STONEFLIES (PLECOPTERA) OF SASKATCHEWAN

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Forty-one species, twenty-nine genera and eight families of Plecoptera are recorded from Saskatchewan. Distinguishing characters are given and keys are provided. Species recorded are: Pteronarcys dorsata *(Say),* Pteronarcella badia *(Hagen),* Taeniopteryx nivalis *(Fitch),* Oemopteryx fosketti *(Ricker),* Capnia coloradensis *Claassen,* Capnia confusa *Claassen,* Capnia gracilaria *Claassen,* Capnia vernalis *Newport,* Paracapnia angulata *Hanson,* Isocapnia crinita *(Needham and Claassen),* Isocapnia missourii *Ricker,* Utacapnia trava *(Nebeker and Gaufin),* Nemoura rickeri *Jewett,* Shipsa rotunda *(Claassen),* Amphinemura linda *(Ricker),* Zapada cinctipes *(Banks),* Malenka californica *(Claassen),* Podmosta delicatula *(Claassen,* Paraleuctra vershina *Gaufin and Ricker,* Leuctra ferruginea *(Walker),* Acroneuria abnormis *(Newman),* Acroneuria lycorias *(Newman),* Hesperoperla pacifica *(Banks),* Claassenia sabulosa *(Banks),* Paragnetina media *(Walker),* Perlesta placida *(Hagen),* Isoperla bilineata *(Say),* Isoperla longiseta *Banks,* Isoperla transmarina *(Newman),* Isoperla patricia *Frison,* Isoperla decolorata *(Walker),* Isoperla marlynia *Needham and Claassen,* Isoperla petersoni *Needham and Christensen,* Arcynopteryx compacta *(MacLachlan),* Skwala parallela *(Frison),* Isogenoides colubrinus *(Hagen),* Isogenoides frontalis *(Newman),* Diura bicaudata *(Linnaeus),* Triznaka signata *(Banks),* Suwallia lineosa *(Banks) and* Hastaperla brevis *(Banks). Nymphs of the following ten species are described for the first time:* Oemopteryx fosketti, Triznaka signata, Suwallia lineosa, Isoperla decolorata, Nemoura rickeri, Malenka californica, Podmosta delicatula, Capnia coloradensis, Capnia confusa, *and* Capnia gracilaria. *Keys to species are provided for mature nymphs except that nymphs of* Isocapnia crinita *and* Isocapnia missourii *are unknown, and nymphs of* Malenka californica *and* Amphinemura linda *are inseparable, as are nymphs of* Capnia coloradensis *from* Capnia confusa *and* Isogenoides frontalis *from* Isogenoides colubrinus.

The following information is presented for each species: selected literature references, diagnostic information, bionomics, and distribution which consists of a brief summary of the species range and a map showing Saskatchewan collection localities. Diagnostic illustrations are provided.

Life history patterns and seasonal succession of Saskatchewan stoneflies are discussed. Life cycles range from more than one year to univoltine. Some species with a one-year life history diapause as embryos, others do not. The post-glacial dispersal of stoneflies to Saskatchewan is discussed.

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Integration of the geographical and ecological distributions of extant species with the post-glacial history of Saskatchewan leads to the inference that the Saskatchewan stonefly fauna is derived mainly from post-glacial dispersal from refugia to the south and northwest of the Wisconsin ice sheets.

Quarante et-une espèces de Plécoptères se rencontrent en Saskatchewan. Ces espèces se distribuent en huit familles et 29 genres. L'adulte de chaque espèces est caractérisé, et nous pourvoyons une clef permettant leur identification. Les especes de cette region sont: Pteronarcys dorsata *(Say),* Pteronarcella badia *(Hagen),* Taeniopteryx nivalis *(Fitch),* Oemopteryx fosketti *(Ricker),* Capnia coloradensis *(Claassen),* Capnia confusa *(Claassen),* Capnia gracilaria *Claassen,* Capnia vernalis *Newport,* Paracapnia angulata *Hanson,* Isocapnia crinita *(Needham et Claassen),* Isocapnia missourii *Ricker,* Utacapnia trava *(Nebeker et Gaufin),* Nemoura rickeri *Jewett,* Shipsa rotunda *(Claassen),* Amphinemura linda *(Ricker),* Zapada cinctipes *(Banks),* Malenka californica*(Claassen),* Podmosta delicatula *(Claassen),* Paraleuctra vershina *Gaufin et Ricker,* Leuctra ferruginea *(Walker),* Acroneuria abnormis *(Newman),* Acroneuria lycorias *(Newman),* Hesperoperla pacifica *(Banks),* Claassenia sabulosa *(Banks),* Paragnetina media *(Walker),* Perlesta placida *(Hagen),* Isoperla bilineata *(Say),* Isoperla longiseta *Banks,* Isoperla transmarina *(Newman),* Isoperla patricia *Frison,* Isoperla decolorata *(Walker),* Isoperla marylnia *Needham et Claassen,* Isoperla petersoni *Needham et Christensen,* Arcynopteryx compacta *(MacLachlan),* Skwala parallela *(Frison),* Isogenoides colubrinus *(Hagen),* Isogenoides frontalis *(Newman),* Diura bicaudata *(Linnaeus),* Triznaka signata *(Banks),* Suwallia lineosa *(Banks) et* Hastaperla brevis *(Banks). Nous décrivons pour la première fois les stades nymph aux des espèces suivantes:* O. fosketti, T. signata, S. lineosa, I. decolorata, N. rickeri, M. californica, P. delicatula, C. coloradensis, C. confusa *et* C. gracilaria. *Nous pourvoyons une clef des espèces pour les nymphes au dernier stade, excepté pour cells d'*I. crinita *et d'*I. missourii *qui ne nous sont pas connues. De plus les nymphes des espèces paires suivantes ne peuvent être separees: le* M. californica, *d'*A. linda, *le* C. coloradensis *de* C. confusa, *et l'*I. frontalis *d'* I. colubrinus.

Pour chaque espèces nous présentons les données suivantes: une série de references choisies, un diagnostic des stades, des notes sur la bionomique, et une distribution décrite brievement dans le texte et illustrée en detail sur une carte de la Saskatchewan. Nous avons illustré tous charactères structuraux d'importance.

Nous discutons pour les Plécoptères de la Saskatchewans les patrons d'histoire naturelle et de succession saisonnière. Le cycle vital s'étend sur une annee (univoltine) our plus (multivoltine). Quelques unes des espèces univoltines ont une période de diapause au stade d'embryo, les autres especes ne l'ont pas. Nous discutons la dispersion post-glaciale des Plécoptères de cette region. L'integration des données écologiques et géograhiques des espèces présentes avec l'histoire post-glaciale de la Saskatchewan suggere que la faune des Plécoptères s'est dispersée après les temps glacaux à partir de refuges au sud au nord-ouest des glaciers partir de refuges au sud au nord-ouest des glaciers de la periode du Wisconsin.

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INTRODUCTION

Introductory background and objectives of the study

Plecoptera, or stoneflies, are a small order of aquatic insects with approximately 2,000 species known in the world, and 470 species recognized from America north of Mexico. Stoneflies comprise a significant part of many lotic ecosystems, and to a lesser extent some lentic ecosystems. The nymphal stage forms an important link in the aquatic food web between the algal-detrital and vertebrate trophic levels. Also, nymphs have potential importance as indicators of water quality. Specific identification as well as knowledge of the distribution and way of life of stoneflies is a preliminary requirement to their use as indicators in assessment of water quality and to understanding dynamics of aquatic communities of which they are a component.

Studies of Plecoptera in Western Canada have largely excluded Saskatchewan. Banks (1907) reported species known from Alberta and British Columbia and Neave (1929, 1933, 1934) published records for several species from Alberta, British Columbia and Manitoba. Needham and Claassen (1925) listed one species from Saskatchewan. Ricker (1943) published a thorough study of the stonefly fauna of southwestern British Columbia and later (1944, 1946, 1965), published records of prairie and northern stoneflies including nine species from Saskatchewan. Cushing (1961) reported two species, from Montreal River, not previously known in the province. Records for these 11 species were from fewer than 10 Saskatchewan localities. It was evident, with the tremendous diversity and number of habitats represented in Saskatchewan, that a varied and extensive fauna should occur in the province. Lotic systems are well represented, especially in the boreal part of the province and, to a lesser extent, in the prairies and Cypress Hills regions.

This study of Saskatchewan Plecoptera had three main objectives. The first objective was to document nymphal as well as adult stages. Although adults of North American stoneflies are well known, less attention has been given to taxonomic characters of the nymphs. For many species, only mature nymphs with underlying adult characters can be definitely recognized at present, though the nymph is the stage of life cycle most commonly encountered in the field. Keys presented in this study, especially for immature stages of Plecoptera, will be useful for future ecological studies.

The second objective was to infer possible sources for the Saskatchewan stonefly fauna by examining their known North American distributions. Until this study, little could be stated of the post-glacial stonefly dispersal to Saskatchewan. Also, distributional information recorded here will be useful in assessing the effects of man's future alterations of Saskatchewan's rivers and streams.

The third objective was to summarize published information on life-cycles and to synthesize this with observations made on the way of life of Saskatchewan stoneflies.

A total of 41 species are known from Saskatchewan, including 30 new records for the province and four new Canadian records. New descriptions are presented for nymphs of ten species.

Morphology

The following text describes basic morphological characters of Plecoptera and is summarized from Hitchcock (1974) Gaufin *et al.* (1972), Merritt and Cummins (1978) and others.

Plecoptera are hemimetabolous, belonging to the orthopteroid group of insects. They are most closely related to Embioptera (Crampton, 1932, Nutting, 1951).

The eyes are generally posterior on the head, but in some species they are placed far forward. A few species have only two lateral ocelli, the majority have three: two lateral and one median with an imaginary or "ocellar triangle" connecting the three ocelli. The Y-shaped ecdysial line forks just posterior to the lateral ocelli. The posterior part of the head, or occipital region, may bear short bristles or long setae forming an occipital ridge.

The mouthparts are of the chewing type, though they are reduced in some adults. Nymphal mandibles may have grinding surfaces or be sharply toothed, depending on feeding habits (Fig. 166). Maxillary appendages include the 5-articled palpus, galea, and laciniae (Fig. 165). Laciniae may have one or two sharp teeth and a row or tuft of bristles. The labium bears a 3-articled palpus and two pairs of lobes distally, the outer paraglossae and inner glossae. Glossae and paraglossae are approximately of equal length in Filipalpia (Fig. 21), but in Setipalpia the glossae are much reduced and in some genera appear only as small projections on the inner side of the paraglossae (Fig. 20). There is a small mentum proximal to the labium, and beyond it a larger submentum (Fig. 20).

The pronotum may have a median longitudinal stripe or a reticulate pattern. The basisternum is the largest thoracic sternal sclerite and this is preceded by the small presternum and followed by the furcastrum (Fig. 18, 19). On each side of the furcasternum are the furcal pits and in certain species they are joined by a transverse ridge with another ridge posterior to each pit forming a Y-shaped line when they join and run together (Fig. 24, 25).

Nymphal fore and hindwing pads may be aligned at an angle (Fig. 14), or they may be subparallel with forewing and hindwing pads in line with each other (Fig. 15).

Adult wing venation shows little variation from the basic form. Except for three North American species, hindwings always bear an enlarged lobe in the anal region. Forewings can have up to three anal veins, with the second anal vein forked in some species. Generally, there is only one anal cell although several anal cells occur in some species. The number and position of crossveins, the point of origin and the degree of upturn of the first branch of the radial vein are important systematic characters.

Brachypterous individuals show distorted venation.

Many nymphs have gills on various parts of the body. Submental gills are small and finger-like arising from the posterior corners of the submentum (Fig. 20). Cervical gills on the neck may be simple (Fig. 11) or branched (Fig. 12). Thoracic gills may also be simple or branched. Some species have simple coxal gills occurring singly on the ventral surface of each coxa (Fig. 13). Abdominal gills occur laterally on basal abdominal segments (Fig. 6, 7), and subanal gills occur between the cerci. Except for coxal gills, larval gill remnants are visible on the adult.

Males bear various genitalic processes, used in mating, and which are important taxonomically. These projections range from small, hardly perceptible processes, to very elongate projections. The male genitalia generally consist of a median epiproct or supra-anal process (an unpaired structure attached to the tenth tergum) which can be simple (Fig. 93), complex (Fig. 50, 51), or not readily visible; there are sclerotized paragenital plates at its base. In some species additional processes occur at the base of the epiproct. Paraprocts are located on each side of the epiproct and can range in structure from being simple and fingerlike (Fig. 117, 118) to complex structures (Fig. 120). The seventh, eighth or ninth sterna have vesicles or basal lobes in some species (Fig. 62, 64) and the ninth sternite may have a heavy knob or "hammer" (Fig. 9). Recurved pointed hooks or "genital hooks" can emerge as paraprocts (Fig. 102) or as part of the tenth tergite (Fig. 8).

The relatively simple female abdomen has the seventh or eighth sternum produced to form a subgenital plate (Fig. 116).

Single-, or many-articled cerci arise from the tip of the abdomen, and may bear characteristic bristles or hairs.

Economic importance of Plecoptera

Stoneflies are economicaly important mainly as natural fish food. A few fish species known to eat stoneflies include grayling (*Thymalus arcticus*), (Rawson, 1950), lake sturgeon (*Acipenser fulvescens*), (Magnin and Harper, 1970), yellow walleye (*Stizostedion vitreum*), (Rawson, 1956) and mooneye (*Hiodon tergisus*) (Glenn, 1975). In Saskatchewan, adults of *Malenka californica* were found in stomachs of brook trout (*Salvenius frontinalis*), (D. Larson, pers. comm.).

Stoneflies also provide a significant food source for some birds. Hamilton (1933) noted that the winter stonefly *Allocapnia recta* constituted an important food source for five species of passerine birds. In Saskatchewan, *Pteronarcys dorsata* nymphs have been found in crops of the Common Merganser (H. Stelfox, pers. comm.).

Generally stoneflies are restricted to well-oxygenated, unaltered streams and so have been used as indicators of water purity. Roback (1974) examined 23 species of stoneflies and found that none occurred in dissolved oxygen concentrations of less than four parts per million (ppm.), alkalinity greater than 1000 ppm., or chloride greater than 1000 ppm. Gaufin (1958) found that fewer stonefly species occurred in the zone of degradation than in the zone of clean water in a polluted stream, and none were found in extremely polluted water.

Taenionema pacifica is a minor pest in orchards in the Pacific Northwest. It has been reported feeding on foliage, buds and fruit of apricots, peaches and plums (Newcomer , 1918, 1933).

Claire and Phillips (1968) observed nymphs of *Hesperoperla pacifica* attacking and killing eggs and alevins of rainbow trout (*Salmo gairdneri*) and cut-throat trout (*Salmo clarki*). However, Nicola (1968) found that scavenging by stonefly nymphs (*Alloperla* sp.) on dead salmon eggs was beneficial since it prevented the spread of fungal infestation to living eggs.

Macy and Bell (1968) found that *Hesperoperla pacifica* was an alternate intermediate host to an internal parasite of birds. Hall and Groves (1963) noted that cercariae of seven of nine trematode

species harboured in river snails entered nymphs of *Hesperoperla pacifica*.

The study area

The limits of the study area were the political boundaries of Saskatchewan. Battle Creek in Cypress Hills was most easily accessible for collecting near Reesor Lake, Alberta, about one-half mile west of the Saskatchewan border. Battle Creek flows east into Saskatchewan, and since stoneflies collected here undoubtedly occurred in Saskachewan also, species collected near Reesor Lake were considered part of the Saskatchewan fauna.

Saskatchewan encompasses a wide range of vegetational, climatic and geological zones. Two of the major North American vegetational zones are represented in the province: Grassland in the semi-arid climate of the southwest, and Boreal Forest in the subhumid north (Coupland and Rowe, 1969).

The southern Grassland zone is mainly higher than 600 meters above sea level and composed of extensive till and lacustrine plain overlaying Cretaceous rock (Richards, 1969). The major drainage basin in the Grassland region is the extensive Saskatchewan River System composed of the North and South Saskachewan Rivers which unite near the edge of the Boreal Forest zone to form the Saskatchewan River. The flow is to the northeast, eventually into Hudson Bay. The Saskatchewan River System is fed both by prairie surface runoff and by snowmelt near its source in the Rocky Mountains resulting in a definite water flow regime (Raby and Richards, 1969). Relatively low winter flows are followed by a rise in early spring when there is snowmelt in the prairies and foothills. After a spring peak, flow tends to decrease but rises again in May-June because of meltwater runoff from the Rocky Mountains. Declining flow leads to low flows in August and September with an even base-flow maintained in winter months.

In the southwestern corner of Saskatchewan, rolling plains gradually rise to the Cypress Hills uplands which reach a maximum elevation of 1393 m, the highest in the province. The highest parts of Cypress Hills are believed to have been unglaciated (Richards, 1969). Battle Creek, which flows through some of the highest Cypress Hills elevations, and Frenchman River which flows down the eastern slope of Cypress Hills, are the two prominent rivers of this area.

The Boreal Forest zone, mostly between 365 and 550 m above sea level, is an area of lakes, bogs, coniferous and mixedwood forest and rock outcrop. In the far north, east of Lake Athabasca, is subarctic lichen-woodland of open coniferous forest and reindeer moss. Extending southward to the Churchill River System is the northern coniferous forest of spruce and pine underlain mainly by Precambrian rock. To the south of the Canadian Shield, soils deepen over sedimentary rock and spruce, pine and poplar are abundant. The southern edge of the Boreal Forest is the aspen belt, transitional between Boreal Forest and Grassland. It is composed mainly of deciduous trees and a variety of shrubs and grasses on rich grey-black soils (Coupland and Rowe, 1969).

On the Shield much of the drainage flows southward to the Churchill River System or to Lake Athabasca in the northwest. Northeastern drainage is primarily to Reindeer Lake and Wollaston Lake. In the Boreal Forest zone, practically any depression in the bedrock is occupied by a lake, bog, or marsh. Streams and rivers are numerous and because of climate and other factors, water levels fluctuate far less than in the south.

MATERIALS AND METHODS

Collection sites

Many areas of the province were collected extensively. These included Cypress Hills, the Saskatchewan River System and much of the boreal forest region. Collecting trips to rivers and creeks

in southcentral and southeastern Saskatchewan produced no specimens so this area was sampled only superficially. In addition, access roads are poor or nonexistent in the northeastern (north of Southend, Sask.) and northwestern (north of Buffalo Narrows, Sask.) parts of the province, so collections are meagre from these areas. Extensive collecting in this far northern region may lead to new provincial records and certainly will modify some of the distributions presented here.

Collection and preservation of specimens

Stonefly nymphs were most commonly collected with a sweep net where one stirs up the river substrate with the feet while walking backward against the current. Stonefly nymphs which had been dislodged from the rocks were carried by the current into the net. The net content was examined for stoneflies by placing it in a white pan with water in the bottom.

Another collection method was simply to examine such submerged objects as rocks or logs by hand-picking and to remove any stoneflies present. Mature final-instar nymphs were collected from rocks close to shore where they had crawled to emerge. The latter method was ideal for streams too small to use the sweep net in, but was less productive than sweeping in larger, more swiftly flowing rivers. Cast skins were found under bridges, on rocks near streams, or on vegetation which borders streams. Nymphs and cast skins were preserved in 70-90 percent alcohol.

In order to rear nymphs for associations with known adults, they were transported to the laboratory in glass bottles or Nalgene plastic bottles containing river water. Since the survival rate of Plecoptera was higher when kept cool, these containers were placed in an ice chest during the period of transit. Periodic oxygenation with a battery operated airpump or replacement of the water in the container with fresh water was necessary on long trips.

Adults were collected by rearing mature nymphs in laboratory aquaria, by sweeping vegetation near streams with an aerial net or by examining bridges, posts, or tree trunks near flowing water. Some adults hide under rocks near the shore and were collected by turning over the rocks. Winter stoneflies (*Capnia*, *Oemopteryx*, *Taeniopteryx*, *Utacapnia*) were collected in large numbers on the snow and ice of river banks, or on bridges. Adults of *Paracapnia* were collected by throwing panfuls of water onto the riverbank. In a few minutes the adults were flooded out of cavities in the ground and were collected with forceps. Although a few species are known to come to light traps, such equipment was not used in this study. Since stoneflies are weak fliers, finding adults was often more difficult than capturing them.

Adults were preserved in 70-90 percent alcohol. Specimens of certain species changed color in alcohol. Adults of *Hastaperla* and *Suwallia* which were bright yellow in life, and *Triznaka* which were green, faded to white when preserved.

Rearing

Rearing nymphs to adults was necessary in order to associate the immature and adult stages of the life cycle. Two methods were used: the first was similar to that described by Smith (1975). An aquarium with dimensions of 1.7 x 0.3 x 0.3 m was filled with cold tap water and dechlorinated using two drops per gallon of a sodium thiosulfate solution (700 grams sodium thiosulfate per liter of water). The water was vigorously aerated, and cooled somewhat by running tap water through glass tubing in the bottom of the aquarium.

Plastic sheets of dimensions 29 cm x 45 cm were suspended from the edge of the aquarium just above the surface of the water. These sheets contained several holes, into which the rearing containers were fitted (Fig. 16). Rearing containers were made from sections of Nitex screening, with a 0.33 mm mesh size glued together to form a tube. A circular piece of screening glued to the lower end of the Nitex tube formed the bottom and a piece of plastic tubing covered with Nitex screening formed the lid

(Fig. 17). The rearing container was then fitted through a hole in the plastic sheet but the upper portion rested on top of the sheet. A mature nymph placed in the container was able to crawl up the screening and out of the water when emerging. The lid prevented escape of the adult. In instances where it was necessary to rear nymphs which were not mature, the appropriate food could be placed in the container with the nymph. Detrivorous species were given dead leaves which had soaked for months in water; carnivorous species were supplied with larval mayflies, caddisflies or other stoneflies.

Rearing of stonefly nymphs which emerge in early spring required temperatures in aquaria of about 1 C to 5 C, much colder than were possible in the apparatus just described, which was kept in a laboratory at room temperature. The second rearing method used was similar to the one described by Sawchyn (1971). Containers with nymphs in them were kept in a Sherer-Gillet controlled-environment cabinet with temperature and photoperiod controls. Temperatures could be maintained within ±1 C of the desired level and the fluorescent lights were controlled by timers. The rearing chambers each consisted of an outside plexiglass vessel measuring 28 x 18 x 10 cm, each holding 15 containers. The cylindrical containers had a frame of plexiglass and were covered with a plastic screening of 8 meshes per cm. The cylinders were suspended in the vessel by wires so that there was sufficient room for mature nymphs to crawl out of the water to emerge. Plastic petri dishes (#1007), placed over the chamber tops, prevented escape of adults. Dechlorinated tap water was used, and aeration was provided by a Model 120 Silent Giant pump.

Clearing of genitalia

It was unnecessary to clear genitalia of Plecoptera in order to observe taxonomic details. Abdominal sclerites of some specimens were contracted when preserved in alcohol, but after placing the abdomen in KOH at room temperature for 5–6 hours, the contracted sclerites were gently pulled apart. This enabled more efficient examination of the genitalia.

Material examined and its disposition

Material examined in this study was based primarily on collections made during the spring and summer of 1974 and 1975 with a few specimens collected in 1976.

In addition, I have examined Saskatchewan material from the personal collections of Drs. D.M. Lehmkuhl and D.J. Larson, Mr. D.H. Smith, and Mr. Ron Demaray. I have also examined some material collected from Stoney Rapids and Black Lake by Mr. L. Kratt and from the Churchill River and Cluff Creek in the collections of the Saskatchewan Research Council.

I was unable to collect either males or females of certain species, but I was usually able to borrow missing specimens from the personal collection of W.E. Ricker for drawings.

Small representative collections of Saskatchewan Nemouridae and Perlidae were sent to R.W. Baumann (Brigham Young University, Provo, Utah) and to B.P. Stark (Mississippi College, Clinton, Miss.), respectively. The Churchill River and Cluff Creek collections remain with the Saskatchewan Research Council. Most of the remaining specimens from other sources have been returned to their collectors. The remainder of the material is in my collection.

Illustrations

Line drawings, prepared using the camera lucida, and photographs using the Zeiss Tessovar photographic unit, are presented to illustrate taxonomic keys and augment descriptions. Illustrations of homologous structures in related species are from the same aspect.

Terms

Most terms for insect structures are based on the usage of Snodgrass (1935). Those specific to Plecoptera are from Needham and Claassen (1925), Frison (1935, 1942), Ricker (1943, 1949, 1952, 1959, 1965), Hanson (1946) and Ricker and Ross (1969). The nomenclature for wing venation follows the system proposed by Comstock and Needham (1898-1899). The section on Morphology (page six) provides a discussion of some of the taxonomically useful characters and includes some explanation of the most important terms.

Verification of species identifications

With the exceptions of *Perlesta placida* (Hagen) and *Isoperla marlynia* Needham and Claassen, all species described in this study have been verified. However, since these two species are particularly distinctive, there is little doubt that my identifications are correct. R.W. Baumann of Brigham Young University, Provo, Utah verified the Nemouridae, and W.E. Ricker of the Fisheries Research Board of Canada, Nanaimo, B.C. confirmed the remainder of the species identifications.

Organization of family, genus and species accounts

The systematic arrangement used for all taxa is that of Illies (1966) and Zwick (1973). A systematic list of Saskatchewan stoneflies is presented in Table 1. Descriptions of each family and genus represented in Saskatchewan are presented after the keys. Information for these descriptions was obtained from Needham and Claassen (1925), Claassen (1931), Frison (1935, 1942a), Ricker (1943, 1952), Gaufin *et al.* (1972) and Hitchcock (1974) as well as from my collections.

For genera with more than one species known from Saskatchewan, a key to adults is provided, and keys to nymphs are given where possible.

Each species heading is followed by a list of references pertaining to the species. No attempt was made to include complete synonomies but the references indicate the various names proposed for each species and may include important taxonomic studies, faunal works, catalogue listings and biological studies.

The North American range of species is outlined in very general terms from published distributional records. Saskatchewan locality records for each species are listed and are plotted on a map.

Measurements are presented at the beginning of species descriptions; length is measured from the most anterior portion of the head to the tip of the folded wings and for brachypterous specimens is from the anterior margin of the head the end of the abdomen.

The species description is a diagnostic statement presenting the principal characters which separate males, females, and nymphs of the species from related forms, even though the related types may not occur in Saskatchewan.

Illustrations augment keys and descriptions. Drawings of male and female genitalia are given for nearly every species. For species where representatives were not collected in this study, and were not borrowed from W.E. Ricker for examination, drawings are not presented.

Table 1. Systematic List of the Stoneflies of Saskatchewan.

