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THE MAYFLY FAMILY BAETISCIDAE (EPHEMEROPTERA). PART I

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ABSTRACT

The history of the taxonomy and phylogeny of *Baetisca*, the single genus in the family Baetiscidae, is reviewed beginning with the description of *Prosopistoma* as a crustacean. The relationship of the Prosopistomatidae to the Baetiscidae is treated as well as the concurrence of the authors with Edmunds' conclusion that the two families are derived from a common ancestor but parallel evolution must explain some of their similarities. There is a summary of presently recognized species and characteristics by which nymphs are differentiated. A brief treatment of the ecology and life history of various species is included.

INTRODUCTION

If Latreille had had nymphal specimens of *Baetisca* in 1833, would he have been as puzzled by them as he was by *Prosopistoma* when he described these curious nymphs as a new genus of crustacean? Certainly, *Baetisca* nymphs are sufficiently different from other Ephemeroptera to cause one to conclude that he might have done so. The superficial similarities of the mesonotal shields and the gills were enough to lead early entomologists to the misconception that the two are very closely related. Only in recent years, through

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modern phylogenetic studies of all stages, has it been recognized that there are significant differences between them.

Say (1839) described a new species of *Baetisca*, which he called *obesa*, because of its short, robust body. Next, Walker (1853) characterized *Baetis obesa* both in Latin and English. Hagen (1861) also briefly redescribed the subimago following Say's earlier descriptions, and the species was recognized by Walsh (1862) as being a member of his new genus *Baetisca* after he secured male imagos. In 1863, he remarked (p. 178) "*B. obesa* Say, Walsh. Both genus and species new to me; very curious." Say's description was based on the subimago. Walsh (1864), after four years, successfully reared adults from the nymph and was then able to relate the two stages. He had sent a specimen of the nymph to Hagen, who wrote to Walsh "The larva No. 66 is the most extraordinary animal I have seen, so that I asked myself whether it really belonged to Insecta." After careful analysis he concluded that it was an insect assigned to the "Ephemera." Even more surprising, he was able to relate the nymph to an adult *Baetisca obesa* which Walsh had sent to him earlier. Walsh (1864), with Hagen's confirmation in hand, gave an excellent description of the nymph and discussed his observations of its habitat and emergence.

Eaton (1871), in his *A Monograph on the Ephemerae*, redescribed the genus and the single, known species, *B. obesa* in Latin. He illustrated the forewing (pl. II, Fig. 6) and the male genitalia (pl. V, Fig. 9), both rather poorly.

Provancher (1876) reported a species from Quebec as *Clève unicolor* Hagen, but in 1877 decided that his specimens represented a new species, which he named *Clève rubescens*, nov. sp. Subsequently, McDunnough (1921), after studying Provancher's male specimen, assigned it to *Baetisca* making *rubescens* the second species to be included in the genus.

Joly (1880) published a French translation of Walsh's (1864) description of *Baetisca* and added comments in footnotes. Here he compared features of *Baetisca* with those of *Prosopistoma punctifrons* (= *P. foliacium* Fourcroy) and *P. variegatum* Latrielle. Vayssière, (1882) in his very comprehensive paper on Ephemeroptera, reported that he saw analogies between *Prosopistoma* and *Baetisca* nymphs in their respiratory apparatus and he discussed their morphology at length as well as providing excellent illustrations. He concluded that *Baetisca* is to North America what *Prosopistoma* is to Europe and Madagascar.

Eaton (1885) described and illustrated both adult and nymphal stages of *Baetisca*. Subsequently, Needham (1905) reported that *B. obesa* had been taken in New York State and in Indiana and he included photographs of the nymph and subimaginal wings. Ulmer

(1920) merely listed the family Baetiscidae with only a single genus, *Baetisca*, included in it. The next reports of the genus were those of Clemens (1913, 1915) in his study of mayflies of the Georgian Bay area of Lake Huron.

Traver (1931) added two new species of *Baetisca*, *carolina* and the enigmatic *callosa* from North Carolina and West Virginia, respectively. Soon afterwards, McDunnough (1932) reported two additional species, *B. laurentina* and *B. lacustris*, from Canada, and also provided a key to the known nymphs. Traver again reported in 1932 on *B. carolina* in North Carolina and in 1937 she described *B. thomsenae* from that State. The latter species was synonymized with *B. carolina* by Berner (1955).

The classic work by Needham, Traver, and Hsu (1935), *The Biology of Mayflies*, gave a comprehensive summary of the taxonomic knowledge of *Baetisca*. Neave (1934) described *B. bajkovi* from Manitoba and Spieth (1933, p. 359) concluded that "*Baetisca* seems a distinct entity in the phylogenetic arrangement of mayflies." He erected the superfamily Baetiscoidea to accommodate the family.

