, include only features by which separation from other species can be effected. Much of the detail is numerical and this has, in general, been omitted from the descriptions and incorporated in table 4 at the end. *B. pumilus* is described more fully than the other species. Such features as the proportions of the leg segments were studied carefully and it was then possible by examining single specimens of other species to find out that they fell within the range of variation of *B. pumilus* and so the character was of no value taxonomically.

#### *BAETIS PUMILUS* (BURM.)

**Previously described** by Gauthier 1935, Verrier 1943, and Landa 1945.

**Material**, 101 nymphal skins, 15 from the River Avon, Hampshire, and the remaining 86 from the Windermere neighbourhood. Of the Lake District specimens 66 were collected in the main rivers flowing into Windermere and 20 were taken in small becks.

**Markings.** The specimen depicted in fig. 3C may be taken as a convenient starting point for a description of the nymphal pattern. To the naked eye such a nymph is very dark brown, almost black, with a distinct white spot near the middle of the body, another at the end of the abdomen and a white line traversing the body from end to end. Under the microscope it is seen that the first and the last two abdominal terga are light coloured and that the central line up the abdomen is due to a triangular white mark distally on each segment.

About a quarter of the specimens conform to this type; the rest show a considerable degree of variation, some having a

greater and others a slighter development of the lightly pigmented areas. A mark resembling a bird's foot is frequently present, surmounting the basal triangle. On 10 specimens it is conspicuous, as shown in fig. 3B, but usually it is quite faint. On 9 specimens this bird's foot mark is the only trace of pale pattern to be detected on abdominal terga 2-8.

Nearly half the total number examined are without any trace of pale markings on abdominal segments 2-8. Some of these specimens have segments 9 and 10 dark also, a few have them both light, and most have them in an intermediate condition, in which either or both segments may be entirely or partly dark. Usually, but not invariably, lack of light pigmentation on segments 2-8 and segments 9 and 10 is found together.

Only 74 specimens had the *cerci* and caudal appendage so complete that the pigmentation could be noted. 54 specimens had the base and the tip slightly darker than the central portion (fig. 3C). This pattern can conveniently be described as DLD and, using the same notation, other variations were LDL 1, DLDL 1, LDLD 6. 11 specimens had the tails uniformly light and in one specimen the tip only was slightly darker than the rest. Thus, there was a considerable range of variation, but, in all the specimens, the contrast between the light and dark areas was slight and none of them exhibited a distinct dark band, conspicuous to the naked eye.

**The lengths** of the nymphs appeared to range from about 5.5 to 8.0 mm. The average size tended to vary according to the locality, and specimens from the Avon were noticeably larger than those from the Lake District.

**Mouthparts.** The *labrum* (fig. 2P) is fairly thickly beset with bristles on the dorsal surface. Those nearer the anterior margin are longer than the rest but they are not noticeably stouter and the distinction between the two is not as great as in some other species. The long bristles near the anterior margin are rather few in number. The outermost tooth on the canine area of the *mandibles* is pointed and set back a little (fig. 4P). The left prosthema has 7-10 long teeth and 3-4 short teeth. Sometimes the teeth are progressively longer down the series and there is no sharp distinction between short teeth and long teeth, such as exists in all the other species except *B. niger*. The right prosthema is reduced to a pair of bristles and this feature immediately distinguishes *B. pumilus* from all the other species examined. The glossa and tip of the paraglossa of the *labium* are depicted on fig. 2g and p, where, for the sake of simplicity, only the points of insertion of the bristles are shown. A detailed examination of the arrangement of the bristles on these structures was made both for *B. pumilus* and *B. niger* and the results are given in table 1.

TABLE I  
Trichiation of the labium of *B. pumilus* and *B. niger*

Number of bristles situated:

Species	Number of specimens examined	Number of bristles situated:			
		along the inner margin of the glossa, including the apical bristle	along the outer margin of the glossa, excluding the apical bristle	in the outer row along the upper and outer edge of the paraglossa	parallel with the inner margin of the paraglossa in the middle of the paraglossa
<i>pumilus</i>	11	9-13	6-10	11-16	3-5
<i>niger</i>	13	11-17	9-12	17-22	4-6

Only along the outer margin of the paraglossa is there a clear difference and, as it is a difference of but one and the total number of specimens examined is not large, no systematic significance can be attached to these figures.

The terminal segment of the palp is beset with conspicuous bristles and with fine hairs which are difficult to make out. The number of hairs which can be discerned is likely to vary according to the quality of the lenses of the observer's microscope and they may be ignored, but the difference in the number of bristles appears to be noteworthy. In *B. pumilus* (fig. 4p) there are about 20 or fewer and they are confined to the distal half of the segment; in *B. niger* there is at least twice this number and the bristles occur all over the terminal segment of the palp.