ORDER PLECOPTERA

Family Pteronarcidae

Genus *Pteronarcys* Newman 1838
Pteronarcys dorsata (Say) 1823
Genus *Pteronacella* Banks 1900
Pteronarcella badia (Hagen) 1873

Family Taeniopterygidae

Genus *Taeniopteryx* Pictet 1841
Taeniopteryx nivalis (Fitch) 1847
Genus *Oemopteryx* Klapálek 1902
Oemopteryx fosketti (Ricker) 1965

Family Capniidae

Genus *Capnia* Pictet 1841
Capnia confusa Claassen 1936
Capnia coloradensis Claassen 1937
Capnia gracilaria Claassen 1924
Capnia vernalis Newport 1848
Genus *Utacapnia* Nebeker and Gaufin 1971
Utacapnia trava (Nebeker and Gaufin) 1965
Genus *Isocapnia* Banks 1938
Isocapnia crinita (Needham and Claassen) 1925
Isocapnia missourii Ricker 1959
Genus *Paracapnia* Hanson 1946
Paracapnia angulata Hanson

Family Nemouridae

Genus *Nemoura* Latreille 1976
Nemoura rickeri Jewett 1971
Genus *Podmosta* Ricker 1952
Podmosta delicatula (Claassen) 1923
Genus *Zapada* Ricker 1952
Zapada cinctipes (Banks) 1897
Genus *Amphinemura* Ris 1902
Amphinemura linda (Ricker) 1952
Genus *Shipsa* Ricker 1952
Shipsa rotunda (Claassen) 1923
Genus *Malenka* Ricker 1952
Malenka californica (Claassen) 1923

Family Leuctridae

Genus *Leuctra* Stephens 1835

Leuctra ferruginea (Walker) 1852
Genus *Paraleuctra* Hanson 1941
Paraleuctra vershina Gaufin and Ricker 1975

Family Chloroperlidae

Genus *Hastaperla* Ricker 1935
Hastaperla brevis (Banks) 1895
Genus *Suwallia* Ricker 1943
Suwallia lineosa (Banks) 1918
Genus *Triznaka* Ricker 1952
Triznaka signata (Banks) 1895

Family Perlidae

Genus *Paragnetina* Klapalek 1907
Paragnetina media (Walker) 1852
Genus *Claassenia* Wu 1934
Claassenia sabulosa (Banks) 1900
Genus *Acroneuria* Pictet 1841
Acroneuria lycorias (Newman) 1839
Acroneuria abnormis (Newman) 1838
Genus *Hesperoperla* Banks 1938
Hesperoperla pacifica (Banks) 1900
Genus *Perlesta* Banks 1906
Perlesta placida (Hagen) 1861

Family Perlodidae

Genus *Arcynopteryx* Klapalek 1904
Arcynopteryx compacta (MacLachlan) 1872
Genus *Skwala* Ricker 1943
Skwala parallela (Frison) 1936
Genus *Diura* Billberg 1820
Diura bicaudata (Linnaeus) 1758
Genus *Isogenoides* Klapálek 1758
Isogenoides colubrinus (Hagen) 1874
Isogenoides frontalis (Newman) 1838
Genus *Isoperla* Banks 1906
Isoperla bilineata (Say) 1823
Isoperla decolorata (Walker) 1852
Isoperla longiseta Banks 1906
Isoperla marlynia Needham and Claassen 1925
Isoperla patricia Frison 1942
Isoperla petersoni Needham and Christensen 1927
Isoperla transmarina (Newman) 1838

SYSTEMATICS

The following keys to families and genera apply only to stoneflies known from Saskatchewan, and are modified from Needham and Claassen (1925), Harper and Hynes (1971b, 1971d), Gaufin *et al.* (1972) and Hitchcock (1974). Keys for nymphs will not separate the very early instars.

Key to families and genera of adult Plecoptera known from Saskatchewan

1		Paraglossae and glossae subequal in length (Fig. 21)	2
1′		Paraglossae much longer than glossae (Fig. 20)	23
2	(1)	Remnants of branched gills on abdominal segments 1 and 2 (Fig. 6, 7); anal area of forewing with two or more rows of crossveins ..... Pteronarcidae	3
2′		No gill remnants on abdominal segments 1 and 2; anal area of forewing without crossveins or with only one row of them (Fig. 33, 34, 36, 37, 39)	4
3	(2)	Gill remnants on abdominal segment 3 (Fig. 7) ..... *Pteronarcella*, p.	21
3′		Gill remnants absent from abdominal segment 3 (Fig. 6) ..... *Pteronarcys*, p.	19
4	(2′)	Tarsal article 2 much shorter than article 1 in lateral view (Fig. 23)	6
4′		Article 2 at least as long as article 1 in lateral view (Fig. 22) ..... Taeniopterygidae	5
5	(4′)	Each coxa with small, round membranous areas on its ventral surface; male cercus with one article (Fig. 40, 43); female sternum 9 without long projection extended across sternum 10 (Fig. 44) ..... *Taeniopteryx*, p.	22
5′		Coxae without membranous areas on ventral surfaces; male cercus with at least 3 articles (Fig. 42); female sternum 9 with long projection extended across sternum 10 (Fig. 45) ..... *Oemopteryx*, p.	23
6	(4)	Cercus of more than one article (Fig. 50–72); A_2 of forewing unbranched (Fig. 37) ..... Capniidae	20
6′		Cercus of only one article (Fig. 73-92); A_2 of forewing branched (Fig. 34, 36)	7
7	(6′)	Wings flat at rest; last article of labial palpus in ventral view subcircular, larger than subterminal article (Fig. 29) ..... Nemouridae	9
7′		Wings rolled around body at rest; last article of labial palpus in ventral view longer than wide, equal in length to subterminal article (Fig. 21) ..... Leuctridae	8
8	(7′)	m-cu of hindwing connected to Cu_1 before it divides (Fig. 36); male cercus normal, without point or projections (Fig. 84) ..... *Leuctra*, p.	41
8′		m-cu crossvein of hindwing connected to Cu_1 after it divides (Fig. 34); male cercus with sharp projections or pointed (Fig. 81, 83) ..... *Paraleuctra*, p.	42
9	(7)	Males: Supra-anal process present (Fig. 73-77, 79); flaplike ventral lobe arising from base of 8th abdominal sternum (Fig. 78, 80)	15
9′		Females: no supra-anal process; no ventral lobe; 8th abdominal sternum modified as subgenital plate (Fig. 85–90)	10
10	(9′)	Gill remnants under neck or head (Fig. 10)	11
10′		Gill remnants absent	13
11	(10)	Gills of most specimens of five branches ..... *Zapada*, p.	36
11′		Gills with six or more branches	12

12 (11′) 7th abdominal sternum with large, sclerotized posterior projection which extends onto 8th sternum (Fig. 88) ..... *Amphinemura*, p. 37
12′ 7th abdominal sternum with small pointed posterior projection not extended onto 8th sternum (Fig. 85) ..... *Malenka*, p. 39
13 (10′) Sternum 7 sclerotized, produced over full length of 8, its hind margin straight to broadly rounded (Fig. 89) ..... *Nemoura*, p. 34
13′ Sternum 7 only slightly or not at all produced over 8; though the narrowly rounded margin of the subgenital plate of the sternum 8 in *Shipsa* may be mistaken for sternum 7 14
14 (13′) Sternum 8 with subgenital plate terminated anterior to its well-developed hind margin (Fig. 87) ..... *Shipsa*, p. 38
14′ Sternum 8 with narrow median sclerotized band contrasted sharply with unsclerotized field at either side (Fig. 90) ..... *Podmosta*, p. 35
15 (9) Gills present, cervical (Fig. 10) 16
15′ Gills absent 18
16 (15) Gills of most specimens with five branches ..... *Zapada*, p. 36
16′ Gills with six or more branches 17
17 (16′) Cerci with mesobasal lobe (Fig. 73) ..... *Malenka*, p. 39
17′ Cerci without mesobasal lobe (Fig. 77) ..... *Amphinemura*, p. 37
18 (15′) Cerci elongate, heavily sclerotized distally, inner surface membranous, tip sharp or with two or more processes (Fig. 79, 80) ..... *Nemoura*, p. 34
18′ Cerci membranous or weakly sclerotized, tip blunt, without spines or processes (Fig. 75, 76) 19
19 (18′) Sides of 10th tergum produced into erect in-curved spiny processes (Fig. 75) ..... *Shipsa*, p. 38
19′ Sides of 10th tergum not as above (Fig. 76) ..... *Podmosta*, p. 35
20 (6) Male supra-anal process simple, comprised of one element; female subgenital plate without notch or conspicuous pattern 21
20′ Male supra-anal process of two distinct elements, one dorsal one ventral (Fig. 50, 51); female subgenital plate slightly notched, sternum 8 with conspicuous pattern (Fig. 69) ..... *Utacapnia*, p. 31
21 (20) R_1 of forewing strongly bent upward at origin, A_1 bent abruptly caudad at junction of cu-a, then curved laterad (Fig. 37) ..... *Capnia*, p. 26
21′ R_1 and/or A_1 of forewing straight (Fig. 33, 39) 22
22 (21′) Prothoracic and mesothoracic presterna broadly united with basisterna (Fig. 18); forewing R_1 straight at origin (Fig. 39); male with lobe on 9th sternum (Fig. 62) ..... *Isocapnia*, p. 32
22′ Prothoracic and mesothoracic presterna separated from basisterna (Fig. 19); R_1 of forewing slightly curved upward at origin (Fig. 33); male 9th sternum without lobe ..... *Paracapnia*, p. 25
23 (1′) remains of branched gills at lower angles of thorax; cu-a of forewing in most specimens either in anal cell or distant from it by no more than its own length 24
23′ Remains of branched gills absent from thorax; cu-a, if present, generally distant from anal cell by more than its own length (Fig. 32, 35, 38) 28
24 (23) Males with raised knob or "hammer" on 9th sternum (Fig. 9); female subgenital plate without deep notch (Fig. 99, 100, 104, 106) 26
24′ Males without "hammer" on 9th sternum, female subgenital plate deeply notched 25

25 (24′) Distinct Y-shaped mesosternal ridge pattern (Fig. 24, 25) hind margin of male 10th tergum deeply cleft, with dorsal projections (genital hooks) extended forward from sides of the cleft; female subgenital plate not hairy (Fig. 105) ..... *Paragnetina*, p. 46

25′ Mesosternal ridge pattern not in distinct, dark Y-shape; hind margin of male 10th tergum not cleft, no dorsal projections on 10th tergum, paraprocts joined; female subgenital plate covered with long hairs ..... *Perlesta*, p. 52

26 (24) Male tergum 10 with hooks arising from lateral angles; paraprocts normal (Fig. 8) ..... *Claassenia*, p. 48

26′ Male tergum 10 unmodified; paraprocts formed as recurved hooks (Fig. 101-103) 27

27 (26) Subanal lobes of male very broadly triangular, terga 9, 10 not covered with spinules (Fig. 101); female subgenital plate considerably produced (Fig. 104) ... *Hesperoperla*, p. 51

27′ Subanal lobes of male slender hooks, terga 9 and 10 with many spinules (Fig. 102, 103); female subgenital plate little if any produced(Fig. 99, 100) ..... *Acroneuria*, p. 49

28 (23′) A_2 of forewing either not forked or forked beyond anal cell (i.e., two main anal veins, and 2nd of which is forked in some species)(Fig. 32) ..... Chloroperlidae 29

28′ Fork of A_2 of forewing included in anal cell, so that two branches leave cell separately (i.e., there are three main anal veins)(Fig. 35, 38) ..... Perlodidae 31

29 (28) Anal area of hindwing apparently absent (Fig. 32) ..... *Hastaperla*, p. 43

29′ Anal area of hindwing present 30

30 (29′) Head unmarked except for ocellar rings (Fig. 163); males with finger-like process directed inward from basal article of each cercus (Fig. 95); female subgenital plate emarginate (Fig. 98) ..... *Suwallia*, p. 44

30′ Head with conspicuous markings of black on yellow, ocellar triangle dark with anterior mark on head as long as broad (Fig. 164); no process at base of male cerci (Fig. 94); female subgenital plate broadly rounded (Fig. 97) ..... *Triznaka*, p. 45

31 (28′) Males: paraprocts modified as recurved hooks, or considerably produced posterad, or genitalia complicated by various stylets and sclerotized areas 32

31′ Females: paraprocts unmodified; genitalia simple, 8th sternite generally produced as genital plate 36

32 (31) 10th tergum completely cleft; genitalia complicated by stylets or various unsclerotized structures (Fig. 110, 111) ..... Isogeninae 33

32′ 10th tergum entire, at most slightly notched; genitalia simple (Fig. 107) 35

33 (32) Wings with four-to-many crossveins beyond cord, generally arranged in irregular network (Fig. 35); 7th sternum without lobe 34

33′ Wings with no more than two crossveins beyond cord (Fig. 38); 7th sternum generally with lobe ..... *Isogenoides*, p. 55

34 (33) Supra-anal process very long, needle-like; lateral stylets absent (Fig. 113) ..... *Arcynopteryx*, p. 53

34′ Supra-anal process blunt, not unusually long; lateral stylets present (Fig. 112) ..... *Skwala*, p. 54

35 (32′) Paraprocts produced postero-mesad, meeting along their inner faces (Fig. 107); no lobe on 8th sternum ..... Perlodinae ..... *Diura*, p. 55

35′ Paraprocts forked as hooks or only slightly modified (Fig. 117-123); 8th sternum always with a lobe ..... Isoperlinae ..... *Isoperla*, p. 57

36 (31′) Numerous irregular crossveins between Rs and R (Fig. 35) 37
36′ Apical crossveins few or absent 38
37 (36) Subgenital plate generally produced more than halfway across ninth sternum; caudal margin slightly emarginate (Fig. 115) ..... *Arcynopteryx*, p. 53
37′ Subgenital plate generally produced less than halfway across ninth sternum; caudal margin straight (Fig. 114) ..... *Skwala*, p. 54
38 (36′) Submental gills present (Fig. 20) ..... *Isogenoides*, p. 55
38′ Submental gills absent 39
39 (38′) General color dark brown with yellow median stripe on pronotum; hairs on margin of groove in femur of proleg not noticeably longer than other hairs on femur; subgenital plate produced halfway or more across 9th sternum (Fig. 108, 109) ..... *Diura*, p. 55
39′ Not as above ..... *Isoperla*, p. 57

Key to families and genera of Plecoptera nymphs known from Saskatchewan

1 Glossae and paraglossae subequal in length (Fig. 21) 2
1′ Paraglossae extended greatly beyond glossae (Fig. 20) 16
2 (1) Branched gill tufts on abdominal segments 1 and 2 (Fig. 6, 7) ..... Pteronarcidae 3
2′ Branched gill tufts absent from abdominal segments 1 and 2 4
2 (2) Gill tufts on first two abdominal segments (Fig. 6) ..... *Pteronacys*, p. 19
3′ Gill tufts on first three abdominal segments (Fig. 7) ..... *Pteronarcella*, p. 21
4 (2′) Tarsi in lateral view with 2nd article much shorter than 1st (Fig. 23) 6
4′ Tarsi in lateral view with 2nd article at least as long as 1st (Fig. 22) 5
5 (4′) A single retractile gill on each coxa (Fig. 13) ..... *Taeniopteryx*, p. 22
5′ No coxal gills ..... *Oemopteryx*, p. 23
6 (4) Extended hind legs exceed end of abdomen; hindwing pads divergent from axis of body (Fig. 14); cervical gills present in some species (Fig. 11, 12) ..... Nemouridae 7
6′ Extended hind legs not exceeding end of abdomen; hindwing pads subparallel to axis of body (Fig. 15); gills absent 11
7 (6) Species with four prosternal gills (Fig. 11, 12) 8
7′ Species without gills 9
8 (7) Prosternal gills commonly five-branched (Fig. 11) ..... *Zapada*, p. 36
8′ Prosternal gills with six or more branches (Fig. 12) ..... *Malenka*, p. 39, *Amphinemura*, p. 37
9 (7′) Pronotum with well-defined lateral fringe of hairs (Fig. 146) ..... *Nemoura*, p. 34
9′ Pronotum without definite fringe of hairs; bristles on lateral margins of pronotum may sometimes be longer than dorsal bristles, but are never set in a distinct line 10
10 (9′) Femora with continuous fringe on long silky hairs; legs banded ..... *Shipsa*, p. 38
10′ Femora without fringe; legs not banded ..... *Podmosta*, p. 35
11 (6′) First eight abdominal segments divided to tergum and sternum by membranous fold (Fig. 138-140) ..... Capniidae 13
11′ First six or less abdominal segments divided to tergum and sternum by membranous fold (Fig. 27) ..... Leuctridae 12
12 (11′) First four abdominal segments divided laterally (Fig. 27); labial palpi extended well beyond paraglossae (Fig. 21) ..... *Leuctra*, p. 41

12′		First six abdominal segments divided laterally; labial palpi extended approximately to tip of paraglossae ... *Paraleuctra*, p.	42
13	(11)	Long swimming hairs along cerci (Fig. 26) ... *Isocapnia*, p.	32
13′		Cerci without long swimming hairs ...	14
14	(13′)	Body with numerous conspicous bristles; head capsule with reticulate purplish pattern ... *Paracapnia*, p.	25
14′		Bristles inconspicuous; head capsule without elaborate pattern ...	15
15	(14′)	Erect bristles on posterior margin of abdominal terga very long, nearly as long as mid-dorsal length of segment ... *Utacapnia*, p.	31
15′		Erect bristles shorter, half (or less) mid-dorsal length of tergum (Fig. 138-140) ... *Capnia*, p.	26
16	(1′)	Tufts of filamentous gills on thorax ... Perlidae ...	17
16′		Thoracic gills absent ...	21
17	(16)	Spinules or long hairs set in row across back of head forming occipital ridge (Fig. 4, 5) .	18
17′		No spinules in row across back of head except near hind margin of eye (i.e., no occipital ridge)(Fig. 2) ...	20
18	(17)	Subanal gills absent (Fig. 5) ... *Paragnetina*, p.	46
18′		Subanal gills present (Fig. 4) ...	19
19	(18′)	Abdomen with numerous "freckles" ... *Perlesta*, p.	52
19′		Abdomen without numerous "freckles", but uniformly brown above (Fig. 4) ... *Claassenia*, p.	48
20	(17′)	Head with central light spot anterad of median ocellus (Fig. 3) ... *Hesperperla*, p.	51
20′		Head without central light spot; with a light M-pattern in front of anterior ocellus (Fig. 1, 2) ... *Acroneuria*, p.	49
21	(16′)	Hindwing pads at angle to axis of body (Fig. 168); cerci as long as, or longer than, abdomen; body commonly patterned; particles of maxillary palpus evenly tapered from 1st to 5th (Fig. 170) ... Perlodidae ...	24
21′		Hindwing pads subparallel to axis of body (Fig. 159); cerci three-quarters length of abdomen; body usually uniformly brown; last article of maxillary palpus abruptly thinner than previous articles (Fig. 162) ... Chloroperlidae ...	22
22	(21′)	Inner margin of hindwing pads straight; body of mature nymph 7 mm or less ... *Hastaperla*, p.	43
22′		Inner margin of hindwing pads sinuate or notched (Fig. 159); body of mature nymph larger than 7 mm ...	23
23	(22′)	Abdominal terga each with two light colored spots laterally, and central median stripe (Fig. 159) ... *Triznaka*, p.	45
23′		Abdomen uniformly brown above ... *Suwallia*, p.	44
24	(21)	Arms of mesosternal Y-ridge approach or meet anterior corners of furcal pits (Fig. 25) .	25
24′		Arms of mesosternal Y-ridge meet posterior corners of furcal pits (Fig. 24) ...	26
25	(24)	Denticles numerous along both sides of outer cusps of both mandibles (Fig. 28) ... *Skwala*, p.	54
25′		Denticles absent from cusps of nymphal mandible, or a few present on outer left cusp only ... *Arcynopteryx*, p.	53
26	(24)	Single fingerlike gills at each basal corner of submentum (Fig. 20) ... *Isogenoides*, p.	55
26′		Submental gills absent ...	27
27	(26′)	Abdominal terga dark, with two dorsolateral spots and a few small lateral spots;	

lacinia of maxilla with sharp angle below small tooth (Fig. 30) ..... *Diura*, p. 55

27′ Abdominal terga with longitudinal or transverse markings or dark dots (Fig. 168); lacinia without sharp angle low small tooth, rounded or, more commonly, tapered from tooth to base (Fig. 170) ..... *Isoperla*, p. 57

Family Pteronacidae

Pteronacids are large, primitive stoneflies occurring in North America and eastern Asia. They are characterized by many-articled cerci, long antennae and wings with numerous cross-veins. The adult male has no vesicle on the ninth sternum and has a conspicuous epiproct and paraprocts on the cleft 10th tergum. Nymphs have gill tufts on the thorax and first two abdominal segments. There are two North American genera in this family; both occur in Saskatchewan.

Genus *Pteronarcys* Newman

Ricker (1925) proposed two subgenera of *Pteronarcys*, *Allonarcys* and *Pteronarcys sensu strictu*, which were later ranked as genera by Illies (1966). *Allonarcys* occurs in eastern North America and adults are characterized by an upright epiproct, cupped paraprocts, the ninth sternum unnotched and without peglike setae at the tip, divided hemitergal lobes on the male tenth tergum and produced female subgenital plates. Nymphs have paired lateral projections on abdominal segments. *Pternarcys* adults differ by having massive epiprocts, fleshy, rounded paraprocts, the ninth sternite notched and with peglike setae near the tip, hemitergal lobes on the tenth tergite projected posterad (Fig. 46), and unproduced female subgenital plates (Fig. 47, 48). Nymphs lack paired lateral projections of the abdominal segments. Six species of *Pteronarcys* are known in North America and the range of one species extends into Saskatchewan.

Pteronarcys dorsata Say
(Fig. 6, 46-48, 180)

Sialis dorsata (Say) 1823: 164.

Pteronarcys dorsata, Frison 1942a: 242.– Harden and Mickel 1952: 9. – Ricker 1964: 68. – Hitchcock 1974: 234. – Baumann, Gaufin, and Surdick 1977: 116.

Pteronarcys dorsata, the one species of this genus found in Saskatchewan, has a transcontinental distribution which extends from Laborador to Alaska, south in the Rockies to Wyoming and in the east to the Great Lakes and south to Georgia. Previous Saskatchewan records include Cushing's (1961) report from Montreal River, Ricker's (1944) record from Wapus River in the Reindeer Lake region, a record from Saskatchewan River (Smith, 1917) and a report from the South Saskatchewan River at Saskatoon (Ricker, 1946). New Saskatchewan records (Fig. 180) include: North Saskatchewan River at Jct. Hwy. 5 (Borden Bridge) and at the ferry 10 mi. E. of Prince Albert, Sask.; South Saskatchewan River at ferry N of Birch Hills, Sask. and at the ferry N. of Lemsford, Sask.; Nipekamew River, Jct. Hwy. 165; Weyakwin River, Jct. Hwy. 2; Waskesiu River, Jct. Hwy. 2; Torch River, Jct. Hwy. 106; Arsenault River, Jct. Hwy. 104; Nemeiben River, Jct. Hwy. 2; Puskwakau River, Jct. Hwy. 2; Puskwakau River, Jct. Hwy. 106; river at mile 34, Jct. Hwy. 105; creek at mile 120, Jct. Hwy. 105; stream 85 mi. N. of La Ronge, Sask., Jct. Hwy. 102; Battle River, 4 mi. S. of Lashburn, Sask.; Overflowing River, Jct. Hwy. 109; Jackfish Creek, Jct. Hwy. 8; Meeyomoot River, Jct. Hwy. 165;

McDougal Creek, Jct. Hwy. 120; Bear River, Jct. Hwy. 106; Martineau River, Jct. Hwy. 55; Mackay Creek, Jct. Hwy. 2; Mackenzie Creek, near Hwy. 165; Bow River, Jct. Hwy. 165, Swan River, Jct. Hwy. 8; Ballantyne River, Jct. Hwy. 106; Churchill River, Jct. Hwy. 2, Wintego Lake Rapids, and Iskwatam lake; Fond du Lac River at outflow of Black Lake; stream at mile 30, Wollaston Lake Road; Caribou Creek, Jct. Hwy. 106; Red Deer River, 2 mi. S. of Hudson Bay, Sask.; and Torch River, Jct. Hwy. 106.

Ricker (1964) presented a North American distribution map for the species.

Diagnostic Characters. – Average length of males, 40.0 mm; females, 60.0 mm (from anterior margin of head to tip of folded wings). Male genitalia with ninth sternum straight near tip; epiproct large, flattened, complex in shape (Fig. 46). Female subgenital plate straight, or with two small projections (Fig. 47, 48).

Nymphal females with projection on tenth tergum projected postero-dorsad to point; nymphal males with projection extended postero-ventrad with peg on caudal surface. Mature male nymphs with a nearly rectangular projection posterad on ninth abdominal sternum.

Needham and Claassen (1925), Nelson and Hanson (1971) and Hitchcock (1974) figured the adult genitalia, and Claassen (1931) figured the nymph.

Bionomics. – Nymphs of this species are common in streams and large rivers. Nymphs occur in rapids (Smith, 1917) and in trash from eddies below stony rapids (Gaufin *et al.*, 1972).

Hilsenhoff and Narf (1972) stated that the life cycle of *Pteronarcys dorsata* is at least two years in Wisconsin; the aquatic stage of *Pteronarcys californica* Newport lasts three years (Elder and Gaufin, 1973). In Saskatchewan, three size classes of *Pteronarcys dorsata* nymphs have been collected at one time, suggesting a three year life cycle. Eight mature nymphs with fully developed wing pads collected at Weyakwin River on June 9, 1975 averaged 34.2 mm long; seven immature nymphs with no wing pad development averaged 17.0 mm long and ten very immature nymphs averaged 12.3 mm in length. Eggs appear to hatch directly and nymphs are likely the overwintering stage since ten nymphs averaging 5.1 mm long were collected at the same river on July 16, 1975, about two months after adult emergence. In Saskatchewan, adult emergence occurs in early June and lasts approximately three weeks.

Pteronarcys dorsata nymphs are detrivores, eating leaves and other vegetable matter that falls into the water. They can be maintained in an aquarium on a diet of dead leaves which are skeletonized (Harden and Mickel, 1952).

Nebeker (1971a) found the longevity of adults was related inversely to the temperature at which the nymphs were maintained. At 10 C the mean life span was 36 days; it was 31 days at 15 C and 17.5 days at 20 C. It was also found that the stonefly could live at higher temperatures than levels where good development and successful emergence occurs. Highest feeding rates were observed at 20 C (no feeding occurred at 1 C and 35 C); the best temperature for emergence was 15 C. Females reared at 15 C produced, on average, 475 eggs, but at 20 C only one female oviposited and then laid only 175 eggs. Water temperature had a great influence on development: at 5 C nymphs did not develop for a nine month testing period (Nebeker, 1971a), but at a constant 20 C adults emerged five months earlier than they normally do in the field, and the separate emergence of the sexes was far more pronounced than is normal (Nebeker, 1971b).

Cushing (1961) reported collecting *Pteronarcys dorsata* in rapids of Montreal River above four associated lakes, but not in rapids below the lakes. A possible explanation for this absence was proposed by Lehmkuhl (1972), who pointed out that one major effect of a large reservoir is to alter the thermal regime of an outflowing river, making it possible for some aquatic insects to complete their life cycles in the river near the reservoir.

Genus *Pteronarcella* Banks

Adults of *Pteronarcella* resemble those of *Pteronarcys* but are only about half the size. Crossveins are fewer, and they are entirely absent from radial areas of the wing. The male ninth abdominal segment is elevated in a broad, tranversely recurved scoop-like lobe. Some of the segments above this lobe bear paired dorsal humps at the sides. At rest, the large U-shaped supra-anal process is concealed between the subanals and the divided halves of the tenth segment. Female subgenital plates are not produced over the ninth sternite (Fig. 44). Nymphs have gills on the first three abdominal segments, with the tenth segment produced into a triangular, pointed, conical process. Two species are known in North America; one is found in Saskatchewan.

Pteronarcella badia (Hagen)
(Fig. 49, 180)

Pteronarcys badia Hagen 1874: 573.
Pteronarcella triloba, Smith 1917: 461, 462.
Pteronarcella badia, Claassen 1940: 23. – Jewett 1956: 57. – Ricker 1964: 55. – Baumann, Gaufin and Surdick 1977: 112.

Pteronarcella badia, the only species of *Pteronarcella* in Saskatchewan, is common in the Rocky Mountain region and extends eastward in Montana, Utah and Arizona. New Saskatchewan records, (Fig. 180) include: Broad Creek, Jct. Hwy. 104 and Mistohay Creek, Jct. Hwy. 226.