Baetisca rogersi was described from northwestern Florida by Berner (1940) and further details were added by him in 1950. He summarized the knowledge of the southeastern species of the genus in 1955 and described two new ones at that time, *B. escam-biensis* and *B. gibbera*. Burks treated the Illinois species in 1953, and in 1962 the late Justin Leonard and his wife Fannie did the same for Michigan. Daggy (1945) reported that the genus occurs in Minnesota.

Following World War II, with the great upsurge of interest in aquatic insects, *Baetisca* was frequently encountered in stream studies and reports of its occurrence grew. In 1959, Berner summarized our knowledge of the genus to that date in tabular form. Until Edmunds' (1960) report no species was known positively to occur in western North America and in that paper he described *Baetisca columbiana*, a species not subsequently reported. Schneider and Berner (1963) described another Florida species, *B. becki*, from the northwestern part of the State. Later, Pescador and Peters (1971) described the imago of *becki* reared from the nymphal stage. The most recently described species, *B. berneri*, is that of Tarter and Kirchner (1978) from West Virginia. The latest treatment of *Baetisca* was given by Edmunds, Jensen, and Berner (1976) in their book on North and Central American mayflies.

PHYLOGENETIC RELATIONSHIPS OF THE BAETISCIDAE

Few papers have been published dealing with the relationships of Baetiscidae and Prosoptomatidae. In 1917, Lameere included

two subfamilies in his Prosopistomidae, Hexagenitinae, which is composed of the fossil genus *Hexagenites*, and Prosopistominae, divided into two tribes, the Baetiscini and Prosopistomini.

In a discussion of the systematic position of *Prosopistoma*, Gillies (1954) concluded that both *Baetisca* and *Prosopistoma* are derived from a common stock of great antiquity, but since then evolution and specialization have proceeded independently. His conclusion was based on the nymphs having many structural features in common, notably a mesonotal carapace, branchial chamber, and cephalization of the central nervous system, and the adults having the similarly unique arrangement of the cubital veins of the wings.

Fontaine (1958), studying the affinities of *Prosopistoma*, noted the nymphal similarities with *Baetisca*. She proposed two causes that might result in the similarities: (1) *Prosopistoma* and *Baetisca* possess true systematic affinities and come from the same ancestor and (2) *Prosopistoma* and *Baetisca* are two evolved genera--*Prosopistoma* having the higher degree of evolution (the mesonotal shield forming a true respiratory chamber, the labium completely encircled in its basilar portion, the nervous system with the thoracic and abdominal ganglia fused into a single mass). They are parallel evolutionary lines and are distinct from the remainder of the Ephemeroptera.

Fifty-two years after the appearance of his study of the morphology of immature Ephemeroptera, Vayssière published in 1934 an anatomical study of *Baetisca obesa* and *B. carolina*. He concluded that the internal anatomy of *Baetisca* is much like that of *Prosopistoma* and that his ideas put forward in 1882 about the relations of the two had now been authenticated.

Landa's (1969) investigation of the comparative anatomy of mayfly nymphs indicated that the Neoephemeridae showed close relationships to the Caenidae, Prosopistomatidae, and particularly to the Baetiscidae. In the Caenidae, he concluded that *Brachycercus* is more closely related to *Baetisca* than is *Caenis*. His phylogeny, based on the comparative anatomy of the tracheal system, Malpighian tubes, and the nerve band of nymphs and illustrated in a 1973 paper, represented the Neoephemeridae and the Baetiscidae as being related and the Caenidae related to the Prosopistomatidae. The four families are derived from a common stem.

Demoulin (1956 and 1969) presents cogent arguments in support of his contention that the Baetiscidae are derived from the Oniscigasterinae and the Prosopistomatidae from the Ameletopsinae and that both families should be included in the superfamily Siphonuroidea. He has given an interesting analysis of morphological evidence leading him to his conclusions; however, we remain in agreement with Edmunds' interpretation of the phylogeny of these