**The legs** are illustrated in fig. 1. Along the upper surface of the femur there is a fairly straight row of relatively few stout sharp spines. Similar spines occur on the tibia and this feature immediately distinguishes *B. pumilus* from all other species except *B. niger*.

The hind leg is the longest in all the specimens measured; the mid and fore legs are usually of the same length though either may be a little longer than the other. Measurements of the femora are: fore-leg, 0.78-1.12 mm.; mid-leg, 0.82-1.10 mm.; hind-leg, 0.91-1.27 mm. The ratios of the leg-segments vary considerably and the range of the ratio tarsus : tibia : femur is: fore-leg, 1 : 1.32-1.84 : 1.63-2.22; mid-leg, 1 : 72-1.89 : 1.92-2.10; hind-leg, 1 : 1.71-1.93 : 2.0-2.63. The hind femora are always longer than the middle and fore femora, which are usually equal in length. The hind tibiae are always the longest and the middle tibiae are usually longer than the fore tibiae. The fore tarsi are usually the longest and the hind tarsi are usually longer than the mid tarsi.

**Gills.** The measurements of the gills shown in fig. 1 are: 0.34, 0.65, 0.72, 0.71, 0.63, 0.57, 0.50 mm.

Of the other species, only *B. niger* and *B. atrebatinus* have the first gill distinctly smaller than the last.

**Habitat notes.** The records suggest that this species is to be found in almost any running water.

#### *BAETIS NIGER* (LINN.)

**Previously described** by Lestage 1919, who, under the name *Baëtis ? niger* gives a description differing in several main points from that below. His adults and nymphs were not associated directly by breeding out.

**Material,** 49 nymphal skins and 50 whole nymphs; 31 skins and 38 nymphs were from Hampshire and the rest from the vice-county WL.

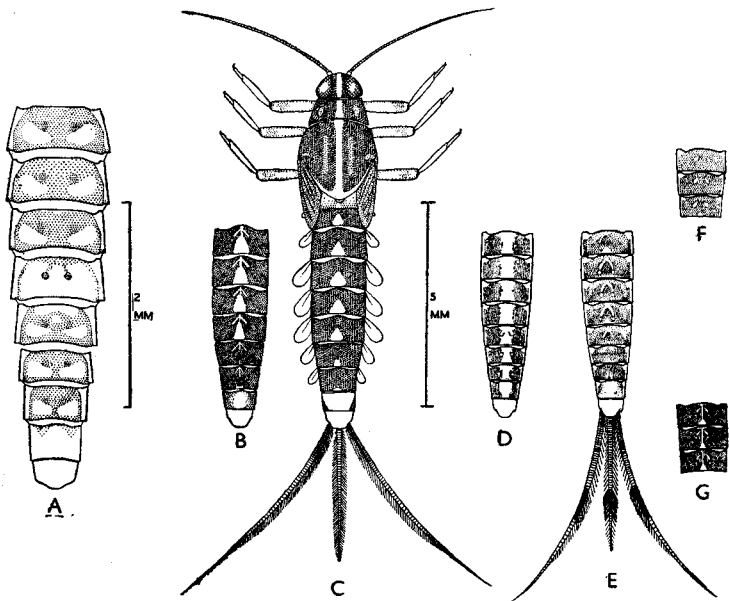


FIG. 3.—Dorsal abdominal patterns of A, *B. scambus*, R. Rothay, WL; B, C, *pumilus*, R. Avon, SH; D—G, *niger*, D, R. Winster, WL, E, Ober Water, SH, F, R. Avon, SH, G, Cunsey Beck, WL.

**Markings.** In general the nymphs are less heavily pigmented than those of *B. pumilus*, though occasional specimens are as dark as any example of this latter species. Fig. 3G depicts a pattern which, though not typical, offers a convenient starting point for a description of the markings on the abdominal terga. Sharply contrasting with a dark background is a light pattern consisting of a basal triangle with a median line proceeding from its apex, and two lateral projections which, with this median line, make the shape of an umbrella in cross-section. There are also two dots which, to continue the analogy, have the position of rain drops falling from the umbrella. Fig. 3D represents a development of this design, in which, although the contrast remains marked, the light area has increased and obliterated the pattern except for the tips of the umbrella and the rain drops.

Most specimens lack this clear distinction between light pattern and dark background and the condition is illustrated in fig. 3E. Frequently the light pattern is even more reduced and nothing remains except two pear-shaped dots representing all

that is left of the umbrella (fig. 3F). Even this remnant is not detectable on some specimens, which are uniformly pigmented.