Diagnostic Characters. – Average length, males 15.0 mm (from anterior portion of head to tips of folded wings); females, 20.0 mm. Male genitalia with appendage on ninth dorsal abdominal segment broadly rounded at apex, side margins sinuous. Hind margin of female subgenital plate rounded, truncate and slightly trilobate but not acutely notched (Fig. 49).

Nymphal gill filaments at least twice as long as basal conical process of gill tufts.

Needham and Claassen (1925), Jewett (1956), Gaufin *et al.* (1966) and Gaufin *et al.* (1972) figured the adult genitalia, and Claassen (1931) figured the nymph.

Bionomics. – Richardson and Gaufin (1971) report that nymphs generally occur in slow areas of streams in Utah and Colorado where debris collects. However, in Saskatchewan, nymphs were commonly collected from swiftly flowing areas of the streams.

Gaufin *et al.* (1972) state that the life cycle probably lasts two years. In Saskatchewan, adult emergence was during the first week of June in 1975. It appears that the eggs hatch in a short period since 11 nymphs averaging 3.9 mm long were collected in mid-July. The nymphs would be the overwintering stage.

Nymphs of *Pteronarcella badia* are predominantly herbivorous though some individuals feed on animal material when plant matter is unavailable or scarce. (Richardson and Gaufin, 1971).

Family Taeniopterygidae

Taeniopterygids have tarsal articles subequal in length; epiprocts of males are prominent and paraprocts are generally greatly modified. Adults are also characterized by cu-m intercubital crossveins. The range includes North America, Eurasia, and northern Africa.

Zwick (1973) recognized two subfamilies. Taeniopteryginae includes the single genus *Taeniopteryx*, and 13 genera are recognized in the Brachypterinae. Ricker and Ross (1975) discussed the distinguishing characters of the two subfamilies. In Brachypterinae, the male ninth sternite is scoop-like

and greatly produced beyond the tenth segment. Inner members of male subanal lobes are complex, asymmetrical and partly membranous. Male cerci have at least two articles. The female ninth sternite is produced well beyond the base of the subanal lobes and coxal gills are absent.

In Taeniopteryginae the male ninth sternite is not scoop-shaped and extends very little beyond the tenth segment. Males have simple, symmetrical and sclerotized subanal lobes, and lack a basicercal process. The female subgenital plate is somewhat produced over the tenth segment and rounded but does not extend to the subanal lobes. Male cerci have a single article and coxal gills are present. Both subfamilies of Taeniopterygidae are represented in Saskatchewan by *Taeniopteryx nivalis* of the Taeniopteryginae, and *Oemopteryx fosketti* of the Brachypterinae.

Genus *Taeniopteryx* Pictet

Nymphs of this genus have coxal gills (Fig. 13). Adults have membranous circular areas on each coxa, which represent coxal gill scars. Male paraprocts are concealed within the ninth sternite and there are usually two membranous lobes behind the female subgenital plate (Fig. 44). Eight *Taeniopteryx* species are known in North America; one species occurs in Saskatchewan.

Taeniopteryx nivalis (Fitch)
(Fig. 13, 40, 41, 43, 44, 181)

Nemoura nivalis Fitch 1847: 274.

Taeniopteryx nivalis, (in part) Needham and Claassen 1925: 240. – Harden and Mickel 1952: 12. – Ricker and Ross 1968: 1434.

Taeniopteryx maura, (in part) Frison 1942a: 248. – Jewett 1959: 55, and 1960: 151.

Taeniopteryx nivalis ranges from Laborador through Quebec and Ontario to Minnesota and south to Pennsylvania, northern Indiana and Illinois. Western records include Oregon and Alberta with this as the first Saskatchewan record. The Saskatchewan distribution (Fig. 181) includes the following localities: Waskesiu River, Jct. Hwy. 2; Crean River, Jct. Hwy. 2; Weyakwin River, Jct. Hwy. 2; Montreal River, Jct. Hwy. 2 (mile 65); Little Red River near Prince Albert, Sask.; Jackfish Creek, Jct. Hwy. 8; Torch River, Jct. Hwy. 106; McDougal Creek, Jct. Hwy. 120, Nipekamew River, Jct. Hwy. 165; and Caribou Creek, Jct. Hwy. 120.

Diagnostic Characters. – Average length males, 11.0 mm (from anterior margin of head to tip of folded wings); females, 17.0 mm. Males without spurs or other projections on hind femur; with vesicle or ventral lobe on ninth sternite, 2–3 times long as wide. Hairs on hind margin of the ninth sternite directed downward, and forward generally much shorter than those situated more anteriorly on sternite (Fig. 40). Aedeagus without brown sclerotized band between the two lateral lobes (Fig. 41). Females with strongly sclerotized V-shaped notch on eighth sternite, produced sides of the notch in contact at acute angle (Fig. 44).

Abdomen of nymph with mid-dorsal stripe or several light dots on the posterior margin of each segment. Abdominal tergites with short, thick bristles and a few long hairs on hind margins.

Needham and Claassen (1925) figured the female; Claassen (1931) and Harper and Hynes (1971c) illustrated the nymphs. Figures of the male genitalia are presented in Fig. 40, 41, and 43.

Bionomics. – Harper and Hynes (1970) determined that the life cycle of *Taeniopteryx nivalis* is univoltine; eggs are deposited in April and May, hatch directly, and nymphs diapause in an undetermined instar (4 or 5). In diapausing nymphs, fat globules accumulate, all bristles are lost, cerci are cast off, legs are folded and head and antennae are reflexed under the thorax. Diapausing nymphs

have not been found in streams probably because they burrow deep into the substratum. Summer diapause enables early instar nymphs to survive high water temperatures; later instars are extremely heat sensitive (Nebeker and Lemke, 1968). Diapause ends in late September (Harper and Hynes, 1972) and most growth occurs in winter (Harper and Hynes, 1970).

Coleman and Hynes (1970) and Harper and Hynes (1972) reported rapid growth from October through the winter months. Emergence of adults begins in mid-March and lasts about one week. Mating occurred soon after emergence. Harper and Hynes (1972) noted that oviposition began about one week after the maximum period of emergence and adults lived for about one month in the field. Under simulated stream conditions in the laboratory, egg hatching occurred about 40 days after oviposition.

In Saskatchewan, adults emerged during the end of March of 1976. Adults remained in ice cavities under bridges in early May when all other ice had melted. If removed, adults immediately crawled back to the same cavity or entered another cavity.

Harper and Hynes (1972) found that the species was primarily detrivorous, but occasionally ingested animal matter.

Genus *Oemopteryx* Klapálek

Wings of adult *Oemopteryx* lack costal crossveins and Rs and Cu_1 each have two branches. Males have two epiproct prongs which are usually set together. Outer members of the paraprocts are elongated and heavily sclerotized (Fig. 42). Female subgenital plates are variable, and nymphal characters have been little studied.

Ricker and Ross (1975) noted that there are four well-marked species groups of *Oemopteryx*, the *loewii* group from central Europe, the *contorta* group from the Appalachian Mountains, the *vanduzeea* group from California and the *glacialis* group from northeastern North America and the plains region. The one species of *Oemopteryx* known from Saskatchewan belongs to the *glacialis* group.

Oemopteryx fosketti (Ricker)
(Fig. 42, 45, 154-158, 171-176, 181)

Brachyptera fosketti Ricker 1965: 475.
Brachyptera zelona, Ricker 1965: 477.
Oemopteryx fosketti, Baumann 1973: 95. – Ricker and Ross 1975: 140

Oemopteryx fosketti is known from the North and South Saskatchewan Rivers, and has also been reported from Utah. The type locality is the South Saskatchewan River at Clarksboro, Sask. The Saskatchewan distribution (Fig. 181) includes the following localities: South Saskatchewan River at Lemsford Ferry, Saskatoon, Sask., and Ferry near Clarksboro, Sask.; and the North Saskatchewan River at Hwy. 5 (Borden Bridge).

Diagnostic Characters. – Average length, females, 10.5 mm (from anterior portion of head to tip of folded wings); males average 7.5 mm (from anterior margin of head to end of abdomen). Males brachypterous, with forewings greatly reduced (about 2.5 mm long) and upturned near the tip; hindwings narrowed and of less than normal length. Male genitalia with supra-anal process divided into four parts: basal bulb brown and smoothly rounded with low, dark, flat, conical apex next to groove separating it from anterior erect member; anterior erect member slender and curved forward with low swellings laterally near tip; posterior erect member near anterior erect member but broader and terminated in two hemispherical membranous bulges separated by angular groove; hind surface of

posterior erect member opened to membranous sleeve or posterior portion of epiproct (Fig. 42). Females with distinct subgenital plate, with hind margin anterior to the hind margin of eighth sternite; subgenital plate rounded and shallowly excavated medially (Fig. 45). The previously unknown nymph is described below.

Description. – Total length of mature nymphs: 10.5 mm (males); 12.0 mm (females).

General color dark brown to nearly black, light yellow ventrally. Head uniformly dark with few dark mottlings near antennae; antennae almost as long as body. Antennal scape and pedicel patterned dorsally as in Fig. 155. Mouthparts as in Fig. 156, 157.

Thoracic nota dark brown; mesonotum with two subrectangular patches of sclerotization at its anterolateral corners. Metanotum with anterior subrectangular sclerotized area separated by membranous area from large metathoracic sclerotized block. Wing pads of mature male nymph pointed and small (the adult is brachypterous); female wing pads normal. Legs yellowish brown, darker at joints; fringes of long hairs along femora, tibiae and tarsi.

Each abdominal tergite with anterior half dark brown, and posterior half light brown. Abdominal terga covered with long clothing hairs; the posterior tergal margin beset with very short bristles and few long hairs (Fig. 158). Sterna 1–7 unsclerotized. Cerci longer than body; cercal articles 1–8 with long bristles, about twice as long as the cercal article; the other articles with whorls of very short bristles, about one-fifth the length of the segment.

Until comparative studies are made of closely related species of this genus, distinguishing characters of the nymph of *Oemopteryx fosketti* cannot be specified.

Bionomics. – Adults emerged on April 16, 17, 18, and 19, 1975 and April 1–4, 1976, at the North Saskatchewan River near Hwy. 5 (Borden Bridge). Water temperature was 0.8 C for the 1975 dates and 1.0 C for the 1976 dates.

Males emerge earlier than females. On April 17, 1975, 121 adults were collected from a small section of the river bank; 106 were males and 15 were females. From a random sample of 79 nymphs collected the same day and reared to adults, 59 were females and 20 were males. This indicated that a significant number of females had yet to emerge. By April 19, 1975, males and females were equally abundant in collections along the river bank: of 77 adults, 41 were males and 36 were females. Earlier male emergence is not uncommon in stoneflies and has been documented for many species. Brinck (1949) suggested a definite advantage to this discrepancy between emergence of the sexes: males are fully developed and ready to mate as soon as females emerge.

Time of ice break-up is probably a critical factor in determining onset of adult emergence. On April 16, 1975, a main channel of water had just started to form but no adults had emerged. By April 17 a main water channel had formed (Fig. 176) and adults were abundant. On April 1, 1976, runoff from highway ditches had melted the river ice under Borden Bridge causing a small opening and adults were present only in this small area. When a large water channel had opened the river adults were numerous along the entire river bank.

Mating occurred immediately after emergence for *Oemopteryx fosketti*: in fact, some males attached to emerging females. After the female had completed ecdysis, they mated immediately.

Males are very active and walk about on snow searching out females (Fig. 171). Many females often remain in small cavities or pockets within the snowbanks (Fig. 172). When discovered by a male, mating usually occurs in the cavity. In one instance, a male encountered a mating pair and also attempted to mate with the female. A struggle ensued (Fig. 173) until one male was driven off. The remaining male mated with the female (Fig. 174).

Abdomens of several *Oemopteryx fosketti* were examined to ascertain degree of egg maturation. Abdomens used were taken from a mature female nymph, an emerging nymph in which the wings had

just begun to leave the nymphal wing pads, a newly emerged female, a fully emerged female collected in the field and a fully emerged female reared in the laboratory.

Abdomens were soaked in 100 percent ethanol for two periods of one hour each, benzene for one hour, one-half benzene and one-half paraffin for one hour and finally were embedded in paraffin. Abdomens were sectioned at 8 microns and placed on glass slides. The slides were dried, the paraffin removed with xylene and stained using Harris' Hematoxylin and Eosin. The tissue was then mounted using Permount. All slides were treated alike.

The eggs appeared similar in all slides studied. In a mature females the eggs stained purple, with a resistant outer covering. No difference was found in a mature female nymph – eggs were in the abdominal cavity and appeared to be as mature as those of a fully developed female. In all abdomens, the eggs appeared identical to eggs which had been deposited on the ice.

Mating soon after adult emergence and the occurrence of mature ova in newly-emerged females is probably an adaptation to the type of habitat in which *Oemopteryx fosketti* lives. After ice break-up occurs, excessive runoff from the surrounding terrain often causes flooding in the North Saskatchewan river. Since emergence occurs as soon as the ice begins to break up, ability to mate and lay eggs immediately ensures that the eggs are fertilized and deposited before the adults may be killed by a flood. Males are brachypterous and could not likely escape a high flood.

The life cycle of this species is probably similar to that described for several other winter stoneflies (Harper and Hynes, 1970). Eggs of winter stoneflies hatch within a month and early-instar nymphs are thought to diapause throughout the summer. Diapause was proposed as an adaptation to survival of high water temperatures in summer. Nymphs in a diapause-like state burrowed deep into the substratum, and this probably explains the absence of members of *O. fosketti* from summer benthic samples. When collected in September, nymphs did not seem to have made any significant growth. Most growth and development occurs during winter.

Family Capniidae

Capniids are small, dark stoneflies characterized by many-articled cerci, wings at rest folded flat on the back, the second tarsal article short, and forewings with only one or two median crossveins and one cubital crossvein. The species are arranged in two subfamilies – the Capniinae of North America, Eurasia and northern Africa, and the Notemourinae of Africa, South America, and Australia and with the single genus *Megaleuctra* in northwestern North America. Four genera of Capniinae *Paracapnia*, *Capnia*, *Utacapnia* and *Isocapnia* occur in Saskatchewan, but the Notemourinae are not known in the province.

Genus *Paracapnia* Hanson

Paracapnia members are distinct in having the mesothoracic postfurcasternal plate united with the furcasternum and the spinasternum (Fig. 19); the meso- and metafurcasternum are transverse and almost rectangular. R_1 of the forewing is bent caudally beyond its base and Cu_1 of the hindwing generally has its apical portion missing (Fig. 33). Two species of this genus are known, and one occurs in Saskatchewan.

Paracapnia angulata Hanson
(Fig. 19, 33, 60, 61, 179)

Paracapnia angulata Hanson 1961: 29. – Hitchcock, 1974: 69.
Capnia opis, Frison 1942a: 264.

Paracapnia angulata and *Paracapnia opis* (Newman) are very closely related and have only recently been recognized as distinct. The geographic range of *Paracapnia angulata* cannot be delimited until previously identified specimens have been checked. This is the first Saskatchewan record of the species; specimens have been collected from the Montreal and Nipekamew Rivers (Fig. 179).

Diagnostic Characters. – Average length, females 8.5 mm (from anterior part of head to tip of folded wings); brachypterous males 4.0 mm (from anterior part of head to end of abdomen). Males of *Paracapnia angulata* are distinguishable from those of *Paracapnia opis* only by the male supra-anal process. In lateral view, *Paracapnia angulata* males have both inner and outer margins of the epiproct angled at the base (Fig. 61). The inner margin is acutely angled or may approach a right angle, but it is not evenly curved as in *Paracapnia opis*. In dorsal view, the epiproct of *Paracapnia angulata* is broadened once and then tapers evenly to the tip (Fig. 60), but the epiproct of male *Paracapnia opis* shows two slight enlargements in dorsal view. Females of these two species are indistinguishable; members of both have the posterior margin of the subgenital plate broadly rounded and with a small, mesal light-colored or membranous spot (Fig. 68).

Nymphs of *Paracapnia angulata* have a long intermediate bristle at the ventral base of the middle and distal cercal articles and short bristles on the inner surface of the tibiae about half as long as the width of the tibia. In *Paracapnia opis* intermediate bristles are absent from cercal articles and the tibial bristles are as long as the width of the tibia.

Hanson (1961) and Harper and Hynes (1971b) figured the adult genitalia; figures of the nymph were published by Harper and Hynes (1971b).

Bionomics. – Harper and Hynes (1972) noted that the emergence pattern of *Paracapnia angulata* was relatively short and synchronous, with the main peak lasting only eight days. Oviposition occurred about one week after emergence and the first nymphs were collected about two months after the appearance of ovipositing females. Growth proceeded rapidly through summer and autumn and by mid-November nearly all specimens had reached the penultimate instar. The last instar was reached by December. Unlike other winter stoneflies, members of *Paracapnia angulata* do not undergo summer diapause, but show significant summer growth.

Harper and Hynes (1970) state that this species is restricted to cold spring-fed streams and thus nymphs are not exposed to high summer water temperatures. Diapause, an adaptation to survival of high summer water temperatures, may then be superfluous since individuals are exposed to low summer water temperatures. In Saskatchewan, *Paracapnia angulata* has been collected in Montreal River and Nipekamew River. Neither of these rivers are spring-fed, but both drain lakes. Lake drainage may affect the temperature scale of out-flowing rivers (Lehmkuhl, 1972), resulting in summer water temperatures which are low enough for *Paracapnia angulata* nymphs to withstand.

Genus *Capnia* Pictet

Adults of this genus are characterized by having vein R_1 of the forewing bent upward toward the costal margin at its origin, and A_1 of the forewing bent caudad at its junction with cu-a and then curved outward (Fig. 37). Thoracic spinasterna are fused to the basisterna, and metathoracic postfurcasternal plates and thoracic presterna are free. Nymphs lack a fringe of cercal bristles. In North America, most

Capnia species are known only from the western part of the continent. Fifty-nine species are known in North America, and four occur in Saskatchewan.

Key to Saskatchewan species of *Capnia*

Adults

1		With supra-anal process recurved forward and above ninth and tenth terga (males)	2
1′		Supra-anal process absent (females)	5
2	(1)	Conspicuous hump on tergum 8; supra-anal process with conspicuous downturned lobe at apex (Fig. 58, 59) *Capnia coloradensis* Claassen	p. 27
2′		No hump on tergum 8; hump on tergum 7 or absent from all terga	3
3	(2′)	Supra-anal process extended to tergum 7; a low hump on tergum 7 near anterior edge (Fig. 52, 53) *Capnia gracilaria* Claassen,	p. 29
3′		Supra-anal process extended at most to middle of tergum 8, no hump on tergum 7	4
4	(3′)	Supra-anal process expanded at the basal 0.66 of length and narrowed near tip (Fig. 56, 57) *Capnia vernalis* Newport,	p. 30
4′		Supra-anal process tapered evenly from base to tip (Fig. 54, 55) *Capnia confusa* Claassen,	p. 28
5	(1′)	Sterna 7 and 8 united by a median sclerotized connection of various widths	7
5′		Sterna 7 and 8 not connected, but separated by membranous area	6
6	(5′)	Posterior edge of sternum 7 membranous with narrow median sclerotized projection extended to or overlapping part of sternum 8 (Fig. 70) *Capnia confusa* Claassen,	p. 28
6′		Posterior edge of sternum 7 sclerotized, uniform, unmodified, medially; posterior edge of subgenital plate projected posteriorly usually with low median and lateral projections (Fig. 72) *Capnia gracilaria* Claassen,	p. 29
7	(5)	Conspicuous subcuticular oval object visible in center of subgenital plate; subgenital plate separated from lateral sclerotized patches by narrow membranous area (Fig. 71) *Capnia coloradensis* Claassen ,	p. 27
7′		Subgenital plate without median oval object, subgenital plate united to lateral sclerotized patches (Fig. 67) *Capnia, vernalis* Newport,	p. 30

Nymphs

1		Tip of galea expanded, with fringe of long hairs (Fig. 141) *Capnia vernalis* Newport,	p. 30
1′		Tip of galea evenly tapered or pointed (Fig. 142–144)	2
2	(1′)	Long setae on head about equal to diameter of eye, male supraanal lobe long (Fig. 138) *Capnia gracilaria* Claassen,	p. 29
2′		Long setae on head about equal to half diameter of eye, male supra-anal lobe short (Fig. 139, 140) *Capnia confusa* Claassen, p. 28; *Capnia coloradensis* Claassen,	p. 27

Capnia coloradensis Claassen
(Fig. 58, 59, 71, 140, 144, 177)

Capnia coloradensis Claassen 1937: 79. – Claassen 1940: 92. – Hanson 1946: 238. – Ricker 1965: 487. – Gaufin, Nebeker and Sessions 1966: 48. – Gaufin, Ricker, Miner, Milam and Hays 1972: 66.

Capnia coloradensis is known from the Rocky Mountain areas of Montana, Idaho, Wyoming, and Colorado in the United States, and from the Yukon, Canada. This is the first Saskatchewan record. The species has been collected (Fig. 177) from: Scarth River, Jct. Hwy. 120; Mackenzie Creek near Bow

River, Jct. Hwy. 165; Trapper Cabin Creek, Jct. Hwy. 120; Cub Creek, Jct. Hwy. 106; and McDougal Creek, Jct. Hwy. 120.

Diagnostic Characters. – Average length, males, 5.0 mm; females, 7.0 mm (from anterior margin of head to tip of folded wings). Males with narrow heavily sclerotized curved band on anterior margin of tergum 7 and median shining area behind it; latter flat in most specimens, but in Saskatchewan specimens with barely perceptible dark knob rising from it. Narrow dark band extended along anterior margin of terga 2–6, interrupted medially. Prominent hump on tergum 8 and supra-anal process long with conspicuous downturned lobe at apex. Sternum 9 without ventral lobe. Female sternum 7 moderately sclerotized, with many long, stout pale hairs on posterior half, sclerotization continuous across intersegmental groove. Subgenital plate with posterior margin small, rounded and with conspicuous subcuticular oval area visible in center; subgenital plate separated from lateral sclerotized areas of sternum 8 by narrow membranous area. The previously unknown nymph is described below.

Description. – Total length of mature nymph: 3.5–4.5 mm.

General color light brown, lighter ventrally; darker on borders of pronotum, anterior corners of meso- and metanota and anteriorly to lateral ocelli. Appendages and wing pads light yellow; no conspicuous color pattern. Maxillae as in Fig. 144.

Head mostly glabrous with few long setae on top of the head, longest about equal to half diameter of eye (Fig. 140).

Pronotum with few long bristles on anterior and posterior borders, with shorter bristles between. Wing pads with many short hairs. Legs with usual fringe of hairs on tibiae and tarsi; tibiae with short stout bristles below fringe. Outer surface of femur with many short bristles and a few interspersed longer ones.

Abdomen covered with short clothing hairs, and a few stout bristles on posterior tergal margins (Fig. 140). Cerci of usual type.

Ricker (1965), Gaufin *et al.* (1966) and Gaufin *et al.* (1972) figured the adult genitalia; drawings of the nymph are presented in Fig. 140 and 144.

Bionomics. – Gaufin *et al.* (1972) noted that adults of *Capnia coloradensis* emerge in March and April. In Saskatchewan, adults were collected on April 18, 1975 at Trapper Cabin Creek, Jct. Hwy. 120; May 29, 1975 at Cub Creek, Jct. Hwy. 106; April 12, 1976 at Mackenzie Creek, Jct. Hwy. 165 and on May 30, 1975 at McDougal Creek, Jct. Hwy. 120. Nymphs were absent from benthic samples after the spring adult emergence indicating a univoltine life history.

Capnia confusa Claassen
(Fig. 37, 54, 55, 70, 139, 142, 179)

Capnia nivalis, Neave 1929: 163.

Capnia confusa Claassen 1936: 623. – Hanson 1946: 238. – Jewett 1959: 43. – Gaufin, Nebeker and Sessions 1966: 47. – Gaufin, Ricker, Miner, Milam and Hays 1972: 67.

Capnia confusa is known from Alaska, Alberta and British Columbia, south to Utah, and east to Wyoming and Montana. This is the first Saskatchewan record, and the species has been collected (Fig. 179) from: North Fork of Scarth River, Jct. Hwy. 120; the stream at mile 83, Jct. Hwy. 106; Mackenzie Creek, near Bow River, Jct. Hwy. 109; River 40 mi. N. of of Hudson Bay, Sask., Jct. Hwy. 109; and Waskwei River, Jct. Hwy. 109.

Ricker (1964) presented a North American distribution map of the species.

Diagnostic Characters. – Average length, males 5.5 mm; females, 7.5 mm (from anterior part of head to tip of folded wings). Males of this species closely resemble those of *Capnia vernalis*, but females of *Capnia confusa* and *Capnia vernalis* are markedly different. Male supra-anal process long, about 10 times longer than wide (Fig. 54), fairly uniform in width throughout its length and tip not down-turned in side view (Fig. 55). Humps absent from both terga 7 and 8. Sterna 7 and 8 of females not united by median sclerotized connection; posterior edge of sternum 7 membranous with narrow median sclerotized projection extended to or overlapping part of sternum 8 (Fig. 70). The first description of a nymph of this secies is given below.

Description. – Total length of mature nymph: 4.5 – 6 mm.

General color light brown, lighter ventrally; darker on borders of pronotum, anterior corners of meso- and metanota and anteriorly to lateral ocelli. Appendages and wing pads yellow. Maxillae as in Fig. 142.

Head mostly glabrous with few long setae, longest about half diameter of eye (Fig. 139).

Pronotum with a few long bristles on anterior and posterior borders, and shorter bristles between meso- and metanota with a few long hairs extended anteriorly and shorter bristles on the disc; wing pads with many short hairs. Legs with usual fringe of hairs on tibiae and tarsi; tibiae with short stout bristles below fringe. Outer surface of femora with many short bristles and few interspersed longer ones.

Abdomen covered with short clothing hairs, and few stout bristles on posterior tergal margins (Fig. 39). Supra-anal lobe of male as in Fig. 139; cerci of the usual type.

I have been unable to distinguish the nymph of this species from the nymph of *Capnia coloradensis*.

Gaufin *et al.* (1966) figured the male and female genitalia; first figures of the nymph are presented in Fig. 139 and 142.

Bionomics. – Gaufin *et al.* (1972) noted that *Capnia confusa* nymphs are common in creeks and adults emerge in February to July. In Saskatchewan, adults were collected from the North Fork of Scarth River, Jct. Hwy. 120 on May 15, 1975, stream at mile 83, Jct. Hwy. 106 on April 26, 1976, Mackenzie Creek near Bow River, Jct. Hwy. 165 on April 16, 1976, and May 7, 1976, McDougal Creek, Jct. Hwy. 120, on May. 30, 1975, and from Waskwei River, Jct. Hwy 109 on June 11, 1975. Nymphs were absent from benthic samples after the adults emerged in spring, indicating a univoltine life history.

Capnia gracilaria Claassen
(Fig. 52, 53, 72, 138, 143, 177)

Capnia gracilaria Claassen 1924: 57. – Needham and Claassen 1925: 258. – Claassen 1940: 93. – Ricker 1943: 99. – Hanson 1946: 239. – Gaufin, Nebeker and Sessions 1966: 46. – Gaufin, Ricker, Miner, Milam and Hays 1972: 67.

Capnia gracilaria is known from British Columbia and Manitoba south to Oregon, Montana and Utah. This first Saskatchewan record is from Cypress Hills at Battle Creek near Reesor Lake (Fig. 177).