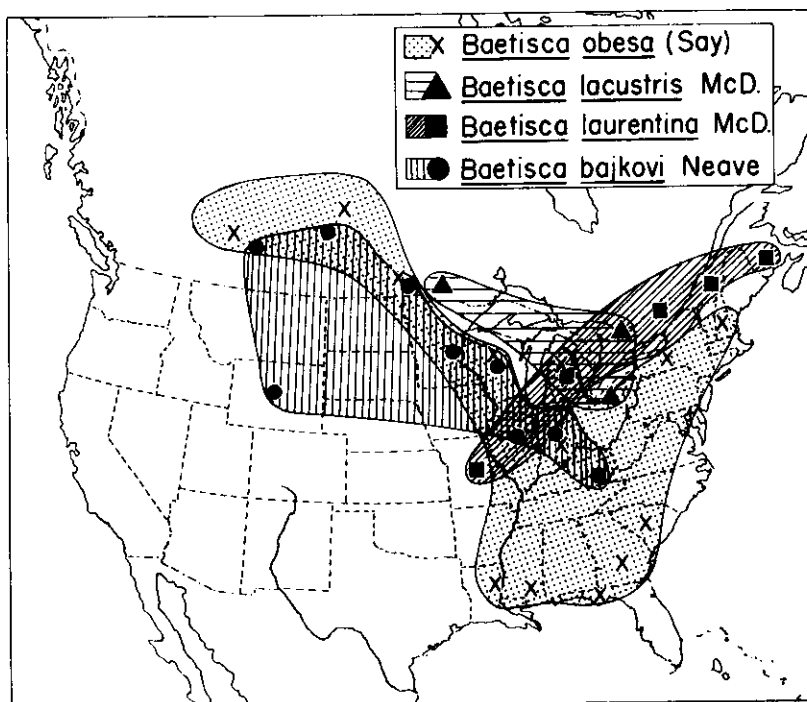


Figure 1. Presently known distribution of the species of *Baetisca* in North America.

two families.

In Edmunds' comprehensive study (1972) of the evolution of Ephemeroptera, a diagram of a probable phylogeny for the families and subfamilies was given. He discussed in detail his reasoning for the derivation as pictured and postulated that parallel evolution must explain some of the similarities existing between the Baetiscidae and Prosopistomatidae. Similar phylogenetic relationships were given by Koss (1973) and Riek (1973) using egg and nymphal characters respectively. Riek is somewhat more reserved, however, about the relationships of these two groups. He stated that although the Prosopistomatidae and Baetiscidae are referred to the same superfamily at present, the differences both in nymphs and adults are such that a more-detailed study may indicate that they are not as closely related as at present assumed. He pointed out that the Prosopistomatidae, in which the venation is very reduced, are the only Recent mayflies in which there is no evidence of a triadic branching of MA. The Baetiscidae, on the other hand, have the most generalized venation of all Recent species;

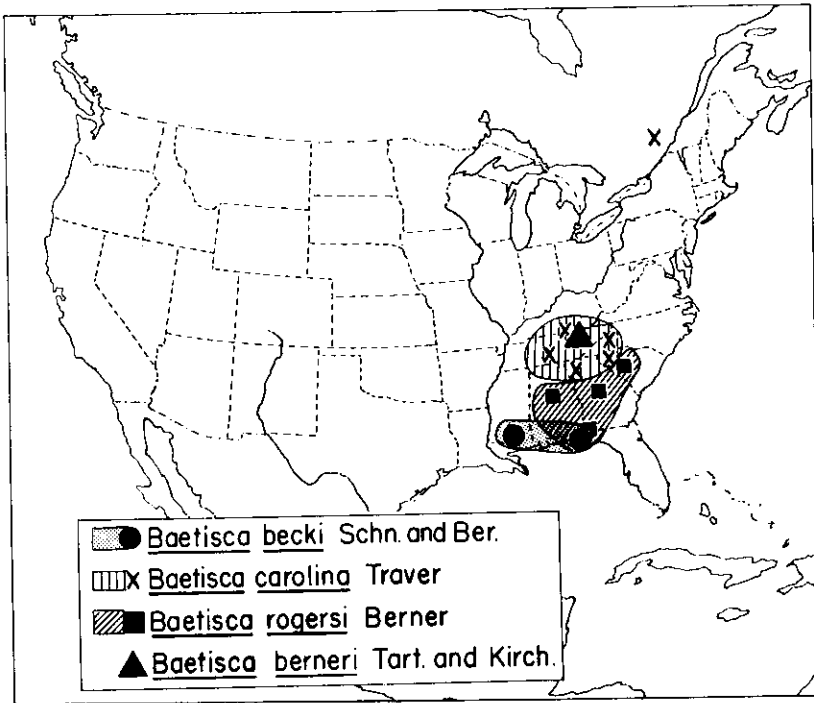


Figure 2. Presently known distribution of the species of *Baetisca* in North America.

the venation differs from that of the Lower Permian *Misthodotidae* mainly in the basal alignment of the veins. There is also a slight reduction in the anal field.

