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A SYSTEMATIC STUDY OF THE FAMILY BOREIDAE (MECOPTERA)

by

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ABSTRACT

General aspects of the biology of Boreidae are discussed, including life cycle and immature forms, ecological relationships, geographical and seasonal distribution, external morphology, variation within species, behavior, and adaptations to boreal or winter existence. A phenetic classification is derived by comparison of states of 37 characters. Four possible phylogenies of the family are obtained by application of different methods, and their differences are compared. These systematic analyses yield a distinct group, ***Hesperoboreus*** (new genus), to include ***Boreus brevicaudus*** Byers (type species) and ***B. notoperates*** Cooper, of western North America. Revision of the North American species results in the following new synonymy: *B. californicus* Packard (=*B. unicolor* Hine, *B. isolatus* Carpenter, and *B. californicus fuscus* Carpenter), *B. nix* Carpenter (=*B. gracilis* Carpenter). Among Old World species, the following new synonymy is noted: *B. navasi* Pliginsky (=*B. aktijari* Pliginsky). Taxonomic keys and illustrations are provided.

INTRODUCTION

Boreidae (named for Boreas, the Greek god of the north wind) are small, dark colored Mecoptera usually found associated with mosses and infrequently seen except on winter snow. Both sexes are flightless, the wings of females being reduced to tiny, sclerotized flaps and those of males being modified as long, thin hooks used to grasp the female during copulation. The elongate rostrum resembles that of Panorpidae. Female boreids have an ovipositor formed from the fused cerci and elements of the 8th through 11th abdominal segments. The larvae are scarabaeiform and have so far been found only among rhizoids of mosses and club mosses.

The taxonomy of North American boreids has not been studied since Carpenter published descriptions and keys (1935, 1936). Three North American species have been described since that time (Byers, 1955, 1961, and Cooper, 1972), and additional taxonomic characters have been found. In the Palearctic region there has not been a comprehensive treatment of species since Esben-Petersen's (1921) world monograph of the Mecoptera. Six Palearctic species have subsequently been described, primarily in Russian literature.

Crampton (1930) pointed out that terminal abdominal appendages of both male and female Boreidae are distinct from those of other Mecoptera, and since the Boreidae are so specialized they could reasonably be placed in a separate suborder, the Neomecoptera. Hinton (1958) raised this suborder to ordinal level on the basis of nine findings: "Larva: (a) the cranium is without a distinct epistomal suture; (b) the cardo is not fused to the basistipes, and the tentorial adductors of the cardo are present; if homologues of these muscles are present in the Mecoptera they are now tentorial adductors of the cardostipes; (c) the postmentum is well developed instead of lost or reduced to an articulating membrane between the prementum and the cranium; (d) the abdomen lacks prolegs, whereas in the Mecoptera prolegs are present on the first eight abdominal segments; and (e) the larvae feed on moss, whereas those of the Mecoptera are carnivorous. Adult: (a) the ovaries are panoistic instead of polytrophic as in the Mecoptera; (b) the 11th abdominal segment of the female lacks cerci, whereas one- or two-segmented cerci are

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present in the Mecoptera; (c) the 9th and 10th abdominal segments are modified to form a large functional ovipositor but no such 'ovipositor' is found in the Mecoptera; and (d) the adult gut lacks the six especial rectal glands of the Mecoptera."

Although most of Hinton's points are valid, a few inaccuracies occur. Byers (1961) pointed out that the tip of the ovipositor in Boreidae is actually the fused cerci, and recently he discovered that larvae of Panorpodidae lack abdominal prolegs and are probably plant feeders. Hepburn, in his morphological study of the thorax of Mecoptera (1970), concludes that Boreidae are probably closely related to "intermediate families" of Mecoptera, and attempts to remove Boreidae from the Mecoptera are unjustified.

Only one previous attempt has been made to reconstruct phylogeny within the Boreidae (Lestage, 1940). Lestage suggested that Boreidae consisted of two genera: *Boreus,* consisting of Palearctic species with male abdominal tergal ridges and medial lobes of the dististyles, and *Euboreus,* consisting of Nearctic species without tergal ridges and medial dististylar lobes. Lestage further stated that the primitive condition was lack of these structures, therefore making *Euboreus* the more primitive genus and North America the place of origin of the family.

The morphological basis of Lestage's reasoning was faulty. All male Boreidae have medial dististylar lobes and only four western European species have abdominal tergal ridges.

This study was undertaken to bring together recent information on taxonomy, morphology, and ecology of the Boreidae. An attempt has been made to synthesize this information into a better concept of systematics of the family. Specifically, primitive and derived sequences of character states have been used to construct the evolutionary development of Boreidae and this, in turn, has been used to determine genera and species groups. Finally, an attempt has been made to present (sometimes for the first time in the English language) the most comprehensive description available for each species.

METHODS OF PRESERVATION OF SPECIMENS

Specimens should be preserved in alcohol. If specimens are preserved dry on points, the membranous areas tend to contract and the abdominal sclerites telescope within one another. The ninth tergum becomes almost completely enclosed by the eighth tergum, and the dististyles recurve over the abdomen to conceal the caudal surface of the ninth tergum. Retraction and shrinkage make observation of this key structure almost impossible. Preservation in 70 percent alcohol also tends to cause retraction and shrinkage, but if specimens are placed in water for a few minutes, they normally will return to normal size and shape. Even greater detail can be seen if specimens are lightly cleared in a 10% solution of cold potassium hydroxide (KOH) for 24 hours. After clearing, it can be seen that under the tergal hood are recessed pockets into which the tips of the dististyles fit.

MORPHOLOGY AND BOREAL ADAPTATIONS

A. BOREAL ADAPTATIONS—Tweedie (1972) lists four traits frequently noted among northern and alpine insects. Many northern insects are small and dark in color. These two characteristics perhaps allow the insects to absorb radiant heat more readily and warm up much faster than larger and lighter individuals of closely related races or species. However, this situation would create a larger surface area per unit volume, and thus also cool the insect more rapidly when radiant heat is absent (see Salt, 1961). Species of Boreidae range from yellow and brown to russet brown to black in color and 2.0 to 7.4 mm. in length. Whether dark coloration in Boreidae helps maintain thermal regulation has yet to be determined.

Northern insects are frequently more hairy than their more southern counterparts (see Downes, 1965). This allows for an insulating layer of air within the hairy coat. Although no boreids are hairy enough to trap such an insulating air layer, variation in hairiness can be seen even within the genus. Those species living along the west coast of North America in rather mild climates have few setae on the body while such species as *nix* and *pilosus* from mountainous western regions have enough setae over the entire body to give these species a "frosted" appearance.

The fourth trait noticed among northern insects is wing reduction. This characteristic has a three-fold advantage. In such extreme environments, generating enough energy to warm and maintain functioning of wing muscles would be extremely difficult (Heinrich and Bartholomew, 1972). The exposed surface area of wings places the insect in greater danger of freezing. Finally, the frequently windswept, barren environments where northern and alpine insects live make it necessary to reduce surface area to avoid being blown away. Boreidae show marked decrease in wing size, the wings being reduced to small, oval flaps in females (Fig. 1, p. 144) and thin, spiny hooks in males (Fig. 2, p. 145).

Two further winter adaptations of Boreidae are the ability to hop and an extended life cycle. No other mecopteran is known to have the ability to hop. Boreidae will frequently hop when suddenly disturbed on moss or snow. Boreids normally walk while feeding or moving across snow, but it has been noticed that on light, fluffy snow where walking is difficult, an individual will take a few steps and then leap up to 12 inches, even though not disturbed. This action may be repeated several times in rapid succession, allowing Boreidae to cross several feet of soft snow in a few minutes.

Strübing (1950) has found that *B. hyemalis* larvae require two years to mature. This extended life cycle is noted among many northern insects. However, Kaufmann (1971) has shown that a carabid beetle, *Pterostichus brevicornis,* requires from 14 to 36 months to complete its life cycle, depending upon the time of oviposition. It remains to be proven that Boreidae take two years to mature under *all* conditions.

B. GENERAL MORPHOLOGICAL DESCRIPTION (Adult)—To facilitate the following discussion, it is mentioned here that I have hereinafter separated the Boreidae into two genera, *Hesperoboreus* and *Boreus,* and *Boreus* in turn has been separated into four species groups, the *californicus, hyemalis, nivoriundus,* and *reductus* groups.

Head prolonged into a rostrum, composed anteriorly of clypeus and labrum, laterally of genae, and caudally of maxillo-labial complex (Hepburn, 1969). Labrum short, spatulate, with triangular sclerite at each side. Mandibles slightly longer than labrum, tapering apically, with six stout teeth at apex. Maxillolabial complex much longer than other mouthparts, varying from .44 to 1.00 times length of rostrum. Maxillary palps five-segmented, basal segment much shorter than distal segments. Labial palps two-segmented, arising at apex of maxillolabial complex. Approximately halfway between bases of maxillary and labial palps two areas of pegs, with about 14 pegs on either side. Eyes large, oval, and usually plum to black in living individuals. Antennae long (though short compared to those of other mecopterans), consisting of subcylindrical scape, bulbous pedicel, and 16 to 23 filiform, pedicellate flagellar segments, arising between or just below eyes. Median ocellus between and just dorsad

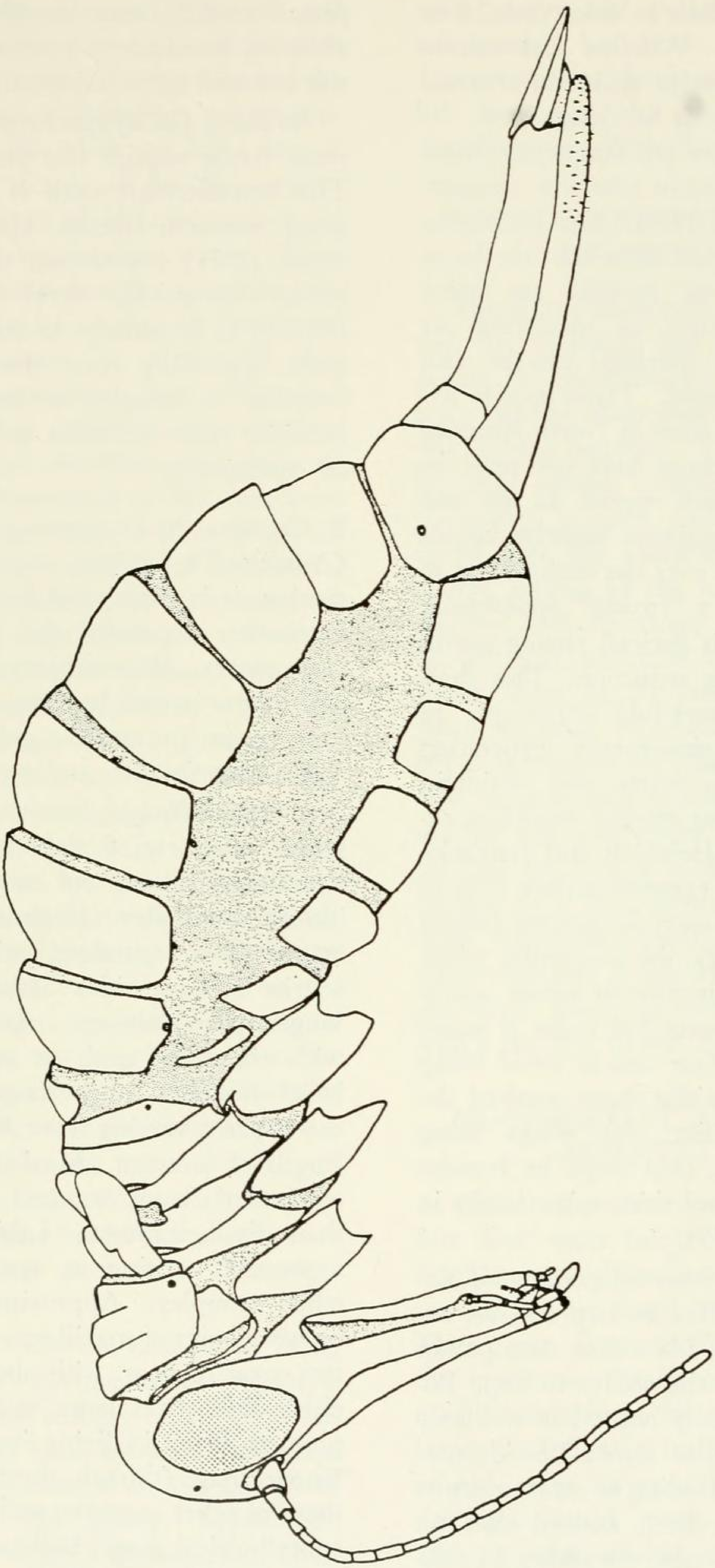


FIGURE 1. *Boreus coloradensis* Byers, female, lateral view, legs removed (39×).

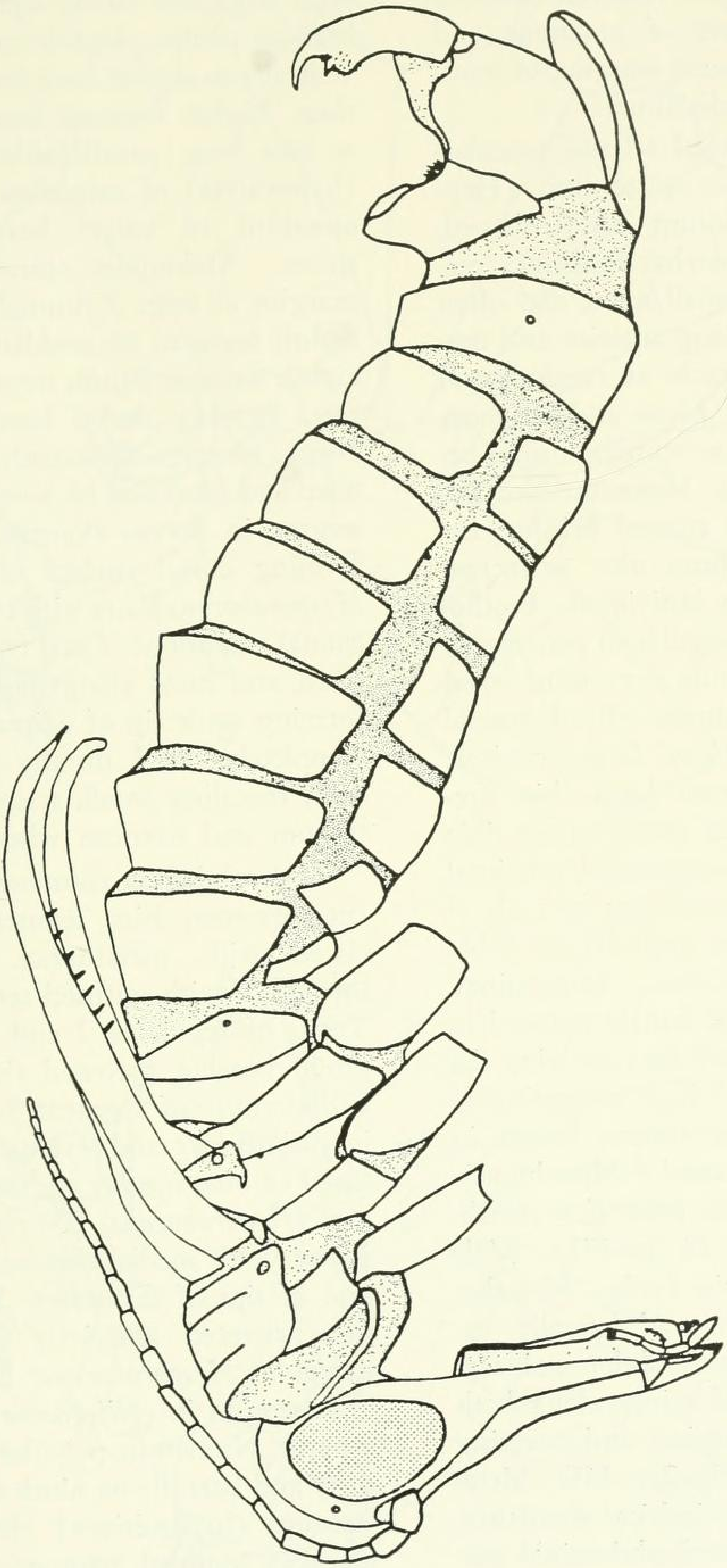


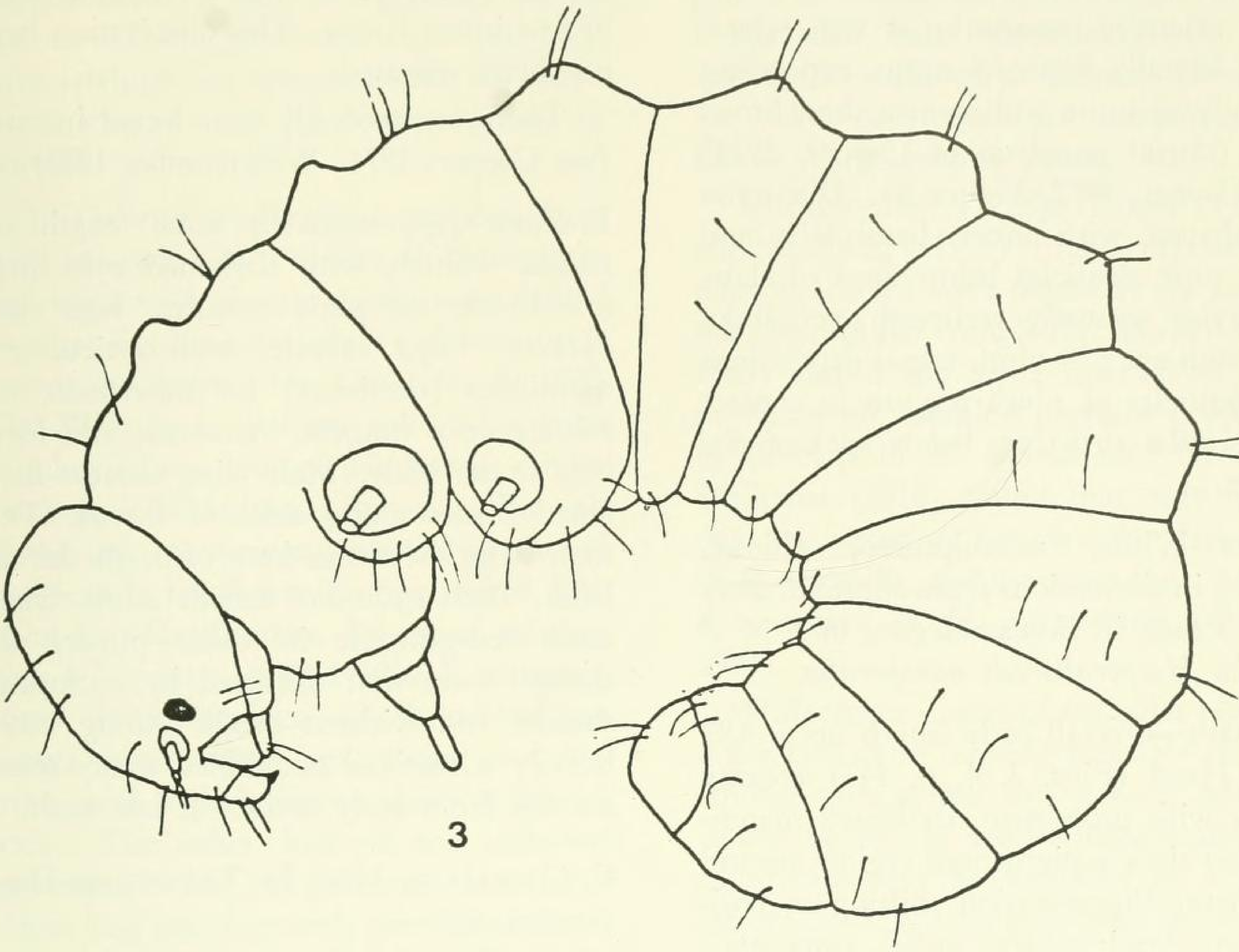
Figure 2. *Boreus coloradensis* Byers, male, lateral view, legs removed (39×).

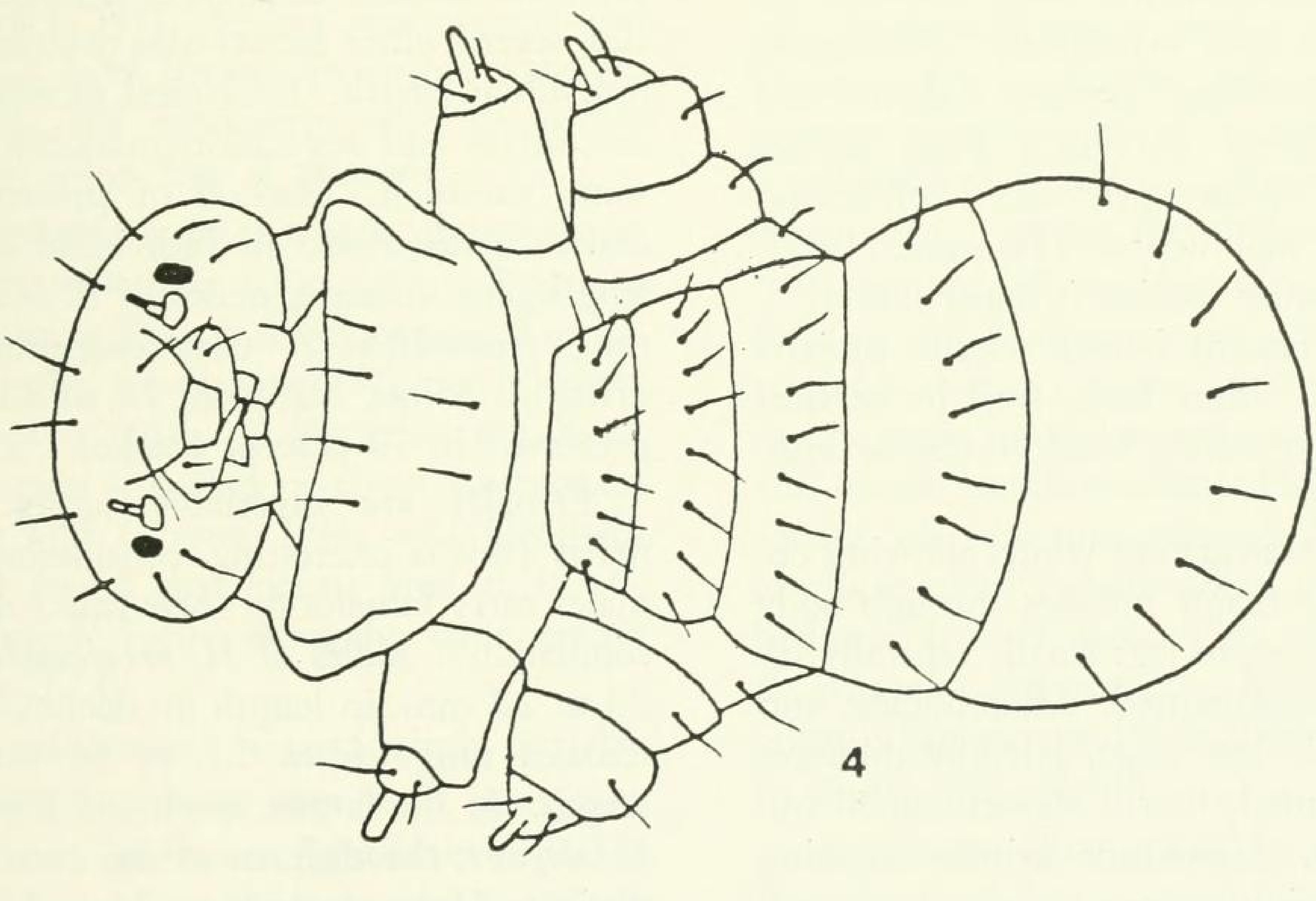
of antennae. Lateral ocelli close to margins of compound eyes. Anterior tentorial pits just below level of antennae and about halfway between margins of compound eyes and medial line.

A long, thin cervical sclerite articulating with prothoracic episternum (Hepburn, 1970). Pronotum saddle-shaped, frequently with somewhat indistinct medial ridge, bearing small setae, and often with large bristles along anterior and posterior margins. Spiracle at caudo-lateral margin of pronotum. Meso- and metanota with raised, triangular scutella visible between reduced wings. Mesoscutellum frequently bearing two crossed bristles; occasionally metascutellum also with two bristles, varying with individual. Prothoracic basisternum triangular to pentagonal in shape. Preepisternum very thin; coxal cavities occupying almost all of sternal region of thorax. Coxa large, conical; trochanter small; femur long, thin, frequently with subapical dorsal spine; tibia long, thin; tarsus five-segmented, proximal tarsomere about twice as long as each of last four; two smooth tarsal claws. Tibia and tarsomeres with many stout spines. Mesothoracic wings of female reduced to oval, densely sclerotized flaps covering the smaller metathoracic wings, extending to caudal margin of metathorax, except in *B. reductus* and *navasi*. Metathoracic wings reduced to little more than small, irregular folds (Fig. 13, p. 153). Male wings modified as thin hooks. Mesothoracic wings curved ventrad laterally, extending to about fourth abdominal segment, bearing rows of spines along both mesal and lateral margins, and covering metathoracic wings (Fig. 2, p. 145). Metathoracic wings thin, cylindrical structures, extending to about fourth abdominal segment, bearing dense, small setae and frequently several stout spines along ventral side.

Female abdomen composed of 11 segments. First segment closely associated with metathorax. Segments 2 through 7 with terga and sterna separated by membranous pleura. Eighth tergum extending ventrally to sternal area, forming a broken ring. Eighth sternum extending caudally as two long, parallel-sided lower valves (hypovalves) of ovipositor, apical half to one-third of valves bearing numerous spines. Abdominal spiracles in ventral margins of terga 2 through 7; spiracles of eighth segment in mid-lateral surfaces of eighth tergum. Ninth tergum short, quadrate, forming dorsal base of ovipositor. Ninth sternum apparently lightly sclerotized and concealed by lower valves. Tenth tergum in *Boreus* elongate, parallel-sided, forming dorsal surface of ovipositor, in *Hesperoboreus* short with two spine-tipped caudal extensions. Cerci triangular, sclerotized, and fused along midline in *Boreus,* forming acute tip of ovipositor. Cerci incompletely fused distally in *Hesperoboreus,* revealing small, sclerotized eleventh tergum and sternum when raised.

Male abdomen composed of 10 apparent segments. First segment closely associated with metathorax. Segments 2 through 7 with unfused terga and sterna. Terga of segments 2 and 3 in *hyemalis* group bearing flattened ridges. Tergum and sternum of segment 8 fused laterally in *californicus* and *hyemalis* groups, unfused in *nivoriundus* and *reductus* groups and *Hesperoboreus*. Tergum 9 raised in *Boreus* with medial depressions for reception of tips of dististyles. Medial depressions covered anteriorly by thin hood except in *Hesperoboreus;* hood with median septum in *californicus* and *hyemalis* groups. Numerous peg-like denticles caudally and laterally on ninth tergum. Ninth sternum (hypandrium) elongate-triangular, apex rounded, truncate, slightly emarginate, or deeply notched. Tenth tergum and sternum reduced to small, oval sclerites between basistyles. Aedeagus membranous, except for small, thin sclerite along anterior surface. Basistyles (gono-





Figures 3,4. *Boreus coloradensis* Byers, larva. Fig. 3, lateral view. Fig. 4, ventral view. Both 42×.

coxites) bulbous, with median dorsal ridge extended anteriorly as two sclerotized, laterally flattened straps, expanding medially to unite and form a thin, broad plate (dorsal gonobase of Cooper, 1974) (see Cooper, 1972, Figure 4). Diststyles claw-shaped with inner, basal lobe and many stout denticles below apex of claw. Diststyles normally recurved over abdomen with apex in ninth tergal depressions and denticles of ninth tergum in contact with similar structures below apex of diststyles.

C. EGG—White, unsculptured, oblong, varying in dimensions from approximately .7 × .5 mm. in *Boreus elegans* to .5 × .3 mm. in *Hesperoboreus notoperates.*

D. LARVA—Overall body length up to 4.83 mm. Head (Figs. 3, 4, p. 147) creamy yellow with prominent, darkened mandibles and darkly pigmented region around stemmata. Pigmentation shifting to position on head where pupal compound eyes will form late in last larval instar (Cooper, 1974). Antennae small, two-segmented, with apical hair, half-way between eyes and mandibles. Mouthparts short, not forming rostrum. Labrum and three-segmented maxillary palpi lightly sclerotized. Many prominent bristles on head and mouthparts (Peterson, 1951), varying among species (Cooper, 1974).

Thin, crescent-shaped sclerite projecting laterally from body wall in cervical region where strong head protractor muscle attaches.

Thorax transparent white, allowing observation of major muscles through body wall. Prothoracic legs small, ventrally directed, two-segmented. Mesothoracic and metathoracic legs large, laterally directed, four-segmented; fourth segment small and transparent. Numerous bristles covering thoracic region.

Abdomen transparent white, 11 segmented, bearing many bristles. No abdominal legs or appendages of any sort. Brauer (1855) mentioned abdominal legs in first instar larvae. This observation has not been repeated.

There are probably four larval instars (see Cooper, 1974; Withycombe, 1922).

E. PUPA—Approximately same length as adults, whitish, with darkened eyes and mandibles. As pupa matures, legs also darken. Pupa exarate, with articulated mandibles (decticous) for movement in subterranean tunnels. Antennae and legs held under body. Male wing sheaths flattened blades along sides of thorax. Female wing sheaths in form of small, dorsal lobes. Both male and female adult structures recognizable in older pupae, although somewhat distorted by enclosing sheaths and without detail. Along with heavily sclerotized mandibles, many setae are lost from body surface at last molt.

F. CHARACTERS USED IN TAXONOMIC DIFFERENTIATION—

a. *Overall size*—Adult Boreidae range in length from 2.0 to 7.4 mm. Although there are distinct differences between species, several other factors also contribute to individual length. Ecological factors such as climate and vegetation probably cause some variation. Method of preservation makes a difference in individual overall length; for instance, males of *B. brumalis* range from 2.0 to 2.7 mm. long preserved dried on points, but from 2.4 to 3.1 mm. preserved in 70 percent alcohol.

Females are invariably larger than males (this is interesting, considering that males carry females on their backs during copulation). Males of *H. brevicaudus* are 2.3 to 2.7 mm. in length in alcohol, while females range from 3.1 to 3.6 mm. in length. In the largest species of Boreidae, *B. elegans,* the differences are even more distinct. Males range from 3.6 to 4.6 mm. in length in alcohol, while females are 6.0 to 7.4 mm. in length.

There is no difference in minimum

length between the two genera, but no species of *Hesperoboreus* has yet been found which can compare with the maximum size attained by *Boreus elegans* or *borealis*.

b. *Coloration*—Previous authors have used coloration as a means of distinguishing species. A simple experiment helped to point out the unreliability of taxonomic use of coloration. On December 1, 1970, Dr. William L. Jellison collected a large number (about 150) of live *Boreus* on the snow near Hamilton, Montana. One-half of the specimens were preserved in alcohol and sent to the Snow Entomological Museum for identification. By use of existing keys (Carpenter, 1935, 1936), all the specimens were identified as *B. californicus fuscus* with yellow legs, wings, and rostrum, and a dark brown (almost black) body. The other half of the collected specimens were placed alive in a large plastic bag together with pine forest detritus, on the shaded north side of Dr. Jellison's home in Hamilton, where they were exposed to seasonal cold temperatures. On January 1, 1971, the bag was opened and live and dead *Boreus* specimens were examined. All specimens were uniformly dark in color, like *B. unicolor*.

In other groups of insects pigmentation is often related to time since eclosion or temperature during development. For example, the grasshopper *Mesopsis* slowly develops a patch of black on the hindwings over a period of about six months (Burtt and Uvarov, 1944) and Goodwin (1952) found that locusts bred at 40° C. were much lighter than the same species bred at 26° C.

B. californicus is particularly variable in coloration. Some specimens are yellow and black; others are light brown, darker russet brown, or dark brown to black. Some russet brown specimens from northeastern California were used in the original species description, causing F. M. Carpenter to describe the more commonly seen forms with light appendages as a subspecies, *B. californicus fuscus*. However, the color differences are sympatric and follow no geographic cline.

Withycombe (1922), Fraser (1943), and Strübing (1950) found that several days to a week were necessary for *B. hyemalis* to darken completely. Brauer (1857, 1863) found the same interval of time necessary for complete pigment deposition to develop in *B. westwoodi*. However, Williams (1916) found that only a half day was necessary for cuticular darkening in *B. brumalis*, and the same time interval is necessary in *H. notoperates* (Cooper, 1974).

Differences in rate of cuticular pigment deposition or in tanning probably do exist among species, but this genetic attribute cannot be used in species identification because rate may be modified by climatic factors, and age of preserved material is rarely known.

c. *Pilosity*—Possibly one of the first things noticed about adult Boreidae when viewed through a microscope is the large number of setae, bristles, spines, and denticles over many parts of the body. These structures are found on all species, most abundantly between the antennae, on the anterior part of the rostrum, along the sides of the thorax, on the wings, coxae, posterior halves of the abdominal segments, male ninth tergum and dististyles, and female eighth sternum. However, two species (*B. nix* and *pilosus*) have more extensive pilosity than others, giving their bodies a "frosted" look. Two other species, *B. brumalis* and *reductus*, have abundant pilosity, but not nearly to the same extent as in *nix* and *pilosus*.

d. *Chromosomes*—Only four species of Boreidae have been studied cytogenetically (Cooper, 1951, 1972, 1974). The haploid number (N) varies from 9 in *H. notoperates* to 11 in *B. brumalis*, to 13 in *nivori-*

undus, to 14 in *hyemalis.* There is an XO sex determining mechanism, except in *B. brumalis* which has X_1X_2Y. Although it is too early to make phylogenetic conclusions from these isolated observations, it does appear that chromosome study holds some promise of adding to our knowledge of the phlogeny of Boreidae.

In two species of *Boreus,* spermatogenesis takes place in the pharate pupa, while in *H. notoperates* spermatogenesis occurs in the mature pupa and pharate adult (Cooper, 1974).

e. *Occipital smoothness*—The occiput of *Hesperoboreus* is rugulose, the uneven surface also covered with many setal pits. In *Boreus* the occipital surface has fine reticulations and setal pits, although these reticulations are barely visible (Fig. 5, p. 151). The surface is much more even than in *Hesperoboreus.* An exception to the occipital reticulation of *Boreus* is the completely smooth occiput of *B. hyemalis* (Fig. 6, p. 151), which has been used to distinguish *hyemalis* from the very closely related *B. westwoodi.* Because I cannot find other characters to separate the species, I doubt the taxonomic significance of the smooth occiput.

f. *Ocelli*—In other mecopteran families, ocelli are arranged in a small triangle just above the antennae. In Boreidae the ocelli are dispersed, the lateral ocelli near the margins of the compound eyes (Figs. 7-10), and the median ocellus, when present, near the antennal bases. In *Hesperoboreus* and the *reductus* group of *Boreus,* the median ocellus is absent. Withycombe (1922) and earlier authors stated that Boreidae possessed no ocelli, but Withycombe later (1926) corrected his earlier statement.

g. *Antennae*—These structures are of use in generic separation. The antennal bases of all *Boreus* lie between the compound eyes (Figs. 8, p. 152; 9, p. 152; 10, p. 152). The antennal bases of *Hesperoboreus* lie at the lower margins of the compound eyes (Fig. 7, p. 152).

Lestage (1940) used number of antennal segments to separate most of the Palearctic species. However, it must be noted that males frequently have one more segment than females, and these is variation among individuals or even between antennae of one individual. For a good statistical analysis of antennal segmentation in *H. notoperates,* see Cooper (1974).

However, the degree of variation differs from one species to another. Males of *H. brevicaudus* consistently have 16 flagellomeres, while males of *B. coloradensis* have flagellomeres numbering from 18 to 22. Thus, the number of flagellomeres can be used taxonomically, as long as the variation is taken into account. The numbers for each species are given below with the species description, but it should be noted that generally *Hesperoboreus* has fewer flagellomeres than *Boreus,* number of flagellomeres varying from 16 to 18 in the former, and 17 to 23 in the latter.

h. *Width of hypostomal bridge*—Variation in hypostomal bridge width makes the maxillo-labial complex appear either shorter or longer. This variation can be expressed as a ratio of the length of the maxillo-labial complex (hypostomal bridge to apex) to the length of the rostrum, as measured from the base of the compound eye to the tip of the labrum. In the genus *Hesperoboreus* this ratio varies from .44 to .71 (Fig. 7, p. 152), while in *Boreus* it varies from .70 to 1.0 (Fig. 10, p. 152). Thus it can be seen that the hypostomal bridge is generally wider in *Hesperoboreus* than in *Boreus.* Within *Boreus,* fluctuation is too great for taxonomic use.

i. *Setae of the maxillo-labial complex*—The maxillo-labial complex of *Boreus* usually has a number of setae along the posterior margins (Fig. 8, p. 152). However, in *Hesperoboreus* these setae are usually completely lacking (Fig. 7, p. 152). Further, *B. nivoriundus* and *elegans* have some setae which are short and so thickened that they are termed spines (Figs. 9, p. 152; 10, p. 152). This character can be used to identify this *Boreus* subgroup.

j. *Notal bristles*—The bristles along the anterior and posterior margins of the pronotum and on the meso- and metanota are so easily visible and so invariable that they should be used for species recognition. Notal bristles are found in *Hesperoboreus* and the *nivoriundus* group of *Boreus* (Figs. 11, p. 153; 12, p. 153). Usually, there are 6 or 8 bristles along the anterior and posterior margins of the pronotum. The scutella of the mesonotum and metanotum may each possess two more bristles, but their presence is much more variable. In all North American species except *B. reductus,* presence of pronotal bristles is correlated with separation of the eighth abdominal tergum and sternum.

k. *Apical femoral spine*—This character is of some value but must be used with caution. The spine is reduced in size in some specimens, and occasionally may be absent entirely. Because smaller setae are also present near the distal ends of the femora, the specimens frequently must be rotated until the spine stands out against a lighted background from the femur and other setae. This spine is present in all North American boreids (Fig. 14, p. 155) except *B. coloradensis* (Fig. 15, p. 155), *reductus,* and sometimes *californicus*. *B. californicus* is very similar to *coloradensis* and no known character differentiates females. In a large collection of specimens from Helena, Montana, *all* female specimens without apical femoral spines were preserved *in copula* with males of *B. coloradensis,* while none of the female specimens with femoral spines and no males of *californicus* were mating when collected. It was hoped that the apical femoral spine could be used for identification, as it seemed reliable for the large

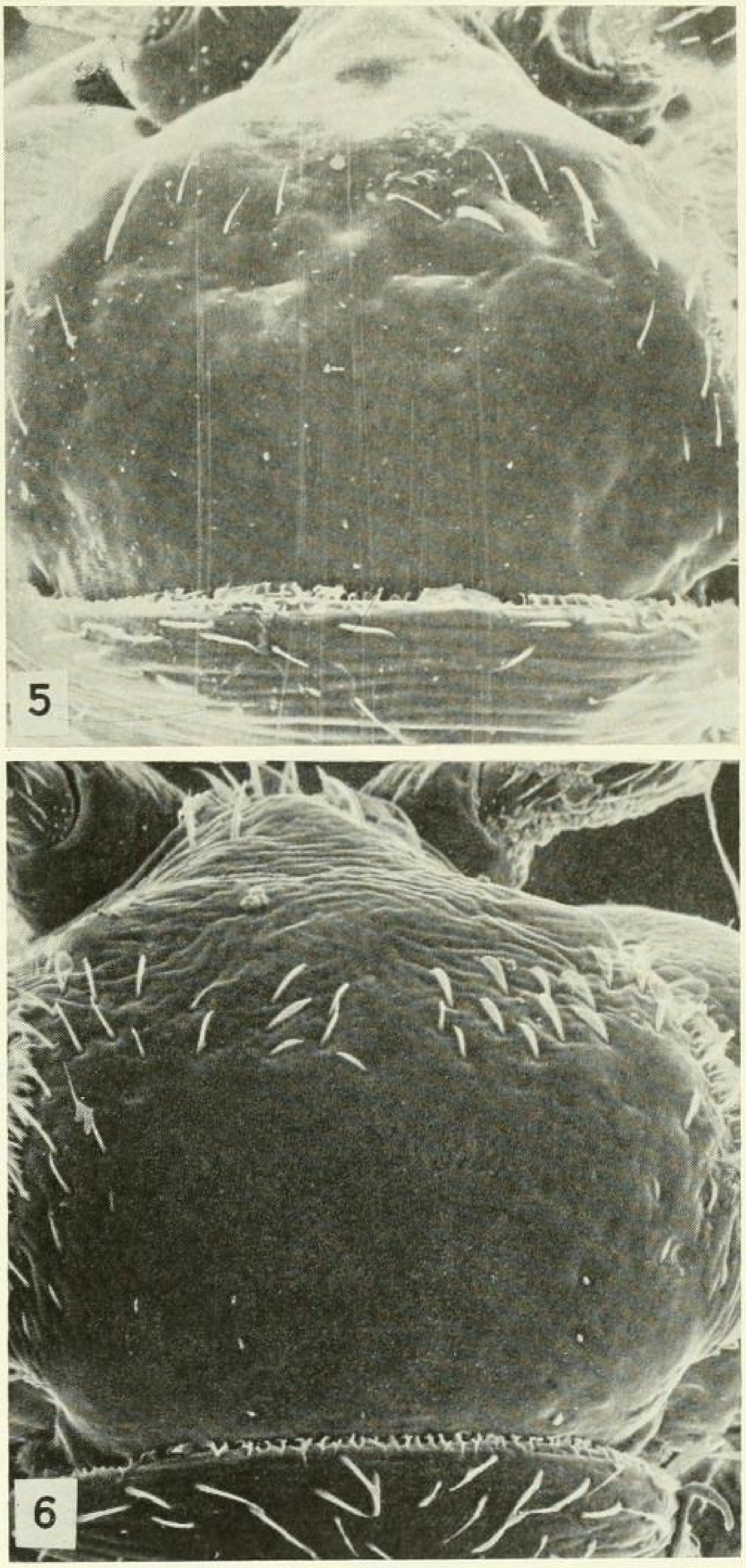
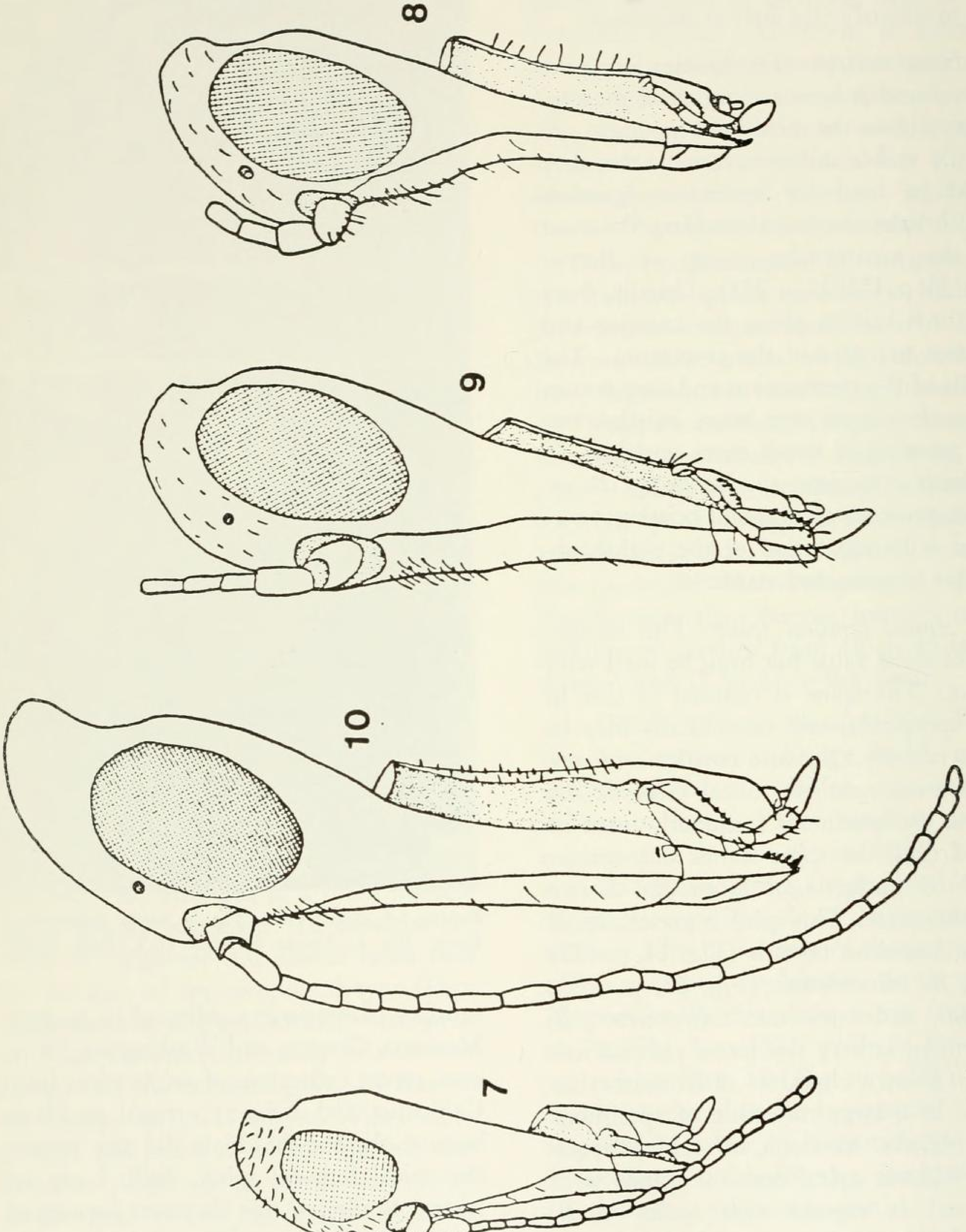


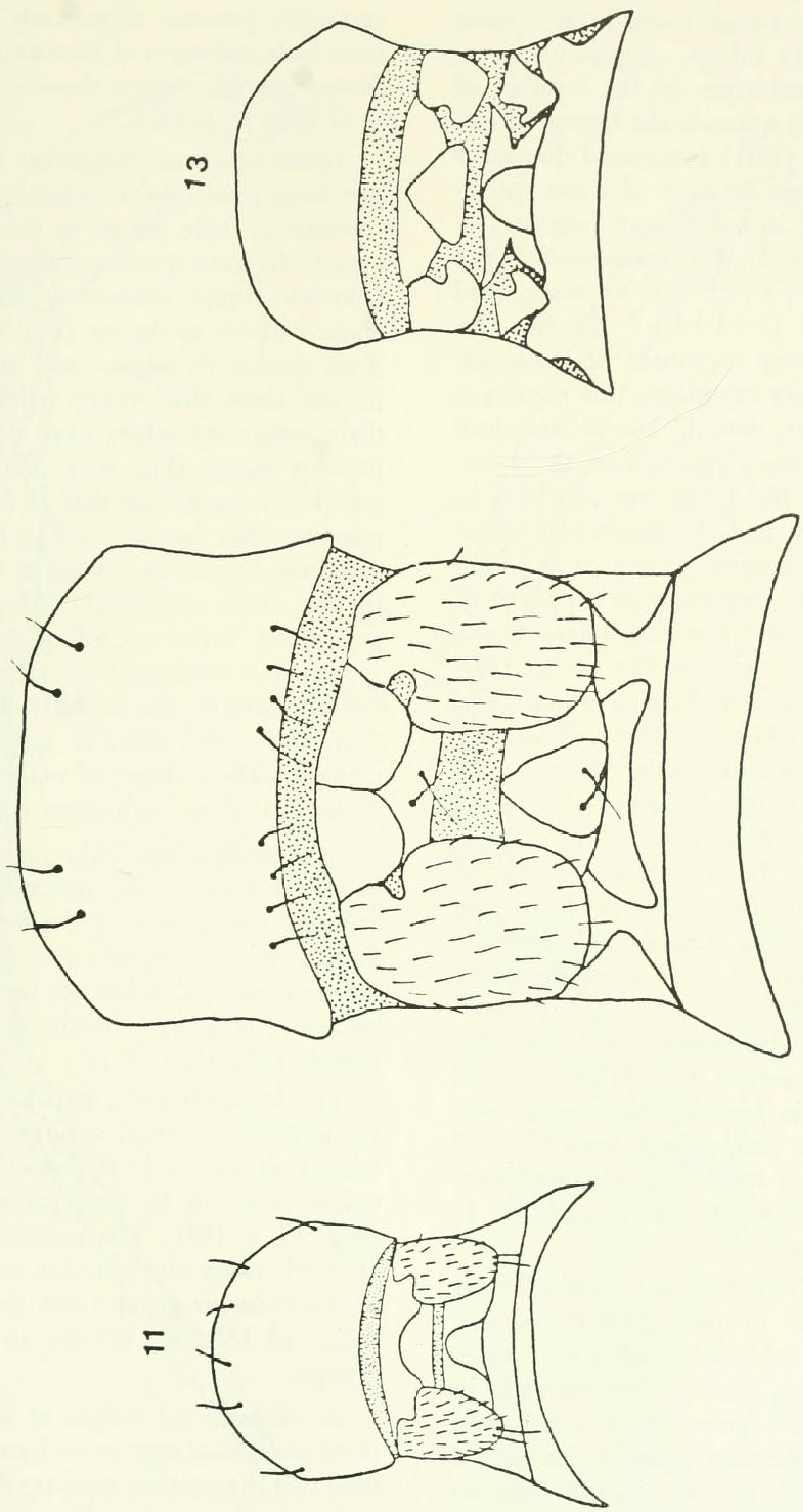
FIGURE 5,6, dorsal view. Fig. 5, *Boreus coloradensis* Byers. Fig. 6, *Boreus hyemalis* (L.). Both 175×.

number of specimens collected in western Montana, Oregon, and Washington. However, recent collections of *californicus* from California and Arizona created problems because these individuals did not possess the apical femoral spine. Still, I am reluctant to discard this character because of its usefulness in northern regions.

l. *Male wings*—Forewings of male boreids have two rows of spines. One row along the anal margin projects mesally (inner forewing spines), while a second row projects ventrally from the costal mar-



FIGURES 7-10, head, lateral view. Fig. 7, *Hesperoboreus brevicaudus* (Byers). Fig. 8, *Boreus coloradensis* Byers. Fig. 9, *Boreus nivoriundus* Fitch. Fig. 10, *Boreus elegans* Carpenter. All 53×.



Figures 11-13, thorax, dorsal view. Fig. 11, *Hesperoboreus brevicaudus* (Byers), 56×. Fig. 12, *Boreus elegans* Carpenter, 50×. Fig. 13, *Boreus reductus* Carp., 50×.

gin (outer forewing spines). The tip of the forewing extends caudally as a spine larger than the others. Apparently there has been a reduction in the number of outer forewing spines in the European species. Lestage (1941) mentioned that outer forewing spines in each of these species were grouped in a consistent pattern: six spines (2+2+2) for *westwoodi,* eight spines (1+1+4+2) for *hyemalis,* and eleven spines (5+1+1+3+1) for *kratochvili.* Among specimens of these species that I have examined, this pattern is not consistently found. North American species have more spines than the European species; the spines are arranged in uniform rows; and the number of spines varies both between species and within species. These appears to be a pattern of reduction in outer forewing spines as one looks from the *nivoriundus* group (Fig. 16, p. 158) to the *californicus* group (Fig. 17, p. 158) of species of *Boreus.* The number of spines among species of the *nivoriundus* group ranges from 14 to 19, in the *reductus* group from 11 to 19, in the *californicus* group from 7 to 13, and in the *hyemalis* group from 6 to 11. However, greatest reduction is seen in *Hesperoboreus* which has no outer forewing spines (Fig. 18, p. 158).

In *Boreus* the number of inner forewing spines ranges from 15 in several species to 36 in *borealis,* the greatest variation being in *californicus,* with 15 to 22 inner forewing spines. In *Hesperoboreus* the range is from 13 in *brevicaudus* to 16 in *notoperates.*

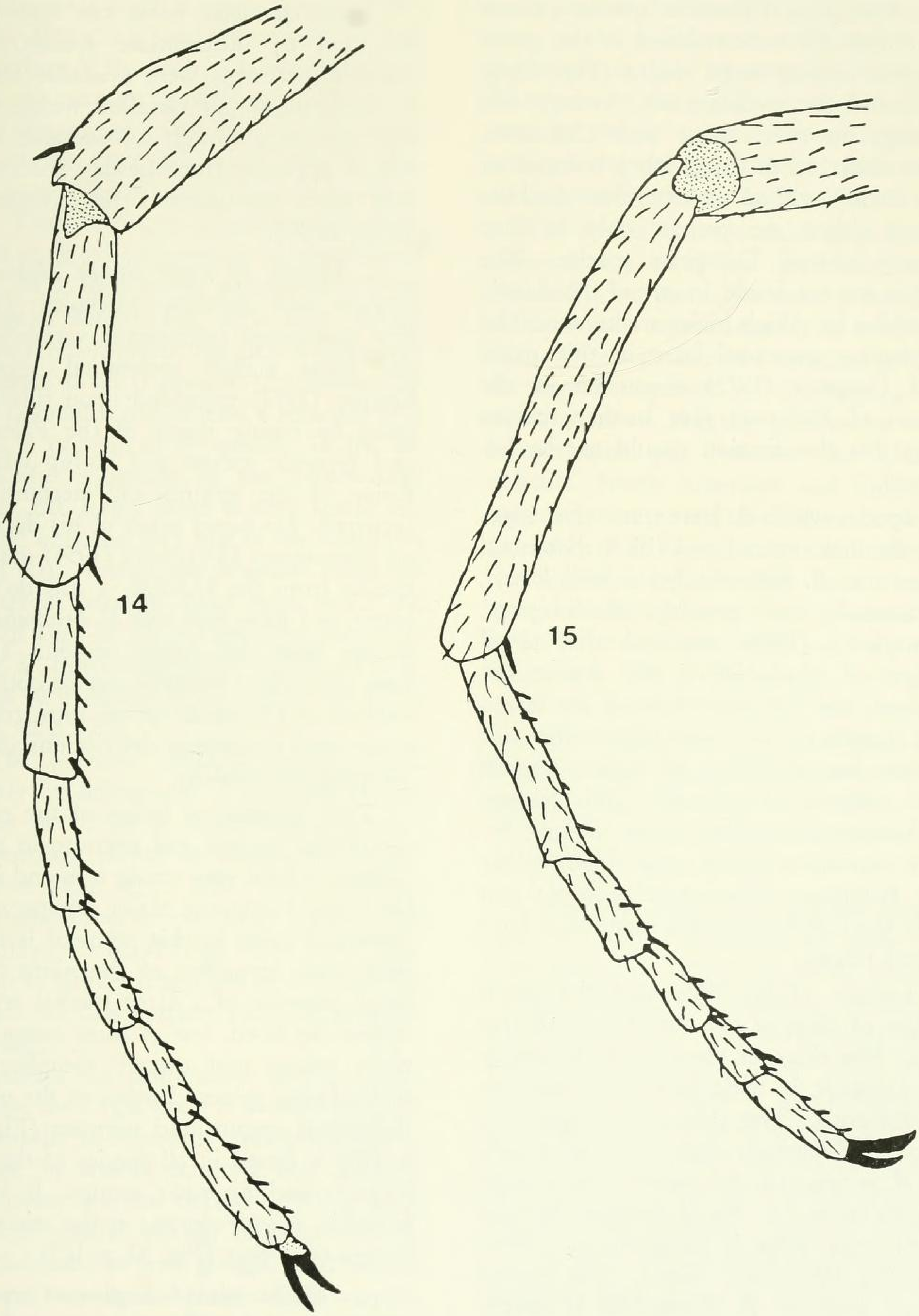
There is a reduction in hindwing spines similar to that in outer forewing spines. These spines are much smaller than those of the forewing, and project ventrally in a row. In the *nivoriundus* group, the number of hindwing spines varies from 9 to 16 (Fig. 16, p. 158), in the *reductus* group, it varies from 3 to 4, and frequently there are no spines at all in species of the *californicus* and *hyemalis* groups (Fig. 17, p. 158), although very small spines are occasionally present. Apparently, there has been little reduction of hindwing spines in *Hesperoboreus,* where there are from 10 to 17 (Fig. 18, p. 158).

Great taxonomic emphasis has in the past been placed on curvature of the outer margins of male wings, as seen in dorsal aspect. In most species of *Boreus,* there is a rather abrupt narrowing of the wing about halfway to the tip (Fig. 19, p. 159). Two species, *B. elegans* and *nivoriundus,* do not show this abrupt narrowing and their wings are wider near the tip than in other species (Fig. 20, p. 159). Carpenter (1936) mentioned that *B. intermedius* possesses this broader wing; however, I could see distinct narrowing at mid-length in the same specimens. Abruptness of narrowing varies according to how the specimen is positioned for viewing, for if viewed from too far laterally, an abruptly narrowed costal margin appears almost straight. Thus, shape of male wings can be used, if done with great caution.

m. *Female wings*—Although all species of boreids have an abundance of fine setae covering the dorsum of the female mesothoracic wings, only one species, *Hesperoboreus brevicaudus,* has yet been noted to possess several larger bristles at the caudal margin (Fig. 11, p. 153).

The female boreid's metathoracic wings are normally reduced to little more than wing vestiges, but in *B. reductus* this condition is found in both pairs of wings (Fig. 13, p. 153). The reduced mesothoracic wings are also found in other species of the *reductus* group from the Crimean region of U.S.S.R., but not in any other groups.

n. *Male tergal ridges of second and third abdominal segments*—Lestage (1940) used two characters to separate the Boreidae into two genera. Nearctic species (plus *B. semenovi*) were placed in the genus *Euboreus,* having no transverse ridges on the



Figures 14,15, left foreleg, dorsal view. Fig. 14, *Boreus elegans* Carpenter, 86×. Fig. 15, *Boreus coloradensis* Byers, 80×.

second and third abdominal terga (Fig. 21, p. 162) and lacking a medial tooth on the diststyles. Palearctic species (minus *B. semenovi*) were retained in the genus *Boreus,* having tergal ridges (Fig. 22, p. 162) and the medial tooth. Lestage was wrong, however, about both characters. The medial tooth (basal lobe) is found on the dististyles of *all* male boreids. And the tergal ridges are present only in four closely related European species. The ridges are not found in *any* of the Asiatic Boreidae for which males are known. The phylogeny presented later in this paper and Cooper's (1972) discussion of the status of *Euboreus* give further reasons why this classification should not be followed.

Species which do have transverse ridges on the male second and third abdominal terga are: *B. hyemalis, kratochvili, lokayi, westwoodi,* and possibly *chadzhigireji.* Martynova (1954) mentions that tergal ridges of *chadzhigireji* are almost not present, and her illustration of the terminal segments of the male suggest that this species has no fusion of eighth tergum and sternum. Fusion of eighth tergum and sternum probably occurred long before acquisition of the tergal ridges within the Boreidae. Thus, it is probable that only the first four species mentioned have tergal ridges.

Lestage (1941) illustrated the tergal ridges of three of the four European species. The ridge of the second tergum in *B. hyemalis* is wide and lobed near its lateral ends. The ridge of tergum 3 is also lobed laterally, but varies in width. In *B. westwoodi* the second tergal ridge is very similar to that of *hyemalis,* but the third tergal ridge is triangular to convex (lacking the lateral lobes). The second tergal ridge of *B. kratochvili* is deeply notched medially, giving the ridge a bipartite appearance. The third tergal ridge of *kratochvili* is obtusely angled to an ill-defined peak. Lestage's key to Palearctic boreids states that the third tergal ridge of *B. lokayi* is reduced to a small tubercle.

These character states can apparently be used to differentiate species. Not enough specimens were available for me to study the tergal variation within these four species, although considerable variation is apparent from Lestage's drawings and from specimens I have examined (Figs. 23-30).

o. *Fusion of male eighth abdominal tergum and sternum*—Mickoleit (1971) first mentioned interspecific variability of the male eighth abdominal segment. Cooper (1972) expanded upon this statement by listing many of the Palearctic and Nearctic species and noting whether fusion of the tergum and sternum had occurred. He based many of his decisions on illustrations Martynova (1954) made of species from the U.S.S.R. I can do little better, as I have seen only *B. hyemalis* and *vlasovi* from the Asiatic region. Therefore, until more material can be obtained, analysis of Palearctic species must rely on often-times incomplete descriptions and inadequate illustrations.

This character of fusion of the eighth abdominal tergum and sternum in males appears to be a very strong one, and it has been used to separate major groups within *Boreus.* Fusion in this segment is correlated with expansion of the ninth tergal hood, presence of a large medial septum within the hood, loss of some outer forewing spines, and usually complete loss of hindwing spines. Fusion of the eighth abdominal tergum and sternum (Fig. 31, p. 165) is found in all species of the *californicus* and *hyemalis* groups. It is not found in *Hesperoboreus* or the other two groups of *Boreus* (Fig. 32, p. 165).

p. *Male ninth tergum*—Carpenter (1931) stated that "The male genitalia are also useless because they are constant in all our species." However, there is more diversity of the male ninth tergum than anywhere else on the external surface of Boreidae (Figs. 34-49).