Although the patterns illustrated are but stages in a continuous series, yet it is possible to assign each specimen to one of them and the numbers falling into each category are shown in Table 2. Nymphal skins only are included. The numbers are divided in such a way as to bring out the fact that the dark specimens with conspicuous pattern are nearly all from non-calcareous localities, whether these be in the New Forest or on the Lake District slates, and that the lighter specimens with ill-defined pattern or no pattern are mainly from calcareous localities. The northern specimens as a whole tend to have more pattern than the southern specimens.

TABLE 2

Number of specimens of *B. niger* belonging to different pattern types

Pattern type as in:	fig. 3G	fig. 3D	fig. 3E	fig. 3F	no pattern
No. of specimens from non-calcareous localities ...	5	2	1	6	3
No. of specimens from calcareous localities ...	1	—	8	16	7
Total ... ..	6	2	9	22	10

The condition of the last two terga shown in fig. 3E is unusual. Commonly the white area of segment 9 is confined to a narrow central band and is ill-marked, and the white area of segment 10 too, though wider and more conspicuous, is usually confined to the centre of the segment.

Thus the markings on the abdomen of *B. niger*, though similar to those of *B. pumilus*, are not identical; but unfortunately they vary so much that they cannot be used to distinguish the species.

The tails are somewhat dark at the base and then get lighter; near the middle there is a distinct black area; beyond, the tails are light again; then there may be a second dark band less obvious than the first; and the tip is usually lighter again, though the pigmentation is often difficult to make out. The tails of one specimen were heavily pigmented from the base to a point near the middle; those of all the rest, though not agreeing in every detail with the description just given, had the pronounced dark band near the centre. This dark band is immediately obvious to the naked eye; no such band was seen on any specimen of *B. pumilus*.

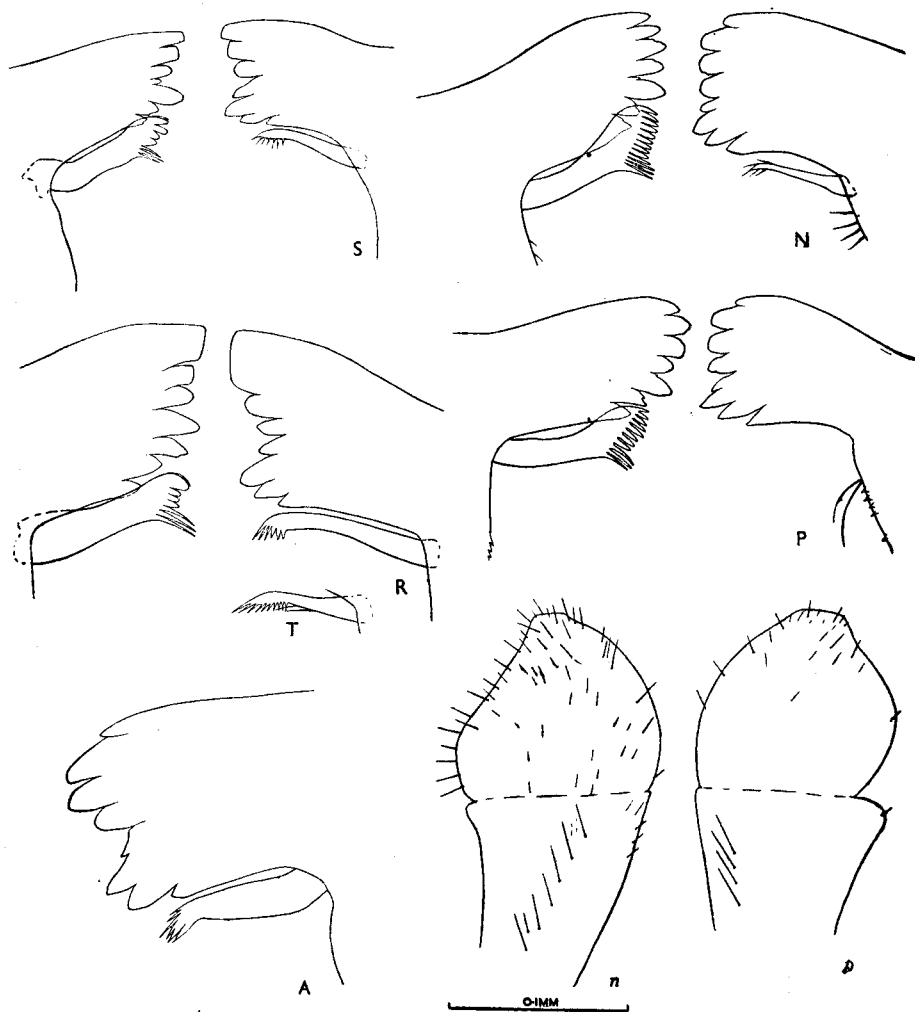


FIG. 4.—S, N, P, R, A, canine area of mandibles of *B. scambus*, *niger*, *pumilus*, *rhodani* and *atrebatinus*; T, right prostheca of *tenax*, n, p, tip of labial palp of *niger* and *pumilus*.