Edmunds *et al.* (1976) again diagrammatically represented the *Baetiscidae* and the *Prosopistomatidae* as being derived from a common ancestor, which are, in turn, related to the *Neoephemeridae* and the *Caenidae*. Our conception of phylogenetic relationships of the *Baetiscidae* are in accord with these. The presumed common origin of the *Baetiscidae* and the *Prosopistomatidae* are reflected in the assignment of the two families to the same superfamily, *Prosopistomatoidea*. McCafferty and Edmunds (1979), in proposing the suborders *Schistonota* and *Pannota*, have retained the superfamily *Prosopistomatoidea* for the *Baetiscidae* and *Prosopistomatidae*. We find no convincing data to contradict Edmunds' argument as to the kinship of these two families.

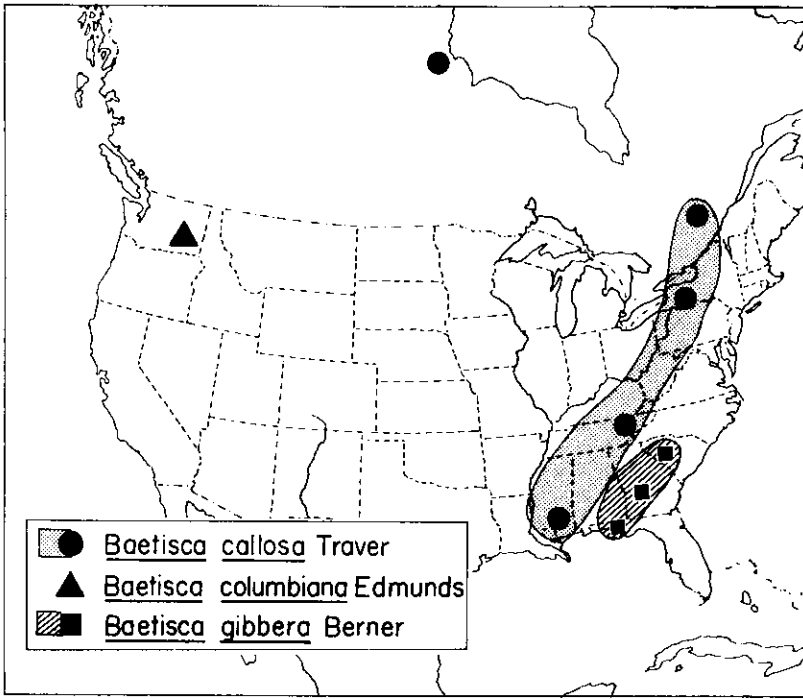


Figure 3. Presently known distribution of the species of *Baetisca* in North America.

TAXONOMY AND DISTRIBUTION

Presently, there are thirteen described species in the genus *Baetisca*, each of which will be treated in detail in Part II of our report on the family. The adults are most readily separated on the basis of wing pigmentation, with the male being the more distinctive sex. There is some likelihood that we shall be able to separate species of subimagos by differences in color pattern in the wings, but further study is necessary before we can determine the validity of this characteristic as a distinguishing one.

The various species of *Baetisca* are most easily characterized by nymphal differences and similarities. The structures we have employed for differentiation include the following:

Head: Shape and size of the frontal projections; shape and size of the genal projections; surface sculpturing.

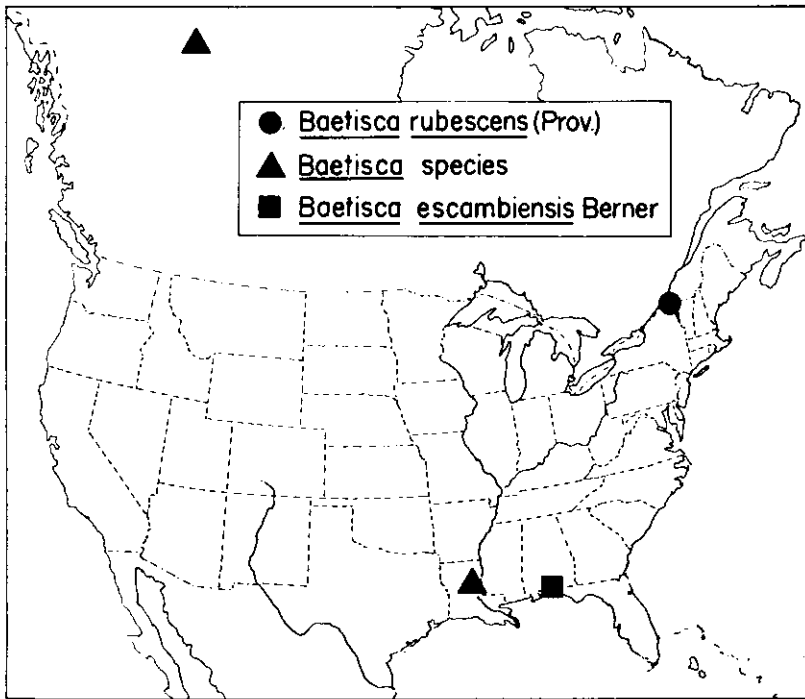


Figure 4. Presently known distribution of the species of *Baetisca* in North America.