The male ninth tergum is narrow laterally, expanding caudally toward the dorsal surface of the body. On the dorsal surface, the tergum is cleft medially for a short distance at its caudal end. On either side of this cleft are apical areas of peglike setae, which I shall refer to as denticles. The number of denticles varies from about eight on each side in *Hesperoboreus* (Fig. 34, p. 166) to over a hundred in some species of *Boreus* (Fig. 40, p. 167). In the genus *Hesperoboreus* the cleft is large and no tergal hood is present. In *Boreus* the cleft is smaller and at least a remnant of a hood is present in all species. In the *nivoriundus* subgroup of the *nivoriundus* group, the tergal hood is very small, enclosing only the very tips of the dististyles (Fig. 40). Within the *brumalis* subgroup the tergal hood is more than twice the size of that of the *nivoriundus* subgroup (Fig. 37, p. 166) and there may be an indication of a medial ridge within the hood (Fig. 46, p. 170).

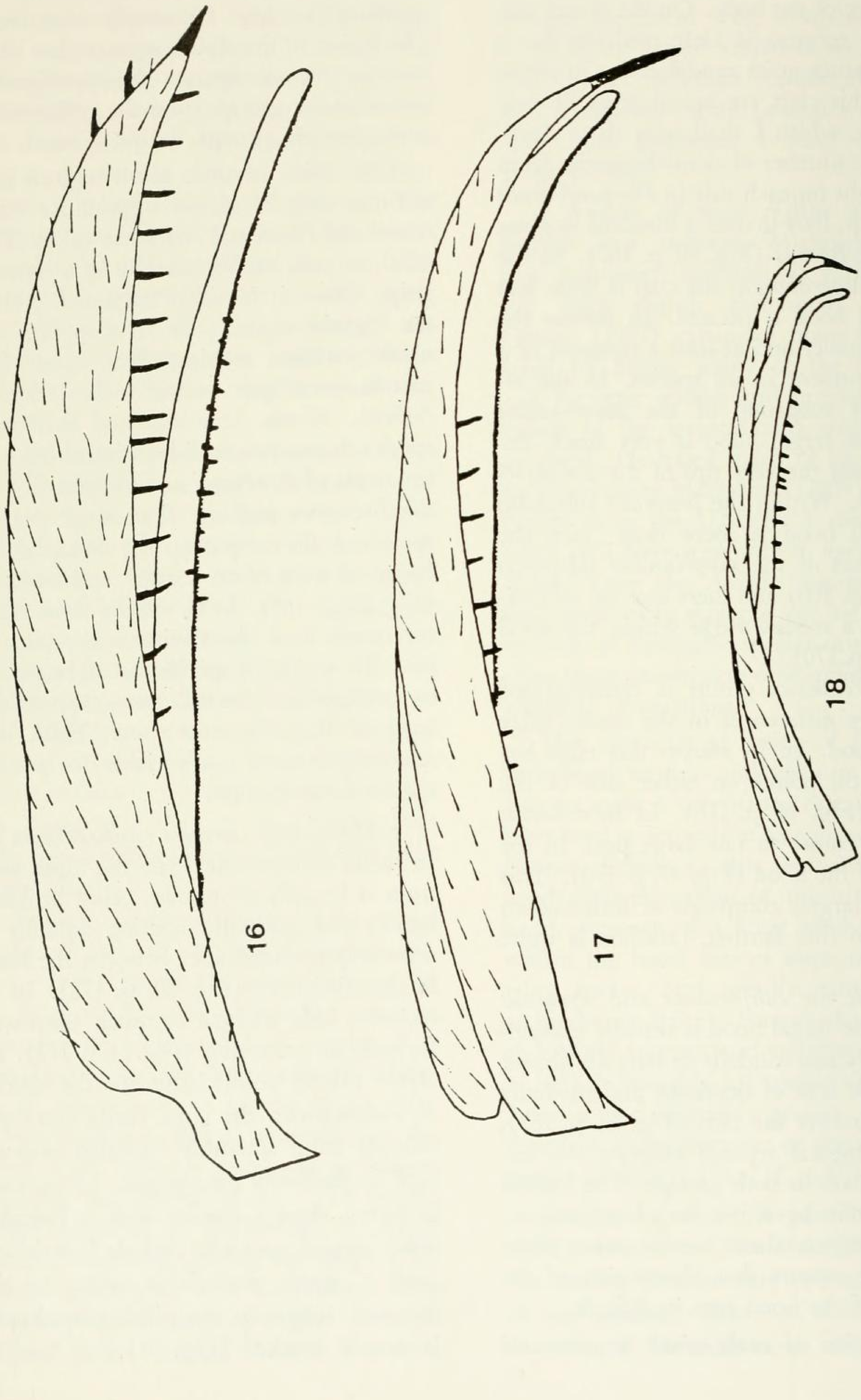
The *reductus* group is characterized mainly by differences in the caudal edge of the hood. In *B. vlasovi* this edge has symmetrical points on either side of the midline (Fig. 48, p. 170). In *B. reductus* the edge comes to one large peak in the middle of the hood (Fig. 47, p. 170). This group is largely composed of little-known species, so that further variation is quite possible.

Within the *californicus* and *hyemalis* groups, the tergal hood is broadly expanded dorsally and caudally to laterally almost engulf the area of denticles, and medially does cover over the cleft (Fig. 42, p. 167). A large medial septum supports this expanded hood in both groups. The medial septum may be either broad or narrow, and sometimes there are so many setae along the septum that observation of the interior of the hood area is difficult.

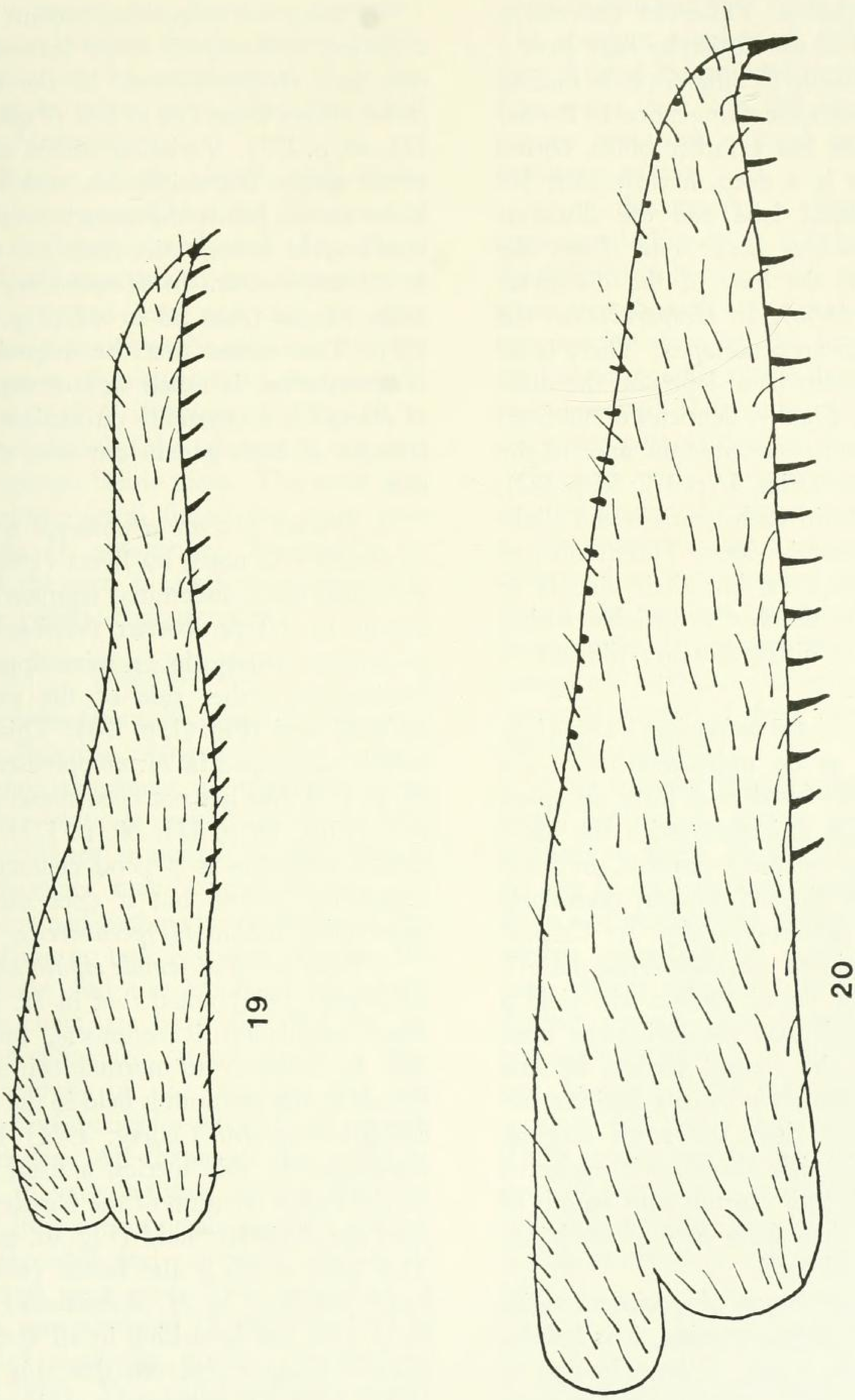
q. *Fusion of male ninth tergum and sternum*—Cooper (1972) mentioned that any revision of the Boreidae would necessarily include fusion of tergum and sternum in the eighth and ninth abdominal segments as key taxonomic characters. The fusion of the eighth segment has been used by me to separate the *nivoriundus* and *reductus* groups from the *californicus* and *hyemalis* groups within *Boreus*.

The fusion of male ninth tergum and sternum may be of less importance taxonomically, but it still has some value. The ninth tergum tapers laterally to a narrow strip. Often it is either retracted within the eighth segment or overlapping the ninth sternum, making observation of a membranous gap between the sclerites difficult. North American and European species do not possess this fusion; however, my study of *B. vlasovi* and examination of the literature indicate that some Asiatic species of *Boreus* possess the potential for fusion of male ninth tergum and sternum (Fig. 33, p. 165). In *B. vlasovi* some male specimens have the fusion, and some do not. These Asiatic species can all be placed in a subgroup of the *reductus* group on the basis of this character state. Thus, this character state is too variable for use in species identification.

r. *Male ninth sternum (hypandrium)*—In males of most Boreidae, the ninth sternum is broadly triangular, being broadest basally and gradually tapering caudally to a broadly rounded apex between the bases of the dististyles (Fig. 50, p. 172). In *B. reductus* this triangle is much narrower, forming an acute apex (Fig. 51, p. 172). As Byers (1955) pointed out for the species *B. coloradensis*, the apex varies intra-specifically from smoothly rounded to truncate to shallowly emarginate. In no case, however, does a species with a rounded ninth sternal apex also include individuals with a *deeply* emarginate apex. In the *brumalis* subgroup, the ninth sternal apex is deeply notched (Fig. 51).



FIGURES 16-18, male, left wing, lateral view. Fig. 16, *Boreus elegans* Carp., 86×. Fig. 17, *Boreus coloradensis* Byers, 86×. Fig. 18, *Hesperoborus brevicaudus* (Byers), 50×.



Figures 19,20, male, left forewing, dorsal view. Fig. 19, *Boreus coloradensis* Byers. Fig. 20, *Boreus elegans* Carpenter. Both 86×.

s. *Male diststyles*—These structures hold the female's eighth sternum in place during copulation. Observed differences in the shape of the diststyles may have a direct relationship to differences in mating posture between the two genera. In *Boreus* the basal lobe has a rather blunt, obtuse apex. There is a deep, narrow cleft between the basal lobe and the diststyle proper. Denticles occur only from the basal lobe to the base of the diststylar claw (Figs. 53-56). In *Hesperoboreus* the basal lobe has an acute apex. There is no cleft between the basal lobe and the diststyle proper. Finally, denticles occur from the basal lobe to very near the apex of the diststylar claw (Figs. 57, p. 172; 58, p. 172). Variation within each genus is too slight to be of taxonomic value. The number of denticles does vary, but their size is so small and the number so variable within a species that differences are difficult to detect.

t. *Length of the ovipositor*—This character varies, as do measurements of the structure. The fused cerci form an apical triangle which articulates with the tenth segment. In preserved specimens, the fused cerci may be directed straight posteriorly or deflected posteroventrally. As Carpenter (1935) pointed out, measuring the ovipositor on the dorsal surface will yield a different length than measuring the same specimen on the ventral surface, because the eighth sternum normally projects farther anteriorly than the tenth tergum. length of ovipositor therefore is measured as length of tenth tergum plus length of cerci, rather than from base of tenth tergum to tips of cerci.

Since overall length of specimens varies with method of preservation, it is helpful to compare the length of the ovipositor to that of some other relatively stable structure. The ratio gives an index of ovipositor length. Carpenter (1931) first used the rostrum as the second structure. Rostral length is measured from the ventral edge of the compound eye to the tip of the labrum.

By using the ovipositor/rostrum index, a distinct difference is noted between *Boreus* and *Hesperoboreus*. In *Boreus* the index ranges from 1.00 to 1.43 (Figs. 59, p. 173; 60, p. 173). Variation within and between species is considerable, making this index useless below the generic level. For instance, the index varies from 1.10 to 1.30 in *B. californicus*. In *Hesperoboreus* the index ranges from .33 to .63 (Fig. 61, p. 173). This means that the ovipositor of *Hesperoboreus* is much shorter than that of *Boreus*, a fact readily discernible when females of both genera are seen side by side.

u. *Process of tenth abdominal segment of female*—As noted by Byers (1961), the shortened tenth abdominal segment of the female in *Hesperoboreus brevicaudus* is prolonged posteriorly as spine-tipped extensions on either side of the partially unfused cerci (Fig. 61, p. 173). This structure is also found in *H. notoperates* (Fig. 62, p. 173), but has not been noted in *Boreus* (Figs. 59, p. 173; 60, p. 173). This caudal extension is a good character for separating genera, but it does not vary appreciably within *Hesperoboreus*.

v. *Basal notch of female eighth sternum*—Cooper (1974) noted that in *H. notoperates* copulation is reciprocal, meaning that in addition to normal coition the female eighth sternum is held in the male's endoandrium (of Cooper, 1974) by his diststyles. In this species, a basal notch on the eighth sternum of the female facilitates the diststylar hold (Fig. 62, p. 173). This basal notch is also found (although much smaller) in *H. brevicaudus* (Fig. 61, p. 173) but is lacking in all species of *Boreus*. Cooper observed that this mechanism helps *H. notoperates* maintain the unusual perpendicular mating position.

w. *Spines of the eighth abdominal sternum of the female*—All female boreids have some spines at the tip of the eighth sternum. Variation in number and placement of spines differs within species and between species, but there are consistent differences between the two genera. Spines only occur on the apical one-third in *Boreus,* while spines occur over the apical half in *Hesperoboreus.*

x. *Fusion of the female cerci*—Byers (1961) first reported that not all species of boreids had fully fused cerci (Fig. 64, p. 174). Until that time it was thought that Boreidae lacked cerci and that the apex of the ovipositor was the eleventh abdominal tergum. Byers separated the partially fused cerci of *H. brevicaudus* (Fig. 63, p. 174) and observed the sclerites of the eleventh segment below them. The same lack of complete cercal fusion has since been noted in *H. notoperates.* Incomplete fusion of the cerci is another taxonomically reliable generic character state.

PHENETICS

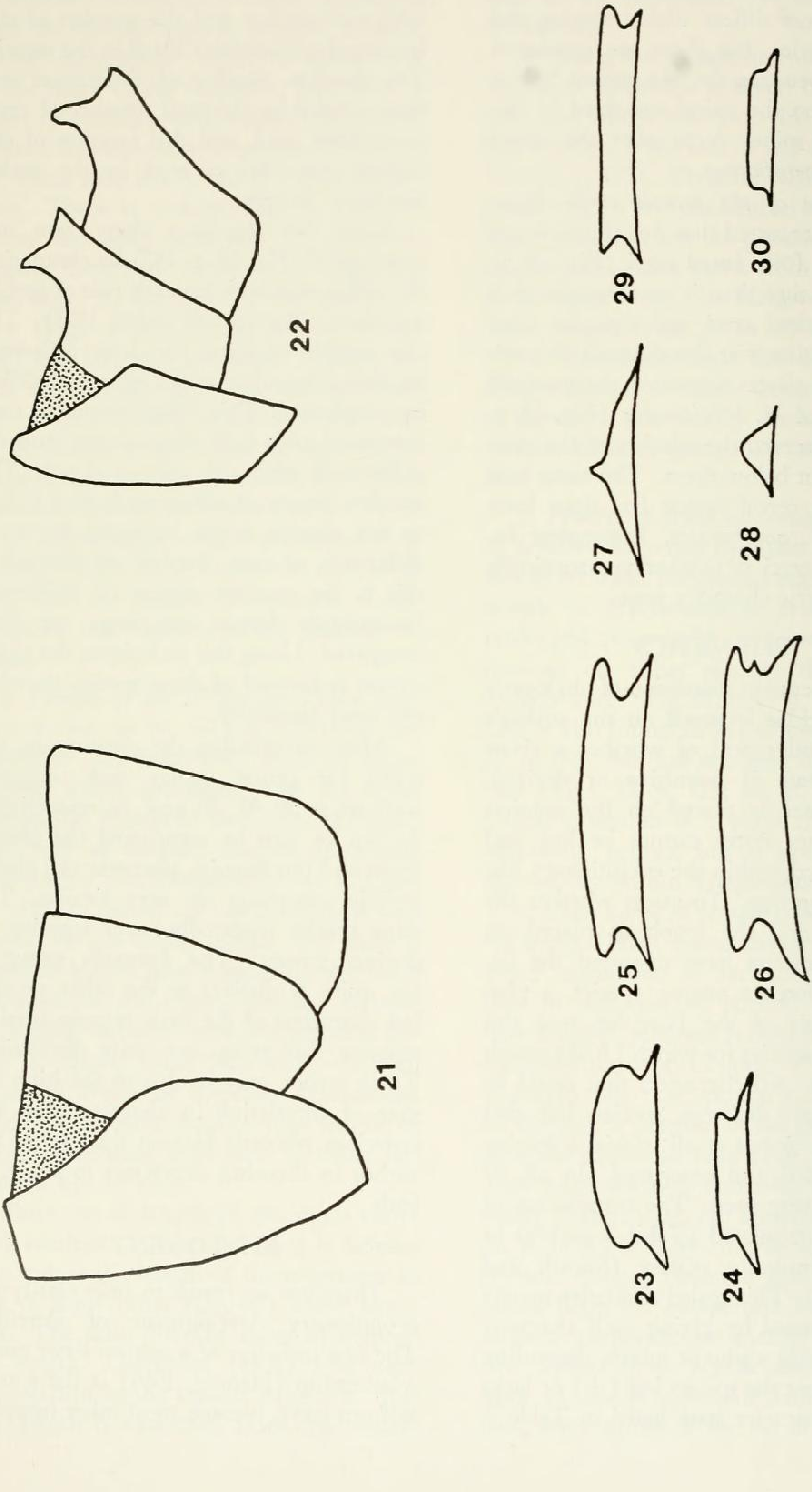
The subsequent discussion of phylogeny of the Boreidae is based on the author's subjective judgement of whether a given character state is primitive or derived. Much reliance is placed on the opinion that character states cannot be lost and then regained within the evolutionary history of the group. To assess whether the judgments and the emphasis placed on certain characters have distorted the degree of difference among species, a phenetic analysis of the Boreidae was also made of all species for which I had enough information. All characters that could be found to vary between species, but that varied little or not at all within a species, were recorded and compared. In all, 37 characters were used. The comparison of species was tabulated (Table 3, p. 176) in a scaled similarity matrix (Sneath and Sokal, 1973). This scaled similarity matrix was constructed by giving each character state (Table 4) a plus or minus, depending upon whether the species has (+) or lacks (—) the character state listed in Table 5, p. 178. The species were then compared with one another and the number of differences (mismatches) listed in the matrix. The absolute number of differences was then divided by the total number of character states used, and this fraction of difference was also entered in the scaled similarity matrix.

From this matrix a phenogram was constructed (Fig. 69, p. 182) by comparing the differences between each pair of species separately (Sneath and Sokal, 1973). The two species showing the least difference are linked together at the degree of difference indicated. This linked couplet is then compared with each other species, and the differences with the pair averaged. The smallest degree of difference is then linked to this couplet at the averaged degree of difference, or new couplets are formed, if this is the smallest degree of difference. Increasingly larger groupings are then compared. Using this technique, the phenogram is formed of these species showing the most similarity.

After constructing the phenogram, the levels for genus, group, and subgroup were set at .30-.40, .20, and .10, respectively. As can be seen by comparing the phenogram and phylogenies, phenetic and phylogenetic groupings are very similar. The same species repeatedly occur together in distinct groups. The *hyemalis* group is not quite as distinct as the other groups, but characters of the male tergum used to separate this group are quite discernible. These results may be due to the high degree of correlation in characters, an unconscious phenetic bias on the part of the author in choosing characters to study, or both.

PHYLOGENY

There are no fossils to help clarify the evolutionary development of Boreidae. The best indicator of a nearest sister group relationship (Hennig, 1965) is the scarabaeiform larva, because most other morpho-



FIGURES 21-30. Figs. 21,22, male, 1-3 abdominal terga, lateral view. Fig. 21, *Boreus coloradensis* Byers. Fig. 22, *Boreus hyemalis* (L.). Figs. 23,25,26, and 29, male, 2nd abdominal tergum, caudal view. Figs. 24,27,28, and 30, male, 3rd abdominal tergum, caudal view. Figs. 22-24, *Boreus hyemalis* (L.). Figs. 25-28, *Boreus lokayi* Klp. Figs. 29,30, *Boreus westwoodi* Hagen. All 100×.

logical traits are either unique or shared by several other mecopterous families.

Most mecopterous larvae are eruciform. Only one other family, the Panorpodidae, has scarabaeiform larvae. Within the Panorpodidae females are moderately to extremely short-winged and flightless, or nearly so. Adults generally live at elevations between 3000 and 8000 feet in the mountains of eastern and western North America, Japan, and Korea. Severe climatic conditions could have forced a population of panorpodid-like ancestors to express the genetic capability for additional cold tolerance with corresponding morphological modifications of size and structure. Comparisons between the two families indicate that within the Boreidae cerci and the tenth abdominal segment of the female fused into a heavily sclerotized ovipositor; adults and larvae adapted to feeding on moss, while panopodid larvae feed on roots and adults on leaf tissue; size became reduced; dark pigmentation increased; wings became reduced to heavily sclerotized flaps in the females and elongate, thin hooks in the males; the ocelli became more dispersed; and the life cycle increased to two years. The length of the life cycle is unknown in Panorpodidae, although in other mecopterous families where such information is available, the life cycle never exceeds one year.

The long rostrum of Boreidae is very

TABLE 1

List of Primitive Character States.

1. Presence of median ocellus
2. Occiput not rugulose
3. No occipital reticulations
4. 21 or more antennal segments
5. Antennal bases between compound eyes
6. Narrow hypostomal bridge
7. Only fine setae on posterior surface of rostrum
8. Setae on body uniformly short
9. Thoracic bristles present
10. Forewings narrowed abruptly at mid-length-male
11. Presence of outer forewing bristles-male
12. Female forewings covering hindwings-female
13. Absence of bristles at caudal margin of wing pad-female
14. No transverse ridges on second abdominal tergum-male
15. No transverse ridges on third abdominal tergum-male
16. No fusion of eighth tergum and sternum-male
17. No ninth tergal hood present-male
18. No fusion of ninth tergum and sternum-male
19. Ninth sternum smoothly rounded apically-male
20. Tenth abdominal segment short-female
21. No posterior process of tenth abdominal segment-female
22. Cerci not fused-female
23. Cerci evenly tapering to apex-female
24. Eighth sternum not notched basally-female

List of Derived Character States.

1. Loss of median ocellus
2. Gain of rugulose occiput
3. Loss of occipital reticulations
4. Loss of antennal segments
5. Movement of antennal bases to below eyes
6. Widening of hypostomal bridge
7. Gain of rostral spines
8. Gain of 25 rostral spines
9. Gain of long pilosity
10. Loss of thoracic bristles
11. Broadening of forewings at mid-length-male
12. Loss of outer forewing spines-male
13. Forewings reduced until they no longer cover hindwings-female
14. Gain of bristles at caudal margin of wing pad-female
15. Gain of transverse ridge on second abdominal tergum-male
16. Gain of transverse ridge on third abdominal tergum-male
17. Transverse ridge of third segment reduced to a tubercle-male
18. Fusion of eighth tergum and sternum-male
19. Development of small tergal hood-male
20. Tergal hood expanded to middle of denticular area-male
21. Tergal hood expanded to lateral margin of
22. Development of projections along lip of tergal denticular area-male
hood-male
23. Development of medial projections along lip of tergal hood-male
24. Gain of medial septum to tergal hood-male
25. Development of narrow median septum-male
26. Gain of short median septum with ventral fork-male
27. Development of numerous setae covering interior of hood-male
28. Fusion of ninth tergum and sternum-male
29. Development of notched ninth sternum-male
30. Lengthening of tenth abdominal segment-female
31. Development of posterior process on tenth abdominal segment-female
32. Complete fusion of cerci-female
33. Gain of abruptly narrowing of cerci at mid-length-female
34. Development of eighth sternal notch-female
35. Expansion of eighth sternal notch-female

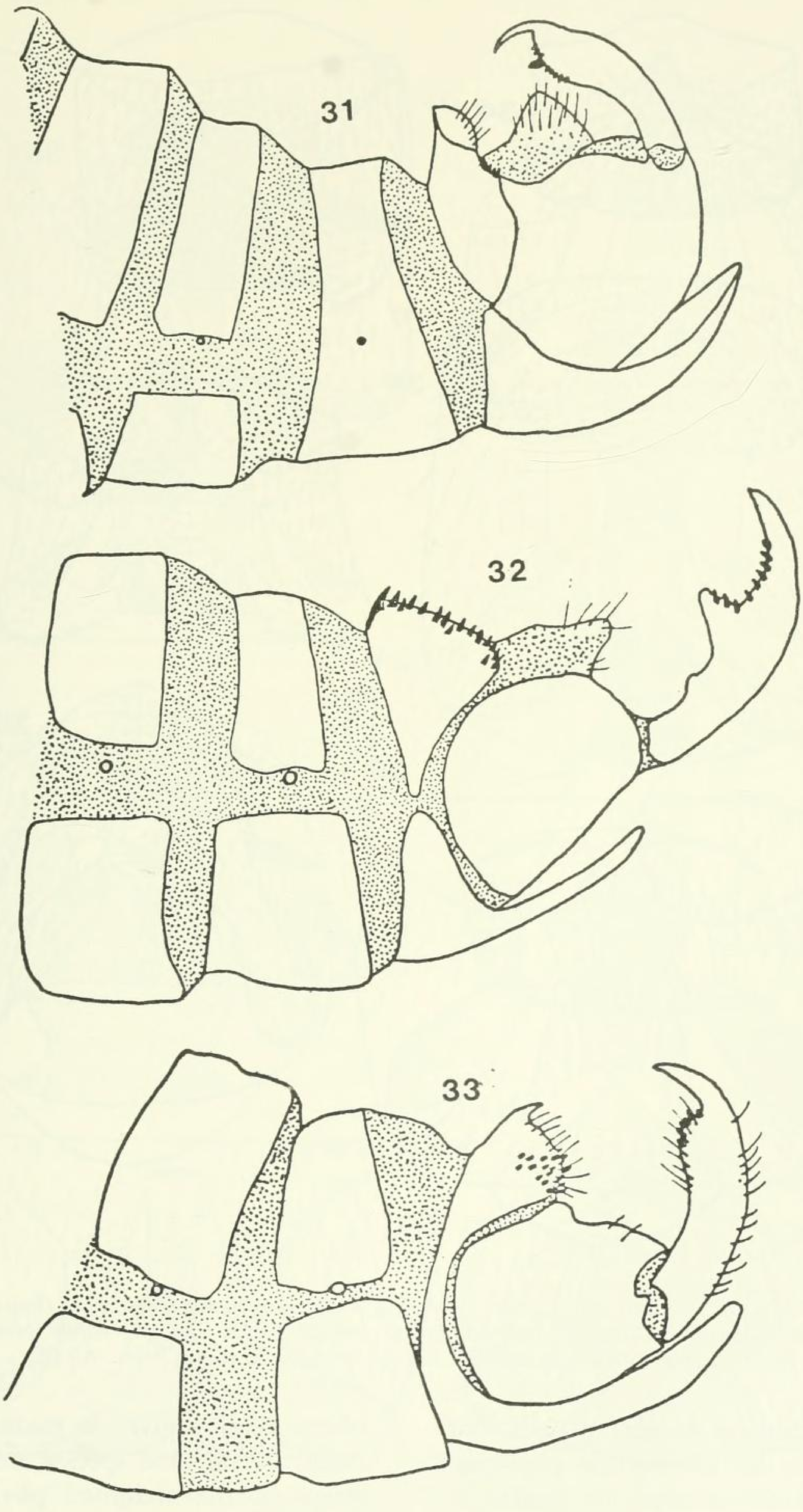
similar to that found in Panorpidae and indicates that ancestral boreids and panorpodids were distinct groups before secondary reduction of the rostrum began in Panorpodidae.

Many different ways can be used to depict diagrammatically the supposed evolution of Boreidae. Four methods are used here. The first (Fig. 66, p. 175) represents a phylogeny in which 35 derived character states (Table 1, p. 163) were chosen which varied between species, but were relatively constant within a species. These 35 character states were then analyzed to determine the probable primitive state for each (Table 1, p. 163) and subsequent development. They were then arranged on an unweighted branching sequence which would give the minimum number of changes in the characters. Although evolution may not always have taken the simplest course, the most parsimonious evolutionary diagram is presumably the best.

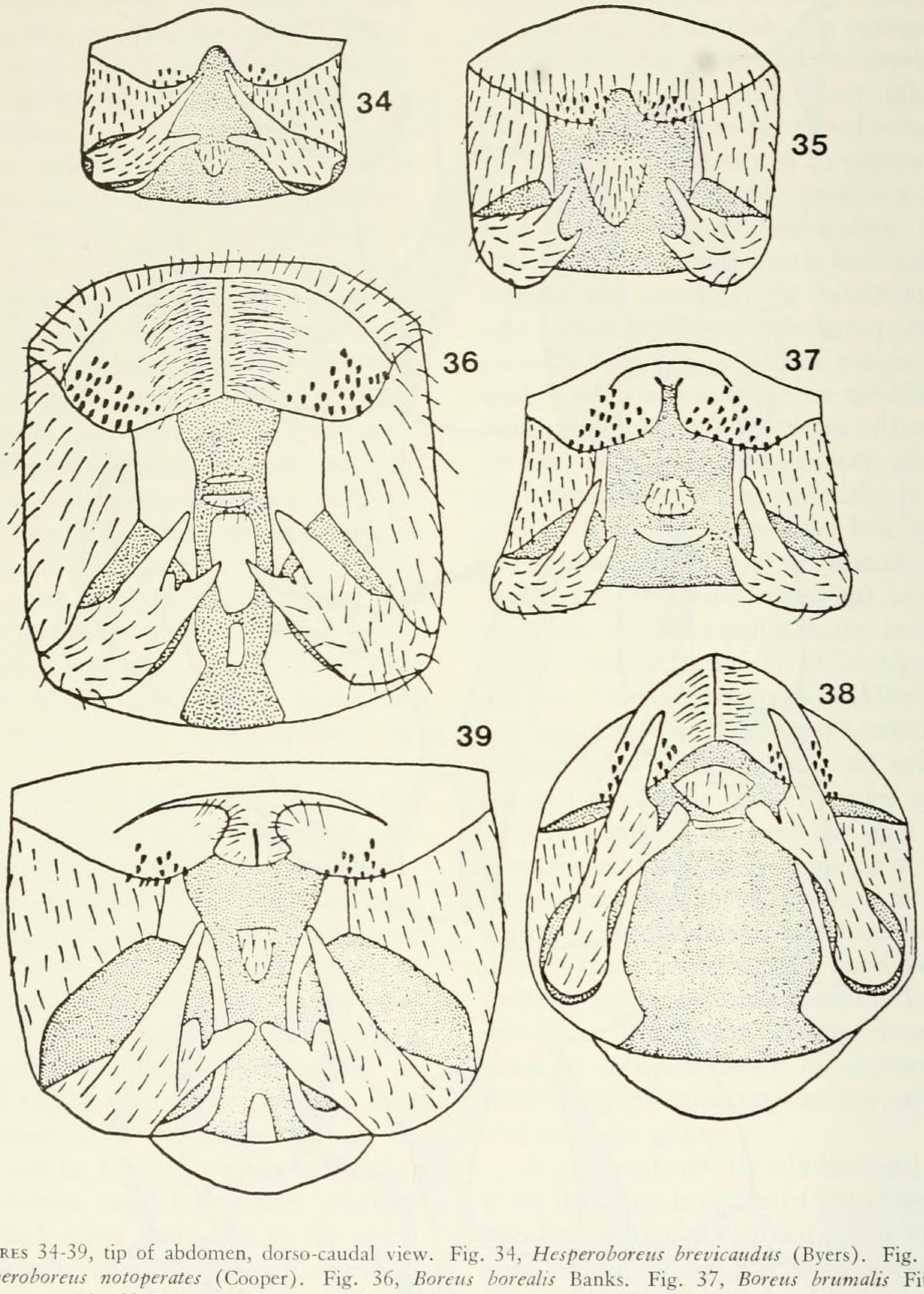
Many of the character states in this list are shared with the rest of Mecoptera, and are, therefore, considered primitive. Almost all Mecoptera have three ocelli, a smooth occiput without fine reticulations, antennal bases between the eyes, a narrow hypostomal bridge, fine setae on the posterior surface of the rostrum (if any setae at all) and prothoracic bristles, as well as unfused eighth tergum and sternum and no elaboration of the ninth tergum, in males, and in females a short tenth segment without caudal processes, unfused cerci which taper uniformly to the apex, and a basally unnotched eighth sternum. Mecoptera have long, filiform antennae with flagellomeres varying in number from about 60 in *Chorista* to 18 in *Bittacus,* with 40 or more being common in most families. Therefore, the largest number of flagellomeres found in Boreidae (23) is considered closest to the ancestral condition. Setation of Mecoptera usually consists of very small hairs on all areas of the body. Some boreids also have small hairs on most areas of the body, but two species (*Boreus nix* and *pilosus*) have developed extensive areas of thick, long pilosity, which I consider derived. Broad wings in the male are found only in *B. elegans* and *nivoriundus* and probably arose in a common ancestor of those two species. Likewise, reduction of the female forewings to vestiges not covering the hindwings is only found in the *reductus* group and is probably derived. A similar process was used to recognize as primitive the absence of bristles on the wing vestiges of females (bristles only in *H. brevicaudus*), absence of abdominal tergal ridges in males (ridges only in *hyemalis* group), the lack of fusion of ninth tergum and sternum of males (fusion only in *vlasovi* subgroup), and the smoothly rounded ninth sternum in males (deeply notched only in *H. notoperates* and the *brumalis* subgroup). Almost all Mecoptera have setae along the costal and anal margins of the wings, and enlargement of these setae could have led to the rows of spines along costal and anal margins of boreid forewings. Absence of these spines along the costal margins of forewings in *Hesperoboreus* is considered derived. The complex tergal hood of the *californicus* and *hyemalis* groups is derived through a progression of steps from no hood in *Hesperoboreus* to increasingly more complex structures in *nivoriundus* and *reductus* groups.

A conventional two-dimensional diagram depicting boreid phylogeny becomes too clustered around certain points to provide a clear idea of branching sequences. Therefore, a three-dimensional diagram was employed to allow more directions for progression. Displacement from one plate to the next above it of one millimeter in any horizontal plane (0°, 45°, 90°) corresponds to a change in one character state. However, direction of displacement has no biological significance.

A second phylogeny (Fig. 67, p. 180)



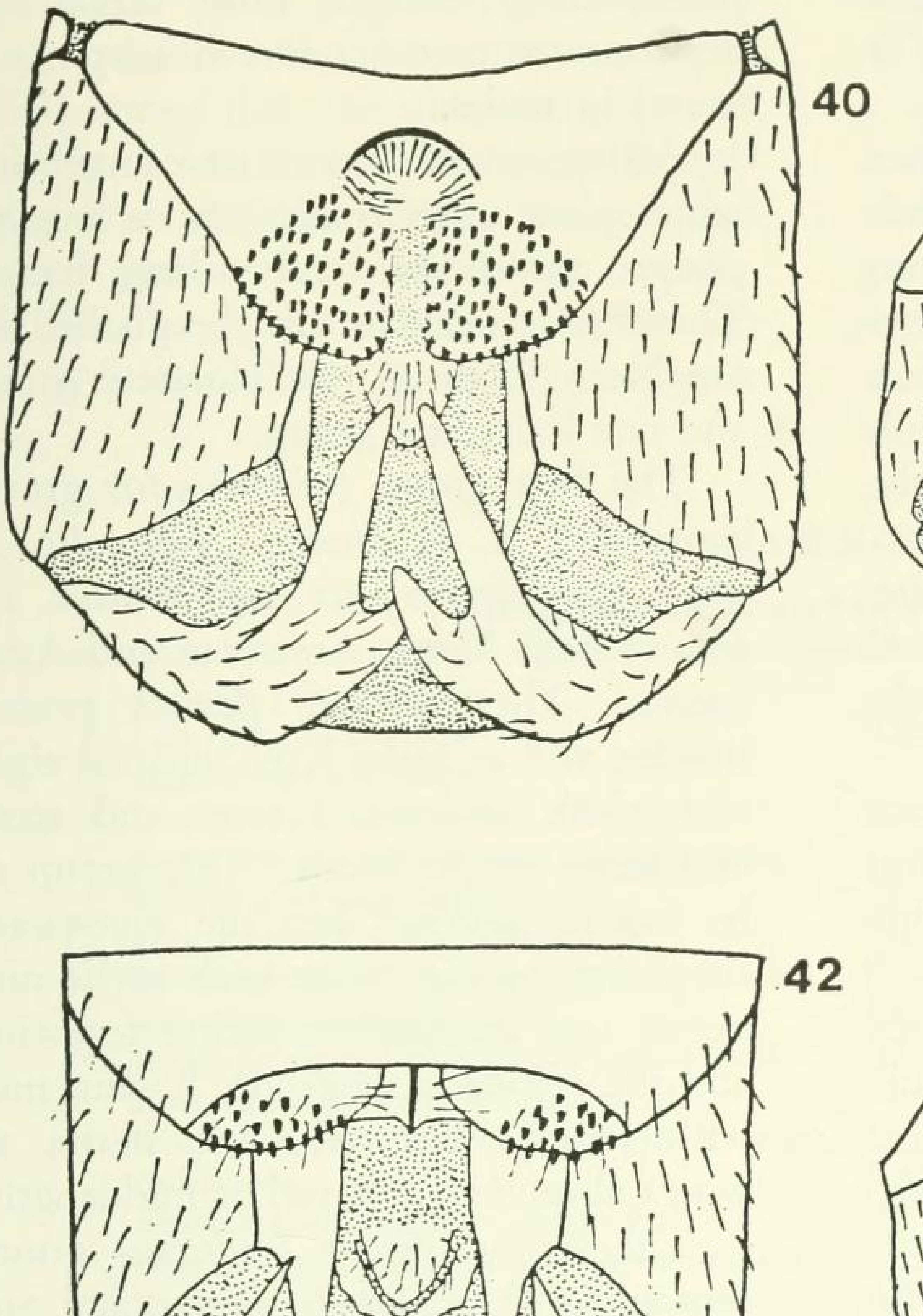
Figures 31-33, male, tip of abdomen, lateral view. Fig. 31, *Boreus coloradensis* Byers. Fig. 32, *Boreus reductus* Carpenter. Fig. 33, *Boreus vlasovi* Martynova. All 78×.



FIGURES 34-39, tip of abdomen, dorso-caudal view. Fig. 34, *Hesperoboreus brevicaudus* (Byers). Fig. 35, *Hesperoboreus notoperates* (Cooper). Fig. 36, *Boreus borealis* Banks. Fig. 37, *Boreus brumalis* Fitch. Fig. 38, *Boreus californicus* Packard. Fig. 39, *Boreus coloradensis* Byers. All 66×.

was constructed by weighting each character state in the unweighted phylogeny according to the number of species involved (Ashlock, unpublished method). This would give more value to those character states which help to unify groups of species. The final horizontal distance between species gives a measure of how closely related the species are. Character states on the weighted phylogenies are listed by branching sequence in Table 2, p. 169.

The third phylogeny (Figure 68, p. 181) illustrates a weighted phylogeny which



Figures 40-45, tip of male abdomen, dorso-caudal view. Fig. 40, *Boreus elegans* Carpenter. Fig. 41, *Boreus hyemalis* (L.). Fig. 42, *Boreus intermedius* Carp. Fig. 43, *Boreus lokayi* Klp. Fig. 44, *Boreus nivoriundus* Fitch. Fig. 45, *Boreus nix* Carpenter. All 66×.

uses not only the number of species involved but also the number of times a character state appears (Brothers, 1975). By assignment of only half value to a character state which has evolved twice, these character states lose much of their value. This is done because we are trying to determine the most probable line of evolution, and character states which appear to have evolved twice are more doubtfully correct and should be given less weight. By reducing their value such lines of evolution which use these character states appear to have diverged less. Figure 68 agrees with my own intuition as to the evolution of this group.

In all three phylogenies, the two genera, *Boreus* and *Hesperoboreus,* appear quite distinct, as do most of the groups and subgroups mentioned earlier. However, it will be noted that in the two weighted phylogenetic diagrams the *vlasovi* subgroup and *hyemalis* group do not appear to be very distinct, while the *nivoriundus* group is very distinct. This is due in part to the material available. All *nivoriundus* group species are represented, while *kratochvili* is lacking from the *hyemalis* group, and the only one *vlasovi* subgroup species is represented. Only one synapomorphous character (Hennig, 1965) separates the *nivoriundus* subgroup from the rest of *Boreus,* but because of the primitive position of this subgroup in the phylogeny and the large number of species involved, the two subgroups of the *nivoriundus* groups appear quite distinct from each other.

Boreids evolved in two directions. One group, given the new generic name *Hesperoboreus,* and containing *H. brevicaudus* and *notoperates,* lives in areas of rather warm climate along the west coast of the United States. These species possess two ocelli; large bristles are present along the anterior and posterior margins of the pronotum; the eighth tergum and sternum are not fused in males; females possess a very short ovipositor with cerci incompletely fused; and no ninth tergal hood development or outer forewing spines are found in males.

All species of *Boreus* have outer forewing spines in the males, and a long ovipositor and fused cerci among females. These species can in turn be divided into one Nearctic group, two Holarctic groups, and one Palearctic group.

The first group (*nivoriundus* group), containing *B. beybienkoi, brumalis, elegans, nivoriundus, nix,* and *pilosus,* consists of both North American and Asiatic species. These species possess pronotal bristles, and in males have unfused eighth and ninth abdominal terga and sterna, and small tergal hoods. This group can be further divided into the *nivoriundus* subgroup, having males with entire ninth sterna and gradually tapering forewings, and the *brumalis* subgroup, having males with deeply notched ninth sterna and wings abruptly narrowed at mid-length.

The second group (*reductus* group), containing *B. reductus, vlasovi,* and probably most Asiatic boreids, is found both in western North America and Asia. These species agree in possessing no pronotal bristles, unfused male eighth tergum and sternum, and a small tergal hood in males. This group also can be subdivided into two subgroups. The *reductus* subgroup has unfused ninth tergum and sternum in males, while the *vlasovi* subgroup usually has fused male ninth tergum and sternum. Most Asiatic species belong in this second subgroup.

B. orientalis may be an exception among Asiatic species. Martynova (1954) has illustrated part of the eighth abdominal segment of this species, showing it as fused. This would be the only known Asiatic species with fusion in both eighth and ninth segments. Until more is known about this species, I feel that it should be considered as a part of the *vlasovi* subgroup of the *reductus* group. Other Asiatic species which Martynova illustrated with fused ninth segment are *chadzhigireji, vlasovi,* and *semenovi.* Cooper (1973) stated that the ninth tergum and sternum of *vlasovi* were unfused, but this varies with the individual. Since *navasi* is very similar to *chadzhigireji,* it probably belongs in this subgroup. Although little is known about *sjoestedti,* perhaps it too belong to the *vlasovi* subgroup. To know with certainty, it will be necessary to collect males of these species.

The third group (*californicus* group) includes *B. borealis, californicus, coloradensis, and intermedius.* These species all possess no pronotal bristles, show fusion of eighth terga and sterna among males but no fusion of male ninth terga and sterna,

TABLE 2

Phylogenetic Character State Sequence.

Between points 1 and 2
1. Loss of median ocellus
2. Gain of rugulose occiput
4. Loss of antennal segments
5. Movement of antennal bases to below eyes
6. Widening of hypostomal bridge
12. Loss of outer forewing spines-male
31. Development of posterior process on tenth abdominal segment-female
34. Development of eighth sternal notch-female

Between point 2 and H. brevicaudus
14. Gain of bristles at caudal margin of wing pad-female

Between point 2 and H. notoperates
29. Development of notched ninth sternum-male
35. Expansion of eighth sternal notch-female

Between points 1 and 3
19. Development of small tergal hood-male
30. Lengthening of tenth abdominal segment-female
32. Complete fusion of cerci-female

Between points 3 and 4
7. Gain of rostral bristles
11. Broadening of forewings at mid-length-male

Between point 4 and B. elegans
8. Gain of 25 rostral bristles

Between point 4 and B. nivoriundus
none

Between points 3 and 5
20. Tergal hood expanded to middle of denticular areas-male

Between points 5 and 6
29. Development of notched ninth sternum-male

Between point 6 and B. brumalis
none

Between points 6 and 7
9. Gain of long pilosity

Between point 7 and B. nix
none

Between point 7 and B. pilosus
Loss of some denticles

Between points 5 and 8
10. Loss of thoracic bristles

Between points 8 and 9
1. Loss of median ocellus
4. Loss of antennal segments
22. Development of projections along lip of hood

Between point 9 and B. reductus
13. Forewings reduced until they no longer cover hindwings-female
23. Development of medial projections along lip of hood-male

Between point 9 and B. vlasovi
28. Fusion of ninth tergum and sternum-male
33. Gain of abruptly narrowed cerci at mid-length-female

Between points 8 and 10
18. Fusion of eighth tergum and sternum-male
21. Tergal hood expanded to lateral margin of denticular areas-male
24. Gain of median septum to tergal hood-male

Between points 10 and 11
none

Between point 11 and B. borealis
27. Development of numerous setae covering interior of tergal hood-male

Between point 11 and B. californicus
25. Development of narrow median septum

Between 11 and B. coloradensis
none

Between point 11 and B. intermedius
26. Gain of short median septum with ventral fork-male

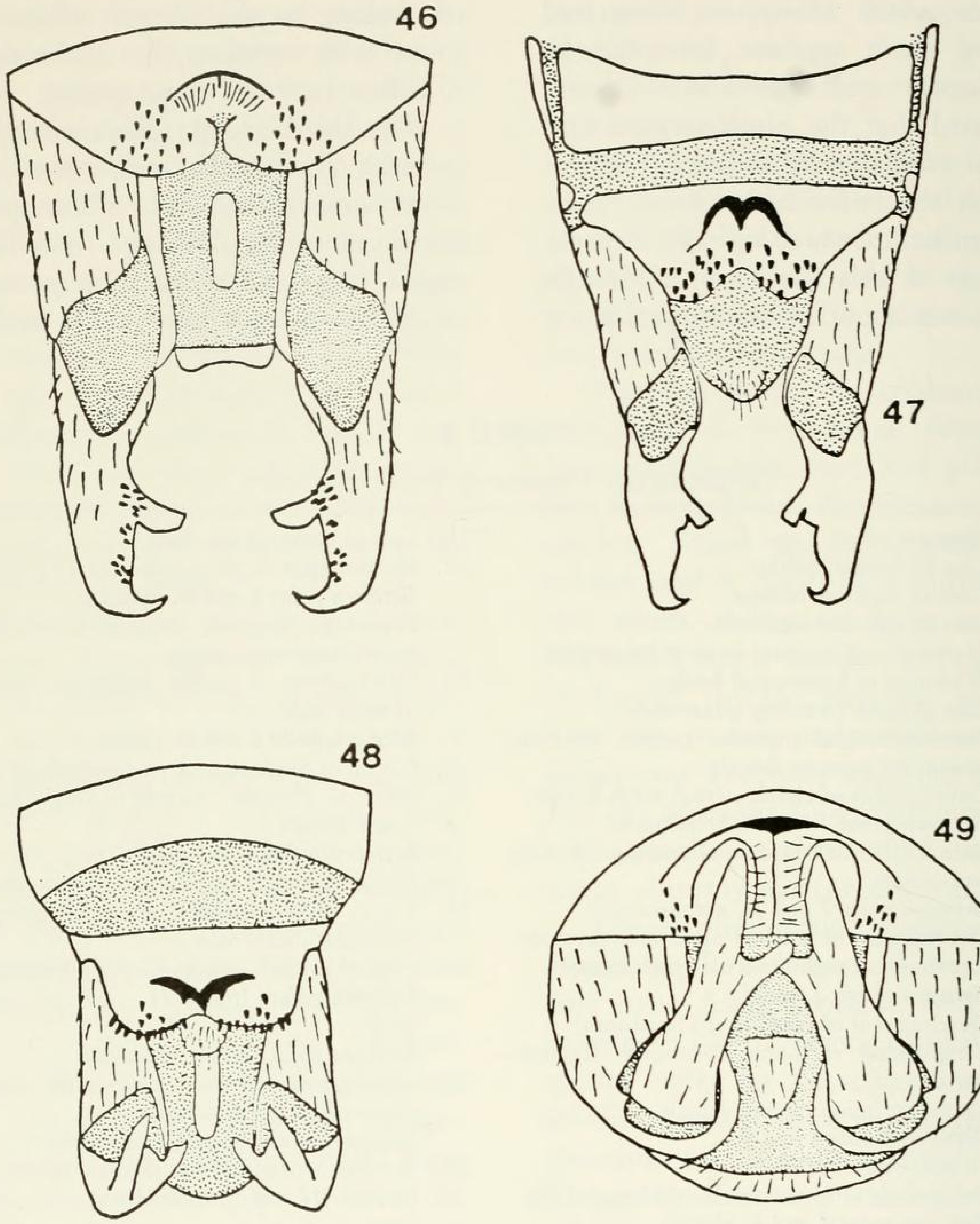
Between points 10 and 12
15. Gain of transverse ridge on second abdominal tergum-male
16. Gain of transverse ridge on third abdominal tergum-male

Between point 12 and B. hyemalis
3. Loss of occipital reticulations

Between points 12 and 13
none

Between point 13 and B. westwoodi
none

Between point 13 and B. lokayi
17. Transverse ridge of third segment reduced to a tubercle-male
26. Gain of short median septum with ventral fork-male



FIGURES 46-49, tip of abdomen, dorso-caudal view. Fig. 46, *Boreus pilosus* Carp. Fig. 47, *Boreus reductus* Carpenter. Fig. 48, *Boreus vlasovi* Martynova. Fig. 49, *Boreus westwoodi* Hagen. All 66×.

and have a large male tergal hood with median septum. All species of this group are Nearctic.

In the Palearctic region a fourth group of species occurs, the *hyemalis* group, consisting of *B. hyemalis, kratochvili, lokayi,* and *westwoodi.* These are similar to the *californicus* group but have transverse ridges on the second and third abdominal terga.

The picture that emerges from the morphology and distribution of these species is the following: ancestral boreids developed in the Nearctic region from a panorpodid-like ancestor, with flightless females, prothoracic bristles, and unfused eighth and ninth abdominal segments in the males. As is the *Hesperoboreus* species, females had incompletely fused cerci, and no elaboration had occurred on the male ninth abdominal tergum. This ancestral stock then split. *H. notoperates* and *brevicaudus* represent the remnant of an ancestral species which further split into two populations as glaciers retreated after the ice ages. One population (*notoperates*) remained in southern California and survived the warming trend by becoming adapted to warmer temperatures and moving to the higher elevations of Mount San Jacinto (and perhaps associated ranges). The other population *(brevicaudus)* remained at a lower elevation and moved or remained northward in western Oregon and Washington.

In the other ancestral stock, i.e., exclusive of *Hesperoboreus,* the female cerci fused entirely and the tenth abdominal segment became more elongate. This stage of development is exemplified by the *nivoriundus* group. This group is trancontinental in distribution in North America and is also found in the Ala-Too Range, north of the Himalayas. Although no specimens are now known from the Rocky Mountains of Colorado to southern Illinois, it seems likely that at one time environmental conditions permitted an east-west movement of *Boreus* across northern North America. Perhaps in the cooler regions of northern Canada this distribution is still contiguous, although there are no specimens to verify this. The presence of this group in Asia indicates a possible early movement into the Palearctic region.

The *nivoriundus* group is here subdivided into the *nivoriundus* subgroup (*elegans* and *nivoriundus*) and *brumalis* subgroup (*brumalis, nix,* and *pilosus*). *B. beybienkoi* is probably in this group, since the original description mentions prothoracic bristles. However, I have not seen specimens of this species and its position within the *nivoriundus* group is still not known.

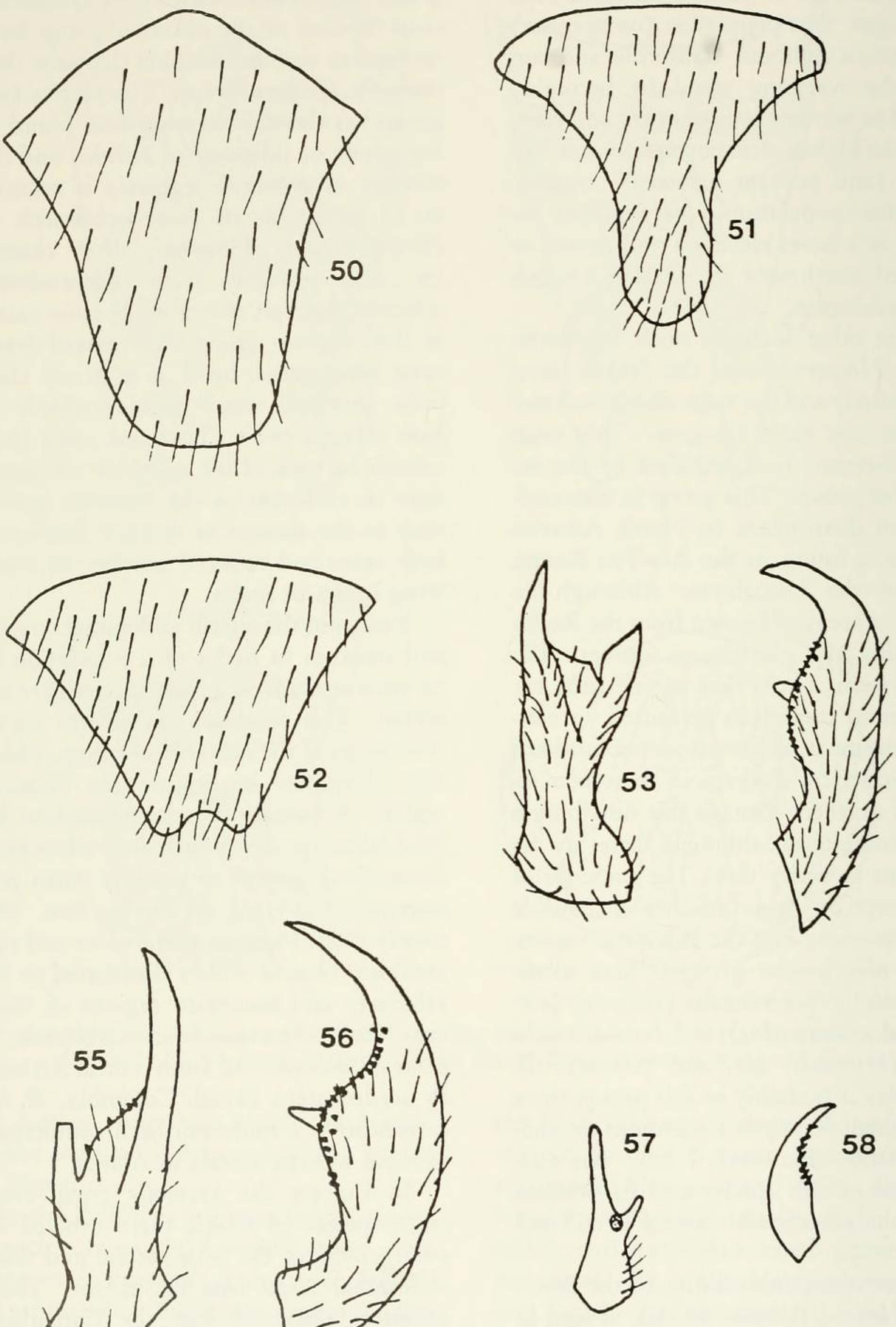
The next step in evolution of the Boreidae was loss of thoracic bristles, as seen in the *reductus* group. The only member of this group in the Nearctic region is *reductus,* distributed in the arid mountain regions of western North America.

There are some character states in this group that cause problems for phylogeneticists. Species of the *reductus* group have no median ocellus, in which character they resemble *Hesperoboreus.* The *vlasovi* subgroup has the shortest ovipositor found in any group or subgroup of *Boreus;* and the number of antennal segments is reduced to 19 or 20, as in some specimens of *Hesperoboreus.* However, these character states probably were independently achieved through reduction, because males of the *reductus* group have a well-developed ninth tergal hood, a relatively elaborate structure which seems unlikely to have evolved twice. There are other indications, as well, of the relatively advanced state of evolution of the *reductus* group, such as the absence of thoracic bristles in both sexes and reduced number of hindwing spines in males.

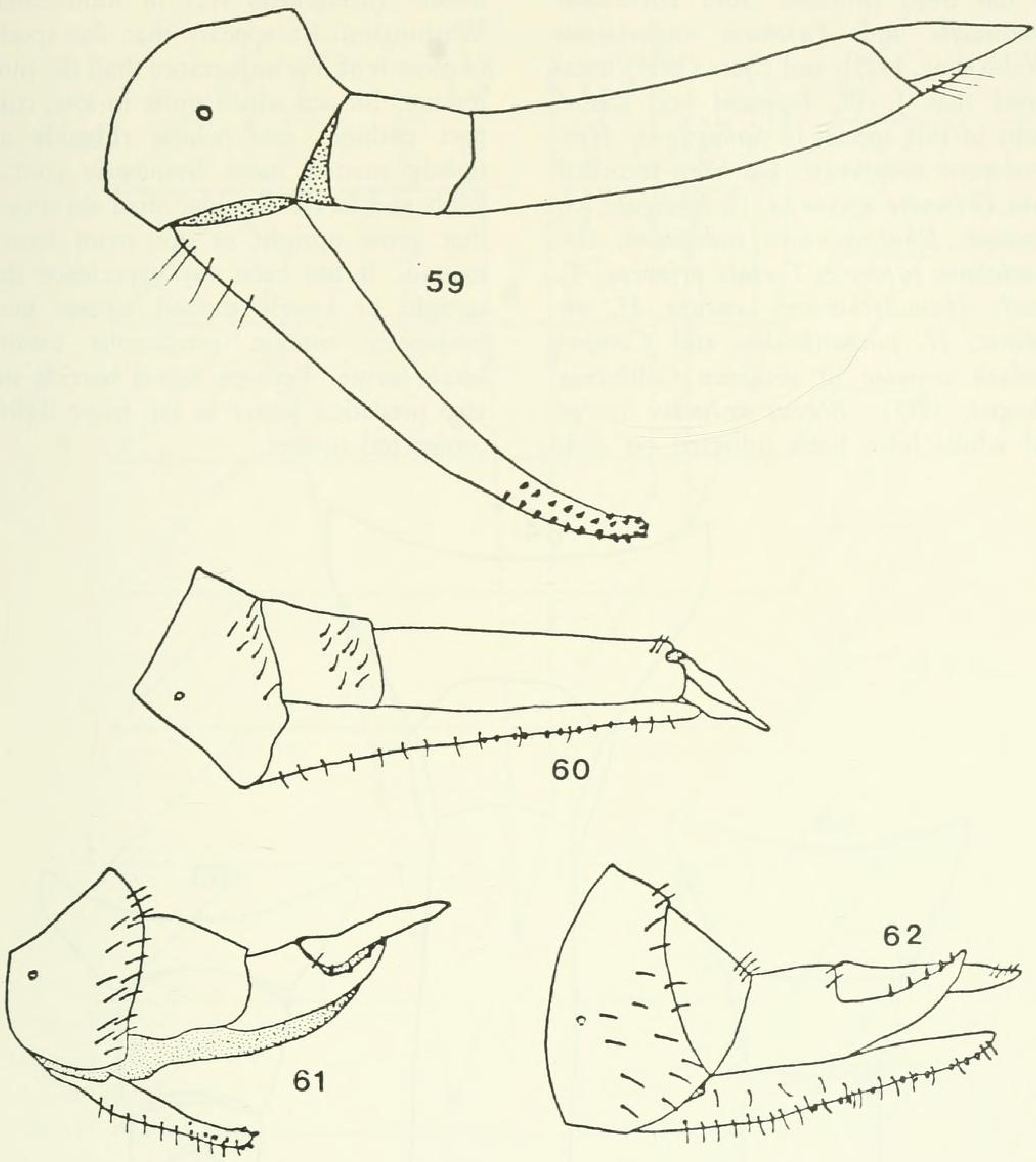
Fusion of the eighth abdominal tergum and sternum in males of a population of an ancient *reductus* group species later occurred. This condition created the ancestral species of the *californicus* group, which later disepersed in or into the Nearctic region. *B. borealis* became isolated on St. Paul Island, probably at a time when land connections existed, or possibly when permanent ice covered the Bering Sea. The closely related species *californicus* and *coloradensis* became widely distributed in the relatively arid mountain regions of western North America from California to central Colorado and from central Arizona to northwestern British Columbia. *B. intermedius* is a more northern counterpart of these western species in Alaska.