**Lengths**, from about 5.5 to about 8.5 mm. Specimens from the River Avon were larger than those from the New Forest and WL.

**Mouthparts, legs and gills.** *B. niger* resembles *B. pumilus* very closely. The mean number of bristles or hairs on certain parts is different but the ranges overlap; details are given under the preceding species and in Table 4. The armature of the terminal segment of the labial palp of the two species (fig. 4 n and p) is distinct but the most satisfactory difference between them is the left prosthema. That of *B. niger* is as in other species (fig. 4N) and that of *B. pumilus* is reduced to two bristles (fig. 4P).

**Habitat notes.** This species was found in calcareous and non-calcareous streams in both the north and the south of England. It was very abundant in the River Avon and it appears to be a species inhabiting weed-beds.

#### BAETIS SCAMBUS EATON

**Material**, 33 nymphal skins and 58 whole nymphs, derived in roughly equal proportions from the River Rothay, WL and the Troutbeck, WL.

**Markings.** On abdominal segments 2-8 inclusive there is a central darker arch-shaped area and, within this, there is a large oval pale area towards each side. A median white dot, such as is shown on segment 6 in fig. 3A, is frequently present on all the other segments as well. Above this dot there may be a trace of a mark shaped like a bird's foot. Near the middle of the segment on either side of the median line are two small patches where the pigmentation is somewhat darker. The light areas of segment 5 are larger than on any other segment, they are fused together, and they encroach over nearly the whole of the dark part. Segments 6, 7 and 8 are usually a little more heavily pigmented than segments 2, 3 and 4. Segments 1, 9 and 10 are light, with never more than a trace of dark pigmentation.

On one specimen the three white patches are fused together on segment 2. On about 12 specimens the contrast between the dark arch-shaped area and the lighter patches on it is not great and, on some of them, segments 6, 7 and 8 appear uniformly pigmented, except at the edges which are always lighter.

The extensive light area on segment 5 is a remarkably constant character and was a conspicuous feature on all the specimens examined. The variation of the abdominal pattern is slight, in comparison with that of *B. pumilus* and *B. niger*, possibly because the specimens come from fewer habitats. To the naked eye the specimens are light with a yellow-greyish tint, and the pale segment 5 gives a characteristic appearance.

The base of the tails is lightly pigmented, then, near the middle is a rather narrow but distinct black area which gives the tails an obvious banded appearance to the naked eye. Beyond this is a light zone and the tip is darker again.

**Lengths.** This is one of the smallest species, the nymphs being some 5-6 mm. long.

**Mouthparts.** The long bristles near the anterior margin of the *labrum* (fig. 2S) are more clearly differentiated from those behind than on the preceding species. They are about three in number. The *mandibles* (fig. 4S) differ from those of *B. pumilus* and *B. niger* in two respects. First, the outermost tooth, which is truncate not pointed, projects as far as or even a little beyond the other teeth and is not set back. Second, the prostheca has fewer teeth; 8 out of 12 specimens examined had 4 short and 3 long (4 + 3), 2 had 4 + 2, and 2 had 5 + 3.

The *maxillae* differ from those of the preceding species in that the palp does not reach beyond the lacinia-galea and may be a little shorter. The *labium* does not differ significantly from that of *B. pumilus* and *B. niger*.

**The leg** armature is characteristic and by it the species may be distinguished from all except *B. bioculatus*. The long spines on the upper surface of the femora are clavate (fig. 6s) and not pointed, they are confined to the femora and there are no short spines between them.

**Gills.** A typical set of gills from a specimen 5.7 mm. long measured 0.24, 0.46, 0.53, 0.51, 0.49, 0.39, 0.28 mm. They are less elongate than those of *B. pumilus* (fig. 1).

**Habitat notes.** All the specimens are from two of the tributaries of Windermere. Both are relatively large and both are characterised by an unstable bottom of round stones without any growth of moss on them.