Diagnostic Characters. – Average length, males, 4.0 mm (from anterior portion of head to tip of folded wings); females, 7.5 mm. Males without conspicuous hump on tergum 8 but most specimens with low hump near anterior edge of tergum 7. Supra-anal process long (about 10 times longer than wide) and round in cross-section, extended to posterior edge of tergum 7 (Fig. 52). In lateral view, supra-anal process gently S-shaped and of same width throughout its length (Fig. 53). Female abdomen with very broad dorsal membranous stripe on segments 1 to 8. Subgenital plate of most specimens slightly anterior to membranous border of eighth sternum and set off laterally by weakly sclerotized areas; posterior edge of subgenital plate is usually straight or slightly rounded often with small median blunt protuberance, plate with 3-toothed appearance (Fig. 72). The nymph is described below for the first

time.

Description. – Total length of mature nymph: 5.0–6.5 mm.

General color light brown, reddish brown in very mature specimens, lighter ventrally, appendages and wing pads light yellow; no conspicuous color pattern.

Head mostly glabrous with a few long setae on top of head, longest about equal to diameter of the eye (Fig. 138). Galea of maxilla without definite fringe of hairs (Fig. 143).

Pronotum with few long bristles at anterior and posterior borders, and few short hairs between. Meso- and meta-nota with few long bristles anteriorly, and few stout bristles along notal discs; wing pads glabrous. Legs with usual fringe of hairs on tibiae and tarsi; tibiae with short stout bristles below fringe. Outer surface of femora with many short bristles and a few interspersed longer ones.

Abdomen with a few stout bristles on posterior tergal margins and a few short hairs along rest of each tergum (Fig. 138). Supra-anal lobe of male as in Fig. 138; cerci of usual type.

Needham and Claassen (1925) figured the male genitalia; Ricker (1943) illustrated the female genitalia. Gaufin *et al.* (1966) and Gaufin *et al.* (1972) figured both male and female genitalia. First nymphal figures are presented in Figs. 138 and 141.

Bionomics. – Gaufin (1972) noted that nymphs of this species are common in creeks and small rivers, with adult emergence occurring from January through May. In Saskatchewan, adults were collected at Battle Creek, Cypress Hills on April 20, 1975, March 28, 1976 and May 19, 1976. Nymphs were absent from benthic samples after the emergence of adults in spring indicating a univoltine life cycle.

Nebeker (1971c) studied the adult emergence of *Capnia graclaria* at altitudes of 2590 meters down to 1530 meters in the Wasatch Mountains, Utah. Emergence was found to be spread up to five months apart depending on altitude (i.e. temperature) for nymphs which received the same photoperiod.

Capnia vernalis Newport
(Fig. 56, 57, 67, 141, 178)

Capnia vernalis Newport 1848: 451. – Claassen 1931: 109. – Ricker 1938: 135. – Claassen 1940: 95. – Harden and Mickel 1952: 24. – Harper and Hynes 1971b: 938. – Hitchcock 1974: 45.

Published records of *Capnia vernalis* are from Alberta, Manitoba, Ontario, Labrador, Minnesota and Ohio. Although specimens were not collected in the present study and there are no published records of the species from Saskatchewan, W.E. Ricker (pers. comm.) has examined a female *Capnia vernalis* from this province, Saskatoon, Sask.; May 19, 1940; A.R. Brooks, coll. An additional female is deposited in the Biology Department Entomology Museum, University of Saskatchewan, Saskatoon, Saskatchewan, with the following collection data: Saskatoon, Sask.; April 24, 1918. The genitalia are shrivelled since this specimen has been pinned, but it appears very close to *Capnia vernalis*. The Saskatchewan distribution of this species is indicated in Fig. 178.

Diagnostic Characters. – Average length, males 4.5 mm; females, 6.5 mm (from anterior part of head to tip of folded wings). Male sternum 9 produced posteriorly into bluntly pointed subanal plate with elongate process at tip lying between subanal lobes; elongate process with second acute anterior projection dorsal to sternum. Subanal lobes each subacute and marked off from sternum by deep notch. Supra-anal process extended forward to hind margin of tergum 8 (Fig. 56); its distal one-third narrower in side view and the tip pointed (Fig. 57). Female subgenital plate with strongly sclerotized posterior lip about one-third width of sternum, and slightly anterior to its hind margin. Sclerotized floor of genital tract visible through exoskeleton (Fig. 67) anterad to posterior lip of subgenital plate. Sterna 7 and 8 connected by narrow sclerotized bridge.

Nymph with tip of galea of maxilla not evenly pointed, but expanded and covered with fringe of long hairs (Fig. 141).

Ricker (1938) figured the type specimens; Harper and Hynes (1971b) illustrated the adult genitalia, wings and nymph.

Bionomics. – There is no available biological information on this species.

Genus *Utacapnia* Nebeker and Gaufin

Nebeker and Gaufin (1965) studied the *Capnia columbiana* complex and reported 10 species in western and arctic America. Further study of this group and other North American *Capnia* resulted in recognition of subgeneric status for this complex under the name *Utacapnia* (Nebeker and Gaufin, 1967), and it was later assigned generic status by Zwick (1973).

Males vary from long-winged to apterous. There is no lobe on sternum 9. With the exception of wingless adults, postfurcasternal plates are partially fused to the spinasternum. The prothoracic spinasternum is fused at lateral angles to the mesothoracic basisternum by a connection four times longer than wide. The supra-anal process is bipartite with the upper part furcate and enlarged at its tip (Fig. 50, 51). Females have the subgenital plate bounded on either side by a well-defined lateral sclerotized plate with various median and anterior sclerotization (Fig. 69). Nymphs are poorly known and inseparable at present. One species of *Utacapnia* is known from Saskatchewan.

Utacapnia trava (Nebeker and Gaufin)
(Fig. 50, 51, 69, 178)

Capnia trava Nebeker and Gaufin 1965: 479.
Capnia (Utacapnia) trava, Nebeker and Gaufin 1967: 236.
Utacapnia trava, Zwick 1973: 392.

Utacapnia trava was previously reported from Montana and Idaho. This is the first Saskatchewan and Canadian record (Fig. 178). Specimens have been collected at Battle Creek, near Reesor Lake, Cypress Hills; Scarth River, Jct. Hwy. 120; Trapper Cabin Creek, Jct. Hwy. 120; and McDougal Creek, Jct. Hwy. 120.

Diagnostic Characters. – Average length: males, 7.5 mm (from anterior margin of head to end of abdomen); females, 8.5 mm (from anterior margin of head to tip of folded wings). Male genitalia with fan-shaped enlargement at tip of upper supra-anal process; lower process massive and greatly enlarged, about as wide as tips of upper process; posterior end of supra-anal process enlarged and notched in dorsal view (Fig. 50, 51). Females with anterior sclerotization of subgenital plate joined by continuous pigmentation from anterior sclerotization extended posteriorly to pigmented tip of subgenital plate; posterior margin notched(Fig. 69). Nymphs of this species are unknown.

Nebeker and Gaufin (1965) and Gaufin *et al.* (1972) illustrated the adult genitalia.

Bionomics. – Adults of this species are usually collected from February to April, but in one collection from a glacial lake emergence was July 11, 1964 as a result of the extremely cold water in which the nymphs lived (Nebeker and Gaufin, 1967). In Saskatchewan, adults were collected from McDougal Creek and Trapper Cabin Creek on April 18, 1975, and from Battle Creek, on April 2, 1975 and March 28, 1976.

Genus *Isocapnia* Banks

Compared to most capniines, specimens of *Isocapnia* are unique because of their large size and the rarity of their collection. Adults are characterized by basally straight veins R_1 and A_1 and the forewing, two or more crossveins in the costal area beyond the cord (Fig. 39), the mesothoracic furcasternum faintly demarked from the postfurcasternal plates with which it is united, metathoracic furcasternum united with and faintly demarked from the first abdominal sternum, and the prothoracic presternum broadly fused with the basisternum (Fig. 18). The known nymphs of *Isocapnia* differ from those of other stonefly species by long swimming hairs along the cerci (Fig 26). Dwarf males occur in some *Isocapnia* species in which wings are very reduced (1–2 mm long) and the body is generally small. Though brachyptery is not rare in Plecoptera, Ricker (1959) noted that the unusual aspect of brachyptery in *Isocapnia* is the occurrence of extremely short-winged and completely long-winged individuals in the same population without intergradation.

Ricker (1959) established three well-defined North American species groups of *Isocapnia* for the eleven species known. These are the *grandis*, *hyalita*, and *abbreviata* species groups. One member of the *grandis* group and one member of the *hyalita* group occur in Saskatchewan.

Key to Saskatchewan species of *Isocapnia*

Adults

1 Costal crossveins one to four before end of Sc, and none to two beyond it; male 9th tergum with prominent posterior notched or bilobed process; female subgenital plate without median recessed tongue set off by unsclerotized notch on either side (Fig. 66) ..... *Isocapnia missourii* Ricker p. 33

1′ Costal crossveins four to eight before end of Sc, two to four beyond it (Fig. 39); no raised process on male 9th tergum (Fig. 63, 64); female subgenital plate with median recessed tongue set off by unsclerotized notch on either side (Fig. 65). ..... *Isocapnia crinita* (Needham and Claassen), p. 32

Nymphs

Since the nymph of *Isocapnia missourii* is unknown, a nymphal species key is not provided.

Isocapnia crinita (Needham and Claassen)
(Fig. 26, 39, 62-65, 179)

Capnia crinita Needham and Claassen 1925: 269.

Isocapnia crinita, Claassen 1940: 96. – Frison 1942b: 69. – Hanson 1946: 239. – Ricker 1959: 643.

Isocapnia crinita has been reported from Colorado, Utah and Montana with this as the first Saskatchewan and Canadian record. It has been collected from Battle Creek, Cypress Hills (Fig. 179).

Diagnostic Characters. – Average length, males, 11.5 mm (from most anterior margin of head to tip of the folded wings); females, 15.0 mm. Male tenth tergum cleft dorsally, with posterior angle of cleft filled by broad, triangular, basal portion of supra-anal process; latter curved gently anterad and upward, with very short blunt tip extended abruptly anterad (Fig. 62–64). Females with dorsal unsclerotized stripe on terga 2–8; all sterna with heavily sclerotized areas anteriorly, broadly interrupted at midline. Sterna 1–6 with series of irregular dots on either side of midline, sternum 7 with two nonsclerotized areas posterlaterally. Subgenital plate situated slightly anteriorly to level of lateral margins of sternum; central sclerotized portion with margins more markedly sclerotized but pigment not extended to hind margin of plate (Fig. 65).

Male nymph with sheath of supra-anal process curved forward as in adult.

It is interesting that a single dwarf male of this species was collected at Battle Creek on May 19, 1976. Long-winged specimens were not collected. *Isocapnia crinita* can now be added to Ricker's (1959) list of *Isocapnia* species in which dwarfing is known to occur, leaving three species *abbreviata*, *grandis* and *mogila* in which only normal males are known.

Frison (1942a), Ricker (1959), and Gaufin *et al.* (1972) figured the male and female genitalia, Ricker (1959) figured the terminalia of the male exuviae.

Bionomics. – Specimens of *Isocapnia crinita* are rarely collected. Gaufin *et al.* (1972) state that in Montana adults emerge from March to May. A single female was found on June 3, 1975 at Battle Creek near Reesor Lake, Cypress Hills, and 15 females and one male were collected on May 19, 1976 at the same locality. Stanford and Gaufin (1974) reported nymphs of *Isocapnia crinita* in subterranean waters about four meters below and 50 meters laterally from the Tobacco and Flathead River channels in Montana. It appears that most of the two-year nymphal life cycle is spent in these hyporheic communities and only when nymphs are mature do they migrate to the surface waters and molt to adults. If a similar hyporheic community exists below Battle Creek, it would explain the absence of nymphs from benthic samples taken a month before adults were collected.

Isocapnia missourii Ricker
(Figs. 66, 178)

Isocapnia missourii Ricker 1959: 651. – Gaufin, Ricker, Miner, Milam and Hays 1972: 82. – Baumann, Gaufin and Surdick 1977: 80.

Isocapnia missourii is known from western United States in Montana and Utah. This first Saskatchewan (and Canadian) record is from Battle Creek near Reesor Lake (Fig. 178).

Diagnostic Characters. – Average length, females, 14.5 mm (from anterior margin of head to tip of folded wings), dwarf males, 9.5 mm (from anterior margin of head to end of abdomen). Wings with one to four costal crossveins before end of subcosta, and none to two (usually one) costal crossveins beyond it. Male genitalia with tergum 9 with prominent notched or bilobed process; supra-anal process long and uniformly slender from base to apex. Female subgenital plate entirely sclerotized, without median recessed sclerotized tongue set off by unsclerotized notch on either side (Fig. 66).

The nymph is unknown.

Ricker (1959) and Gaufin *et al.* (1972) figured the adult genitalia.

Bionomics. – Gaufin *et al.* (1972) reported emergence of adults of *Isocapnia missourii* from March to May in Montana. I collected four females at Battle Creek near Reesor Lake on May 19, 1976. Nymphs were not collected in sweep net samples on this date, nor on March 28, 1976.

Stanford and Gaufin (1974) reported collecting nymphs of *Isocapnia missourii* as well as of *Isocapnia crinita* in subterranean waters below two Montana rivers. Apparently most of the two-year nymphal life cycle is spent below the main river channel and mature nymphs migrate to the surface stream to molt to adults. A similar community probably exists below Battle Creek; this would explain the absence of nymphs from benthic collections.

Family Nemouridae

Nemouridae is the largest family of Plecoptera comprising 373 species occurring in North America, Eurasia and northern Africa. The family was established by Newman (1853) but Klapalek (1905) later arranged this group in four families: Nemouridae, Capniidae, Leuctridae, and Taeniopterygidae.

Needham and Claassen (1925) described one subgenus of Nemouridae. Ricker (1952) recognized 12 subgenera in North America, which were later ranked as genera by Illies (1966). Baumann (1975) revised the family for the world adding three new genera and a new subfamily.

Useful structures in generic definitions include clear, pigmented or banded wings, presence or absence of cervical gills, membranous or partly sclerotized cerci, and presence or absence of a lobe at the base of the male ninth sternum. Adults of this family have a slanting crossvein between the costa and vein R_1 of the forewing, the wings at rest folded flat over the body and the last article of the labial palp subcircular in lateral view. The male supra-anal process is fully sclerotized and anteriorly recurved in members of most taxa. Either the seventh or eighth sterna of female are produced to form the subgenital plate. Nymphs are distinguished by number, size and arrangement of body setae. Six genera of Nemouridae live in Saskatchewan.

Genus *Nemoura* Latreille

Baumann (1975) observed that species belonging to *Nemoura* are mainly in more northern regions. Males are distinguished by terminal hooks on sclerotized cerci (Fig. 79, 80) and females have a large pregenital plate (on the seventh sternum) (Fig. 89), with lightly sclerotized truncate cerci. Nymphs lack cervical gills. Four species occur in North America; one lives in Saskatchewan.

Nemoura rickeri Jewett
(Fig. 79,80,89,145,146,151,183)

Nemoura rickeri Jewett 1971: 190. – Baumann 1975: 21.

Nemoura rickeri has previously been reported from two Alaskan localities only. This first Saskatchewan and Canadian report (Fig. 183) is from the following localities: Puskwakau River, Jct. Hwy. 106; Mackay Creek, Jct. Hwy. 2; stream 40 mi. N. of Hudson Bay, Sask., Jct. Hwy. 109; stream at Promontory Campground, 15 mi. N. of La Ronge, Sask., Jct. Hwy. 2; and the stream at mile 5, Jct. Hwy. 165.

There is some question whether *Nemoura rickeri* is conspecific with the Palearctic *Nemoura sahlbergi* Morton, but it sould be considered a valid species until a detailed study of all northern species is completed (R.W. Baumann, pers. comm.).

Diagnostic Characters. – Average length, males, 7.5 mm (from anterior portion of head to tip of folded wings); females, 9.0 mm. Male cerci strongly sclerotized on outer surface, directed upward; cercal tips each with outwardly directed, sharply pointed hairy tooth. Male genitalia with tenth tergum deeply incised medially; epiproct recurved, massive, and rectangular, in dorsal view tip blunt and twice as long as wide, but in lateral view tip is bluntly pointed; paraprocts simple and broad (Fig. 79, 80). Female seventh sternum produced over most of sternum eight in form of broad rounded plate, hairy and heavily sclerotized along border; ninth sternum with small median plate extended anteriorly to margin of extended seventh sternum (Fig. 89). Since the nymph of this species has not previously been known, a detailed description follows.

Description. – Total length of mature nymph: 5.5–8.0 mm.

General color medium to light brown, underside very light brown; thin white ecdysial line the only marking. Head with dark brown subtriangular spots just behind antennae. Antennae light brown, first three articles dark brown; femora light brown, tibiae and tarsi slightly darker; cerci light brown, first five articles darker; each cercal article with dark band at base, width about one-fifth length of article.

Head with numerous short stout bristles slightly longer behind eyes and with a few long hairs on

anterior region of head.

Pronotum trapezoidal, wider anteriorly, and with short dorsal bristles and pronotal fringe (Fig. 146); meso- and meta-nota with numerous short stout bristles longer at anterior corners.

Legs with numerous short stout bristles; no tibial fringe but several long hairs along length of tibial margin; femora in side view about four times as long as wide (Fig. 145).

Abdomen with numerous short stout bristles with marginal bristles longer, up to one-third tergal length. Tenth abdominal tergum of mature male nymph with distinct pattern (Fig. 148). Cercal bristles in regular whorls, bristle length between one-quarter and one-half that of cercal article (Fig. 151).

Until comparative study is made of nymphs of *Nemoura*, it is impossible to identify distinguishing characters of *Nemoura rickeri* nymphs.

Bionomics. – In Alaska, *Nemoura rickeri* specimens were collected on June 30, 1968. Saskatchewan collection dates for adults are: Puskwakau River, Jct. Hwy. 106, June 10, 1975, and May 30, 1976; stream 40 mi. N. of Hudson Bay, Sask., June 11, 1975; stream at mile 5, Hwy. 165, May 29, 1975; and stream at Promontory Campground, 15 mi. N. La Ronge, Sask., June 21, 1976. The secies appears to have an extended emergence because a large series of nymphs collected at the stream 15 mi. N. of of La Ronge, Sask. showed a wide variation in wing pad development from very mature to having wing pads just beginning to form.

Genus *Podmosta* Ricker

This genus is characterized by absence of cervical gills, simple male cerci and a male supra-anal process which is short, thick, slightly curved, complex in structure and mostly membranous. The male tenth tergum has a deep median depression (Fig. 76). The female seventh sternum is unmodified, but the eighth sternum is produced into a subgenital plate which is straight or excavated posteriorly and usually slightly notched. There is a distinct darkly sclerotized stripe along the midline of the subgenital plate (Fig. 90). Five North American species of *Podmosta* are known and one is found in Saskatchewan.

Podmosta delicatula (Claassen)
(Fig. 76, 90, 150, 152, 182)

Nemoura delicatula Claassen 1923: 285. – Claassen 1940: 54.
Nemoura (Podmosta) delicatula, Ricker 1952: 43. – Jewett 1959: 33.
Podmosta delicatula, Illies 1966: 219. – Baumann 1973: 92.

Podmosta delicatula is known from the Rocky Mountain areas of North America including British Columbia, California, Colorado, and Utah. First Saskatchewan records (Fig. 182) include Battle Creek, Cypress Hills near Reesor Lake; Shuard Creek, 11 mi. S. of Piapot, Sask.; and Bear Creek 10 mi. S. of Piapot, Sask.

Diagnostic Characters. – Average length, males,5.5 mm (from anterior margin of head to tip of folded wings); females, 7.0 mm. Male genitalia with supra-anal process divided into long narrow ventral portion and short broad dorsal portion, with two thin, forked, sclerotized processes at apex of dorsal process (Fig. 76). Females with seventh sternum unmodified, and with median sclerotized stripe of eighth sternum three to four times as long as its greatest width and of fairly uniform width throughout its length; margin of eighth sternum with tiny median notch (Fig. 90). Since the nymph of this species has not previously been known, a detailed description follows.

Description. – Total length of mature nymph: 4.0–5.5 mm.

Color light brown; head darker, especially anterior to lateral ocelli, white markings extend from ecdysial line to tip of abdominal terga. Head with central light spot between lateral ocelli extending anteriorly about halfway between lateral ocelli and median ocellus. Antennae golden-brown; scape and pedicel darker. Cerci very light brown; lower half of each cercal article slightly darker.

Head covered with very short setae; ocelli form an equilateral triangle.

Pronotum narrower than head, trapezoidal, narrowed posteriorly with numerous short bristles; short setae extended over mesonotum and metanotum. Legs with short bristles; a few long hairs on tibiae, longest about equal to greatest width of tibiae. No tibial fringe.

Abdomen with numerous very short setae, largest bristles about one-quarter mid-dorsal tergum length. Each dorsal abdominal segment with distinct row of bristles along its posterior margin (Fig. 150). Whorls of cercal bristles at base of each cercal article, longest about one-third article length; dorsal and ventral bristles longer on distal cercal articles, where they may be 0.50-0.75 article length (Fig. 152).

The distinguishing characters of the nymph of this species cannot be specified now.

Needham and Claassen (1925) and Gaufin *et al.* (1972) figured the male and female genitalia. The first illustrations of nymphs are presented in Fig. 150 and 152. *Podmosta delicatula* is closely related to the eastern species *Podmosta macdunnoughi* (Ricker) but differs by not having the male dorsal process bent near its middle.

Bionomics. – Gaufin *et al.* (1972) state that the species is common in creeks and rivers throughout its range with adult emergence occurring from April to August. In Saskatchewan, adults were collected from Battle Creek, Cypress Hills near Reesor Lake on June 3, 1975, June 23, 1975, and July 13, 1975; from Bear Creek, 10 mi. S. of of Piapot, Sask., on May 17, 1975; and from Shuard Creek, 11 mi. S. of of Piapot, Sask. on June 3, 1975, June 23, 1975 and May 19, 1976. Nymphs were absent from benthic samples after the spring adult emergence, suggesting a univoltine life history.

Genus *Zapada* Ricker

Specimens of *Zapada* are commonly encountered, especially in western North America. Adults generally emerge in early spring. Males have large angular outer paraproctal lobes and a short broad epiproct with a well developed dorsal sclerite (Fig. 74). The female seventh sternum is slightly produced over an unsclerotized eighth sternum (Fig. 86). The four cervical gills are unbranched except in *Zapada cinctipes* whose specimens have four to five branches.

Nymphs have whorls of large spines on all femora. Seven North American species are known; one in Saskatchewan.

Zapada cinctipes (Banks)
(Fig. 10, 11, 14, 74, 86, 183)

Nemoura cinctipes Banks 1897: 21. – Needham and Claassen 1925: 212. – Claassen 1940: 53.

Nemoura (Zapada) cinctipes, Ricker 1952: 57. – Jewett 1959: 35. – Gaufin, Ricker, Miner, Milam and Hays 1972: 41.

Zapada cinctipes, Illies 1966: 250. – Baumann 1975: 31. – Baumann, Gaufin and Surdick 1977: 42.

Zapada cinctipes is common in western Canada and United States from Alaska to California and Utah and east to Manitoba, South Dakota, Montana and Ohio. This first Saskatchewan report (Fig. 183) is based on material from the following localities: stream 80 mi. N. of La Ronge, Sask., Jct.

Hwy. 102; stream 39 mi. N. of Hudson Bay, Sask., Jct. Hwy. 109; Broad Creek, Jct. Hwy. 104; stream at Otter Lake, Missinipi, Jct. Hwy. 2; Mackay Creek, Jct. Hwy. 2; Caribou Creek, Jct. Hwy. 106; north fork of Scarth River, Jct. Hwy. 120; Mackenzie Creek near Bow River, Jct. Hwy. 165; Cub Creek, Jct. Hwy. 106; Battle Creek, Cypress Hills, near Reesor Lake; and east block of Cypress Hills Provincial Park, stream one-third mi. W. of Park Gates.

Diagnostic Characters. – Average length, males, 9.5 mm (from anterior part of head to tip of folded wings); females, 13 mm. Adults with four groups of branched gill remnants, membranous cerci and wings with dark, transverse bands. Male genitalia with subanal lobes broad with short spine-like processes on inner margins; supra-anal process recurved, largely membranous and spinulose on outer halves (Fig. 74). Female seventh sternum produced over entire eighth sternum as a broadly rounded subgenital plate (Fig. 86).

Nymphs with distinct transverse line of bristles on femora; cervical gills with 4–5 branches.

Needham and Claassen (1925) and Jewett (1959, 1960) figured the adult genitalia. Castle (1939) described the nymph.

Bionomics. – Emergence of *Zapada cinctipes* is regulated by an initial photoperiodic response and a temperature stimulus (Nebeker, 1971c).

Clifford (1969) found that while most adults emerged in early spring after ice started breaking up in the Bigoray River, Alberta, some nymphs had molted to adults while the stream was still completely ice-covered. These were found in air spaces between the ice and water. Early-instar nymphs were first collected in samples in late June, and growth was steady throughout fall and winter. The life history was univoltine.

At Battle Creek, near Reesor Lake, Cypress Hills, adults and mature nymphs were collected in this study on March 28, 1976, and adults were still abundant, though no nymphs were found, on May 19, 1976.

Genus *Amphinemura* Ris

Adults of this genus are characterized mainly by the presence of cervical gill remnants and unmodified cerci. Male subanal lobes are divided into two narrow parts which may be recurved forward alongside the supra-anal process. Usually both inner and outer parts bear few to many heavy spinules (Fig. 77, 78). The female seventh sternum is produced about halfway over sternum 8 which bears a median notch and may be produced (Fig. 88). Nymphs have branched prosternal gills (Fig. 12). Ten North American species are known, and one occurs in Saskatchewan.

Amphinemura linda (Ricker)
(Fig. 12, 77, 78, 88, 182)

Nemoura (Amphinemura) linda Ricker 1952: 22.
Amphinemura linda, Illies, 1966: 181. – Baumann, Gaufin and Surdick 1977: 26.

Amphinemura linda is a common species in Canada and northern United States. Previous records include British Columbia, Alberta, Manitoba, Quebec, Ontario, Labrador, and Michigan. This first Saskatchewan record fills in the central Canadian distributional gap for the species. Specimens have been collected in the following localities (Fig. 183): Mistohay Creek, Jct. Hwy. 226; Nemeiben River, Jct. Hwy. 2; stream 10 mi. E. of Squaw Rapids Power Station; stream 80 mi. N. of of La Ronge, Sask., Jct. Hwy. 102; stream 85 mi. N. of of La Ronge, Sask., Jct. Hwy. 102, Mackay Creek, Jct. Hwy. 2; Nipekamew River, Jct. Hwy. 165, stream 37 mi. N. of Green Lake Sask., Jct. Hwy. 155; stream at mile

98, Jct. Hwy. 155; creek between Bedard Creek and Bisset Creek, Jct. Hwy. 106; Puskwakau River, Jct. Hwy. 106; creek at mile 135, Jct. Hwy. 106; Swan River, Jct. Hwy. 8; and the stream at mile 34 on the Wollaston Lake Road.

Diagnostic Characters. – Average length, males 6.5 mm (from anterior margin of head to tip of folded wings); females, 8.5 mm. Male genitalia with anterior lobe on sternum 9 and posterior projection; subanal lobes double with both branches bearing spines, most specimens with two spines on outer branch, and four to five on inner branch (Fig. 77); subanal lobes not recurved forward, and usually seen only in ventral view (Fig. 78); supra-anal process mainly membranous with sclerotized sides. Female seventh sternum produced halfway over sternum 8, and subgenital plate sclerotized and sinuate (Fig. 88).