Thorax: Lateral and dorsal projections of the mesothoracic shield; sculpturing and mottling pattern dorsally and ventrally.

Abdomen: Postero-median elevations and postero-lateral spines; mottling pattern

Based on our preliminary data, other nymphal characters that show considerable taxonomic value for species identification include: Head - marginal setation; eyes with or without stripes. Thorax - ratio between maximum length and width (including lateral projections) of mesonotal shield; legs, form and shape of femoral setae, setation of tibiae, and color pattern. Abdomen - form and shape of tergal setae and color pattern of caudal filaments.

The species, using nymphal morphology alone, fall roughly into four major groups as shown below. As the nymphal stage of *B. rubescens* is unknown, we have not listed it.

GROUP

A	B	C	D
<i>B. bajkovi</i>	<i>B. becki</i>	<i>B. callosa</i>	<i>B. escambiensis</i>
<i>B. lacustris</i>	<i>B. bermeri</i>	<i>B. columbiana</i>	
<i>B. laurentina</i>	<i>B. carolina</i>	<i>B. gibbera</i>	
<i>B. obesa</i>	<i>B. rogersi</i>		

The various species are distributed widely over most of the eastern part of North America and into the Great Plains and north-westward to the Northwest Territories of Canada (Wiens *et al.* 1975). No species has yet been reported from the southwestern United States but one, *B. columbiana*, was described from the State of Washington. A single, dubious report of a California collection of *Baetisca obesa* was given by Eaton (1885) but there has been no further substantiation of the occurrence of the genus in this area (Day 1956). We have, therefore, concluded that Eaton's record was in error. Specific distributions of the species will be given in Part II but in general the known species, other than *B. obesa*, have rather restricted ranges. Some of this restriction reflects inadequate collecting rather than localization of the species (Figs. 1 - 4).

ECOLOGY AND LIFE HISTORY

There are only few detailed studies of the ecology and life histories of any species of *Baetisca*. Lehmkuhl (1972) reported on his study of the biology of *B. bajkovi* in Saskatchewan. Here, nymphs hatched in late summer, spent the winter under ice, and adults emerged in June and July of the following year. Pescador and Peters (1974) provided a detailed report of the life history and ecology of the southeastern *B. rogersi* in Florida. They concluded that eggs were dormant during the hot summer months, nymphs appeared in September and continued to be present through June of the following year. Emergence of adults began in April and continued to early July with only a single generation each year. The most recent life history study is that of Chaffee and Tarter (1979); working with *B. bajkovi* in West Virginia, they found it to be univoltine with greatest growth occurring from July to August. Subimagos emerged during May.

Most species of *Baetisca* are strictly rheophilic, except for *B. lacustris* and *B. obesa*. The nymphs of *B. lacustris* were described as lake dwellers while *B. obesa* can live in both running waters and ponds. Traver (1931) described the nymphal habitats of *B. carolina* and *B. callosa* and stated that the *carolina* nymphs were mostly collected from streams with their beds composed of loose gravel and sand near the quiet edge. Quoting Needham's account of his collecting of *callosa* nymphs in Johnny Cake Run near Mt. Storm,

West Virginia, Traver stated that they were found in a stream only a few inches deep with water flowing among the small stones and gravel. Traver also described the habits of nymphs, subimagos and imagos of *B. carolina*.

A paper by Berner (1955) on the Southeastern species of *Baetisca* gave accounts of the nymphal habitats of *B. escambiensis*, *B. gibbera* and *B. obesa* and included brief notes on the nymphal habits of *escambiensis* and *obesa*. Berner observed that *escambiensis* nymphs were collected most abundantly from river sandbars where an admixture of clay in the sand prevailed, the water current was relatively slow, and algal growth over the bottom was minimal. The nymphs of *gibbera* were taken, from rather swiftly flowing streams, clinging to the underside of logs anchored at the bank or in areas where there was a thin overlaying layer of small pebbles. Compared to Walsh's observation of *obesa* nymphs in which he noted that they frequent rapidly-running rivers and attached themselves in repose to the undersurfaces of submerged stones, Berner observed a totally different sort of habitat of the species. He found the nymphs to occur almost invariably in very slow to almost stagnant water where they may be very common in moss which is attached to submerged trunks of trees, or other vegetation. Recently Pescador collected several nymphs of *obesa* from residual pools in flooded areas adjacent to the Chipola River in northwestern Florida.