#### *BAETIS BIOCULATUS* (LINN.)

**Previously described** by Landa, 1945.

**Material,** 13 specimens, comprising 6 skins and 7 nymphs, all from Hampshire; 3 came from Ober Water, a small stream in the New Forest and the rest were taken in the River Avon.

**Markings.** The pattern of the abdominal terga is similar to that of *B. scambus*. Contrast, however, is usually not great and a distinct light gap at segment 5, visible to the naked eye, is not conspicuous. The bird's foot mark near the anterior margin, absent or obscure on all the specimens of *B. scambus* seen, is often rather clearly developed.

**Lengths.** The specimens from Ober Water are of about the same size as *B. scambus* but those from the Avon are a little larger, about 7 mm. long.

In all **other characters** *B. bioculatus* resembles *B. scambus* very closely and the only difference which has been discovered is in the number of spines on the last segment of the labial palp. 19 palps on 11 specimens of *B. scambus* and 13 palps on 9 specimens of *B. bioculatus* have been examined, and the number of spines ranged in *B. scambus* from 18-26 and in *B. bioculatus* from 30-34. Fine hairs on the palps have not been counted; the distinction between them and the relatively robust pointed spines is quite clear. Landa (1945) finds that this species has spines on the gills, similar to those of *B. rhodani*.

**Habitat notes.** 9 out of the 10 specimens from the Avon came from stretches where the current was swift, for that river, and the bottom consisted of small rounded stones.

#### *BAETIS RHODANI* (PICT.)

**Previously described** by Lestage 1917, and Landa 1945.

**Material,** 43 nymphal skins and 35 whole nymphs. 3 skins and 8 nymphs were from the River Avon and streams in the neighbourhood, and the rest were from 10 localities in the Lake District.

**Markings.** A specimen with the pattern more clearly developed and the contrast between light and dark areas greater than in most is illustrated in fig. 5. Segments 2 to 8 inclusive are dark, except at the sides, and within this central darker area there are two lighter oval areas situated laterally. On segments 2 to 6 inclusive there is an obscure pale mark shaped like a bird's foot in the centre near the anterior margin.

In most specimens the markings are less clear; some trace, at least, of the pattern just described is to be made out on segments 2 to 5, but segments 6 to 8 are uniformly dark except at the sides and segments 9 and 10 are dark more often than not. In all the Avon and three of the Lake District specimens no pattern can be made out at all and the segments are uniformly dark, except at the sides.

In three specimens, on the other hand, the pattern is more developed than that illustrated in fig. 5. On segment 5 the three light areas are in contact proximally as well as distally so that there are two dark islands instead of two dark peninsulas as in fig. 5. Two other specimens resemble the figure but on them the bird's foot mark is more strongly developed and contrasted, and it resembles that seen in *B. pumilus* and illustrated in fig. 3B. Sometimes darker dots, similar to those of *B. scambus* (fig. 3A), can be detected.

When it is present and contrasted, the pattern is of the same type as that of *B. scambus*, but it is not identical, the

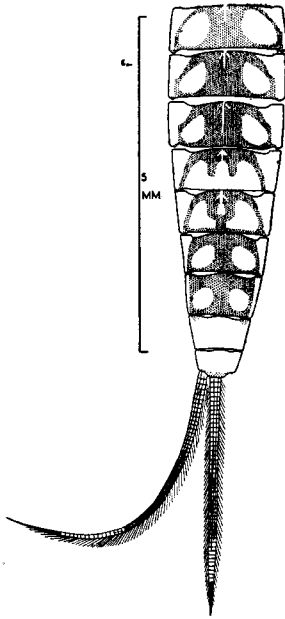


FIG. 5.—Dorsal abdominal pattern on segments 2—10 of *B. rhodani* from Stock Ghyll, WL.

most important difference being that the long axis of the pale oval marks lies in a different direction in the two species.

The tails are lightly pigmented at the base and then become slightly darker. Just beyond the middle of the outer cerci there is an area devoid of pigment and then the tips are quite dark. This arrangement was constant throughout the range of specimens examined. There were variations in the intensity of pigmentation but a distinct black band, obvious to the naked eye, was never present.

**Lengths.** This species is remarkably variable in size; some specimens are quite small, only about 7 mm. long, but others, ranging up to 11 mm., are larger than any other specimens in the genus.

**Mouthparts.** The *labrum* is shown in fig. 2R. The long bristles near the anterior margin are more numerous than in *B. scambus*; the usual number is 7, but as many as 12 and as few as 5 have been observed. The *mandibles* do not differ greatly from those of the two preceding, but the outermost tooth is larger (fig. 4R). The *maxillae* are similar to those

of *B. scambus* and *B. bioculatus*. The *labium* differs in that the bristles along the outer margin of the paraglossa are arranged in three rows and not in two as in all four preceding species (cf. fig. 2p).