Nymphs with long and pointed pronotal bristles; cercal bristles at least three-quarters length of each cercal article; and large femoral and tibial bristles darker in color than rest of leg.

Ricker (1952) figured the adult genitalia, and Harper and Hynes (1971d) illustrated the nymph.

Bionomics. – Harper (1973b) noted that *Amphinemura linda* was an autumnal species in which the first adults were found in late August and adult emergence was extended throughout September. The emergence pattern of males and females was similar, but males emerged earlier than females. The intensity of emergence was about the same throughout. Oviposition occurred mainly at midday and early afternoon of late September and early October.

The life history of *Amphinemura linda* was shown to be univoltine (Harper, 1973b). Eggs hatched in the laboratory under simulated stream conditions showed a short initial development in October, embryonic diapause for five months in winter and resumed development in March. Hatching occurred in April. Nymphal growth was continuous throughout the summer and ended just before emergence of adults. In one river with warm winter water temperatures, embryonic diapause lasted only two months although emergence occurred about the same time. This slower summer growth was due to a cooler summer stream temperature.

In Saskatchewan, *Amphinemura linda* emerges in July and August. Adults were collected from the creek between Bedard Creek and Bisset Creek, Jct. Hwy. 106 on July 2, 1975, from Puskwakau River, Jct. Hwy. 106 on July 17, 1975, from the stream at mile 98 near Ile-a-la-Crosse, Sask. on July 10, 1975, and from Mistohay Creek, Jct. Hwy. 226 on August 12, 1975.

Genus *Shipsa* Ricker

Adults of this genus have banded wings, unmodified cerci and lack cervical gills. The male tenth tergum is produced into long terminal projections with one on each side of the epiproct. The epiproct is modified by having the ventral sclerite extending to the dorsal surface and it terminates in a prominent forcep-shaped structure (Fig. 75). The female seventh sternum is produced and laterally excavated with the produced part of sternum 7 attached basally to sternum 8. The eighth sternum is not produced (Fig. 87). Nymphs have a fringe of long hairs along the posterior margins of the tibiae.

Shipsa rotunda (Claassen)
(Fig. 75, 87, 183)

Nemoura rotunda Claassen 1923: 290. – Needham and Claassen 1925: 219. – Harden and Mickel 1952: 17.
Nemoura (Shipsa) rotunda, Ricker 1952: 50.
Shipsa rotunda, Illies 1966: 247.

Shipsa rotunda, the single known species of this genus, has been reported from Alaska, Saskatchewan, Ontario, the Maritimes and eastern United States. Ricker (1944) reported the species from Black Lake, Saskatchewan and additional collection records include (Fig. 183): Little Red River, Prince Albert, Sask.; Nipekamew River, Jct. Hwy. 165; Mackay Creek, Jct. Hwy. 2; stream at south end of Wollaston Lake, Jct. Hwy. 105; Torch River, Jct. Hwy. 106; North Saskatchewan River, Jct. Hwy. 5; and North Saskatchewan River at Prince Albert, Sask.

Diagnostic Characters. – Average length, males, 7.5 mm (from anterior part of head to tip of folded wings); females, 10.5 mm. Since this is the only known species of *Shipsa*, generic characters also define specific characters.

Needham and Claassen (1925) figured the adult genitalia; Harden and Mickel (1952) illustrated nymphal characters.

Bionomics. – Harper (1973b) reported collecting early-instar nymphs of *Shipsa rotunda* in November in a southern Ontario stream. Growth was rapid and without arrest throughout the winter even though the stream had a thick ice cover. Nymphal development was complete by mid-April, about one week before adult emergence.

In Saskatchewan, *Shipsa rotunda* was most abundant at the North Saskatchewan River at Hwy. 5 (Borden Bridge). Mature nymphs were collected on April 25, 1974, May 2, 1974, and May 4, 1974. Adults were collected on May 4, 1974.

Genus *Malenka* Ricker

This common western North American genus is characterized by the presence of mesobasal lobes on male cerci (Fig. 73), a nipple-like ventral projection on the female seventh sternum and a notch on the posterior margin of the female eighth sternum (Fig. 85). Nymphs have four branched cervical gills. Eleven species are known in North America; one occurs in Saskatchewan.

Malenka californica (Claassen)
(Fig. 76, 90, 147, 149, 153, 182)

Nemoura californica Claassen 1923: 284. – Frison 1942a: 261.
Nemoura lobata, Frison 1936: 260.
Nemoura (Malenka) californica, Ricker 1952: 33. – Jewett 1959: 32. – Gaufin, Ricker, Miner, Milam and Hays 1972: 32.
Malenka californica, Illies 1966: 191.

This species has been recorded mainly from the cordillera including New Mexico and California north to British Columbia and western Alberta. This first Saskatchewan report (Fig. 183) is from the following localities: Broad Creek, Jct. Hwy. 104; Mackenzie Creek, Jct. Hwy. 165; Waskwei River, Jct. Hwy. 109; and Scarth River, Jct. Hwy. 120.

Diagnostic Characters. – Average length, males, 8.0 mm (from anterior margin of head to tip of folded wings); females 8.5 mm. Male cercus with mesobasal lobe sclerotized, sharply pointed, and directed inward and backward. Male genitalia with outer part of subanal lobes broad and with notch on mesal margin (Fig. 73). Female seventh sternum with erect nipple-like protuberance on produced portion with its base anterior to hind margin of sternum; sternum 8 notched about halfway across and with no margin of extra sclerotization (Fig. 85). The nymph is described below for the first time.

Description. – Total length of mature nymph: 5.0–6.5 mm.

Color medium brown; antennae a little darker; legs brown; bristles on legs slightly darker than

ground color of leg; cerci pale.

Short bristles covering head capsule, those behind eyes longer and stout. Antennal bristles large near base but very small and short near tip.

Pronotum rectangular, covered with short bristles and hairs. Pronotal fringe well-defined consisting of long pointed bristles which are long on corners but very short along medial margin (Fig. 147). Meso- and metanota covered with medium-sized bristles especially on anterior corners. Legs with long stout bristles, the longest femoral bristles equal to about two-thirds of greatest femoral width; no tibial fringe of hairs but profuse tibial bristles.

Prosternal gills in four tufts; each tuft of 6–8 filaments forming a whorl about a central axis.

Abdomen with numerous long bristles, longest about 1.3 times as long as mid-dorsal length of corresponding tergum (Fig. 149). Whorls of cercal bristles regular; length of bristles equal to total length of cercal article (Fig. 153).

The nymph of this species is almost identical to that of *Amphinemura linda*, but if the two are compared there are several distinguishing features. *Amphinemura linda* has an overall orange-red color, while *Malenka californica* is brown. The body bristles of *Malenka californica* are much darker than the body; in *Amphinemura linda*, the bristles, especially the leg bristles, are only slightly darker than the body. The two species are also temporally separated. *Amphinemura linda* is a mid- to latesummer species with mature nymphs occurring in mid-July. However, *Malenka californica* is a fall species with mature nymphs occurring in late August.

Needham and Claassen (1925), Jewett (1959) and Gaufin *et al.* (1972) figured the male and female genitalia. Nymphal characters are illustrated in Fig. 147, 149 and 153.

Bionomics. – *Malenka californica* is found in small streams, creeks and small springs. Adults emerge in late summer or fall (Baumann, 1975), as soon as there is a sharp decrease of stream temperature (Nebeker, 1971c).

In Saskatchewan, adults have been collected on August 8, 1975 at Mackenzie Creek, Jct. Hwy. 165, September 1, 1975 at Waskwei River, Jct. Hwy. 109, and on September 25, 1975 at Scarth River, Jct. Hwy. 120. Adults of this species have been found in stomachs of brook trout at Scarth River (D. Larson, pers. comm.).

Nymphs were not present in samples taken at Mackenzie Creek, Jct. Hwy. 165 in April or May of 1976. However, early instar nymphs were collected at the same locality on June 25, 1975. There is probably an embryonic diapause over the winter and early spring, with the main nymphal development occurring throughout June, July, and early August.

Family Leuctridae

Leuctridae are characterized by having wings rolled around the body at rest, cu-m and intercubital crossveins in the forewings, a forked cubitus and simple media in the hindwings of most genera, single articled cerci (simple in most genera), an inconspicuous male epiproct and absence of gills. Male leuctrids are unique by having a long median process or subanal probe between the paraprocts (Ricker and Ross, 1969). Nymphs have the first tarsal article longer than the second, hindwing pads subparallel to the body axis, and the first six or less abdominal segments divided into tergum and sternum by a membranous fold. The family occurs in North America, Eurasia and northern Africa.

At present, the nomenclature of Leuctridae is somewhat confused. Hanson (1941) proposed the genus name *Paraleuctra* for seven North American species previously in the genus *Leuctra*. Frison (1942a), Ricker (1943, 1952), Jewett (1956, 1959, 1960) and Gaufin *et al.* (1972) considered *Paraleuctra* a subgenus of *Leuctra*, but Illies (1966) maintained the generic status of *Paraleuctra*, this was accepted

by Ricker and Ross (1969) and Hitchcock (1974). I follow the nomenclature of Illies (1966). Both *Leuctra* and *Paraleuctra* occur in the province but the other North American genera of this family, *Perlomyia*, *Megaleuctra* and *Zealeuctra*, were not found.

Genus *Leuctra* Stephens

Adults of *Leuctra* differ from the closely related genera *Paraleuctra* and *Zealeuctra* by having the m-cu crossvein in the hindwing proximal to the dichotomy of Cu_1, and Rs and M originating from different points on the radius (Fig. 36). Male cerci are unmodified. The number and shape of processes on the male seventh and eighth terga are often used for species determinations. Nymphs differ from other genera because the first four abdominal segments are divided into tergum and sternum by a membranous fold (Fig. 27), and labial palpi extend well beyond the paraglossae (Fig. 21).

Members of this genus seem to prefer smaller streams (Hitchcock, 1974). The adults are small, brownish and inconspicuous. Of 22 North American species, one species of *Leuctra* was collected in Saskatchewan, *Leuctra ferruginea*.

Leuctra ferruginea (Walker)
(Fig. 21, 27, 36, 84, 92, 184)

Nemoura ferruginea Walker 1852: 183.
Leuctra decepta, Claassen 1923: 260. – Claassen 1940: 77. – Frison 1942a: 257. – Harden and Mickel 1952: 21.
Leuctra ferruginea, Illies 1966: 87. – Hitchcock 1974: 76.

Leuctra ferruginea ranges from eastern Canada (Ontario, Quebec, Newfoundland, Nova Scotia, and New Brunswick), eastern United States (Maine to Florida) to Illinois and Minnesota in the west. The new Saskatchewan record is the most western extension of the species range. Specimens were collected from the following localities (Fig. 183): stream 85 mi. N. of La Ronge, Sask., Jct. Hwy. 102; Broad Creek, Jct. Hwy. 104; stream at mile 30 on the Wollaston Lake Road; Mackay Creek, Jct. Hwy. 2; Low Creek, Jct. Hwy. 104 and Waddy River, Jct. Hwy. 102.

Diagnostic Characters. – Average length, males, 6 mm (from anterior margin of head to tip of folded wings); females, 8.5 mm. Male genitalia with subanal lobes slender and considerably longer than specilla; supra-anal lobe broadly rounded and cerci unmodified, small raised process on eighth abdominal tergum in most specimens, but in some individuals missing (Fig. 84). Some specimens with dark sclerotization on tergum 7 which resembles a process but not raised. Female sternum 8 produced into broad and deeply notched subgenital plate which reaches nearly halfway across sternum 9, two rounded lobes of subgenital plate separated by membranous tissue (Fig. 92).

Nymphs with all abdominal terga covered with short stout bristles but no stout bristles on abdominal sterna.

Needham and Claassen (1925), Frison (1942a) and Hitchcock (1974) figured the adult genitalia; Claassen (1931) and Harper and Hynes (1971a) figured the nymph.

Bionomics. – Harper and Hynes (1971a) noted that *Leuctra ferruginea* occurs predominantly in small cold streams although it may be found in a wide variety of streams and even small warm rivers. Harper (1973b) found that adult emergence in southern Ontario was extended, lasting from early May to September of 1968, although the majority of individuals emerged in late May and early June. Males emerged slightly earlier than females. Adult feeding began soon after emergence but mating did not occur for a few days. Oviposition was observed in the field from mid-June until mid-October. Each

egg batch contained an average of 204 eggs. Females produced an average of 26 egg batches.

Eggs maintained at a constant temperature of 10 C and photoperiod of 12 hours light:12 hours darkness hatched in 49 days (Harper, 1973b). There was no evidence of embryonic diapause. Cooler temperatures lengthened embryonic development; therefore, eggs laid in mid-October would not hatch until spring.

Nymphal growth and emergence appeared to depend upon water temperatures. Only newly hatched nymphs were collected from October to May in streams coldest in summer and warmest in winter. Nymphs hatching in October grew rapidly in fall but little growth occurred during winter. Some of these nymphs emerged in late summer, but the majority of the population was only half grown by the end of the summer and did not emerge until the following year. Growth continued until October, slowed for winter, and resumed in March. Most nymphs matured in May and June. The number of individuals which completed their nymphal growth in one year was very small; most required two years.

A semivoltine growth pattern was still apparent in the warmest stream where *Leuctra ferruginea* was common, but in this case a large part of the population was univoltine. Adult emergence was short and late (most mature nymphs were collected in July).

It is not known whether the life history of this species is univoltine or semivoltine in Saskatchewan. Adults were collected on July 4, 14, and August 7 of 1974 from the stream 85 mi. N. of La Ronge, Sask., Jct. Hwy. 102. This was the only Saskatchewan stream sampled where the species was abundant.

Genus *Paraleuctra* Hanson

Paraleuctra differs from other leuctrid genera in having the m-cu crossvein reach Cu_1 after it has divided (Fig. 34), heavily sclerotized male cerci (Fig. 83), the male ninth tergum entire and the female dorsum with a longitudinal sclerotized stripe on either side. Nymphs have labial palpi extending to the tip of the paraglossae, the first six abdominal segments divided into tergum and sternum by a membranous fold, and the subanal lobes not partly fused but separate. Eight species are known in North America and one occurs in Saskatchewan.

Paraleuctra vershina (Gaufin and Ricker)
(Fig. 34, 81-83, 91, 184)

Leuctra occidentalis, Needham and Claassen 1925: 231.
Paraleuctra occidentalis, Hanson 1941: 57. – Jewett 1959: 39 and 1960: 141. – (in part) Illies 1966: 114.
Paraleuctra occidentalis auct., Hanson 1962: 135.
Paraleuctra vershina Gaufin and Ricker 1974: 285.

Paraleuctra vershina ranges from the cordilleran regions of Canada and the U.S. (British Columbia, Alberta, California and Washington) and east to Colorado, Montana and Utah. This, the first Saskatchewan record, is from Battle Creek near Reesor Lake (Fig. 184).

Diagnostic Characters. – Average length, males 6.0 mm (from anterior margin of head to tip of folded wings); females, 8.0 mm. Male genitalia with tergum 10 partly cleft; supra-anal lobe triangular and bearing slender, recurved, whip-like process at tip (Fig. 81, 82); cerci modified into chitinous armed processes, bulbous at base and each bearing sharp tooth above and below (Fig. 83); subanal lobes modified into probe with each lobe receding into ninth segment. Female subgenital plate produced into two lobes lined with long hairs and separated by a broad notch (Fig. 91). Nymphs of this species are unknown.

Needham and Claassen (1925) illustrated the adult genitalia. Hanson (1962) figured the male cerci

showing the characters which distinguish *Paraleuctra vershina* from other *Paraleuctra*.

Bionomics. – Little is known of the biology of this species. In Battle Creek adult specimens were collected on June 23, July 13, and July 20, 1975.

Family Chloroperlidae

Chloroperlidae are small to medium size stoneflies charcterized by having paraglossae much longer than glossae, gills absent, three ocelli, reduced wing venation (only two anal veins) and a small or absent anal area in the hindwing. The family is found in North America, eastern and western Asia and Europe. Male genitalia have unmodified paraprocts and a well developed epiproct. The male tenth tergum is cleft and lobes are absent from all male sterna. Female subgenital plates are variable.

Nymphs lack anal gills, have cerci about three-quarters the abdominal length, and have hindwing pads subparallel to the axis of the body. The last article of each nymphal maxillary palp is abruptly thinner than previous segments.

In North America, Chloroperlidae presently consists of two subfamilies, ten genera, and about 56 species. The subfamily Paraperlinae of western North America is comprised of the genera *Utaperla* Ricker and *Kathroperla* Banks which are monotypic and the genus *Paraperla* Banks with two species. The subfamily Chloroperlinae, of eastern and western North America, originally consisted of three genera: *Hastaperla* Ricker, *Chloroperla* Newman and *Alloperla* Banks. The five subgenera of *Alloperla* have recently been assigned full generic status (Illies, 1966).

Three genera of Chloroperlinae are known in Saskatchewan: *Hastaperla*, *Suwallia* and *Triznaka*.

Genus *Hastaperla* Ricker

Adults of *Hastaperla* are distinguished from other chloroperlid genera by the lack of a fold separating the anal area from the remainder of the hindwing. The anal cell of the forewing gives rise to a single unbranched vein (Fig. 32). Nymphs of *Hastaperla* cannot be distinguished from *Chloroperla*; both have the inner margins of the hindwing pads straight and mature larvae are 7 mm in length or less. Of the three species of *Hastaperla* known in North America, one lives in Saskatchewan.

Hastaperla brevis (Banks)
(Fig. 32, 93, 96, 185)

Chloroperla brevis Banks 1895: 314.

Hastaperla calcarea, Ricker 1935: 200.

Hastaperla brevis, Claassen 1940: 197. – Frison 1942a: 340. – Harden and Mickel 1952: 62. – Ricker 1964: 54. – Hitchcock 1974: 168.

Hastaperla brevis is the most widespread species of Chloroperlidae (Gaufin, 1964), ranging from Nova Scotia through New England, south to Georgia, and west to Oklahoma and Manitoba. Though not previously reported in Saskatchewan new collection records (Fig. 185) for the province include: South Saskatchewan River at the ferry North of Birch Hills, Sask.; Weyakwin River, Jct. Hwy. 2; Ballantyne River, Jct. Hwy. 106; Mackenzie Creek, Jct. Hwy. 165; Bow River, Jct. Hwy. 165; Nipekamew River, Jct. Hwy. 165; Red Deer River, Jct. Hwy. 8; Waskwei River, Jct. Hwy. 109; McDougal Creek, Jct. Hwy. 120; Puskwakau River, Jct. Hwy. 106; Torch River, Jct. Hwy. 106; stream at mile 83, Jct. Hwy. 106, Waddy River, Jct. Hwy. 102; Overflowing River, Jct. Hwy. 109; Crean River, Jct. Hwy. 2; Pine Creek, Jct. Hwy. 165; Cluff Creek near Cluff Lake; Churchill River at Wintego Lake

rapids; Mackay Creek, Jct. Hwy. 2; Fond du Lac River at Black Lake; and Montreal River Jct. Hwy. 2.

Diagnostic Characters. – Average length, males, 6.5 mm (from anterior margin of head to tip of folded wings); females, 9.0 mm. Male genitalia with ninth abdominal segment produced ventrad, rounded and hairy behind, with penis lying beneath; curved chitinous process on each side of penis joined at posterior end to form blunt, prong-like tip (may be conspicuous only in cleared-mount); male epiproct rounded (Fig. 93). Female subgenital plate produced over most of ninth sternum, triangular and rounded at tip (Fig. 96).

Nymphal hindwing pads subparallel to axis of body and inner wing pad margins straight; cerci three-quarters abdominal length; mature larvae 7 mm in length or less (from anterior tip of head to end of abdomen).

Adult genitalia have been figured by Needham and Claassen (1925), Ricker (1935), Frison (1935, 1942a) and Gaufin *et al.* (1966); nymphs were illustrated by Frison (1935). Adults differ from the closely related species, *Hastaperla orpha* (Frison) by lacking a dorsal abdominal stripe.

Bionomics. – Harper and Magnin (1969) studied the life cycle of *Hastaperla brevis* in Quebec. Adult emergence began in June, with the period of time for egg laying and hatching being relatively short. Nymphs were first collected in October, and growth was rapid during fall and early winter but slow in January. In May growth continued and maximum size was reached. It was concluded that growth was not closely synchronized since nymphs in various stages of maturity were collected in each sample. Though Hitchcock (1974) stated that the nymphs were herbivorous, Harper and Magnin (1969) contended that nymphs were at least partly carnivorous.

Genus *Suwallia* Ricker

Males of this genus are characterized by having slender, curved finger-like processes developed from the basal article of the cerci. The male supra-anal body is a membranous lobe with a small hairy process at its tip (Fig. 95). Adults have a small anal lobe on the hindwing, a dark dorsal stripe on the abdomen, and dark U-marks on the meso- and metanota. Few nymphs of *Suwallia* have been described, so nymphal generic characters are not defined.

Suwallia lineosa (Banks)
(Fig. 95, 98, 163, 165-167)

Alloperla lineosa Banks 1918: 7. – Claassen 1940: 186. – Ricker 1964: 68.
Alloperla (Suwallia) lineosa, Ricker 1943: 139. – Jewett 1955: 151. – Gaufin 1964: 42.
Suwallia lineosa, Illies 1966: 449.

Suwallia lineosa occurs in the Rocky Mountains of western Canada (British Columiba and Alberta) and westward to the Cascade and Wallowa Mountains (Colorado, Montana, Oregon, Washington, Wyoming). Though not previously reported in Saskatchewan, specimens were collected in Cypress Hills at Battle Creek near Reesor Lake (Fig. 185). It was not collected further downstream in Battle Creek near Consul, Sask.

Diagnostic Characters. – Average length, males, 7.8 mm (from anterior margin of head to tip of folded wings); females, 8.9 mm. Adult without head or pronotal markings except for ocellar rings and faint stripe in centre of pronotum (Fig. 163). Male genitalia with aedeagus with single V-shaped patch of sclerotized spinules; cerci with slender, curved, finger-like processes developed from basal article; supra-anal body membranous, hairy and weakly sclerotized (Fig. 95). Female subgenital plate emarginate; produced completely over sternum 9 and nearly all of sternum 10 (Fig. 98). A first

description of the mature nymph is given below.

Description. – Length from apex of head to end of abdomen in mature nymphs, 7.8 mm.

General color of head, thorax and abdomen pale brown; head and abdomen without conspicuous bands, spots or stripes of contrasting colors. Abdomen pale ventrally. Prothorax suboval, at least twice as long as broad, and dark brown on margin but may be lighter laterally. Mesothorax margined with dark brown at anterior end.

Wing pads with lateral margins broadly rounded.

Head with three ocelli forming nearly equilateral triangle; distance between ocelli about same as distance to inner margin of compound eye. Labium, maxillae and mandibles as Fig. 165–167. No occipital ridge.

Jewett (1955) figured the male genitalia, and Needham and Claassen (1925) and Gaufin *et al.* (1972) figured the female genitalia. Nymphal mouthparts are figured for the first time in Fig. 165–167.

Bionomics. – The biology of *Suwallia lineosa* is poorly known. In Battle Creek, adult emergence began early in July, 1975 and lasted at least three weeks. Several stages of maturity of nymphs from one sample were observed, indicating little synchrony of emergence. By the end of July nymphs were absent from benthic collections, suggesting a one-year life cycle since all had emerged.

Genus *Triznaka* Ricker

This genus was originally proposed as a subgenus of *Alloperla* (Ricker, 1952). Species of *Triznaka* have the male supra-anal process short and lying along the surface of and fused to the tenth tergum. It is usually in a slight depression but never in a deep groove. The tip of the process is directed upward and may be curved anterad, but there is no apparatus of erection (Fig. 94). Adults also have a black stripe on the abdominal terga, and a small anal lobe on the hindwing. Nymphal generic characters are not defined since few of the nymphs have been described.

Triznaka signata (Banks)
(Fig. 94, 97, 159-162, 164, 185)

Chloroperla signata Banks 1895: 314.

Alloperla signata, Claassen 1940: 188.

Alloperla (Triznaka) signata, Ricker 1952: 186. – Gaufin 1964: 47. – Gaufin, Ricker, Miner, Milam and Hays 1972: 146.

Triznaka signata, Illies 1966: 154. – Baumann, Gaufin and Surdick 1977: 184.

Triznaka signata ranges from Wasington and Montana south to Colorado and Utah. New collection records include Broad Creek and Mistohay Creek in northeastern Saskatchewan (Fig. 185).

Diagnostic Characters. – Average length, males 7.5 mm (from anterior margin of head to tip of folded wings); females, 9.8 mm. Adult head with anterior mark as long as broad and produced in midline to median ocellus in most specimens; ocellar triangle dark; pronotal rugosities only lightly pigmented; median pronotal mark broadly T-shaped, little produced laterally rearward (Fig. 164). Female subgenital plate extended over ninth sternum and broadly rounded posteriorly (Fig 97). A first description of the nymph is given below.

Description. – Length from apex of head to end of abdomen of mature nymphs, 8.0 mm.

General color of head, thorax and abdomen pale brown. Head with small light spot in front of anterior ocellus, and small light area at base of ocellar triangle extended posteriorly to end of head. Each compound eye connected to lateral ocelli by a light area. Prothorax suboval, at least twice as long

as wide with a lighter subcircular area in center, margin of dark brown, but broken laterally and at midline. Meso- and metathoracic regions patterned. Central median stripe on dorsal abdomen with two light spots on either side of stripe per segment. Abdomen pale ventrally; lateral margins of wing pads broadly rounded (Fig. 159).

Head with three ocelli forming a nearly equilateral triangle; distance between ocelli about same as distance to inner margin of compound eye. Labium, maxillae and mandibles as in Fig. 160–162. No occipital ridge.

Needham and Claassen (1925) and Gaufin *et al.* (1972) illustrated the male and female genitalia; first figures of the nymph are presented in Fig. 159–162.

Bionomics. – In Saskatchewan, mature nymphs were collected near the end of May and adults emerged in June of 1975 at Broad Creek. Nymphs of various stages of maturity could be collected in one sample indicating little synchrony of emergence. By July, nymphs were not present, indicating that all had emerged and a univoltine life history is probable.

Family Perlidae

Perlidae have profusely branched gills at lower angles of the thorax, the male epiproct reduced and inconspicuous and the Cu-A crossvein of the forewing located either in the anal cell or very close to it.

Both subfamilies of Perlidae, Acroneuriinae and Perlinae occur in Saskatchewan. The genital hooks of male acroneuriines are modified paraprocts. The subfamily occurs in the Americas and in southeastern Asia. Genital hooks of perlines are outgrowths of a cleft tenth tergum and paraprocts are little modified. This subfamily occurs in Africa, Eurasia and North America. Saskatchewan Perlidae, *Paragnetina media* and *Claassenia sabulosa* are in the subfamily Perlinae: *Acroneuria abnormis*, *Acroneuria lycorias*, *Hesperoperla pacifica* and *Perlesta placida* belong to the subfamily Acroneuriinae.

Genus *Paragnetina* Klapalek

Paragnetina members are characterized by the absence of anal gills, three ocelli, and a Y-shaped median ridge on the prosternum and mesosternum. Males are distinguished from those of other genera by having genital hooks arising from the side of the cleft tenth tergum and extending to the hind margin of the ninth tergum. The female subgenital plate is slightly produced past the hind margin of the eighth sternum (Fig 105). Nymphs have a transverse line of spinules on the occiput (Fig. 5). Five species of *Paragnetina* are presently known in North America and one occurs in Saskatchewan.

Paragnetina media (Walker)
(Fig. 5, 105, 187)

Perla media Walker 1852: 145.
Acroneuria salvelini, Ricker 1935: 26.
Togoperla media, Claassen 1940: 150.
Paragnetina media, Ricker 1949: 287, and 1964: 59. – Harden and Mickel 1952: 51.