The nymphs of *B. rogersi* usually inhabit gravel beds in sand bottom creeks (Berner 1940, 1950). Pescador and Peters (1974) observed that mature *rogersi* nymphs were typical members of a lithophilous association, living in the exposed, stony substratum section of the stream. Younger nymphs in the fourth through seventh instar live only in areas with a thick growth of filamentous algae and filamentous moss. Nymphs approaching emergence moved to quiet shallow sections of the stream, presumably to search for objects or places to leave the stream and emerge. Pescador and Peters also comprehensively discussed the habits of nymphs, subimagos and imagos of the species.

Nymphs of *B. becki* were observed by Schneider and Berner (1963) to occur in a swiftly flowing, clear, shallow, sand-bottomed stream under six to ten inches of water. Pescador and Peters (1971) collected *becki* nymphs from swifter, deeper water with more shifting, cleaner sand than nymphs of *rogersi* living in the same river. In a study of mayflies of Illinois, Burks (1953) observed that the nymphs of *B. bajkovi* developed in fairly rapid creeks and moderate-sized rivers. The early instar nymphs occur in the swift current, while the late instar nymphs migrate to the comparatively still eddies along the banks. Lehmkuhl (1972) stated that while nymphs of *B. bajkovi* are frequently collected in silty areas, their normal microhabitat appears to be solid substrate.

Except for McDunnough's (1932) brief comments on collecting numerous nymphal skins of *B. lacustris* found along the shores of Lake Erie and a mature nymph found in a pool, no other published accounts of the nymphal habitat of this species are known.

Leonard and Leonard (1962) briefly described the habitat of *B. laurentina* nymphs. The nymphs seem to prefer medium-sized to large rivers, where they partially submerge themselves in the flocculent surface layer of silt beds in quiet areas near the bank. In Wisconsin, Hilsenhoff (1975) found the nymphs of *Baetisca* in sandy streams where they inhabit sand and silt near the banks.

Nymphs of the recently described *B. berneri* seemed to prefer slow to medium water speeds with depths ranging from 15 to 46 cm, and a substrate mixture of sand, gravel, and small stones (Tarter and Kirchner 1978).

RESUME

Les auteurs examinent l'histoire de la taxonomie et de la phylogénie de la *Baetisca*, l'unique genre de la famille des baetiscidés, en décrivant d'abord le *Prosopistoma* en tant que crustacé. Ils traitent de la parenté qui existe entre la famille des prosopistomatidés et celle des baetiscidés et se déclarent d'accord avec la conclusion d'Edmund à l'effet que les deux familles descendent d'un ancêtre commun et que les similitudes sont sans doute dues au fait que leur évolution s'est effectuée parallèlement. L'ouvrage contient un précis des espèces présentement connues et des traits qui différencient les larves. Il contient également un aperçu de l'écologie et du cycle de vie des diverses espèces.

ZUSSAMENFASSUNG

Die Taxonomie und Phylogenie von *Baetisca*, der einzigen Gattung der Familie Baetiscidae, wird im geschichtlichen Überblick dargestellt, beginnend mit der Beschreibung der Nymphe von *Prosopistoma* als Kriebstierchen. Es wird sowohl die verwandtschaftliche Beziehung der Prosopistomatiden zu den Baetisciden behandelt, als auch die Übereinstimmung der Autoren mit Edmunds' Schlußfolgerung, daß die beiden Familien auf eine gemeinsame Ahnenform zurückzuführen sind. Einige ihrer Ähnlichkeiten müssen jedoch durch parallele Evolution erklärt werden. Daran schließt sich eine Übersicht der zur Zeit anerkannten Arten und Charakteristiken, nach denen die Nymphen unterschieden werden. Auch eine kurze Behandlung der Ökologie und Lebensgeschichte verschiedener Arten ist beigefügt.