In Europe, the *hyemalis* group arose from species in which there evolved an enlargement of the male second and third abdominal terga into flat ridges. These ancestors dispersed into the Carpathian Mountains and western Europe.

Martynova (1954) stated that *B. chadzhigireji* had tergal ridges but that they were almost absent. The figures accompanying her description showed no fusion



FIGURES 50-52, male, *ninth sternum,* ventral view. Fig. 50, *Boreus coloradensis* Byers. Fig. 51, *Boreus reductus* Carp. Fig. 52, *Boreus brumalis* Fitch. Figs. 53-58, male, dististyle. Figs. 53-54, *Boreus coloradensis* Byers. Figs. 55,56, *Boreus elegans* Carp. Figs. 57,58, *Hesperoboreus brevicaudus* (Byers). Figs. 53,55, and 57, caudal view. Figs. 54,56, and 58, lateral view. All 88×.



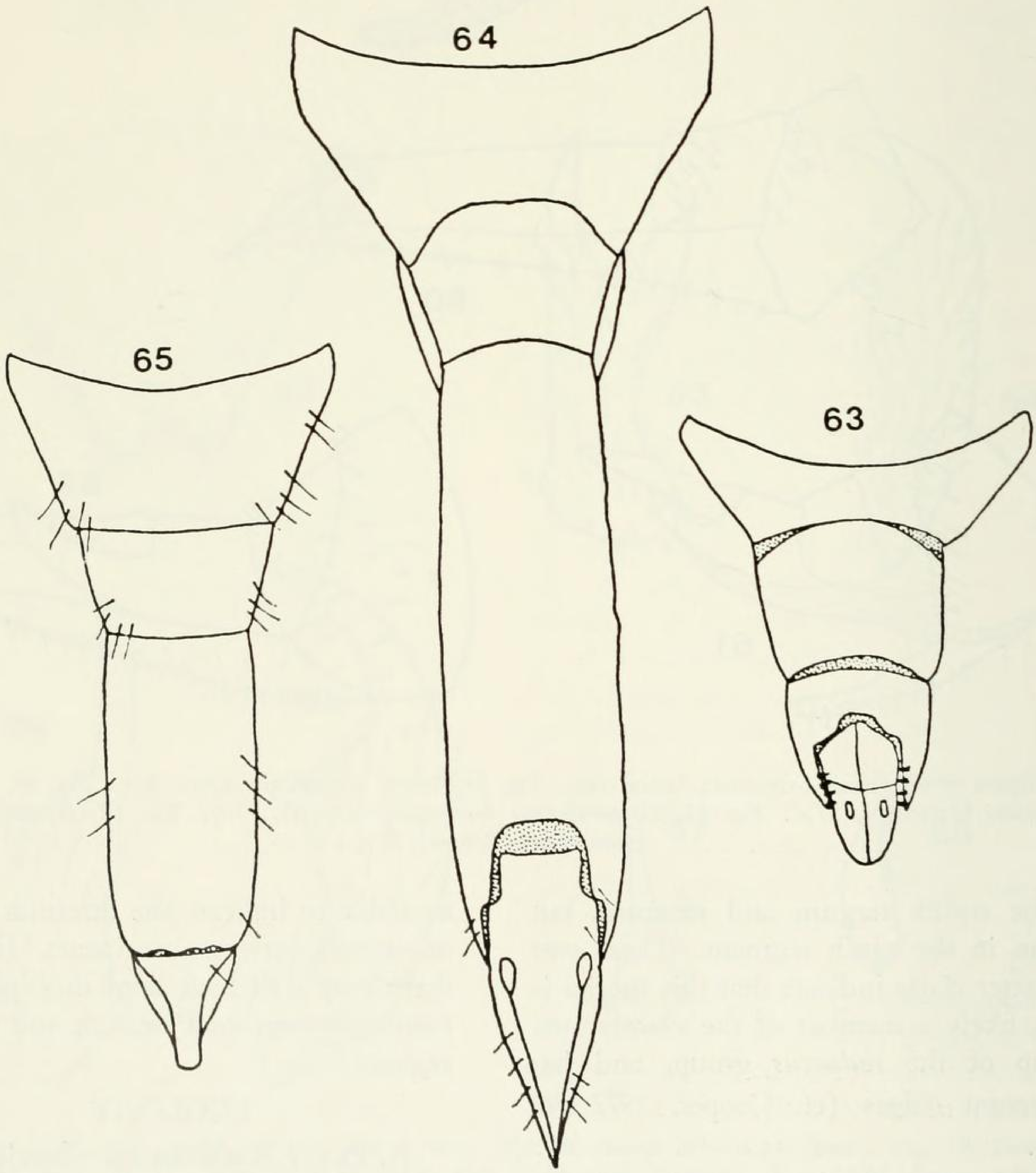
Figures 59-62, female ovipositors, lateral view. Fig. 59, *Boreus coloradensis* Byers, 50×. Fig. 60, *Boreus vlasovi* Martynova, 57×. Fig. 61, *Hesperoboreus brevicaudus* (Byers), 57×. Fig. 62, *Hesperoboreus notoperates* (Cooper), 57×.

of the eighth tergum and sternum, but fusion in the ninth segment. These two character states indicate that this species is most likely a member of the *vlasovi* subgroup of the *reductus* group, and has no tergal ridges (cf. Cooper, 1972:276-277).

Both the *nivoriundus* and *reductus* groups are Holarctic, and little evidence is available to indicate the direction of their movement between continents. However, there may well have been multiple movements between the Palearctic and Nearctic regions.

ECOLOGY

A. Plant Associations—Boreidae have been taken from many mosses. *Boreus brumalis* larvae from eastern North America has been collected from *Dicranella heteromalla* and *Atrichum angustatum* (Webb et al., 1975), and Byers (1954) mentioned that J. W. Leonard had found adults of this species in *Sphagnum*. *Hesperoboreus notoperates* has been recorded from *Grimmia apocarpa, G. laevigata, G. montana, Rhacomitrium sudeticum, Orthotrichum rupestre, Tortula princeps, T. ruralis, Homalothecium aeneum, H. nevadense, H. pinnatifidum,* and *Campothecium amesiae* in southern California (Cooper, 1974). *Boreus reductus* larvae and adults have been collected on club mosses (*Selaginella* sp.) in southeastern Washington. It appears that the species of moss is of less importance than the moss texture. Mosses which grow in low, compact cushions and whose rhizoids are tightly matted more frequently contain adult and larval Boreidae than do mosses that grow upright or are more loosely matted. It has been my experience that upright or loosely matted mosses more frequently contain predaceous carabid beetle larvae. Perhaps, larval boreids survive predation better in the more tightly compacted mosses.



FIGURES 63-65, female ovipositors, dorsal view. Fig. 63, *Hesperoboreus brevicaudus* (Byers). Fig. 64, *Boreus coloradensis* Byers. Fig. 65, *Boreus vlasovi* Martynova. All 66×.

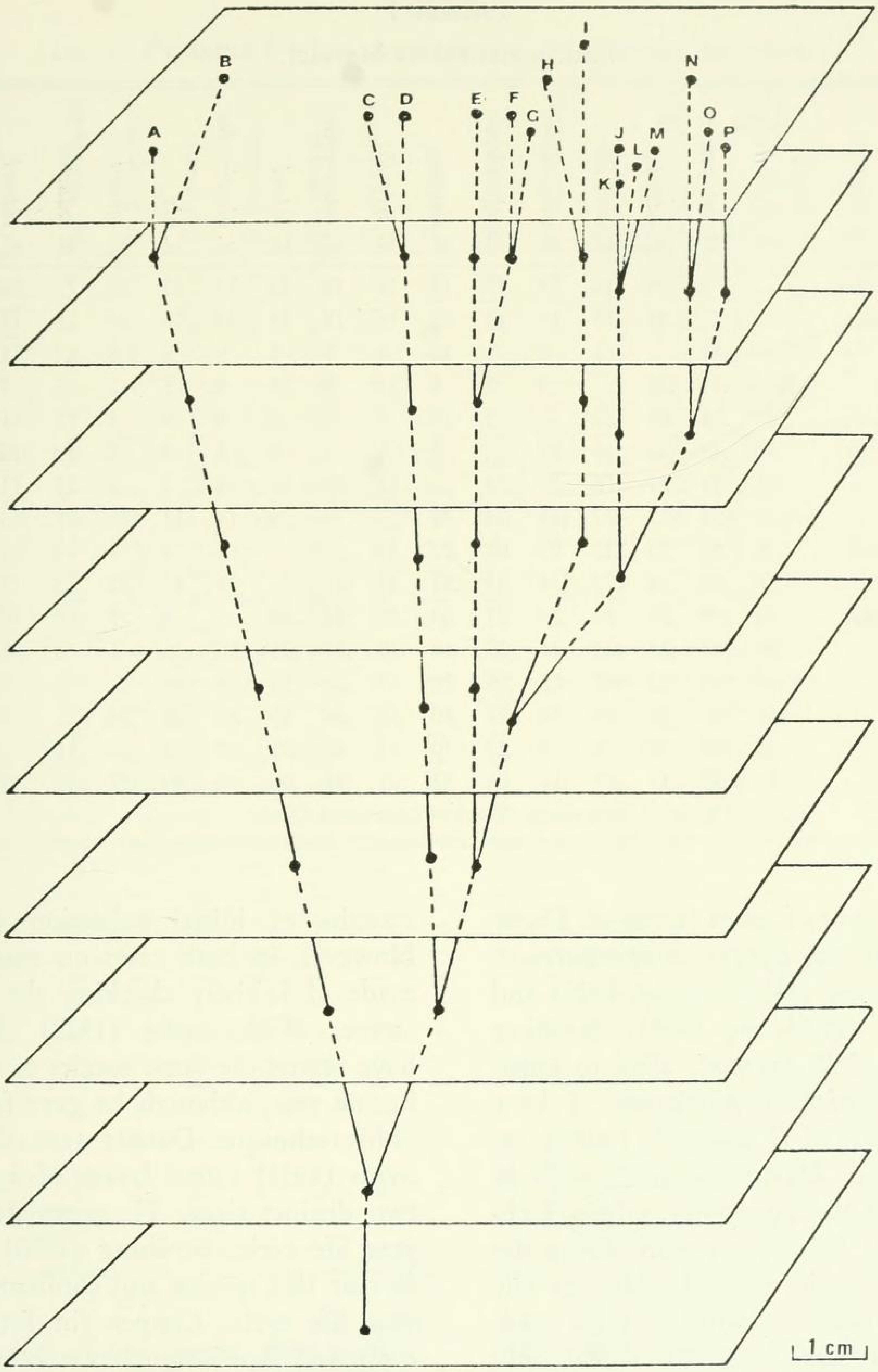


Figure 66. Three dimensional unweighted phylogeny. Movement between plates in any direction of 1 cm indicates one character state change. (Direction of change in position between plates has no biological significance.) A is *H. notoperates*, B is *H. brevicaudus*, C is *B. elegans*, D is *B. nivoriundus*, E is *B. brumalis*, F is *B. nix*, G is *B. pilosus*, H is *B. reductus*, I is *B. vlasovi*, J is *B. coloradensis*, K is *B. borealis*, L is *B. californicus*, M is *B. intermedius*, N is *B. lokayi*, O is *B. westwoodi*, and P is *B. hyemalis*.

B. Feeding—Withycombe (1922) mentioned keeping one female of *Boreus hyemalis* alive for 37 days on juices of crushed flies, although in a later paper (Withycombe, 1926) he states that the diet of *Boreus* is moss. Other authors (Brauer, 1855, and Steiner, 1937) have speculated that *Boreus* feeds on collembolans, although no evidence has been presented to support this. The European *B. hyemalis*

TABLE 3

SCALED SIMILARITY MATRIX.

	H. brevicaudus	*H. notoperates*	*B. borealis*	*B. brumalis*	*B. californicus*	*B. coloradensis*	*B. elegans*	*B. hyemalis*	*B. intermedius*	*B. lokayi*	*B. nivoriundus*	*B. nix*	*B. pilosus*	*B. reductus*	*B. vlasovi*	*B. westwoodi*
H. brevicaudus	....	3	18	16	18	17	18	18	18	22	17	17	16	17	16	20
H. notoperates	.08	....	19	15	19	18	19	19	19	23	18	16	15	18	18	21
B. borealis	.49	.51	....	8	2	1	10	4	2	6	9	9	8	11	11	4
B. brumalis	.43	.41	.22	....	8	7	6	10	8	10	5	1	2	7	7	10
B. californicus	.49	.51	.05	.22	....	1	10	4	2	6	9	9	8	11	11	4
B. coloradensis	.46	.49	.03	.19	.03	....	9	3	1	5	8	8	7	10	10	3
B. elegans	.49	.51	.27	.16	.27	.24	....	12	10	12	1	7	8	11	11	12
B. hyemalis	.49	.51	.11	.27	.11	.08	.32	....	4	4	11	11	10	13	13	2
B. intermedius	.49	.51	.05	.22	.05	.03	.27	.11	....	4	9	9	8	11	11	4
B. lokayi	.60	.63	.16	.27	.16	.14	.32	.11	.11	....	11	11	12	13	13	2
B. nivoriundus	.46	.49	.24	.14	.24	.22	.03	.30	.24	.30	....	6	7	10	10	11
B. nix	.46	.43	.24	.03	.24	.22	.19	.30	.24	.30	.16	....	1	8	8	11
B. pilosus	.43	.41	.22	.05	.22	.19	.22	.27	.22	.32	.19	.03	....	9	9	10
B. reductus	.46	.49	.30	.19	.30	.27	.30	.35	.30	.35	.27	.22	.24	....	4	13
B. vlasovi	.43	.49	.30	.19	.30	.27	.30	.35	.30	.35	.27	.22	.24	.11	....	13
B. westwoodi	.54	.57	.11	.27	.11	.08	.32	.05	.11	.05	.30	.30	.27	.35	.35	....

Number of Differences

Ratio of Differences/Total of Characters Used

has been found to feed as larvae on *Dicranella heteromalla, Byrum atropurpureum, Mnium hornum* (Withycombe, 1926) and *Pylaisia* sp. (Boldyrev, 1914). Strübing kept larvae of *B. hyemalis* alive to pupation on *Polytrichum piliferum*. I have observed larvae of *B. brumalis* feeding on the rhizoids of *Dicranella heteromalla* in the field. In the laboratory, adults I observed placed the long rostrum among the moss leaves, as if to feed, although the tip of the rostrum could not be seen. Stomach contents of adults reveal only small globules of a liquid substance, possibly because of masticating activity of the proventriculus (see Richards, 1965). That adult boreids do indeed feed on mosses and occasionally other substances has been recorded by numerous other observers.

C. LIFE CYCLE—Both Brauer (1855) and Steiner (1937) found large larvae of *Boreus hyemalis* in terraria within a few months of initial collection of adults. However, in both cases no mention was made of initially checking the moss for larvae. Withycombe (1922) claimed to have reared the same species to adulthood in one year, although he gave few details of his technique. Doubts were raised when Syms (1933) found larvae of *hyemalis* of two distinct sizes. He postulated a two-year life cycle. Strübing (1950) was able to rear this species and confirmed a two-year life cycle. Cooper (in litt.) reports early and late instar larvae occurring together for *B. brumalis, B. nivoriundus, B. elegans, H. brevicaudus* and *H. notoperates*.

This two-year life span seems reasonable in light of other boreal adaptations. Other cold-adapted insects have increased the length of the life cycle. In the high arctic environment most Lepidoptera spend two or more years in the larval stage (Downs, 1964), and even northerly or

TABLE 4

List of Presence (+) vs. Absence (—) of a Character State.

Character no.	*H. brevicaudus*	*H. notoperates*	*B. borealis*	*B. brumalis*	*B. californicus*	*B. coloradensis*	*B. elegans*	*B. hyemalis*	*B. intermedius*	*B. lokayi*	*B. nivoriundus*	*B. nix*	*B. pilosus*	*B. reductus*	*B. vlasovi*	*B. westwoodi*
1	—	—	+	+	+	+	+	+	+	+	+	+	+	—	—	+
2	+	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—
3	—	—	+	+	+	+	+	—	+	+	+	+	+	+	+	+
4	+	+	—	—	—	—	—	—	—	—	—	—	—	+	+	—
5	+	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—
6	+	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—
7	—	—	—	—	—	—	+	—	—	—	+	—	—	—	—	—
8	—	—	—	—	—	—	+	—	—	—	—	—	—	—	—	—
9	—	—	—	—	—	—	—	—	—	—	—	+	+	—	—	—
10	+	+	—	+	—	—	+	—	—	—	+	+	+	—	—	—
11	+	+	+	+	+	+	—	+	+	+	—	+	+	+	+	+
12	+	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—
13	+	+	+	+	+	+	+	+	+	+	+	+	+	—	+	+
14	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
15	—	—	—	—	—	—	—	+	—	+	—	—	—	—	—	+
16	—	—	—	—	—	—	—	+	—	+	—	—	—	—	—	+
17	—	—	—	—	—	—	—	—	—	+	—	—	—	—	—	+
18	—	—	+	—	+	+	—	+	+	+	—	—	—	—	—	+
19	—	—	+	+	+	+	+	+	+	+	+	+	+	+	+	+
20	—	—	—	—	—	—	+	—	—	—	+	—	—	—	—	—
21	—	—	—	+	—	—	—	—	—	—	—	+	+	+	+	—
22	—	—	+	—	+	+	—	+	+	+	—	—	—	—	—	+
23	—	—	—	—	—	—	—	—	—	—	—	—	—	+	+	—
24	—	—	—	—	—	—	—	—	—	—	—	—	—	+	—	—
25	—	—	+	—	+	+	—	+	+	+	—	—	—	—	—	+
26	—	—	—	—	+	—	—	—	—	—	—	—	—	—	—	—
27	—	—	—	—	—	—	—	—	+	+	—	—	—	—	—	—
28	—	—	+	—	—	—	—	—	—	—	—	—	—	—	—	—
29	—	—	—	+	—	—	+	—	—	+	+	+	—	+	+	—
30	—	—	—	—	—	—	—	—	—	—	—	—	—	—	+	—
31	—	+	—	+	—	—	—	—	—	—	—	+	+	—	—	—
32	+	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—
33	+	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—
34	—	—	+	+	+	+	+	+	+	+	+	+	+	+	+	+
35	+	+	+	+	+	+	+	+	+	+	+	+	+	+	—	+
36	+	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—
37	—	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—

montane races of one species may have a prolonged life cycle (Downes, 1965). Thus, finding this adaptation within another group of holometabolous insects is not surprising. However, Kaufmann (1971) has shown that an arctic carabid beetle, *Pterostichus brevicornis,* can have a variable length of life cycle. A two-year life cycle needs to be confirmed for other populations and species of Boreidae.

The pupal and adult stages of the life cycle usually occur during the cool or cold months of the year, yet pupae of a few species have been found as early as mid-August. Pupae of *B. brumalis* have been collected only from September 30 until October 18. Pupae collected on October 13 were maintained in the laboratory until the adults emerged from November 24 to December 4. Adults of this species have been collected from November 19 until April 24. Two adult specimens in the

TABLE 5

LIST OF CHARACTER STATES USED IN TABLE 4.

1. Presence of median ocellus.
2. Occiput very rugulose.
3. Occiput with fine reticulations.
4. 19 or 20 antennal segments.
5. Antennal base below eyes.
6. Wide hypostomal bridge.
7. Spines on caudal margin of rostrum.
8. More than 24 rostral spines.
9. Body covered with long pilosity.
10. Thoracic bristles present.
11. Forewings abruptly narrowed at mid-length-male.
12. Complete loss of outer forewing spines-male.
13. Forewings covering hindwings-female.
14. Bristles on caudal margin of wing pad-female.
15. Transverse ridge on second abdominal tergum-male.
16. Transverse ridge on third abdominal tergum-male.
17. Third tergal ridge reduced to a tubercle-male.
18. Eighth abdominal tergum and sternum fused-male.
19. Tergal hood on ninth abdominal segment-male.
20. Lateral margin of hood reaching only medial margin of denticular areas-male.
21. Lateral margin of hood reaching only middle of denticular areas-male.
22. Lateral margin of hood reaching lateral margins of denticular areas-male.
23. Projections along lip of tergal hood-male.
24. Medial projections along lip of tergal hood-male.
25. Tergal hood with median septum-male.
26. Median septum narrow-male.
27. Median septum short and forked ventrally-male.
28. Interior of tergal hood obscured by numerous setae-male.
29. More than 25 denticles on either side of ninth tergum-male.
30. Ninth tergum and sternum fused-male.
31. Presence of deeply notched ninth sternum-male.
32. Tenth segment as short dorsally as ninth-female.
33. Posterior process on tenth abdominal segment-female.
34. Complete fusion of cerci-female.
35. Cerci tapering evenly-female.
36. Eighth sternal notch present-female.
37. Eighth sternal notch large-female.

Ohio State University Collection are labelled August 15, 1935, but surely these are atypical. Adults of other species have also been collected generally from November until April; however, adults of *B. coloradensis* have been collected as late as May 27 in the mountains around Logan, Utah, and those of *B. borealis* have been collected in the Pribilof Islands only during May, July, and August.

Emergence appears to be delayed until moderate weather conditions exist for species living in montane and high latitudinal environments. The populations of *B. coloradensis* at 2,134 to 3,657 m. in Boulder County, Colorado, have only been collected in April, whereas this same species is collected from November until May at 1,676 m. around Logan, Utah. *Boreus nix* is found from November to February in Montana and British Columbia, but has only been collected in April in Alaska. *B. intermedius* also has only been collected in April in Alaska. Thus, emergence is to be expected later in northern and montane regions.

In the laboratory, I maintained adults of *B. coloradensis* and *nivoriundus* for 48 and 51 days, respectively. This is possibly shorter than natural adult longevity, yet the rigors of the laboratory environment may have been offset by protection from predation or severe cold.

D. MATING AND OVIPOSITION—The mating behavior of Boreidae has been discussed by Cooper (1940, 1974) and various other authors. Briefly, the mating behavior is as follows: In *Boreus,* the male upon encountering a female, attempts to clasp her with his dististyles; if he is successful, the female becomes quiescent and the male uses his long, thin hook-like wings to pull the female upon his back. The female tucks her rostrum and antennae under her thorax and between her legs while the male's wings clasp her forelegs; the hypovalves of the female's eighth sternum are inserted into the male endoandrium, where they are held in place by the basal lobes of the male dististyles. The male carries the female upon his back for an extended period of time; Marechal (1939) used the figure of 55 hours, although the duration is usually much shorter than that. During this time the female moves very little. Later, the female places small, white oval eggs among the moss rhizoids and the bases of the leafy stems.

In *Hesperoboreus,* the male approaches and leaps at the female, grasping whatever part of her anatomy he can with his dististyles. The female actively tries to escape, dragging the male with her. When she rests, he tries to grasp her with his wing hooks. If successful, he clutches her between her head and mesonotum, holding her body parallel to his own. When the female becomes submissive, the male moves his dististyles to the ovipositor, and the wing grip is released. The valves of the female's eighth sternum are pried down and apart. The male holds the valves down by hooking the basal notch of the valves with the basal lobe of his dististyles. The valves are forced into the subepandrial pockets and held there. The female then rocks backwards 90°, and rests with rostrum and antennae folded between the forelegs. She remains perpendicular to the male in a "female perpendicular pose" that contrasts with the copulatory position of *Boreus* which Lamb (1922) has termed "female vertical pose," but in which the final copulatory position of the female is above and parallel to the male.

E. Moisture—The water required for boreid survival can probably be obtained from the food. However, the relative humidity requirements of the microhabitat may be a major limiting factor. The humidity must be high enough to support a good growth of moss, and the luxuriance of moss banks where most specimens of *Boreus* have been collected indicates high humidity most of the year. On the other hand, boreid larvae have sometimes been found in mosses that appeared desiccated and friable (Cooper, 1974). There has even been one collection of adults of *B. coloradensis* in sagebrush desert at Promontory, Utah. *H. notoperates* survives in *Grimmia,* a moss of dry, rocky habitats. Therefore, no one statement can cover the moisture requirements of all species of Boreidae.

F. Elevation—Elevation greatly influences such climatic conditions as moisture and temperature; however, its effects on the distribution of Boridae have not been determined. *B. brumalis* is found in eastern North America from sea level to 4,000 feet (1,220 m). *H. brevicaudus* has been collected from the bottom of the Columbia River gorge at 100 feet (31 m.) and on Spencer Butte near Eugene, Oregon, from 1,200 to 1,900 feet (366 to 580 m.). On the other hand, *B. coloradensis* is normally found in mountainous regions from 4,700 feet (1,457 m.) around Logan, Utah, up to 12,000 feet (3,660 m.) near Boulder, Colorado.

G. Temperature—The effect of temperature, like that of moisture, can only be guessed at because of the insects' behavior in selection of microhabitat. However, various species' distributions do appear to be governed to some extent by differences in average temperature. The distributions of *H. brevicaudus, B. elegans,* and possibly *H. notoperates* appear to be influenced by the mild, modifying effects of the Pacific Ocean. None of these species has been collected more than 90 miles from the Coast. The mildness of temperatures in this region can be seen in monthly means at Mount San Jacinto, California, Portland, Oregon, Seattle, Washington,

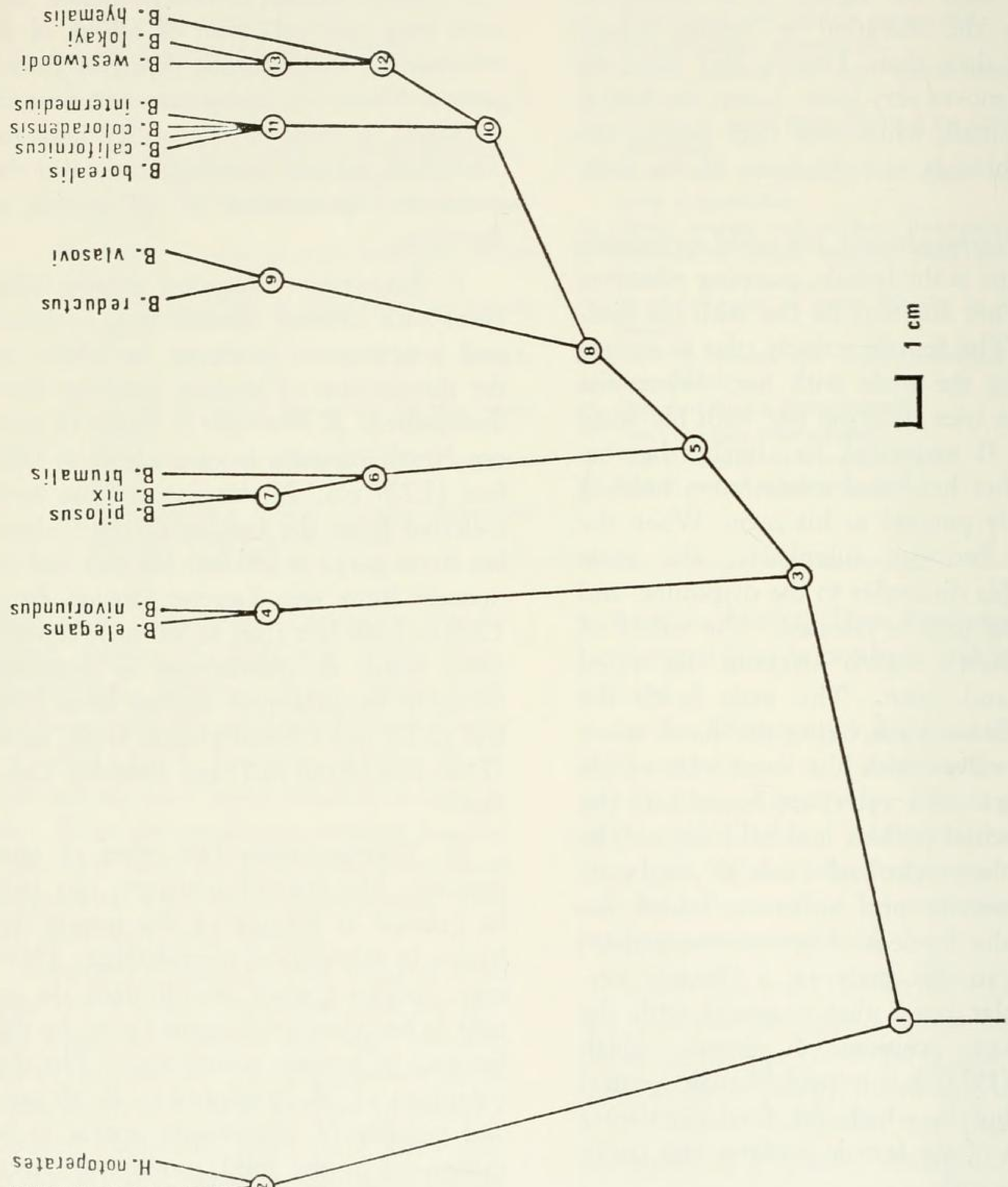


FIGURE 67. Phylogeny weighted by number of species involved. (Number of character state changes × number of species involved equals horizontal distance.)

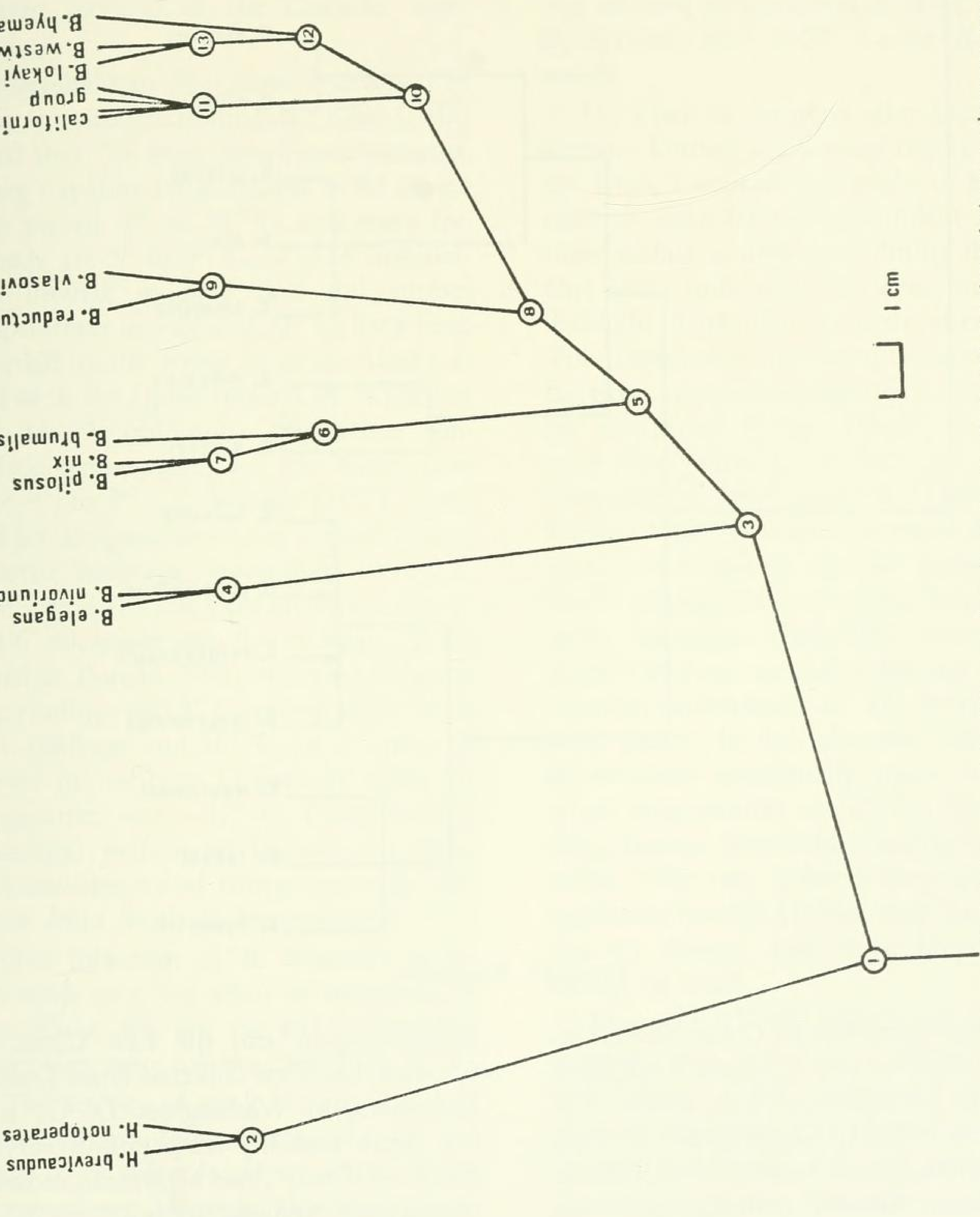


FIGURE 68. Phylogeny weighted by number of species involved and number of times a character state appears. [(Number of character state changes—½ for each change occurring twice) × number of species involved equals horizontal distance.]

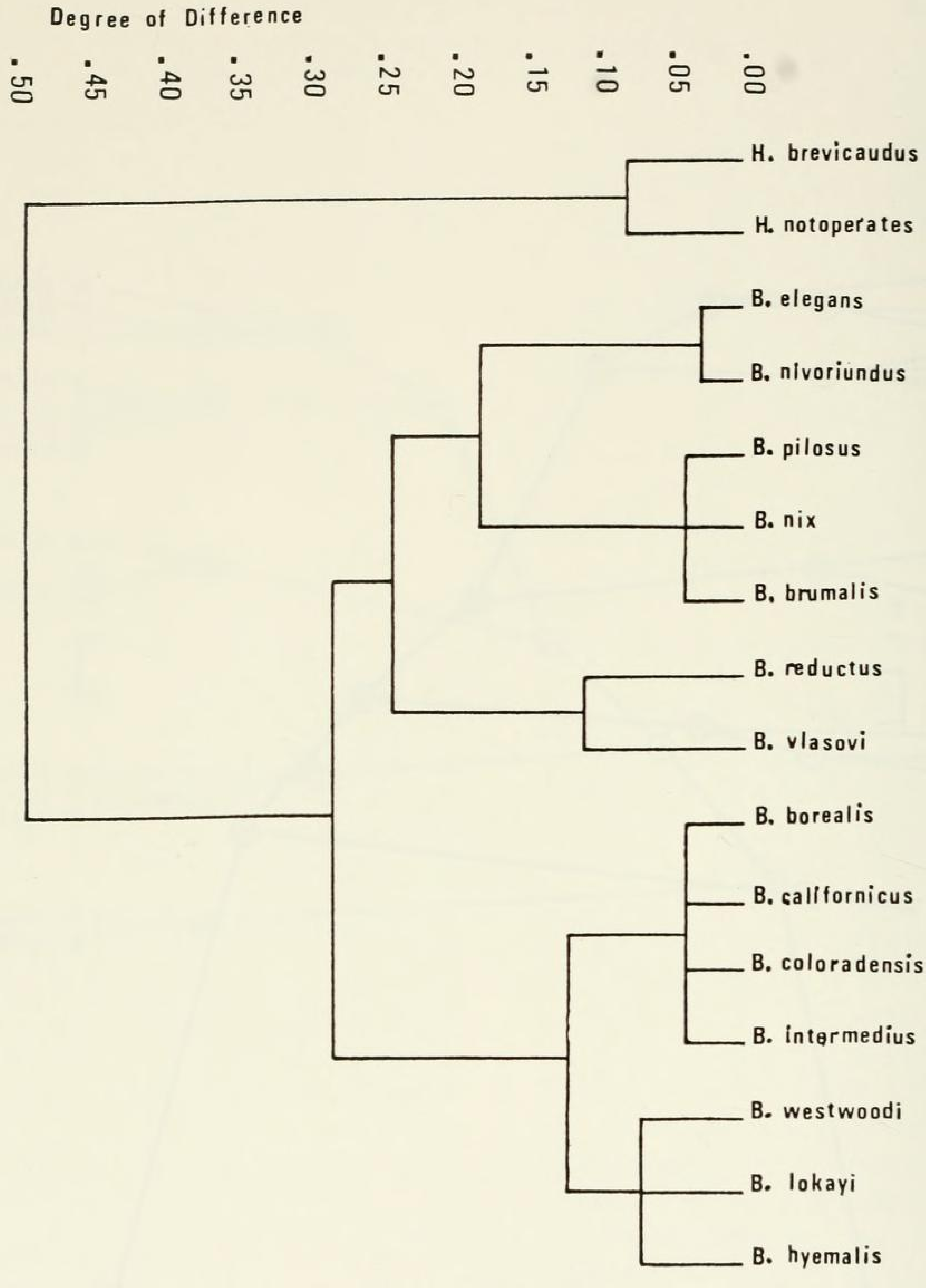


FIGURE 69. Phenogram.

and Vancouver, British Columbia—all localities close to places where these three species of Boreidae have been found. The low mean monthly temperatures for these four localities range from 0° to 8°, and the high mean monthly temperatures range from 18° to 28° C. The high temperature recorded for these cities in 1971 was 46° and the low temperature was —13° C. This contrasts sharply with temperature tolerances of species from the western plateau region and the East Coast. *B. brumalis* has been collected from Duluth, Minnesota, to Washington, D. C., with low mean monthly temperatures varying from —13° to 3°, and high mean monthly temperatures ranging from 19° to 26° C. High and low temperatures for these two localities in 1971 were 34° and —32° C. Helena, Montana, is within the range of three western species, and it, too, has severe changes in temperature with high and low monthly mean temperatures of 20° and —7° C. The change in species composition with climatic zone seems to be particularly abrupt in Oregon and Washington, where *B. californicus* is found from the Cascade Range eastward, and *H. brevicaudus* is found from the western foothills of the Cascades westward.

Microhabitats offer climatic diversity in these extreme environments. Bliss (1969) noted that "In these severe environments, where day-time temperatures at 0.7 m seldom exceed 13° to 18° C. and more frequently are 5° to 8° C., it is of considerable interest to note that soil surface temperatures in excess of 38° C. have been recorded by the writer in arctic Alaska as well as in the alpine tundras of Wyoming and Mt. Washington. Night-time soil-surface temperatures for the same dates were 4° to 7° C." Wilson (1957) found that air temperatures near a small clump of arctic *Saxifraga oppositifolia* were 0.5° C. at 2 m, 3.5° C. at 1 cm above the clump, and 6° C. inside two flower buds. Wulff (cited in Porsild, 1951) recorded temperature readings of 3.5° C. among dead leaves of a saxifrage and 10° C. in a clump of mosses in northern Greenland when air temperature was — 12° C. Thus, through behavioral preferences boreids can select microenvironmental temperatures far different from local air temperatures.

One collection of *B. brumalis* larvae was made on a day when air temperatures were about 24°, but the soil temperature where they were collected was only 10° C.

The activity of adult boreids is clearly influenced by temperature. At 0° C., adults of *B. coloradensis* are active on the snow surface; however, this temperature appears to be close to the minimum for most boreid activity. Below this temperature, they can be seen lying on the snow but will not move, even when picked up. Overnight temperatures of — 37° C. in British Columbia killed specimens of *B. elegans* and *H. brevicaudus* I was transporting in plastic cartons for study. The maximum temperatures of adult activity are not known, but adults of *B. brumalis* survived a temperature of 20° for a few hours time. Herter (1943) recorded maximal survival temperatures of 32-32° C. for *B. hyemalis* and 34-37° C. for *B. westwoodi*.

H. Time of Activity and Light Reaction—During a collecting trip in northern Utah, I noticed that adults of *B. coloradensis* were far more abundant on the snow surface at dusk than during the day. One active individual was even found by flashlight more than an hour after dark. This observation led to speculation that Boreidae are mainly crepuscular, or possibly nocturnal. Fraser (1943) made the same observation for *B. hyemalis*. While observing *H. brevicaudus* in Washington, I noted that the insects on snow did not move, even though the air temperature was 5° C. and the area was in bright sunlight. However, about three hours later (2:00 P.M.), at another collecting site 2° warmer, individuals of *H. brevicaudus* were active. In the laboratory, adults of *B. brumalis* occasionally move at night when temperatures are 7° C.; but most often remain immobile, clinging to moss stems. The two isolated observations of numerous boreids at dusk may have been due to chance, and more observations should be made.

Marechal (1939) mentioned that *B. hyemalis* was attracted to electric lights, and Lestage (1940) speculated that this reaction explained why *Boreus* was more frequently collected on bright, sunny days. Lestage's suggestion is contrary to my own observations, although I recognize it applies to a species I have not observed alive. All North American species I have collected are as abundant on cloudy days as on sunlit days. Temperature appears to be a more important factor than light in their activity.

TAXONOMY

KEY TO THE GENERA OF BOREIDAE

1. Males with no outer forewing spines; females with tenth abdominal tergum as short as ninth, bearing caudal, spiniferous extensions; female eighth abdominal sternum notched basally; cerci not fused apically .... *Hesperoboreus* n. gen.
   Males with outer forewing spines; females with long tenth abdominal segment without caudal extensions; female eighth abdominal sternum not notched basally; cerci completely fused .... *Boreus* Latreille

Hesperoboreus, new genus

Hesperoboreus (from the Greek *hesperus* = western and *boreus* = boreal) describes the western Nearctic distribution of this genus. Type species: *Boreus brevicaudus* Byers.

This genus can be separated from *Boreus* by the following characters: Hypostomal bridge wide; ratio of length of maxillo-labial complex to rostrum less than .60. Male forewings with no outer row of spines. Female eighth sternum with basolateral notch. Female tenth segment as short as ninth, bearing spiniferous caudal extensions; cerci not fused apically. Mating posture perpendicular.

KEY TO SPECIES OF *Hesperoboreus*

1. Apex of male ninth sternum smoothly rounded; forewing of female with apical bristles .... *brevicaudus*
   Apex of male ninth sternum deeply notched; forewing of female without apical bristles .... *notoperates*

SPECIES DESCRIPTIONS

Hesperoboreus brevicaudus (Byers), new combination.

Boreus brevicaudus Byers, 1961, J. Kansas Entomol. Soc. 34:73-78, Figs. 1-6.

Holotype and allotype in Oregon State University collection, Corvallis.

Present description based on 1 female pinned, 6 males and 18 females in alcohol.

HEAD: Occiput dark brown shading to light brown at base of rostrum to yellowish-brown at tip of rostrum. Occiput rugulose with many fine setae. Median ocellus absent. Antenna light brown, with 16 flagellomeres. Viewed in profile, anterior surface of rostrum with few setae; hind margin of hypostomal bridge with none. Ratio of length of maxillo-labial complex to rostrum = .44.

THORAX: Tergum and pleuron dark brown. Anterior margin of pronotum with 6 to 8 bristles, posterior margin with 4 bristles. Meso- and metanotum usually without bristles, occasionally 2 to 4 bristles on mesothorax.

LEGS: Yellowish-brown with numerous dark brown setae and apical femoral spine. Two tibial spurs light brown.

MALE WING: Light brown, abruptly narrowed at mid-length, with 13 inner spines at anal margin; covering hindwings.

FEMALE FOREWING: Dark brown, oval, with large bristles at caudal margin; covering hindwing.

MALE ABDOMEN: Dark brown changing to yellowish-brown on last two segments. No tergal ridges on second and third segments. No fusion of eighth tergum and sternum or ninth tergum and sternum. Ninth tergum without hood; median partition between denticular areas; 13 denticles on either side of partition. Dististyle with about 6 spines arising from below basal lobe almost to apex of dististylar claw. Ninth sternum broadly rounded apically, not reaching bases of dististyles.

FEMALE ABDOMEN: First seven segments dark brown, last three visible segments light brown. Ratio of length of ovipositor to rostrum = .33. Caudal extensions of tenth segment each bearing 3 to 4 apical spines. Cerci dark brown with transparent tip. Eighth sternum with shallow basolateral notch.

Body length, male, 2.3 to 2.7 mm. in alcohol (holotype 2.6 mm., pinned); female, 3.1 to 3.6 mm. in alcohol (allotype 2.7 mm., pinned).

Intraspecific variation: Females from northern Washington vary from those from southern Oregon by occasionally lacking bristles on the forewings, having fewer spines on the eighth sternum and having only 3 spines on the extensions of the tenth segment.

Holotype male, 3 miles south of Eugene, Lane Co., OREGON, 427 m., 27 Nov. 1959. Allotype female, 1 male, 4 females, and 7 larvae, same locality, but dates of 23 Nov. 1959 (for allotype) and 26 Dec. 1971. This locality is a small park on Spencer's Butte overlooking the city of Eugene. Specimens have been collected on moss from 366 to 579 m. on this butte. Additional collections (Fig. 70) are: OREGON: Multnomah Co., 7 mi W of Bonneville, 16 Oct. 1955, K. M. Fender, 1 female (paratype); Yamhill Co., near McMinnville, 8 Nov. 1946, K. M. Fender, 1 female (paratype); Josephine Co., 7 mi SW of Williams, 23 Dec. 1971, N. D. Penny, 3 males, 5 females; Benton Co., Yew Creek, 27 Dec. 1971, N. D. Penny, 1 male, 1 female; Clatsop Co., 2 mi E of Elsie, 28 Dec. 1971, N. D. Penny, 2 females; WASHINGTON, Clallam Co., 4 mi S of Port Angeles, 31 Dec. 1971, N. D. Penny, 1 male, 6 females.

This species has only been collected at low elevations between 30 and 579 m.

H. brevicaudus is very similar to *H. notoperates,* but can be separated by the smaller number of flagellomeres, by the smoothly rounded male ninth sternum, and apical bristles on the female forewings. *H. brevicaudus* usually is not as dark as *H. notoperates,* lives at lower elevations, and is found in a moister, more northern climate.

Hesperoboreus notoperates (Cooper), new combination

Boreus notoperates Cooper, 1972, Psyche 79:269-283, Figs. 1-9.

Holotype and allotype in Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts.

Present description based on 3 males and 1 female pinned, 1 male and 1 female in alcohol.

Head: Black shading to dark brown near tip of rostrum. Occiput rugulose, with many fine setae. Median ocellus absent. Antenna dark brown, with 16 to 18 flagellomeres. Viewed in side profile, anterior surface of rostrum with few setae; posterior margin of hypostomal bridge with none. Ratio of length of maxillolabial complex to rostrum = .52.

Thorax: Nota and pleura dark brown. Pronotum with two transverse incisions, anterior margin with 6 bristles, middle of notum with 2 to 8 bristles, posterior margin with 4 bristles. Meso- and metanotum sometimes with bristles. Numerous smaller setae cover thorax.

Legs: Dark brown with numerous paler setae and dark brown apical femoral spine. Tibial spurs light brown.

Male wings: Light brown and abruptly narrowed at mid-length; 16 inner forewing and 17 hindwing spines.

Female forewing: Oval, light brown, covering hindwing, with many setae, without large bristles at apical margin.

Male abdomen: Dark brown throughout. No tergal ridges on second and third abdominal segments. No fusion of eighth tergum and sternum or ninth tergum and sternum. Ninth tergum without hood; 8 denticles on either side of medial partition. Dististyle with about 10 spines arranged from below basal lobe to near apex of dististylar claw. Ninth sternum deeply notched, not reaching base of dististyles.

FEMALE ABDOMEN: All segments dark brown. Ratio of length of ovipositor to rostrum = .63. Caudal extensions of tenth segment each bearing 5 apical spines. Cerci dark brown with semitransparent tips. Eighth sternum with deeply incised, basolateral notch.

BODY LENGTH: MALE—about 2.7 mm. in alcohol (holotype 2.5 mm., pinned); female, about 3.9 mm. in alcohol (allotype 3.6 mm., pinned).

INTRASPECIFIC VARIATION: Antennae vary from 18 to 20 segments, with 19 being the most common number.

Holotype male, allotype female, and all known specimens from Coldwater and Black Canyons, near town of Mountain Center on Mt. San Jacinto, Riverside Co., CALIFORNIA, from 27 Dec. to 22 Jan., collected by K. W. Cooper and family (Fig. 70).

A detailed study of the habitat, life history, and behavior of this species has been published by Cooper (1974). Among his observations are that this species forms a larval cell in dry weather to conserve moisture, that many species of moss are used as food, and that mating is perpendicular (Cooper's terminology) rather than parallel, as in *Boreus.* This species is aided in this unusual mating position by reciprocal locking of genitalia and the basal notch of the female eighth sternum (a structure also found in *H. brevicaudus*).

In his original description Cooper went beyond a mere external morphological description, including in the paper excellent comparisons of this species' male and female reproductive systems with those of other species and giving further notes on boreid chromosomes.

H. notoperates can be separated from *H. brevicaudus* by a deeply notched male ninth sternum, lack of apical bristles on the female forewings, and larger notch to the female eighth sternum. *H. notoperates* is usually darker in color than *H. brevicaudus,* lives at a higher elevation, in a drier, more southern climate.

Boreus Latreille (1816)

Boreus Latreille. 1816. Nouveau dictionnaire d'histoire naturelle 4:152-153. Type species: *Panorpa hyemalis* L.

Ateleptera Dalman. 1823. Analecta Entomologica. Holmiae, Lindholm. 104 p. Type species: *Ateleptera hiemalis* L.

Euboreus Lestage. 1940. Pour l'histoire des *Boreus* (Stegopteres-Mecopteres). Annales de Societe royale zoologique de Belgique 71:5-22. Type species: *Euboreus nivoriundus* Fitch.

This genus can be separated from *Hesperoboreus* by the following characters: Hypostomal bridge narrow; ratio of length of maxillo-labial complex to rostrum more than .61. Male forewings with an outer row of spines. Female eighth sternum without basal notch. Female tenth tergum at least twice as long as ninth, bearing no caudal extensions. Cerci fused completely. Mating posture parallel.

KEY TO MALES OF NEARCTIC *Boreus*

1. Bristles on pronotum 2
   No bristles on pronotum 6
2. Apex of ninth sternum deeply notched 3
   Apex of ninth sternum smoothly rounded, truncate, or shallowly notched 5
3. Pilosity of thorax and abdomen half as long as thoracic bristles (western North America) 4
   Short pilosity on thorax and abdomen (eastern North America) .... *brumalis*
4. Ninth tergum bearing 25 or fewer denticles at each side of median partition .... *pilosus*
   Ninth tergum bearing 26 or more denticles at each side of median partition .... *nix*
5. Posterior surface of rostrum bearing 25 or more stout setae (western North America) .... *elegans*

Posterior surface of rostrum bearing 24 or fewer stout setae (eastern North America) .... *nivoriundus*

6. Eighth abdominal tergum and sternum fused 7

   Eighth abdominal tergum and sternum not fused .... *reductus*

7. Interior of hood of tergum IX obscured by numerous setae (Alaska) .... *borealis*

   Interior of hood visible 8

8. Median septum of hood short, forked ventrally (Alaska) .... *intermedius*

   Median septum of hood long, unforked ventrally (western North America) 9

9. Median septum of hood with only a narrow crest .... *californicus*

   Median septum of hood wide, with raised area between crest and tergal pockets .... *coloradensis*

Key to Females of Nearctic *Boreus*

1. Bristles on pronotum 2

   No bristles on pronotum 6

2. Stout setae on posterior (ventral) surface of rostrum 3

   No stout setae on posterior (ventral) surface of rostrum, only fine setae 4

3. Posterior surface of rostrum bearing 25 or more spines (western North America) .... *elegans*

   Posterior surface of rostrum bearing 24 or fewer spines (eastern North America) .... *nivoriundus*

4. Pilosity of thorax and abdomen as long as thoracic bristles (western North America) 5

   Pilosity of thorax and abdomen shorter than thoracic bristles (eastern North America) .... *brumalis*

5. Legs black or dark brown .... *nix*

   Legs yellowish-brown .... *pilosus*

6. Forewings reduced to small vestiges not covering hindwings .... *reductus*

   Forewings oval; covering hindwings .... *borealis, californicus, coloradensis,* and *intermedius*

SPECIES DESCRIPTIONS

Boreus borealis Banks

Boreus borealis Banks, 1923, North American Fauna 46:158, pl. IX, Fig. 8.

One male syntype (labelled paratype) in Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts. Although Banks originally described *borealis* from both sexes, all that remains is one male. Apparently four specimens composed the original collection (Banks, 1923). Carpenter (1931) mentioned the lone remaining male (as cotype), as well as the absence of any females. This male bears the following five labels: "St. Paul Id., Bering Sea, May 23, 1914," "A. G. W. Lot No. 157," "A. G. Whitney Collector," "Type, 11277" (red), and "*Boreus borealis* Bks, paratype." Since this is actually a syntype and is the only remaining specimen of the type series, it is hereby designated lectotype.

Present description based on 1 additional male (teneral) and 1 female pinned.

Head: Occiput reticulately striated (Fig. 5), without setae. Occiput and vertex dark brown shading to light brown on rostrum; tip of rostrum dark brown. Median ocellus present. Antenna light brown, with 18 flagellomeres (missing from present specimens, but one antenna glued to base of point holding male specimen). Numerous setae on anterior surface of rostrum near antennal bases, also on posterior surface, but sparse elsewhere on rostrum. Ratio of length of maxillo-labial complex to rostrum = .84.

Thorax: Pronotum dark brown, with two lateral incisions and no bristles. Meso- and metanotum light brown, without bristles. A few small setae on dorsum and pleuron.

Legs: Light brown with numerous lighter colored setae and dark brown apical femoral spine. Tibial spurs light brown.

Male wings: Yellowish-brown, abruptly narrowed at mid-length, with 36 inner and 13 outer forewing spines, no hindwing spines.

Female forewing: Yellowish-brown, oval, covering hindwing.

MALE ABDOMEN: Glossy black with some blue reflections. No tergal ridges on second and third terga. Eighth tergum and sternum fused; ninth tergum and sternum not fused. Ninth tergum with large hood extending laterally to outer edge of denticular area; median septum long, thin; long setae almost completely covering median septum and tergal pockets, smaller setae on dorsal surface of hood. Denticles about 15 in number, of equal size. Dististyle with about 21 spines arranged from below basal lobe to base of dististylar claw; covered with many setae, except on dististylar claw and basal lobe; basal lobe with blunt tip and cleft between it and base of dististyle. Ninth sternum smoothly rounded at apex, reaching to bases of dististyles.

FEMALE ABDOMEN: Dark brown dorsally, lighter brown ventrally; ninth and tenth segments yellowish-brown. Ovipositor to rostrum ratio = 1.05. Cerci dark brown, evenly tapering to apex.

BODY LENGTH: Male, 5.0 mm. pinned; female, 5.4 mm., pinned. Syntypes from St. Paul Island, Bering Sea, ALASKA, 16-23 May 1914, A. G. Whitney. Two other known specimens (1 male, 1 female) from same locality as types, July-Aug. 1925, A. Christofferson.

INTRASPECIFIC VARIATION: Banks (1923) mentioned wings as well as overall size of both male and female as being larger than those of other North American species. Carpenter (1931) mentioned that the female wing pad is about as long as in other *Boreus,* and speculated that the original female may have been somewhat shriveled. The male I have examined also appears not to have wings longer than in other species. Carpenter, in the same paper, mentioned that the body color had a bronzy sheen. Although the specimens I examined did not display this bronzy color, the male was obviously teneral and may not have displayed the full color of the species.

This species has been collected only from St. Paul Island in the Pribilofs (Fig. 80) which has a maximum elevation of 203 feet and dominant vegetation of cottonsedge tundra. Sage (1973) has characterized the area as follows: "Most of the Bering Sea islands are remote and this fact, coupled with the formidable combination of frequent fog, gales, and violent seas, means that opportunities to visit most of them even in summer are few."

This species appears to emerge at a different time than all other boreids, probably due to the severity of climatic conditions. All specimens were also collected at a lower elevation than any other species of the *californicus* group.

B. borealis is structurally similar to *californicus, coloradensis,* and *intermedius,* but males can be identified by the large number of setae lining the tergal hood. Females cannot be positively identified, except by locality. Banks (1923) mentioned that this was the only species with pale coxae and pleura, but some individuals of *californicus* and *pilosus* also have pale coxae and pleura.

Boreus brumalis Fitch

Boreus brumalis Fitch, 1847, Amer. J. Agr. Sci., 5:278.

One male and one female, both syntypes, in Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts. The male bears the labels "316," "Hagen," "*B. brumalis* Fitch, ♂" (green), "Type, 11118" (red), "*Boreus brumalis* Fitch." It is in good condition and is hereby designated lectotype.

Present description based on 189 males, 246 females.

HEAD: Dark brown, shading to light brown on rostrum. Occiput smooth, except for fine reticulations and setal pits. Median ocellus present. Antenna light brown, with 20 to 21 flagellomeres. Numerous setae on anterior surface of rostrum near antennal bases, also on posterior surface, but sparse elsewhere on rostrum. Ratio of length of maxillo-labial complex to rostrum = .83.

Thorax: Pronotum dark brown, with two transverse incisions; anterior and posterior margins each with four bristles. No bristles on meso- and metanotum. Small setae covering thorax.

Legs: Light brown to dark brown with numerous lighter-colored setae. Dark brown apical femoral spine. Tibial spurs light brown to translucent.

Male wings: Dark brown to light brown, abruptly narrowed at mid-length, with 20 inner and 15 outer forewing spines, three hindwing spines.

Female forewing: Dark brown, oval; covering hindwing.

Male abdomen: Dark brown to glossy black. No tergal ridges on second and third abdominal segments. No fusion of eighth tergum and sternum or ninth tergum and sternum. Ninth tergum with small medially cleft hood, extending laterally only to medial margins of denticular areas; median septum absent. Denticles about 29 in number on each side, smaller toward pockets of hood. Diststyle with about 15 spines arranged from below basal lobe to base of diststylar claw; basal lobe blunt tipped, separated from base of diststyle by cleft. Ninth sternum deeply notched at apex, extending to bases of diststyles.

Female abdomen: Dark brown to glossy black. Ratio of length of ovipositor to rostrum = 1.00. Cerci dark brown, evenly tapering to apex.

Body length: Male, 2.4 to 3.1 mm., in alcohol, 2.0 to 2.7 mm., pinned; female 3.6 to 4.1 mm., in alcohol, 2.9 to 3.8 mm., pinned.

Intraspecific variation: Overall color varies. Most brown specimens are from the more southern parts of the range.

B. brumalis has generally been collected from 19 Nov. to 24 April, but 1 male and 1 female in the Ohio State University Collection are labelled 15 Aug. 1935.

This species is widespread over eastern North America (Fig. 71), from the Smoky Mountains (Cole, 1938) and Cumberland Mountains (Goslin, 1950) of TENNESSEE to southern ILLINOIS (Stannard, 1957) to Sauk County, WISCONSIN and Duluth, MINNESOTA, to Brownsburg, QUEBEC. Specimens have been collected in almost all states within these boundaries. The southern Illinois population is 370 miles from the nearest known population in central OHIO. Stannard (1957) suggested that the Illinois population is a remnant of a once widespread population living in the mesophytic forest that stretched from eastern Tennessee to the Ozark Plateau and that is now only tenuously linked through southern Illinois. Despite intensive searching, no specimens have been found in nearby Missouri or the lower Ohio River Valley.

The elevational records vary from sea level in New England to 4000 feet (1220 m.) in the Cumberland and Smoky Mountains of Tennessee.

There are no records to indicate that northern populations emerge earlier or later in the winter than southern populations.

B. brumalis larvae can be collected at any time of the year in their southern Illinois habitats, where they are found tunneling just beneath the rhizoids of *Dicranella heteromalla* and *Atrichum angustatum*. This species apparently does not form the dry weather cells, such as Cooper (1974) described for *H. notoperates*. In the same area, larvae and adults are most frequently collected on moss on sandy loam soil rather than mossy rocks, as are other species in other areas.

The deeply notched ninth sternum of separate this eastern species from all other the male and bristles of the pronotum species of *Boreus,* except *nix* and *pilosus.* The pilosity of *brumalis* is shorter than in either of these latter two western species.

Boreus californicus Packard

Boreus californicus Packard, 1870, Proc. Boston Soc. Nat. Hist. 13:408.

Boreus unicolor Hine, 1901, Bull. Sci. Lab., Denison Univ. 11:256. New synonymy.

Boreus isolatus Carpenter, 1935, Psyche 42:115, Fig. 11. New synonymy.

Boreus californicus fuscus Carpenter, 1935, Psyche 42:117-118. New synonymy.

Three male, three female syntypes of *californicus* are in the Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts. (These are the types originally deposited in the Museum of the Peabody Academy of Science.) All six specimens bear the following three labels: "Ft. Bidwell, Siskiyou Calif.," "Type, 11119" (red), and "californicus." As Lattin (1956) mentioned, Ft. Bidwell is in Modoc Co. The best preserved male is hereby designated lectotype. Two female syntypes of *unicolor* are in the United States National Museum of Natural History, Washington, D.C. (In 1931 Carpenter designated a male in the Museum of Comparative Zoology as allotype.) Both specimens are labelled "Helena, Mon. 26.4" "Coll. Hubbard & Schwarz" "Type No. 5743 U.S.N.M." The better specimen is hereby designated lectotype. Holotypes of *isolatus* and *californicus fuscus* are in the Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts.

All previous authors have referred to *B. californicus* as having been originally described in 1871 in volume 8 of the *Proceedings of the Boston Society of Natural History.* Actually, it was described in 1870 in volume 13.

Present description based on 372 males, 432 females.

HEAD: Occiput dark brown to black shading to lighter brown on rostrum. Occiput smooth. Median ocellus present. Antenna light brown basally to dark brown apically, with 20 to 23 flagellomeres. Numerous setae on anterior surface of rostrum near antennal bases, also on posterior surface, but sparse elsewhere on rostrum. Ratio of length of maxillo-labial complex to rostrum = .70 to .90.