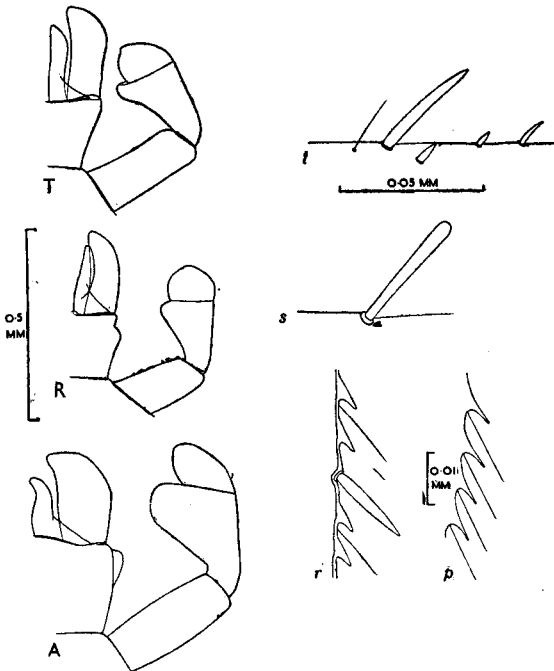


FIG. 6.—T, R, A, labium of *B. tenax*, *rhodani* and *atrebatinus*; t, s, spines on the upper margin of the femur of *tenax* and *scambus*; r, p, portion of the gill margin of *rhodani* and *pumilus*.

**Legs.** The armature is of a third and equally distinct type. Long spines are confined to the femora, as in *B. scambus* and *B. bioculatus*, but they are mostly pointed not clavate. They are also more numerous (see table 4). The most conspicuous difference, however, is that in *B. rhodani* there are numerous shorter spines between the long ones (cf. fig. 6t). These short spines and fine hairs occur also on the tibiae and the tarsi.

**Gills.** The margins of the gills are denticulate and fringed with hairs, though the teeth are a little smaller than in other species. In addition, spines occur at intervals along the margin of the gill (fig. 6r), and in this character *B. rhodani* is unique among the species so far examined. There are about

6 spines on the smallest gills, the number increases on successive gills, and reaches about 20 on the largest, though these figures may be exceeded on particularly big specimens.

The size of the gills is discussed under *B. tenax*.

**Habitat notes.** All but one of the specimens from the River Avon were taken in moss on weir walls and the impression gained in the Lake District is that this species inhabits more swiftly flowing places than others.

#### BAETIS TENAX EATON

**Material,** 18 nymphal skins and 2 nymphs from the Hampshire Avon and its tributaries; 4 nymphal skins and 6 nymphs from Cressbrookdale in Derbyshire.

**Markings.** The specimens from the Avon are characterised by a pale colour and almost complete absence of detectable pattern. On the abdominal terga there is a trace of the dark arch-shaped central area, similar to that seen in *B. rhodani*, and within this there may be very faint lighter patches forming a pattern similar to that of *B. rhodani* (cf. fig. 5), but in some specimens no such lighter patches can be made out. Sometimes the median proximal bird's foot mark, and sometimes the lateral oval areas are the more conspicuous. The last two or three segments are usually a little darker than the rest.

The specimens from Cressbrookdale are darker and marked more clearly. The pattern resembles that of *B. rhodani*, but on all the ten specimens the fusion of the pale areas within the darker arch on segment 5 is extensive and causes a light dot visible to the naked eye as in *B. scambus*. The distal half of tergum 9 and the whole of tergum 10 is paler than the other terga.

In both series the cerci have a distinct black tip but, otherwise, are uniformly pale, except occasionally for a faint darkening in the middle in the same position as the more definite darkening of *B. rhodani*.

**Lengths.** This is a moderate-sized species, the nymphs being some 7 to 9.5 mm. long.

**Mouthparts.** The *labrum* resembles that of *B. rhodani*, but the long bristles near the anterior margin tend to be less robust and do not extend so far towards the middle line, but the difference is not sufficient to give a clear cut distinction between the two species.

The other mouthparts are similar except that the hair-bearing area of the right prosthema is a little longer in *B. tenax* (fig. 4T), and this species also has a larger process of the labial palp (cf. figs. 6T and R).