REFERENCES

- Berner, L. 1940. *Baetisca rogersi*, a new mayfly from northern Florida. *Can. Entomol.* 72: 156-160.
- Berner, L. 1950. The mayflies of Florida. Univ. Fla. Press, Gainesville. (*Biol. Sci. Ser.* IV, No. 4).
- Berner, L. 1955. The southeastern species of *Baetisca* (Ephemeroptera: Baetiscidae). *Q. J. Fla Acad. Sci.* 18(1): 1-19.
- Berner, L. 1959. A tabular summary of the biology of North American mayfly nymphs (Ephemeroptera). *Bull. Fla State Mus.* 4(1): 1-58.
- Burks, B.D. 1953. The mayflies or Ephemeroptera, of Illinois. *Bull. Ill. Nat. Hist. Surv.* 26(1): 1-216.
- Chaffee, D.L., and D.C. Tarter. 1979. Life history and ecology of *Baetisca bajkovi* Neave in Beech Fork of Twelvepole Creek, Wayne County, West Virginia (Ephemeroptera). (Abstract). *ASB (Assoc. Southeast. Biol.) Bull.* 26(2): 87.
- Clemens, W.A. 1913. New species and new life histories of Ephemeroptera or mayflies. *Can. Entomol.* 45: 246-262; 329-341.
- Clemens, W.A. 1915. Rearing experiments and ecology of Georgian Bay Ephemeroptera. *Contr. Can. Biol.* 4: 113-128.
- Daggy, R.H. 1945. New species and previously undescribed naiads of some Minnesota mayflies (Ephemeroptera). *Ann. Entomol. Soc. Am.* 38: 373-396.
- Day, W.C. 1956. Ephemeroptera pp. 79-105. in R.L. Usinger, ed. Aquatic insects of California. Univ. Calif. Press, Berkeley.
- Demoulin, G. 1956. Les Baetiscidae dans la classification des Ephemeroptères. *Bull. Inst. R. Sci. Nat. Belg.* 32(35): 1-4.
- Demoulin, G. 1969. Remarques critiques sur la position systématique des Baetiscidae et des Prosopistomatidae (Ephemeroptera). *Bull. Inst. R. Sci. Nat. Belg.* 45(17): 1-17.
- Eaton, A.E. 1871. A monograph of the Ephemeroptera. *Trans. Entomol. Soc. Lond.* pp. 1-164.
- Eaton, A.E. 1885. A revisional monograph of recent Ephemeroptera or mayflies. *Trans. Linn. Soc. Lond. Ser.* 2, 3: 153-230.
- Edmunds, G.F., Jr. 1960. The mayfly genus *Baetisca* in western North America (Ephemeroptera: Baetiscidae). *Pan-Pac. Entomol.* 36: 102-104.
- Edmunds, G.F., Jr. 1972. Biogeography and evolution of Ephemeroptera. *Annu. Rev. Entomol.* 17: 21-42.
- Edmunds, G.F., Jr., S.L. Jensen, and L. Berner. 1976. The mayflies of North and Central America. Univ. Minnesota Press, Minneapolis.
- Fontaine, J. 1958. Les affinités systématiques du genre *Prosopistoma* Latreille (Ephemeroptère). Deuxième note: Le genre *Baetisca* Walsh: les formes Ailees. *Bull. Mens. Soc. Linn. Lyon* 27: 133-140.
- Gillies, M.T. 1954. The adult stages of *Prosopistoma* Latreille (Ephemeroptera) with descriptions of two new species from Africa. *Trans. R. Entomol. Soc. Lond.* 105: 355-372.

- Hagen, H. 1861. Synopsis of the Neuroptera of North America with a list of South American species. *Smithson. Misc. Collect.* 4: 38-55.
- Hilsenhoff, W.L. 1975. Aquatic insects of Wisconsin with generic keys and notes on biology, ecology, and distribution. *Tech. Bull. Dep. Nat. Resour., Wisc.* 89: 1-53.
- Joly, E. 1880. Sur la nymphe du genre d'Ephémérines *Baetisca* Walsh. *Bull. Soc. Etudes Sci. Angers.* 8: 157-173.
- Koss, R.W. 1973. The significance of the egg stage to taxonomic and phylogenetic studies of the Ephemeroptera. pp. 73-78. in: *Proc. First Intern. Confer. on Ephemeroptera.* E.J. Brill, Leiden.
- Lameere, A. 1917. Etude sur l'évolution des Ephémères. *Bull. Soc. Zool. Fr.* 42: 41-48.
- Landa, V. 1969. Comparative anatomy of mayfly larvae (Ephemeroptera). *Acta Entomol. Bohemoslov.* 66: 289-316.
- Landa, V. 1973. A contribution to the evolution of the order Ephemeroptera based on comparative anatomy. pp. 155-178. in: *Proc. First Intern. Confer. on Ephemeroptera.* E.J. Brill, Leiden.
- Latreille, M. 1833. Description d'un nouveau genre de Crustacés. *Nouv. Ann. Mus. Hist. Natur.* 2: 23-24.
- Lehmkuhl, D.M. 1972. *Baetisca* (Ephemeroptera: Baetiscidae) from the western interior of Canada with notes on the life cycle. *Can. J. Zool.* 50: 1015-1017.
- Leonard, J.W., and F.A. Leonard. 1962. Mayflies of Michigan trout streams. Cranbrook Inst. Sci. Bloomfield Hills, Mich.
- McCafferty, W.P., and G.F. Edmunds, Jr. 1979. The higher classification of Ephemeroptera and its evolutionary basis. *Ann. Entomol. Soc. Am.* 72: 5-12.
- McDunnough, J. 1921. Two new Canadian mayflies. *Can. Entomol.* 53: 117-120.
- McDunnough, J. 1932. New species of North American Ephemeroptera II. *Can. Entomol.* 64: 209-215.
- Neave, F. 1934. A contribution to the aquatic insect fauna of Lake Winnipeg. *Int. Rev. gesamten Hydrobiol.* 31: 157-170.
- Needham, J.G. 1905. Mayflies and midges of New York. N.Y. *State Mus. Bull.* 86: 17-62.
- Needham, J.G., J.R. Traver, and Yin-Chi Hsu. 1935. The biology of mayflies. Comstock Publ. Co., Ithaca.
- Pescador, M.L. and W.L. Peters. 1971. The imago of *Baetisca becki* Schneider and Berner (Baetiscidae: Ephemeroptera). *Fla. Entomol.* 54: 329-334.
- Pescador, M.L. 1974. The life history and ecology of *Baetisca rogersi* Berner (Ephemeroptera: Baetiscidae). *Bull. Fla. State Mus., Biol. Sci.* 17: 151-209.
- Provancher, L. 1876. Petite faune entomologique du Canada. Néuroptères. Fam. III. Ephémérides. Ephermeridae. *Nat. Can. (Que.)* 8: 264-268.
- Provancher, L. 1877. Petite faune entomologique du Canada et