THORAX: Pronotum dark brown, with indistinct medial transverse ridge and no bristles. Meso- and metanotum dark brown, without bristles. Many small setae covering thorax.

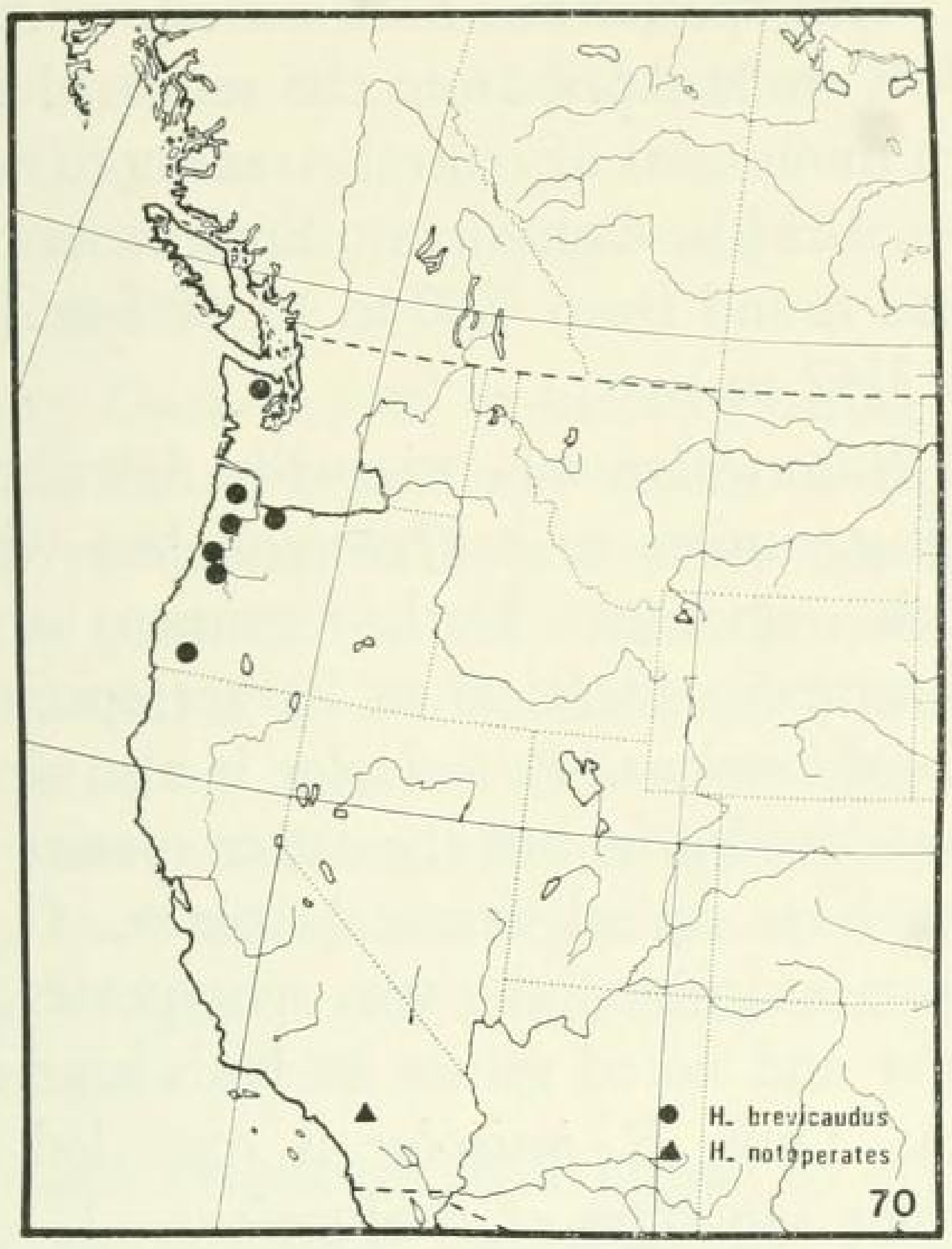
LEGS: Yellowish-brown to dark brown with darker colored spines; usually with dark brown apical femoral spine. Tibial spurs light brown.

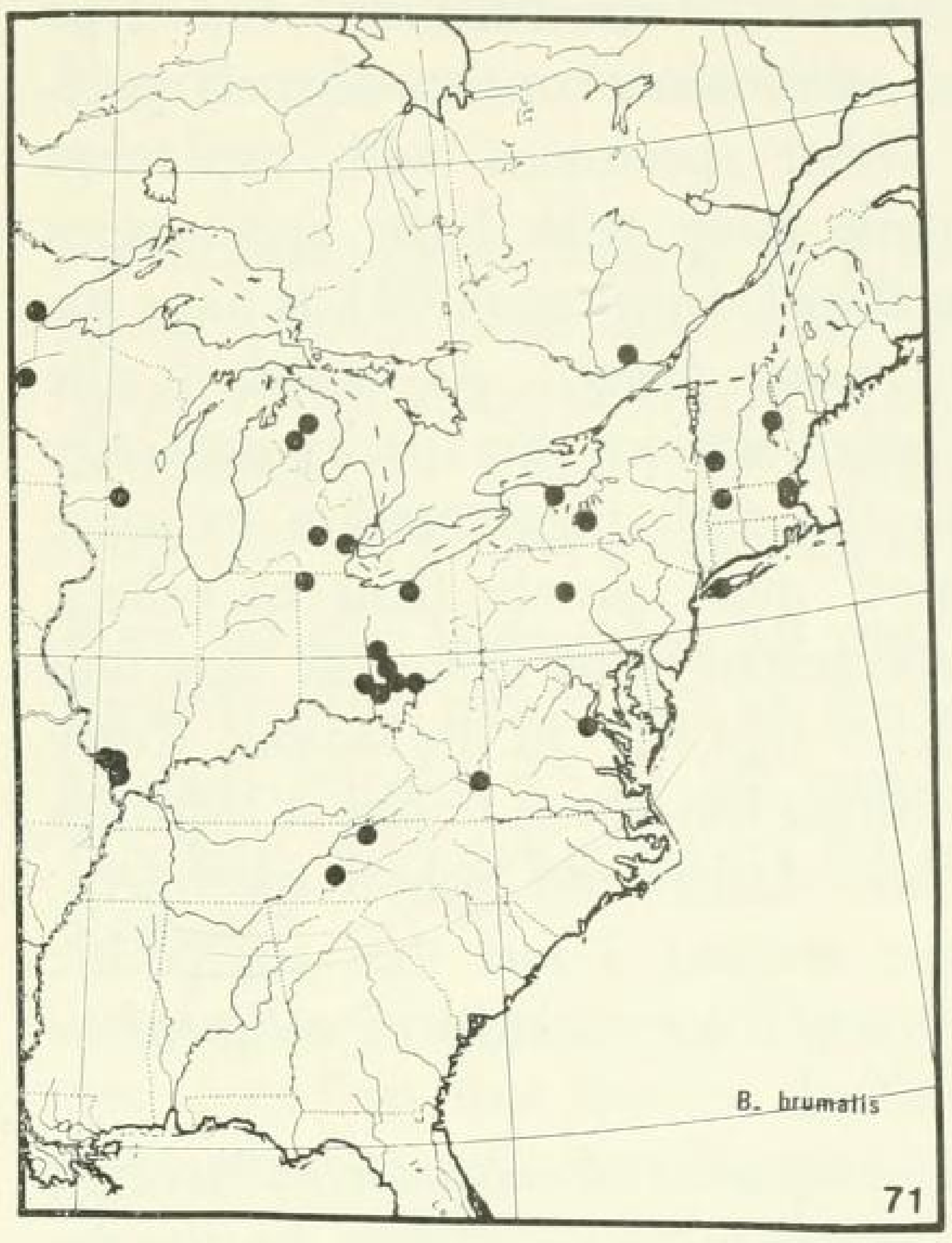
MALE WINGS: Yellowish-brown to dark brown and abruptly narrowed at midlength; 15 to 23 inner and 7 to 13 outer forewing spines; usually no hindwing spines.

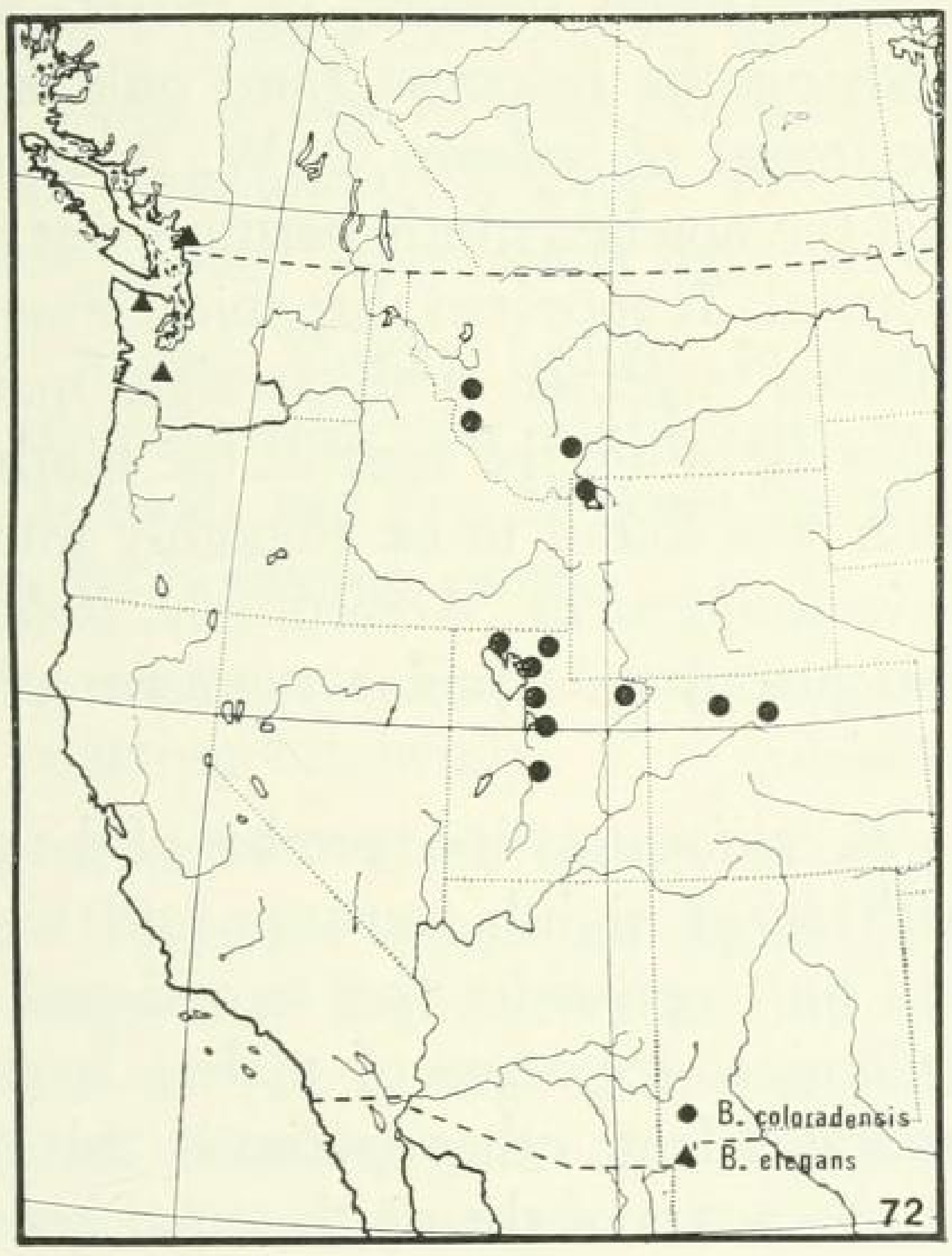
FEMALE FOREWING: Light to dark brown, oval, with many small setae but no large bristles at apical margin; covering hindwing.

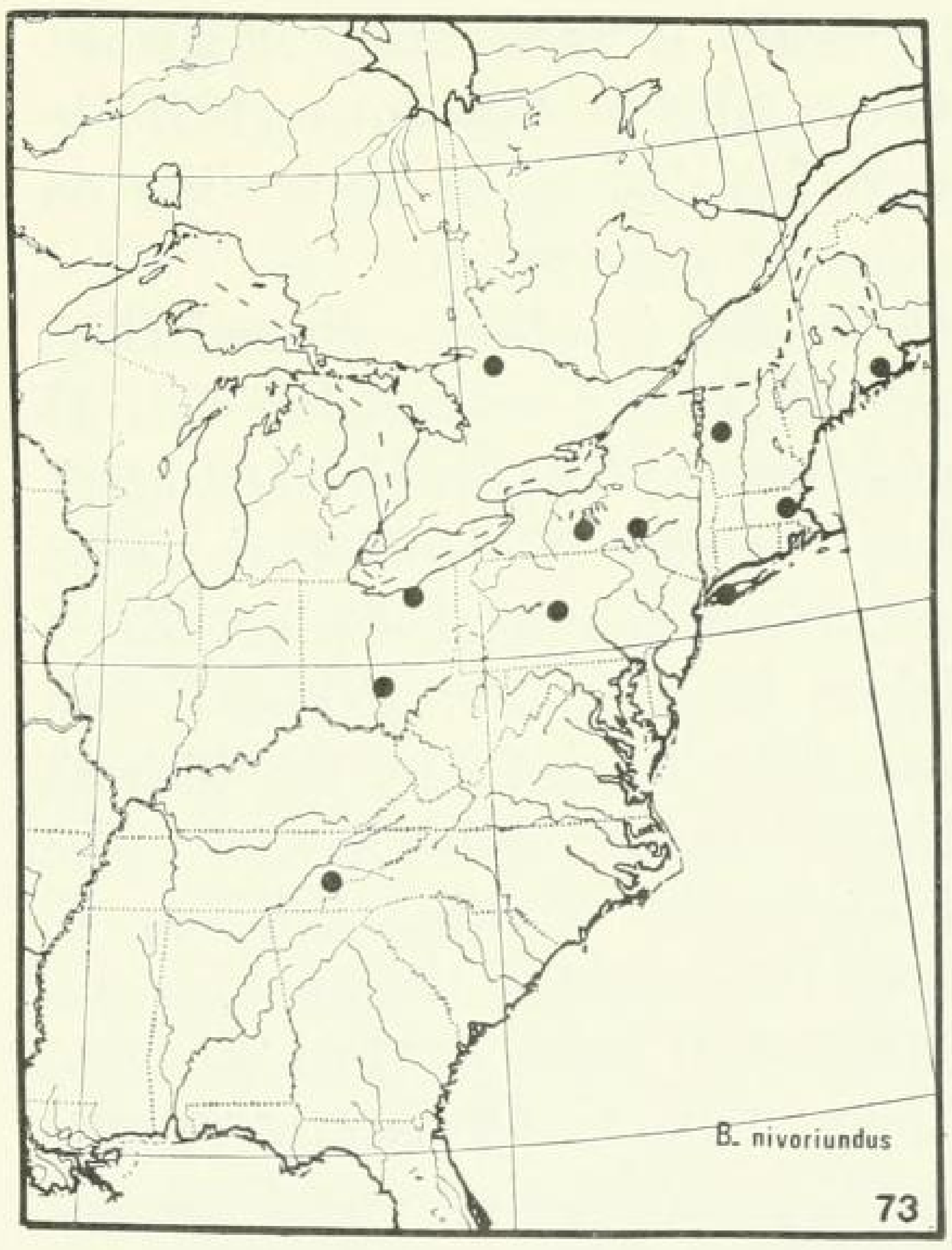
MALE ABDOMEN: Dark brown to black. No tergal ridges on second and third segments. Eighth tergum and sternum fused; ninth tergum and sternum not fused. Ninth tergum with large hood, extending to lateral margins of denticular areas; median septum long, thin, with some setae in tergal pockets; smaller setae on dorsal surface of hood. Denticles about 26 in number, of equal size. Dististyle with many small spines arranged from below basal lobe to base of dististylar claw; basal lobe blunt tipped, separated from base of dististyle by cleft. Ninth sternum reaching to bases of dististyles, its apex smoothly rounded to bluntly squared to shallowly depressed medially.

FEMALE ABDOMEN: Dark brown to black; ninth and tenth segments yellowish-brown









Figures 70-73. Fig. 70, distribution of *Hesperoboreus brevicaudus* and *H. notoperates*. Fig. 71, distribution of *Boreus brumalis*. Fig. 72, distribution of *Boreus coloradensis* and *B. elegans*. Fig. 73, distribution of *Boreus nivoriundus*.

to dark brown. Ratio of length of ovipositor to rostrum = 1.10 to 1.30. Cerci light brown to dark brown, evenly tapering to apex.

Body length: Male, 3.6 to 5.0 mm., in alcohol; female, 5.4 to 6.5 mm., in alcohol.

Intraspecific variation: This widespread western species shows considerable variation in coloration, size, number of antennal segments, and male wing spines. Some males from Alberta have very small spines on the hindwings. One color variety is rusty brown. Unfortunately, the type series of *californicus* consists of such specimens. Other specimens with the more usual dark body with light appendages were used by Carpenter (1935) as basis for *B. californicus fuscus*. As noted in the section on coloration, this species generally develops the dark pigmentation in some body parts more slowly than in others. Thus, specimens with yellowish legs will have darker legs later in the season. Rusty red specimens have been found at localities having also darker and lighter specimens. For these reasons, I feel that subspecific rank for any color variants of *californicus* is unjustified.

Most specimens of *californicus* have an apical femoral spine on all legs, but in the northern parts of the range it may be lacking from some legs, and in Arizona and California it is lacking altogether. Eye color, as used by Carpenter (1931) in his key to females, varies depending on the method of preservation.

B. californicus has been collected (Fig. 74) from ARIZONA: Coconino Co., 15 mi. S. of Flagstaff; CALIFORNIA: Mariposa, Co., Yosemite National Park; Inyo Co., 4 mi. N. of Schulman Grove; Sierra Co., Hobart Mills (Lattin, 1956); Lassen Co., Susanville; Modoc Co., Ft. Bidwell and Goose Lake; NEVADA: Nye Co., Kawick Mt. (Lattin, 1956, as *B. unicolor*); Washoe Co., Reno (Carpenter, 1935); OREGON; Umatilla Co., Fly Creek Valley; WASHINGTON: Whitman Co., Pullman area; Spokane Co., Spokane; Pierce Co., near Deer Creek; IDAHO: Latah Co., Moscow area; Idaho Co., Papoose Creek; MONTANA: Ravalli Co., Hamilton area; Missoula Co., Missoula area; Flathead Co., Daphnia Pond; Mineral Co., St. Regis; Lewis & Clark Co., Helena; Lake Co., Lion Creek; Powell Co., Pass Creek; BRITISH COLUMBIA: Ashnola River Valley; Kaslo; Terrace; Salmon Arm; ALBERTA: Banff; Jasper National Park.

This species has been collected from 4 Nov. to 26 April from the semiarid western mountains of central Arizona to northern British Columbia. Specimens have been found from 4000 to 10,300 feet (1220 to 3142 m.).

B. unicolor was originally described as being similar to *californicus*, but with a dark ovipositor. Dark specimens appear structurally identical to lighter specimens of *californicus*. *B. unicolor* is also similar to *coloradensis*, but the latter species does not have apical femoral spines. G. W. Byers examined the two syntypes of *unicolor* and noted spines on both hind femora. Thus, *B. unicolor* is regarded as a junior synonym of *californicus*.

B. isolatus was described as being similar to *californicus*, but with a deeply notched ninth sternum in males. While studying the holotype (and only known specimen) of *isolatus*, G. W. Byers noted that the notched ninth sternum was asymmetrical. It appeared that apical setae were adhered together with foreign material. After cleaning, the apex of the ninth sternum was found to be smoothly rounded, as in *californicus*. Accordingly, *isolatus* is also placed as a junior synonym of *californicus*.

B. californicus is a member of the group with fused eighth sternum and tergum, and no tergal ridges on second and third abdominal segments of males. It can be separated from other species in this group by characters of the ninth tergal hood, including a long, narrow septum bearing sparse setae that do not obscure the interior of the tergal pockets. *B. californicus* is most often confused with *coloradensis*, which is found farther east, and which has a broader tergal septum, and never has apical femoral spines.

Boreus coloradensis Byers

Boreus coloradensis Byers, 1955, Occ. Pap. Mus. Zool., Michigan Univ. No. 562, Figs. 1-5.

Holotype male and allotype female in the University of Colorado Museum, Boulder, Colorado.

Present description based on 123 males, 132 females.

HEAD: Dark brown to black, shading to slightly lighter brown on rostrum. Occiput finely reticulate, with few setae. Median ocellus present. Antenna dark brown to black, with 20 to 22 flagellomeres. Numerous setae on anterior surface of rostrum near antennal bases, also on posterior surface, but sparse elsewhere on rostrum. Ratio of length of maxillo-labial complex to rostrum = .86.

THORAX: Pronotum dark brown to black, with an indistinct transverse ridge near mid-length; no bristles. Meso- and metanotum dark brown to black, without bristles. Many small setae covering thorax.

LEGS: Dark brown to black with numerous pale setae and dark spines. No apical femoral spines. Tibial spurs light brown.

MALE WINGS: Light brown to black, abruptly narrowed near mid-length, with 19 to 22 inner and 8 to 13 outer forewing spines; no hindwing spines.

FEMALE FOREWING: Dark brown to black, oval, covering hindwing.

MALE ABDOMEN: Dark brown to glossy black. No tergal ridges on second and third segments. Eighth tergum and sternum fused. Ninth tergum and sternum not fused. Ninth tergum with large hood extending to lateral margins of denticular areas; median septum long, wide, with thin crest and less densely sclerotized region between crest and pockets; numerous long setae not obscuring interior of hood, and smaller setae on dorsal surface of hood. Ninth tergal apex with 22 denticles of equal size. Dististyle with many small denticles arranged from below basal lobe to base of dististylar claw; basal lobe blunt tipped, separated by cleft from base of dististyle. Ninth sternum reaching bases of dististyles, smoothly rounded to bluntly squared to shallowly depressed apically.

FEMALE ABDOMEN: Mostly dark brown to glossy black; ninth and tenth segments light brown. Ratio of length of ovipositor to rostrum = 1.30 to 1.43. Cerci dark brown to black, evenly tapering to apex.

BODY LENGTH: Male, 2.5 to 3.0 mm., pinned (holotype 2.5 mm.), 3.2 to 4.9 mm., in alcohol; female, 4.5 to 5.0 mm., pinned (allotype, 4.5 mm.), 4.3 to 5.4 mm., in alcohol.

INTRASPECIFIC VARIATIONS: The only variation noted in this species was a slightly lighter brown coloration in specimens preserved in alcohol, some variation in the apex of the ninth sternum (see Byers, 1955, for discussion), and differences in number of antennal flagellomeres, wing spines, and other minor numerical differences. There appears to be no geographical or elevational pattern to this variation.

Holotype, allotype, and all paratypes from 12 to 20 miles west of Boulder, Boulder Co., COLORADO. Other specimens (Fig. 72) have been collected at COLORADO: Routt Co., Steamboat Springs; UTAH: Cache Co., Logan area (Blacksmith Fork Canyon, Green Canyon, Logan Canyon); Utah Co., Rock Canyon; Uinta Co., Split Mountain Gorge; Weber Co., Ogden Canyon; Sampete Co., Maple Canyon; Box Elder Co., Promontory; Salt Lake Co., Mill Creek Canyon; WYOMING: Yellowstone National Park (Carpenter, 1935, as *unicolor*); MONTANA: Gallatin Co., Bozeman; Missoula Co., Missoula; Ravalli Co., Hamilton area (Boulder Creek, Gird's Creek, Skalkaho Creek).

In Colorado this species has been collected only high in the Rocky Mountains. Near Boulder it has been taken from 7000 to 12,000 feet (2135 to 3660 m.), and at Steamboat Springs from 7000 to 10,000 feet (2135 to 3050 m.). In Utah *B. coloradensis* can be found at lower elevations from 4700 to 6550 feet (1434 to 1998 m.).

B. coloradensis appears to be tolerant of arid conditions. In the Bitterroot Valley near Hamilton, Montana, this species is only collected on the dry eastern side of the valley. It has been collected on snow in sagebrush desert at Promontory, Utah. However, it has also been collected in thick carpets of moss only a few feet from the bank of Blacksmith Fork near Logan, Utah, obviously a very humid habitat.

Specimens of this species were collected from 1 Oct. to 27 May in Utah, Montana, Wyoming, and western Colorado, and from 31 March to 24 April in central Colorado.

B. coloradensis is a member of the *californicus* group, having fused eighth tergum and sternum and no tergal ridges on second and third abdominal segments of males. *B. coloradensis* has a long median septum of the hood, unlike *B. intermedius,* and fewer long hood setae than *B. borealis. B. coloradensis* is most often confused with *californicus,* but the latter species has a narrow median septum on the ninth tergum. Byers (1955) mentioned that *coloradensis* could be separated from *unicolor* (a synonym of *californicus*) by the latter species having shorter male forewings, indistinct pronotal ridge, blunter denticles on the ninth tergum, and narrower septum on the ninth tergum. I can see only the last of these character states. Differences between the two species are so minor that perhaps specific rank for *coloradensis* is not warranted. However, consistent lack of the apical femoral spine and the broader hood septum in *coloradensis* make me think this is a valid species.

Boreus elegans Carpenter

Boreus elegans Carpenter, 1935, Psyche 42:119, 122, Figs. 8, 12.

Holotype, male, in California Academy of Science, San Francisco.

Present description based on 7 males, 13 females in alcohol.

HEAD: Rusty brown. Occiput finely reticulated, with no setae. Median ocellus present. Antenna light brown basally, becoming dark brown toward apex, with 20 to 22 flagellomeres. Anterior surface of rostrum with few setae; posterior surface of rostrum with fine setae and numerous stouter setae. Ratio of length of maxillolabial complex to rostrum = .77.

THORAX: Pronotum rusty brown with indistinct transverse ridge near mid-length; anterior and posterior margins with four to six bristles each. Two bristles each on meso- and metanotum. Small setae covering thorax.

LEGS: Light brown, with numerous dark brown spines, setae, and apical femoral spine. Tibial spurs light brown.

MALE WINGS: Light brown, tapering evenly to apex, with 16 inner and 16 outer forewing spines, 12 hindwing spines.

FEMALE FOREWING: Rusty brown, oval, covering hindwing.

MALE ABDOMEN: Rusty brown oval, covering hindwing.

MALE ABDOMEN: Rusty brown except yellowish-brown on basistyles and dististyles. No tergal ridges on second and third segments. No fusion of eighth tergum and sternum or ninth tergum and sternum. Ninth tergum with hood only reaching mesal margins of denticular areas. About 75 denticles on either side of median cleft. Dististyle with about 30 denticles arranged from below basal lobe to near base of dististylar claw. Ninth sternum broadly rounded apically, reaching bases of dististyles.

FEMALE ABDOMEN: Rusty brown. Ratio of length of ovipositor to rostrum = 1.15. Cerci rusty brown, evenly tapering to apex.

BODY LENGTH: Male, 4.0 to 4.6 mm., in alcohol (holotype and paratype 3.5 to 3.8

mm., pinned); female, 6.0 to 7.4 mm., in alcohol.

Intraspecific variation: This species shows the usual variation in number of antennal flagellomeres.

Holotype and paratype males, Vancouver, BRITISH COLUMBIA, Dec. 1930, H. E. Hinton. Other specimens (Fig. 72) from WASHINGTON: Cowlitz Co., Seaquest State Park, 29 Dec. 1971, N. D. Penny, 4 females; Clallam Co., 1 mi. E. of Lake Crescent, 30 Dec. 1971, N. D. Penny, 7 males, 9 females.

This species was appropriately named, for it is truly the most elegant boreid known. In color it differs from all other boreids except the reddish color variety of *californicus*. *B. elegans* is the largest boread species and can be seen and recognized on winter snow a considerable distance away. It lives in the warm-winter, maritime climate of western North America where rainfall is abundant and temperatures seldom are below —13° C. (see ecology section on temperature). All three collections of this species were below 1,600 feet (488 m.) elevation.

B. elegans is in the *nivoriundus* subgroup of the nivoriundus group, having bristles on the pronotum and the apex of the male ninth sternum rounded. It can be separated from the only other member of this subgroup, *nivoriundus,* by its large size, more reddish coloration, and more numerous stout setae on the back of the rostrum.

Boreus intermedius Lloyd

Boreus intermedius Lloyd, 1934, Pan-Pacific Entomol. 10:119, Fig. 2.

Holotype male and allotype female, catalogued 7454 and 7453, respectively, were deposited in the Thomas Burke Memorial Washington State Museum, Seattle, but the curator has been unable to locate them for me. Specimens used in this description, from the Museum of Comparative Zoology, Harvard University, were collected from the same locality by the same collector exactly one year later than the type specimens.

Present description based on 1 male in alcohol, 2 females pinned.

Head: Black shading to yellowish-brown on rostrum. Occiput finely reticulated, with a few setae near margins of compound eyes. Median ocellus present. Antenna light brown shading to dark brown toward apex, with 18 to 19 flagellomeres. Numerous setae on anterior surface of rostrum near antennal bases, also on posterior surface, but sparse elsewhere on rostrum. Ratio of length of maxillo-labial complex to rostrum = .91.

Thorax: Dark brown on nota, becoming yellowish-brown on pleural and sternal regions. Pronotum with indistinct ridge at mid-length; no bristles. Meso- and metanotum without bristles. Small white setae dense over entire thorax.

Legs: Yellowish-brown with stout setae and apical femoral spine dark brown; finer setae and tibial spurs yellowish.

Male wings: Yellowish-brown, abruptly narrowed at mid-length; with 33 inner and 10 outer forewing spines, no hindwing spines.

Female forewing: Yellowish-brown, oval, covering hindwing.

Male abdomen: Segments 1 through 8 dark brown; segment 9, basistyles and dististyles yellowish-brown. No tergal ridges on second and third segments. Eighth tergum and sternum fused. Ninth tergum and sternum not fused. Ninth tergum with large hood, extending laterally to lateral margins of denticular areas. Median septum of hood short, with thin crest and extensive sclerotized area between crest and pockets. Caudal medial cleft of ninth tergum large, between ventral fork of medial septum. About 75 denticles on either side of medial septum. Dististyle with many small denticles arranged from below basal lobe to base of dististylar claw. Apex of ninth sternum truncate medially, reaching bases of dististyles.

FEMALE ABDOMEN: First 7 segments black, last 3 visible segments yellowish-brown. Ratio of length of ovipositor to rostrum = 1.14. Cerci yellowish-brown, evenly tapering to apex.

BODY LENGTH: Male, 5.0 mm., in alcohol (holotype 3.5 mm., pinned); female, 4.5 to 4.6 mm., pinned (allotype 4.5 mm., pinned).

INTRASPECIFIC VARIATION: The specimens I examined agree with Lloyd's original description, except the ovipositor of the allotype was described as being twice as long as rostrum (as compared to 1.14).

Holotype male and allotype female from between Kennicott (spelling corrected) and McCarthy, ALASKA, 15 April 1934, Wilbur Lloyd (Lloyd, 1934). Other specimens (Fig. 80) are from Kennicott, ALASKA, 15 April 1935, Lloyd, 1 male, 2 females, in Museum of Comparative Zoology, and Carpenter (1936) mentioned specimens collected at McCarthy, ALASKA, 29 April 1935, 1 male, 2 females.

Kennicott (61°29′ N, 142°54′ W) and McCarthy (61°26′ N, 142°55′ W) are located about four miles apart at the base of Kennicott Glacier, near Fireweed Mountain in the Wrangell Range. Elevation at Kennicott is 2,000 feet (610 m.), at McCarthy 1,400 feet (427 m.).

Males of *B. intermedius* can be separated from other members of the *californicus* group by the septum of the ninth tergal hood, which is short and deeply divided ventrally.

Boreus nivoriundus Fitch

Boreus nivoriundus Fitch, 1847, Amer. J. Agr. Sci. 5:277.

Male and female syntypes in Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts. The male bears the labels "8088," "Hagen," "B. nivoriundus ♂ Fitch" (green), "Type, 11117" red), and "*Boreus nivoriundus* Fitch." It is hereby designated lectotype.

Present description based on 76 males, 80 females.

HEAD: Dark brown shading to lighter brown on rostrum. Occiput finely reticulate, with a few setae. Median ocellus present. Antenna light brown basally, becoming dark brown toward apex, with 20 flagellomeres. Numerous small setae on anterior surface of rostrum near antennal bases, but sparse elsewhere. Posterior surface of rostrum with a few fine setae ventrally and more stout setae dorsally. Ratio of length of maxillo-labial complex to rostrum = .90.

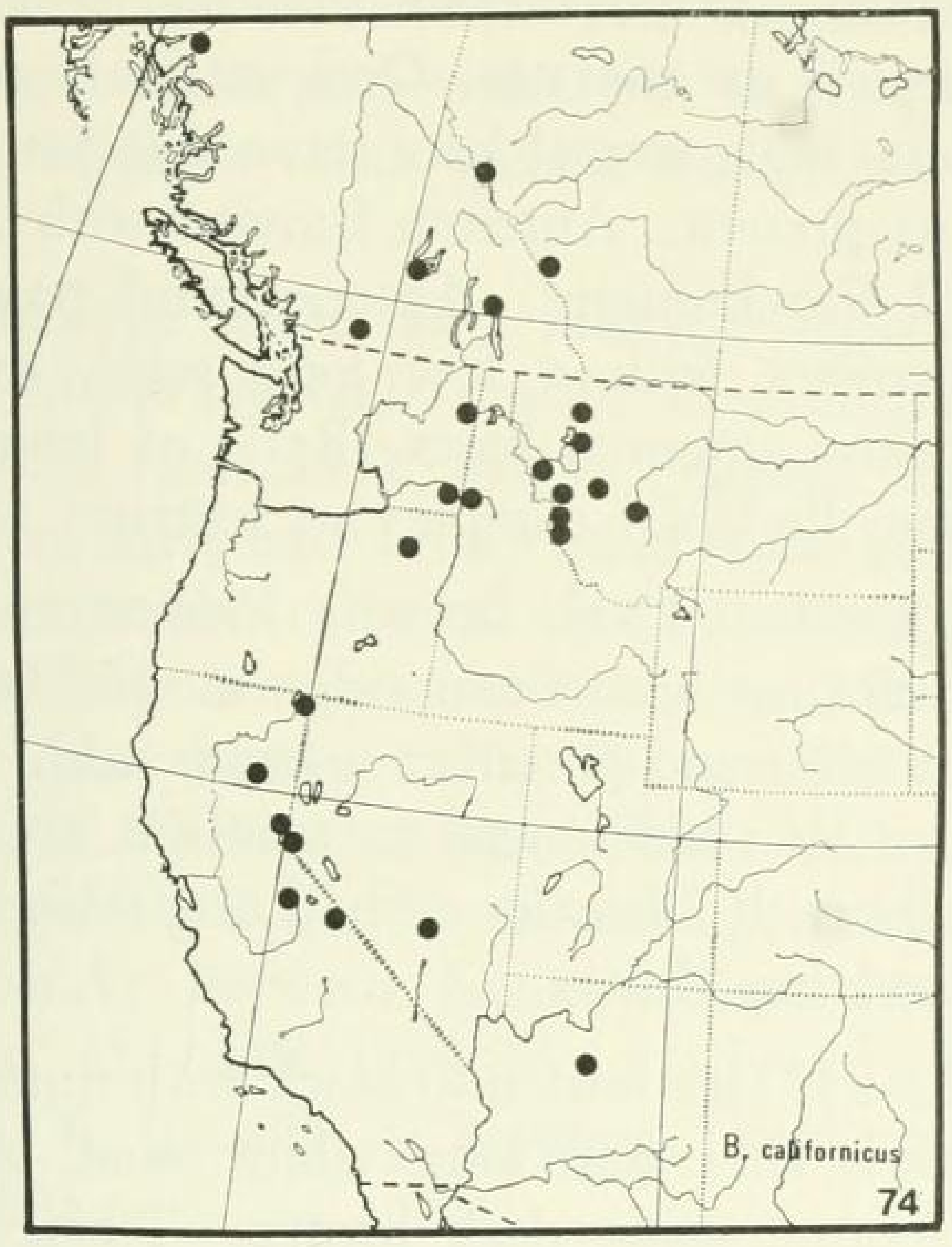
THORAX: Dark brown. Pronotum with no transverse ridge at mid-length; anterior and posterior margins with 4 to 6 bristles. Meso- and metanota occasionally with 2 dark bristles each. Small setae covering thorax.

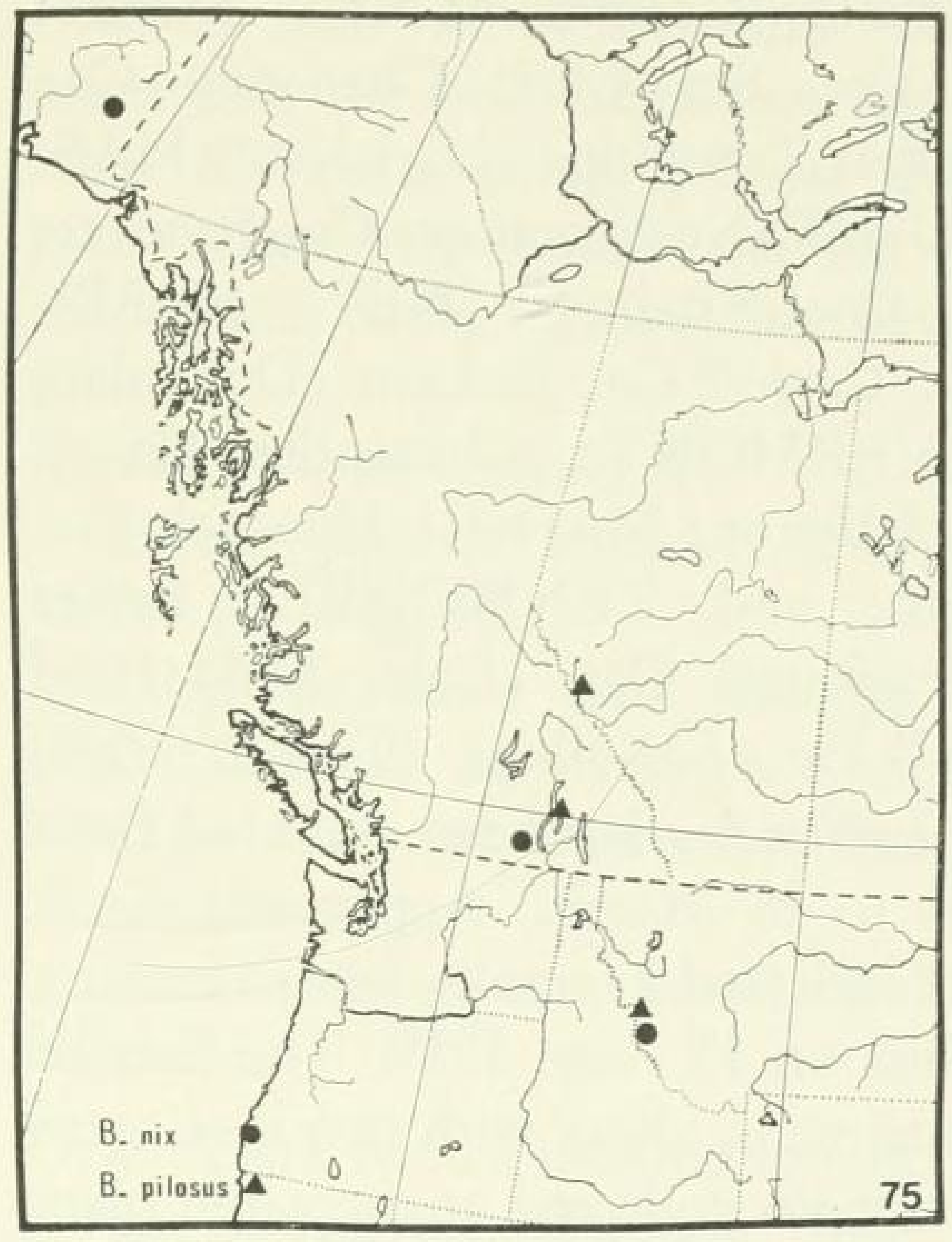
LEGS: Dark brown, with dark brown apical femoral spine. Setae dark brown and light brown. Tibial spurs yellowish-brown.

MALE WINGS: Light brown, evenly tapered to apex, with 16 to 18 inner and 14 outer forewing spines, 16 hindwing spines.

FEMALE FOREWING: Light brown, oval, covering hindwing.

MALE ABDOMEN: Dark brown except light brown on last two abdominal segments. No tergal ridges on second and third segments. No fusion of eighth tergum and sternum or ninth tergum and sternum. Ninth tergum with small hood extending laterally only to mid-width of denticular areas. No median septum below hood. Medial cleft between areas of about 50 denticles each. Denticles becoming smaller toward hood. Dististyle with about 20 denticles arranged from below basal lobe to base of dististylar claw. Ninth sternum





Figures 74-76. Fig. 74, distribution of *Boreus californicus*. Fig. 75, distribution of *Boreus nix* and *B. pilosus*. Fig. 76, distribution of *Boreus reductus*.

broadly rounded apically, reaching bases of dististyles.

Female abdomen: Dark brown. Ratio of length of ovipositor to rostrum = 1.30. Cerci dark brown, evenly tapering to apex.

Body length: Male, 4.9 to 5.4 mm., in alcohol, 2.3 to 3.6 mm., pinned; female, 4.9 to 5.8 mm., in alcohol, 3.5 to 4.4 mm., pinned.

Intraspecific variation: The coloration and number of thoracic bristles vary.

This species has been collected (Fig. 73) from OHIO: Fairfield Co., Lancaster area; Hocking Co., "Neotoma"; Medina

Co., Hinckley Reservation; NEW YORK: Nassau Co., Sea Cliff; Chenango Co., Bainbridge; Tompkins Co., Ithaca; MASSACHUSETTS: Worcester Co., Spencer; Suffolk Co., Roxbury; NEW HAMPSHIRE: Carroll Co., Jackson (Dohanian, 1915); VERMONT: Chittenden Co., 3 mi. N. of Bolton; MAINE: Hancock Co., Ellsworth; and TENNESSEE: Sevier Co., Newfound Gap (Cole, 1938); and Campbell Co., LaFollette (Goslin, 1950).

B. nivoriundus has been collected from 19 Nov. to 28 March. Apparently E. S. Thomas collected 2 females from Hocking Co., Ohio, on 15 Aug. 1935. The date of these specimens, along with two specimens of *B. brumalis* collected at the same place on the same date by the same collector, is unusual. Only in the Bering Sea area have other specimens of Nearctic *Boreus* been collected at this time of year. Localities for *B. nivoriundus* range in elevation from sea level to about 5000 ft. (1500 m.).

B. nivoriundus can be separated from all other species of *Boreus,* except *elegans,* by the combination of pronotal bristles and rounded ninth sternum of males. *B. nivoriundus* can be separated from the western *elegans* by the former species' smaller size, fewer stout rostral setae, and smaller denticles near the hood.

Boreus nix Carpenter

Boreus nix Carpenter, 1935, Psyche 42: 114, Fig. 7.

Boreus gracilis Carpenter, 1935, Psyche 42:118. New synonymy.

Holotype male and allotype female of *nix* (no. 22359) in Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts. Holotype female of *gracilis* (no. 7452) cannot be located at the Burke Memorial Washington State Museum, Seattle. One paratype female (no. 22361) in Museum of Comparative Zoology, Harvard University.

Present description based on 12 males, 9 females.

HEAD: Dark brown shading to lighter brown on rostrum. Occiput finely reticulate, with several long setae. Median ocellus present. Antenna brown, with 21 to 22 flagellomeres. Anterior and posterior surfaces with a few long setae, mainly below antennal bases. Ratio of length of maxillo-labial complex to rostrum = .88.

THORAX: Dark brown. Pronotum with indistinct transverse ridge at mid-length; anterior and posterior margins with 4 to 6 bristles. Meso- and metanotum occasionally with 2 bristles each. Long white setae covering thorax.

LEGS: Dark brown to black with numerous dark setae and long white setae. Apical femoral spine dark brown. Tibial spurs light brown.

MALE WINGS: Dark brown, abruptly narrowed at mid-length, with 16 inner and 15 outer forewing spines, 10 to 11 hindwing spines.

FEMALE FOREWING: Dark brown, oval; covering hindwing.

MALE ABDOMEN: Dark brown to black with long white setae on all segments, giving this species a frosted appearance. No tergal ridges on second and third segments. No fusion of eighth tergum and sternum or ninth tergum and sternum. Ninth tergum with hood extending laterally to mid-width of denticular areas (Fig. 45); no median septum; medial cleft between areas of denticles; about 33 denticles on each side. Diststyle with about 20 small denticles arranged from below basal lobe almost to base of diststylar claw. Ninth sternum deeply notched apically; reaching bases of diststyles.

FEMALE ABDOMEN: Dark brown to black. Long white setae on all segments. Ratio of length of ovipositor to rostrum = 1.39. Cerci dark brown, evenly tapering to apex.

BODY LENGTH: Male, 4.3 to 4.5 mm., in alcohol, 2.4 to 4.1 mm., pinned; female, 4.8 mm., in alcohol, 3.3 to 4.5 mm., pinned.

Intraspecific variation: The length of the setae varies somewhat, but is always longer than in other species, except *pilosus.*

Holotype male and allotype female from MONTANA: Ravalli Co., Gird's Creek, 2 Nov. 1934, W. L. Jellison. In addition, there have been 9 other males and 4 other females collected by C. B. Phillip and W. L. Jellison around Hamilton, Montana. Other localities (Fig. 75) are BRITISH COLUMBIA: Ashnola River Valley, 23 Nov. 1963, P. R. Grant, 2 males; ALASKA: between Kennicott and McCarthy, 15 April 1934, W. L. Lloyd, 3 males, 6 females (Carpenter, 1936, as *gracilis*).

Gird's Creek is about 5 miles straight east of Hamilton, Montana. The creek is on the dry eastern side of the Bitterroot River Valley, and is relatively inaccessible. However, this is the only locality where this species has been consistently collected.

B. nix has been collected from 2 Nov. to 11 Feb. in Montana and southern British Columbia, while Alaskan specimens were collected from mid- to late-April. The climate and evaluation of the Alaskan localities were discussed under *B. intermedius.* The dry, hilly area east of Hamilton, Montana, seems to be considerably different from the glacial lowland of Alaska, but differences in climate may be modified by different emergence dates.

When Carpenter (1936) discussed *B. gracilis,* he mentioned that this species differed from *nix* only in having male wings which were not abruptly narrowed at mid-length. However, in observing the series he used in describing the male, I noted that these specimens do have such abruptly narrowed wings. As there are no other differences, I consider *gracilis* as a junior synonym of *nix.*

This species is a member of the *brumalis* subgroup of the *nivoriundus* group, having bristles on the pronotum and a notched male ninth sternum. The long pilosity of the body separates this species from all others except *pilosus.* Males of *pilosus* have only about 19 denticles in each tergal area, while males of *nix* have about 33.

Boreus pilosus Carpenter

Boreus pilosus Carpenter, 1935, Psyche 42:114-115, Fig. 10.

Holotype male and allotype female (no. 22360) in Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts.

Present description based on 7 males, 9 females.

Head: Dark brown shading to light brown on tip of rostrum. Occiput finely reticulate, with a few whitish setae. Median ocellus present. Antenna brown, with 18 to 20 flagellomeres. Anterior and posterior surfaces of rostrum with long, whitish setae, numerous near antennal bases, sparse over rest of rostrum. Ratio of length of maxillo-labial complex to rostrum = .80.

Thorax: Dark brown. Pronotum with indistinct transverse ridge at mid-length. Anterior and posterior margins of pronotum with 2 to 6 yellowish-brown bristles. Meso- and metanotum occasionally with 2 bristles each. Small setae covering thorax.

Legs: Yellowish-brown with numerous dark brown and long, white setae. Apical femoral spine present, dark brown. Tibial spurs light brown.

Male wing: Yellowish-brown, abruptly narrowed at mid-length, with 19 to 22 inner and 16 to 19 outer forewing spines, 9 to 15 hindwing spines.

Female forewing: Yellowish-brown, oval; covering hindwing.

Male abdomen: Dark brown except yellowish-brown on ninth segment, basistyles, and dististyles. Sclerites with many long, white setae. No tergal ridges on second and third segments. No fusion of eighth tergum and sternum or ninth tergum and sternum. Ninth tergum with hood extending laterally to mid-width of denticular areas; no median septum in hood. Denticles somewhat scattered, only 19 on each side. Dististyle with 17 denticles arranged from below basal lobe to base of dististylar claw. Ninth sternum deeply notched apically, extending to bases of dististyles.

Female abdomen: Dark brown, except for rusty brown ovipositor and cerci. Ratio of length of ovipositor to rostrum = 1.09. Cerci evenly tapering to apex.

Body length: Male, 2.6 to 2.9 mm., pinned, 3.0 to 4.0 mm., in alcohol; female, 4.1 to 4.6 mm., pinned, 5.2 mm., in alcohol.

Intraspecific variation: There is considerable variation in number of antennal segments and male wing spines. Sometimes prothoracic bristles are rubbed off, giving this species the apearance of a combination of characters unlike any group.

Holotype, allotype, and 11 paratypes from BRITISH COLUMBIA: Kaslo, Dec. 1932. Other collections (Fig. 75) are from ALBERTA: Jasper National Park, 2-4 Oct. 1964, 6200 feet, 1 male, 1 female; MONTANA: Missouri Co., 26 Feb. 1957, H. R. Dodge, 2 males; Missouri Co., Grant Creek, 11 April 1972, R. A. Haick, 1 male; Missoula Co., Elk Creek, 4000 feet, 22 Jan. 1972, R. A. Haick, 1 female.

George Ball (personal communication) states that the Alberta specimens were collected in "an alpine meadow on a snow-covered, windblown, northeast-facing slope of Mount Edith Cavell, at 6200 feet." These specimens were collected in association with *B. californicus,* as have been all other known specimens of *B. pilosus.*

B. pilosus has been collected from 4000 to 6200 feet (1220 to 1891 m.) between 4 Oct. and 11 April.

This species is part of the *brumalis* subgroup of the *nivoriundus* group, having thoracic bristles and a deeply notched male sternum. It can be separated from the eastern *brumalis* by the long pilosity, and from the western *nix* by its lighter coloration and by having fewer ninth tergal denticles in males.

Boreus reductus Carpenter

Boreus reductus Carpenter, 1933, Can. Entomol. 65:94-95, Fig. 1A.

Holotype male and allotype female in Canada Department of Agriculture collection, Ottawa.

Present description based on 25 males, 24 females.

Head: Dark brown. Occiput finely reticulate, with numerous setal pits. Median ocellus absent. Antennae dark brown; 17 to 18 flagellomeres. Rostrum with many long setae near antennal bases, few setae over remainder of rostrum. Ratio of length of maxillo-labial complex to rostrum = .90.

Thorax: Dark brown. Pronotum with indistinct transverse ridge at mid-length; no bristles present. No bristles on meso- and metanotum.

Legs: Dark brown with numerous light-colored and dark setae. No apical femoral spine. Tibial spurs light brown.

Male wings: Dark brown, abruptly narrowed at mid-length, with 19 inner and 16 to 19 outer forewing spines, three hindwing spines.

Female wings: Dark brown; reduced to small vestiges; forewing not overlapping hindwing; with short, whitish setae.

Male abdomen: Dark brown throughout. No tergal ridges on second and third segments. No fusion of eighth tergum and sternum or ninth tergum and sternum. Ninth tergal hood extending laterally to mid-width of denticular areas. Hood projecting dorso-caudally as a medial point (Fig. 47). Denticular areas large, with about 20 denticles on each side, forming a continuous area when medial cleft is not opened by internal pressure. Dististyle with about 13 denticles arranged from basal lobe to dististylar claw. Cleft between blunt-tipped basal lobe and rest of diststyle. Ninth sternum narrowed sharply at mid-length, smoothly rounded at apex, not reaching bases of diststyles.

FEMALE ABDOMEN: Dark brown. Ratio of length of ovipositor to rostrum = 1.10. Cerci dark brown, evenly tapering to apex. Internal sclerotized plate of eighth segment shaped like oval disc with two ventral funnels.

BODY LENGTH: Male, 1.9 to 2.4 mm., pinned, 3.3 to 3.9 mm., in alcohol; female, 2.8 to 3.1 mm., pinned, 4.8 mm., in alcohol.

INTRASPECIFIC VARIATION: Only variation noted is in number of antennal segments and male wing spines.

Holotype and allotype from BRITISH COLUMBIA: Kaslo, 29 Dec. 1906, J. W. Cockle. In addition, there is one other female with the same data, but no type label, in the Museum of Comparative Zoology. Other specimens (Fig. 76) are from BRITISH COLUMBIA: Lillooet, Jan. 1917, A. W. A. Phair, 1 male, 2 females; Ashnola River Valley, 23 Nov. 1963, P. R. Grant, 1 female; MONTANA: Ravalli Co., Hamilton area, from 27 Nov. to 31 Jan., W. L. Jellison, 15 males, 7 females; Missoula Co., from 6 Feb. to 11 March, John Chapman, D. S. Potter, and R. A. Haick, 6 males, 7 females; Mineral Co., St. Regis, 28 Dec. 1957, H. R. Dodge, 1 male, 6 females; Flathead Co., near Strick, 11 March 1961, W. L. Jellison, 1 male; WASHINGTON: Spokane Co., Spokane, 28 Dec. 1942, H. W. Prescott, many specimens; Whitman Co., 8 mi. W. of Colton, 18 Feb. 1972, W. J. Turner and J. Brunner, 2 males, 8 larvae; IDAHO: Oneida Co., 5 mi. SW. of Juniper, 22 Nov. 1969, George Knowlton, 1 female; NEVADA: White Pine Co., T18N, R54E, 1 Jan. 1971, Chambers and Nelson, 2 females.

This species has been taken in the arid Great Basin and mountainous regions of western North America, frequently in association with *B. californicus*. Specimens from Whitman Co., Washington were collected by Berlese funnel from *Selaginella* sp., a club moss.

B. reductus is unusual in many ways, and should not be confused with any other North American species of *Boreus*. Females of this species alone have forewings which do not overlap the hindwings. This is the only species for which an internal sclerotized plate is known in females. Males have no pronotal bristles and unfused eighth tergum and sternum—a combination unique among North American species. The *B. reductus* group is the only group of *Boreus* with no median ocellus. The ninth tergal hood is distinctive in having a medial point.

The nearest relatives of this species are found in the Old World, from the Crimea to the Pacific Ocean. Whether *B. reductus* is an early relic of this group in the Nearctic Region, or has more recently moved back into this region, cannot be determined at this time.

KEY TO MALES OF PALEARCTIC *Boreus*

1. Bristles present on margins of pronotum .... *beybienkoi*
   No bristles present on pronotum 2
2. Transverse ridge on second abdominal tergum 3
   No transverse ridge on second abdominal tergum 6
3. Ridge on second abdominal tergum divided medially .... *kratochvili*
   Ridge not divided medially 4
4. Occiput smooth .... *hyemalis*
   Occiput rugulose 5
5. Transverse ridge on third abdominal tergum .... *westwoodi*
   Tubercle on third abdominal tergum .... *lokayi*
6. Tergal hood present on ninth abdominal segment 7
   No tergal hood on ninth abdominal segment .... *chadzhigireji*
7. Symmetrical points on either side of midline of margin of hood .... *vlasovi*

Medial point on margin of ninth tergal hood 8
8. Medial point of tergal hood acute .... *semenovi*
Medial point of tergal hood smoothly rounded apically .... *orientalis*

No males are known for *sjoestedti* and *navasi.*

KEY TO FEMALES OF PALEARCTIC *Boreus*

1. Bristles present on margins of pronotum .... *beybienkoi*
No bristles present on pronotum 2
2. Forewings not covering hindwings 3
Forewings covering hindwings 4
3. Forewings similar in shape to hindwings .... *navasi*
Forewings longer and broader than hindwings .... *chadzhigireji*
4. Cerci evenly tapering to a point 5
Cerci narrowing abruptly at mid-length .... *vlasovi*
5. Known distribution—Europe 6
Known distribution—eastern Asia 8
6. Occiput smooth .... *hyemalis*
Occiput finely reticulated 7
7. Known distribution—mainly northern Europe .... *westwoodi*
Known distribution—the Balkan Peninsula .... *lokayi*
8. Known distribution—Kamtchatka Peninsula .... *sjoestedti*
Known distribution—Asian continent proper .... *semenovi and orientalis*

No females are known for *kratochvili.*

SPECIES DESCRIPTIONS

Boreus beybienkoi Tarbinsky

Boreus bey-bienkoi Tarbinsky, 1962, Sbornik Entomologicheskikh Rabot. Akademiia Nauk Kirgizsk 1:134-135.

Holotype, allotype, and all paratypes in Tarbinsky's collection.

The following is a translation by Mr. Christopher Starr of Tarbinsky's original description:

"Males smaller than females. Body short. Length of body 2.75 mm. Color of body black, short with metallic bronze. Pleura of thorax (episterna and epimera) and coxae of middle and hind legs dull. Entire body covered by short white setae. An especially heavy pubescence visible on abdomen, front coxae and base of rostrum. Abdomen wide. Legs long, forelegs shorter than middle legs, middle legs shorter than hind legs, hind legs more than twice as long as body. To transverse ridges. Antennae 21-segmented. Basal segment of antennae wide, second segment thick and round-oblong, apical segments almost twice as short as segments placed closer to base. Two pairs of wings. Forewings not bent hook-like, held straight along body. Setae along edges of forewings somewhat bent, and at ends directed toward wingtip. Forewings comparatively narrow at base, 0.25 mm; length of wing, including terminal spine 1.45 mm; terminal spine 0.2 mm. Length of wing almost six times greater than width at base. Forewings long (relative to length of body), with terminal spines, reaching to sixth abdominal segment. Along front and hind edge wings are covered by long spines, the longest of them shorter than terminal spine, placed at tip of wing. In middle part of wing all spines comparatively equal in length; shorter ones placed nearer to base of wing, but longer ones near tip of wing. Spines placed along front edge of wing began somewhat nearer to base of wing than spines along hind edge of wing. All spines evenly spaced. On dorsal surface of wings close to base up to 3 long bristles; entire wings covered by sparse but clearly visible hairs. Bases of wings brown, remaining parts black. Second pair of wings even more modified and in this species very thin, long and toward tip strongly curved in pincer-like form. Width of wing at base 0.15 mm.; length 1.05 mm. When extended, small spines visible from below in middle part of hindwings, but on inner edge in curved part of wing a fringe of very small setae. Hindwings brown. Pronotum short; along front edge of it 4 bristles placed in pairs, also some bristles on hind legs.

"No tergal ridges on dorsal side of second and third terga. Ninth tergum short; on top a comparatively deep and broad cavity. Caudal apex of tergal hood rounded off, blunt, and densely covered with short, thick, blunt setae on each side. Above base of cavity, covering it (when examined from above), rises up a small, triangular plate which fuses at its base with middle of tergum. Ninth sternum (subgenital plate) with detached apical part and obtuse engraving along apical edge. Lateral edges of sternum with visible cavities. In its total form ninth sternum similar to that of *B. chadzhigireji* Plig., differing from it by wider apical part and cavity along front edge. Length of ninth sternum along mid-line 0.65 mm. Gonocoxites massive, with wide tips, their bases with rather long end; dististyles with wide base, their width being from claw on inner side to lower edge of base. Apical part of dististyles terminates in massive and comparatively short claw. Cavity between base of apical claw and claw on inner side of dististyles is uniformly deep; edge of cavity covered with short, easily visible denticles. Claw on inner side of dististyles blunt with shovel-shaped broadened upper part.

"Females larger than males. Length of body, including ovipositor, 3.16 to 3.6 mm. Eighth tergum very large, one side making blunt angle with rounded tip. Ninth segment comparatively short and wide. Tenth segment short and thick; when examined from above greatest width in middle, visibly narrowed toward tip and base. Twelfth segment wide at base with detached, bluntly cut off tip. Valves of ovipositor (eighth segment) with wide base. Distal ends of valves separate near small angle, but at base of them small cavity visible. From below, distal end of valves covered with strong, short spines, tips of which are directed toward base of valves.

"Examined material: northern slope of Kirghiz Ala-Tau range (Fig. 78), low hills-foothills (the massif Paspeldik); 9 Dec. 1957, 2 males; 5 Jan. 1958, 16 males, 12 females; 4 Feb. 1960, 45 males, 40 females. Author's collections."

This species can be separated from all other Palearctic boreids by the presence of spines on the pronotum. For this reason *B. beybienkoi* apparently is a member of the *nivoriundus* group. The description indicates that the male ninth sternum (hypandrium) and uncurved wings are markedly different from those of other species, and may also be diagnostic characters. However, further description and illustration of these structures is needed for clarity.

Boreus chadzhigireji Pliginsky

Boreus chadzhi-gireji Pliginsky, 1914, Revue Russe d'Entomologie 14:366-367, figs. 9-13.

The two female types from Sevastopol and Simferol, and 1 male, 2 females from Eupatoria, all in Pliginsky's private collection have probably been lost (Martynova, 1954). Four males and 12 females from Eupatoria are in the collection of the Zoological Museum, Academy of Science, Leningrad.