Paragnetina media occurs in the Maritimes to northern Ontario, central Quebec, Manitoba, northern Saskatchewan, northern Illinois, southern Michigan, central Pennsylvania and southern New England. A North American distribution map for the species was given by Ricker (1964) and the Saskatchewan distribution is illustrated in Fig. 187. Ricker (1944) reported the species from Wapus River in the Reindeer Lake region, and additional Saskatchewan collection localities include Mackay

Creek, Jct. Hwy. 2; Weyakwin River, Jct. Hwy. 2; Churchill River, Jct. Hwy. 2; stream 85 mi. N. of La Ronge, Sask., Jct. Hwy. 102; Bow River Jct. Hwy. 165; and Caribou Creek, Jct. Hwy. 106.

Diagnostic Characters. – Average length, males, 18 mm (from most anterior portion of head to tip of folded wings); females, 32 mm. Male fifth tergum produced very shallowly, broady excavated or practically straight. Male genitalia with hooks rounded at tip; male sternum 9 without raised knob or "hammer". Female subgenital plate little produced with base of median notch in line with sides of hind margin of sternum 8 (Fig. 105). Adult pronotum with black margins and black median stripe.

Nymphal abdominal terga uniformly brown, some specimens with faint median line (Fig. 5).

Needham and Claassen (1925), Frison (1935) and Hitchcock (1974) illustrated the adult genitalia; Claassen (1931) and Frison (1935) figured the nymph.

Bionomics. – Ricker (1949) noted that *Paragnetina media* was absent from colder trout streams and rivers of that region. Nymphs are usually found under stones in the larger streams but can also be collected in lakes and ponds (Claassen, 1931).

Though Claassen (1931) stated that nymphs of *Paragnetina media* probably require three years to complete their life cycle, Tarter and Krumholz (1971) found that in Kentucky *Paragnetina media* required only two years to complete the life cycle. In Saskatchewan, two size classes can be collected at one time, also suggesting a two year life cycle. For example, at Mackay Creek on June 5, 1974 seven mature nymphs with well-developed wing pads ranged from 20–23 mm in length (average length, 20.5 mm) and were near the end of their life cycle since the species emerged in the first week of July in both 1974 and 1975. Four specimens of the immature size class of nymphs, characterized by having poorly developed wing pads, ranged from 8.6–9.8 mm in length (average length, 9.5 mm). No very small nymphs were collected in mid-August and either the eggs from adults laid in July had not yet hatched or nymphs were yet too small to be collected in a sweep net. A significant growth of both hatchling nymphs and year-old nymphs must occur between fall and spring.

Harper and Pilon (1970) noted that the adult emergence period of *Paragnetina media* lasted from 5 to 25 days.

Based on dissected nymphs, the females produce an average of 802 eggs (Tarter and Krumholz, 1971) and the egg incubation period is 30 days at room temperature (Heiman and Knight, 1970).

Steffan (1965) described larvae of the new genus and species of Chironomidae (Diptera), *Plecopteracoluthus downesi*, which live phoretically on nymphal *Paragnetina media* in a gelatinous case and feed on detritus caught in the long hairs of the stonefly. Of the Perlidae carrying chironomids, six percent were *Paragnetina media*. In Saskatchewan, phoretic Chironomidae have not been found on *Paragnetina media* though they are commonly encountered on nymphs of *Acroneuria lycorias*.

Adults of *Paragnetina media* are rarely encountered in the field. Sweeping the vegetation along stream banks and searching under rocks and under bridges yielded no specimens. This was also observed by Tarter and Krumholz (1971). The only adults examined in this study were from reared specimens. Females reared in laboratory aquarium cages where no males were present were found to produce egg masses even though copulation could not have occurred. Harper (1973a) incubated eggs laid by a virgin female and found that 13 percent hatched. This ability of eggs to develop parthenogenetically was thought to act as a safeguard in large carnivorous species, which are rarely abundant in their habitat, because the chances of meeting mates may be small. Frison (1935) noted that adults of *Paragnetina media* are diurnal and that mating occurs during the day.

Nymphs are carnivorous, feeding primarily on Ephemeroptera, Trichoptera and Diptera, but adults do not feed. Larvae are food for fish and crayfish (Tarter and Krumholz, 1971).

Genus *Claassenia* Wu

Males of *Claassenia* are distinct from other genera of Perlidae by having genital hooks darkly sclerotized at their tips and arising from lateral angles of tergum 10 (Fig. 8). Males also have a raised knob or "hammer" on sternum 9. The female subgenital plate is broadly rounded, usually with a shallow median recession and is little produced over sternum 9. It has with a row of spinules along its posterior margin (Fig 106). Nymphs resemble the eastern genus *Phasganophora* by having anal gills and an occipital ridge composed of closely set spinules, but are distinguished by having dorsal abdominal segments almost wholly brown and a banded pattern on the legs (Fig. 4).

Claassenia sabulosa, the single North American species of this genus, occurs in Saskatchewan.

Claassenia sabulosa (Banks)
(Fig. 4, 8, 106, 187)

Perla sabulosa Banks 1900: 242.
Claassenia languida, Needham and Claassen 1925: 100. – Claassen 1940: 181.
Claassenia arctica, Frison 1942a: 285.
Claassenia sabulosa, Ricker 1952: 190. – Jewett 1959: 90. – Gaufin, Ricker, Miner, Milam and Hays 1972: 156.

Claassenia sabulosa ranges from the cordilleran region of British Columbia and Alberta through the Cascade and Rocky Mountains to New Mexico and east to northern Manitoba and northern Ontario. Ricker (1964) provided a North American distribution map for the species. *Claassenia sabulosa* has not previously been reported from Saskatchewan, and new collection records include McDougal Creek, Jct. Hwy. 120; Creek at Mile 145, Jct. Hwy. 105; Overflowing River, Jct. Hwy. 109; Cluff Creek near Cluff Lake; and the South Saskatchewan River at the ferry N. of Lemsford, Sask. (Fig. 187). Though the species is abundant at McDougal Creek, it has rarely been collected in the South Saskatchewan River.

Diagnostic Characters. – Average length, brachypterous males, 19.6 mm (from anterior margin of head to end of abdomen); females, 31.4 mm (from anterior margin of head to wing tips). Since *Claassenia* is monotypic, generic characters also define specific characters.

Ricker (1938), Gaufin *et al.* (1966) and Gaufin *et al.* (1972) figured the adult genitalia; Claassen (1931) and Frison (1942a) figured the nymph.

Bionomics. – The habitat of *Claassenia sabulosa* is under stones in swift riffle areas where food is abundant (Richardson and Gaufin, 1971).

Three size classes of nymphs present in the same sample suggest a three-year life cycle. For example, on May 28, 1975 at McDougal Creek three nearly mature male nymphs with well developed wing pads averaged 23.0 mm and two females averaged 32.5 mm in length. Fourteen specimens in the next size class, with little wing pad development, averaged 13 mm in length and four specimens in the youngest age class, with no wing pad development, averaged 7.4 mm long. In 1975 adults emerged in the second week of July.

Richardson and Gaufin (1971) found that the species is carnivorous and Ephemeroptera make up the largest percentage of food ingested (37 per cent). Simuliid and chironomid larvae also comprised a large percentage of ingested material.

Frison (1942a) noted that the adults are nocturnal, emerging at nightfall and when active at dusk or night have the ability to move on the surface of the water somewhat like water-striders. Mating can take place as soon as a female emerges from its nymphal skin.

Genus *Acroneuria* Pictet

Sternal ridge patterns of nymphs and adult *Acroneuria* lack a distinct Y-shape, but three ocelli are present. Male *Acroneuria* have an undivided tenth tergum, paraprocts that are recurved into genital hooks and a hammer on the ninth sternum (Fig. 9, 102, 103). The female subgenital plate is little to moderately produced over the ninth sternum (Fig. 99, 100). Nymphs of most species lack an occipital ridge of closely set spinules, but if one is present it is broken at the midline. Seventeen species are known in North America; two occur in Saskatchewan.

Key to Saskatchewan species of *Acroneuria*

Adults

1 Remnants of subanal gills visible either dorsally or ventrally on tenth abdominal segment; head with ocellar triangle enclosed with dark brown to black sclerotization and extended anteriorly; female subgenital plate slightly emarginate (Fig. 100) ..... *Acroneuria lycorias* (Newman), p. 50

1′ No remnants of subanal gills; head with ocellar rings as only dark markings; female subgenital plate broadly rounded (Fig. 99) ..... *Acroneuria abnormis* (Newman), p. 49

Nymphs

1 With subanal gills; general color dark brown and yellow dorsally (Fig. 2) ..... *Acroneuria lycorias* (Newman), p. 50

1′ Without subanal gills; general color light brown and yellow dorsally (Fig. 1) ..... *Acroneuria abnormis* (Newman), p. 49

Acroneuria abnormis (Newman)
(Fig. 1, 99, 103, 186)

Perla abnormis Newman 1838: 177.

Acroneuria abnormis, Needham and Claassen 1925: 178. – Claassen 1940: 171. – Harden and Mickel 1952: 54. – Ricker 1964: 54. – Frison 1935: 391. – Hitchcock 1974: 149.

Acroneuria abnormis, a common prairie stonefly (Ricker, 1946), ranges from northern Quebec and the Maritimes to New England and south to Florida. It occurs west to Manitoba, Illinois and Minnesota. Stark and Gaufin (1976) reported *Acroneuria abnormis* from the South Saskatchewan River at Saskatoon, Sask., and additional collection localities include the North Saskatchewan River at Hwy. 5 (Borden Bridge), and 10 mi. E. of Prince Albert, Sask.; the South Saskatchewan River at the ferry N. of Lemsford, Sask.; and the Saskatchewan River 2 mi. S.W. of Nipawin, Sask. (Fig. 186).

Diagnotic Characters. – Average length, males, 25.0 mm (from anterior margin of head to tip of folded wings); females, 42.0 mm. Male genitalia with paraprocts broad, triangular and sharp; spinules present on terga 9 and 10 (Fig. 103). Female subgenital plate slightly produced and broadly rounded (Fig. 99).

Nymphs without anal gills; with light M-pattern in front of median ocellus (Fig. 1).

Needham and Claassen (1925) and Frison (1935) figured the adult genitalia and the nymph was illustrated by Claassen (1931) and Frison and Hitchcock (1974). Hitchcock (1974) noted that there was a wide range of variability in the abdominal color pattern of Connecticut nymphs, and a similar variation occurs in Saskatchewan specimens. It may vary from being all dark to having two broad, paired, semicircular dark patches on the basal part of most abdominal terga.

Bionomics. – Most nymphs of *Acroneuria abnormis* are found under larger rocks in water about one meter deep. Steffan (1967) noted that the species occurs in rivers where it is exposed to the strongest current.

The species probably has a three-year life cycle since three nymphal size classes can be collected at one time. For example, the average length of six near-mature nymphs with well-developed wing pads collected at the South Saskatchewan River (Lemsford Ferry) on May 23, 1974 was 25.5 mm. Six nymphs with little wing pad development averaged 17.6 mm in length, and two nymphs with no wing pad development averaged 8.2 mm long.

In Saskatchewan, adult emergence began in the first week of July of 1974 and 1975 and lasted approximately two weeks. Eggs evidently hatch soon after they are laid because a nymph measuring 2.66 mm long was collected at the ferry north of Lemsford, Sask. on August 9, 1974. The nymph would be the overwintering stage. Harper and Pilon (1970) graphed the emergence of the species in Quebec and suggested that emergence variation from year to year was dependent on water temperature. Males were found to emerge earlier than females. Hitchcock (1974) stated that nymphs are carnivorous and after a drought in which streams had dried up reported collecting small nymphs from the streams when they had again started to flow. Steffan (1967) observed that *Acroneuria abnormis* was active when the water temperature was -0.5 C, presumably in the absence of ice.

Steffan (1967) found that larval phoresis of a chironomid on *Acroneuria abnormis* was common in a Quebec stream. Eighty-three percent of chironomids on stonefly nymphs were on specimens of *Acroneuria abnormis*, evidently the preferred host. This type of phoresis is known for *Acroneuria lycorias* in Saskatchewan, but has not been observed for *Acroneuria abnormis*.

Acroneuria lycorias (Newman)
(Fig. 2, 100, 102, 186)

Perla lycorias Newman 1839: 35.

Acroneuria perbranchiata, Neave 1933: 236. – Claassen 1940: 175.

Acroneuria lycorias, Claassen 1940: 174. – Frison 1942a: 283. – Harden and Mickel 1952: 55. – Ricker 1964: 54. – Hitchcock 1974: 155.

Acroneuria lycorias occurs in northern Quebec and south through New England to Florida, and west to Ontario, Manitoba, Saskatchewan and Tennessee. It is common throughout its range. Cushing (1961) reported the species from Montreal River, and additional Saskatchewan collection records include (Fig. 186): Weyakwin River, Jct. Hwy. 2; stream 85 mi. N. of La Ronge, Sask., Jct. Hwy. 102; Mackay Creek, Jct. Hwy. 2; Nipekamew River, Jct. Hwy. 165; Jackfish Creek, Jct. Hwy. 8; Cub Creek, Jct. Hwy. 106; Nemeiben River, Jct. Hwy. 2; Torch River, Jct. Hwy. 106; Cole Creek, Jct. Hwy. 104; Puskwakau River, Jct. Hwy. 106; Arsenault River, Jct. Hwy. 104; Overflowing River, Jct. Hwy. 109; Red Deer River, Jct. Hwy. 23, and Jct. Hwy. 109; Pine Creek, Jct. Hwy. 165; Montreal River, Jct. Hwy. 2; Waterhen River, Jct. Hwy. 226; stream 87 mi. N. of Southend, Sask.; Ballantyne River, Jct. Hwy. 165; Churchill River, Jct. Hwy. 2, Pita Lake Rapids and Wapumon Lake Rapids; Caribou Creek near Caribou Lake, Jct. Hwy. 106; Bear River, Jct. Hwy. 106; Martineau River, Jct. Hwy. 55; Little Red River, near Prince Albert, Sask.; Bow River, Jct. Hwy. 165; Waskesiu River, Jct. Hwy. 2; and Beaver River, Jct. Hwy. 155.

Diagnostic Characters. – Average length, males, 18.0 mm (from anterior margin of head to tip of folded wings); females, 35.0 mm. Male genitalia with paraprocts flattened, triangular and sharply pointed at anteriorly directed tips; spinules present on terga 9 and 10 (Fig. 102). Female subgenital plate produced and flattened or emarginate apically (Fig. 100). Adult head with ocellar triangle dark. Adult

with anal gill remnants.

Nymphs with anal gills; banded pattern on abdominal terga; light M-pattern in front of anterior ocellus (Fig. 2).

Needham and Claassen (1925), Hitchcock (1974) and Frison (1942a) figured the adult genitalia, and Frison (1942a) illustrated the nymph.

Bionomics. – In Saskatchewan, *Acroneuria lycorias* seems to have a three-year life cycle since three size classes of nymphs can be collected at one time. For example, at the Nemeiben River on June 5, 1974, the average length of seven mature nymphs with well-developed wing pads was 25.3 mm; the average length of five immature nymphs which had little wing pad development was 20.0 mm, and the average size of six very immature nymphs with no wing pad development was 10.1 mm.

In Saskatchewan, emergence occurs about the first two weeks of July. Harper and Pilon (1970) noted that the emergence period is short.

Nymphs have most often been collected from under rocks in rapids, and are probably carnivorous.

Steffan (1967) noted that chironomid larvae of *Plecopteracoluthus downesi* were phoretic on nymphs of *Acroneuria lycorias*. Of the Perlidae carrying chironomid larvae, three per cent were *Acroneuria lycorias*. In Saskatchewan, phoresis of a chironomid on *Acroneuria lycorias* nymphs is very common in some rivers.

Genus *Hesperoperla* Banks

In *Hesperoperla* male paraprocts are flattened, triangular and pointed; spinules are absent from both the ninth and tenth abdominal terga (Fig. 101). The female subgenital plate is produced over half of sternum 9; the hind margin is slightly angulate and usually has squarish shiny spot at its apex (Fig. 104). The nymph has anal gills but lacks an occipital ridge. The nymphal head has a yellow mark extending from labrum to the anterior ocellus, and the abdominal terga are brown (Fig. 3).

Hesperoperla, a monotypic genus, occurs in Saskatchewan.

Hesperoperla pacifica (Banks)
(Fig. 101, 104, 186)

Acroneuria pacifica Banks 1900: 242. – Frison 1942b: 72. – Jewett, S.G. 1959: 89. – Claassen 1940: 175.
Acroneuria pumila, Banks 1906: 335.
Acroneuria okanagan, Ricker 1935: 262. – Claassen 1940: 173.
Acroneuria (Hesperoperla) pacifica, Ricker 1943: 130. – Gaufin, Ricker, Miner, Milam and Hays 1972: 154.
Hesperoperla pacifica, Illies 1966: 336. – Baumann, Gaufin and Surdick 1977: 162.

Hesperoperla pacifica ranges from British Columbia to California and New Mexico and east to Alberta and South Dakota. This first Saskatchewan collection record is from Cypress Hills at Battle Creek near Reesor Lake (Fig. 186). It was abundant at this locality but was not collected further downstream in the same river near Consul, Sask.

Diagnostic Characters. – Average length, males, 25 mm (from anterior margin of head to tips of folded wings); females, 37 mm. Since this is the only known species of *Hesperoperla*, generic characters also define specific characters.

Needham and Claassen (1925), Gaufin *et al.* (1972), Stark and Gaufin (1966) figured the adult genitalia; Claassen (1931) figured the nymph.

Bionomics. – Three size classes of nymphs have been collected at one sampling time suggesting a three-year life cycle. For example, four near-mature nymphs with well-developed wing pads were collected at Battle Creek on June 3, 1975 which averaged 28.5 mm long. Nineteen nymphs with little wing pad development averaged 14.9 mm long and seven very immature nymphs with no wing pad development averaged 5.3 mm long.

In 1975 adults emerged about the last week of June and emergence lasted for approximately two weeks.

Richardson and Gaufin (1971) found the species to be carnivorous, its diet consisting of 88.3 per cent animal matter. The prey was chiefly Ephemeroptera nymphs and chironomid and Trichoptera larvae.

Genus *Perlesta* Banks

Adults of this genus have remnants of nymphal subanal gills, a yellowish-white costal margin in the forewings, and lack anal crossveins. Males have spinule patches only on the tenth abdominal tergum and lack a hammer on sternum 9. Paraprocts are sclerotized and recurved over the tenth tergum. The female subgenital plate is slightly produced, and distinctly notched mesally. Nymphs have a distinct occipital ridge and dark freckled spots on abdominal terga.

Superficially, *Perlesta* adults resemble *Isoperla* but the gill remnants and light coloring in the costal area of the wing are distinctive.

Two species are presently recognized in North America and one occurs in Saskatchewan.

Perlesta placida (Hagen)
(Fig. 187)

Perla placida Hagen 1861: 28.

Perlesta placida, Needham and Claassen 1925: 158. – Frison 1942a: 271. – Ricker 1964: 54. – Hitchcock 1974: 161.

Perlesta placida is a widely distributed species occurring from the Maritimes to Florida and west to Manitoba, Wyoming and Texas. This first Saskatchewan record is the most northerly range extension of the species. It has been collected from Bisset Creek, Jct. Hwy. 55, and from the Assiniboine River near Tadmore, Sask., Jct. Hwy. 9 (Fig. 187).

Diagnostic Characters. – Average length, males, 8.5 mm (from anterior margin of head to tip of folded wings); females, 14 mm. Adult head with central, longitudinal black stripe darkest between ocelli. Male genitalia with genital hooks tapered from bases to tips. Female subgenial plate slightly produced, notched in center, and covered with long hairs.

Nymphs with speckled appearance; with single light stripe extended down midline of abdomen; abdominal terga lined with intercalary spinules.

Needham and Claassen (1925), Frison (1935, 1942a), and Hitchcock (1974) figured the adults; Claassen (1931) and Frison (1935) figured the nymph.

Bionomics. – Stewart *et al.* (1969) studied the mating behaviour of *Perlesta placida*. Males lived four to six days and females lived seven to eight days; both could mate several times during this period. Mating occurred the first day after adult emergence and began by the aggressive capture of females by the males soon after contact. The male genital hooks attached to the lobes of the female subgenital plate allowing a space between the male subanal lobes directly below the female genital opening. This space served as a "channel" for the aedeagus which was everted from beneath the posterior portion of the

subgenital plate, through the space, and into the female genital opening.

This species has been found in a wide variety of streams, even intermittent ones (Harden and Mickel, 1952). In Saskatchewan, it emerges in mid-summer: mature nymphs were collected at Bisset Creek on July 19, 1976; adults were found on July 22, 1976. Nymphs are carnivorous, feeding mainly on chironomid larvae (Frison, 1935).

Family Perlodidae

Although few features characterize this family as a whole, perlodids all have slender maxillary palpi and glossae reduced to small knobs fused to the side of the paraglossae. Perlodidae differ from Perlidae by the absence of dissected thoracic gills, and pointed rather than rounded paraglossae. Although a few exceptions occur, perlodids are distinct from chloroperlids by having the two branches of A_2 in the forewing leaving the anal cell separately and by having a flatter nymphal body.

This family occurs in North America, Eurasia and northern Africa and has been divided into three subfamilies: the more primitive Isogeninae, and more highly advanced Perlodinae and Isoperlinae. Isogninae have a cleft male tenth tergum, a well developed supra-anal process, and usually have submental gills. Male paraprocts are generally produced into recurved hooks in Isoperlinae and project upward or backward in Perlodinae. All three subfamilies are represented in Saskatchewan. *Isogenoides*, *Arcynopteryx* and *Skwala* are in the subfamily Isogninae; *Isoperla* belongs to Isoperlinae and *Diura* is a representative of Perlodinae.

Genus *Arcynopteryx* Klapálek

Arcynopteryx is characterized by having a mesosternal Y-ridge attached to the anterior corners of the furcal pits and the absence of a transverse ridge (Fig. 25). The male ninth tergum is emarginate and bears many spinules on its posterior margin. The tenth tergum is cleft with the posterior section modified into a pair of flat arms on dorsal lobes which are curved in a lateral direction. The supra-anal process consists of a very long, thin spine projecting from an expansive membranous region (Fig. 113). The female subgenital plate is broad, produced halfway or more over sternum 9, and is trilobed or occasionally bilobed (Fig. 115). Nymphs lack abdominal and thoracic gills but have well-developed submental gills. Nymphal mandibles usually lack denticles on their cusps but may have a few present on the outer left cusp only. The major cusp of these mandibles is slightly serrate marginally.

This Holarctic genus is monotypic and occurs in Saskatchewan.

Arcynopteryx compacta (MacLachlan)
(Fig. 113, 115, 188)

Dictyopteryx compacta MacLachlan 1872: 53.
Arcynopteryx lineata, Smith 1917: 476.
Arcynopteryx ignota, Smith 1917: 479.
Arcynopteryx inornata, Smith 1917: 480.
Perlodes minor, Ricker 1938: 144.
Arcynopteryx minor, Hanson 1942: 396
Arcynopteryx americana, Ricker 1943: 114, and 1944: 183.
Arcynopteryx compacta, Brinck 1949: 58. – Illies 1966: 352.

In North America, *Arcynopteryx compacta* extends from the arctic southward to Colorado, Lake Superior and New Hampshire. The single Saskatchewan record was given by Ricker (1944) from Tazin River near Lake Athabasca. Ricker (1964) presented a North American distribution map of the species; the Saskatchewan collection record is mapped in Fig. 188.

Diagnostic Characters. – Average length, brachypterous males, 11 mm (from anterior margin of head to end of abdomen); females, 20 mm. (from anterior part of head to tip of folded wings). Since this is the only known species of *Arcynopteryx*, generic characters also define specific characters.

Hanson (1942) figured the male and female genitalia; Brinck (1949) figured the nymph.

Bionomics. – Brinck (1949) found that adults of *Arcynopteryx compacta* emerge in mid-summer during the night or early morning when humidity is highest. After mating, the female carries the extruded egg mass on the abdomen and the eggs fall off as the female runs across the water. The eggs then become attached to the substrate by adhesive projections. Nymphal growth is greatest in fall and the following spring. Nymphs are mainly carnivorous feeding on mayfly and chironomid larvae.

Genus *Skwala* Ricker

This genus has the arms of the mesosternal Y-ridge terminating at the anterior corners of the furcal pits; a transverse ridge is absent. The male tenth tergum is cleft with inward and forward directed lobes which are fairly long and spinulose. The male lateral stylets are well-developed (Fig. 112). The female subgenital plate is produced somewhat and truncate (Fig. 114). The nymphal mandibles have numerous denticles along both sides of their outer cusps (Fig. 28).

This genus is represented by two North American species; one occurs in Saskatchewan.

Skwala parallela (Frison)
(Fig. 25, 28, 35, 112, 114, 177)

Perlodes americana, Needham and Claassen 1925: 61. – Claassen 1940: 111.
Hydroperla parallela, Frison 1936: 261, and 1942a: 298. – Claassen 1940: 104.
Arcynopteryx (Skwala) parallela, Ricker 1943: 113. – Jewett 1959: 64.
Skwala parallela, Illies 1966: 378.

Skwala parallela has been previously reported from western Canada and United States, including British Columbia, Oregon, California and Utah. In Saskatchewan it occurs in the following localities (Fig 188): McDougal Creek, Jct. Hwy. 120; Cub Creek, Jct. Hwy. 106; Mackenzie Creek, Jct. Hwy. 165; Shuard Creek, 11 mi. S. of Piapot, Sask.; and Battle Creek, Cypress Hills, near Reesor Lake.

Diagnostic Characters. – Average length, brachypterous males, 19.0 mm (from anterior margin of head to end of abdomen); females, 25.0 mm (from anterior margin of head to tip of folded wings). Male genitalia with tenth tergum cleft; subcylindrical lobes medially on tergum 10, 2–3 times as long as breadth of their middle constricted portion (Fig. 112). Female subgenital plate extended only slightly over sternum 9; posterior margin straight and corners angulate (Fig. 114).

Nymphs with serrations along major mandibular cusps (Fig. 28); partial occipital ridge, interrupted in middle, borders hind margins of compound eyes.

Frison (1936, 1937) and Gaufin *et al.* (1972) figured the male and female genitalia; Frison (1942a) figured the nymph.

Bionomics. – Mature nymphs of *Skwala parallela* were collected from Battle Creek near Reesor Lake on March 28, 1976 and from Cub Creek, Jct. Hwy. 106 and McDougal Creek, Jct. Hwy. 120 on April 12, 1976. Adults were collected from Battle Creek (Reesor Lake) on May 19, 1976.

Richardson and Gaufin (1971) found that nymphs lived beneath rocks in swift, well-oxygenated water and were principally carnivorous, feeding on mayfly and chironomid nymphs, and occasionally on small stonefly nymphs. Filamentous algae, diatoms and detritus also formed significant parts of the diet.

Genus *Diura* Billberg

Diura, the only North American Perlodinae, is characterized by having an uncleft male tenth tergum and paraprocts which are extended backward to meet on the median margin of the tenth tergum (Fig. 107). Females have the subgenital plate produced halfway or more over the ninth sternum (Fig. 108, 109). Nymphs have dark abdominal terga with large paired spots laterally and a few smaller lateral spots. The nymphal lacinia, or inner projecting process of the maxilla, has a sharp angle just below the smaller tooth (Fig. 10) in contrast to other Saskatchewan perlodid genera in which the region below the smaller tooth is rounded or, more commonly, tapering from the tooth to the base (Fig. 170).