- particulament de la Province de Quebec. *Nat. Can.* (Que.) 9: 80-84.
- Riek, E.F. 1973. The classification of the Ephemeroptera pp. 160-178. *in*: Proc. First Intern. Conf. on Ephemeroptera. E.J. Brill, Leiden.
- Say, T. 1939. Descriptions of new North American neuropterous insects, and observations on some already described. *J. Acad. Nat. Sci. Phila.* 8: 9-46.
- Schneider, R.F., and L. Berner. 1963. A new southeastern species of *Baetisca* (Ephemeroptera: Baetiscidae). *Fla. Entomol.* 46: 183-187.
- Spieth, H.T. 1933. The phylogeny of some mayfly genera. *J. N.Y. Entomol. Soc.* 41: 55-86: 327-391.
- Tarter, D.C., and R.F. Kirchner. 1978. A new species of *Baetisca* from West Virginia (Ephemeroptera: Baetiscidae). *Entomol. News* 89: 209-213.
- Traver, J.R. 1931. The ephemerid genus *Baetisca*. *J. N.Y. Entomol. Soc.* 39: 45-66.
- Traver, J.R. 1932. Mayflies of North Carolina. *J. Elisha Mitchell Sci. Soc.* 47: 85-161.
- Traver, J.R. 1937. Notes on mayflies of the southeastern States (Ephemeroptera). *J. Elisha Mitchell Sci. Soc.* 53: 27-86.
- Ulmer, G. 1920. Übersicht über die Gattungen der Ephemeropteren, nebst Bemerkungen über einzelne Arten. *Stett. Entomol. Zeit.* 81: 97-144.
- Vayssière, A. 1882. Recherches sur l'organisation des larves des Ephémérines. *Ann. Sci. Nat.* (6): *Zool.* 13(1): 1-137.
- Vayssière, A. 1934. Etude anatomique des larves nymphales des *Baetisca obesa* et *carolina*. *Ann. Sci. Nat. Zool. Ser.* 10, 17: 381-406.
- Walker, F. 1853. List of the specimens of neuropterous insects in the collection of the British Museum. Part III. (Termitidae-Ephemeridae). British Museum (Natural History), London. (pp. 533-585).
- Walsh, B.D. 1862. List of the Pseudoneuroptera of Illinois contained in the cabinet of the writer, with the description of over 40 new species, and notes on their structural affinities. *Proc. Acad. Sci. Phila. Ser.* 2: 361-402.
- Walsh, B.D. 1863. Observations on certain N.A. Neuroptera, by H. Hagen, M.D., of Königsberg, Prussia; translated from the original French Ms., and published by permission of the author, with notes and descriptions of about twenty new N.A. species of Pseudoneuroptera. *Proc. Entomol. Soc. Phila.* 2: 167-179.
- Walsh, B.D. 1864. On the pupa of the ephemerous genus *Baetisca* Walsh. *Proc. Entomol. Soc. Phila.* 3: 200-206.
- Wiens, A.P., D.M. Rosenberg, and N.B. Snow. 1975. Species list of aquatic plants and animals collected from Mackenzie and Porcupine river watershed from 1971-1973. *Can. Fish. Mar. Serv. Tech. Rep.* 557: 1-39.