Following is Esben-Petersen's (1921) translation of the original Russian description, followed by my translation of the German summary:

"Female shining; dark greenish metallic coloured or partly purplish shining. Rostrum yellowish-brown, darker at the tip. Palpi blackish. Eyes elliptical, yellowish. Head between the eyes evenly punctuate. Antennae 19-jointed, blackish; 1st joint large and robust; 2nd globular, half as broad as 1st, and twice as long as broad; 3rd joint small, cylindrical, half as broad as 2nd, and twice as long as broad; 4th joint longer than 3rd; 5th-10th long, cylindrical. 11th-18th cylindrical, somewhat longer than broad; 19th joint elliptical; all the joints clothed with very short blackish and whitish hairs. Prothorax as long as broad, narrowed in front, and finely rugosed transversely. Mesothorax as broad as hind margin of prothorax, with parallel lateral margins and somewhat incised posterior margin. Metathorax broad, with a semi-lunar incision posteriorly and with a transversely placed groove in its centre. Wings yellowish; forewings oblong and punctuate; hindwings have the shape of small narrow plates. Abdomen evenly clothed with short whitish hairs, transversely rugose. Ovipositor almost straight. Legs slender, yellowish, whitish haired; tarsi somewhat darker.

"Length: 3 mm.; breadth: 0.75 mm.

"Male. The male only differs from that of *B. navasi* in possessing 19-jointed antennae.

"The female of this species is separated from the other species of the genus by a completely straight ovipositor and through the appearance of the forewings, which are strongly elongate and comparatively large. The male is distinguished from *B. navasi* only by its 19-segmented antennae.

"The area around Sevastopol and Simferopol, 2 females in my collection; Eupatoria, 5 males and 14 females in the collection of the Zoological Museum of the Academy of Science and in my collection."

In addition to this description, further characters can be mentioned (Martynova, 1954). In the male, the eighth tergum and sternum are not fused, the ninth tergum and sternum are fused, and the ninth sternum does not taper evenly to the apex, but narrows rather abruptly at mid-length, as in *reductus,* ending in a square-tipped apex. The female tenth tergum is relatively short, but no ovipositor-to-rostrum ratio is available. There are no caudal extensions of the female tenth segment below the cerci, and cerci narrow rather sharply, as in *vlasovi.* Spines are present only on the apical one-third of the hypovalves.

Pliginsky made no mention of abdominal tergal ridges, and Martynova stated that they were almost absent. Because this species appears to be a part of the *reductus* group, having fused ninth tergum and sternum, I am inclined to think that it has no tergal ridges.

From Martynova's illustration it appears that males of *B. chadzhigireji* have no tergal hood. However, the absence of pronotal bristles, fusion of ninth tergum and sternum, and shortening of female forewings are traits which I feel are derived, and evolved after development of the tergal hood. Therefore, Martynova's illustration is probably incomplete; I suspect that this species does have a tergal hood that extends to the middle of the denticular areas.

The three localities of Sevastopol (44° 36′ N, 33°32′ E), Simferopol (44° 57′ N, 34°06′ E), and Eupatoria (Yeupatoriya) (45°12′ N, 33°22′ E) are all located near the southern and western coast of the Crimean Peninsula of the U.S.S.R. in an outlying range of the Caucasus Mountains (Fig. 78).

Martynova (loc. cit.) recorded the dates of collection of the type material from Eupatoria as 10 July 1905 and 18 Nov. 1905—3 Jan. 1906. The July record seems unusual, and perhaps was misread or misprinted, although there have also been reports of collections of *B. brumalis, hyemalis,* and *nivoriundus* from mid-summer.

Females of *B. chadzhigireji* are unusual in not having oval forewings covering the hindwings like most boreids, nor forewings reduced to small vestiges like *reductus* and *navasi,* but rather intermediate forewings that are small enough not to cover hindwings, but large enough to form an elongate wing pad. Males may be identified by the sharply narrowing ninth sternum.

Boreus hyemalis (Linnaeus)

Panorpa hyemalis Linnaeus, 1767, Systema Naturae 1:915. 12th edition.

Gryllus proboscideus Panzer, 1796, Faunae insectorum Germanicae initia 27:18.

Bittacus hiemalis (Linnaeus) Latreille, 1805, Histoire Naturelle générale et particulière des Crustacés et des Insectes 13:20.

Boreus hyemalis (Linnaeus) Latreille, 1816, Nouveau Dictionnaire d'Histoire Naturelle 4:152-153.

Boreus hiemalis (Linnaeus) Latreille, 1817, Le Regne Animal 3:433-434.

Ateleptera hiemalis (Linnaeus) Dalman. Analecta Entomologica p. 34. (1823)

Boreus gigas Brauer, 1876, Festschrift der K. K. zool.—bot. Gesellschaft in Wien, pp. 263-300. Nomen nudum.

Whereabouts of type specimens unknown.

Present description based on 8 males, 8 females in alcohol.

Head: Dark brown shading to yellowish-brown on rostrum. Occiput smooth with numerous small setae. Median ocellus present, light brown. Antenna light brown basally, dark brown apically, with 20 to 21 flagellomeres. Many light setae on rostrum close to antennal bases, few setae over rest of rostrum. Ratio of length of maxillolabial complex to rostrum = .89.

Thorax: Dark brown. Indistinct transverse ridge on pronotum at mid-length; no pronotal bristles.

Legs: Yellowish-brown with dark brown setae. Apical femoral spine present. Tibial spurs light brown.

Male wings: Light brown, abruptly narrowed at mid-length, with 22 inner and 8 to 10 outer forewing spines, no hindwing spines.

Female forewing: Yellowish-brown, oval; covering hindwing.

Male abdomen: Dark brown except yellowish-brown on ninth abdominal segment, basistyles, and dististyles. Transverse ridge on second tergum tilted anteriorly. Lateral margin of ridge with dorsal lobes. Tergal ridge of third segment reduced to rugulose area or smaller ridge with dorso-lateral lobes. Eighth tergum and sternum fused. Ninth tergum and sternum not fused. Large hood of ninth tergum extending laterally to lateral edges of denticular areas. Median septum of hood long, narrow. About 20 denticles on each side of septum very sharply tipped, more like spines. About 17 spines along anterior margin of dististyle from below basal lobe to base of dististylar claw; basal lobe sharp-tipped with cleft between lobe and rest of dististyle. Ninth sternum smoothly rounded at apex, reaching bases of dististyles.

Female abdomen: Dark brown except yellowish-brown on last 4 visible segments. Ratio of length of ovipositor to rostrum = 1.14. Cerci yellowish-brown, evenly tapering to apex.

Body length: Male, 2.7 to 3.5 mm., in alcohol; female, 3.8 to 4.5 mm., in alcohol.

Interspecific variation: I have seen some German specimens with light brown coloration. The most important variation is in the shape of the ridges of the second and third abdominal terga, which sometimes have no lobes. The shape of the ridges has been used to distinguish species of the *hyemalis* group.

B. hyemalis has been collected from many localities (Fig. 81) in: Austria, Belgium, Czechoslovakia, Denmark, France, Germany, Great Britain, Italy, the Netherlands, Norway, Poland, Rumania, Sweden, and Switzerland.

Specimens have been collected from 7 Sept. to 13 April in Norway. The adult emergence period appears to be shorter than that farther south. One Dutch specimen was supposedly collected on 22 June.

This species has been collected at 1400 m. in Norway to 2000 m. in the Alps of southern France and northern Italy to 2500 m. in the French Pyrenees, but also has been collected near sea level of the Netherlands and Belgium.

B. hyemalis is the typical member of the *hyemalis* group, having abdominal tergal ridges in the male. Of the other species in this group, *B. kratochvili* has a forked ridge on the second abdominal tergum, *westwoodi* has a ridge on the third abdominal tergum with no lateral lobes, and *lokayi* has a tubercle in place of the tergal ridge on the third abdominal tergum. Because of the variation noted in the ridge of the third abdominal tergum of *B. hyemalis,* this character may be unreliable in taxonomy. Meinander (1962) and others have noted that *hyemalis* has a smooth occiput with scattered setal pits, while *westwoodi* and *lokayi* have a rugulose occiput. In the admittedly inadequate amount of material I studied, the third abdominal tergum was variable and differences in smoothness of the occiput hard to detect. It is my impression that with further study of a larger number of specimens, *B. kratochvili, lokayi,* and *westwoodi* will be synonymized.

Boreus kratochvili Mayer

Boreus kratochvili Mayer, 1938, Entomologicke listy 1:132, Figs. 3, 6, 9, 12, 15, 18, 24.

Location of type specimens unknown.

The following is my translation of the summary of Mayer's (1938) original description:

"Large like *Boreus hyemalis* (male 2.5-3.5 mm.).

"Body pitch black with metallic blue reflections. Rostrum, antennae, palpi, second and third thoracic segments, legs, wings, and genital appendages brown (like *Boreus hyemalis* L.).

"Head: Surface very weakly wrinkled (high magnification!), without large pits. Antennae: male with 25 segments; the 2 basal segments and the whole distal half dark. The first antennal segment is stout, somewhat smaller on the distal end. The second segment is broader in the middle than at the base and at the distal end; maximal breadth to length 1:1.5. Third and fourth antennal segments very short, the fifth through twelfth elongate to the distal end. From the thirteenth segment on, they are shortened again.

"The second pair of mandibles brown, like *Boreus hyemalis.* Lacinia has on the base only nine, stout, dark brown bristles that sit on wider rings. On the distal end of the lacinia is a brush of long, whitish hairs.

"The first thoracic segment is very dark, almost black, clearly cross-furrowed. The underside of the forewing has two rows of stouter, short, nearly black bristles; the outer row consists of 11 (5+1+1+3+1) bristles. On the end the first pair of wings terminates in a long, black spine.

"The second abdominal tergum bears before the hind margin a stout, somewhat foreward-bent ridge, that terminates on both sides in sharp points, but in the middle is cut strongly in V-shape. For this reason the male of this species is conspicuously distinguished from the other males of this genus. On the third tergum is a much smaller ridge, that resembles the form of a single specimen of *Boreus hyemalis;* on the upper margin it is again pointed and weakly squared on the side.

"The subgenital plate brown, like *Boreus hyemalis;* base to height 1:43:1, the end (from only 2 males) appears to be somewhat rounded.

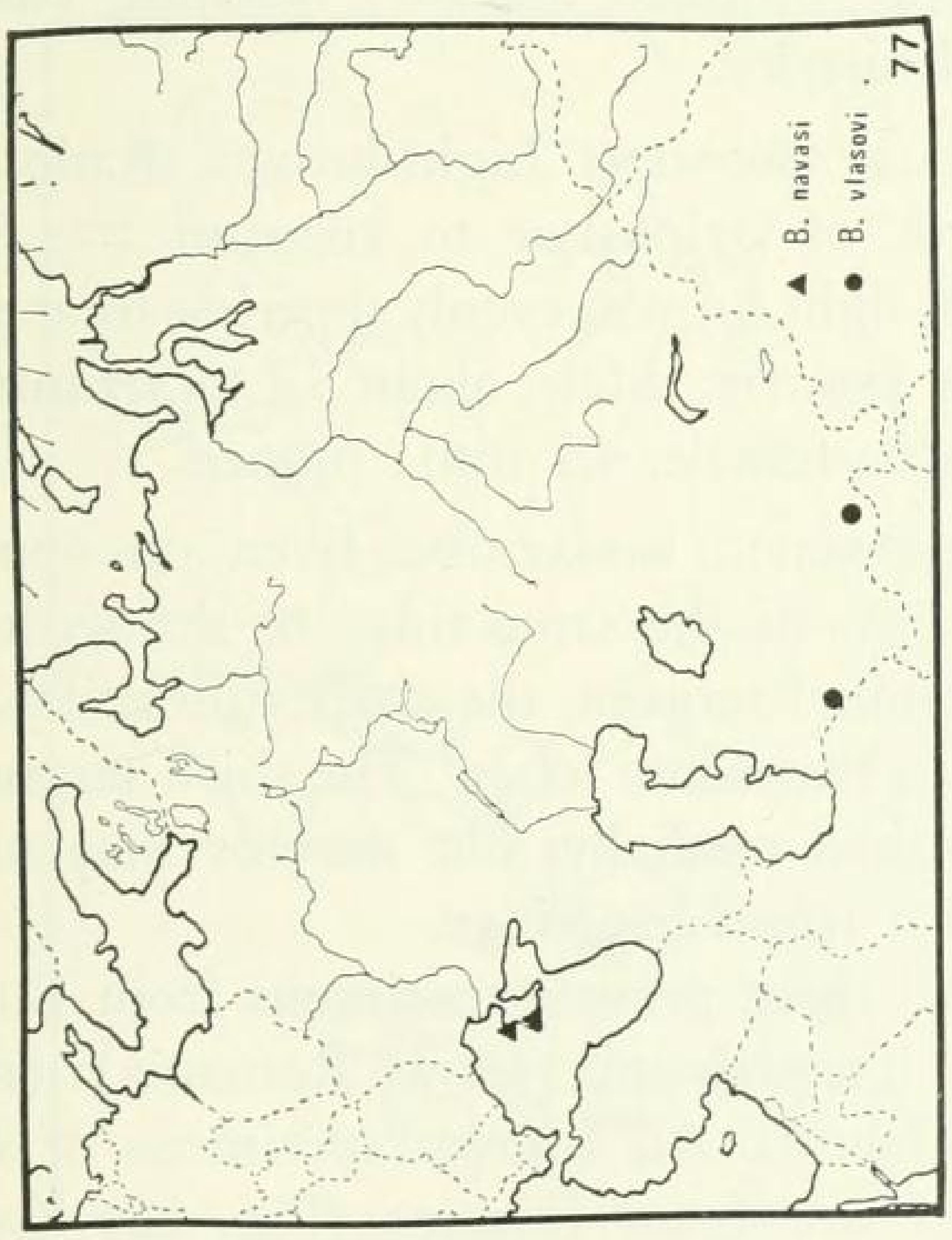
"The genital appendages are stout, two-branched; the upper branch is bent-hook-shaped and the second shortened; both are dark brown.

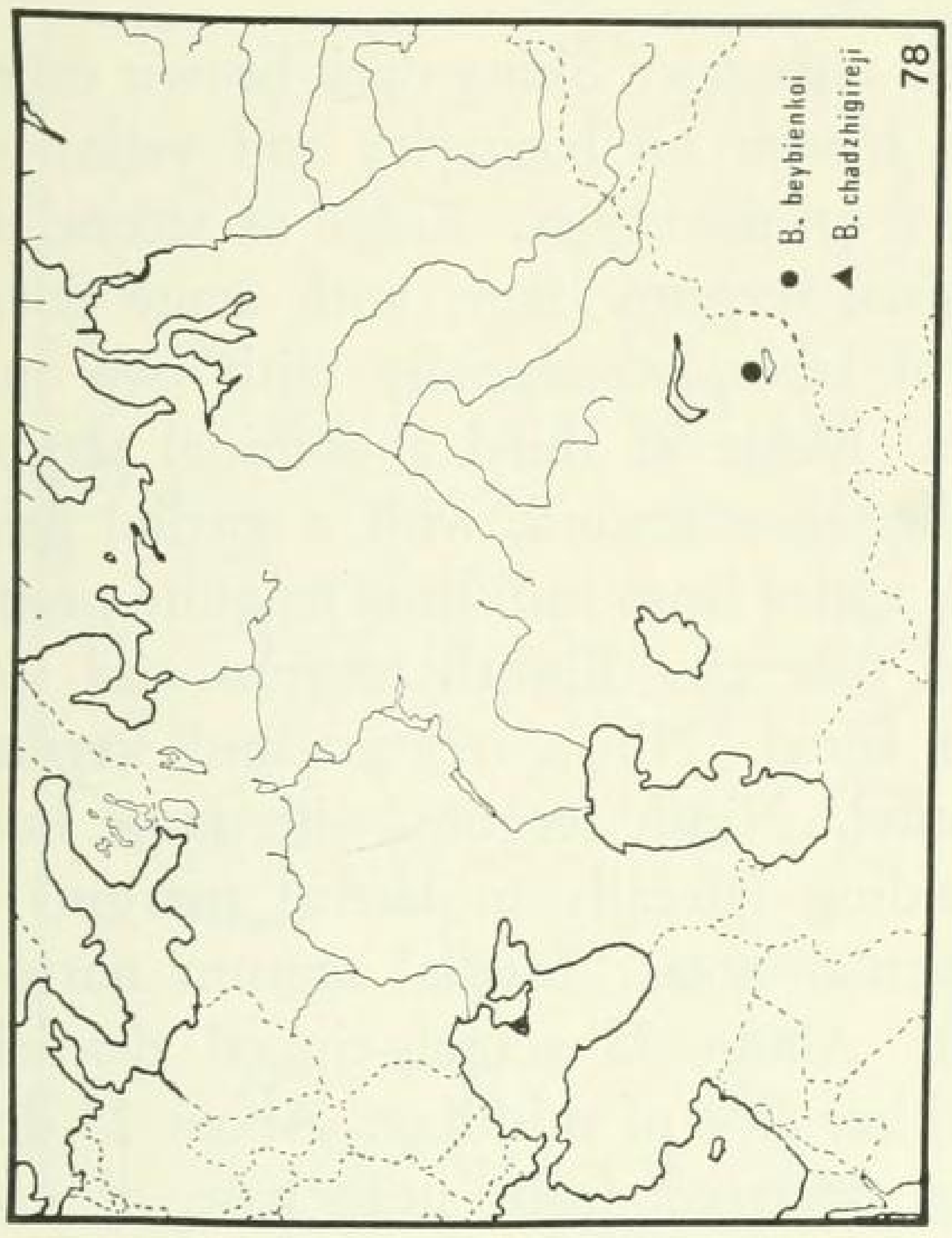
"The tongue-shaped extension of the ninth episclerite brown, strongly chitinized, filled with long bristles, ending in a rather high, colorless, compact cone. Base to height 1.8:1.

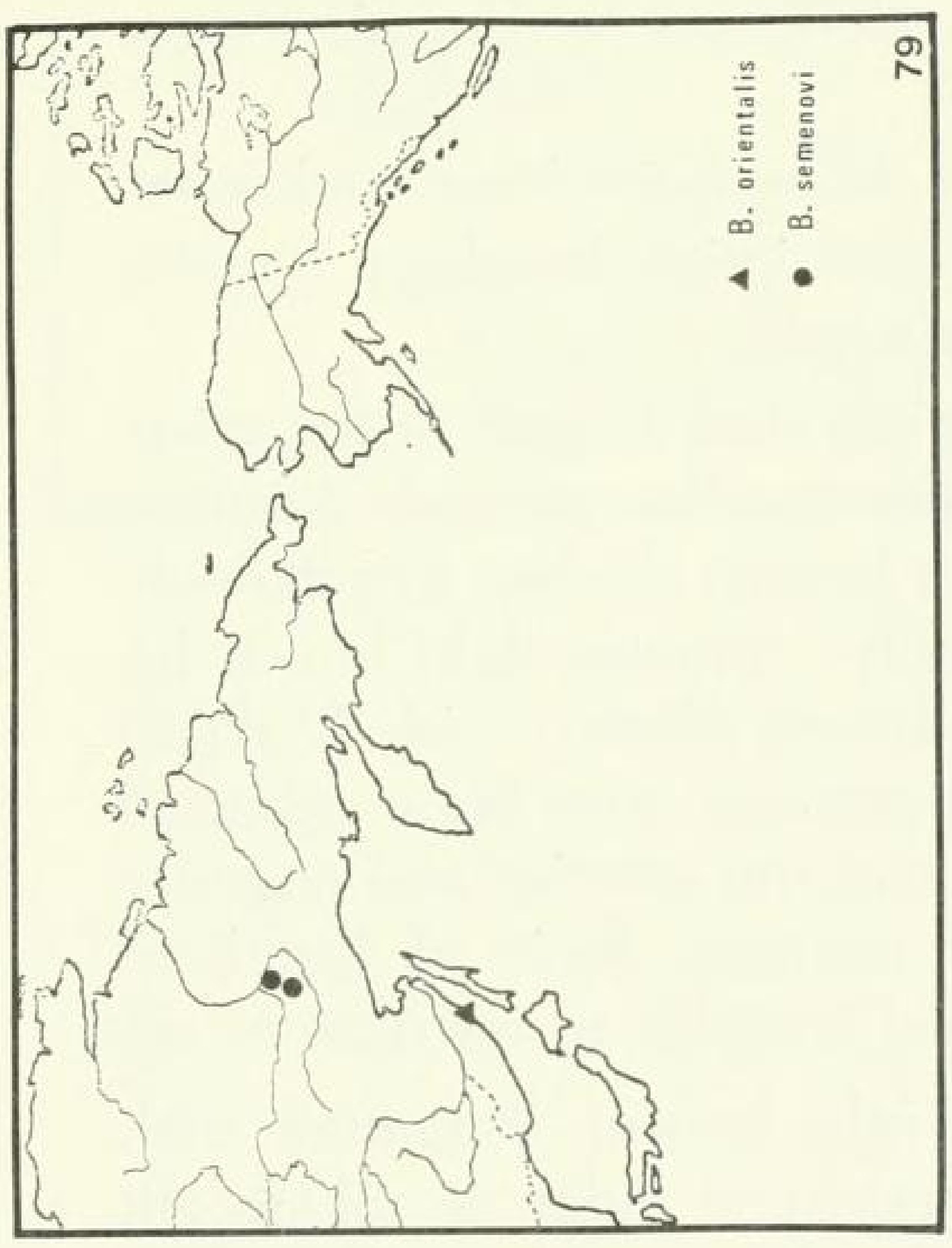
"Female unknown.

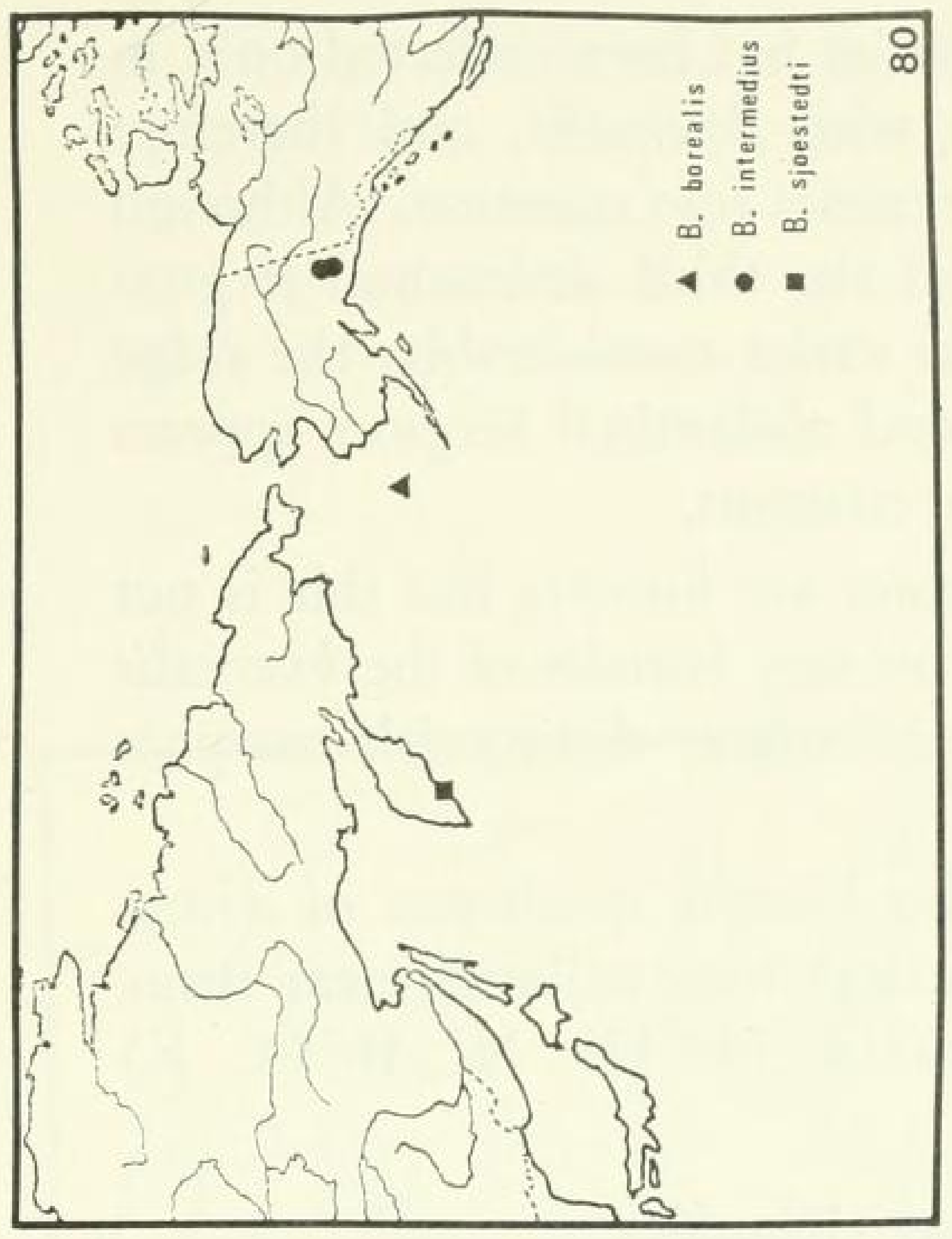
"This species has until now only been collected from three localities in the vicinity of Brno together with *Boreus hyemalis* L."

Little is known about this species. Lestage (1941) illustrated the second abdomi-









Figures 77-80. Fig. 77, distribution of *Boreus navasi* and *B. vlasovi*. Fig. 78, distribution of *Boreus beybienkoi* and *B. chadzhigireji*. Fig. 79, distribution of *Boreus orientalis* and *B. semenovi*. Fig. 80, distribution of *Boreus borealis*, *B. intermedius*, and *B. sjoestedti*.

nal tergum of the male as having a bipartite ridge, which would indicate that *kratochvili* is a member of the *hyemalis* group. This character state also distinguishes it from all other members of the group.

This species has been collected only in association with *hyemalis,* and therefore its validity comes into question. Although the ridge of the third abdominal tergum of *hyemalis* varies considerably, the ridge of the second abdominal tergum appears to be fairly constant.

No females are known, but this is not surprising because females of the *hyemalis* group are difficult to distinguish morphologically.

The only known specimens of *kratochvili* (3 males) were collected near Brno, Czechoslovakia (49°12′ N, 16°40′ E) (Fig. 82).

Boreus lokayi Klapálek

Boreus lokayi Klapálek, 1901, Rozpravy Ceská Akademie císare Frantiska Josefa pro Védy, slovesnost, a Umeni, Prague 10(21):1-19.

Location of type specimens unknown.

Present description based on 2 males, 1 female, pinned.

HEAD: Occiput dark brown, finely reticulated. Median ocellus present. Rostrum light brown basally, shading to yellowish-brown distally. Antenna light brown basally, dark brown distally, with 19 flagellomeres. Numerous setae below antennal bases, few setae on anterior and posterior surfaces of rostrum. Ratio of length of maxillo-labial complex to rostrum = .90.

THORAX: Light brown. Pronotum with indistinct transverse ridge at mid-length and no bristles along anterior and posterior margins. Meso- and metanota without bristles.

LEGS: Yellowish-brown, with numerous setae and apical femoral spine. Tibial spurs light brown.

MALE WINGS: Yellowish-brown, abruptly narrowed at mid-length, with about 25 inner and 8 to 10 outer forewing spines; 18 very small hindwing spines.

FEMALE FOREWING: Yellowish-brown, oval; covering hindwing.

MALE ABDOMEN: Shiny dark brown except light brown on basistyles and yellowish-brown on dististyles. Ridge of second abdominal tergum large, with acute dorsolateral lobes, occasionally with two such lobes. Ridge of third abdominal tergum smaller than second, with a medial peak. Peak varies from indistinct to quite prominent tubercle. Eighth tergum and sternum fused. Ninth tergum and sternum unfused. Ninth tergum with large hood extending laterally to lateral margins of denticular areas. Medial septum narrow, short. About 35 acutely-tipped denticles on either side of mid-line. About 23 denticles arranged from near base of each dististyle to near base of dististyle to near base of dististylar claw. Ninth sternum broadly rounded apically, reaching bases of dististyles.

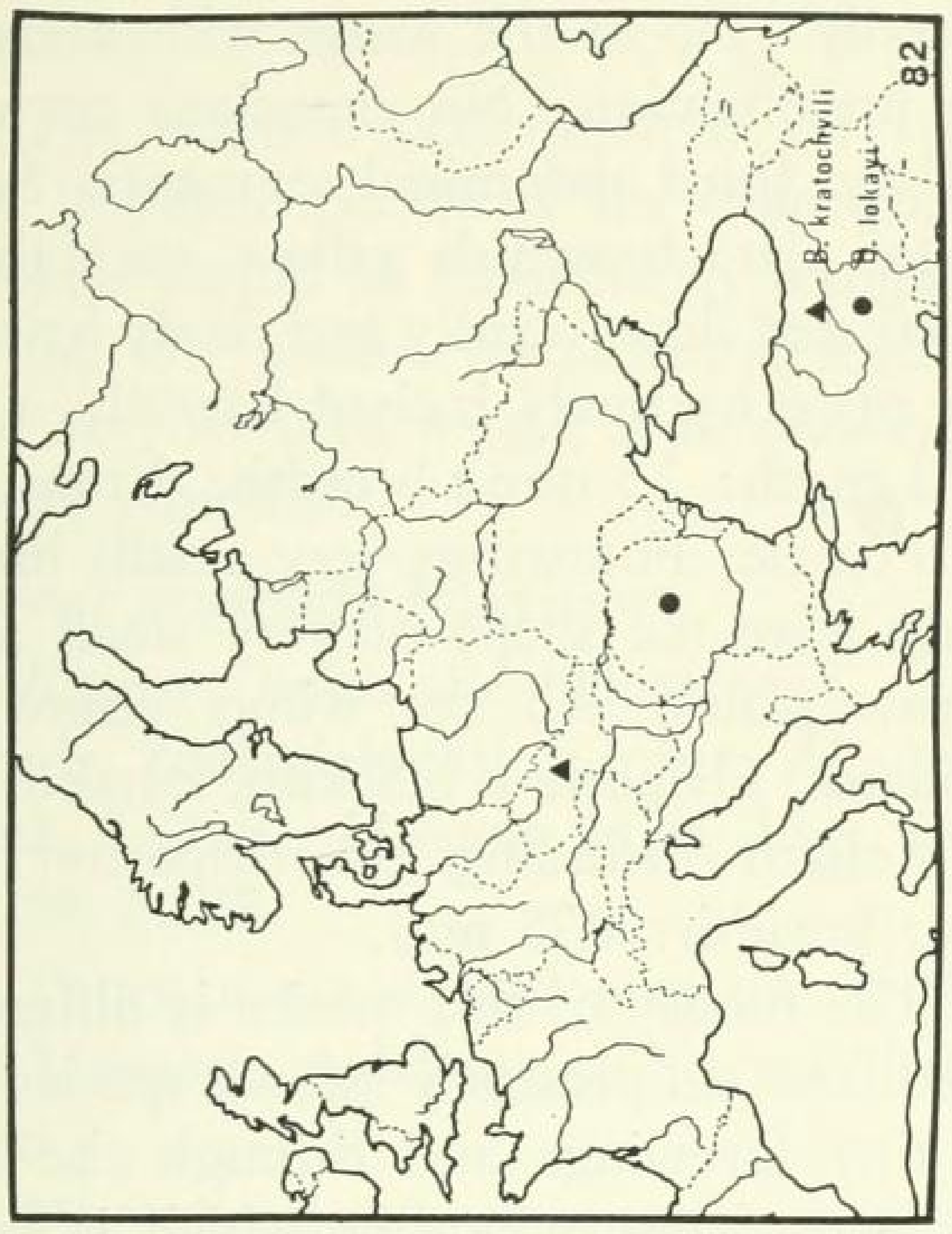
FEMALE ABDOMEN: Light brown. Ratio of length of ovipositor to rostrum = .66. Cerci light brown, evenly tapering to apex.

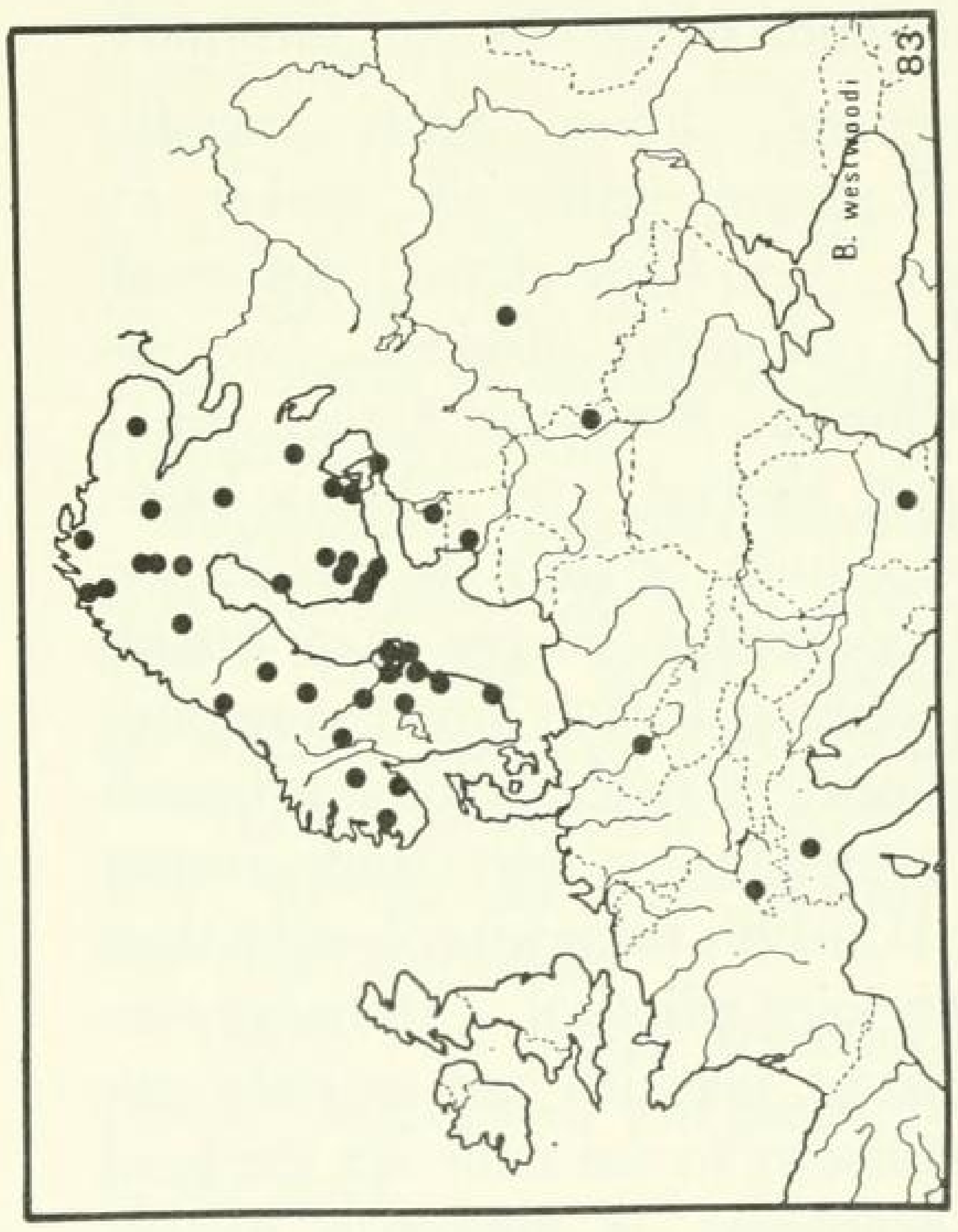
BODY LENGTH: Male, about 3.2 to 3.9 mm., pinned; female, 4.1 mm., pinned.

INTRASPECIFIC VARIATION: Even on opposite sides of the same ridge of the second abdominal tergum, the shapes differ from one to two acute lobes. The third tergum is peaked medially, but may or may not have a transverse ridge.

All three present specimens from Bucsecs, Transylvania (now Romania) (no date label). All known specimens of *B. lokayi* are from Bucsecs (Fig. 82) (see Cooper, 1972:280).

This species is very similar, if not identical, to *B. hyemalis.* However, I have not seen enough variation in the second and third tergal ridges of *B. hyemalis* to warrant synonymy at this time.





Figures 81-83. Fig. 81, distribution of *Boreus hyemalis.* Fig. 82, distribution of *Boreus kratochvili* and *B. lokayi.* Fig. 83, distribution of *B. westwoodi.*

Boreus navasi Pliginsky

Boreus navasi Pliginsky, 1914, Revue Russe d'Entomologie 14:364-366, Figs. 1-8.

Boreus aktijari Pliginsky, 1914, Revue Russe d'Entomologie 14:367, Fig. 14. New synonymy.

Syntypes (3 males, 1 female) of *navasi* and holotype female of *aktijari* in Pliginsky's private collection. According to Martynova (1954) these type specimens have not been preserved. They are the only known specimens.

I repeat here the translation of the original Russian description of *navasi* appearing in Esben-Petersen (1921), followed by my translation of the German summary.

"Dark-green, almost black, metallic shining. Rostrum yellowish, darker towards apex. First joint of palpi brownish yellow, the remainder blackish. Eyes elliptical, yellowish. Antennae 20-segmented, blackish and clothed with whitish hairs; basal joint robust, as long as broad; second joint somewhat longer than broad; third joint oblong, half as broad as second; 4th-8th cylindrical, twice as long as broad; 9th-11th somewhat stouter and shorter than 8th; 11th-19th somewhat longer than broad; 20th joint elliptical. Prothorax narrowed in front, blackish and coarsely striated transversely; in the male sex the hind part of prothorax is brownish yellow. Mesothorax broad, trapezoidal, punctuated and not so coarsely striated transversely as the prothorax; in the centre a transversely placed groove. Metathorax broader and shorter than the mesothorax, with a transversely placed groove in its centre and with a deep semi-lunar incision posteriorly. Abdomen black, greenish metallic shining and finely rugosed transversely; in the male sex the abdomen is clothed with short white hairs; in the female sex it is naked. Legs tiny, yellowish; tarsi blackish.

"Male. Wings yellowish, reaching the third abdominal segment. Forewing curved, darker at apex, shining, punctate, and finely rugose and haired dorsally; coarsely haired ventrally. Hindwings narrower and shorter than forewings; densely haired ventrally. Hindwings narrower and shorter than forewings; densely haired ventrally. Tip of the wings with a claw-like prolongation. No elevations on second and third abdominal segments. Subgenital plate brownish yellow, very thin, punctuated downwardly and finely haired. The plate narrowly incised laterally.

"Length: 2.5 mm.; breadth: 1 mm.

"Female. Forewings very small; hindwings have the shape of very small and narrow plates. All the wings yellowish coloured. Ovipositor blackish, curved.

"Length including the ovipositor: 3 mm.; breadth: 0.75 mm.

"The female of this species is differentiated from all presently known species by the tiny forewings and through the appearance of the ovipositor which is bent under at a nearly straight angle.

"The area around Sevastopol (Fig. 77), 20 Dec. 1913, 3 males and 1 female in my collection."

Mountains near Sevastopol (44°36′ N, 33°32′ E) are a part of the Caucasus Range in the Crimea of southern U.S.S.R.

Pliginsky separated *aktijari* from *navasi* on the basis of *aktijari's* 19-segmented antennae, rounded female forewings, lack of fine abdominal striations, and angle of depression of the cerci. *B. reductus* has antennae which vary from 19 to 20 segments, and Cooper (1974) has found antennal segments to vary from 18 to 20 in *H. notoperates,* pointing out the questionableness of making distinctions on this basis. Fine abdominal striations and depression of the cerci, which Pliginsky identifies as the ovipositor, are not useful taxonomic characters due to variation in both. As can be seen in Pliginsky's Figures 6 and 14, the shape of the female forewings is almost identical. In addition, both nominal species have been collected only in the vicinity of Sevastopol. Because there are no type specimens, and because of lack of useful distinguishing character states, any future collections could be placed in either species with equal facility. Therefore, I feel that *aktijari* is a junior synonym of *navasi.*

The original description is very poor, but if other specimens are collected, the females should be immediately recognized by the low number of antennal segments and very reduced wings, as in *reductus* of North America.

Boreus orientalis Martynova

Boreus orientalis Martynova, 1954, Trudy Zoologicheskii institut, Akademia nauk S.S.S.R., Moscow 15:65, Figs. 6, 11, 15, 20, 24, 27.

Types in the collection of the Zoological Museum, Academy of Science, Leningrad.

The following is a translation by Christopher Starr of Martynova's original description:

"Male. Front wing a little shorter than in *B. semenovi* Plig., but with base of same width; length of wing, including terminal spine, 1.4 mm.; along front edge of wing, spines begin a little closer to base and end a little closer to tip than along hind edge of wing; spines uniformly spaced. No tergal ridges on dorsal side of second and third terga. Ninth tergum almost trapezoidal; at base almost same width as at tip; tip truncated, as in *B. semenovi* Plig., divided into two blades, forming somewhat shorter slit; base of slit placed in depression, over which is small hood, as in *B. semenovi* Plig., but of somewhat different form; base of hood without cavity, projection on distal side of it very gently sloping and cavities not as deep; ninth sternum (subgenital plate) very short, almost one-third the length in *B. semenovi* Plig., with very deep and wide cavity along top edge; gonocoxite with shorter and blunter base than in *B. semenovi* Plig., also with wedge-shaped, but shorter distal end and with less massive claw on inner side of dististyles.

"Female. Eighth tergum in form resembles eighth tergum of *B. semenovi* Plig., but outer corner of lateral line of it placed lower, therefore not in form of isosceles triangle; front edge of eighth sternum at base forms large projection, then sharply narrows and remains uniform width to the end; valves of ovipositor separate gradually, forming cavity; ninth segment of almost same form as in *B. semenovi* Plig.; tenth segment not as long, with deep cavity on dorsal side of distal end; this cavity in form similar to that of *B. westwoodi* Hag., but longer than latter; valves of ovipositor and first segment terminate at same level; twelfth segment in *B. semenovi* Plig. and *B. orientalis* sp. n. alike, but in *B. orientalis* lower side with two shallow cavities.

"Examined material: Sovetskaya Harbor, Maritime Provinces (Fig. 79), 29 VIII-1 IX 1908, 1 male, 1 female (types), on outdoor woodpile (ZIN collection).

"Both east-Siberian species closely related, though also quite sharply different, one from the other."

There is no twelfth segment in female *Boreus;* Martynova was probably referring to the cerci.

The tergal hood has a medial point, which is not as acute as in *B. semenovi.* The male ninth sternum appears to be extremely short, perhaps being broken off.

Martynova's Figure 6 shows the male *B. orientalis* with fused eighth tergum and sternum, and ninth tergum and sternum. Because fusion of the ninth tergum and sternum and presence of a medial point on the tergal hood are only known in the *reductus* group, the eighth tergum and sternum are likely unfused.

If *B. orientalis* has unfused eighth tergum and sternum, it is in the *reductus* group, and can be separated from other eastern Asiatic species by the less acute angle of the medial point of the hood. At this time the female cannot be definitely separated from *B. semenovi* and *sjoestedti*.

Sovetskaya Harbor (48°58′ N, 140°18′ E) is in the Tatarskiy Proliv between the Sea of Japan and the Sea of Okhotsk.

Boreus semenovi Pliginsky

Boreus semenovi Pliginsky, 1930, Revue Russe d'Entomologie 24: 230-231.

Holotype male in collection of Academy of Sciences Museum, Leningrad.

I present here my translation of Lestage's (1941) French translation of Pliginsky's original Russian description of *B. semenovi*.

"Male. Black with slight purplish reflections. Head metallic green, smooth above, save some points between the eyes. Frons smooth. Eyes large, elliptical. Rostrum and palps yellow-brown. Antennae brown-black, with 24 segments.

"Wings I yellow, sclerotized, punctuated, wrinkled, with little black spines on the borders, enlarged basally, narrowed at the apex, which terminates in a point, triangular seen from above, gradually narrowed, without lateral sinuousity, covered with a yellow pubescence directed backwards.

"Wings II forming yellow, narrow lances.

"Abdomen laterally reddish; terga smooth and without ridges; sides near the edges with dark hairs; sterna covered with whitish hairs.

"Ninth sternum very convex, conical, tapered caudally, its extremity slightly notched. Apex of gonopods acuminate and black. Femur I relatively thin. All legs clear brown.

"Length: 4 mm.

"Distribution. Russia, Aian-Nelkansk Expedition, 62nd kilometer."

Illustrations from Martynova (1954) give additional information about this species. Male with 10 inner and 14 outer forewing spines. Male eighth tergum and sternum unfused, ninth tergum and sternum fused. Ninth tergum with hood extending laterally to middles of denticular areas. Margin of tergal hood produced into a caudally directed, medial projection. Female eighth sternum with spines on apical one-third of hypovalves. Tenth segment long, but ratio of length of ovipositor to rostrum not available. Tenth segment may have short caudal extensions below cerci. Cerci tapering evenly to apex.

The holotype was collected in U.S.S.R.: Yakut S.S.R., Jakoti, on 20. IV. 1903. The specimen was collected by the Aian-Nelkansk Expedition on the slopes of the Oijski Mountain Range between the Lena and Aldan Rivers. Neither the locality nor the mountain range can be found on available maps. However, the collection was probably made somewhere along the track that leads from Ayan (56°27′ N, 138°10′ E) to Nel'kan (57°40′ N, 136°13′ E) to Yakutsk (62°00′ N, 129°40′ E).

One other collection of 7 males, 1 female was made in 1926 at the confluence of the Tumpsu and Aldan Rivers (Fig. 79), Yakut S.S.R. The Tumpsu River cannot be located on available maps either.

This species appears to belong to the *reductus* group, and males can be separated from other Asiatic members of this group by the medial projection of the hood, as in the North American *reductus*. Females cannot be distinguished at this time.

Boreus sjoestedti Navás

Boreus sjöstedti Navás, 1925, Arkiv för Zoologi 18B(2):3-4, Fig. 2.

Holotype female in Naturhistoriska Riksmuseet, Stockholm, Sweden.

Present description based on original description and unpublished notes on the type specimen by George W. Byers.

HEAD: Black shading to brown on rostrum. Occiput with fine surface sculpturing and setal pits. Antenna brown, with 18 flagellomeres. Rostrum with many whitish setae at antennal bases, few setae elsewhere on rostrum. Ratio of length of maxillo-labial complex to rostrum = .81.

Thorax: Black. Pronotum with indistinct transverse ridge at mid-length, anterior and posterior margins without bristles, finely striated.

Legs: Brownish.

Female forewing: Brownish, oval; covering hindwing.

Female abdomen: Shiny black with short setae along caudal margins of terga and over all of sterna. Ratio of length of ovipositor to rostrum = 1.14.

Body length: Female, 4.9 mm., pinned.

Holotype female (and only known specimen) from Achomten Bay (Bukhta Akhomten: 52°26′ N, 158°30′ E3, Kamtchatka Peninsula, U.S.S.R.

This specimen was collected on 12 June 1925 by R. Malaise. Although this summer collection date seems late, specimens of *borealis* from the Bering Sea area have been collected at a similar date, and there are a few scattered collections of other species at this time of year.

Achomten Bay is a small, uninhabited inlet in Kamtchatka (Fig. 80), 42 miles south of Petropavlovsk, with 7000-foot-high Sopka Mutnaya volcano of the Kamchatka-Kuril Range rising steeply to the west.

This female specimen is very similar to other eastern Asiatic and Alaskan specimens of other species, allowing no easy differentiation. Navás gave no useful characters for separating this from other species. However, since this is the only species described within a radius of 820 miles, it may well be a valid species and more male specimens from the Kamtchatka Peninsula may give us additional characters for this species. Martynova (1954) did not include this species in her monograph of Boreidae of the U.S.S.R.

Boreus vlasovi Martynova

Boreus vlasovi Martynova, 1954, Trudy Zoologicheskii institut, Akademiia nauk S.S.S.R., Moscow 15:61-62, Figs. 4, 9, 13, 18, 22, 26.

Whereabouts of type specimens unknown.

Present description based on 7 males, 2 females in alcohol.

Head: Dark brown. Occiput rugulose with many white setae. Median ocellus absent. Antenna dark brown, with 16 to 17 flagellomeres. Many long setae near antennal bases of rostrum; few setae over rest of rostrum. Ratio of length of maxillo-labial complex to rostrum = 1.00.

Thorax: Dark brown. No transverse ridge at mid-length or marginal bristles on pronotum.

Legs: Dark brown with light-colored and dark brown setae. Apical femoral spine absent. Tibial spurs dark brown.

Male wings: Light brown, abruptly narrowed at mid-length, with 15 inner and 11 to 12 outer forewing spines, 3 to 4 hindwing spines.

Female forewing: Light brown, oval, short, reaching only middle of metanotum, barely covering hindwing vestiges, with many whitish setae.

Male abdomen: Dark brown throughout. No tergal ridges on second and third segments. No fusion of eighth tergum and sternum, but ninth tergum and sternum fused in many cases. Ninth tergum with hood extending laterally to middles of denticular areas. Margin of hood produced caudally on either side of mid-line. Small median septum of hood present. About 20 denticles on each side. Dististyle with about 15 denticles arranged from below basal lobe to base of dististylar claw; basal lobe blunt-tipped, with cleft between it and rest of dististyle. Ninth sternum smoothly rounded apically, reaching bases of dististyles.

FEMALE ABDOMEN: Dark brown. Ratio of length of ovipositor to rostrum = .93. Cerci dark brown, not evenly tapering to point, but sharply pointed at apex; fused.

BODY LENGTH: Male, 2.3 to 4.1 mm., in alcohol; female, 3.6 to 4.0 mm., in alcohol.

INTRASPECIFIC VARIATION: One male was noted to have two spines at apex of ninth sternum; normally this species has no spines on ninth sternum. The sharp projections of the caudal margin of the female eighth tergum, illustrated in Martynova's (1954) Figure 18, were not noted in specimens examined. Fusion of ninth tergum and sternum is complete in only about half the available specimens. (cf. Cooper, 1973).

Collections of this species are from (Fig. 77) Turkmen S.S.R., Ashkabad (37° 57′ N, 58°23′ E), 3 Jan. to 20 Feb. 1932, and 1935, 148 males and females; Tadzhik S.S.R., 30 km N of Stalinabad (Dushanbe), 1100 m (38°33′ N, 68°48′ E), 10 to 12 March 1943, 3 males, 3 females; and Turkmen S.S.R., Askhabad, Dec. 1955, 7 males, 2 females. There is 1 male in the Deutsches Entomologisches Institut, Berlin, which I did not examine.

This species is a member of the *reductus* group having no thoracic spines and unfused eighth tergum and sternum. Although other Asiatic species are poorly known, this species probably can be differentiated by the two caudal projections of the lip of the hood in males, and the sharply narrowed cerci in females.

Boreus westwoodi Hagen

Boreus westwoodi Hagen, 1866, Entomol. Monthly Mag. 3:132.

Boreus tarnanii Navás, 1911, Revue Russe d'Entomologie 11:277-278, Fig. 1.

Boreus boldyrevi Navás, 1911, Revue Russe d'Entomologie 11:278, Fig. 2.

Location of all type specimens unknown.

In the original description, Hagen gave no information on type locality, although he listed the distribution as Germany, Finland, and England. As currently delimited, *B. westwoodi* is a northern and alpine species, not found in England, as MacLachlan (1869) pointed out. However, since the types cannot be located, it is impossible to say whether the current *B. westwoodi* is the same one that Hagen envisioned, or even if it is a valid species.

Navás (1911) mentioned no repository of types of *boldyrevi* and *tarnaii* and they, too, cannot be located. However, the type localities are listed as "Russie, environs de Moscou" and "Pologne de la Russie: Novaja-Alexandria," respectively. Martynova (1954) considered both *boldyrevi* and *tarnanii* as synonyms of *westwoodi,* which is commonly collected in the vicinity of Moscow.

Present description based on 18 males, 14 females, pinned.

HEAD: Occiput black with fine reticulations. Rostrum yellowish-brown; fine setae on caudal surface, no stout setae. Median ocellus present between antennal lobes. Antenna light brown basally, becoming dark brown apically; with 21 to 23 flagellomeres. Ratio of length of maxillolabial complex to rostrum = .85.

THORAX: Dark brown. Indistinct transverse ridge at mid-length of pronotum; no pronotal bristles.

LEGS: Yellowish. Apical femoral spine present, dark brown. Tibial spurs light brown.

MALE WINGS: Yellowish-brown. Forewing abruptly narrowed at mid-length, with 26 to 29 inner and 6 to 9 outer forewing spines. Hindwing with ventral fringe of setae, no spines.

FEMALE FOREWING: Yellowish, oval, covering hindwing.

MALE ABDOMEN: Dark brown, except yellowish-brown dististyles. Transverse ridge of second tergum with large dorso-lateral lobes. Ridge of third abdominal tergum prominent, without dorso-lateral lobes. Eighth tergum and sternum fused. Ninth tergum and sternum not fused. Ninth tergum with large hood extending laterally to lateral margins of denticular areas. Medial septum short, thin. Only about 16 sharp-tipped denticles on each side. Ninth sternum smoothly rounded apically, reaching bases of dististyles. Denticles on dististyle arranged from below basal lobe to base of dististylar claw. Cleft between basal lobe and rest of dististyle.

Female abdomen: Segments 1 to 8 dark brown, segments 9-10 and cerci yellowish-brown Ratio of length of ovipositor to rostrum = 1.41. Cerci evenly tapered to apex.

Body length: Male, 3.0 to 3.5 mm., pinned; female, 4.0 to 4.5 mm., pinned.

Intraspecific variation: There is some variation in number of antennal segments and male wing spines. Lestage (1941) in-indicated variation in the male ridge of the third abdominal tergum.

Svensson (1972) listed the distribution of *westwoodi* as the following (Fig. 83): Bulgaria, Czechoslovakia, East Balticum, Finland, Germany, Italy, Norway, Poland, Sweden, Switzerland, and U.S.S.R.

This species has been frequently collected from November to April, with a few scattered records from June, September, and October.

B. westwoodi is a member of the *hyemalis* group, having tergal ridges. It can be separated from *hyemalis* by the fine reticulations on the occiput, from *kratochvili* by the unipartite second tergal ridge with dorso-lateral lobes, and from *lokayi* by the ridged third tergum (no tubercle).

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LITERATURE CITED

Banks, N. 1923. Mecoptera. *In* McAtee, Insects, Arachnids, and Chilopods of the Pribilof Islands, Alaska. U.S.D.A., Bureau of Biological Survey, North American Fauna 46:158.

Bliss, L. C. 1962. Adaptations of arctic and alpine plants to environmental conditions. Arctic 15:117-144.

Boldyrev, B. T. 1914. Notice sur le *Boreus boldyrevi* Navás (Neuroptera, Panorpidae). Revue Russe d'Entomologie 1:203-210.

Brauer, F. 1855. Beiträge zur Kenntniss des inneren Baues und der Verwandlung der Neuropteren. Verhandlungen zoologisch-botanischen Gesellschaft in Wien 5:701-726.

———. 1857. Beiträge zur Kenntniss der Verwandlung der Neuropteren. Verhandlungen zoologisch-botanischen Gesellschaft in Wien 7: 69-70.

———. 1863. Beiträge zur Kenntniss der Panorpiden-Larven. Verhandlungen zoologisch-botanischen Gesellschaft in Wien 13:307-324.

———. 1876. Die Neuropteren Europas und insbesondere Österreichs mit Rücksicht auf ihre geographische Verbreitung. Festschrift der zoologisch-botanischen Gesellschaft in Wien pp. 263-300.

———. 1885. Systemisch-zoologische Studien. Sitzungsberichte der Akademie der Wissenschaften in Wien 41:237-413.

Brothers, D. 1975. A revision of the aculeate Hymenoptera with special reference to the Mutillidae. Kansas Sci. Bull. 50:483-648.

Burtt, E. D. and B. P. Uvarov. 1944. Changes in wing pigmentation during the adult life of Acrididae (Orthoptera). Proc. Roy. Entomol. Soc. London (a) 32:30-34.

Byers, G. W. 1954. Notes on North American Mecoptera. Ann. Entomol. Soc. Amer. 47: 484-510.

———. 1955. A new species of *Boreus* (Mecoptera: Boreidae) from Colorado. Occ. Pap. Mus. of Zool., Univ. of Michigan 562:1-4.

———. 1961. An unusual new species of *Boreus* (Mecoptera: Boreidae) from Oregon. J. Kansas Entomol. Soc. 34:73-78.

CARPENTER, F. M. 1931. Revision of the nearctic Mecoptera. Bull. Mus. Comp. Zool., Harvard Univ. 72:205-277.

———. 1933. A new *Boreus* from British Columbia (Mecoptera). Can. Entomol. 65:94-95.

———. 1935. New nearctic Mecoptera with notes on other species. Psyche 42:105-121.

———. 1936. Descriptions and records of nearctic Mecoptera. Psyche 43:56-64.

———. 1939. Records and notes of nearctic Mecoptera and Raphidiodea. Bull. Brooklyn Entomol. Soc. 34:162-166.

COLE, A. C., JR. 1938. Insect collecting in the Great Smoky Mountains National Park, Tennessee. J. Tenn. Acad. Sci. 13:274-276.

COOPER, K. W. 1940. The genital anatomy and mating behavior of *Boreus brumalis* Fitch (Mecoptera). Amer. Midland Natur. 23:354-367.

———. 1951. Compound sex chromosomes with anaphasis precocity in the male mecopteran, *Boreus brumalis* Fitch. J. Morphol. 89:37-58.

———. 1972. A southern California *Boreus, B. notoperates* n. sp. I. Comparative morphology and systematics (Mecoptera: Boreidae). Psyche 79:269-283.

———. 1973. Patterns of abdominal fusions in male *Boreus* (Mecoptera). Psyche 80:270.

———. 1974. Sexual biology, chromosomes, development, life histories and parasites of *Boreus,* especially of *B. notoperates.* A southern California *Boreus. II.* (Mecoptera: Boreidae). Psyche 81:84-120.

DALMAN, J. W. 1823. Analecta Entomologica. Holmiae, Lindholm. 104 p.

DOWNES, J. A. 1964. Arctic insects and their environment. Can. Entomol. 96:279-307.

———. 1965. Adaptations of insects in the Arctic. Ann. Rev. Entomol. 10:257-274.

ESBEN-PETERSEN, P. 1921. Mecoptera. Collections Zoologiques du Baron Edm. de Selys Longchamps 5(2):1-172.

FITCH, A. 1847. Winter insects of eastern New York. Amer. J. Agr. Sci. 5:274-284.

FRASER, F. C. 1943. Ecological and biological notes on *Boreus hyemalis* (L.) (Mecoptera, Boreidae). J. Soc. Brit. Entomol. 2:125-129.

GOODWIN, T. W. 1952. The biochemistry of locust pigmentation. Biol. Rev. Cambridge Phil. Soc. 27:439-460.

GOSLIN, R. M. 1950. Additional records of *Boreus brumalis* (Mecoptera: Boreidae) from Tennessee. J. Tennessee Acad. Sci. 25:309.

HAGEN, H. A. 1866. Synopsis of the genus *Boreus.* Entomol. Monthly Mag. 3:132.

HEINRICH, B. AND G. A. BARTHOLOMEW. 1972. Temperature control in flying moths. Sci. Amer. 226:71-77.

HEPBURN, H. R. 1969. The skeleto-muscular system of Mecoptera: the head. Univ. Kansas Sci. Bull. 48:721-765.

———. 1970. The skeleto-muscular system of Mecoptera: the thorax. Univ. Kansas Sci. Bull. 48:801-844.

HERTER, K. 1943. Die Beziehungen zwischen der Ökologie und der Thermotaxis der Tiere. Biologia Generalis 17(1-2).

HINE, J. S. 1901. A review of the Panorpidae of America north of Mexico. Bull. Sci. Lab. Denison Univ. 11:241-264.

HINTON, H. E. 1958. The phylogeny of the panorpoid orders. Ann. Rev. Entomol. 3:181-206.

KAUFMANN, T. 1971. Hibernation in the arctic beetle, *Pterostichus brevicornis,* in Alaska. J. Kansas Entomol. Soc. 44:81-92.

KLAPÁLEK, F. 1903. Ueber neue und wenig bekannte Arten der Paläarktischen Neuropteroiden. Bulletin international (Sciences, mathematiques, et naturelles) Ceská akademie cisare Frantiska Josefa pro védy, slovesnost a umeni v Praze 7:1-14.

LAMB, C. G. 1922. The geometry of insect pairing. Proc. Roy. Entomol. Soc. London (B) 94: 1-11.

LATREILLE, P. A. 1805. Histoire Naturelle générale et particulière des Crustacés et des Insectes 13:17-21.

———. 1816. Nouveau dictionnaire d'Histoire Naturelle 4:152-153.

———. 1817. Le Règne Animal 3:433-434.

LATTIN, J. D. 1956. The first California record of *Boreus californicus fuscus* Carpenter. Pan-Pacific Entomol. 32:81-82.

LESTAGE, J. A. 1940. Pour l'histoire des *Boreus* (Stegopteres-Mecopteres). I. Annales de Societe Royale zoologique de Belgique 71:5-22.

———. 1941. Pour l'histoire des *Boreus* (Stégoptères-Mécoptères). III. Systematique. Annales de Société Royale zoologique de Belgique 72:105-125.

LINNÉ, C. 1967. Systema Naturae. 12th edition (facsimile). W. Junk, Gravenhage. 824 p.

LLOYD, L. C. 1934. Two species of Mecoptera from Alaska. Pan-Pacific Entomol. 10:119-120.

MACLACHLAN, R. 1869. Note on *Boreus hyemalis* and *B. westwoodii.* Trans. Roy. Entomol. Soc. London S.4. 2:399-401.

MARECHAL, P. 1939. Contribution a la connaisance de *Boreus hyemalis* L. Bulletin et Annales de la Société Entomologique de Belgique 79:111-116.