This genus is represented by three species in North America: two are Holarctic (*nanseni* and *bicaudata*) and one (*knowltoni*) occurs in western United States and Canada. *Diura bicaudata* occurs in northern Saskatchewan.

Diura bicaudata (Linnaeus)

Phryganea bicaudata Linnaeus 1758: 548.
Dictyopterygella postica, Ricker 1944: 178.
Diura bicaudata, Brinck 1949: 61.

This Holarctic species has North American reports from Alaska, Yukon, Mackenzie, and Keewatin. This first Saskatchewan record is based on a collection of a single female nymph from the shore of Wollaston Lake (Fig. 189) by D.S. Rawson and identified by W.E. Ricker.

Diagnostic Characters. – Average length, brachypterous males, 12.0 mm (from anterior margin of head to end of abdomen); females, 17.0 mm (from anterior margin of head to tip of folded wings). Male genitalia with subanal lobes produced posterad, together subcylindrical, and glabrous with tips lighter than the remainder (Fig. 107). Female subgenital plate variable. Ricker (1944) reported specimens with subgenital plate produced about halfway over sternum 9, its sides broadly rounded and deeply excavated. Brinck (1949) presented figures showing eight different forms of subgenital plate. Drawings presented here (Fig. 108, 109) show two common forms of subgenital plate with posterior edge broadly rounded (Fig. 108), and shallowly emarginate medially (Fig. 109).

Nymphs without underlying adult characters are presently indistinguishable from other species of *Diura*.

Bionomics. – Brinck (1949) has reported females of *Diura bicaudata* ovipositing while walking across the water surface or when flying. Egg incubation was found to last one to two months with nymphs showing a high growth rate in autumn and spring, but very retarded winter growth.

Nymphs are mainly predatory, feeding on chironomid larvae but occasionally they ingest vegetable matter (Brinck 1949).

Genus *Isogenoides* Klapalek

Isogenoides, the only Saskatchewan representative of Isogeninae, is characterized by having the arms of the mesosternal Y-ridge meeting the posterior corners of the furcal pits in addition to having a

median ridge joining the transverse ridge to the fork of the Y (Fig. 24). Submental gills are long. The male tenth tergum is completely cleft, and the genital lobes are directed medially or anteriorly rather than posteriorly. The male supra-anal process is slender with a terminal or subterminal hook or hooks. Lateral stylets are slender, acute or blunt, and the subanal lobes are quite expanded (Fig. 110, 111). The female subgenital plate is moderately produced, and either rounded or notched (Fig. 116). Nymphal mandibles usually have the ventral cusps serrate marginally but the denticles are minute.

Two of nine North American species of *Isogenoides* occur in Saskatchewan. These are the closely related species *Isogenoides colubrinus* (Hagen) and *Isogenoides frontalis* (Newman) which were ranked as subspecies of *Isogenoides frontalis* by Ricker (1952) but assigned full specific status by Illies (1966). *Isogenoides colubrinus* and *Isogenoides frontalis* are separable taxonomically only by examination of the male genital structures; Ricker (1952) was unable to establish characters to distinguish between females. I have reared a large series of females of both species but also have been unable to find any differences between the two which hold true for all or even most specimens. Nymphs of the two species have shown a similar agreement in all characters examined.

Key to Saskatchewan species of *Isogenoides*

Males

1	Posterior inner angles of genital hooks (terminal sclerotized corners of 10th tergum) sharp, practically a right angle (Fig. 110)..... *Isogenoides colubrinus* (Hagen), p.	56
1′	Posterior inner angles of the genital hooks broadly obtuse or rounded (Fig. 111) ..... *Isogenoides frontalis* (Newman), p.	57

Isogenoides colubrinus (Hagen)
(Fig. 20, 24, 38, 110, 116, 189)

Isogenus colubrinus Hagen 1874: 576. – (in part) Claassen 1940: 106. – Ricker 1964: 55, 67.
Isogenoides frontalis, Hanson 1943: 660.
Isogenus frontalis, Harden and Mickel 1952: 33.
Isogenus (Isogenoides) frontalis colubrinus, Ricker 1952: 110.
Isogenoides colubrinus, Illies 1966: 363.

Isogenoides colubrinus is known in Alaska, the cordilleras to Utah, northern Alberta to the Mackenzie River, Great Slave Lake, Lake Athabasca, central Saskatchewan and as far east as The Pas, Manitoba. Ricker (1946) reported the species from St. Laurent, Sask. (South Saskatchewan River) and additional collection records (Fig. 189) include the North Saskatchewan River, Jct. Hwy. 5 (Borden Bridge); South Saskatchewan River at the ferry north of Lemsford, Sask., the ferry Fenton, Sask., and the ferry north of Birch Hills, Sask.; and the Saskatchewan River 2 mi. S.W. of Nipawin, Sask. Ricker (1964) mapped the North American distribution pattern of this species.

Diagnostic Characters. – Average length, males, 18.0 mm (from anterior part of head to tip of folded wings); females, 24.0 mm. Adults with submental gills long; fork of the mesosternal Y-ridge connected with transverse ridge (Fig. 24). Male genitalia with posterior angles of genital hooks slightly acute and approaching right angles (Fig. 110); epiproct with hook at its tip. Female subgenital plate only slightly produced with deep U-rounded notch (Fig. 116).

Nymphal mandibles in most specimens serrate marginally, with scarcely distinguishable denticles; abdominal terga uniformly light brown.

Hanson (1943) and Gaufin *et al.* (1972) figured the male and female genitalia; Claassen (1931)

figured the nymph.

Bionomics. – In Saskatchewan, mature nymphs were collected from Lemsford Ferry, Borden Bridge, and Birch Hills Ferry in mid-May of 1974 and 1975. Adults were collected at the end of May of 1974. Mature nymphs were not found in collections from the North and South Saskatchewan Rivers from mid-June onward in both 1974 and 1975 with the unusual exception of two mature nymphs from Lemsford Ferry on July 7, 1975. They were reared and emerged in the laboratory on July 10, 1975. Eggs apparently develop rapidly since six immature nymphs averaging 5 mm in length were collected from Lemsford Ferry on August 10, 1974.

Isogenoides frontalis (Newman)
(Fig. 111, 189)

Isogenus frontalis Newman 1838: 178. – (in part) Claassen 1940: 106. – Frison 1942a: 290. – Ricker 1964: 65, 67.

Isogenus hudsonicus, Hanson 1943: 662.

Isogenus (Isogenoides) frontalis frontalis, Ricker 1952: 110.

Isogenoides frontalis, Illies 1966: 365.

Isogenoides frontalis is considered an eastern and northern species (Ricker, 1952) ranging from the Maritimes to northeastern United States and west to Michigan, Minnesota and Churchill, Manitoba. This first Saskatchewan report represents the most westerly range extension of the species. Specimens have been collected from the following localities (Fig. 189): Weyakwin River, Jct. Hwy. 2; stream at mile 83, Jct. Hwy. 106; stream at mile 85, Jct. Hwy. 102; stream 39 mi. N. of Hudson Bay, Sask., Jct. Hwy. 109; Meeyomoot River, Jct. Hwy. 165; Torch River, Jct. Hwy. 106; Waskwei River, Jct. Hwy. 109; Puskwakau River, Jct. Hwy. 106; and Mistohay Creek, Jct. Hwy. 226.

Ricker (1964) presented a North American distribution map of this species. The species is probably much more widespread than indicated on the Saskatchewan distribution map since I have collected nymphs and females from several other northern rivers which key to *Isogenoides*, but without adult males it is impossible to assign specific names to these specimens. I believe them to be *Isogenoides frontalis* since *Isogenoides colubrinus* has been found only in the Saskatchewan River System.

Diagnostic Characters. – *Isogenoides frontalis* differs from *Isogenoides colubrinus* only in shape of male genital hooks. In *Isogenoides frontalis*, posterior inner angles of genital hooks are broadly obtuse or rounded (Fig. 111).

Needham and Claassen (1925), Frison (1942a) and Hanson (1943) figured the male and female genitalia; Frison (1942a) figured the nymph.

Bionomics. – *Isogenoides frontalis* appears to have a one-year life cycle. Forty-three mature nymphs with well-developed wing pads collected from Weyakwin River, Jct. Hwy. 2 on May 6, 1976 had an average length of 20.2 mm. There were no nymphs of a younger age-class present (less than 17 mm in length). Adult emergence occurred at the end of May and early June of 1974 and 1975. Nymphs were absent from samples taken from the same river in late June and mid-July of 1974 and 1975. Egg development and early nymphal growth appear rapid since twelve early-instar nymphs averaging 8.9 mm in length were collected from Weyakwin River on August 8, 1975.

Genus *Isoperla* Banks

Males of this genus are characterized by having an uncleft tenth tergum, the absence of both gills and epiproct, and modified paraprocts. The male eighth sternum bears a lobe on its hind margin

(except in *maxana* Harden and Mickel which has lobes on both sterna 7 and 8 and in *ebria* (Hagen) and *trictura* (Hoppe) in which lobes are absent). Females of *Isoperla* are difficult to separate from *Isogenoides*, but in most *Isoperla* species females do not have subgenital plates produced as greatly as in *Isogenoides*. Most nymphs have a longitudinal or transverse striped pattern on the abdomen.

This large, difficult genus is in great need of revision; many of the 50 known species probably should be synonomized.

Because there is a great variation in both color patterns and genitalic structures within many species, the keys, taken largely from Frison (1942a), Gaufin *et al.* (1972) and Hitchcock (1974) may be inoperative for some specimens.

Key to Saskatchewan species of *Isoperla*

Adults

1		Ninth ventral abdominal segment much produced posteriorly and recurved upward, sternum 10 mostly or entirely concealed. Sternum 8 with small lobe in middle of posterior portion (Fig. 118)(males) 2
1′		Ninth ventral abominal segment poorly or not at all produced; tenth segment always visible from below. Sternum 8 without small lobe in middle of posterior portion; posterior margin either broadly rounded or strongly produced as subgenital plate (females) 8
2	(1)	Cerci about twice as long as relaxed abdomen, length of 12th cercal article 6 to 8 times its greatest width; two conspicuous semi-circular patches of spinules on ninth abdominal tergum (Fig. 120) ..... *Isoperla longiseta* Banks, p. 61
2′		Cerci less than 1.5 times as long as relaxed abdomen, length of 12th cercal article 3 to 5 times its greatest width; if spinules present on abdominal tergum 9, spinules not arranged in semi-circular pattern 3
3	(2′)	Patches of short stout hairs on posterior margin of tergum 9; most specimens with red tinge to some abdominal segments (Fig. 122) ..... *Isoperla patricia* Frison, p. 62
3′		No patches of stout hairs on tergum 9; most specimens without red tinge to abdominal segments 4
4	(3′)	Longitudinal dark stripes on abdominal terga (Fig. 119) ..... *Isoperla transmarina* (Newman), p. 64
4′		Abdomen uniformly brown or yellow 5
5	(4′)	Paraprocts projecting little if at all over tergum 10 (Fig. 117, 118, 121) 6
5′		Paraprocts recurved upward and forward over tergum 10 (Fig. 123) 7
6	(5)	Paraprocts scarcely sclerotized (Fig. 117, 118) ..... *Isoperla bilineata* (Say), p. 60
6′		Paraprocts very heavily sclerotized (Fig. 121) ..... *Isoperla decolorata* (Walker), p. 60
7	(5′)	Aedeagus with slender process, forked at its base and visible as rod-shaped structure through sternum 9 (Fig. 123, 124) ..... *Isoperla petersoni* Needham and Christensen, p. 63
7′		Aedeagus without slender sharp process ..... *Isoperla marlynia* Needham and Claassen, p. 62
8	(1′)	Light spot in ocellar triangle broadly open caudally, forming a broad V; subgenital plate subtriangular or slightly notched posteriorly (Fig. 125–128) ..... *Isoperla bilineata* (Say), p. 60
8′		Ocellar triangle completely enclosed by dark sclerotization with central light spot completely enclosed or narrowly open caudally; subgenital plate variable 9
9	(8′)	Cerci about twice as long as relaxed abdomen, length of 12th cercal article 6 to 8 times

its greatest width; subgenital plate rounded in most specimens, slightly excavated, or rarely slightly pointed (Fig. 129–132) ..... *Isoperla longiseta* Banks, p. 61

9′ Cerci less than 1.5 times as long as relaxed abdomen, length of the 12th cercal article 3 to 5 times its greatest width; subgenital plates variable 10

10 (9′) Subgenital plate truncate (Fig. 135) ..... *Isoperla transmarina* (Newman), p. 64

10′ Subgenital plate not truncate 11

11 (10′) Subgenital plate subtriangular (Fig. 133) ..... *Isoperla decolorata* (Walker), p. 60

11′ Subgenital plate not subtriangular 12

12 (11′) Subgenital plate with deep wide excavation (Fig. 136); most specimens with red cast to some abdominal segments ..... *Isoperla patricia* Frison, p. 62

12′ Subgenital plate without deep, wide excavation; without red tinge to abdominal segments 13

13 (12′) Species with lateral light spots anterior to median ocellus and with crescent-shaped light spot anterior to median ocellus (Fig. 137) ..... *Isoperla marlynia* Needham and Claassen, p. 62

13′ Species without lateral light spots anterior to median ocellus and without subcircular light spot anterior to median ocellus (Fig. 134) ..... *Isoperla petersoni* Needham and Christensen, p. 63

Nymphs

1 Abdominal terga with longitudinal stripes 2

1′ Abdominal terga with transverse stripes with both posterior and anterior tergal margins dark and middle tergal portion light ..... *Isoperla marlynia* Needham and Claassen, p. 62

2 (1) Abdominal stripes indistinct; 6 to 8 dark dots on each abdominal terga ..... *Isoperla bilineata* (Say), p. 60

2′ Abdominal stripes distinct, no dark dots on abominal terga 3

3 Cerci less than 1.5 times as long as relaxed abdomen 4

4 (3′) Abdominal terga with broad longitudinal yellow band in center bordered on each side by dark band ..... *Isoperla petersoni* Needham and Christensen, p. 63

4′ Abdominal terga with narrow dark band in center bordered on either side by light band 5

5 (4′) Light spot within ocellar triangle very small and inconspicuous (Fig. 168) ..... *Isoperla decolorata* (Walker), p. 60

5′ Light spot within ocellar triangle at least as large in diameter as half the distance between lateral ocelli 6

6 (5′) Abdominal terga with central dark band bordered on each side by a much broader light band; light area within ocellar triangle equal in diameter to about half the distance between lateral ocelli ..... *Isoperla patricia* Frison, p. 62

6′ Abdominal terga with central dark band bordered on each side by light band of about the same width; light area within ocellar triangle equal in diameter to more than half the distance between lateral ocelli ..... *Isoperla transmarina* (Newman), p. 64

Isoperla bilineata (Say)
(Fig. 31, 117, 118, 125-128, 190)

Sialis bilineata Say 1823: 165.
Isoperla bilineata, Needham and Claassen 1925: 154. – Frison 1935: 436. – Claassen 1940: 198. – Harden and Mickel 1952: 39. – Ricker 1964: 54.

Isoperla bilineata is a common species from central and eastern Canada and the United States. It has been collected from Newfoundland, New York, New Jersey and North Carolina and west to Saskatchewan, Minnesota and Colorado. Needham and Claassen (1925) reported the species from "Saskatchewan", and additional collection records (Fig. 190) include: Little Red River near Prince Albert, Sask.; the North Saskatchewan River at Hwy. 5 (Borden Bridge), Hwy. 12, Prince Albert, Sask., Cecil Ferry, and the ferry north of Maidstone, Sask.; the South Saskatchewan River at Saskatoon, Sask., Fenton Ferry, ferry north of Lemsford, Sask., ferry east of Hague, Sask., ferry north of Birch Hills, Sask.; Battle River, 4 mi. S. of Lashburn, Sask.; Fox Creek; and the river 87 mi. N. of Southend, Sask. on the Wollaston Lake Road.

Diagnostic Characters. – Average length, males, 10.0 mm (from anterior margin of head to tip of folded wings); females, 14.0 mm. Adults with head and body pale in color; ocelli in most specimens connected by dark V-shaped mark. Male genitalia with paraprocts little modified, scarcely sclerotized and somewhat recurved; lobe on sternum 8 broadly rounded (Fig. 117, 118). Female subgenital plate sub-triangular and produced about halfway over sternum 9 (Fig. 126); or is slightly emarginate posteriorly (Fig. 127, 128).

Nymphs with dark longitudinal stripes and six to eight dark dots on abdominal terga and light spot in ocellar triangle.

Needham and Claassen (1925) and Frison (1935) figured the adult genitalia and wings; Frison (1935) and Claassen (1931) figured the nymph.

Bionomics. – Frison (1935) noted that *Isoperla bilineata* was a member of the Illinois spring stonefly fauna with adult emergence occurring at night and beginning by the end of March. Maximum abundance of adults was reached in mid-May and adults were absent by the end of June. In Saskatchewan, adults first appear by the end of May, and the species is very commonly collected throughout June but practically absent by July. One peculiar collection was a female from the stream 87 mi. N. of Southend, Sask. on the Wollaston Lake Road on August 7, 1975. This record is interesting because of the late collection date and northern location.

There is some confusion regarding the feeding habits of this species. Frison (1935) stated that the species seemed to be herbivorous, but Harden and Mickel (1952) found the larval gut contents to be principally Chironomidae. Eggs collected in June and kept in the laboratory did not hatch until October (Harden and Mickel, 1952).

Isoperla decolorata (Walker)
(Fig. 121, 133, 168-170, 192)

Perla decolorata Walker 1852: 170.
Isoperla decolorata, Claassen 1940: 199. – Ricker 1944: 183. – Ricker, 1955: 256. – Ricker 1964: 56.

Isoperla decolorata is a rare species known only from northern Canada (Great Bear Lake, Keewatin, Fort Churchill, northern Ontario) and Alaska. The collection of a single male from the North Saskatchewan River at Hwy. 5 (Borden Bridge) represents the most southerly known locality for this species.

Diagnostic Characters. – Average length, males, 10.5 mm (from anterior margin of head to tip of wings); females, 11.5 mm. Adults with general dark brown color and yellow markings; ocellar spot small and inconspicuous. Male sternum 8 with lobe broad at tip and constricted at base. Male genitalia with darkly sclerotized paraprocts fairly broad at their bases, sharp at tips and recurved but not over tergum 10 (Fig. 121). Female subgenital plate subtriangular with broad base extended about halfway over sternum 9 (Fig. 113). A first description of the nymph is given below.

Description. – Total length of mature nymph about 10 mm.

General color yellow with fuscous areas on head, thorax and abdomen as in Fig. 168; light yellow ventrally. Antennae light brown with first two articles darker; legs light yellow and darker at joints; cerci light brown.

Head with ocelli forming nearly equilateral triangle; maxillae and mandibles as in Fig. 169, 170.

Abdominal terga with central longitudinal dark stripe and light subcircular areas on either side; tergum 10 with central bilobed light area, as in Fig. 168. Abdominal terga covered with numerous clothing hairs and longer bristles on posterior margins of each terga, longest about one-third the mid-dorsal tergal length. Cerci with regular whorls of bristles near anterior margin of each article and a few long hairs which become more numerous on distal cercal articles.

Ricker (1944) figured the male and female genitalia; the nymph is illustrated for the first time in Fig. 168–170.

Bionomics. – Little is known of the biology of this species. From a sample of 205 *Isoperla* collected and reared from the North Saskatchewan River at Hwy. 5 (Borden Bridge) on May 27, 1975 only one was *Isoperla decolorata*; the remainder were *Isoperla bilineata*. The *Isoperla decolorata* adult emerged May 29, 1975 in the laboratory.

Isoperla longiseta Banks
(Fig. 120, 129-132, 191)

Isoperla longiseta Banks 1906: 337. – Needham and Claassen 1925: 156. – Claassen 1940: 203. – Frison 1942a: 318. – Ricker 1943: 124. – Harden and Mickel 1952: 41. – Ricker 1964: 56.

Isoperla longiseta is considered a typical prairie species (Ricker, 1964) and is abundant in large rivers of the plains and inter-mountain regions from the Mississippi to the Great Basin and from Colorado and Missouri northward. In Canada it occurs characteristically on the prairies but also as far north as Norman Wells on the Mackenzie River. Ricker (1946) reported several collections of this species from Saskatoon, Sask., and additional records (Fig. 191) include: the North Saskatchewan River at Hwy. 5 (Borden Bridge), North Battleford, Sask., Cecil Ferry, ferry south of Maymont, Sask., Prince Alberta, Sask., and the ferry 20 mi. N. of Lloydminister, Sask.; the South Saskatchewan River at the ferry north of Lemsford, Sask., the ferry north of BirchHills, Sask., and the ferry north of Fenton, Sask.; the Saskatchewan River 2 mi. S.W. of Nipawin, Sask., and 10 mi. E. of the Squaw Rapids Power Station; and a record from Melfort, Sask.

Ricker (1964) presented a North American distribution map for this species.

Diagnostic Characters. – Average length, males, 10.0 mm (from anterior margin of head to tip of folded wings); females, 13.0 mm. Adults with yellowish color and darker markings on head; long cerci, about twice abdominal length. Male genitalia with paraprocts sharp, slender and recurved over tergum 10; tergum 10 with two brown patches of setae and a bilobed brown patch on tergum 9 (Fig. 120). Female subgenital plate produced about halfway across sternum 9; strongly sclerotized; posterior margin of subgenital plate rounded in most specimens (Fig. 129), but slightly or greatly emarginate (Fig. 130, 131) or even slightly pointed in some specimens (Fig. 132).

Nymphs with light color and faint longitudinal stripes on abdominal terga; light area within ocellar triangle not completely enclosed by darker area.

Needham and Claassen (1925), Frison (1942a), Gaufin *et al.* (1966) and Gaufin *et al.* (1972) figured the adult genitalia; Frison (1942a) figured the nymph.

Bionomics. – This species is apparently restricted to fairly large rivers. It is abundant in the Saskatchewan River System with adult emergence beginning in mid-June and lasting until about the end of July. The life-cycle appears to be univoltine since nymphs were absent from benthic collections for a time following the summer adult emergence.

Isoperla marlynia Needham and Claassen
(Fig. 137, 191)

Isoperla marylnia Needham and Claassen 1925: 148. – Claassen 1940: 203. – Frison 1942a: 330. – Harden and Mickel 1952: 203. – Hitchcock 1974: 202.

Isoperla marlynia is a common species of eastern Canada and United States. It has been reported from Virginia to New Brunswick, and west to Manitoba and Minnesota. This first Saskatchewan collection record (Fig. 191) is from Torch River, Jct. Hwy. 106, and Red Deer River near Chelan, Sask., Jct. Hwy. 23.

Diagnostic Characters. – Average length, males, 12.0 mm (from anterior margin of head to tip of folded wings); females, 13.0 mm. Adults with light color and brown markings; head with crescent-shaped light spot and two lateral light spots anterior to median ocellus. Male genitalia with paraprocts fairly long and slender, pointed at tips and recurved over tergum 10. Female subgenital plate produced less than halfway over sternum 9; with shallow median emargination (Fig. 137).

Nymphs with three possible distinct color phases. Light phase: mainly yellow with black lateral stripes on both posterior and anterior margins of each abdominal tergum. Intermediate phase: light markings laterally on each abdominal tergum with few light markings on head and pronotum. Dark phase: dark without yellow markings.

Needham and Claassen (1925) and Frison (1942a) figured the adult genitalia; Frison (1942a) figured the nymph. The three possible color phases of nymphs are apparently equally common, and may occur in the same population (Frison, 1942a). Only the light phase has been found in Saskatchewan specimens.

Bionomics. – A female nymph collected from Torch River, Jct. Hwy. 106 on April 12, 1976 emerged under laboratory conditions on June 15, 1976.

Isoperla patricia Frison
(Fig. 122, 136, 190)

Isoperla patricia Frison 1942a: 313. – Ricker 1943: 126. – Jewett 1959: 74. – Ricker 1964: 55. – Gaufin, Nebeker and Sessions 1966: 70. – Gaufin, Ricker, Miner, Milam and Hays 1972: 118.

Isoperla patricia, a common species in western Canada and United States, has been collected from British Columbia to California and Utah and east to Idaho, Montana and South Dakota. This first Saskatchewan record (Fig. 190) is from the South Saskatchewan River at Lemsford Ferry and the following Cypress Hills localities: Bear Creek, 10 mi S. of Piapot, Sask.; Shuard Creek, 11 mi S. of Piapot, Sask.; and Conglomerate Creek at Ravenscrag, Sask.

Diagnostic Characters. – Average length, males, 10.0 mm (from anterior margin of head to tip of folded wings); females, 12.5 mm. Most adult specimens with red pigmentation on abdominal segments.

Male genitalia with subanal lobes recurved upwards over tergum 10 and with slender, sharply pointed tips; posterior margin of sternum 9 with patches of short stout hairs (Fig. 122). Female subgenital plate produced about halfway over sternum 9 and deeply excavated in most specimens (Fig. 136).

Nymph with dark narrow band in center of abdominal terga bordered on each side by broader light band.

Frison (1942a), Gaufin *et al.* (1966) and Gaufin *et al.* (1972) figured the male and female genitalia; Frison (1942a) figured the nymph.

Bionomics. – This species appears to have a two-year life cycle in Saskatchewan. From a sample of 45 nymphs collected on June 3, 1975 at Shuard Creek, 11 mi S. of Piapot, Sask., 21 nymphs ranging in length from 4.0 mm to 9.5 mm (with an average length of 5.9 mm) had very little wing pad development and could not have emerged until the following year. Twenty-four mature nymphs ranging in length from 8.5 mm to 12.0 mm (with an average length of 10.3 mm) had full-grown wing pads and would have emerged the same year. There were several stages of nymphal development present at one time among the nearly mature specimens indicating little synchrony of emergence.

Isoperla petersoni Needham and Christensen
(Fig. 123, 124, 143, 192)

Isoperla petersoni Needham and Christensen 1927: 19. – Jewett 1959: 74. – Ricker 1964: 55. – Gaufin, Ricker, Miner, Milam and Hays 1972: 118.

Isoperla fontium, Neave 1929: 161. – Ricker 1943: 122.

Isoperla petersoni is found in western Canada and United States including Alberta, British Columbia, Utah and Montana. This first Saskatchewan record (Fig. 192) is from Mackenzie Creek near Bow River, Jct. Hwy. 165 and the stream at mile 83, Jct. Hwy. 106.

Diagnostic Characters. – Average length, males 12.5 mm (from anterior margin of head to tip of folded wings); females, 14.5 mm. Adults with yellow color and dark brown markings on head and thorax. Male genitalia with paraprocts slender, recurved over tenth tergum and darkly sclerotized (Fig. 123); aedeagus with slender sharp process forked at its base (Fig. 124), aedeagal process visible through sternum 9 of most specimens as dark rod-shaped structure; when not visible, aedeagal process may be exposed by dissecting away sternum 9. Female subgenital plate produced nearly halfway over sternum 9, and slightly emarginate at tip (Fig. 134).

Nymphs with longitudinal striped pattern on abdomen, but differ from other Saskatchewan *Isoperla* species by having broad central light band bordered on each side by dark band.

Neave (1929), Gaufin *et al.* (1966) and Gaufin *et al.* (1972) figured the female genitalia; Claassen (1931) figured the nymph.

Brachyptery has been reported in males of this species in Montana (Gaufin *et al.*, 1972) and in Utah (Gaufin *et al.*, 1966), but Saskatchewan specimens all have wings of normal length. The *Isoperla* species key for Montana nymphs given by Gaufin *et al.* (1972) states that nymphs of *Isoperla petersoni* lack a fringe of long hairs on the legs. Saskatchewan nymphs of this species all have a definite fringe of hairs on the legs though the hairs are shorter than in other species of this genus.