**Legs.** The leg armature is identical with that of *B. rhodani*.

TABLE 3. Gill lengths of *B. rhodani* and *B. tenax*

Species	No. of sets measured	Gill lengths, mm.										Ratios								Length of specimen	Remarks
<i>B. rhodani</i>	30	0.28	0.55	0.66	0.64	0.54	0.45	0.28	1	1.96	2.35	2.28	1.92	1.60	1	6.5 mm.	The smallest set and the greatest difference between largest and smallest gill. The largest set. Least difference between largest and smallest gill.				
		0.66	1.04	1.27	1.26	1.09	0.90	0.68	—	—	—	—	—	—	—	11.8 mm.					
<i>B. tenax</i> Cressbrookdale	5	0.59	0.88	1.02	1.00	0.91	0.73	0.55	1	1.47	1.73	1.69	1.54	1.23	0.93	10.2 mm.	Least difference between largest and smallest gill.				
		0.39	0.62	0.77	0.79	0.72	0.58	0.40	1	1.59	1.97	2.02	1.84	1.48	1.02	8.0 mm.					
<i>B. tenax</i> R. Avon, etc.	10	0.52	0.79	0.93	0.91	0.86	0.73	0.53	1	1.52	1.79	1.75	1.65	1.40	1.01	8.8 mm.	Greatest difference between largest and smallest gill. Largest set. Smallest set. Least difference between largest and smallest gill.				
		0.64	0.95	1.06	1.08	0.99	0.79	0.59	—	—	—	—	—	—	—	9.3 mm.					
		0.45	0.66	0.77	0.77	0.68	0.61	0.46	—	—	—	—	—	—	—	7.2 mm.					
		0.65	0.84	0.93	0.93	0.89	0.73	0.61	1	1.29	1.43	1.43	1.37	1.12	0.93	9.4 mm.					

**Gills.** Table 3 sets out some details of the gill sizes of *B. rhodani* and *B. tenax*. The Avon specimens of *B. tenax* tend to have gills in which the difference in size between the smallest and the largest is less than in *B. rhodani*, though the ratios just overlap. The Cressbrookdale specimens of *B. tenax* are intermediate in this character which is clearly quite valueless for systematic purposes. But the gills of *B. tenax* lack spines and the two species are readily distinguished on this character.

**Habitat notes.** This species was taken in the Avon itself and also in tributaries flowing off the lime-deficient soil of the New Forest. Cressbrookdale is a stony stream emerging at the end of a typical dry limestone valley. Kimmins (1942) records it in the Lake District.

#### BAETIS VERNUS CURT.

**Previously described** by Lestage 1919, Verrier 1944 and Ulmer 1943. Lestage, with a qualifying query, describes a species with a very short middle tail and it seems probable that his material was misnamed.

A large collection of nymphs was made from Bottisham Lode, Cambridgeshire, in May, 1940. Only 5 adults were obtained. It appeared likely that all the nymphs belonged to this species and a number of them have been examined, in order to gain a wide view of the characteristics of the species.

*B. vernus* is indistinguishable from *B. tenax*.

Bottisham Lode is a sluggish canal-like fenland waterway.

#### BAETIS ATREBATINUS EATON

**Material,** 3 nymphal skins and 3 nymphs, all from the River Avon.

**Markings.** The terga and the tails are light in colour with little pattern and the general appearance is like that of *B. tenax* or *B. vernus*. There is a darker central arch on the terga and, within it, on four specimens, there are paired dots near the median line; they are like the dots shown in fig. 3F but they lie near the middle of the segment and not near the anterior margin. On the other two specimens the central arch is uniformly dark.

**Lengths.** This is a medium-sized species, 8.0-9.0 mm. long.

**Mouthparts.** The *labrum* (fig. 2A) is larger than that of other species and the armature is strikingly different. The foremost row of bristles, except near the extreme centre, is set on the anterior margin and not just behind it, as in the other species. They are not frayed or feathered. Most of them have been omitted from fig. 2A, as in the other figures, and only the bases are shown. On the rest of the *labrum* there are

hardly any bristles, except for a row a little distance behind the anterior margin. In other species the bristles of this row are well separated and not very regularly aligned; in *B. atrebatinus* they are more numerous, 15 to 20 being the total, and inserted in a close-set row.

There are usually 8 teeth on the canine area of each mandible (fig. 4A). The outermost is small and set back as in *B. pumilus* and *B. niger*. The left prosthema has 4 short and 4-6 long teeth; the right prosthema is fairly robust and terminates in a series of deep irregular denticulations. The labium is more convex than that of any other species, and the shapes and proportions of the various parts provide a criterion by which this can be distinguished at once from all the other species examined (fig. 6A). The glossa is small, the paraglossa short and broad, and the projection of the penultimate joint of the palp is large and broader than the whole terminal joint, which is small. The inner margin of the glossa is somewhat rounded and beset with rather short bristles. They are irregular in arrangement and it is not possible to make out a definite marginal row. Along the outer edge there are 6-8 long bristles. The bristles of the outer margin of the paraglossa are set close together, are rather smaller than those of the other species, and are beset with fine teeth along the inner edge. There appear to be 4 rows but the arrangement is not as regular as in the rest of the species.