MARTYNOVA, O. M. 1954. Mecoptera fauna of U.S.S.R. Part I, Boreidae. Trudy zoologicheskiĭ institut Akademiia nauk S.S.S.R., Moscow 15:54-66. (In Russian)

MAYER, K. 1938. Rod *Boreus* (Panorpata - Boreidae) Ceskoslovensku. Entomologické listy 2:129-140, 1 plate.

MEINANDER, M. 1962. The Neuroptera and Mecoptera of eastern Fennoscandia. Fauna Fennica 13:1-87.

MICKOLEIT, G. 1971. Das exoskelet von *Notiothauma reedi* MacLachlan, ein Beitrag zur Morphologie und Phylogenie der Mecoptera (Insecta). Zeitschrift für morphologie und ökologie der tiere 69:318-362.

Navás, L. 1911. Deux *Boreus* nouveaux d'Europe (Neuroptera). Revue Russe d'Entomologie 11:277-278. (In French with Latin descriptions.)

———. 1925. Entomologische Ergebnisse der schwedischen Kamtchatka-expedition. 1920-1922. Part 6. Neuroptera et Mecoptera. Arkiv för Zoologi 18B(2):1-3. (In German with Latin descriptions.)

Packard, A. S. 1870. New or rare American Neuroptera, Thysanura, and Myriapoda. Proc. Boston Soc. Nat. Hist. 13:405-410.

Panzer, G. W. F. 1796. Faunae Insectorum Germanicae. Felssecker, Nürnberg.

Peterson, A. 1951. Larvae of Insects. Part II. Coleoptera, Diptera, Neuroptera, Siphonaptera, Mecoptera, Trichoptera. Edwards Bros., Columbus, Ohio. v + 416 p.

Pliginsky, V. G. 1914. New *Boreus* species from the Crimea (Neuroptera, Panorpidae). Revue Russe d'Entomologie 14:363-367. (In Russian with German summary.)

———. 1930. A new species of the genus *Boreus* Latr. (Neuroptera, Panorpidae). Revue Russe d'Entomologie 24:230-231. (In Russian.)

Porsild, A. E. 1951. Plant life in the Arctic. Canad. Geograph. J. 42:120-145.

Richards, A. G. 1965. The proventriculus of adult Mecoptera and Siphonaptera. Ent. News 76: 253-256.

Sage, B. L. 1973. Alaska and its wildlife. The Viking Press, New York. 128 p.

Salt, R. W. 1961. Principles of insect cold-hardiness. Ann. Rev. Entomol. 6:55-74.

Sneath, P. H. A. and R. R. Sokal. 1973. Numerical Taxonomy. W. H. Freeman and Company, San Francisco. 573 p.

Stannard, L. J. 1957. The first records of *Boreus* (Boreidae, Mecoptera) in Illinois. Trans. Illinois State Acad. Sci. 50:279-280.

Steiner, P. 1936. Beitrag zur Fortflanzungsbiologie und Morphologie des Genitalapparates von *Boreus hiemalis* L. Zeitschrift für Morphologie und Ökologie der Tiere 32:276-288.

Stephens, J. F. 1829. A Systematic Catalogue of British Insects. Baldwin, London. 416 p.

Strübing, H. 1950. Beiträge zur biologie von *Boreus hyemalis* L. Zoologische Beiträge (N.F.) 1:51-110.

Svensson, S. A. 1972. *Boreus* Latreille, 1825 (Mecoptera). A synopsis of described species. Entomologica scandanavica 3:26-32.

Syms, E. E. 1934. Notes on British Mecoptera. Trans. South London Entomol. Nat. Hist. Soc. 1933/1934:84-88.

Tarbinsky, S. P. 1962. Finding scorpion-flies, *Boreus* sp. n. (Mecoptera, Boreidae) in the foothills of the Kirghiz Ala-Too. Sbornik Entomologicheskikh Rabot. Akademiia Nauk Kirgizsk 1:131-136. (In Russian.)

Tweedie, M. 1972. Northern and mountain insects. Animals 14:460-463.

Webb, D. W., N. D. Penny and J. C. Marlin. 1975. The Mecoptera, or scorpionflies, of Illinois. Bull. Illinois Nat. Hist. Surv. 31:251-316.

Williams, F. X. 1916. The pupa of *Boreus brumalis* Fitch. Psyche 23:36-39.

Wilson, W. 1957. Observations on the temperatures of arctic plants and their environment. J. Ecol. 45:499-531.

Withycombe, C. L. 1922. On the life-history of *Boreus hyemalis* L. Trans. Roy. Entomol. Soc. London 54:312-318.

———. 1926. Additional remarks upon *Boreus hyemalis* L. Entomol. Monthly Mag. 62:81-83.

Wulff, T. 1902. Botanische Beobachtungen aus Spitzbergen. I. Über die Transpiration der arktischen Gewächse. Lund. pp. 3-32.

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A SYSTEMATIC STUDY OF THE FAMILY
BOREIDAE (MECOPTERA)

by

Norman D. Penny

ABSTRACT

General aspects of the biology of Boreidae are discussed, including life cycle and immature forms, ecological relationships, geographical and seasonal distribution, external morphology, variation within species, behavior, and adaptations to boreal or winter existence. A phenetic classification is derived by comparison of states of 37 characters. Four possible phylogenies of the family are obtained by application of different methods, and their differences are compared. These systematic analyses yield a distinct group, Hesperoboretts (new genus), to include Boreus brevicaudus Byers (type species) and B. notoperates Cooper, of western North America. Revision of the North American species results in the following new synonymy: B. californicus Packard (^B. unicolor Hine, B. isolatus Carpenter, and B. californicus fuscus Carpenter), B. nix Carpenter {^B. gracilis Carpenter). Among Old World species, the following new synonymy is noted: B. navasi Pliginsky {=.B. at{tijari Pliginsky). Taxonomic keys and illustrations are provided.

INTRODUCTION

Boreidae (named for Boreas, the Greek god of the north wind) are small, dark colored Mecoptera usually found associated with mosses and infrequently seen except on winter snow. Both sexes are flightless, the wings of females being reduced to tiny, sclerotized flaps and those of males being modified as long, thin hooks used to grasp the female during copulation. The elongate rostrum resembles that of Panorpidae. Female boreids have an ovipositor formed from the fused cerci and elements of the 8th through 11th abdominal segments. The larvae are scarabaeiform and have so far been found only among rhizoids of mosses and club mosses.

The taxonomy of North American boreids has not been studied since Carpenter published descriptions and keys (1935, 1936). Three North American species have been described since that time (Byers, 1955, 1961, and Cooper, 1972), and additional taxonomic characters have been found. In the Palearctic region there has not been a comprehensive treatment of species since Esben-Petersen's (1921) world monograph of the Mecoptera. Six

1. Contribution no. 1624 from the Department

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Palearctic species have subsequently been described, primarily in Russian literature. Crampton (1930) pointed out that terminal abdominal appendages of both male and female Boreidae are distinct from those of other Mecoptera, and since the Boreidae are so specialized they could reasonably be placed in a separate suborder, the Neomecoptera. Hinton (1958) raised this suborder to ordinal level on the basis of nine findings: "Larva: (a) the cranium is without a distinct epistomal suture; (b) the cardo is not fused to the basistipes, and the tentorial adductors of the cardo are present; if homologues of these muscles are present in the Mecoptera they are now tentorial adductors of the cardostipes; (c) the postmentum is well developed instead of lost or reduced to an articulating membrane between the prementum and the cranium; (d) the abdomen lacks prolegs, whereas in the Mecoptera prolegs are present on the first eight abdominal segments; and (e) the larvae feed on moss, whereas those of the Mecoptera are carnivorous. Adult: (a) the ovaries are panoistic instead of polytrophic as in the Mecoptera; (b) the 11th abdominal segment of the female lacks cerci, whereas one- or two-segmented cerci are

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present in the Mecoptera; (c) the 9th and 10th abdominal segments are modified to form a large functional ovipositor but no such 'ovipositor' is found in the Mecoptera; and (d) the adult gut lacks the six especial rectal glands of the Mecoptera."

Although most of Hinton's points are valid, a few inaccuracies occur, Byers (1961) pointed out that the tip of the ovipositor in Boreidae is actually the fused cerci, and recently he discovered that larvae of Panorpodidae lack abdominal prolegs and are probably plant feeders.

Hepburn, in his morphological study of the thorax of Mecoptera (1970), concludes that Boreidae are probably closely related to "intermediate families" of Mecoptera, and attempts to remove Boreidae from the Mecoptera are unjustified.

Only one previous attempt has been made to reconstruct phylogeny within the Boreidae (Lestage, 1940). Lestage suggested that Boreidae consisted of two genera: Boreus, consisting of Palearctic species with male abdominal tergal ridges and medial lobes of the dististyles, and Ettboretts, consisting of Nearctic species without tergal ridges and medial dististylar lobes. Lestage further stated that the primitive condition was lack of these structures, therefore making Enboreits the more primitive genus and North America the place of origin of the family.

The morphological basis of Lestage's reasoning was faulty. All male Boreidae have medial dististylar lobes and only four western European species have abdominal tergal ridges.

This study was undertaken to bring together recent information on taxonomy, morphology, and ecology of the Boreidae. An attempt has been made to synthesize this information into a better concept of systematics of the family. Specifically, primitive and derived sequences of character states have been used to construct the evolutionary development of Boreidae and this, in turn, has been used to deter-

mine genera and species groups. Finally, an attempt has been made to present (sometimes for the first time in the English language) the most comprehensive description available for each species.

METHODS OF PRESERVATION OF SPECIMENS

Specimens should be preserved in alcohol. If specimens are preserved dry on points, the membranous areas tend to contract and the abdominal sclerites telescope within one another. The ninth tergum becomes almost completely enclosed by the eighth tergum, and the dististyles recurve over the abdomen to conceal the caudal surface of the ninth tergum. Retraction and shrinkage make observation of this key structure almost impossible. Preservation in 70 percent alcohol also tends to cause retraction and shrinkage, but if specimens are placed in water for a few minutes, they normally will return to normal size and shape. Even greater detail can be seen if specimens are lightly cleared in a 10% solution of cold potassium hydroxide (KOH) for 24 hours. After clearing, it can be seen that under the tergal hood are recessed pockets into which the tips of the dististyles fit.

MORPHOLOGY AND BOREAL ADAPTATIONS

A. Boreal Adaptations — Tweedie (1972) lists four traits frequently noted among northern and alpine insects. Many northern insects are small and dark in color. These two characteristics perhaps allow the insects to absorb radiant heat more readily and warm up much faster than larger and lighter individuals of closely related races or species. However, this situation would create a larger surface area per unit volume, and thus also cool the insect more rapidly when radiant heat is absent (see Salt, 1961). Species of Boreidae range from yellow and brown to

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russet brown to black in color and 2.0 to 7.4 mm. in length. Whether dark coloration in Boreidae helps maintain thermal regulation has yet to be determined.

Northern insects are frequently more hairy than their more southern counterparts (see Downes, 1965). This allows for an insulating layer of air within the hairy coat. Although no boreids are hairy enough to trap such an insulating air layer, variation in hairiness can be seen even within the genus. Those species living along the west coast of North America in rather mild climates have few setae on the body while such species as nix and pilosiis from mountainous western regions have enough setae over the entire body to give these species a "frosted" appearance.

The fourth trait noticed among northern insects is wing reduction. This characteristic has a three-fold advantage. In such extreme environments, generating enough energy to warm and maintain functioning of wing muscles would be extremely difficult (Heinrich and Bartholomew, 1972). The exposed surface area of wings places the insect in greater danger of freezing. Finally, the frequently windswept, barren environments where northern and alpine insects live make it necessary to reduce surface area to avoid being blown away. Boreidae show marked decrease in wing size, the wings being reduced to small, oval flaps in females (Fig. 1, p. 144) and thin, spiny hooks in males (Fig. 2, p. 145).

Two further winter adaptations of Boreidae are the ability to hop and an extended life cycle. No other mecopteran is known to have the ability to hop. Boreidae will frequently hop when suddenly disturbed on moss or snow. Boreids normally walk while feeding or moving across snow, but it has been noticed that on light, fluffy snow where walking is difficult, an individual will take a few steps and then leap up to 12 inches, even though not disturbed. This action may be re-

peated several times in rapid succession, allowing Boreidae to cross several feet of soft snow in a few minutes.

Striibing (1950) has found that B. hyemalis larvae require two years to mature. This extended life cycle is noted among many northern insects. However, Kaufmann (1971) has shown that a carabid beetle, Pterostichtis brevicornis, requires from 14 to 36 months to complete its life cycle, depending upon the time of oviposition. It remains to be proven that Boreidae take two years to mature under all conditions.

B. General Morphological Description (Adult) — To facilitate the following discussion, it is mentioned here that I have hereinafter separated the Boreidae into two genera, Hesperoboreus and Boreus, and Boreus in turn has been separated into four species groups, the californicus, hyemalis, nivoriundus , and rediictus groups. Head prolonged into a rostrum, composed anteriorly of clypeus and labrum, laterally of genae, and caudally of maxillo-labial complex (Hepburn, 1969). Labrum short, spatulate, with triangular sclerite at each side. Mandibles slightly longer than labrum, tapering apically, with six stout teeth at apex. Maxillolabial complex much longer than other mouthparts, varying from .44 to 1.00 times length of rostrum. Maxillary palps five-segmented, basal segment much shorter than distal segments. Labial palps two-segmented, arising at apex of maxillo-labial complex. Approximately halfway between bases of maxillary and labial palps two areas of pegs, with about 14 pegs on either side. Eyes large, oval, and usually plum to black in living individuals. Antennae long (though short compared to those of other mecopterans), consisting of subcylindrical scape, bulbous pedicel, and 16 to 23 filiform, pedicellate flagellar segments, arising between or just below eyes. Median ocellus between and just dorsad

[Begin Page: Fig. 1, Page 144]

X

1

[Begin Page: Fig. 2, Page 145]

[Begin Page: Page 146]

of antennae. Lateral ocelli close to mar-
gins of compound eyes. Anterior tentorial

pits just below level of antennae and about halfway between margins of compound eyes and medial line.

A long, thin cervical sclerite articulating with prothoracic episternum (Hepburn, 1970). Pronotum saddle-shaped, frequently with somewhat indistinct medial ridge, bearing small setae, and often with large bristles along anterior and posterior margins. Spiracle at caudo-lateral margin of pronotum. Meso- and metanota with raised, triangular scutella visible between reduced wings. Mesoscutellum frequently bearing two crossed bristles; occasionally metascutellum also with two bristles, varying with individual. Prothoracic basisternum triangular to pentagonal in shape. Preepisternum very thin; coxal cavities occupying almost all of sternal region of thorax. Coxa large, conical; trochanter small; femur long, thin, frequently with subapical dorsal spine; tibia long, thin; tarsus five-segmented, proximal tarsomere about twice as long as each of last four; two smooth tarsal claws. Tibia and tarsomeres with many stout spines. Mesothoracic wings of female reduced to oval, densely sclerotized flaps covering the smaller metathoracic wings, extending to caudal margin of metathorax, except in B. reditctiis and navasi. Metathoracic wings reduced to little more than small, irregular folds (Fig. 13, p. 153). Male wings modified as thin hooks. Mesothoracic wings curved ventrad laterally, extending to about fourth abdominal segment, bearing rows of spines along both mesal and lateral margins, and covering metathoracic wings (Fig. 2, p. 145) . Metathoracic wings thin, cylindrical structures, extending to about fourth abdominal segment, bearing dense, small setae and frequently several stout spines along ventral side.

Female abdomen composed of 11 segments. First segment closely associated

with metathorax. Segments 2 through 7 with terga and sterna separated by membranous pleura. Eighth tergum extending ventrally to sternal area, forming a broken ring. Eighth sternum extending caudally as two long, parallel-sided lower valves (hypovalves) of ovipositor, apical half to one-third of valves bearing numerous spines. Abdominal spiracles in ventral margins of terga 2 through 7; spiracles of eighth segment in mid-lateral surfaces of eighth tergum. Ninth tergum short, quadrate, forming dorsal base of ovipositor. Ninth sternum apparently lightly sclerotized and concealed by lower valves. Tenth tergum in Boreus elongate, parallel-sided, forming dorsal surface of ovipositor, in Hesperohoreiis short with two spine-tipped caudal extensions. Cerci triangular, sclerotized, and fused along midline in Boreus, forming acute tip of ovipositor. Cerci incompletely fused distally in Hesperoboreiis, revealing small, sclerotized eleventh tergum and sternum when raised.

Male abdomen composed of 10 apparent segments. First segment closely associated with metathorax. Segments 2 through 7 with unfused terga and sterna. Terga of segments 2 and 3 in hyemalis group bearing flattened ridges. Tergum and sternum of segment 8 fused laterally in calijornicus and hyemalis groups, unfused in nivoriiindiis and rediicttis groups and Hesperohoreiis. Tergum 9 raised in Boreus with medial depressions for reception of tips of dististyles. Medial depressions covered anteriorly by thin hood except in Hesperohoreiis; hood with median septum in califomicus and hyemalis groups. Numerous peg-like denticles caudally and laterally on ninth tergum. Ninth sternum (hypandrium) elongate-triangular, apex rounded, truncate, slightly emarginate, or deeply notched. Tenth tergum and sternum reduced to small, oval sclerites between basistyles. Aedeagus membranous, except for small, thin sclerite along anterior surface. Basistyles (gono-

[Begin Page: Figs. 3-4, Page 147]

Figures 3,4. Boietts colorculcnsis Byers, larva. Fig. 3, lateral view. Fig. 4, ventral view. Both 42 X-

[Begin Page: Page 148]

coxites) bulbous, with median dorsal ridge extended anteriorly as two sclerotized, laterally flattened straps, expanding medially to unite and form a thin, broad plate (dorsal gonobase of Cooper, 1974) (see Cooper, 1972, Figure 4). Diststyles claw-shaped with inner, basal lobe and many stout denticles below apex of claw. Diststyles normally recurved over abdomen with apex in ninth tergal depressions and denticles of ninth tergum in contact with similar structures below apex of dis-tistyles.

C. Egg — White, unsculptured, oblong, varying in dimensions from approximately .7 X .5 mm. in Boreus elegans to .5 X .3 mm. in Hesperoboreus notoperates.

D. Larva — Overall body length up to 4.83 mm. Head (Figs. 3, 4, p. 147) creamy yellow with prominent, darkened mandibles and darkly pigmented region around stemmata. Pigmentation shifting to position on head where pupal compound eyes will form late in last larval instar (Cooper, 1974). Antennae small, two-segmented, with apical hair, half-way between eyes and mandibles. Mouthparts short, not forming rostrum. Labrum and three-segmented maxillary palpi lightly sclerotized. Many prominent bristles on head and mouthparts (Peterson, 1951), varying among species (Cooper, 1974).

Thin, crescent-shaped sclerite projecting laterally from body wall in cervical region where strong head protractor muscle attaches.

Thorax transparent white, allowing observation of major muscles through body wall. Prothoracic legs small, ventrally directed, two-segmented. Mesothoracic and metathoracic legs large, laterally directed, four-segmented; fourth segment small and transparent. Numerous bristles covering thoracic region.

Abdomen transparent white, 11 segmented, bearing many bristles. No abdominal legs or appendages of any sort.

Brauer (1855) mentioned abdominal legs in first instar larvae. This observation has not been repeated.

There are probably four larval instars (see Cooper, 1974; Withycombe, 1922).

E. Pupa — Approximately same length as adults, whitish, with darkened eyes and mandibles. As pupa matures, legs also darken. Pupa exarate, with articulated mandibles (decticous) for movement in subterranean tunnels. Antennae and legs held under body. Male wing sheaths flattened blades along sides of thorax. Female wing sheaths in form of small, dorsal lobes. Both male and female adult structures recognizable in older pupae, although somewhat distorted by enclosing sheaths and without detail. Along with heavily sclerotized mandibles, many setae are lost from body surface at last molt.

F. Characters Used In Taxonomic Differentiation —

a. Overall size — Adult Boreidae range in length from 2.0 to 7.4 mm. Although there are distinct differences between species, several other factors also contribute to individual length. Ecological factors such as climate and vegetation probably cause some variation. Method of preservation makes a difference in individual overall length; for instance, males of B. brumalis range from 2.0 to 2.7 mm. long preserved dried on points, but from 2.4 to 3.1 mm. preserved in 70 percent alcohol.

Females are invariably larger than males (this is interesting, considering that males carry females on their backs during copulation). Males of H. brevicaudus are 2.3 to 2.7 mm. in length in alcohol, while females range from 3.1 to 3.6 mm. in length. In the largest species of Boreidae, B. elegans, the differences are even more distinct. Males range from 3.6 to 4.6 mm. in length in alcohol, while females are 6.0 to 7.4 mm. in length.

There is no difference in minimum

[Begin Page: Page 149]

length between the two genera, but no

species of Hesperoboreus has yet been found which can compare with the maximum size attained by Boreus elegans or borealis.

b. Coloration — Previous authors have used coloration as a means of distinguishing species. A simple experiment helped to point out the unreliability of taxonomic use of coloration. On December 1, 1970, Dr. William L. Jellison collected a large number (about 150) of live Boreus on the snow near Hamilton, Montana. One-half of the specimens were preserved in alcohol and sent to the Snow Entomological Museum for identification. By use of existing keys (Carpenter, 1935, 1936), all the specimens were identified as B. californicus fuscus with yellow legs, wings, and rostrum, and a dark brown (almost black) body. The other half of the collected specimens were placed alive in a large plastic bag together with pine forest detritus, on the shaded north side of Dr. Jellison's home in Hamilton, where they were exposed to seasonal cold temperatures. On January 1, 1971, the bag was opened and live and dead Boreus specimens were examined. All specimens were uniformly dark in color, like B. unicolor.

In other groups of insects pigmentation is often related to time since eclosion or temperature during development. For example, the grasshopper Mesopsis slowly develops a patch of black on the hindwings over a period of about six months (Burtt and Uvarov, 1944) and Goodwin (1952) found that locusts bred at 40° C. were much lighter than the same species bred at 26° C.

B. californicus is particularly variable in coloration. Some specimens are yellow and black; others are light brown, darker russet brown, or dark brown to black. Some russet brown specimens from northeastern California were used in the original species description, causing F. M. Carpenter to describe the more commonly seen forms with light appendages as a subspecies, B. californicus fuscus. However, the color differences are sympatric and follow no geographic cline.

Withycombe (1922), Fraser (1943),

and Strijbing (1950) found that several days to a week were necessary for B. hyemalis to darken completely. Brauer (1857, 1863) found the same interval of time necessary for complete pigment deposition to develop in B. westwoodi. However, Williams (1916) found that only a half day was necessary for cuticular darkening in B. brumalis, and the same time interval is necessary in H. notoperates (Cooper, 1974).

Differences in rate of cudcular pigment deposition or in tanning probably do exist among species, but this genetic attribute cannot be used in species identification because rate may be modified by climatic factors, and age of preserved material is rarely known.

c. Pilosity — Possibly one of the first things noticed about adult Boreidae when viewed through a microscope is the large number of setae, bristles, spines, and denticles over many parts of the body. These structures are found on all species, most abundantly between the antennae, on the anterior part of the rostrum, along the sides of the thorax, on the wings, coxae, posterior halves of the abdominal segments, male ninth tergum and dististyles, and female eighth sternum. However, two species {B. nix and pilosus) have more extensive pilosity than others, giving their bodies a "frosted" look. Two other species, B. brumalis and reductus, have abundant pilosity, but not nearly to the same extent as in nix and pilosus.

d. Chromosomes — Only four species of Boreidae have been studied cytogenetically (Cooper, 1951, 1972, 1974). The haploid number (N) varies from 9 in H. notoperates to 11 in B. brumalis, to 13 in nivori-

[Begin Page: Page 150]

undiis, to 14 in hyetnalis. There is an XO sex determining mechanism, except in B. brumalis which has X1X2Y, Although it is too early to make phylogenetic conclusions from these isolated observations, it does appear that chromosome study holds some promise of adding to our knowledge of the phlogeny of Boreidae.

In two species of Boreas, spermatogenesis takes place in the pharate pupa, while in H. notoperates spermatogenesis occurs in the mature pupa and pharate adult (Cooper, 1974).

e. Occipital smoothness — The occiput of Hesperoboreiis is rugulose, the uneven surface also covered with many setal pits. In Boreus the occipital surface has fine reticulations and setal pits, although these reticulations are barely visible (Fig. 5, p. 151). The surface is much more even than in Hesperoboreiis. An exception to the occipital reticulation of Boreus is the completely smooth occiput of B. hyemalis (Fig. 6, p. 151), which has been used to distinguish hyemalis from the very closely related B. westwoodi. Because I cannot find other characters to separate the species, I doubt the taxonomic significance of the smooth occiput.

f. Ocelli — In other mecopteran families, ocelli are arranged in a small triangle just above the antennae. In Boreidae the ocelli are dispersed, the lateral ocelli near the margins of the compound eyes (Figs. 7-10), and the median ocellus, when present, near the antennal bases. In Hesperoboreus and the red actus group of Boreas, the median ocellus is absent. Withycombe (1922) and earlier authors stated that Boreidae possessed no ocelli, but Withycombe later (1926) corrected his earlier statement.

g. Antennae — These structures are of use in generic separation. The antennal bases of all Boreas lie between the compound eyes (Figs. 8, p. 152; 9, p. 152; 10, [\ 152) . The antennal bases of Hesperoboreiis

lie at the lower margins of the compound eyes (Fig. 7, p. 152).

Lestage (1940) used number of antennal segments to separate most of the Palearctic species. However, it must be noted that males frequently have one more segment than females, and these is variation among individuals or even between antennae of one individual. For a good statistical analysis of antennal segmentation in H. notoperates , see Cooper (1974).

However, the degree of variation differs from one species to another. Males of H. brevicaudus consistently have 16 flagellomeres, while males of B. coloradensis have flagellomeres numbering from 18 to 22. Thus, the number of flagellomeres can be used taxonomically, as long as the variation is taken into account. The numbers for each species are given below with the species description, but it should be noted that generally Hesperoboreus has fewer flagellomeres than Boreas, number of flagellomeres varying from 16 to 18 in the former, and 17 to 23 in the latter.

h. Width of hypostomal bridge — Variation in hypostomal bridge width makes the maxillo-labial complex appear either shorter or longer. This variation can be expressed as a ratio of the length of the maxillo-labial complex (hypostomal bridge to apex) to the length of the rostrum, as measured from the base of the compound eye to the tip of the labrum. In the genus Hesperoboreiis this ratio varies from .44

to .71 (Fig. 7, p. 152), while in Boreas it varies from .70 to 1.0 (Fig. 10, p. 152). Thus it can be seen that the hypostomal bridge is generally wider in Hesperoboreiis than in Boreas. Within Boreas, fluctuation is too great for taxonomic use.

i. Setae of the maxillo-labial complex — The maxillo-labial complex of Boreas usually has a number of setae along the posterior margins (Fig. 8, p. 152). However, in Hesperoboreiis these setae arc usually completely lacking (Fig. 7, p. 152). Fur-

[Begin Page: Figs. 5-6, Page 151]

ther, B. niuoriitndits and elegans have some setae which are short and so thickened that they are termed spines (Figs. 9, p. 152; 10, p. 152). This character can be used to identify this Boreus subgroup.

j . Notal bristles — The bristles along the anterior and posterior margins of the pronotum and on the meso- and metanota are so easily visible and so invariable that they should be used for species recognition. Notal bristles are found in Hesperoboreus and the nivoriundus group of Boreus (Figs. 11, p. 153; 12, p. 153). Usually, there are 6 or 8 bristles along the anterior and posterior margins of the pronotum. The scutella of the mesonotum and metanotum may each possess two more bristles, but their presence is much more variable. In all North American species except B. reductiis, presence of pronotal bristles is correlated with separation of the eighth abdominal tergum and sternum.

k. Apical femoral spine — This character is of some value but must be used with caution. The spine is reduced in size in some specimens, and occasionally may be absent entirely. Because smaller setae are also present near the distal ends of the femora, the specimens frequently must be rotated until the spine stands out against a lighted background from the femur and other setae. This spine is present in all North American boreids (Fig. 14, p. 155) except B. coloradensis (Fig. 15, p. 155), rediictiis, and sometimes calijornicits. B. calijornicus is very similar to coloradensis and no known character differentiates females. In a large collection of specimens from Helena, Montana, all female specimens without apical femoral spines were preserved in copula with males of B. coloradensis, while none of the female specimens with femoral spines and no males of calijornicus were mating when collected. It was hoped that the apical femoral spine could be used for identification, as it seemed reliable for the large

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Figure 5,6, dorsal view. Fig. 5, Boreus coloyaJtnsis Byers. Fig. 6, Boreus hyemalis (L.). Both 175 X-

number of specimens collected in western Montana, Oregon, and Washington. However, recent collections of calijornicus from California and Arizona created problems because these individuals did not possess the apical femoral spine. Still, I am reluctant to discard this character because of its usefulness in northern regions.

1. Male wings — Forewings of male boreids have two rows of spines. One row along the anal margin projects mesally (inner forewing spines), while a second row projects ventrally from the costal mar-

[Begin Page: Figs. 7-10, Page 152]

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gin (outer forewing spines). The tip of the forewing extends caudaily as a spine larger than the others. Apparently there has been a reduction in the number of outer forewing spines in the European species. Lestage (1941) mentioned that outer forewing spines in each of these species were grouped in a consistent pattern: six spines (2+2+2) for westivoodi, eight spines (1+1+4+2) for hyemalis, and eleven spines (5+1+1+3 + 1) for I{ratochvili. Among specimens of these species that I have examined, this pattern is not consistently found. North American species have more spines than the European species; the spines are arranged in uniform rows; and the number of spines varies both between species and within species. These appears to be a pattern of reduction in outer forewing spines as one looks from the nivoriundus group (Fig.

16, p. 158) to the californicits group (Fig.

17, p. 158) of species of Boreas. The number of spines among species of the nivoriiindiis group ranges from 14 to 19, in the reductus group from 11 to 19, in the californicus group from 7 to 13, and in the hyemalis group from 6 to 11. However, greatest reduction is seen in Hesperoboreits which has no outer forewing spines (Fig. 18, p. 158).

In Boreus the number of inner forewing spines ranges from 15 in several species to 36 in borealis, the greatest variation being in californicits, with 15 to 22 inner forewing spines. In Hesperoboreus the range is from 13 in brevicaiidiis to 16 in notoperates.

There is a reduction in hindwing spines similar to that in outer forewing spines. These spines are much smaller than those of the forewing, and project ventrally in a row. In the nivoriundus group, the number of hindwing spines varies from 9 to 16 (Fig. 16, p. 158), in the reductus group, it varies from 3 to 4, and frequently there are no spines at all in species of the calijornicus and hyemalis groups (Fig, 17,

p. 158), although very small spines are occasionally present. Apparently, there has been little reduction of hindwing spines in

Hesperoboreus, where there are from 10 to 17 (Fig. 18, p. 158).

Great taxonomic emphasis has in the past been placed on curvature of the outer margins of male wings, as seen in dorsal aspect. In most species of Boreus, there is a rather abrupt narrowing of the wing about halfway to the tip (Fig. 19, p. 159). Two species, B. elegans and nivoriundus, do not show this abrupt narrowing and their wings are wider near the tip than in other species (Fig. 20, p. 159). Carpenter (1936) mentioned that B. intermedius possesses this broader wing; however, I could see distinct narrowing at mid-length in the same specimens. Abruptness of narrowing varies according to how the specimen is positioned for viewing, for if viewed from too far laterally, an abruptly narrowed costal margin appears almost straight. Thus, shape of male wings can be used, if done with great caution.

m. Female wings — Although all species of boreids have an abundance of line setae covering the dorsum of the female mesothoracic wings, only one species, Hesperoboreus brevicaudus, has yet been noted to possess several larger bristles at the caudal margin (Fig. 11, p. 153).

The female boreid's metathoracic wings are normally reduced to little more than wing vestiges, but in B. reductus this condition is found in both pairs of wings (Fig. 13, p. 153). The reduced mesothoracic wings are also found in other species of the reductus group from the Crimean region of U.S.S.R., but not in any other groups,

n. Male tergal ridges of second and third abdominal segments — Lestage (1940) used two characters to separate the Boreidae into two genera. Nearctic species (plus B. semenovi) were placed in the genus Euboreus, having no transverse ridges on the

[Begin Page: Figs. 14-15, Page 155]

Figures 14,15, left foreleg, dorsal view. Fig. 14, Boretis elegans Carpenter, 86X. Fig. 15, Boieiis

coloradensis Byers, 80 X-

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second and third abdominal terga (Fig. 21, p. 162) and lacking a medial tooth on the diststyles. Palearctic species (minus B. semenovi) were retained in the genus Boreiis, having tergal ridges (Fig. 22, p. 162) and the medial tooth. Lestage was wrong, however, about both characters. The medial tooth (basal lobe) is found on the diststyles of all male boreids. And the tergal ridges are present only in four closely related European species. The ridges are not found in any of the Asiatic Boreidae for which males are known. The phylogeny presented later in this paper and Cooper's (1972) discussion of the status of Euboreus give further reasons why this classificadon should not be followed.

Species which do have transverse ridges on the male second and third abdominal terga are: B. hyemalis, J{i-atochvili , lo\ayi, westwoodi, and possibly chadzhigireji. Martynova (1954) mentions that tergal ridges of chadzhigireji are almost not present, and her illustration of the terminal segments of the male suggest that this species has no fusion of eighth tergum and sternum. Fusion of eighth tergum and sternum probably occurred long before acquisition of the tergal ridges within the Boreidae. Thus, it is probable that only the first four species mentioned have tergal ridges.

Lestage (1941) illustrated the tergal ridges of three of the four European species. The ridge of the second tergum in B. hyemalis is wide and lobed near its lateral ends. The ridge of tergum 3 is also lobed laterally, but varies in width. In B. westwoodi the second tergal ridge is very similar to that of hyemalis, but the third tergal ridge is triangular to convex (lacking the lateral lobes). The second tergal ridge of B. J^ratochvili is deeply notched medially, giving the ridge a bipartite appearance. The third tergal ridge of f^ratochpili is obtusely angled to an ill-defined peak. Lestage's key to Palearctic

boreids states that the third tergal ridge of B. lokayi is reduced to a small tubercle.

These character states can apparently be used to differentiate species. Not enough specimens were available for me to study the tergal variation within these four species, although considerable variation is apparent from Lestage's drawings and from specimens I have examined (Figs. 23-30).

o. Fusion of male eighth abdominal tergum and sternum — Mickoleit (1971) first mentioned interspecific variability of the male eighth abdominal segment. Cooper (1972) expanded upon this statement by lisdng many of the Palearctic and Nearctic species and noting whether fusion of the tergum and sternum had occurred. He based many of his decisions on illustrations Martynova (1954) made of species from the U.S.S.R, I can do little better, as I have seen only B. hyemalis and vlasovi from the Asiatic region. Therefore, until more material can be obtained, analysis of Palearctic species must rely on often-times incomplete descriptions and inadequate illustrations.

This character of fusion of the eighth abdominal tergum and sternum in males appears to be a very strong one, and it has been used to separate major groups within Boreus. Fusion in this segment is correlated with expansion of the ninth tergal hood, presence of a large medial septum within the hood, loss of some outer forewing spines, and usually complete loss of hindwing spines. Fusion of the eighth abdominal tergum and sternum (Fig. 31, p. 165) is found in all species of the californicus and hyemalis groups. It is not found in Hesperoboreus or the other two groups of Boreus (Fig. 32, p. 165) .

p. Male ninth tergum — Carpenter (1931) stated that "The male genitaha are also useless because they are constant in all our species." However, there is more diversity of the male ninth tergum than anywhere else on the external surface of Boreidae (Figs. 34-49).

The male ninth tergum is narrow laterally, expanding caudally toward the dorsal surface of the body. On the dorsal surface, the tergum is cleft medially for a short distance at its caudal end. On either side of this cleft are apical areas of peglike setae, which I shall refer to as denticles. The number of denticles varies from about eight on each side in Hesperoboreus (Fig. 34, p. 166) to over a hundred in some species of Boreus (Fig. 40, p. 167). In the genus Hesperoboreus the cleft is large and no tergal hood is present. In Boreus the cleft is smaller and at least a remnant of a hood is present in all species. In the nivoriiindus subgroup of the nivoriundus group, the tergal hood is very small, enclosing only the very tips of the dististyles

(Fig. 40). Within the brumalis subgroup the tergal hood is more than twice the size of that of the nivoriundus subgroup (Fig. 37, p. 166) and there may be an indication of a medial ridge within the hood (Fig. 46, p. 170).

The reductus group is characterized mainly by differences in the caudal edge of the hood. In B. vlasovi this edge has symmetrical points on either side of the midline (Fig. 48, p. 170). In B. reductus the edge comes to one large peak in the middle of the hood (Fig. 47, p. 170). This group is largely composed of little-known species, so that further variation is quite possible.

Within the californicus and hyemalis groups, the tergal hood is broadly expanded dorsally and caudally to laterally almost engulf the area of denticles, and medially does cover over the cleft (Fig. 42, p. 167). A large medial septum supports this expanded hood in both groups. The medial septum may be either broad or narrow, and sometimes there are so many setae along the septum that observation of the interior of the hood area is difficult.

q. Fusion of male ninth tergum and

sternum— Coo^tt (1972) mentioned that any revision of the Boreidae would necessarily include fusion of tergum and sternum in the eighth and ninth abdominal segments as key taxonomic characters. The fusion of the eighth segment has been used by me to separate the nivoriundus and reductus groups from the californicus and hyemalis groups within Boreus.

The fusion of male ninth tergum and sternum may be of less importance taxonomically, but it still has some value. The ninth tergum tapers laterally to a narrow strip. Often it is either retracted within the eighth segment or overlapping the ninth sternum, making observation of a membranous gap between the sclerites difficult. North American and European species do not possess this fusion; however, my study of B. vlasovi and examination of the literature indicate that some Asiatic species of Boreus possess the potential for fusion of male ninth tergum and sternum (Fig. 33, p. 165). In B. vlasovi some male specimens have the fusion, and some do not. These Asiatic species can all be placed in a subgroup of the reductus group on the basis of this character state. Thus, this character state is too variable for use in species identification.

r. Male ninth sternum (hypandrium) — In males of most Boreidae, the ninth sternum is broadly triangular, being broadest basally and gradually tapering caudally to a broadly rounded apex between the bases of the dististyles (Fig. 50, p. 172). In B. reductus this triangle is much narrower, forming an acute apex (Fig. 51, p. 172). As Byers (1955) pointed out for the species B. coloradensis , the apex varies intra-specifically from smoothly rounded to truncate to shallowly emarginate. In no case, however, does a species with a rounded ninth sternal apex also include individuals with a deeply emarginate apex. In the brumalis subgroup, the ninth sternal apex is deeply notched (Fig, 51).

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s. Male diststyles — These structures

hold the female's eighth sternum in place during copulation. Observed differences in the shape of the diststyles may have a direct relationship to differences in mating posture between the two genera. In Boreus the basal lobe has a rather blunt, obtuse apex. There is a deep, narrow cleft between the basal lobe and the diststyle proper. Denticles occur only from the basal lobe to the base of the diststylar claw (Figs. 53-56). In Hesperoboreus the basal lobe has an acute apex. There is no cleft between the basal lobe and the diststyle proper. Finally, denticles occur from the basal lobe to very near the apex of the diststylar claw (Figs. 57, p. 172; 58, p. 172). Variation within each genus is too slight to be of taxonomic value. The number of denticles does vary, but their size is so small and the number so variable within a species that differences are difficult to detect.

t. Length of the ovipositor — This character varies, as do measurements of the structure. The fused cerci form an apical triangle which articulates with the tenth segment. In preserved specimens, the fused cerci may be directed straight posteriorly or deflected posteroventrally. As Carpenter (1935) pointed out, measuring the ovipositor on the dorsal surface will yield a different length than measuring the same specimen on the ventral surface, because the eighth sternum normally projects farther anteriorly than the tenth tergum. length of ovipositor therefore is measured as length of tenth tergum plus length of cerci, rather than from base of tenth tergum to tips of cerci.

Since overall length of specimens varies with method of preservation, it is helpful to compare the length of the ovipositor to that of some other relatively stable structure. The ratio gives an index of ovipositor length. Carpenter (1931) first used the rostrum as the second structure. Rostral length is measured from the ventral

edge of the compound eye to the tip of the labrum.

By using the ovipositor/rostrum index, a distinct difTerence is noted between Boreus and Hesperoboreus. In Boreus the index ranges from 1.00 to 1.43 (Figs. 59, p.

173; 60, p. 173). Variation within and between species is considerable, making this index useless below the generic level. For instance, the index varies from 1.10 to 1.30 in B. ealifornicus. In Hesperoboreus the index ranges from .33 to .63 (Fig. 61, p. 173). This means that the ovipositor of Hesperoboreus is much shorter than that of Boreus, a fact readily discernible when females of both genera are seen side by side.

u. Process of tenth abdominal segment of female — As noted by Byers (1961), the shortened tenth abdominal segment of the female in Hesperoboreus brevicaudus is prolonged posteriorly as spine-tipped extensions on either side of the partially unfused cerci (Fig. 61, p. 173). This structure is also found in H. notoperates (Fig. 62, p. 173), but has not been noted in Boreus (Figs. 59, p. 173; 60, p. 173). This caudal extension is a good character for separating genera, but it does not vary appreciably within Hesperoboreus.

V. Basal notch of female eighth sternum — Cooper (1974) noted that in H. notoperates copulation is reciprocal, meaning that in addition to normal coition the female eighth sternum is held in the male's endoandrium (of Cooper, 1974) by his diststyles. In this species, a basal notch on the eighth sternum of the female facilitates the diststylar hold (Fig. 62, p. 173). This basal notch is also found (although much smaller) in H. brevicaudus (Fig. 61, p. 173) but is lacking in all species of Boreus. Cooper observed that this mechanism helps H. notoperates maintain the unusual perpendicular mating position.

w. Spines of the eighth abdominal sternum of the female — All female boreids have some spines at the tip of the eighth

sternum. Variation in number and placement of spines differs within species and between species, but there are consistent differences between the two genera. Spines only occur on the apical one-third in Boreiis, while spines occur over the apical half in Hesperoboreus.

X. Fusion of the female cerci — Byers (1961) first reported that not all species of boreids had fully fused cerci (Fig. 64, p. 174). Until that time it was thought that Boreidae lacked cerci and that the apex of the ovipositor was the eleventh abdominal tergum. Byers separated the partially fused cerci of H. brevicaudus (Fig. 63, p. 174) and observed the sclerites of the eleventh segment below them. The same lack of complete cereal fusion has since been noted in H. notoperates. Incomplete fusion of the cerci is another taxonomically reliable generic character state.

PHENETICS

The subsequent discussion of phylogeny of the Boreidae is based on the author's subjective judgement of whether a given character state is primitive or derived. Much reliance is placed on the opinion that character states cannot be lost and then regained within the evolutionary history of the group. To assess whether the judgments and the emphasis placed on certain characters have distorted the degree of difference among species, a phenetic analysis of the Boreidae was also made of all species for which I had enough information. All characters that could be found to vary between species, but that varied little or not at all within a species, were recorded and compared. In all, 37 characters were used. The comparison of species was tabulated (Table 3, p. 176) in a scaled similarity matrix (Sneath and Sokal, 1973). This scaled similarity matrix was constructed by giving each character state (Table 4) a plus or minus, depending upon whether the species has (-{-) or lacks (—) the character state listed in Table 5, p. 178. The species were then compared with one another and the number of differences (mismatches) listed in the matrix. The absolute number of differences was then divided by the total number of character states used, and this fraction of difference was also entered in the scaled similarity matrix.

From this matrix a phenogram was constructed (Fig. 69, p. 182) by comparing the differences between each pair of species separately (Sneath and Sokal, 1973). The two species showing the least difference are linked together at the degree of difference indicated. This linked couplet is then compared with each other species, and the differences with the pair averaged. The smallest degree of difference is then linked to this couplet at the averaged degree of difference, or new couplets are formed, if this is the smallest degree of difference. Increasingly larger groupings are then compared. Using this technique, the phenogram is formed of these species showing the most similarity.

After constructing the phenogram, the levels for genus, group, and subgroup were set at 30-.40, .20, and .10, respectively. As can be seen by comparing the phenogram and phylogenies, phenetic and phylogenetic groupings are very similar. The same species repeatedly occur together in distinct groups. The hyemalis group is not quite as distinct as the other groups, but characters of the male tergum used to separate this group are quite discernible.

These results may be due to the high degree of correlation in characters, an unconscious phenetic bias on the part of the author in choosing characters to study, or both.

PHYLOGENY

There are no fossils to help clarify the evolutionary development of Boreidae. The best indicator of a nearest sister group relationship (Hennig, 1965) is the scarabaeiform larva, because most other morpho-

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logical traits are either unique or shared by several other mecopterous families.

Most mecopterous larvae are eruciform. Only one other family, the Panorpodidae, has scarabaeiform larvae. Within the Panorpodidae females are moderately to extremely short-winged and flightless, or nearly so. Adults generally live at elevations between 3000 and 8000 feet in the mountains of eastern and western North America, Japan, and Korea. Severe climatic conditions could have forced a population of panorpodid-like ancestors to express the genetic capability for additional cold tolerance with corresponding morphological modifications of size and structure. Comparisons between the two families indicate that within the Boreidae cerci and the tenth abdominal segment of the female fused into a heavily sclerotized ovipositor; adults and larvae adapted to feeding on moss, while panopodid larvae feed on roots and adults on leaf tissue; size became reduced; dark pigmentation increased; wings became reduced to heavily sclerotized flaps in the females and elongate, thin hooks in the males; the ocelli became more dispersed; and the life cycle increased to two years. The length of the life cycle is unknown in Panorpodidae, although in other mecopterous families where such information is available, the life cycle never exceeds one year.

The long rostrum of Boreidae is very

TABLE 1

List of Primitive Character States.

1. Presence of median ocellus

2. Occiput not rugulose

3. No occipital reticulations

4. 21 or more antennal segments

5. Antennal bases between compound eyes

6. Narrow hypostomal bridge

7. Only fine setae on posterior surface of rostrum

8. Setae on body uniformly short

9. Thoracic bristles present

10. Forewings narrowed abruptly at mid-length-male

1 1 . Presence of outer forcwing bristles-male

12. Female forewings covering hindwings-femalc

13. Absence of bristles at caudal margin of wing pad-female

14. No transverse ridges on second abdominal tergum-male

15. No transverse ridges on third abdominal tcrgum-male

16. No fusion of eighth tergum and sternum-male

17. No ninth tergal hood present-male

18. No fusion of ninth tergum and sternum-male

19. Ninth sternum smoothly rounded apically-male

20. Tenth abdominal segment short-female

21. No posterior process of tenth abdominal segment-female

22. Cerci not fused-female

23. Cerci evenly tapering to apex-female

24. Eighth sternum not notched basally-female

List of Derived Character States.

1. Loss of median ocellus

2. Gain of rugulose occiput

3. Loss of occipital reticulations

4. Loss of antennal segments

5. Movement of antennal bases to below eyes

6. Widening of hypostomal bridge

7. Gain of rostral spines

8. Gain of 25 rostral spines

9. Gain of long pilosity

10. Loss of thoracic bristles

1 1. Broadening of forewings at mid-length-male

12. Loss of outer forewing spines-male

13. Forewings reduced until they no longer cover hindwings-female

14. Gain of bristles at caudal margin of wing pad-female

15. Gain of transverse ridge on second abdominal tergum-male

16. Gain of transverse ridge on third abdominal tergum-male

17. Transverse ridge of third segment reduced to a tubercle-male

18. Fusion of eighth tergum and sternum-male

19. Development of small tergal hood-male

20. Tergal hood expanded to middle of denticular area-male

21. Tergal hood expanded to lateral margin of

22. Development of projections along lip of tergal denticular area-male

hood-male

23. Development of medial projections along lip of tergal hood-male

24. Gain of medial septum to tergal hood-male

25. Development of narrow median septum-male

26. Gain of short median septum with ventral fork-male

27. Development of numerous setae covering interior of hood-male

28. Fusion of ninth tergum and sternum-male

29. Development of notched ninth sternum-male

30. Lengthening of tenth abdominal segment-female

31. Development of posterior process on tenth abdominal segment-female

32. Complete fusion of cerci-female

ii. Gain of abruptly narrowing of cerci at mid-length-fcmale

34. Development of eighth sternal notch-female

35. Expansion of eighth sternal notch-female

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similar to that found in Panorpidae and indicates that ancestral boreids and panorpodids were distinct groups before secondary reduction of the rostrum began in Panorpodidae.

Many diflferent ways can be used to depict diagrammatically the supposed evolution of Boreidae. Four methods are used here. The first (Fig. 66, p. 175) represents a phylogeny in which 35 derived character states (Table 1, p. 163) were chosen which varied between species, but were relatively constant within a species. These 35 character states were then analyzed to determine the probable primitive state for each (Table 1, p. 163) and subsequent development. They were then arranged on an unweighted branching sequence which would give the minimum number of changes in the characters. Although evolution may not always have taken the simplest course, the most parsimonious evolutionary diagram is presumably the best.

Many of the character states in this list are shared with the rest of Mecoptera, and are, therefore, considered primitive. Almost all Mecoptera have three ocelli, a smooth occiput without fine reticulations, antennal bases between the eyes, a narrow hypostomal bridge, fine setae on the posterior surface of the rostrum (if any setae at all) and prothoracic bristles, as well as unfused eighth tergum and sternum and no elaboration of the ninth tergum, in males, and in females a short tenth segment without caudal processes, unfused cerci which taper uniformly to the apex, and a basally unnotched eighth sternum. Mecoptera have long, filiform antennae with flagellomeres varying in number from about 60 in Chorista to 18 in Bittactts, with 40 or more being common in most families. Therefore, the largest number of flagellomeres found in Boreidae (23) is considered closest to the ancestral condition. Setation of Mecoptera usually consists of very small hairs on all areas of the

body. Some boreids also have small hairs on most areas of the body, but two species (Boreits nix and pilosus) have developed extensive areas of thick, long pilosity, which I consider derived. Broad wings in the male are found only in B. elegans and nivoriitndiis and probably arose in a common ancestor of those two species. Likewise, reduction of the female forewings to vestiges not covering the hindwings is only found in the reductiis group and is probably derived. A similar process was used to recognize as primitive the absence of bristles on the wing vestiges of females (bristles only in H. brevicaudiis), absence of abdominal tergal ridges in males (ridges only in hy emails group), the lack of fusion of ninth tergum and sternum of males (fusion only in vlasovi subgroup), and the smoothly rounded ninth sternum in males (deeply notched only in H. notoperates and the brumalls subgroup). Almost all Mecoptera have setae along the costal and anal margins of the wings, and enlargement of these setae could have led to the rows of spines along costal and anal margins of boreid forewings. Absence of these spines along the costal margins of forewings in Hesperoboreiis is considered derived. The complex tergal hood of the calif ornlciis and hyemalis groups is derived through a progression of steps from no hood in Hesperoboreus to increasingly more complex structures in nivoriundus and reductiis groups.

A conventional two-dimensional diagram depicting boreid phylogeny becomes too clustered around certain points to provide a clear idea of branching sequences. Therefore, a three-dimensional diagram was employed to allow more directions for progression. Displacement from one plate to the next above it of one millimeter in

any horizontal plane (0°, 45°, 90°) corre-

sponds to a change in one character state.

However, direction of displacement has no

biological significance.

A second phylogeny (Fig. 67, p. 180)

[Begin Page: Figs. 31-33, Page 165]

Figures 31-33, male, tip of abdomen, lateral view. Fig. 31, Bonus coloradensis Byers. Fig. 32, Borciis

lal lu/ lis Cirpcntcr. Fig. ii, Bonus i/ihori Martynova. All 78 X-

[Begin Page: Figs. 34-39, Page 166]

Figures 34-39, tip of abdomen, dorso-caudal view. Fig. 34, Hespeioboretis brevicaudtis (Byers). Fig. 35, Hesperoborciis notoperates (Cooper). Fig. 36, Boreiis borealis Banks. Fig. 3)7, Boietts bmmalis Fitch.

Fig. 38, Boretis calijornicus Packard. Fig. 39, Borctis coloiadensis Byers. AH 66 X-

was constructed by weighting each character state in the unweighted phylogeny according to the number of species involved (Ashlock, unpubHshed method). This would give more value to those character states which help to unify groups of species. The final horizontal distance be-

tween species gives a measure of how closely related the species are. Character states on the weighted phylogenies are listed by branching sequence in Table 2, p. 169.

The third phylogeny (Figure 68, p. 181) illustrates a weighted phylogeny which

[Begin Page: Figs. 40-45, Page 167]

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Figures 40-45, tip of male abdomen, dorso-caudal view. Fig. 40, Boieiis elegans Carpenter. Fig. 41, Boreits hyemalis (L.). Fig. 42, Boreus intermedins Carp. Fig. 43, Boietts loliuyi Kip. Fig. 44, Boreits nivoriimdits Fitch. Fig. 45, Boreus nix Carpenter. All 66X-

[Begin Page: Page 168]

uses not only the number of species involved but also the number o£ times a character state appears (Brothers, 1975). By assignment o£ only half value to a character state which has evolved twice, these character states lose much of their value. This is done because we are trying to determine the most probable line of evolution, and character states which appear to have evolved twice are more doubtfully correct and should be given less weight. By reducing their value such lines of evolution which use these character states appear to have diverged less. Figure 68 agrees with my own intuition as to the evolution of this group.

In all three phylogenies, the two genera, Boreus and Hesperoboretts, appear quite distinct, as do most of the groups and sub-groups mentioned earlier. However, it will be noted that in the two weighted phylogenetic diagrams the vlasovi sub-group and hyemalis group do not appear to be very distinct, while the nivoriiindus group is very distinct. This is due in part to the material available. All nivoriiindus group species are represented, while l^a-tochvili is lacking from the hyemalis group, and the only one vlasovi subgroup species is represented. Only one synapo-morphous character (Hennig, 1965) sepa-rates the nivoriiindus subgroup from the rest of Boreus, but because of the primitive position of this subgroup in the phylogeny and the large number of species involved, the two subgroups of the nivoriiindus groups appear quite distinct from each other.

Boreids evolved in two directions. One group, given the new generic name Hesperoboreus, and containing H. brevicaudus and notoperates, lives in areas of rather warm climate along the west coast of the United States. These species possess two ocelli; large bristles are present along the anterior and posterior margins of the pronotum; the eighth tergum and sternum are not fused in males; females possess a

very short ovipositor with cerci incompletely fused; and no ninth tergal hood development or outer forewing spines are found in males.

All species of Boreus have outer forewing spines in the males, and a long ovipositor and fused cerci among females. These species can in turn be divided into one Nearctic group, two Holarctic groups, and one Palearctic group.

The first group (nivoriundiis group), containing B. beybien\oi, brumalis, elegans, nivoriiindus , nix, and pilosus, consists of both North American and Asiatic species. These species possess pronotal bristles, and in males have unfused eighth and ninth abdominal terga and sterna, and small tergal hoods. This group can be further divided into the nivoriundus subgroup, having males with entire ninth sterna and gradually tapering forewings, and the brumalis subgroup, having males with deeply notched ninth sterna and wings abruptly narrowed at mid-length.

The second group {reductus group), containing B. reductus, vlasovi, and probably most Asiatic boreids, is found both in western North America and Asia. These species agree in possessing no pronotal bristles, unfused male eighth tergum and sternum, and a small tergal hood in males. This group also can be subdivided into two subgroups. The reductus subgroup has unfused ninth tergum and sternum in males, while the vlasovi subgroup usually has fused male ninth tergum and sternum. Most Asiatic species belong in this second subgroup.

B. ori en talis may be an exception among Asiatic species. Martynova (1954) has illustrated part of the eighth abdominal segment of this species, showing it as fused. This would be the only known Asiatic species with fusion in both eighth and ninth segments. Until more is known about this species, I feel that it should be considered as a part of the vlasovi subgroup of the reductus group. Other Asi-

[Begin Page: Page 169]

atic species which Martynova illustrated with fused ninth segment are chadzhigireji, vlasovi, and semenovi. Cooper (1973) stated that the ninth tergum and sternum of vlasovi were unfused, but this varies with the individual. Since navasi is very similar to chadzhigireji, it probably belongs in this subgroup. Although little is known about sjoestedti, perhaps it

too belong to the vlasovi subgroup. To know with certainty, it will be necessary to collect males of these species.

The third group {calijornicus group) includes B. borealis, calijornicus , coloradensis, and intermedius. These species all possess no pronotal bristles, show fusion of eighth terga and sterna among males but no fusion of male ninth terga and sterna,

TABLE 2

Phylogenetic Character State Sequence.

1.

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29.

35.

19.

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32.

7.

11.

20.

29.

Between points 1 and 2 4.

Loss of median ocellus 22.

Gain of rugulose occiput

Loss of antennal segments 13.

Movement of antennal bases to below eyes

Widening of hypostomal bridge 23.

Loss of outer forewing spines-male

Development of posterior process on tendi

abdominal segment-female 28.

Development of eighth sternal notch-female 33.

Between point 2 and H. brevicaudus

Gain of bristles at caudal margin of wing

pad-female 18.

Between point 2 and H. notoperates 21.

Development of notched ninth sternum-male

Expansion of eighth sternal notch-female 24.

Between points 1 and 3

Development of small tergal hood-male

Lengthening of tenth abdominal segment-

female 27.

Complete fusion of cerci-female

Between points 3 and 4

Gain of rostral bristles 25.

Broadening of forewings at mid-length-male

Between point 4 and B. elegans

Gain of 25 rostral bristles

Between point 4 and B. nivoritmdtis 26.

none

Between points 3 and 5

Tergal hood expanded to middle of denticu- 15.

lar areas-male

Between points 5 and 6 16.

Development of notched ninth sternum-male

Between point 6 and B. brttmalis

none 3.

Between points 6 and 7

Gain of long pilosity

Between point 7 and B. nix

none

Between point 7 and B. pilosus

Loss of some denticles 17.

Between points 5 and 8

Loss of thoracic bristles 26.

Between points 8 and 9

Loss of median ocellus

Loss of antennal segments

Development of projections along lip of hood

Between point 9 and B. reductus

Forewings reduced until they no longer

cover hindwings-female

Development of medial projections along lip of hood-male

Between point 9 and B. vlasovi

Fusion of ninth tergum and sternum-male

Gain of abruptly narrowed cerci at mid-length-female

Between points 8 and 10

Fusion of eighth tergum and sternum-male

Tergal hood expanded to lateral margin of denticular areas-male

Gain of median septum to tergal hood-male

Between points 10 and 11

none

Between point 11 and B. borealis

Development of numerous setae covering interior of tergal hood-male

Between point 11 and B. calijornicus

Development of narrow median septum

Between 11 and B. coloradensis

none

Between point 11 and B. intermedius

Gain of short median septum with ventral fork -male

Between points 10 and 12

Gain of transverse ridge on second abdominal

tergum-male

Gain of transverse ridge on third abdominal

tergum-male

Between point 12 and B. hyemalis

Loss of occipital reticulations

Between points 12 and 13

none

Between point 13 and B. westwoodi

none

Between point 13 and B. lo\ayi

Transverse ridge of third segment reduced

to a tubercle-male

Gain of short median septum with ventral

fork-male

[Begin Page: Figs. 46-49, Page 170]

Figures 46-49, tip of abdomen, dorso-caudal view. Fig. 46, Boreiis pilostis Carp. Fig. 47, Boieiis rcductus Carpenter. Fig. 48, Boreas vlasovi Martynova. Fig. 49, Borcits westwoodi Hagen. All 66 X-

and have a large male tergal hood with median septum. All species of this group are Nearctic.

In the Palearctic region a fourth group of species occurs, the hyemalis group, consisting of B. hyemalis, I^ratochvili, loJ^ayi, and westwoodi. These are similar to the californicus group but have transverse ridges on the second and third abdominal terga.

The picture that emerges from the morphology and distribution of these spe-

cies is the following: ancestral boreids developed in the Nearctic region from a panorpodid-like ancestor, with flightless females, prothoracic bristles, and unfused eighth and ninth abdominal segments in the males. As is the Hesperoboreits species, females had incompletely fused cerci, and no elaboration had occurred on the male ninth abdominal tergum. This ancestral stock then split. H. notoperates and brevicaiidus represent the remnant of an ancestral species which further .split into

[Begin Page: Page 171]

two populations as glaciers retreated after the ice ages. One population {notoperates) remained in southern CaUfornia and survived the warming trend by becoming adapted to warmer temperatures and moving to the higher elevations of Mount San Jacinto (and perhaps associated ranges). The other population (brevicaudus) remained at a lower elevation and moved or remained northward in western Oregon and Washington.

In the other ancestral stock, i.e., exclusive of Hesperoboreiis, the female cerci fused entirely and the tenth abdominal segment became more elongate. This stage of development is exemplified by the nivoriundus group. This group is trancontinental in distribution in North America and is also found in the Ala-Too Range, north of the Himalayas. Although no specimens are now known from the Rocky Mountains of Colorado to southern Illinois, it seems likely that at one time environmental conditions permitted an east-west movement of Boreiis across northern North America. Perhaps in the cooler regions of northern Canada this distribution is still contiguous, although there are no specimens to verify this. The presence of this group in Asia indicates a possible early movement into the Palearctic region.

The nivoriundus group is here subdivided into the nivoriundus subgroup {elegans and nivoriundus) and brumalis subgroup (brumalis, nix, and pilosus). B. beybienkoi is probably in this group, since the original description mentions prothoracic bristles. However, I have not seen specimens of this species and its position within the nivoriundus group is still not known.

The next step in evolution of the Boreidae was loss of thoracic bristles, as seen in the reductus group. The only member of this group in the Nearctic region is reductus, distributed in the arid mountain regions of western North America.

There are some character states in this group that cause problems for phylogeneticists. Species of the reductus group have no median ocellus, in which character they resemble Hesperoboreus. The vlasovi subgroup has the shortest ovipositor found in any group or subgroup of Boreus; and the number of antennal segments is reduced to 19 or 20, as in some specimens of Hesperoboreus. However, these character states probably were independently achieved through reduction, because males of the reductus group have a well-developed ninth tergal hood, a relatively elaborate structure which seems unlikely to have evolved twice. There are other indications, as well, of the relatively advanced state of evolution of the reductus group, such as the absence of thoracic bristles in both sexes and reduced number of hindwing spines in males.

Fusion of the eighth abdominal tergum

and sternum in males of a population of an ancient reductus group species later occurred. This condition created the ancestral species of the californicus group, which later disepersed in or into the Nearcdc region. B. borealis became isolated on St. Paul Island, probably at a time when land connections existed, or possibly when permanent ice covered the Bering Sea. The closely related species californicus and coloradensis became widely distributed in the relatively arid mountain regions of western North America from California to central Colorado and from central Arizona to northwestern British Columbia. B. intermedins is a more northern counterpart of these western species in Alaska,

In Europe, the hyemalis group arose from species in which there evolved an enlargement of the male second and third abdominal terga into flat ridges. These ancestors dispersed into the Carpathian Mountains and western Europe.

Martynova (1954) stated dbat B. chadzhigireji had tergal ridges but that they were almost absent. The figures accompanying her description showed no fusion

[Begin Page: Figs. 50-58, Page 172]

Figures 50-52, male, ninth sternum, ventral view. Fig. 50, Boretts coloiadensis Byers. Fig. 51, Boretts reductus Carp. Fig. 52, Boretis brtnnalis Fitch. Figs. 53-58, male, dististyle. Figs. 53-54, Boreas coloradensis Byers. Figs. 55,56, Boretis elegans Carp. Figs. 57,58, Hesperoboreiis hrevicaiidus (Byers). Figs. 53,55, and 57, caudal view. Figs. 54,56, and 58, lateral view. All 88 X-

[Begin Page: Figs. 59-62, Page 173]

Figures 59-62, female ovipositors, lateral view. Fig. 59, Boretis coloradensis Byers, 50 X- Fig. 60, Boreus vlasovi Martynova, 57X. Fig. 61, Hesperoboretis brevicaudtis (Byers), 57X. Fig. 62, Hesperoboretis not operates (Cooper), 57 X-of the eighth tergum and sternum, but fusion in the ninth segment. These two character states indicate that this species is most Hkely a member of the vlasovi sub-group of the reductus group, and has no tergal ridges (cf. Cooper, 1972:276-277).

Both the nivoriundus and reductus groups are Holarctic, and little evidence is

available to indicate the direction of their movement between continents. However, there may well have been multiple move-ments between the Palearctic and Nearctic regions.

ECOLOGY

A. Plant Assocl\tions — Boreidae have been taken from many mosses. Boreus brumalis larvae from eastern North Amer-

[Begin Page: Figs. 63-65, Page 174]

ica has been collected from Dicranella heteromalla and Atrichtim angustatum (Webb et al., 1975), and Byers (1954) mentioned that J. W, Leonard had found adults of this species in Sphagntun. Hesperoboreus notoperates has been recorded from Grimmia apocarpa, G. laevigata, G. montana, Rhacomitrium sudeticum, Orthotrichum rupestre, Tortilla princeps, T. rtiralis, Homalothecittm aeneitm, H. nevadense, H. pinnatifidum, and Campothecitim a?nesiae in southern California (Cooper, 1974). Boreas reductus larvae and adults have been collected on club

mosses {Selaginella sp.) in southeastern Washington. It appears that the species of moss is of less importance than the moss texture. Mosses which grow in low, compact cushions and whose rhizoids are tightly matted more frequently contain adult and larval Boreidae than do mosses that grow upright or are more loosely matted. It has been my experience that upright or loosely matted mosses more frequently contain predaceous carabid

beetle larvae. Perhaps, larval boreids sur-

vive predation better in the more tightly

compacted mosses.

Figures 63-65, female ovipositors, dorsal view. Fig. 63, Hesperoboretis hrevicaiidtis (Byers). Fig. 64, Boreus coloradensis Byers. Fig. 65, Boretis vlasovi Martynova. All 66 X-

[Begin Page: Fig. 66, Page 175]

Figure 66. Three dimensional unweighted phylogeny. Movement between plates in any direction of 1 cm indicates one character state change. (Direction of change in position between plates has no biological significance.) A is H. notoperates , B is H. brevicaudus. C is B. elegans, D is B. nivoriundus, E is B. hrtimalis, F is B. nix, G is B. pilosus, H is B. reductus, I is B. vlasovi, J is B. coloradensis, K is B. borealis, L is B. calijornictis, M is B. intermedins, N is B. lo\ayi, O is B. westwoodi, and P is B. hyemalis.

B. Feeding — Withycombe (1922) men-

tioned keeping one female of Boretis hye-

malis alive for 37 days on juices of crushed

flies, although in a later paper (Withy-

combe, 1926) he states that the diet of

Boreus is moss. Other authors (Brauer,

1855, and Steiner, 1937) have speculated that Boreits feeds on collembolans, although no evidence has been presented to support this. The European B. hyemalis

[Begin Page: Page 176]

has been found to feed as larvae on Dicranella heteromalla, Byriim atropurpitreum, Mnium horntim (Withycombe, 1926) and Pylaisia sp, (Boldyrev, 1914). Striibing kept larvae of B. hyemalis alive to pupation on Polytrichtun pilifentiyj. I have observed larvae of B. brtimalis feeding on the rhizoids of Dicranella heteromalla in the field. In the laboratory, adults I observed placed the long rostrum among the moss leaves, as if to feed, although the tip of the rostrum could not be seen. Stomach contents of adults reveal only small globules of a liquid substance, possibly because of masticating activity of the proventriculus (see Richards, 1965). That adult boreids do indeed feed on mosses and occasionally other substances has been recorded by numerous other observers.

C. Life Cycle— Both Brauer (1855) and Steiner (1937) found large larvae of Boreus hyemalis in terraria within a few

months of initial collection of adults. However, in both cases no mention was made of initially checking the moss for larvae. Withycombe (1922) claimed to have reared the same species to adulthood in one year, although he gave few details of his technique. Doubts were raised when Syms (1933) found larvae of hyemalis of two distinct sizes. He postulated a two-year life cycle. Striibing (1950) was able to rear this species and confirmed a two-year life cycle. Cooper (in litt.) reports early and late instar larvae occurring together for B. bnimalis, B. nivoriitndits, B. elegans, H. brevicaudiis and H. notoperates.

This two-year life span seems reasonable in light of other boreal adaptations. Other cold-adapted insects have increased

11

the length of the life cycle. In the high arctic environment most Lepidoptera spend two or more years in the larval stage (Downs, 1964), and even northerly or

[Begin Page: Page 177]

TABLE 4

List of Presence (-f-) vs. Absence (—) of a Character State.

1

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montane races of one species may have a
prolonged life cycle (Downes, 1965). Thus,

finding this adaptation within another group of holometabolous insects is not surprising. However, Kaufmann (1971) has shown that an arctic carabid beetle, Pterostichus brevicornis, can have a variable length of life cycle. A two-year life cycle needs to be confirmed for other populations and species of Boreidae.

The pupal and adult stages of the life

cycle usually occur during the cool or cold months of the year, yet pupae of a few species have been found as early as mid-August. Pupae of B. briimalis have been collected only from September 30 until October 18. Pupae collected on October 13 were maintained in the laboratory until the adults emerged from November 24 to December 4. Adults of this species have been collected from November 19 until April 24. Two adult specimens in the

[Begin Page: Page 178]

TABLE 5

List of Character States used in Table 4.

1. Presence of median ocellus.
2. Occiput very rugulose.
3. Occiput with fine reticulations.
4. 19 or 20 antennal segments.
5. Antennal base below eyes.
6. Wide hypostomal bridge.
7. Spines on caudal margin of rostrum.
8. More than 24 rostral spines.
9. Body covered with long pilosity.
10. Thoracic bristles present.
11. Forewings abrupdy narrowed at mid-length-male.

12. Complete loss of outer forewing spines-male.

13. Forewings covering hindwings-female.

14. Bristles on caudal margin of wing pad-
female.

15. Transverse ridge on second abdominal tergum-
male.

16. Transverse ridge on third abdominal tergum-
male.

17. Third tergal ridge reduced to a tubercle-
male.

18. Eighth abdominal tergum and sternum fused-
male.

19. Tergal hood on ninth abdominal segment-
male.

20. Lateral margin of hood reaching only medial
margin of denticular areas-male.

21. Lateral margin of hood reaching only middle
of denticular areas-male.

22. Lateral margin of hood reaching lateral mar-

gins of denticular areas-male.

23. Projections along lip of tergal hood-male.

24. Medial projections along lip of tergal hood-male.

25. Tergal hood with median septum-male.

26. Median septum narrow-male.

27. Median septum short and forked ventrally-male.

28. Interior of tergal hood obscured by numerous setae-male.

More than 25 denticles on either side of ninth tergum-male.
Ninth tergum and sternum fused-male.

Presence of deeply notched ninth sternum-male.

Tenth segment as short dorsally as ninth-female.

Posterior process on tenth abdominal segment-female.

Complete fusion of cerci-female.

Cerci tapering evenly-female.

36. Eighth sternal notch present-female.

37. Eighth sternal notch large-female.

29.

30.

31.

32.

33.

34.

35.

Ohio State University Collection are labelled August 15, 1935, but surely these are atypical. Adults of other species have also been collected generally from November until April; however, adults of B. coloradensis have been collected as late as May 27 in the mountains around Logan, Utah, and those of B. borealis have been collected in the Pribilof Islands only during May, July, and August,

Emergence appears to be delayed until moderate weather conditions exist for species living in montane and high latitudinal environments. The populations of B. coloradensis at 2,134 to 3,657 m. in Boulder County, Colorado, have only been collected in April, whereas this same species is collected from November until May at 1,676 m. around Logan, Utah. Boreus nix is found from November to February in Montana and British Columbia, but has only been collected in April in Alaska. B. intertJiediits also has only been collected

in April in Alaska. Thus, emergence is to be expected later in northern and montane regions.

In the laboratory, I maintained adults of B. coloradensis and nivoriiindiis for 48 and 51 days, respectively. This is possibly shorter than natural adult longevity, yet the rigors of the laboratory environment may have been offset by protection from predation or severe cold.

D. Mating and Oviposition — The mating behavior of Boreidae has been discussed by Cooper (1940, 1974) and various other authors. Briefly, the mating behavior is as follows: In Boreus, the male upon encountering a female, attempts to clasp her with his dististyles; if he is successful, the female becomes quiescent and the male uses his long, thin hook-like wings to pull the female upon his back. The female tucks her rostrum and antennae under her thorax and between her legs

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while the male's wings clasp her forelegs; the hypovalves of the female's eighth sternum are inserted into the male endoandrium, where they are held in place by the basal lobes of the male dististyles. The male carries the female upon his back for an extended period of time; Marechal

(1939) used the figure of 55 hours, although the duration is usually much shorter than that. During this time the female moves very little. Later, the female places small, white oval eggs among the moss rhizoids and the bases of the leafy stems.

In Hesperoboreus, the male approaches and leaps at the female, grasping whatever part of her anatomy he can with his dististyles. The female actively tries to escape, dragging the male with her. When she rests, he tries to grasp her with his wing hooks. If successful, he clutches her between her head and mesonotum, holding her body parallel to his own. When the female becomes submissive, the male moves his dististyles to the ovipositor, and the wing grip is released. The valves of the female's eighth sternum are pried down and apart. The male holds the valves down by hooking the basal notch of the valves with the basal lobe of his dististyles. The valves are forced into the subepandrial pockets and held there. The female then rocks backwards 90°, and rests with rostrum and antennae folded between the forelegs. She remains perpendicular to the male in a "female perpendicular pose" that contrasts with the copulatory position of Boretis which Lamb (1922) has termed "female vertical pose," but in which the final copulatory position of the female is above and parallel to the male.

E. Moisture — The water required for boreid survival can probably be obtained from the food. However, the relative humidity requirements of the microhabitat may be a major limiting factor. The humidity must be high enough to support a good growth of moss, and the luxuriance of moss banks where most specimens of Boreas have been collected indicates high humidity most of the year. On the other hand, boreid larvae have sometimes been found in mosses that appeared desiccated and friable (Cooper, 1974). There has even been one collection of adults of B. coloradensis in sagebrush desert at Promontory, Utah. H. notoperates survives in Grimmia, a moss of dry, rocky habitats. Therefore, no one statement can cover the moisture requirements of all species of

Boreidae.

F. Elevation — Elevation greatly influences such climatic conditions as moisture and temperature; however, its effects on the distribution of Boridae have not been determined. B. briimalis is found in eastern North America from sea level to 4,000 feet (1,220 m). H. hrevicatidus has been collected from the bottom of the Columbia River gorge at 100 feet (31 m.) and on Spencer Butte near Eugene, Oregon, from 1,200 to 1,900 feet (366 to 580 m.). On die other hand, B. coloradensis is normally found in mountainous regions from 4,700 feet (1,457 m.) around Logan, Utah, up to 12,000 feet (3,660 m.) near Boulder, Colorado.

G. Temperature — The efIfect of temperature, Hke that of moisture, can only be guessed at because of the insects' behavior in selection of microhabitat. However, various species' distributions do appear to be governed to some extent by differences in average temperature. The distributions of H. hrevicatidus, B. elegans, and possibly H. notoperates appear to be influenced by the mild, modifying effects of the Pacific Ocean. None of these spe-

cies has been collected more than 90 miles

from the Coast. The mildness of tempera-

tures in this region can be seen in monthly

means at Mount San Jacinto, California,

Portland, Oregon, Seattle, Washington,

[Begin Page: Fig. 67, Page 180]

si|Eiii3Aq -g

lAeJfoi -a

lp00MJS9M -g

snipanjjajui -g

sisuspBJ0|03 "g

snaiujojiiED 'g

Sjjesjoq 'g

lAosBiA -g

snjanpaJ '8

X

SI I BUI mq *g

xiu -g

snso|id -g

snpuniJOAlu 'g

suBbaj3 "8

sajEJsdojou "H

snpnE3]A3jq -^

if

[Begin Page: Fig. 68, Page 181]

sjieiuaAq'fl

dnojB

snoiujojiiea

iAOse|A-a

sn^anpaJ'a

si|eujniq-g

xiu -a

snsoijd '8

snpunijoAiu *a

su'efiaia "g

sajejadoiou "H

snpne3]A3jq *H

[Begin Page: Fig. 69, Page 182]

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Degree of Difference

^ cjn o tn ^ "^ C-J

CJ1 CD CJ1

Figure 69. Phenogram.

H. brevicaudus

H. notoperates

_ B. elegans

_ B. nlvorlundus

_ B. pjlosus

_ B. nix

_ B, brumalis

B. reductus

. B. vlasQvi

. B. boreali's

. B. calffornicus

. B. coloradensi's

, B. intgrmedfus

B. westwoodi

B. lokayi

B. hyemalis

and Vancouver, British Columbia — all localities close to places where these three species of Boreidae have been found. The low mean monthly temperatures for these four localities range from 0° to 8°, and the high mean monthly temperatures range from 18° to 28° C. The high temperature recorded for these cities in 1971 was 46° and the low temperature was — 13° C. This contrasts sharply with temperature tolerances of species from the western

plateau region and the East Coast. B. bntmalis has been collected from Duluth, Minnesota, to Washington, D. C, with low mean monthly temperatures varying from — 13° to 3°, and high mean monthly temperatures ranging from 19° to 26° C. High and low temperatures for these two localities in 1971 were 34° and — 32° C. Helena, Montana, is within the range of three western species, and it, too, has severe changes in temperature with high

[Begin Page: Page 183]

and low monthly mean temperatures of 20° and — 7° C. The change in species composition with climatic zone seems to be particularly abrupt in Oregon and Washington, where B. calijorniciis is found from the Cascade Range eastward, and H. brevicaudiis is found from the western foothills of the Cascades westward.

Microhabitats offer climatic diversity in these extreme environments. Bliss (1969) noted that "In these severe environments, where day-time temperatures at 0.7 m seldom exceed 13° to 18° C. and more frequently are 5° to 8° C, it is of considerable interest to note that soil surface temperatures in excess of 38° C. have been recorded by the writer in arctic Alaska as well as in the alpine tundras of Wyoming and Mt. Washington. Night-time soil-surface temperatures for the same dates were 4° to 7° C." Wilson (1957) found that air temperatures near a small clump of arctic Saxifraga oppositifolia were 0.5° C. at 2 m, 3.5° C. at 1 cm above the clump, and 6° C. inside two flower buds. Wulff (cited in Porsild, 1951) recorded temperature readings of 3.5° C. among dead leaves of a saxifrage and 10° C. in a clump of mosses in northern Greenland when air temperature was — 12° C. Thus, through behavioral preferences boreids can select microenvironmental temperatures far different from local air temperatures.

One collection of B. brumalis larvae was made on a day when air temperatures were about 24°, but the soil temperature where they were collected was only 10° C.

The activity of adult boreids is clearly influenced by temperature. At 0° C, adults of B. coloradensis are active on the snow surface; however, this temperature appears to be close to the minimum for most boreid activity. Below this temperature, they can be seen lying on the snow but will not move, even when picked up. Overnight temperatures of — 37° C. in

British Columbia killed specimens of B. elegans and H. brevicaudus I was transporting in plastic cartons for study. The maximum temperatures of adult activity are not known, but adults of B. brumalis survived a temperature of 20° for a few hours time. Herter (1943) recorded maximal survival temperatures of 32-32° C. for B. hyemalis and 34-37° C. for B. westwoodi.

H. Time of Activity and Light Reaction — During a collecting trip in northern Utah, I noticed that adults of B. coloradensis were far more abundant on the snow surface at dusk than during the day. One active individual was even found by flashlight more than an hour after dark. This observation led to speculation that Boreidae are mainly crepuscular, or possibly nocturnal, Fraser (1943) made the same observation for B. hyemalis. While observing H. brevicaudus in Washington, I noted that the insects on snow did not move, even though the air temperature was 5° C. and the area was in bright sunlight. However, about three hours later (2:00 P.M.), at another collecting site 2° warmer, individuals of H. brevicaudus were active. In the laboratory, adults of B. brumalis occasionally move at night when temperatures are 7° C; but most often remain immobile, clinging to moss stems. The two isolated observations of numerous boreids at dusk may have been due to chance, and more observations should be made.

Marechal (1939) mentioned that B. hyemalis was attracted to electric lights, and Lestage (1940) speculated that this reaction explained why Boreus was more frequently collected on bright, sunny days. Lestage's suggestion is contrary to my own observations, although I recognize it applies to a species I have not observed alive. All North American species I have collected are as abundant on cloudy days as on sunlit days. Temperature appears to be

[Begin Page: Page 184]

a more important factor than light in their activity.

TAXONOMY

Key to the Genera of Boreidae

1. Males with no outer forewing spines; females with tenth abdominal tergum as short as ninth, bearing caudal, spiniferous extensions; female eighth abdominal sternum notched basally; cerci not fused

apically Hesperoboreus n. gen.

Males with outer forewing spines; females with long tenth abdominal segment without caudal extensions; female eighth abdominal sternum not notched basally;

cerci completely fused

Boreus Latreille

Hesperoboreus, new genus

Hesperoboreus (from the Greek hesperus = western and boreus = boreal) describes the western Nearctic distribution of this genus. Type species : Boreus brevicaudus Byers.

This genus can be separated from Boreus by the following characters: Hypostomal bridge wide; ratio of length of maxillo-labial complex to rostrum less than .60. Male forewings with no outer row of spines. Female eighth sternum with basolateral notch. Female tenth segment as short as ninth, bearing spiniferous caudal extensions; cerci not fused apically. Mating posture perpendicular.

Key to Species of Hesperoboreus

1. Apex of male ninth sternum smoothly rounded; forewing of female with apical

bristles brevicaudus

Apex of male ninth sternum deeply notched; forewing of female without apical bristles notoperates

SPECIES DESCRIPTIONS

Hesperoboreus brevicaudus (Byers), new combination.

Boreus brevicaudus Byers, 1961, J. Kansas Entomol. Soc. 34:73-78, Figs. 1-6.

Holotype and allotype in Oregon State

University collection, Corvallis.

Present description based on 1 female pinned, 6 males and 18 females in alcohol.

Head: Occiput dark brown shading to light brown at base of rostrum to yellowish-brown at tip of rostrum. Occiput rugulose with many fine setae. Median ocellus absent. Antenna light brown, with 16 flagellomeres. View^ed in profile, anterior surface of rostrum with few setae; hind margin of hypostomal bridge with none. Ratio of length of maxillo-Iabial complex to rostrum = .44.

Thorax: Tergum and pleuron dark brown. Anterior margin of pronotum with 6 to 8 bristles, posterior margin with 4 bristles. Meso- and metanotum usually without bristles, occasionally 2 to 4 bristles on mesothorax.

Legs: Yellowish-brown with numerous dark brown setae and apical femoral spine. Two tibial spurs light brown.

Male waNo: Light brown, abruptly narrowed at mid-length, with 13 inner spines at anal margin; covering hindwings.

Female forewing: Dark brown, oval, with large bristles at caudal margin; covering hindwing.

Male abdomen: Dark brown changing to yellowish-brown on last two segments. No tergal ridges on second and third segments. No fusion of eighth tergum and sternum or ninth tergum and sternum. Ninth tergum without hood; median partition between denticular areas; 13 denticles on either side of partition. Dististyle with about 6 spines arising from below basal lobe almost to apex of dististylar claw. Ninth sternum broadly rounded apically, not reaching bases of dististyles.

Female abdomen: First seven segments dark brown, last three visible segments light brown. Ratio of length of ovipositor to rostrum = .33. Caudal extensions of

[Begin Page: Page 185]

tenth segment each bearing 3 to 4 apical spines. Cerci dark brown with transparent tip. Eighth sternum with shallow baso-lateral notch.

Body length, male, 2.3 to 2.7 mm. in alcohol (holotype 2.6 mm., pinned); female, 3.1 to 3.6 mm. in alcohol (allotype 2.7 mm., pinned) .

Intraspecific variation: Females from northern Washington vary from those from southern Oregon by occasionally lacking bristles on the forewings, having fewer spines on the eighth sternum and having only 3 spines on the extensions of the tenth segment.

Holotype male, 3 miles south of Eugene, Lane Co., OREGON, 427 m., 27 Nov. 1959. Allotype female, 1 male, 4 females, and 7 larvae, same locality, but dates of 23 Nov. 1959 (for allotype) and 26 Dec. 1971. This locality is a small park on Spencer's

Butte overlooking the city of Eugene. Specimens have been collected on moss from 366 to 579 m. on this butte. Additional collections (Fig, 70) are: OREGON: Multnomah Co., 7 mi W of Bonneville, 16 Oct, 1955, K. M. Fender, 1 female (paratype) ; Yamhill Co., near McMinnville, 8 Nov. 1946, K. M. Fender, 1 female (paratype) ; Josephine Co., 7 mi SW of WilUams, 23 Dec, 1971, N. D. Penny, 3 males, 5 females; Benton Co,, Yew Creek, 27 Dec. 1971, N. D, Penny, 1 male, 1 female; Clatsop Co., 2 mi E of Elsie, 28 Dec. 1971, N, D. Penny, 2 females; WASHINGTON, Clallam Co., 4 mi S of Port Angeles, 31 Dec. 1971, N. D. Penny, 1 male, 6 females.

This species has only been collected at low elevations between 30 and 579 m.

H. brevicaudiis is very similar to H. notoperates, but can be separated by the smaller number of flagellomeres, by the smoothly rounded male ninth sternum, and apical bristles on the female forewings. H. brevicaudiis usually is not as dark as H. notoperates, lives at lower elevations.

and is found in a moister, more northern climate.

Hesperoboreus notoperates (Cooper), new

combination

Bore us notoperates Cooper, 1972, Psyche 79:269-283, Figs. 1-9.

Holotype and allotype in Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts.

Present description based on 3 males and 1 female pinned, 1 male and 1 female in alcohol.

Head: Black shading to dark brown near tip of rostrum. Occiput rugulose, with many fine setae. Median ocellus absent. Antenna dark brown, with 16 to 18 flagellomeres. Viewed in side profile, anterior surface of rostrum with few setae; posterior margin of hypostomal bridge with none. Ratio of length of maxillolabial complex to rostrum ^ .52.

Thorax: Nota and pleura dark brown. Pronotum with two transverse incisions, anterior margin with 6 bristles, middle of notum with 2 to 8 bristles, posterior margin with 4 bristles. Meso- and metanotum sometimes with bristles. Numerous smaller setae cover thorax.

Legs: Dark brown with numerous paler setae and dark brown apical femoral spine. Tibial spurs light brown.
Male wings: Light brown and abruptly narrowed at mid-length; 16 inner forewing and 17 hind wing spines.

Female forewing: Oval, light brown, covering hindwing, with many setae, without large bristles at apical margin,

Male abdomen: Dark brown throughout. No tergal ridges on second and third abdominal segments. No fusion of eighth tergum and sternum or ninth tergum and sternum. Ninth tergum without hood; 8 denticles on either side of medial partition. Diststyle with about 10 spines arranged from below basal lobe to near apex of

[Begin Page: Page 186]

diststylar claw. Ninth sternum deeply the female eighth sternum. H. notoper-

notched, not reaching base of diststyles. ates is usually darker in color than H.

T^ .,, .- J 1 brevicaiidus, lives at a higher elevation, in

Female abdomen: All segments dark it-

L D • £ 1 .u £ • V ^^ a drier, more southern climate,

brown. Ratio of length of ovipositor to '

rostrum = .63. Caudal extensions of tenth 5or(f//i- Latreille (1816)

segment each bearing 5 apical spines. Cerci .

,,, ., • ^ ^- . Boreits Latreille. 1816. Nouveau diction-

dark brown with semitransparent tips. ,,, • i. . -.c-, -.^o

y,. L , -.u J 1 • J u^.^ naire dhistoire naturelle 4:152-153.

Eighth sternum with deeply incised, baso- • r, ; 7- t

I , , Type species: Fanorpa hyemalts L.

Ateleptera Dalman. 1823. Analecta Ento-

BoDY length: MALE-about 2.7 mm. in mologica. Holmiae, Lindholm. 104 p.

alcohol (holotype 2.5 mm., pinned); fe- Type species: Ateleptera hiemalis L.

male, about 3.9 mm. in alcohol (allotype Euboreiis Lestage. 1940. Pour I'histoire

3.6 mm., pinned) . jg^ Boreas (Stegopteres-Mecopteres) .

Intraspecific variation: Antennae vary Annales de Societe royale zoologique

from 18 to 20 segments, with 19 being the de Belgique 71:5-22. Type species: Eu-

most common number. boreits nivoriundiis Fitch.

Holotype male, allotype female, and all ^j^j^ ^^^^^ ^^^ be separated from Hes-

known specimens from Coldwater and peroborens by the following characters:

Black Canyons, near town of Mountain Hypostomal bridge narrow; ratio of length

Center on Mt. San Jacinto, Riverside Co., ^£ maxillo-labial complex to rostrum more

CALIFORNIA, from 27 Dec. to 22 Jan., ^^^^ ^^ j^^j^ forewings with an outer collected by K. W. Cooper and family ^^^ ^f ^^^^^^ ^^mzXt eighth sternum

(rig. /Uj. without basal notch. Female tenth tergum

A detailed study of the habitat, life ^^ j^^^^ ^^^^^^ ^^ ^^^^ ^^ ^-^^h, bearing no

history, and behavior of this species has ^^^j^j extensions. Cerci fused completely,

been published by Cooper (1974). Among Umxig posture parallel,

his observations are that this species forms

a larval cell in dry weather to conserve Key to Males of Nearctic Boreiis

moisture, that many species of moss are j Bristles on pronotum 2

used as food, and that mating is perpendic- No bristles on pronotum 6

ular (Cooper's terminology) rather than i. Apex of ninth sternum deeply notched ....

parallel, as in Boreiis. This species is aided 3

in this unusual mating position by re- Apex of ninth sternum smoothly rounded,

ciprocal locking of genitalia and the basal truncate, or shallowly notched 5

notch of the female eighth sternum (a 3. Pilosity of thorax and abdomen half as

structure also found in H. brevicandiis). long as thoracic bristles (western North

In his original description Cooper went America) 4

beyond a mere external morphological de- ^hort pilosity on thorax and abdomen

• 1 r • .u n * (eastern North America) brumahs

scnption, including in the paper excellent ^ . ^ . .

£ V- • , , 1 r 4. Ninth tergum beanng 25 or tewer denti-

comparisons of this species male and le- , i • , ,- i-

, , . -11 c cles at each side or median partition ....

male reproductive systems with those or nl

other species and giving further notes on Ninth'tergum"bearing 26 "or'more der!d-

boreid chromosomes. ^\^^ ^^ ^^^l^ jj^j^ pf median partition ....

H. notoperates can be separated from nix

H. brevicaiidus by a deeply notched male 5. Posterior surface of rostrum bearing 25

ninth sternum, lack of apical bristles on or more stout setae (western North

the female forewings, and larger notch to America) elegans

[Begin Page: Page 187]

Posterior surface of rostrum bearing 24 or
fewer stout setae (eastern North Amer-
ica) nivoriundus

6. Eighth abdominal tergum and sternum

fused 7

Eighth abdominal tergum and sternum
not fused reductus

7. Interior of hood of tergum IX obscured

by numerous setae (Alaska) borealis

Interior of hood visible 8

8. Median septum of hood short, forked

ventrally (Alaska) intermedius

Median septum of hood long, unforked
ventrally (western North America) 9

9. Median septum of hood with only a nar-

row crest californicus

Median septum of hood wide, with raised
area between crest and tergal pockets ....
coloradensis

Key to Females of Nearctic Boreus

1. Bristles on pronotum 2

No bristles on pronotum 6

2. Stout setae on posterior (ventral) surface

of rostrum 3

No stout setae on posterior (ventral) sur-
face of rostrum, only fine setae 4

3. Posterior surface of rostrum bearing 25

or more spines (western North Amer-
ica) elegans

Posterior surface of rostrum bearing 24

or fewer spines (eastern North America)

nivoriundus

4. Pilosity of thorax and abdomen as long as

thoracic bristles (western North Amer-

ica) 5

Pilosity of thorax and abdomen shorter

than thoracic bristles (eastern North

America) brumalis

5. Legs black or dark brown nix

Legs yellowish-brown pilosus

6. Forewings reduced to small vestiges not

covering hindwings reductus

Forewings oval; covering hindwings

borealis, californicus, coloradensis, and

intermedius

SPECIES DESCRIPTIONS

Boreus borealis Banks

Boreus borealis Banks, 1923, North American Fauna 46:158, pi. IX, Fig. 8.

One male syntype (labelled paratype) in Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts. Although Banks originally described borealis from both sexes, all that remains is one male. Apparently four specimens composed the original collection (Banks, 1923). Carpenter (1931) mentioned the lone remaining male (as cotype), as well as the absence of any females. This male bears the following five labels: "St. Paul Id., Bering Sea, May 23, 1914," "A. G. W. Lot No. 157," "A. G. Whitney Collector," "Type, 11277" (red), and "Boreus borealis Bks, paratype." Since this is actually a syntype and is the only remaining specimen of the type series, it is hereby designated lectotype.

Present description based on 1 additional male (teneral) and 1 female pinned.

Head: Occiput reticulately striated (Fig. 5), without setae. Occiput and vertex dark brown shading to light brown on rostrum; tip of rostrum dark brown. Median ocellus present. Antenna light brown, with 18 flagellomeres (missing from present specimens, but one antenna glued to base of point holding male specimen) . Numerous setae on anterior surface of rostrum near antennal bases, also on posterior surface, but sparse elsewhere on rostrum. Ratio of length of maxillo-labial complex to rostrum = .84.

Thorax : Pronotum dark brown, with two lateral incisions and no bristles. Meso- and metanotum light brown, without bristles. A few small setae on dorsum and pleuron.

Legs : Light brown with numerous lighter colored setae and dark brown apical femoral spine. Tibial spurs light brown.

Male wings: Yellowish-brown, abruptly narrowed at mid-length, with 36 inner and 13 outer fore wing spines, no hind wing spines.

Female forewing: Yellowish-brown, oval,

covering hindwing.

[Begin Page: Page 188]

Male abdomen: Glossy black with some blue reflections. No tergal ridges on second and third terga. Eighth tergum and sternum fused; ninth tergum and sternum not fused. Ninth tergum with large hood extending laterally to outer edge of denticular area; median septum long, thin; long setae almost completely covering median septum and tergal pockets, smaller setae on dorsal surface of hood. Denticles about 15 in number, of equal size. Dististyle with about 21 spines arranged from below basal lobe to base of dististylar claw; covered with many setae, except on dististylar claw and basal lobe; basal lobe with blunt tip and cleft between it and base of dististyle. Ninth sternum smoothly rounded at apex, reaching to bases of dististyles.

Female abdomen: Dark brown dorsally, lighter brown ventrally; ninth and tenth segments yellowish-brown. Ovipositor to rostrum ratio = 1.05. Cerci dark brown, evenly tapering to apex.

Body length: Male, 5.0 mm. pinned; female, 5.4 mm., pinned. Syntypes from St. Paul Island, Bering Sea, ALASKA, 16-23 May 1914, A. G. Whitney. Two other known specimens (1 male, 1 female) from same locaUty as types, July-Aug. 1925, A. Christoflerson.

Intraspecific variation: Banks (1923) mentioned wings as well as overall size of both male and female as being larger than those of other North American species. Carpenter (1931) mentioned that the female wing pad is about as long as in other Boreus, and speculated that the original female may have been somewhat shriveled. The male I have examined also appears not to have wings longer than in other species. Carpenter, in the same paper, mentioned that the body color had a bronzy sheen. Although the specimens I examined did not display this bronzy color, the male was obviously teneral and may not have displayed the full color of the species.

This species has been collected only from St. Paul Island in the Pribilofs (Fig. 80) which has a maximum elevation of 203 feet and dominant vegetation of cottonsedge tundra. Sage (1973) has characterized the area as follows: "Most of the Bering Sea islands are remote and this fact, coupled with the formidable combination of frequent fog, gales, and violent seas, means that opportunities to visit most of them even in summer are few."

This species appears to emerge at a different time than all other boreids, probably due to the severity of climatic conditions. All specimens were also collected at a lower elevation than any other species of the californiciis group.

B. borealis is structurally similar to calif ornicus, coloradensis, and intermedins, but males can be identified by the large number of setae lining the tergal hood. Females cannot be positively identified, except by locality. Banks (1923) mentioned that this was the only species with pale coxae and pleura, but some individuals of californiciis and pilosiis also have pale coxae and pleura.

Boreiis britmalis Fitch

Boreus britmalis Fitch, 1847, Amer. J. Agr.Sci., 5:278.

One male and one female, both syntypes, in Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts. The male bears the labels "316," "Hagen," "B. britmalis Fitch, $ " (green), "Type, 11118" (red), "Boreus brumalis Fitch." It is in good condition and is hereby designated lectotype.

Present description based on 189 males, 246 females.

Head: Dark brown, shading to light brown on rostrum. Occiput smooth, except for fine reticulations and setal pits. Median ocellus present. Antenna light brown, with 20 to 21 flagellomeres. Numerous setae on anterior surface of rostrum near antennal bases, also on posterior

[Begin Page: Page 189]

surface, but sparse elsewhere on rostrum. Ratio of length of maxillo-labial complex to rostrum = .83.

Thorax : Pronotum dark brown, with two transverse incisions; anterior and posterior margins each with four bristles. No bristles on meso- and metanotum. Small setae covering thorax.

Legs: Light brown to dark brown with numerous lighter-colored setae. Dark brown apical femoral spine. Tibial spurs light brown to translucent.

Male wings: Dark brown to light brown, abruptly narrowed at mid-length, with 20 inner and 15 outer forewing spines, three hindwing spines.

Female forewing: Dark brown, oval; covering hindwing.

Male abdomen: Dark brown to glossy black. No tergal ridges on second and third abdominal segments. No fusion of eighth tergum and sternum or ninth tergum and sternum. Ninth tergum with small medially cleft hood, extending laterally only to medial margins of denticular areas; median septum absent. Denticles about 29 in number on each side, smaller toward pockets of hood. Dististyle with about 15 spines arranged from below basal lobe to base of dististylar claw; basal lobe blunt tipped, separated from base of dististyle by cleft. Ninth sternum deeply notched at apex, extending to bases of dististyles.

Female abdomen: Dark brown to glossy black. Ratio of length of ovipositor to rostrum = 1.00. Cerci dark brown, evenly tapering to apex.

Body length: Male, 2.4 to 3.1 mm., in alcohol, 2.0 to 2.7 mm., pinned; female 3.6 to 4.1 mm., in alcohol, 2.9 to 3.8 mm., pinned.

Intraspecific variation: Overall color varies. Most brown specimens are from the more southern parts of the range.

B. brumalis has generally been collected from 19 Nov. to 24 April, but 1 male and 1 female in the Ohio State University Collection are labelled 15 Aug. 1935.

This species is widespread over eastern North America (Fig. 71), from the Smoky Mountains (Cole, 1938) and Cumberland Mountains (Goslin, 1950) of TENNESSEE to southern ILLINOIS (Stannard, 1957) to Sauk County, WISCONSIN and Duluth, MINNESOTA, to Brownsburg, QUEBEC. Specimens have been collected in almost all states within these boundaries. The southern Illinois population is 370 miles from the nearest known population in central OHIO. Stannard (1957) suggested that the Illinois population is a remnant of a once widespread population living in the mesophytic forest that stretched from eastern Tennessee to the Ozark Plateau and that is now only tenuously linked through southern Illinois. Despite intensive searching, no specimens have been found in nearby Missouri or the lower Ohio River Valley.

The elevational records vary from sea level in New England to 4000 feet (1220 m.) in the Cumberland and Smoky Mountains of Tennessee.

There are no records to indicate that northern populations emerge earlier or later in the winter than southern populations.

B. brumalis larvae can be collected at any time of the year in their southern Illinois habitats, where they are found tunneling just beneath the rhizoids of Dicranella heteromalla and Atrichiim angiistatum. This species apparently does not form the dry weather cells, such as Cooper (1974) described for H. notoperates. In the same area, larvae and adults are most frequently collected on moss on sandy loam soil rather than mossy rocks, as are other species in other areas.

The deeply notched ninth sternum of

separate this eastern species from all other the male and bristles of the pronotum

[Begin Page: Page 190]

species of Boreas, except nix and pilosus. The pilosity of brumalis is shorter than in either of these latter two western species.

Boreas californiciis Packard

Bore Its californiciis Packard, 1870, Proc. Boston Soc. Nat. Hist. 13:408.

Boreiis iinicolor Hine, 1901, Bull. Sci. Lab., Denison Univ. 11:256. New synonymy.

Boreiis isolatiis Carpenter, 1935, Psyche 42:115, Fig. 11. New synonymy.

Boreiis californiciis fitscus Carpenter, 1935, Psyche 42:117-118. New synonymy.

Three male, three female syntypes of californiciis are in the Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts. (These are the types originally deposited in the Museum of the Peabody Academy of Science.) All six specimens bear the following three labels: "Ft. Bidwell, Siskiyou Calif.," "Type, 11119" (red), and "caHfornicus." As Lattin (1956) mentioned. Ft. Bidwell is in Modoc Co. The best preserved male is hereby designated lectotype. Two female syntypes of iinicolor are in the United States National Museum of Natural History, Washington, D.C. (In 1931 Carpenter designated a male in the Museum of Comparative Zoology as allotype.) Both specimens are labelled "Helena, Mon. 26.4" "Coll. Hubbard & Schwarz" "Type No. 5743 U.S.N.M." The better specimen is hereby designated lectotype. Holotypes of isolatiis and californiciis fiisciis are in the Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts.

All previous authors have referred to

B. caHfornicus as having been originally described in 1871 in volume 8 of the Proceedings of the Boston Society of Natural History. Actually, it was described in 1870 in volume 13.

Present description based on 372 males, 432 females.

Head : Occiput dark brown to black shading to lighter brown on rostrum. Occiput smooth. Median ocellus present. Antenna light brown basally to dark brown apically, with 20 to 23 flagellomeres. Numerous setae on anterior surface of rostrum near antennal bases, also on posterior surface, but sparse elsewhere on rostrum. Ratio of length of maxillo-labial complex to rostrum = .70 to .90.

Thorax: Pronotum dark brown, with indistinct medial transverse ridge and no bristles. Meso- and metanotum dark brown, without bristles. Many small setae covering thorax.

Legs: Yellowish-brown to dark brown with darker colored spines; usually with dark brown apical femoral spine. Tibial spurs light brown.

Male wings: Yellowish-brown to dark brown and abruptly narrowed at mid-length; 15 to 23 inner and 7 to 13 outer fore wing spines; usually no hind wing spines.

Female forewixg: Light to dark brown, oval, with many small setae but no large bristles at apical margin; covering hind-wing.

Male abdomen : Dark brown to black. No tergal ridges on second and third segments. Eighth tergum and sternum fused; ninth tergum and sternum not fused. Ninth tergum with large hood, extending to lateral margins of denticular areas; median septum long, thin, with some setae in tergal pockets; smaller setae on dorsal surface of hood. Denticles about 26 in number, of equal size. Dististyle with many small spines arranged from below basal lobe to base of dististylar claw; basal lobe blunt tipped, separated from base of dististyle by cleft. Ninth sternum reaching to bases of dististyles, its apex smoothly

rounded to bluntly squared to shallowly

depressed medially.

Female abdomen: Dark brown to black;

ninth and tenth segments yellowish-brown

[Begin Page: Figs. 70-73, Page 191]

Figures 70-73. Fig. 70, distribution of Hesperohoreus brevicatidus and H. notoperates. Fig. 71, distribution of Boretis brumalis. Fig. 72, distribution of Boreus coloradensis and B. elegans. Fig. 73, distribution of

Boreus nivoriundus.

to dark brown. Ratio of length of oviposi-

tor to rostrum =^ 1.10 to 1.30. Cerci light

brown to dark brown, evenly tapering to

apex.

Body length: Male, 3.6 to 5.0 mm., in

alcohol; female, 5.4 to 6.5 mm., in alcohol.

Intraspecific variation: This widespread western species shows considerable variation in coloration, size, number of antennal segments, and male wing spines. Some males from Alberta have very small spines on the hindwings. One color variety is

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rusty brown. Unfortunately, the type series of calif ornicus consists of such specimens. Other specimens with the more usual dark body with light appendages were used by Carpenter (1935) as basis for B. californicus jiisciis. As noted in the section on coloration, this species generally develops the dark pigmentation in some body parts more slowly than in others. Thus, specimens with yellowish legs will have darker legs later in the season. Rusty red specimens have been found at localities having also darker and lighter specimens. For these reasons, I feel that subspecific rank for any color variants of californicus is unjustified.

Most specimens of californicus have an apical femoral spine on all legs, but in the northern parts of the range it may be lacking from some legs, and in Arizona and CaHfornia it is lacking altogether. Eye color, as used by Carpenter (1931) in his key to females, varies depending on the method of preservation.

B. californicus has been collected (Fig. 74) from ARIZONA: Coconino Co., 15 mi. S. of Flagstaff; CALIFORNIA: Mari-posa, Co., Yosemite National Park; Inyo Co., 4 mi. N. of Schulman Grove; Sierra Co., Hobart Mills (Lattin, 1956); Lassen Co., Susan ville; Modoc Co., Ft. Bidwell and Goose Lake; NEVADA: Nye Co., Kawick Mt. (Lattin, 1956, as B. unicolor); Washoe Co., Reno (Carpen-ter, 1935); OREGON; Umatilla Co., Fly Creek Valley; WASHINGTON: Whitman Co., Pullman area; Spokane Co., Spokane; Pierce Co., near Deer Creek; IDAHO: Latah Co., Moscow area; Idaho Co., Papoose Creek; MONTANA: Ra-valli Co., Hamilton area; Missoula Co., Missoula area; Flathead Co., Daphnia

Pond; Mineral Co., St. Regis; Lewis & Clark Co., Helena; Lake Co., Lion Creek; Powell Co., Pass Creek; BRITISH COLUMBIA: Ashnola River Valley; Kaslo; Terrace; Salmon Arm; ALBERTA: Banff; Jasper National Park.

This species has been collected from 4 Nov. to 26 April from the semiarid western mountains of central Arizona to northern British Columbia. Specimens have been found from 4000 to 10,300 feet (1220 to 3142 m.).

B. unicolor was originally described as being similar to californicus, but with a dark ovipositor. Dark specimens appear structurally identical to lighter specimens of californicus. B. unicolor is also similar to coloradensis, but the latter species does not have apical femoral spines. G. W. Byers examined the two syntypes of unicolor and noted spines on both hind femora. Thus, B. unicolor is regarded as a junior synonym of californicus.

B. isolatus was described as being similar to californicus , but with a deeply notched ninth sternum in males. While studying the holotype (and only known specimen) of isolatus, G. W. Byers noted that the notched ninth sternum was asymmetrical. It appeared that apical setae were adhered together with foreign material. After cleaning, the apex of the ninth sternum was found to be smoothly rounded, as in californicus. Accordingly, isolatus is also placed as a junior synonym of californicus.

B. californicus is a member of the group with fused eighth sternum and tergum, and no tergal ridges on second and third abdominal segments of males. It can be separated from other species in this group by characters of the ninth tergal hood, including a long, narrow septum bearing sparse setae that do not obscure the interior of the tergal pockets. B. californicus is most often confused with coloradensis, which is found farther east, and which has a broader tergal septum, and never has apical femoral spines.

Boreus coloradensis Byers

Bore us coloradensis Byers, 1955, Occ.

Pap. Mus. Zool., Michigan Univ. No. 562,

Figs. 1-5.

[Begin Page: Page 193]

Holotype male and allotype female in the University of Colorado Museum, Boulder, Colorado.

Present description based on 123 males, 132 females.

Head: Dark brown to black, shading to slightly lighter brown on rostrum. Occiput finely reticulate, with few setae. Median ocellus present. Antenna dark brown to black, with 20 to 22 flagellomeres. Numerous setae on anterior surface of rostrum near antennal bases, also on posterior surface, but sparse elsewhere on rostrum. Ratio of length of maxillo-labial complex to rostrum ^= .86.

Thorax: Pronotum dark brown to black, with an indistinct transverse ridge near mid-length; no bristles. Meso- and metanotum dark brown to black, without bristles. Many small setae covering thorax. Legs: Dark brown to black with numerous pale setae and dark spines. No apical femoral spines. Tibial spurs light brown.

Male wings: Light brown to black, abruptly narrowed near mid-length, with 19 to 22 inner and 8 to 13 outer forewing spines; no hindwing spines.

Female forewing: Dark brown to black, oval, covering hindwing.

Male abdomen: Dark brown to glossy black. No tergal ridges on second and third segments. Eighth tergum and sternum fused. Ninth tergum and sternum not fused. Ninth tergum with large hood extending to lateral margins of denticular areas; median septum long, wide, with thin crest and less densely sclerotized region between crest and pockets; numerous long setae not obscuring interior of hood, and smaller setae on dorsal surface of hood. Ninth tergal apex with 22 denticles of equal size. Dististyle with many small denticles arranged from below basal lobe to base of dististylar claw; basal lobe blunt tipped, separated by cleft from base of dististyle. Ninth sternum reaching

bases of dististyles, smoothly rounded to bluntly squared to shallowly depressed apically.

Female abdomen: Mostly dark brown to glossy black; ninth and tenth segments light brown. Ratio of length of ovipositor to rostrum = 1.30 to 1,43. Cerci dark brown to black, evenly tapering to apex.

Body length: Male, 2.5 to 3.0 mm., pinned (holotype 2.5 mm.), 3.2 to 4.9 mm., in alcohol; female, 4.5 to 5.0 mm., pinned (allotype, 4.5 mm.), 4.3 to 5.4 mm., in alcohol.

Intraspecific variations: The only variation noted in this species was a slightly lighter brown coloration in specimens preserved in alcohol, some variation in the apex of the ninth sternum (see Byers, 1955, for discussion), and differences in number of antennal flagellomeres, wing spines, and other minor numerical differences. There appears to be no geographical or elevational pattern to this variation.

Holotype, allotype, and all paratypes from 12 to 20 miles west of Boulder, Boulder Co., COLORADO. Other specimens (Fig. 72) have been collected at COLORADO: Routt Co., Steamboat Springs; UTAH: Cache Co., Logan area (Blacksmith Fork Canyon, Green Canyon, Logan Canyon); Utah Co., Rock Canyon; Uinta Co., Split Mountain Gorge; Weber Co., Ogden Canyon; Sampete Co., Maple Canyon; Box Elder Co., Promontory; Salt Lake Co., Mill Creek Canyon; WYOMING: Yellowstone National Park (Carpenter, 1935, as tinicolor); MONTANA: Gallatin Co., Bozeman; Missoula Co., Missoula; Ravalli Co., Hamilton area (Boulder Creek, Gird's Creek, Skalkaho Creek) .

In Colorado this species has been collected only high in the Rocky Mountains. Near Boulder it has been taken from 7000 to 12,000 feet (2135 to 3660 m.), and at Steamboat Springs from 7000 to 10,000 feet (2135 to 3050 m.). In Utah B. coloradensis can be found at lower elevations

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from 4700 to 6550 feet (1434 to 1998 m.).

B. coloradensis appears to be tolerant of arid conditions. In the Bitterroot Valley near Hamilton, Montana, this species is only collected on the dry eastern side of the valley. It has been collected on snow in sagebrush desert at Promontory, Utah. However, it has also been collected in thick carpets of moss only a few feet from the bank of Blacksmith Fork near Logan, Utah, obviously a very humid habitat.

Specimens of this species were collected from 1 Oct. to 27 May in Utah, Montana, Wyoming, and western Colorado, and from 31 March to 24 April in central Colorado.

B. coloradensis is a member of the californicus group, having fused eighth tergum and sternum and no tergal ridges on second and third abdominal segments of males. B. coloradensis has a long median septum of the hood, unlike B. intermedins, and fewer long hood setae than B. borealis. B. coloradensis is most often confused with californicus, but the latter species has a narrow median septum on the ninth tergum. Byers (1955) mentioned that coloradensis could be separated from unicolor (a synonym of californicus) by the latter species having shorter male forewings, indistinct pronotal ridge, blunter denticles on the ninth tergum, and narrower septum on the ninth tergum. I can see only the last of these character states. Differences between the two species are so minor that perhaps specific rank for coloradensis is not warranted. However, consistent lack of the apical femoral spine and the broader hood septum in coloradensis make me think this is a valid species.

Boreus elegans Carpenter

Boreits elegans Carpenter, 1935, Psyche 42:119, 122, Figs. 8, 12.

Holotype, male, in California y\cademy of Science, San Francisco.

Present description based on 7 males, 13 females in alcohol.

Head: Rusty brown. Occiput finely reticulated, with no setae. Median ocellus present. Antenna light brown basally, becoming dark brown toward apex, with 20 to 22 flagellomeres. Anterior surface of rostrum with few setae; posterior surface of rostrum with fine setae and numerous stouter setae. Ratio of length of maxillolabial complex to rostrum = .77.

Thorax: Pronotum rusty brown with indistinct transverse ridge near mid-length; anterior and posterior margins with four to six bristles each. Two bristles each on meso- and metanotum. Small setae covering thorax.

Legs: Light brown, with numerous dark brown spines, setae, and apical femoral spine. Tibial spurs light brown.

Male wings : Light brown, tapering evenly to apex, with 16 inner and 16 outer forewing spines, 12 hindwing spines.

Female forewixg: Rusty brown, oval, covering hindwing.

Male abdomen: Rusty brown oval, covering hindwing.

Male abdomen: Rusty brown except yellowish-brown on basistyles and dististyles. No tergal ridges on second and third segments. No fusion of eighth tergum and sternum or ninth tergum and sternum. Ninth tergum with hood only reaching mesal margins of denticular areas. About 75 denticles on either side of median cleft. Dististyle with about 30 denticles arranged from below basal lobe to near base of dististylar claw. Ninth sternum broadly rounded apically, reaching bases of dististyles.

Female abdomen: Rusty brown. Ratio of length of ovipositor to rostrum ^ 1.15. Cerci rusty brown, evenly tapering to apex.

Body length: Male, 4.0 to 4.6 mm., in

alcohol (holotype and paratype 3.5 to 3.8

[Begin Page: Page 195]

mm., pinned) ; female, 6.0 to 7.4 mm., in

alcohol.

Intraspecific variation: This species

shows the usual variation in number of

antennal flagellomeres.

Holotype and paratype males, Van-

couver, BRITISH COLUMBIA, Dec.

1930, H. E. Hinton. Other specimens (Fig.

72) from WASHINGTON: CowUtz Co.,

Seaquest State Park, 29 Dec. 1971, N. D.

Penny, 4 females; Clallam Co., 1 mi. E.

of Lake Crescent, 30 Dec. 1971, N. D.

Penny, 7 males, 9 females.

This species was appropriately named,

for it is truly the most elegant boreid known. In color it differs from all other boreids except the reddish color variety of californicits. B. elegans is the largest boread species and can be seen and recognized on winter snow a considerable distance away. It lives in the warm-winter, maritime climate of western North America where rainfall is abundant and temperatures seldom are below — 13° C. (see ecology section on temperature). All three collections of this species were below 1,600 feet (488 m.) elevation.

B. elegans is in the nivoriiindiis subgroup of the nivoriundus group, having bristles on the pronotum and the apex of the male ninth sternum rounded. It can be separated from the only other member of this subgroup, nivoriundus, by its large size, more reddish coloration, and more numerous stout setae on the back of the rostrum.

Bore Its intermedins Lloyd

Bore Its intermediits Lloyd, 1934, Pan-Pacific Entomol. 10:119, Fig. 2.

Holotype male and allotype female, catalogued 7454 and 7453, respectively, were deposited in the Thomas Burke Memorial Washington State Museum, Seattle, but the curator has been unable to locate them for me. Specimens used in this description, from the Museum of Comparative Zoology, Harvard University, were collected from the same locality by the same collector exactly one year later than the type specimens.

Present description based on 1 male in alcohol, 2 females pinned.

Head: Black shading to yellowish-brown on rostrum. Occiput finely reticulated, with a few setae near margins of compound eyes. Median ocellus present. Antenna light brown shading to dark brown toward apex, with 18 to 19 flagellomeres. Numerous setae on anterior surface of rostrum near antennal bases, also on posterior surface, but sparse elsewhere on rostrum. Ratio of length of maxillo-labial complex to rostrum = .91.

Thorax: Dark brown on nota, becoming

yellowish-brown on pleural and sternal regions. Pronotum with indistinct ridge at mid-length; no bristles. Meso- and metanotum without bristles. Small white setae dense over entire thorax.
Legs: Yellowish-brown with stout setae and apical femoral spine dark brown; finer setae and tibial spurs yellowish.

Male wings: Yellowish-brown, abruptly narrowed at mid-length; with 33 inner and 10 outer forewing spines, no hindwing spines.

Female forewing : Yellowish-brown, oval, covering hindwing.

Male abdomen: Segments 1 through 8 dark brown; segment 9, basistyles and dististyles yellowish-brown. No tergal ridges on second and third segments. Eighth tergum and sternum fused. Ninth tergum and sternum not fused. Ninth tergum with large hood, extending laterally to lateral margins of denticular areas. Median septum of hood short, with thin crest and extensive sclerotized area between crest and pockets. Caudal medial cleft of ninth tergum large, between ventral fork of medial septum. About 75 denticles on either side of medial septum. Dististyle with many small denticles arranged from

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below basal lobe to base of dististylar claw. Apex of ninth sternum truncate medially, reaching bases of dististyles.

Female abdomen: First 7 segments black, last 3 visible segments yellowish-brown. Ratio of length of ovipositor to rostrum = 1.14. Cerci yellowish-brown, evenly tapering to apex.

Body length: Male, 5.0 mm., in alcohol (holotype 3.5 mm., pinned) ; female, 4.5 to 4.6 mm., pinned (allotype 4.5 mm., pinned).

Intraspecific variation: The specimens I examined agree with Lloyd's original description, except the ovipositor of the allotype was described as being twice as long as rostrum (as compared to 1.14).

Holotype male and allotype female from between Kennicott (spelling corrected) and McCarthy, ALASKA, 15 April 1934, Wilbur Lloyd (Lloyd, 1934). Other specimens (Fig. 80) are from Kennicott, ALASKA, 15 April 1935, Lloyd, 1 male, 2 females, in Museum of Comparative Zoology, and Carpenter (1936) mentioned specimens collected at McCarthy, ALASKA, 29 April 1935, 1 male, 2 females.

Kennicott (61°29' N, 142°54' W) and McCarthy (61°26' N, 142°55' W) are located about four miles apart at the base of Kennicott Glacier, near Fireweed Mountain in the Wrangell Range. Elevation at Kennicott is 2,000 feet (610 m.), at McCarthy 1,400 feet (427 m.).

Males of B, intermedins can be separated from other members of the californicus group by the septum of the ninth tergal hood, which is short and deeply divided ventrally.

Boreus nivoriundus Fitch

Boreas nivoriundus Fitch, 1847, Amer. J. Agr. Sci. 5:277.

Male and female syntypes in Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts, The male

bears the labels "8088," "Hagen," "B. nivoriundus <5 Fitch" (green), "Type, 11117" red), and "Boreus nivoriundus Fitch." It is hereby designated lectotype. Present description based on 76 males, 80 females.

Head: Dark brown shading to lighter brown on rostrum. Occiput finely reticulate, with a few setae. Median ocellus present. Antenna light brown basally, becoming dark brown toward apex, with 20 flagellomeres. Numerous small setae on anterior surface of rostrum near antennal bases, but sparse elsewhere. Posterior surface of rostrum with a few fine setae ventrally and more stout setae dorsally. Ratio of length of maxillo-labial complex to rostrum = .90.

Thorax: Dark brown. Pronotum with no transverse ridge at mid-length; anterior and posterior margins with 4 to 6 bristles. Meso- and metanota occasionally with 2 dark bristles each. Small setae covering thorax.

Legs: Dark brown, with dark brown apical femoral spine. Setae dark brown and light brown. Tibial spurs yellowish-brown.

Male wings : Light brown, evenly tapered to apex, with 16 to 18 inner and 14 outer forewing spines, 16 hindwing spines.

Female forewing: Light brown, oval, covering hindwing.

Male abdomen: Dark brown except light brown on last two abdominal segments. No tergal ridges on second and third segments. No fusion of eighth tergum and sternum or ninth tergum and sternum. Ninth tergum with small hood extending laterally only to mid-width of denticular areas. No median septum below hood.

Medial cleft between areas of about 50
denticles each. Denticles becoming smaller
toward hood. Diststyle with about 20
denticles arranged from below basal lobe
to base of dististvlar claw. Ninth sternum

[Begin Page: Figs. 74-76, Page 197]

Figures 74-76. Fig. 74, distribution of Boretis calif oniicns. Fig. 75, distribution of Boretis nix and B. pilostis. Fig. 7G, distribution of Boreiis redticttis.

broadly rounded apically, reaching bases
of diststyles.

Female abdomen: Dark brown. Ratio of
length of ovipositor to rostrum = 1.30.
Cerci dark brown, evenly tapering to apex.
Body length: Male, 4.9 to 5.4 mm., in
alcohol, 2.3 to 3.6 mm., pinned; female,

4.9 to 5.8 mm., in alcohol, 3.5 to 4.4 mm.,
pinned.

Intraspecific variation: The coloration
and number of thoracic bristles vary.

This species has been collected (Fig. 73) from OHIO: Fairfield Co., Lancaster area; Hocking Co., "Neotoma"; Medina

[Begin Page: Page 198]

Co., Hinckley Reservation; NEW YORK: Nassau Co., Sea Cliff; Chenango Co., Bainbridge; Tompkins Co., Ithaca; MASSACHUSETTS: Worcester Co., Spencer; Suffolk Co., Roxbury; NEW HAMPSHIRE: Carroll Co., Jackson (Dohanian, 1915); VERMONT: Chittenden Co., 3 mi. N. of Bolton; MAINE: Hancock Co., Ellsworth; and TENNESSEE: Sevier Co., Newfound Gap (Cole, 1938); and Campbell Co., LaFollette (Goslin, 1950).

B. nivoriundiis has been collected from 19 Nov. to 28 March. Apparently E. S. Thomas collected 2 females from Hocking Co., Ohio, on 15 Aug. 1935. The date of these specimens, along with two specimens of B. brumalis collected at the same place on the same date by the same collector, is unusual. Only in the Bering Sea area have other specimens of Nearctic Boreiis been collected at this time of year. Localities for B. nivoriundiis range in elevation from sea level to about 5000 ft. (1500 m.).

B. nivoriundiis can be separated from all other species of Boreus, except elegans, by the combination of pronotal bristles and rounded ninth sternum of males. B. nivoriundus can be separated from the western elegans by the former species' smaller size, fewer stout rostral setae, and smaller denticles near the hood.

Boreus nix Carpenter

Boreus nix Carpenter, 1935, Psyche 42: 114, Fig. 7.

Boreus gracilis Carpenter, 1935, Psyche 42:118. New synonymy.

Holotype male and allotype female of nix (no. 22359) in Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts. Holotype female of gracilis (no. 7452) cannot be located at the Burke Memorial Washington State Museum, Seattle. One paratype female (no. 22361) in Museum of Comparative Zoology, Harvard University.