**Legs.** The upper surface of the femora bears spines similar in size and shape to those of *B. pumilus* and *B. niger*, though they do not extend to the tibiae. In two features the legs differ from those of all the species so far examined. First, the number of spines in the tuft at the tip of the femora is usually a little greater than the number on the rest of the femora; in other species there are no more than 2-5 spines in this tuft. Second, the number of teeth on the claws is about 20; in other species it lies between 10 and 16.

**Gills.** The measurements of the only complete set of gills were:

0.44 0.93 1.02 1.05 1.03 0.91 0.72 mm.

There were, however, sufficient gills on two of the other specimens to warrant the statement that a first gill smaller than all the others is characteristic.

**Habitat notes.** All six specimens were taken in weeds in the mill pond at East Mill, near Fordingbridge on the River Avon.

## V. SUMMARY

Table 4 summarizes the points of difference between the various species and also gives details of the number of bristles

on various parts of the body, whether these be of systematic importance or not. Since the tale of species is not complete, it would be premature to construct a key, but a resumé of the differences may be given. The species fall into four groups and the distinction may be based most easily on the armature of the upper surface of the legs:

1. femora with long pointed spines, the number in the apical tuft about the same as the number along the shaft; no long spines on the tibiae; resembling group 2 in the other features mentioned ..... *atrebatinus*.
2. femora with long pointed spines, but the number in the apical tuft smaller than the number along the shaft; long spines on the tibiae; mandible with outermost tooth pointed and set back; maxillary palp extending beyond tip of galea-lacinia; first gill smaller than all the others.....*pumilus* and *niger*.
3. femora with long clavate spines; no long spines on the tibiae; mandible with the outermost tooth truncate and not set back; maxillary palp not extending beyond the tip of the galea-lacinia; first and last gills about the same size; bristles on the outer margin of the paraglossae in two rows.....*scambus* and *bioculatus*.
4. femora with long pointed or clavate spines and also short pointed spines; no long spines on the tibiae; mandibles, maxillae and gills as in group 3; bristles on the outer margin of the paraglossae in three rows  
*rhodani*, *vernus* and *tenax*.

*B. atrebatinus*, in group 1, is alone and is very distinct from all the rest, other characteristic features being the shape of the various parts of the labium, the bristles of the paraglossae in four not very regular rows, the close set line of large bristles near the anterior margin of the labrum and the greater number of teeth on the claws.

In group 2 *B. pumilus* is separated from *B. niger* by only one really good character, but this character, the right prosethca represented by two bristles, serves to distinguish it from all the other species examined.

In group 3 *B. scambus* and *B. bioculatus* are identical except for one not very good character, the number of spines on the labial palp.

In group 4 no difference has been found between *B. tenax* and *B. vernus*. *B. rhodani* may be told from these two, and also from all the other species, by the spines along the margin of the gills.

Differences in the markings also exist, but the pattern is variable, and no conclusion can be drawn about its reliability

or otherwise for distinguishing species, until much more material has been examined.

#### ADDENDUM

Since the above was written, three years ago, the author and his assistant, Miss Jean Hampshire, have identified a large number of nymphs from the Lake District, and this practical experience seems worth putting on record.

*Baëtis pumilus* and *B. rhodani* are the two most common species. The dark uniform back of *B. pumilus*, with never more ornamentation than a lighter central line, contrasts immediately with the lighter variegated back of *B. rhodani*. The latter also tends to have a light-coloured ventral surface. Moreover *B. rhodani* tapers from the thorax to the tip of the abdomen more strongly than *B. pumilus*, and therefore the outline provides a good distinction which was overlooked originally. The contrast between the narrow, rather symmetrical gills of *B. pumilus* and *B. niger*, and the broader, less symmetrical gills of the other species has not been stressed enough in the descriptions above.

The unique features of *B. rhodani* and *B. pumilus*, that is, the spines on the gills and the two-haired right prostheca respectively, are clear on specimens less than 3 mm. long.

Fewer specimens of *B. scambus* and *B. niger* have been seen. Microscopic examination has confirmed in every instance the identity of species separated on markings by the naked eye.

The length of the maxillary palp relative to the galea-lacinia is probably not as constant a character as the above descriptions suggest.

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