Present description based on 12 males, 9 females.

Head: Dark brown shading to lighter brown on rostrum. Occiput finely reticulate, with several long setae. Median ocellus present. Antenna brown, with 21 to 22 flagellomeres. Anterior and posterior surfaces with a few long setae, mainly below antennal bases. Ratio of length of maxillo-labial complex to rostrum = .88.

Thorax: Dark brown. Pronotum with indistinct transverse ridge at mid-length; anterior and posterior margins with 4 to 6 bristles. Meso- and metanotum occasionally with 2 bristles each. Long white setae covering thorax.

Legs : Dark brown to black with numerous dark setae and long white setae. Apical femoral spine dark brown. Tibial spurs light brown.

Male wings: Dark brown, abruptly narrowed at mid-length, with 16 inner and 15 outer fore wing spines, 10 to 11 hind wing spines.

Female forewixg: Dark brown, oval; covering hindwing.

Male abdomen : Dark brown to black with long white setae on all segments, giving this species a frosted appearance. No tergal ridges on second and third segments. No fusion of eighth tergum and sternum or ninth tergum and sternum. Ninth tergum with hood extending laterally to mid-width of denticular areas (Fig. 45) ; no median septum; medial cleft between areas of denticles; about 33 denticles on each side. Dististyle with about 20 small denticles arranged from below basal lobe almost to base of dististylar claw. Ninth sternum deeply notched apically; reaching bases of dististyles.

Female abdomen: Dark brown to black.

Long white setae on all segments. Ratio

of length of ovipositor to rostrum = 1.39.

Cerci dark brown, evenly tapering to apex.

Body length: Male, 4.3 to 4.5 mm., in

alcohol, 2.4 to 4.1 mm., pinned; female, 4.S

mm., in alcohol, i3 to 4.5 mm., pinned.

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Intraspecific variation: The length of

the setae varies somewhat, but is always

longer than in other species, except pilo-

sus.

Holotype male and allotype female

from MONTANA: Ravalli Co, Gird's

Creek, 2 Nov. 1934, W. L. Jellison. In

addition, there have been 9 other males and

4 other females collected by C. B. Phillip

and W. L. Jellison around Hamilton, Mon-

tana. Other localities (Fig. 75) are BRIT-

ISH COLUMBIA: Ashnola River Valley,

23 Nov. 1963, P. R. Grant, 2 males; ALASKA: between Kennicott and Mc-Carthy, 15 April 1934, W. L. Lloyd, 3 males, 6 females (Carpenter, 1936, as gracilis) .

Gird's Creek is about 5 miles straight east of Hamilton, Montana. The creek is on the dry eastern side of the Bitterroot River Valley, and is relatively inaccessible. However, this is the only locality where this species has been consistently collected.

B. nix has been collected from 2 Nov. to 11 Feb. in Montana and southern British Columbia, while Alaskan specimens were collected from mid- to late-April. The climate and evaluation of the Alaskan localities were discussed under B. intermedins. The dry, hilly area east of Hamilton, Montana, seems to be considerably different from the glacial lowland of Alaska, but differences in climate may be modified by different emergence dates.

When Carpenter (1936) discussed B. gracilis, he mentioned that this species differed from nix only in having male wings which were not abruptly narrowed at mid-length. However, in observing the series he used in describing the male, I noted that these specimens do have such abruptly narrowed wings. As there are no other differences, I consider gracilis as a junior synonym of nix.

This species is a member of the brumalis subgroup of the nivoriundus group, having bristles on the pronotum and a

notched male ninth sternum. The long

pilosity of the body separates this species

from all others except pilosus. Males of

pilostis have only about 19 denticles in each

tergal area, while males of nix have about

33.

Boreas pilosus Carpenter

Boreas pilosus Carpenter, 1935, Psyche 42:114-115, Fig. 10.

Holotype male and allotype female (no. 22360) in Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts.

Present description based on 7 males, 9 females.

Head: Dark brown shading to light brown on tip of rostrum. Occiput finely reticulate, with a few whitish setae. Median ocellus present. Antenna brown, with 18 to 20 flagellomeres. Anterior and posterior surfaces of rostrum with long, whitish setae, numerous near antennal bases, sparse over rest of rostrum. Ratio of length of maxillo-labial complex to rostrum = .80.

Thorax: Dark brown. Pronotum with indistinct transverse ridge at mid-length. Anterior and posterior margins of pronotum with 2 to 6 yellowish-brown bristles. Meso- and metanotum occasionally with 2 bristles each. Small setae covering thorax.

Legs: Yellowish-brown with numerous dark brown and long, white setae. Apical femoral spine present, dark brown. Tibial spurs light brown.

Male wing: Yellowish-brown, abruptly narrowed at mid-length, with 19 to 22 inner and 16 to 19 outer forewing spines, 9 to 15 hindwing spines.

Female forewing: Yellowish-brown, oval; covering hindwing.

Male abdomen: Dark brown except yellowish-brown on ninth segment, basistyles, and diststyles. Sclerites with many long, white setae. No tergal ridges on second and third segments. No fusion of eighth tergum and sternum or ninth tergum and

[Begin Page: Page 200]

sternum. Ninth tergum with hood extending laterally to mid-width of denticular areas; no median septum in hood. Denticles somewhat scattered, only 19 on each side. Diststyle with 17 denticles arranged from below basal lobe to base of dististylar claw. Ninth sternum deeply notched apically, extending to bases of dististyles.

Female abdomen : Dark brown, except for rusty brown ovipositor and cerci. Ratio of length of ovipositor to rostrum := 1.09. Cerci evenly tapering to apex.

Body length: Male, 2.6 to 2.9 mm., pinned, 3.0 to 4.0 mm., in alcohol; female, 4.1 to 4.6 mm., pinned, 5.2 mm., in alcohol.

Intraspecific variation: There is considerable variation in number of antennal segments and male wing spines. Sometimes prothoracic bristles are rubbed oflf, giving this species the apearance of a combination of characters unlike any group.

Holotype, allotype, and 11 paratypes from BRITISH COLUMBIA: Kaslo, Dec. 1932. Other collections (Fig. 75) are from ALBERTA: Jasper National Park, 2-4 Oct. 1964, 6200 feet, 1 male, 1 female; MONTANA: Missouri Co., 26 Feb. 1957, H. R. Dodge, 2 males; Missouri Co., Grant Creek, 11 April 1972, R. A. Haick, 1 male;

Missoula Co., Elk Creek, 4000 feet, 22 Jan. 1972, R. A. Haick, 1 female.

George Ball (personal communication) states that the Alberta specimens were collected in "an alpine meadow on a snow-covered, windblown, northeast-facing slope of Mount Edith Cavell, at 6200 feet." These specimens were collected in association with B. californiciis, as have been all other known specimens of B. pilosits.

B. pilosus has been collected from 4000 to 6200 feet (1220 to 1891 m.) between 4 Oct. and 11 April.

This species is part of the briimalis subgroup of the nivoriundus group, having thoracic bristles and a deeply notched male sternum. It can be separated from the eastern briimalis by the long pilosity,

and from the western nix by its lighter coloration and by having fewer ninth tergal denticles in males.

Boreiis rediictus Carpenter

Boreiis rediictus Carpenter, 1933, Can.

Entomol. 65:94-95, Fig. lA.

Holotype male and allotype female in Canada Department of Agriculture collection, Ottawa.

Present description based on 25 males, 24 females.

Head: Dark brown. Occiput finely reticulate, with numerous setal pits. Median ocellus absent. Antennae dark brown; 17 to 18 flagellomeres. Rostrum with many long setae near antennal bases, few setae over remainder of rostrum. Ratio of length of maxillo-labial complex to rostrum = .90.

Thorax : Dark brown. Pronotum with indistinct transverse ridge at mid-length; no bristles present. No bristles on meso- and metanotum.

Legs: Dark brown with numerous light-colored and dark setae. No apical femoral spine. Tibial spurs light brown.

Male wings: Dark brown, abruptly narrowed at mid-length, with 19 inner and 16 to 19 outer forewing spines, three hind-wing spines.

Female wings: Dark brown; reduced to small vestiges; forewing not overlapping hind wing; with short, whitish setae.

Male abdomen: Dark brown throughout. No tergal ridges on second and third segments. No fusion of eighth tergum and sternum or ninth tergum and sternum. Ninth tergal hood extending laterally to mid-width of denticular areas. Hood projecting dorso-caudally as a medial point (Fig. 47). Denticular areas large, with about 20 denticles on each side, forming a continuous area when medial cleft is not opened by internal pressure. Diststyle with about 13 denticles arranged from basal lobe to diststylar claw. Cleft be-

[Begin Page: Page 201]

tween blunt-tipped basal lobe and rest of dististyle. Ninth sternum narrowed sharply at mid-length, smoothly rounded at apex, not reaching bases of dististyles.

Female abdomen: Dark brown. Ratio of length of ovipositor to rostrum ^ 1.10. Cerci dark brown, evenly tapering to apex. Internal sclerotized plate of eighth segment shaped like oval disc with two ventral funnels.

Body length: Male, 1.9 to 2.4 mm., pinned, 3.3 to 3.9 mm., in alcohol; female, 2.8 to 3.1 mm., pinned, 4.8 mm., in alcohol.

Intraspecific variation: Only variation noted is in number of antennal segments and male wing spines.

Holotype and allotype from BRITISH COLUMBIA: Kaslo, 29 Dec. 1906, J. W. Cockle. In addition, there is one other female with the same data, but no type label, in the Museum of Comparative Zoology. Other specimens (Fig. 76) are from BRITISH COLUMBIA: Lillooet, Jan. 1917, A. W. A. Phair, 1 male, 2 females; Ashnola River Valley, 23 Nov. 1963, P. R. Grant, 1 female; MONTANA: Ravalli Co., Hamilton area, from 27 Nov. to 31 Jan., W, L. JelHson, 15 males, 7 females; Missoula Co., from 6 Feb. to 11 March, John Chapman, D. S. Potter, and R. A. Haick, 6 males, 7 females; Mineral Co., St. Regis, 28 Dec. 1957, H. R. Dodge, 1 male, 6 females; Flathead Co., near Strick, 11 March 1961, W. L. JelHson, 1 male; WASHINGTON: Spokane Co., Spokane, 28 Dec. 1942, H. W. Prescott, many specimens; Whitman Co., 8 mi. W. of Colton, 18 Feb. 1972, W. J. Turner and J. Brunner, 2 males, 8 larvae; IDAHO: Oneida Co., 5 mi. SW. of Juniper, 22 Nov. 1969, George Knowlton, 1 female; NE-VADA: White Pine Co., T18N, R54E, 1 Jan. 1971, Chambers and Nelson, 2 fe-males.

This species has been taken in the arid Great Basin and mountainous regions of western North America, frequently in as-

sociation with B. californicus. Specimens from Whitman Co., Washington were col-lected by Berlese funnel from Selaginella sp., a club moss.

B. rediictus is unusual in many ways, and should not be confused with any other North American species of Boreus. Females of this species alone have forewings which do not overlap the hindwings. This is the only species for which an internal sclerotized plate is known in females. Males have no pronotal bristles and unfused eighth tergum and sternum — a combination unique among North American species. The B. reductus group is the only group of Boreus with no median ocellus. The ninth tergal hood is distinctive in having a medial point.

The nearest relatives of this species are found in the Old World, from the Crimea to the Pacific Ocean. Whether B. reductus is an early relic of this group in the Nearctic Region, or has more recently moved back into this region, cannot be determined at this time.

Key to Males of Palearctic Boreus

1. Bristles present on margins of pronotum

heybien\oi

No bristles present on pronotum 2

2. Transverse ridge on second abdominal

tergum 3

No transverse ridge on second abdominal

tergum 6

3. Ridge on second abdominal tergum di-

vided medially \ratochvili

Ridge not divided medially 4

4. Occiput smooth hyemalis

Occiput rugulose 5

5. Transverse ridge on third abdominal ter-

gum westwoodi

Tubercle on third abdominal tergum

lokayi

6. Tergal hood present on ninth abdominal

segment 7

No tergal hood on ninth abdominal seg-

ment chadzhigireji

7. Symmetrical points on either side of mid-

line of margin of hood vlasovi

[Begin Page: Page 202]

Medial point on margin of ninth tergal

hood 8

8. Medial point of tergal hood acute

semenovi

Medial point of tergal hood smoothly

rounded apically orietitalis

No males are known for sjoestedti and navasi.

Key to Fenl\les of Palearctic Boreits

3.

Bristles present on margins of pronotum

beybien]{oi

No bristles present on pronotum 2

Forewings not covering hindwings 3

Forewings covering hindwings 4

Forewings similar in shape to hindwings

navasi

Forewings longer and broader than hind-
wings chadzhigireji

4. Cerci evenly tapering to a point 5

Cerci narrowing abruptly at mid-length

vlasovi

5. Known distribution — Europe 6

Known distribution — eastern Asia 8

6. Occiput smooth hyemalis

Occiput finely reticulated 7

7. Known distribution — mainly northern

Europe westwoodi

Known distribution — the Balkan Penin-
sula lo\ayi

8. Known distribution — Kamtchatka Penin-

sula sjoestedti

Known distribution — Asian continent

proper semenovi and orientalis

No females are known for \ratochvili.

SPECIES DESCRIPTIONS

Boreus heybien\oi Tarbinsky

Boreits bey-bien}{oi Tarbinsky, 1962, Sbornik Entomologicheskikh Rabot. Akademiia Nauk Kirgizsk 1:134-135.

Holotype, allotype, and all paratypes in Tarbinsky's collection.

The following is a translation by Mr. Christopher Starr of Tarbinsky's original description :

"Males smaller than females. Body short. Length of body 2.75 mm. Color of body black, short with metallic bronze. Pleura of thorax (episterna and epimera) and coxae of middle and hind legs dull.

Entire body covered by short white setae. An especially heavy pubescence visible on abdomen, front coxae and base of rostrum. Abdomen wide. Legs long, forelegs shorter than middle legs, middle legs shorter than hind legs, hind legs more than twice as long as body. To transverse ridges. Antennae 21-segmented. Basal segment of antennae wide, second segment thick and round-oblong, apical segments almost twice as short as segments placed closer to base. Two pairs of wings. Forewings not bent hook-like, held straight along body. Setae along edges of forewings somewhat bent, and at ends directed toward wingtip. Forewings comparatively narrow at base, 0.25 mm; length of wing, including terminal spine 1.45 mm; terminal spine 0.2 mm. Length of wing almost six times greater than width at base. Forewings long (relative to length of body), with terminal spines, reaching to sixth abdominal segment. Along front and hind edge wings are covered by long spines, the longest of them shorter than terminal spine, placed at tip of wing. In middle part of wing all spines comparatively equal in length; shorter ones placed nearer to base of wing, but longer ones near tip of wing. Spines placed along front edge of wing began somewhat nearer to base of wing than spines along hind edge of wing. All spines evenly spaced. On dorsal surface of wings close to base up to 3 long bristles; entire wings covered by sparse but clearly visible hairs. Bases of wings brown, remaining parts black. Second pair of wings even more modified and in this species very thin, long and toward tip strongly curved in pincer-like form. Width of wing at base 0.15 mm.; length 1.05 mm. When extended, small spines visible from below in middle part of hindwings, but on inner edge in curved part of wing a fringe of very small setae. Hindwings brown. Pronotum short; along front edge of it 4 bristles placed in pairs, also some bristles on hind legs.

[Begin Page: Page 203]

"No tergal ridges on dorsal side of second and third terga. Ninth tergum short; on top a comparatively deep and broad cavity. Caudal apex of tergal hood rounded off, blunt, and densely covered with short, thick, blunt setae on each side. Above base of cavity, covering it (when examined from above), rises up a small, triangular plate which fuses at its base with middle of tergum. Ninth sternum (subgenital plate) with detached apical part and obtuse engraving along apical edge. Lateral edges of sternum with visible cavities. In its total form ninth sternum similar to that of B. chadzhigireji Plig., differing from it by wider apical part and cavity along front edge. Length of ninth sternum along mid-line 0.65 mm. Gonocoxites massive, with wide tips, their bases with rather long end; dististyles with wide base, their width being from claw on inner side to lower edge of base. Apical part of dististyles terminates in massive and comparatively short claw. Cavity between base of apical claw and claw on inner side of dististyles is uniformly deep; edge of cavity covered with short, easily visible denticles. Claw on inner side of dististyles blunt with shovel-shaped broadened upper part.

"Females larger than males. Length of body, including ovipositor, 3.16 to 3.6 mm. Eighth tergum very large, one side making blunt angle with rounded tip. Ninth segment comparatively short and wide. Tenth segment short and thick; when examined from above greatest width in middle, visibly narrowed toward tip and base. Twelfth segment wide at base with detached, bluntly cut off tip. Valves of ovipositor (eighth segment) with wide base. Distal ends of valves separate near small angle, but at base of them small cavity visible. From below, distal end of valves covered with strong, short spines, tips of which are directed toward base of valves.

"Examined material: northern slope of Kirghiz Ala-Tau range (Fig. 78), low hills-foothills (the massif Paspeldik) ; 9

Dec. 1957, 2 males; 5 Jan. 1958, 16 males, 12 females; 4 Feb. 1960, 45 males, 40 females. Author's collections."

This species can be separated from all other Palearctic boreids by the presence of spines on the pronotum. For this reason B. beybienl^oi apparently is a member of the nivoriiindus group. The description indicates that the male ninth sternum (hypandrium) and uncurved wings are markedly different from those of other species, and may also be diagnostic characters. However, further description and illustration of these structures is needed for clarity.

Boreus chadzhigireji Pliginsky

Boreus chadzhi-gireji Pliginsky, 1914, Revue Russe d'Entomologie 14:366-367, figs. 9-13.

The two female types from Sevastopol and Simferol, and 1 male, 2 females from Eupatoria, all in Pliginsky's private collection have probably been lost (Martynova, 1954). Four males and 12 females from Eupatoria are in the collection of the Zoological Museum, Academy of Science, Leningrad.

Following is Esben-Petersen's (1921) translation of the original Russian description, followed by my translation of the German summary:

"Female shining; dark greenish metallic coloured or partly purplish shining. Rostrum yellowish-brown, darker at the tip. Palpi blackish. Eyes elliptical, yellowish. Head between the eyes evenly punctuate. Antennae 19-jointed, blackish; 1st joint large and robust; 2nd globular, half as broad as 1st, and twice as long as broad;

3rd joint small, cylindrical, half as broad as 2nd, and twice as long as broad; 4th joint longer than 3rd; 5th-10th long, cylindrical. llth-18th cylindrical, somewhat longer than broad; 19th joint elliptical; all the joints clothed with very short blackish and whitish hairs. Prothorax as long as broad, narrowed in front, and finely rugosed transversely. Mesothorax as

[Begin Page: Page 204]

broad as hind margin of prothorax, with parallel lateral margins and somewhat incised posterior margin. Metathorax broad, with a semi-lunar incision posteriorly and with a transversely placed groove in its centre. Wings yellowish; forewings oblong and punctuate; hind wings have the shape of small narrow plates. Abdomen evenly clothed with short whitish hairs, transversely rugose. Ovipositor almost straight. Legs slender, yellowish, whitish haired; tarsi somewhat darker,

"Length: 3 mm.; breadth: 0.75 mm.

"Male. The male only differs from that of B. navasi in possessing 19-iointed antennae.

"The female of this species is separated from the other species of the genus by a completely straight ovipositor and through the appearance of the forewings, which are strongly elongate and comparatively large. The male is distinguished from B. navasi only by its 19-segmented antennae.

"The area around Sevastopol and Simferopol, 2 females in my collection; Eupatoria, 5 males and 14 females in the collection of the Zoological Museum of the Academy of Science and in my collection."

In addition to this description, further characters can be mentioned (Martynova, 1954) . In the male, the eighth tergum and sternum are not fused, the ninth tergum and sternum are fused, and the ninth sternum does not taper evenly to the apex, but narrows rather abruptly at mid-length, as in redtictus, ending in a square-tipped apex. The female tenth tergum is relatively short, but no ovipositor-to-rostrum ratio is available. There are no caudal extensions of the female tenth segment below the cerci, and cerci narrow rather sharply, as in vlasovi. Spines are present only on the apical one-third of the hypovalves.

Pliginsky made no mention of abdominal tergal ridges, and Martynova stated that they were almost absent. Because this

species appears to be a part of the reditctiis group, having fused ninth tergum and sternum, I am inclined to think that it has no tergal ridges.

From Martynova's illustration it appears that males of B. chadzhigireji have no tergal hood. However, the absence of pronotal bristles, fusion of ninth tergum and sternum, and shortening of female forewings are traits which I feel are derived, and evolved after development of the tergal hood. Therefore, Martynova's illustration is probably incomplete; I suspect that this species does have a tergal hood that extends to the middle of the denticular areas.

The three localities of Sevastopol (44° 36' N, 33°32' E), Simferopol (44= 57' N, 34° 06' E), and Eupatoria (Yeupatoriya) (45°12' N, 33°22' E) are all located near the southern and western coast of the Crimean Peninsula of the U.S.S.R. in an outlying range of the Caucasus Mountains (Fig. 78).

Martynova (loc. cit.) recorded the dates of collection of the type material from Eupatoria as 10 July 1905 and 18 Nov. 1905 — 3 Jan. 1906. The July record seems unusual, and perhaps was misread or misprinted, although there have also been reports of collections of B. briimalis, hyemalis, and nivoriundus from mid-summer.

Females of B. chadzhigireji are unusual in not having oval forewings covering the hindwings like most boreids, nor forewings reduced to small vestiges like reditctiis and navasi, but rather intermediate forewings that are small enough not to cover hindwings, but large enough to form an elongate wing pad. Males may be identified by the sharply narrowing ninth sternum.

Boreus hyemalis (Linnaeus)

Panorpa hyemalis Linnaeus, 1767, Systema Naturae 1:915. 12th edition.

Grylliis proboscideits Panzer, 1796, Faunae insectorum Germanicae initia 27:18.

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Bittaciis hiemalis (Linnaeus) Latrcillc, 1805, Histoire Naturelle generale et particuliere des Crustaces et des Insectes 13:20.

Boreas hyetnalis (Linnaeus) Latreille,

1816, Nouveau Dictionnaire d'Histoire

Naturelle 4:152-153.

Boreas /liemalis (Linnaeus) Latreille,

1817, Le Regne Animal 3:433-434.

Ateleptera hiemalis (Linnaeus) Dal-

man. Analecta Entomologica p. 34. (1823)

Boreas gigas Brauer, 1876, Festschrift

der K. K. zool. — hot. Gesellschaft in Wien,

pp. 263-300. Nomen nudum.

Whereabouts of type specimens unknown.

Present description based on 8 males, 8 females in alcohol.

Head: Dark brown shading to yellowish-brown on rostrum. Occiput smooth with numerous small setae. Median ocellus present, light brown. Antenna light brown basally, dark brown apically, with 20 to 21 flagellomeres. Many light setae on rostrum close to antennal bases, few setae over rest of rostrum. Ratio of length of maxillo-labial complex to rostrum = .89.

Thorax: Dark brown. Indistinct transverse ridge on pronotum at mid-length ; no pronotal bristles.

Legs: Yellowish-brown with dark brown setae. Apical femoral spine present. Tibial spurs light brown.

Male wings: Light brown, abruptly narrowed at mid-length, with 22 inner and 8 to 10 outer forewing spines, no hindwing spines.

Female forewing: Yellowish-brown, oval; covering hindwing.

Male abdomen: Dark brown except yellowish-brown on ninth abdominal segment, basistyles, and dististyles. Transverse ridge on second tergum tilted anteriorly. Lateral margin of ridge with dorsal lobes. Tergal ridge of third segment reduced to rugulose area or smaller ridge with dorso-lateral lobes. Eighth ter-

gum and sternum fused. Ninth tergum and sternum not fused. Large hood of ninth tergum extending laterally to lateral edges of denticular areas. Median septum of hood long, narrow. About 20 denticles on each side of septum very sharply tipped, more like spines. About 17 spines along anterior margin of dististyle from below basal lobe to base of dististylar claw; basal lobe sharp-tipped with cleft between lobe and rest of dististyle. Ninth sternum smoothly rounded at apex, reaching bases of dististyles.

Female abdomen: Dark brown except yellowish-brown on last 4 visible segments. Ratio of length of ovipositor to rostrum = 1.14. Cerci yellowish-brown, evenly tapering to apex.

Body length: Male, 2.7 to 3.5 mm., in alcohol; female, 3.8 to 4.5 mm., in alcohol.

Interspecific variation: I have seen some German specimens with light brown coloration. The most important variation is in the shape of the ridges of the second and third abdominal terga, which sometimes have no lobes. The shape of the ridges has been used to distinguish species of the hyemalis group.

B. hyemalis has been collected from many localities (Fig. 81) in: Austria, Belgium, Czechoslovakia, Denmark, France, Germany, Great Britain, Italy, the Netherlands, Norway, Poland, Rumania, Sweden, and Switzerland.

Specimens have been collected from 7 Sept. to 13 April in Norway. The adult emergence period appears to be shorter than that farther south. One Dutch specimen was supposedly collected on 22 June.

This species has been collected at 1400 m. in Norway to 2000 m, in the Alps of southern France and northern Italy to 2500 m. in the French Pyrenees, but also has been collected near sea level of the Netherlands and Belgium.

B. hyemalis is the typical member of the hyemalis group, having abdominal ter-

[Begin Page: Page 206]

gal ridges in the male. Of the other species in this group, B. J^ratochvili has a forked ridge on the second abdominal tergum, westwoodi has a ridge on the third abdominal tergum with no lateral lobes, and lo\ayi has a tubercle in place of the tergal ridge on the third abdominal tergum. Because of the variation noted in the ridge of the third abdominal tergum of B. hyemalis, this character may be unreUable in taxonomy. Meinander (1962) and others have noted that hyemalis has a smooth occiput with scattered setal pits, while westwoodi and lokayi have a rugulose occiput. In the admittedly inadequate amount of material I studied, the third abdominal tergum was variable and differences in smoothness of the occiput hard to detect. It is my impression that with further study of a larger number of specimens, B. \ratochvili, lokayi, and westwoodi will be synonymized.

Boreus \ratochvili Mayer

Boreus kratochvili Mayer, 1938, Entomologicke listy 1 :132, Figs. 3, 6, 9, 12, 15, 18, 24.

Location of type specimens unknown.

The following is my translation of the summary of Mayer's (1938) original description :

"Large like Boreits hyemalis (male 2.5-3.5 mm.).

"Body pitch black with metallic blue reflections. Rostrum, antennae, palpi, second and third thoracic segments, legs, wings, and genital appendages brown (like Boreus hyemalis L.).

"Head: Surface very weakly wrinkled (high magnification!), without large pits. Antennae: male with 25 segments; the 2 basal segments and the whole distal half dark. The first antennal segment is stout, somewhat smaller on the distal end. The second segment is broader in the middle than at the base and at the distal end; maximal breadth to length 1:1.5. Third and fourth antennal segments very short, the fifth through twelfth elongate to the distal end. From the thirteenth segment on, they are shortened again.

"The second pair of mandibles brown, like Boreus hyemalis. Lacinia has on the base only nine, stout, dark brown bristles that sit on wider rings. On the distal end of the lacinia is a brush of long, whitish hairs.

"The first thoracic segment is very dark, almost black, clearly cross-furrowed. The underside of the forewing has two rows of stouter, short, nearly black bristles; the outer row consists of 11 (5+1 + 1+3 + 1) bristles. On the end the first pair of wings terminates in a long, black spine.

"The second abdominal tergum bears before the hind margin a stout, somewhat foreward-bent ridge, that terminates on both sides in sharp points, but in the mid-dle is cut strongly in V-shape. For this reason the male of this species is conspicu-ously distinguished from the other males of this genus. On the third tergum is a much smaller ridge, that resembles the form of a single specimen of Boreus hyemalis; on the upper margin it is again pointed and weakly squared on the side.

"The subgenital plate brown, like Boreus hyemalis; base to height 1:43:1, the end (from only 2 males) appears to be somewhat rounded.

"The genital appendages are stout, two-branched; tlie upper branch is bent-hook-shaped and the second shortened; both are dark brown.

"The tongue-shaped extension of the ninth episclerite brown, strongly chitinized, filled with long bristles, ending in a rather high, colorless, compact cone. Base to height 1.8:1.

"Female unknown.

"This species has until now only been collected from three localities in the vicinity of Brno together with Boreus hyetnalis L."

Little is known about this species. Lestage (1941) illustrated the second abdomi-

[Begin Page: Figs. 77-80, Page 207]

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nal tergum of the male as having a bipartite ridge, which would indicate that \ratochvili is a member of the hyemalis group. This character state also distinguishes it from all other members of the group.

This species has been collected only in association with hyemalis, and therefore its validity comes into question. Although

the ridge of the third abdominal tergum
of hyemalis varies considerably, the ridge
of the second abdominal tergum appears
to be fairly constant.

No females are known, but this is not
surprising because females of the hyemalis
group are difficult to distinguish morpho-
logically.

The only known specimens of \rato-
chvili (3 males) were collected near Brno,
Czechoslovakia (49°12' N, 16°40' E)
(Fig. 82).

Boreus lokayi Klapalek

Boreits loJ^ayi Klapalek, 1901, Rozpravy
Ceska Akademie cisare Frantiska Josefa
pro Vedy, slovesnost, a Umeni, Prague
10(21) :1-19.

Location of type specimens unknown.

Present description based on 2 males,
1 female, pinned.

Head: Occiput dark brown, finely reticulated. Median ocellus present. Rostrum light brown basally, shading to yellowish-brown distally. Antenna light brown basally, dark brown distally, with 19 flagellomeres. Numerous setae below antennal bases, few setae on anterior and posterior surfaces of rostrum. Ratio of length of maxillo-labial complex to rostrum = .90.

Thorax: Light brown. Pronotum with indistinct transverse ridge at mid-length and no bristles along anterior and posterior margins. Meso- and metanota without bristles.

Legs: Yellowish-brown, with numerous setae and apical femoral spine. Tibial spurs licht brown.

Male wings: Yellowish-brown, abruptly narrowed at mid-length, with about 25 inner and 8 to 10 outer forewing spines; 18 very small hindwing spines.

Female forewing : Yellowish-brown, oval ; covering hindwing.

Male abdomen: Shiny dark brown except light brown on basistyles and yellowish-brown on diststyles. Ridge of second abdominal tergum large, with acute dorsolateral lobes, occasionally with two such lobes. Ridge of third abdominal tergum smaller than second, with a medial peak. Peak varies from indistinct to quite promiment tubercle. Eighth tergum and sternum fused. Ninth tergum and sternum unfused. Ninth tergum with large hood extending laterally to lateral margins of denticular areas. Medial septum narrow, short. About 35 acutely-tipped denticles on either side of mid-line. About 23 denticles arranged from near base of each diststyle to near base of diststyle to near base of diststylar claw. Ninth sternum broadly rounded apically, reaching bases of diststyles.

Female abdomen: Light brown. Ratio of length of ovipositor to rostrum = £6. Cerci light brown, evenly tapering to apex. Body length: Male, about 3.2 to 3.9 mm., pinned; female, 4.1 mm., pinned. Intraspecific variation: Even on opposite sides of the same ridge of the second abdominal tergum, the shapes differ from one to two acute lobes. The third tergum is peaked medially, but may or may not have a transverse ridge.

All three present specimens from Bucsecs, Transylvania (now Romania) (no date label). All known specimens of B. lokayi are from Bucsecs (Fig. 82) (see Cooper, 1972:280).

This species is very similar, if not identical, to B. hyemalis. However, I have not seen enough variation in the second and third tergal ridges of B. hyemalis to warrant synonymy at this time.

[Begin Page: Figs. 81-83, Page 209]

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Boreits navasi Pliginsky

Boreits fjavasi Pliginsky, 1914, Revue Russe d'Entomologie 14:364-366, Figs. 1-8.

Boreus al{tijari Pliginsky, 1914, Revue Russe d'Entomologie 14 :367, Fig. 14. New synonymy.

Syntypes (3 males, 1 female) of navasi and holotype female of al^tijari in Pliginsky's private collection. According to Martynova (1954) these type specimens have not been preserved. They are the only known specimens.

I repeat here the translation of the original Russian description of navasi appearing in Esben-Petersen (1921), followed by my translation of the German summary.

"Dark-green, almost black, metallic shining. Rostrum yellowish, darker towards apex. First joint of palpi brownish yellow, the remainder blackish. Eyes elliptical, yellowish. Antennae 20-segmented, blackish and clothed with whitish hairs; basal joint robust, as long as broad; second joint somewhat longer than broad; third joint oblong, half as broad as second; 4th-8th cylindrical, twice as long as broad; 9th-llth somewhat stouter and shorter than 8th; llth-19th somewhat longer than broad; 20th joint elliptical. Prothorax narrowed in front, blackish and coarsely striated transversely; in the male sex the hind part of prothorax is brownish yellow. Mesothorax broad, trapezoidal, punctuated and not so coarsely striated transversely as the prothorax; in the centre a transversely placed groove. Metathorax broader and shorter than the mesothorax, with a transversely placed groove in its centre and with a deep semi-lunar incision posteriorly. Abdomen black, greenish metallic shining and finely rugosed transversely; in the male sex the abdomen is clothed with short white hairs; in the female sex it is naked. Legs tiny, yellowish; tarsi blackish.

"Male. Wings yellowish, reaching the third abdominal segment. Forewing

curved, darker at apex, shining, punctate, and finely rugose and haired dorsally; coarsely haired ventrally. Hindwings narrower and shorter than forewings; densely haired ventrally. Hindwings narrower and shorter than forewings; densely haired ventrally. Tip of the wings with a clawhke prolongation. No elevadons on second and third abdominal segments. Subgenital plate brownish yellow, very thin, punctuated downwardly and finely haired. The plate narrowly incised laterally.

"Length: 2.5 mm,; breadth: 1 mm.

"Female. Forewings very small; hindwings have the shape of very small and narrow plates. All the wings yellowish coloured. Ovipositor blackish, curved.

"Length including the ovipositor: 3 mm.; breadth: 0.75 mm.

"The female of this species is differentiated from all presently known species by the tiny forewings and through the appearance of the ovipositor which is bent under at a nearly straight angle.

"The area around Sevastopol (Fig. 77), 20 Dec. 1913, 3 males and 1 female in my collection."

Mountains near Sevastopol (44°36' N, 33°32' E) are a part of the Caucasus Range in the Crimea of southern U.S.S.R.

Pliginsky separated a\tijari from navasi on the basis of aJ{tijari's 19-segmented antennae, rounded female forewings, lack of fine abdominal striations, and angle of depression of the cerci. B. rediictiis has antennae which vary from 19 to 20 segments, and Cooper (1974) has found antennal segments to vary from 18 to 20 in H. notoperates , pointing out the questionableness of making distinctions on this

basis. Fine abdominal striations and de-
pression of the cerci, which Pliginsky iden-
tifies as the ovipositor, are not useful
taxonomic characters due to variation in
both. As can be seen in Pliginsky's Fig-
ures 6 and 14, the shape of the female
forewings is almost identical. In addition,
both nominal species have been collected

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only in the vicinity of Sevastopol. Because
there are no type specimens, and because
of lack of useful distinguishing character
states, any future collections could be
placed in either species with equal facihty.
Therefore, I feel that a\tijari is a junior
synonym of navasi.

The original description is very poor,
but if other specimens are collected, the
females should be immediately recognized
by the low number of antennal segments

and very reduced wings, as in re ductus of North America.

Boreus orientalis Martynova

Boreits orientalis Martynova, 1954, Trudy Zoologicheskii institut, Akademia nauk S.S.S.R., Moscow 15:65, Figs. 6, 11, 15, 20, 24, 27.

Types in the collection of the Zoological Museum, Academy of Science, Leningrad.

The following is a translation by Christopher Starr of Martynova's original description :

"Male. Front wing a little shorter than in B. semenovi Plig., but with base of same width; length of wing, including terminal spine, 1.4 mm.; along front edge of wing, spines begin a little closer to base and end a little closer to tip than along hind edge of wing; spines uniformly spaced. No tergal ridges on dorsal side of second and third terga. Ninth tergum almost trapezoidal; at base almost same width as at tip; tip truncated, as in B. semenovi Plig., divided into two blades, forming somewhat shorter slit; base of slit placed in depression, over which is small hood, as in B. semenovi Plig., but of somewhat different form; base of hood without cavity, projection on distal side of it very gently sloping and cavities not as deep; ninth sternum (subgenital plate) very short, almost one-third the length in B. semenovi Plig., with very deep and wide cavity along top edge; gonocoxite with shorter and blunter base than in B. semenovi Plig.,

also with wedge-shaped, but shorter distal end and with less massive claw on inner side of dististyles,

"Female. Eighth tergum in form resembles eighth tergum of B. semenovi Plig., but outer corner of lateral line of it placed lower, therefore not in form of isosceles triangle; front edge of eighth sternum at base forms large projection, then sharply narrows and remains uniform width to the end; valves of ovipositor separate gradually, forming cavity; ninth segment of almost same form as in B. semenovi Plig.; tenth segment not as long, with deep cavity on dorsal side of distal end; this cavity in form similar to that of B. westwoodi Hag., but longer than latter; valves of ovipositor and first segment terminate at same level; twelfth segment in B. semenovi Plig. and B. orientalis sp. n. alike, but in B. orientalis lower side with two shallow cavities.

"Examined material: Sovetskaya Harbor, Maritime Provinces (Fig. 79), 29 VIII-1 IX 1908, 1 male, 1 female (types), on outdoor woodpile (ZIN collection).

"Both east-Siberian species closely related, though also quite sharply different, one from the other."

There is no twelfth segment in female Boreus; Martynova was probably referring to the cerci.

The tergal hood has a medial point, which is not as acute as in B. semenovi. The male ninth sternum appears to be extremely short, perhaps being broken off.

Martynova's Figure 6 shows the male

B. orientalis with fused eighth tergum and sternum, and ninth tergum and sternum. Because fusion of the ninth tergum and sternum and presence of a medial point on the tergal hood are only known in the reductus group, the eighth tergum and sternum are likely unfused.

If B. orietJtalis has unfused eighth tergum and sternum, it is in the reductus group, and can be separated from other eastern Asiatic species by the less acute

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angle of the medial point of the hood. At this time the female cannot be definitely separated from B. semenovi and sjoestedti. Sovetskaya Harbor (48°58' N, 140° 18' E) is in the Tatarskiy Proliv between the Sea of Japan and the Sea of Okhotsk.

Boreits semenovi Pliginsky

Boreas semenovi Pliginsky, 1930, Revue Russe d'Entomologie 24: 230-231.

Holotype male in collection of Academy of Sciences Museum, Leningrad.

I present here my translation of Lestage's (1941) French translation of Pliginsky's original Russian description of B. semenovi.

"Male. Black with slight purplish reflections. Head metallic green, smooth above, save some points between the eyes. Frons smooth. Eyes large, elliptical. Rostrum and palps yellow-brown. Antennae brown-black, with 24 segments.

"Wings I yellow, sclerotized, punctuated, wrinkled, with little black spines on the borders, enlarged basally, narrowed at the apex, which terminates in a point, triangular seen from above, gradually narrowed, without lateral sinuousity, covered with a yellow pubescence directed backwards.

"Wings II forming yellow, narrow

lances.

"Abdomen laterally reddish; terga smooth and without ridges; sides near the edges with dark hairs; sterna covered with whitish hairs.

"Ninth sternum very convex, conical, tapered caudally, its extremity slightly notched. Apex of gonopods acuminate and black. Femur I relatively thin. All legs clear brown.

"Length: 4 mm.

"Distribution. Russia, Aian-Nelkansk Expedition, 62nd kilometer."

Illustrations from Martynova (1954) give additional information about this species. Male with 10 inner and 14 outer forewing spines. Male eighth tergum and sternum unfused, ninth tergum and sternum fused. Ninth tergum with hood extending laterally to middles of denticular areas. Margin of tergal hood produced into a caudally directed, medial projection.

Female eighth sternum with spines on apical one-third of hypovalves. Tenth segment long, but ratio of length of ovipositor to rostrum not available. Tenth segment may have short caudal extensions below cerci. Cerci tapering evenly to apex.

The holotype was collected in U.S.S.R.: Yakut S.S.R.,' Jakoti, on 20. IV. 1903. The specimen was collected by the Aian-Nelkansk Expedition on the slopes of the Oijski Mountain Range between the Lena and Aldan Rivers. Neither the locality nor the mountain range can be found on available maps. However, the collection was probably made somewhere along the track that leads from Ayan (56°27' N, 138°10' E) to Nel'kan (57°40' N, 136° 13' E) to Yakutsk (62°00' N, 129°40' E).

One other collection of 7 males, 1 female was made in 1926 at the confluence of the Tumpsu and Aldan Rivers (Fig. 79), Yakut S.S.R. The Tumpsu River cannot be located on available maps either.

This species appears to belong to the reductiis group, and males can be separated from other Asiatic members of this group by the medial projection of the hood, as in the North American reductus. Females cannot be distinguished at this time.

Boreas sjoestedti Navas

Boreas sjostedti Navas, 1925, Arkiv for Zoologi 18B(2):3-4, Fig. 2.

Holotype female in Naturhistoriska Riksmuseet, Stockholm, Sweden.

Present description based on original description and unpublished notes on the type specimen by George W. Byers.

Head: Black shading to brown on rostrum. Occiput with fine surface sculpturing and setal pits. Antenna brown, with 18

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flagellomeres. Rostrum with many whitish setae at antennal bases, few setae elsewhere on rostrum. Ratio of length of maxillo-labial complex to rostrum = .81.

Thorax: Black. Pronotum with indistinct transverse ridge at mid-length, anterior and posterior margins without bristles, finely striated.

Legs: Brownish.

Female forewing: Brownish, oval; covering hindwing.

Female abdomen: Shiny black with short setae along caudal margins of terga and over all of sterna. Ratio of length of ovipositor to rostrum = 1.14.

Body length : Female, 4.9 mm., pinned.

Holotype female (and only known specimen) from Achomten Bay (Bukhta Akhomten: 52°26' N, 158°30' E3, Kamtchatka Peninsula, U.S.S.R.

This specimen was collected on 12 June 1925 by R. Malaise. Although this summer collection date seems late, specimens of borealis from the Bering Sea area have been collected at a similar date, and there are a few scattered collections of other species at this time of year.

Achomten Bay is a small, uninhabited inlet in Kamtchatka (Fig. 80), 42 miles south of Petropavlovsk, with 7000-foot-high Sopka Mutnaya volcano of the Kamchatka-Kuril Range rising steeply to the west.

This female specimen is very similar to other eastern Asiatic and Alaskan specimens of other species, allowing no easy differentiation. Navas gave no useful characters for separating this from other species. However, since this is the only species described within a radius of 820 miles, it may well be a valid species and more male specimens from the Kamtchatka Peninsula may give us additional characters for this species. Martynova (1954) did not include this species in her monograph of Boreidae of the U.S.S.R.

Boreus vlasovi Martynova

Boreus vlasovi Martynova, 1954, Trudy Zoologicheskii institut, Akademiia nauk S.S.S.R., Moscow 15:61-62, Figs. 4, 9, 13, 18, 22, 26.

Whereabouts of type specimens unknown.

Present description based on 7 males, 2 females in alcohol.

Head: Dark brown. Occiput rugulose with many white setae. Median ocellus absent. Antenna dark brown, with 16 to 17 flagellomeres. Many long setae near antennal bases of rostrum; few setae over rest of rostrum. Ratio of length of maxillo-labial complex to rostrum = 1.00.

Thorax: Dark brown. No transverse ridge at mid-length or marginal bristles on pronotum.

Legs: Dark brown with light-colored and dark brown setae. Apical femoral spine absent. Tibial spurs dark brown.

Male wings: Light brown, abruptly narrowed at mid-length, with 15 inner and 11 to 12 outer forewing spines, 3 to 4 hindwing spines.

Female forewing: Light brown, oval, short, reaching only middle of metanotum, barely covering hindwing vestiges, with many whitish setae.

Male abdomen: Dark brown throughout. No tergal ridges on second and third segments. No fusion of eighth tergum and sternum, but ninth tergum and sternum fused in many cases. Ninth tergum with hood extending laterally to middles of denticular areas. Margin of hood produced caudally on either side of mid-line. Small median septum of hood present. About 20 denticles on each side. Dististyle with about 15 denticles arranged from below basal lobe to base of dististylar claw; basal lobe blunt-tipped, with cleft between it and rest of dististyle. Ninth sternum smoothly rounded apically, reaching bases of dististyles.

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Female abdomen: Dark brown. Ratio o£ length of ovipositor to rostrum = .93. Cerci dark brown, not evenly tapering to point, but sharply pointed at apex; fused.

Body length: Male, 2.3 to 4.1 mm., in alcohol; female, 3.6 to 4.0 mm., in alcohol. Intraspecific vacation: One male was noted to have two spines at apex of ninth sternum; normally this species has no spines on ninth sternum. The sharp projections of the caudal margin of the female eighth tergum, illustrated in Martynova's (1954) Figure 18, were not noted in specimens examined. Fusion of ninth tergum and sternum is complete in only about half the available specimens, (cf. Cooper, 1973).

Collections of this species are from (Fig. 77) Turkmen S.S.R., Ashkabad (37°

57' N, 58°23' E), 3 Jan. to 20 Feb. 1932, and 1935, 148 males and females; Tadzhik S.S.R., 30 km N of StaUnabad (Dushanbe), 1100 m (38°33' N, 68°48' E), 10 to 12 March 1943, 3 males, 3 females; and Turkmen S.S.R., Askhabad, Dec. 1955, 7 males, 2 females. There is 1 male in the Deutsches Entomologisches Institut, Berlin, which I did not examine.

This species is a member of the reditctus group having no thoracic spines and unfused eighth tergum and sternum. Although other Asiatic species are poorly known, this species probably can be differentiated by the two caudal projections of the lip of the hood in males, and the sharply narrowed cerci in females.

Boreiis westwoodi Hagen

Bore lis westwoodi Hagen, 1866, Entomol. Monthly Mag. 3:132.

Boreas tarnanii Navas, 1911, Revue Russe d'Entomologie 11:277-278, Fig. 1.

Boreus boldyrevi Navas, 1911, Revue Russe d'Entomologie 11:278, Fig. 2.

Location of all type specimens unknown.

In the original description, Hagen gave

no information on type locality, although he listed the distribution as Germany, Finland, and England. As currently delimited, B. westwoodi is a northern and alpine species, not found in England, as MacLachlan (1869) pointed out. However, since the types cannot be located, it is impossible to say whether the current B. westwoodi is the same one that Hagen envisioned, or even if it is a valid species.

Navas (1911) mentioned no repository of types of boldyrevi and tarnaii and they, too, cannot be located. However, the type localities are listed as "Russie, environs de Moscou" and "Pologne de la Russie: Novaja-Alexandria," respectively. Martynova (1954) considered both boldyrevi and tarnanii as synonyms of westwoodi, which is commonly collected in the vicinity of Moscow.

Present description based on 18 males, 14 females, pinned.

Head: Occiput black with fine reticulations. Rostrum yellowish-brown; fine setae on caudal surface, no stout setae. Median ocellus present between antennal lobes. Antenna light brown basally, becoming dark brown apically; with 21 to 23 flagellomeres. Ratio of length of maxillolabial complex to rostrum ^ .85.

Thorax: Dark brown. Indistinct transverse ridge at mid-length of pronotum; no pronotal bristles.

Legs: Yellowish. Apical femoral spine present, dark brown. Tibial spurs light brown.

Male wings: Yellowish-brown. Forewing abruptly narrowed at mid-length, with 26 to 29 inner and 6 to 9 outer forewing spines. Hindwing with ventral fringe of setae, no spines.

Female forewing: Yellowish, oval, covering hindwing.

Male abdomen : Dark brown, except yellowish-brown dististyles. Transverse ridge of second tergum with large dorso-lateral

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lobes. Ridge of third abdominal tergum prominent, without dorso-lateral lobes. Eighth tergum and sternum fused. Ninth tergum and sternum not fused. Ninth tergum with large hood extending laterally to lateral margins of denticular areas. Medial septum short, thin. Only about 16 sharp-tipped denticles on each side. Ninth sternum smoothly rounded apically, reaching bases of dististyles. Denticles on dististyle arranged from below basal lobe to base of dististylar claw. Cleft between basal lobe and rest of dististyle.

Female abdomen: Segments 1 to 8 dark brown, segments 9-10 and cerci yellowish-brown Ratio of length of ovipositor to rostrum = 1.41. Cerci evenly tapered to apex.

Body length: Male, 3.0 to 3,5 mm., pinned; female, 4.0 to 4.5 mm,, pinned.

Intraspecific variation: There is some variation in number of antennal segments and male wing spines. Lestage (1941) in-indicated variation in the male ridge of the third abdominal tergum,

Svensson (1972) listed the distribution of westwoodi as the following (Fig, 83) : Bulgaria, Czechoslovakia, East Balticum, Finland, Germany, Italy, Norway, Poland, Sweden, Switzerland, and U.S.S.R.

This species has been frequently collected from November to April, with a few scattered records from June, September, and October,

B. westwoodi is a member of the hyemalis group, having tergal ridges. It can be separated from hyemalis by the fine reticulations on the occiput, from \ratochvili by the unipartite second tergal ridge with dorso-lateral lobes, and from lo\ayi by the ridged third tergum (no tubercle).

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LITERATURE CITED

Banks, N. 1923. Mecoptera. In McAtee, Insects, Arachnids, and Chilopods of the Pribilof Islands, Alaska. U.S.D.A., Bureau of Biological Survey, North American Fauna 46:158.

Bliss, L. C. 1962. Adaptations of arctic and alpine plants to environmental conditions. Arctic 15:117-144.

BoLDYREV, B. T. 1914. Notice sur le Boreas boldyrevi Navas (Neuroptera, Panorpidae). Revue Russe d'Entomologie 1:203-210.

Brauer, F. 1855. Beitriige zur Kenntniss des inneren Baues und der Vervvandlung der Neuropteren. Verhandlungen zoologisch-botanischen Gesellschaft in Wien 5:701-726.

. 1857. Beitrage zur Kenntniss der Verwandlung der Neuropteren. Verhandlungen zoologisch-botanischen Gesellschaft in Wien 7: 69-70.

. 1863. Beitrage zur Kenntniss der Panorpiden-Larven. Verhandlungen zoologisch-botanischen Gesellschaft in Wien 13:307-324.

. 1876. Die Neuropteren Europas und ins-

besondere Osterreichs mit Riicksicht auf ihre
geographische Verbreitung. Festschrift der
zoologisch-botanischen Gesellschaft in Wien
pp. 263-300.

. 1885. Systemisch-zoologische Studien. Sit-

zungsberichte der Akademie der Wissenschaf-
ten in Wien 41:237-413.

Brothers, D. 1975. A revision of the aculeate Hy-
menoptcra w^ith special reference to the Mu-
tillidae. Kansas Sci. Bull. 50:483-648.

Burtt, E. D. and B. p. Uvarov. 1944. Changes in
wing pigmentation during the adult life of
Acrididae (Orthoptera). Proc. Roy. Entomol.
Soc. London (a) 32:30-34.

Byers, G. W. 1954. Notes on North American
Mecoptera. Ann. Entomol. Soc. Amer. 47:
484-510.

. 1955. A new species of Boretis (Mecoptera:

Boreidae) from Colorado. Occ. Pap. Mus. of
Zool., Univ. of Michigan 562:1-4.

[Begin Page: Page 216]

. 1961. An unusual new species of Boieus

(Mecoptera: Boreidae) from Oregon. J. Kansas Entomol. Soc. 34:73-78.

Carpenter, F. M. 1931. Revision of the nearctic Mecoptera. Bull. Mus. Comp. Zoo!., Harvard Univ. 72:205-277.

. 1933. A new Boreiis from British Columbia

(Mecoptera). Can. Entomol. 65:94-95.

, 1935. New nearctic Mecoptera with notes

on other species. Psyche 42:105-121.

. 1936. Descriptions and records of nearctic

Mecoptera. Psyche 43:56-64.

. 1939. Records and notes of nearctic

Mecoptera and Raphidiodea. Bull. Brooklyn
Entomol. Soc. 34:162-166.

Cole, A. C, Jr. 1938. Insect collecting in the
Great Smoky Mountains National Park, Ten-
nessee. J. Tenn. Acad. Sci. 13:274-276.

Cooper, K. W. 1940. The genital anatomy and
mating behavior of Boreas brttmalis Fitch
(Mecoptera). Amer. Midland Natur. 23:354-
367.

. 1951. Compound sex chromosomes with

anaphasis precocity in the male mecopteran,
Boretis brttmalis Fitch. J. Morphol. 89:37-58.

. 1972. A southern California Boretis, B.

notoperates n. sp. I. Comparative morphology
and systematics (Mecoptera: Boreidae). Psyche
79:269-283.

. 1973. Patterns of abdominal fusions in male Boretts (Mecoptera). Psyche 80:270.

. 1974. Sexual biology, chromosomes, development, life histories and parasites of Boretts, especially of B. notoperates. A southern California Boreus. II. (Mecoptera: Boreidae). Psyche 81:84-120.

Dalman, J. W. 1823. Analecta Entomologica. Holmiae, Lindholm. 104 p.

Downes, J. A. 1964. Arctic insects and their environment. Can. Entomol. 96:279-307.

. 1965. Adaptations of insects in the Arctic.

Ann. Rev. Entomol. 10:257-274.

Esben-Petersen, p. 1921. Mecoptera. Collections Zoologiques du Baron Edm. de Selys Longchamps 5(2) :1-172.

Fitch, A. 1847. Winter insects of eastern New York. Amer. J. Agr. Sci. 5:274-284.

Fraser, F. C. 1943. Ecological and biological notes on Boretis hyemalis (L.) (Mecoptera, Boreidae). J. Soc. Brit. Entomol. 2:125-129.

Goodwin, T. W. 1952. The biochemistry of locust pigmentation. Biol. Rev. Cambridge Phil. Soc. 27:439-460.

GosLiN, R. M. 1950. Additional records of Boretis brumalis (Mecoptera: Boreidae) from Tennessee. J. Tennessee Acad. Sci. 25:309.

Hagen, H. a. 1866. Synopsis of the genus Boretis. Entomol. Monthly Mag. 3:132.

Heinrich, B. and G. a. Bartholomew. 1972. Temperature control in flying moths. Sci. Amer. 226:71-77.

Hepburn, H. R. 1969. The skeleto-muscular system of Mecoptera: the head. Univ. Kansas Sci. Bull. 48:721-765.

. 1970. The skeleto-muscular system of

Mecoptera: the thorax. Univ. Kansas Sci. Bull. 48:801-844.

Herter, K. 1943. Die Beziehungen zwischen der Okologie und der Thermotaxis der Tierc. Biologia Generalis 17(1-2).

Hine, J. S. 1901. A review of the Panorpidae of America north of Mexico. Bull. Sci. Lab. Denison Univ. 11:241-264.

HiNTON, H. E. 1958. The phylogeny of the panor- poid orders. Ann. Rev. Entomol. 3:181-206.

Kaufmann, T. 1971. Hibernation in the arctic beede, Pterostichtis breuicornis, in Alaska. J. Kansas Entomol. Soc. 44:81-92.

Klapalek, F. 1903. Ueber neue und wenig bekannte Arten der Palaarktischen Neuropteroiden. Bul- letin international (Sciences, mathematiques, et naturelles) Ceska akademie cisare Frantiska Josefa pro vedy, slovesnost a umeni v Praze 7:1-14.

Lamb, C. G. 1922. The geometry of insect pairing. Proc. Roy. Entomol. Soc. London (B) 94: 1-11.

Latreille, p. a. 1805. Histoire Naturelle generale et particuliere des Crustaces et des Insectes 13:17-21.

. 1816. Nouvcau dictionnaire d'Histoire

Naturelle 4:152-153.

. 1817. Le Regne Animal 3:433-434.

Lattin, J. D. 1956. The first California record of Boretis californictis ftisctts Carpenter. Pan-Pacific Entomol. 32:81-82.

Lestage, J. A. 1940. Pour I'histoire des Boretis (Stegopteres-Mecopteres). I. Annales de Societe Royale zoologiquc de Belgique 71:5-22.

. 1941. Pour I'histoire des Boreus (Stegopteres-Mecopteres). III. Systematique. Annales de Societe Royale zoologique de Belgique 72:105-125.

LiNNE, C. 1967. Systema Naturae. 12th edition (facsimile). W. Junk, Gravenhage. 824 p.

Lloyd, L. C. 1934. Two species of Mecoptera from Alaska. Pan-Pacific Entomol. 10:119-120.

MacLachlan, R. 1869. Note on Boretts hyemalis and B. tvestwoodii. Trans. Roy. Entomol. Soc. London S.4. 2:399-401.

Marechal, p. 1939. Contribution a la connaisance
de Boretis hyemalis L. Bulletin et Annales
de la Societe Entomologique <le Belgique
79:111-116.

Martynova, O. M. 1954. Mecoptera fauna of
U.S.S.R. Part I, Boreidae. Trudy zoologiche-
skii institut Akadcmiia nauk S.S.S.R., Mos-
cow 15:54-66. (In Russian)

Mayer, K. 1938. Rod Bor^/^ (Panorpata - Boreidae)
Ceskoslovensku. Entomologicke listy 2:129-
140, 1 plate.

Meinander, M. 1962. The Neuroptera and Mecop-
tera of eastern Fennoscandia. Fauna Fennica
13:1-87.

MicKOLEiT, G. 1971. Das exoskelet von Notiothatima
reedi MacLachlan, ein Bcitrag zur Mor-

[Begin Page: Page 217]

phologie unci Phylogenic der Mecoptera (Insecta). Zeitschrift fiir morphologic und okologie der tiere 69:318-362.

Navas, L. 1911. Deux Boreus nouveaux d'Europe (Neuroptera). Revue Russe d'Entomologie 11:277-278. (In French with Latin descriptions.)

. 1925. Entomologische Ergebnisse der

schwedischen Kamtchatka-expedition. 1920-1922. Part 6. Neuroptera et Mecoptera. Arkiv for Zoologi 18B(2):l-3. (In German with Latin descriptions.)

Packard, A. S. 1870. New or rare American Neuroptera, Thysanura, and Myriapoda. Proc. Boston Soc. Nat. Hist. 13:405-410.

Panzer, G. W. F. 1796. Faunae Insectorum Germanicae. Felssecker, Niirnberg.

Peterson, A. 1951. Larvae of Insects. Part II. Coleoptera, Diptera, Neuroptera, Siphonaptera, Mecoptera, Trichoptera. Edwards Bros., Columbus, Ohio, v -j- 416 p.

Pliginsky, V. G. 1914. New Boietis species from the Crimea (Neuroptera, Panorpidae). Revue Russe d'Entomologie 14:363-367. (In Russian with German summary.)

. 1930. A new species of the genus Boretis

Latr. (Neuroptera, Panorpidae). Revue Russe d'Entomologie 24:230-231. (In Russian.)

PoRsiLD, A. E. 1951. Plant life in the Arctic. Canad. Geograph. J. 42:120-145.

Richards, A. G. 1965. The proventriculus of adult Mecoptera and Siphonaptera. Ent. News 76: 253-256.

Sage, B. L. 1973. Alaska and its wildlife. The Viking Press, New York. 128 p.

Salt, R. W. 1961. Principles of insect cold-hardiness. Ann. Rev. Entomol. 6:55-74.

Sneath, p. H. a. and R. R. Sokal. 1973. Numerical Taxonomy. W. H. Freeman and Company, San Francisco. 573 p.

Stannard, L. J. 1957. The first records of Boreits

(Borcidae, Mecoptera) in Illinois. Trans.

Illinois State Acad. Sci. 50:279-280.

Steiner, p. 1936. Beitrag zur Fortflanzungsbiologie

und Morphologic des Genitalapparates von

Boreus hiemalis L. Zeitschrift fiir Morphologic

und Okologie der Tiere 32:276-288.

Stephens, J. F. 1829. A Systematic Catalogue of

British Insects. Baldwin, London. 416 p.

Strubing, H. 1950. Beitrage zur biologic von

Boreus hyemalis L. Zoologischc Beitrage

(N.F.) 1:51-110.

Svensson, S. a. 1972. Boreus Latreille, 1825

(Mecoptera). A synopsis of described species.

Entomologica scandanavica 3:26-32.

Syms, E. E. 1934. Notes on British Mecoptera.

Trans. South London Entomol. Nat. Hist.

Soc. 1933/1934:84-88.

Tarbinsky, S. p. 1962. Finding scorpion-flies, Boreus sp. n. (Mecoptera, Borcidae) in the foothills of the Kirghiz Ala-Too. Sbornik Entomologicheskikh Rabot. Akademiia Nauk Kirgizsk 1:131-136. (In Russian.)

Tweedie, M. 1972. Northern and mountain insects. Animals 14:460-463.

Webb, D. W., N. D. Penny and J. C. Marlin. 1975. The Mecoptera, or scorpionflies, of Illinois. Bull. Illinois Nat. Hist. Surv. 31:251-316.

Williams, F. X. 1916. The pupa of Boreus brttmalis Fitch. Psyche 23:36-39.

Wilson, W. 1957. Observations on the temperatures of arctic plants and their environment. J. Ecol. 45:499-531.

Withycombe, C. L. 1922. On the life-history of Boreus hyemalis L. Trans. Roy. Entomol.

Soc. London 54:312-318.

. 1926. Additional remarks upon Boreus hyemalis L. Entomol. Monthly Mag. 62:81-83.

WuLFF, T. 1902. Botanische Beobachtungen aus Spitzbergen. I. Uber die Transpiration der arktischen Gewachse. Lund. pp. 3-32.