Bionomics. – Hales and Gaufin (1971) stated that this species is restricted to spring-fed streams or streams largely influenced by springs. Adult emergence was found to be relatively short, lasting about two weeks. In Saskatchewan, adults emerged in the end of June and early July of 1974.

Mackenzie Creek empties into the Bow River near Hwy. 165, and it is interesting that this species was found only in Mackenzie Creek. Samples from Bow River, even at the point of entry of Mackenzie Creek, showed numbers of *Isoperla transmarina*, but not *Isoperla petersoni*. In both rivers where

Isoperla petersoni was collected, larvae of Rhyacophilidae (Trichoptera) were also abundant though they are fairly uncommon in other Saskatchewan rivers.

Isoperla transmarina (Newman)
(Fig. 119, 135, 192)

Chloroperla transmarina Newman 1838: 499.
Isoperla fumosa, Neave 1933: 235.
Isoperla transmarina, Frison 1942a: 316. – Harden and Mickel 1952: 46. – Hitchcock 1974: 210.

Isoperla transmarina is a common North American species ranging from the Maritimes south to New Jersey and west to Minnesota, Manitoba and British Columbia. This first Saskatchewan report is from collections made at the following localities (Fig. 192): Little Red River, near Prince Albert, Sask.; stream 80 mi. N. of La Ronge, Sask. on Hwy. 102; Martineau River near Cold Lake; Cole Creek, Jct. Hwy. 104; Weyakwin River, Jct. Hwy. 2; Waskwei River, Jct. Hwy. 109; Mackay Creek, Jct. Hwy. 2; Nemeiben River, Jct. Hwy. 2; Bear River, Jct. Hwy. 106; Puskwakau River, Jct. Hwy. 106; Ballantyne River, Jct. Hwy. 106; Crean River, Jct. Hwy. 2; Churchill River at Wintego Lake Rapids, Otter Rapids, Iskwatam Lake, and Pita Lake; Montreal River, Jct. Hwy. 165 and at La Ronge, Sask.; Waskesiu River, Jct. Hwy. 2; Torch River, Jct. Hwy. 106; Overflowing River, Jct. Hwy. 109; Waterhen River, Jct. Hwy. 226; Broad Creek, Jct. Hwy. 104; McDougal Creek, Jct. Hwy. 120; North Saskatchwan River at Hwy. 5 (Borden Bridge); Bow River, Jct. Hwy. 165; Waddy River, Jct. Hwy. 102; Meeyomoot River, Jct. Hwy. 165; Arsenault River, Jct. Hwy. 104; Mistohay Creek, Jct. Hwy. 226; Nipekamew River, Jct. Hwy. 165; Caribou Creek, Jct. Hwy. 106; stream entering south end of Wollaston Lake, Jct. Hwy. 105; Fond du Lac River at Black Lake; Cluff Creek near Cluff Lake; Cub Creek, Jct. Hwy. 106; and Green Lake, Sask.

Diagnostic Characters. – Average length, males, 10.0 mm (from anterior margin of head to tip of folded wings); females, 14.0 mm. Adult with light brown and yellow coloration; light spot of ocellar triangle completely enclosed by darker areas in some specimens or may be slightly open posteriorly. Male genitalia with paraprocts sharply pointed, darkly sclerotized and recurved over tergum 10. Male abdominal terga with striped pattern, most easily seen on posterior segments (Fig. 119). Female subgenital plate truncate and produced about halfway over sternum 9.

Nymph with large light spot within ocellar triangle; longitudinal striped pattern on abdominal terga with central dark band bordered on each side by light stripes of about same width.

Ricker (1938) figured the male genitalia, and Neave (1933) figured the female genitalia (under the name *fumosa*). Frison (1942a) figured the nymph.

Bionomics. – Gaufin (1958) studied the effects of pollution on the Mad River in Ohio and found that the occurrence of *Isoperla transmarina* was limited entirely to the cleanest sections of the stream. Harden (1942) stated that nymphs seemed to prefer a habitat of matted leaves and vegetation trapped by submerged objects.

Harper (1973a) provided life cycle data for this species from southern Ontario. Adult emergence was fairly synchronous, beginning in early May and lasting 40 days. Emergence occurred in early morning and males emerged earlier than females. Oviposition was first observed in late May and early June. Egg hatching lasted from 34 to 43 days under simulated stream conditions. Early-instar nymphs were collected in the field in July which closely matched the laboratory incubation period. Rapid growth ensued until January when growth was minimal up to April. Growth was then continued and completed a few weeks before the May emergence.

DISCUSSION

Types of life histories and seasonal succession of Saskatchewan Plecoptera

The invertebrate benthos of flowing waters in temperate climates shows a clear succession of events as species appear and disappear from collections and one species after another completes its life cycle (Hynes, 1970). A life cycle classification will be employed to categorize how and when Saskatchewan stonefly species initiate and complete their development.

The system of classification proposed by Hynes (1961) can be applied to Saskatchewan stonefly life cycles. Basically a distinction is made between univoltine and seasonal species and non-univoltine or non-seasonal species. Non-seasonal species have individuals of all sizes present at all times while seasonal cycles show a distinct change of size distribution with time. Univoltine species are then separable into two groups. The "F" or fast type of cycle implies an embryonic diapause; species of "S" or slow type do not diapause. Each of these types can be further arbitrarily separated into four groups depending on the time of year when adults emerge. For example, group F_1 contains species of the fast seasonal type which emerge from mid-winter until April, adults of F_2 species emerge in May and June, F_3 species emerge in July and early August and F_4 species emerge in late August and in fall.

As can be seen from Table II, Saskatchewan Plecoptera have varied life histories and can contain, as far as is presently known, species representing all types except S_4 and F_3. A large number of species remain unclassified due to a paucity of life cycle data. Further life history studies on the uncategorized species will certainly increase the variety of types depicted.

The simplest seasonal type is S_1 in which embryonic development is immediate. Harper and Hynes (1972) further divided this category, separating species which undergo nymphal diapause from those which do not. For the sake of simplicity this grouping has not been followed here. Saskatchewan stoneflies with this type of life cycle are the so-called winter stoneflies.

Several Perlodidae and Chloroperlidae fall into the S_2 type. There are, however, still differences in the timing and deviation of adult emergence. For example, *Isoperla bilineata* emerges in late May; *Isoperla transmarina* emerges in early to mid-June, and *Hastaperla brevis* emerges throughout all of June.

Isoperla longiseta emerges in July and although it is not established for certain that an embryonic diapause is absent, the species probably is of the S_3 type.

Species with fast seasonal cycles undergo a long diapause at the onset of embryogenesis allowing them to survive the warm summer season as an underdeveloped egg. Saskatchewan stoneflies with this type of development include *Shipsa rotunda* emerging in late April (F_1), *Diura bicaudata* emerging in late spring (F_2) and *Amphinemura linda* and probably *Malenka californica* which emerge in late summer and autumn (F_4). *Amphinemura linda* may emerge as soon as early July in a few warm streams, but most often it does not emerge until mid-August, and thus will be considered type F_4.

Species which are listed in the uncertain section of Table 1 have inadequate life history information available for placement in any of the other categories.

Figure 193 presents the seasonal distribution of adult Plecoptera in Saskatchewan. The late winter and early spring fauna is evidently very rich, and this is succeeded by an equally diverse late spring and early summer fauna. There are few summer species and only *Amphinemura linda* and *Malenka californica* can be considered late summer and fall species. Several species, which have not been indicated in Fig. 193, are adventitious and their seasonal distributions are poorly known.

Table II. Types of life histories known in Saskatchewan Plecoptera. Data are from the literature and present study. The question marks (?) indicate that the life-cycle of the species is incompletely investigated and that it is placed in the most likely category from data available.

I. Non-seasonal species (life history longer than one year):
Pteronarcys dorsata (present study)
Claassenia sabulosa (present study)
Acroneuria lycorias (present study)
Acroneuria abnormis (present study)
Hesperoperla pacifica (present study)
Paragnetina media (Harper, 1973a; Heiman and Knight, 1970; Tarter and Krumholz, 1971; present study)

II. Seasonal species (life history of one year duration):
A. Slow type (no embryonic diapause):
S_1 (adult emergence from mid-winter until April)
Zapada cinctipes (Clifford, 1969)
Paracapnia angulata (Harper and Hynes, 1970; Harper and Hynes, 1972)
? *Oemopteryx fosketti*
? *Capnia confusa*
? *Capnia coloradensis*
? *Capnia gracilaria*
? *Utacapnia trava*
S_2 (adult emergence in May and June):
Isoperla transmarina (Harper, 1973a)
? *Isoperla bilineata*
? *Isoperla petersoni*
? *Isoperla patricia*
? *Skwala parallela*
? *Hastaperla brevis*
? *Triznaka signata*
? *Isogenoides frontalis*
? *Isogenoides colubrinus*
S_3 (adult emergence in July and early August):
? *Isoperla longiseta*

B. Fast type (Embryonic diapause):
F_1 (adult emergence from mid-winter until April):
Shipsa rotunda (Harper, 1973b)
F_2 (adult emergence in May and June):
Diura bicaudata (Brinck, 1949)
F_4 (adult emergence in late August and fall):
Amphinemura linda (Harper, 1973b)
? *Malenka californica*

III. Species of uncertain life cycle.

Perlesta placida
Suwallia lineosa
Pteronarcella badia
Isoperla decolorata
Isoperla marlynia
Nemoura rickeri
Podmosta delicatula
Paraleuctra vershina
Leuctra ferruginea
Capnia vernalis
Isocapnia crinita
Isocapnia missourii
Arcynopteryx compacta

Although the period of adult occurrence overlaps for several species, the timing of their maximum abundance differs.

The differences in stonefly life histories and adult seasonal successions are important in limiting interspecific and intraspecific competition and allowing the coexistence of several stonefly species in the same stream.

Winter stoneflies, which concentrate the largest proportion of their nymphal growth in fall and winter, have utilized several ecological opportunities as Harper and Hynes (1972) point out. Food, in the form of dead plant matter, is especially abundant in this time of year. Also, few other stream insects are active during this season. Species which grow rapidly in early spring and undergo nymphal diapause in summer are able to use an abundant spring food supply in form of dead leaves which have soaked right through the winter.

Many carnivorous Perlodidae and Chloroperlidae show a wide range of size-frequency distributions in a given sample indicating the simultaneous co-existence of specimens of different sizes. Harper (1973a) argues that this has the result of lessening intraspecific competition because it provides predatory individuals with a wider variety of prey organisms.

Some related species of the same genus or family show a distinct succession of adults, with the obvious advantage of limiting possible mating encounters.

Saskatchewan stonefly species show a variety of life history patterns and adult seasonal distributions. Life cycle differences enable the co-existence of several stonefly species in the same stream, and a succession of adults permits maintenance of a higher level of diversity.

Origin and past dispersal of Saskatchewan Plecoptera

In order to reconstruct the faunal history of a region it is necessary to integrate information of the geographical and ecological distribution of existent species with knowledge of the geological and climatic history of the area. To determine past dispersals of species it is requisite to assume that each species is now found in the same type of habitat which it occupied in the past and that geographical changes in the distribution of a species' habitat have also affected the possible range of that species. Also, it is assumed that non-glaciated areas presently occupied by a species represent refugia or regions where the species was able to pass the glacial maximum (Larson, 1975).

The destructive results of the Pleistocene glaciation had a major effect in shaping the distributional history of the extant fauna. There were four major glaciations in the Pleistocene but the last of the glacial advances, the Wisconsin, obliterated the effects of the previous glaciations and virtually eliminated the fauna of Saskatchewan. The present-day faunal composition of areas previously ice-covered originated with the retreat of Wisconsin ice.

In order to arrive at a reasonable explantion of post-glacial stonefly dispersal into Saskatchewan, several events of the Wisconsin glaciation will be discussed including the full extent of the ice sheets and locations of possible refugia, subsequent retreat of ice from the glacial maximum and the important post-glacial lakes and river systems and their development to the present.

The Wisconsin glaciation began about 50,000 years before present (B.P.) and extended about 11,000 years B.P. (McPhail and Lindsey, 1970). At its maximum extent (17,000 years B.P.) almost all of Saskatchewan was ice-covered by the Laurentide ice sheet except Cypress Hills and a small area in southcentral Saskatchewan on the present-day Canada-United States border (Prest, 1968) By about 14,000 years B.P., Prest (1968) suggests that the glaciers had retreated from southwestern Saskatchewan and by 13,000 years B.P. most of southcentral Saskatchewan was also ice-free. Two-thirds of Saskatchewan was ice-free about 10,000 years B.P.

As the Laurentide ice sheet began its retreat, Glacial Lake Agassiz formed over roughly 200,000 square miles of the provinces of Ontario, Manitoba and Saskatchewan and the states of Minnesota, North Dakota and South Dakota (Elson, 1967). The morphometry and the outlets of Lake Agassiz changed as the glaciers advanced and retreated for short periods. Elson (1967) noted that the lake originally drained south to the Mississippi River System and later to the Great Lakes, and to the Athabasca River in the northeast. As the ice receded, the lake drained north to Hudson Bay.

The Saskatchewan River System began to flow south, prior to 12,000 years B.P., into the Big Muddy-Missouri System because the ice front prevented a northerly flow (Elson, 1967). Further retreat of the ice sheet diverted its course to the Souris-Lake Agassiz drainage, and then to the Qu'Appelle Valley-Assiniboine River drainage. Finally, the ice retreated sufficiently to allow a northern drainage to Hudson Bay.

The present-day stonefly fauna of Saskatchewan is the result of post-glacial dispersal from ice-free refugia. The Cypress Hills was unglaciated (Westgate, 1964), and could have served as a refugium. Also, there were unglaciated areas in Alaska and Yukon which served as important refugia for some organisms (McPhail and Lindsey, 1970; Munroe, 1956). Three important refugia formed south of the continental ice sheet: the Pacific refugium west of the continental divide, the Mississippi comprised of the Missouri River and Upper Mississippi River Systems and the Atlantic refugium (McPhail and Lindsey, 1970).

Ricker (1964) proposed that the most likely species which survived glaciation in the northwestern refuge of Alaska and Yukon are the present-day tundra species: *Nemoura arctica*, *Capnia nearctica*, *Isoperla decolorata*, *Diura bicaudata* and *Arcynopteryx compacta*. These species have since migrated as far east as Hudson Bay but as yet have been unable to pass around its southern extremity. The latter three species have been found in Saskatchewan: *Diura bicaudata* and *Arcynopteryx compacta* in the northern boreal region and a single specimen of *Isoperla decolorata* collected in the North Saskatchewan River.

The collection of *Diura bicaudata* in northern Saskatchewan and a record from approximately the same latitude near Hudson Bay in Manitoba represent the most southerly known point to which this species has been able to penetrate the boreal forest. *Arcynopteryx compacta*, however,

has not only been collected in northern Canada west of Hudson Bay, but also from the Great Lakes, New Hampshire, southern Alberta and Wyoming. Ricker (1964) suggests that the species must have lived in Glacial Lake Agassiz and dispersed eastward when the lake drained to the Great Lakes. The common factor in the distribution of *Arcynopteryx compacta* is that it occurs principally in cold lakes. *Isoperla decolorata* has crossed the tundra and boreal forest, reaching its most southerly distribution on the Saskatchewan parkland. *Nemoura rickeri* has been collected previously only in Alaska and also probably dispersed from a northwestern refugium.

A number of species reach their most westerly ranges in the boreal regions of Saskatchewan, Alberta and northeastern British Columiba, and are abundant in nonglaciated areas of eastern North America. These species probably originated in an eastern boreal refugium and dispersed to the north and west. Saskatchewan species with this type of distribution include *Acroneuria lycorias*, *Perlesta placida*, *Paragnetina media*, *Pteronarcys dorsata*, *Isoperla transmarina*, *Isoperla marlynia*, *Shipsa rotunda*, *Hastaperla brevis*, *Taeniopteryx nivalis*, *Amphinemura linda*, *Isogenoides frontalis*, and *Leuctra ferruginea*. The extent to which southeastern species have invaded Saskatchewan varies from species to species. *Paragnetina media*, *Taeniopteryx nivalis* and *Isoperla marlynia* are found in northeastern Saskatchewan but not in the northwest. *Perlesta placida* occurs only in eastcentral Saskatchewan. Other species range entirely across the northern part of the province and beyond: *Hastaperla brevis* extends to the Mackenzie River, *Amphinemura linda* enters southern Yukon; *Isoperla transmarina* reaches northern British Columbia and *Shipsa rotunda* extends to the Mackenzie River delta. *Pteronarcys dorsata*, an exceptionally widespread species, occurs across Canada except in southern British Columbia and on the tundra.

Several species are widespread in the mountains of western North America and also occur in Saskatchewan boreal regions. They probably survived glaciation in the western portion of the southern North American refugium and dispersed north and east from the eastern border of the Rockies. Species with this type of distribution are: *Pteronarcella badia*, *Isoperla petersoni*, *Capnia confusa*, *Capnia coloradensis*, *Capnia vernalis*, *Utacapnia trava*, *Claassenia sabulosa*, *Zapada cinctipes*, *Malenka californica* and *Triznaka signata*. On reaching the boreal forest, these species moved eastward in varying degrees: *Pteronarcella badia* and *Triznaka signata* occur only in northwestern Saskatchewan and the rest of the species have reached northeastern Saskatchewan.

The Cypress Hills remained unglaciated in the Wisconsin (McPhail and Lindsey, 1970) and there is no reason to believe that they could not have harbored stoneflies even though the area was completely surrounded by ice. Westgate (1964) provided evidence in Cypress Hills of ponds with vegetation and animals, not only at the ice edge, but actually on the ice surface where debris had accumulated to provide a suitable substrate.

Bird (1962), studying bryophytes, Russell (1951), studying land snails and Yeatman (1967) studying pines, demonstrated that the Cypress Hills flora and fauna has its principal affinities with the Rocky Mountains. Russell (1951) contended that most or all of the land snails entered the Cypress Hills postglacially across a "bridge" of suitable climatic and edaphic conditions connected with the mountains. The bridge later disappeared as the glaciers retreated further and the climate warmed. This proposal agrees with the statements of Love (1959) regarding the direction of floral movement across the southern prairies.

Cypress Hills stoneflies are all montane species and their affinities are with present-day species of the Rocky Mountains. Though not a likely possibility, these stoneflies could have been present in the Cypress Hills prior to the Wisconsin and passed the glacial maximum in the Cypress Hills refugia. This proposal assumes that the area was connected to the mountains by a similar type of

climatic and edaphic "bridge" sometime prior to the Wisconsin glaciation. Though little is known of pre-Wisconsin geography, the formation of such a connection from the Cypress Hills to the mountains could as easily have occurred after pre-Wisconsin glaciations just as it could following the Wisconsin glaciation.

The second, more likely origin of Cypress Hills Plecoptera could be by post-Wisconsin dispersal to the area from the Rockies by a connecting bridge of montane climatic and edaphic conditions which is proposed to have formed as the ice retreated. As the climate warmed and the bridge disappeared, the stoneflies were separated from their parent population.

Montane species occurring in the Cypress Hills include *Hesperoperla pacifica*, *Podmosta delicatula*, *Suwallia lineosa*, *Paraleuctra vershina*, *Capnia gracilaria*, *Isocapnia crinita*, *Isocapnia missourii*, *Zapada cinctipes*, *Utacapnia trava*, *Skwala parallela* and *Isoperla patricia*.

Cypress Hills stoneflies have been unsuccessful in dispersing to, or populating, surrounding prairie rivers either because of the large expanses of prairie separating them from the rivers or because of their ecological preference for cool water. The single exception is *Isoperla patricia* which has been collected at Lemsford Ferry on the South Saskatchewan River, about 80 miles north of Cypress Hills.

A group of species occurs in the Saskatchewan boreal forest region and in the Cypress Hills. All are widespread in the western North American mountains including the western portion of the southern North American refugium. These separated Saskatchewan populations probably have a dual origin. The Cypress Hills fauna likely originated by a connection to the mountains either in pre-Wisconsin or post-Wisconsin time. The western species occurring in the boreal forest probably dispersed east and north from the eastern border of the Rockies. Species showing this distribution are *Zapada cinctipes*, *Utacapnia trava* and *Skwala parallela*. It is unlikely that these species originated from the Cypress Hills refugium and dispersed northward because they do not occur either in the prairie rivers or in rivers on the southern margin of the boreal forest in Saskatchewan.

Some of the prairie and parkland fauna consists of a northern Great Plains component. These species occur in the northern part of the Great Plains east of the Rockies and west of the Mississippi. Species showing this form of distribution are *Isoperla longiseta*, *Isoperla bilineata* and *Acroneuria abnormis*. These species probably entered the Saskatchewan River System when it flowed south to the Big Muddy-Missouri Systems. The southeastern and southcentral prairie species then had a direct aquatic dispersal route, and subsequent changes in drainage patterns have isolated Saskatchewan River populations from their parent populations.

Oemopteryx fosketti occurs in the Saskatchewan River System and also in the Colorado System. It probably dispersed northward in a manner similar to that proposed by Lehmkuhl (1976) for the mayfly *Analetris eximia* Edmunds. A direct aquatic invasion route is not evident, but the species could possibly have crossed from the Colorado to the Missouri System in Wyoming and then entered the Saskatchewan System from tributaries of the Missouri in southern Alberta and Saskatchewan.

The present-day stonefly fauna of Saskatchewan is of diverse origins, showing a variety of distributional patterns and histories. Northern glacial refugia contributed to a small percentage of the post-glacial stonefly re-colonization of Saskatchewan. The majority of the present fauna was derived from refugia south of the main Wisconsin ice sheets.

SUMMARY AND CONCLUSIONS

Saskatchewan has a diverse stonefly fauna which comprises at least 41 species. Nymphs were reared in the laboratory in order to associate them with known adults and this has enabled the first nymphal descriptions of the following species: *Oemopteryx fosketti*, *Triznaka signata*, *Suwallia lineosa*, *Isoperla decolorata*, *Nemoura rickeri*, *Malenka californica*, *Podmosta delicatula*, *Capnia coloradensis*, *Capnia confusa* and *Capnia gracilaria*. Keys are provided for most nymphs and all adults except females of *Isogenoides frontalis* and *Isogenoides colubrinus*.

The life cycle classification devised by Hynes (1961) was used to categorize the life histories of several Saskatchewan Plecoptera. Both univoltine and non-univoltine life cycles are evident in Saskatchewan species with univoltine types ranging from slow with an early emergence (S_1) to fast with a late emergence (F_4). Winter stoneflies all seem to be in type S_1 in which an embryonic diapause is absent and adults emerge in late winter and early spring. The majority of non-winter species appear to belong to type S_2 in which embryonic diapause is also absent but adult emergence is later in May and June. Few species have been classified as fast seasonal types with an embryonic diapause. At present, life cycle types S_4 and F_3 are unknown in Saskatchewan species. Only 13 of the 41 stonefly species known in the province have been definitely classified, indicating the large amount of research required to determine all the life cycles of Saskatchewan Plecoptera.

All or most of the present-day Saskatchewan stonefly fauna originated with the retreat of the Wisconsin Laurentide Ice Sheet and the subsequent recolonization of the province by species from ice-free regions to the north and south. Five probable origins have been proposed for the extant fauna. The Cypress Hills fauna has its affinities with the Rocky Mountains and was derived by a connective bridge of flora and fauna which formed either after the Wisconsin or following earlier glaciations. The fauna to the extreme north of the province has tundra elements and is likely derived from a northwestern refugium. The boreal fauna is derived from southern North American refugia in the northeast and northwest and the prairie fauna is derived chiefly from the southcentral North American refugium.

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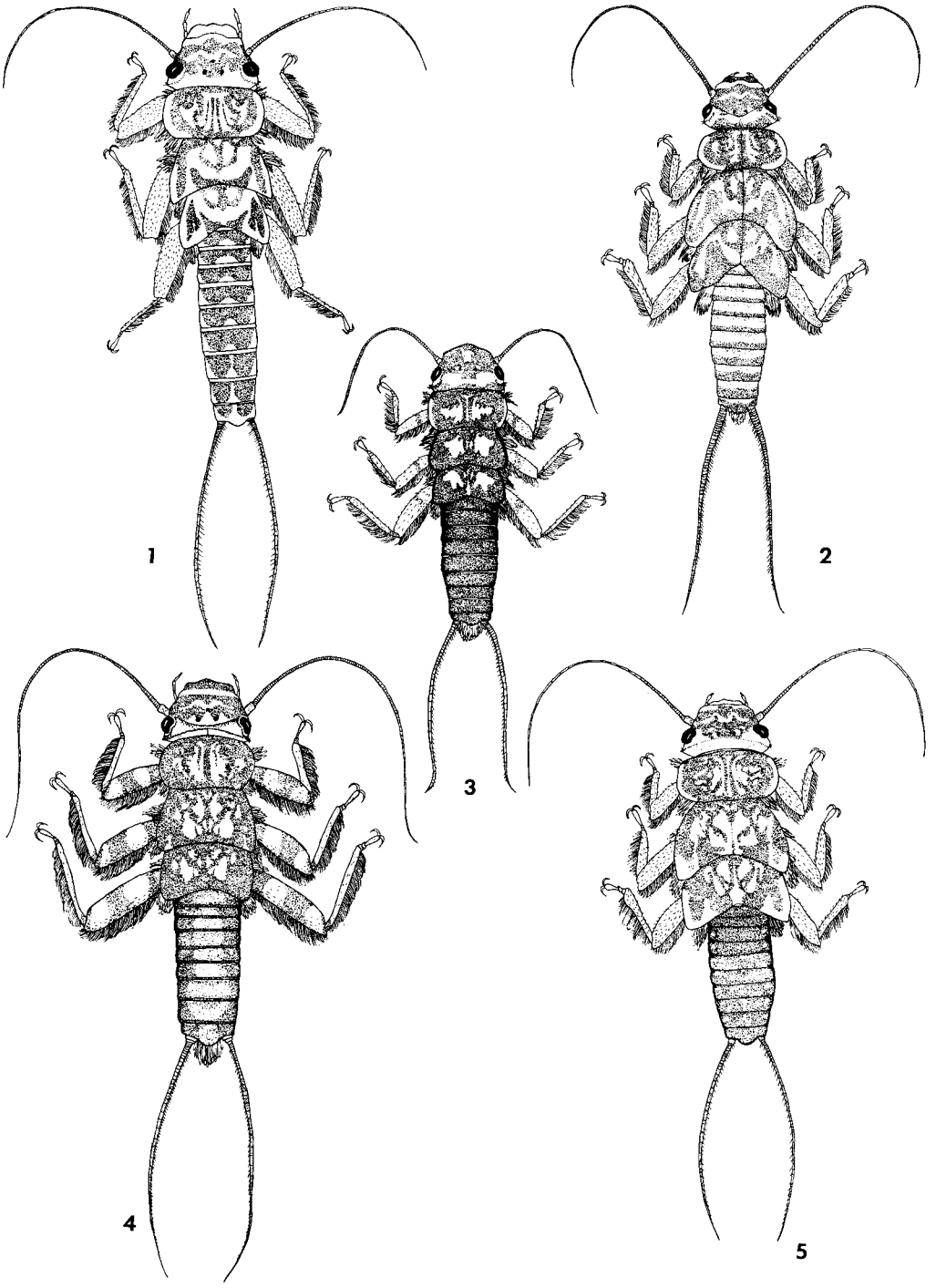


Figures 1–5. Nymphs of Perlidae. Fig. 1, *Acroneuria abnormis;* Fig. 2, *A. lycorias;* Fig. 3, *Hesperoperla pacifica;* Fig. 4, *Claassenia sabulosa;* Fig. 5, *Paragnetina media.*

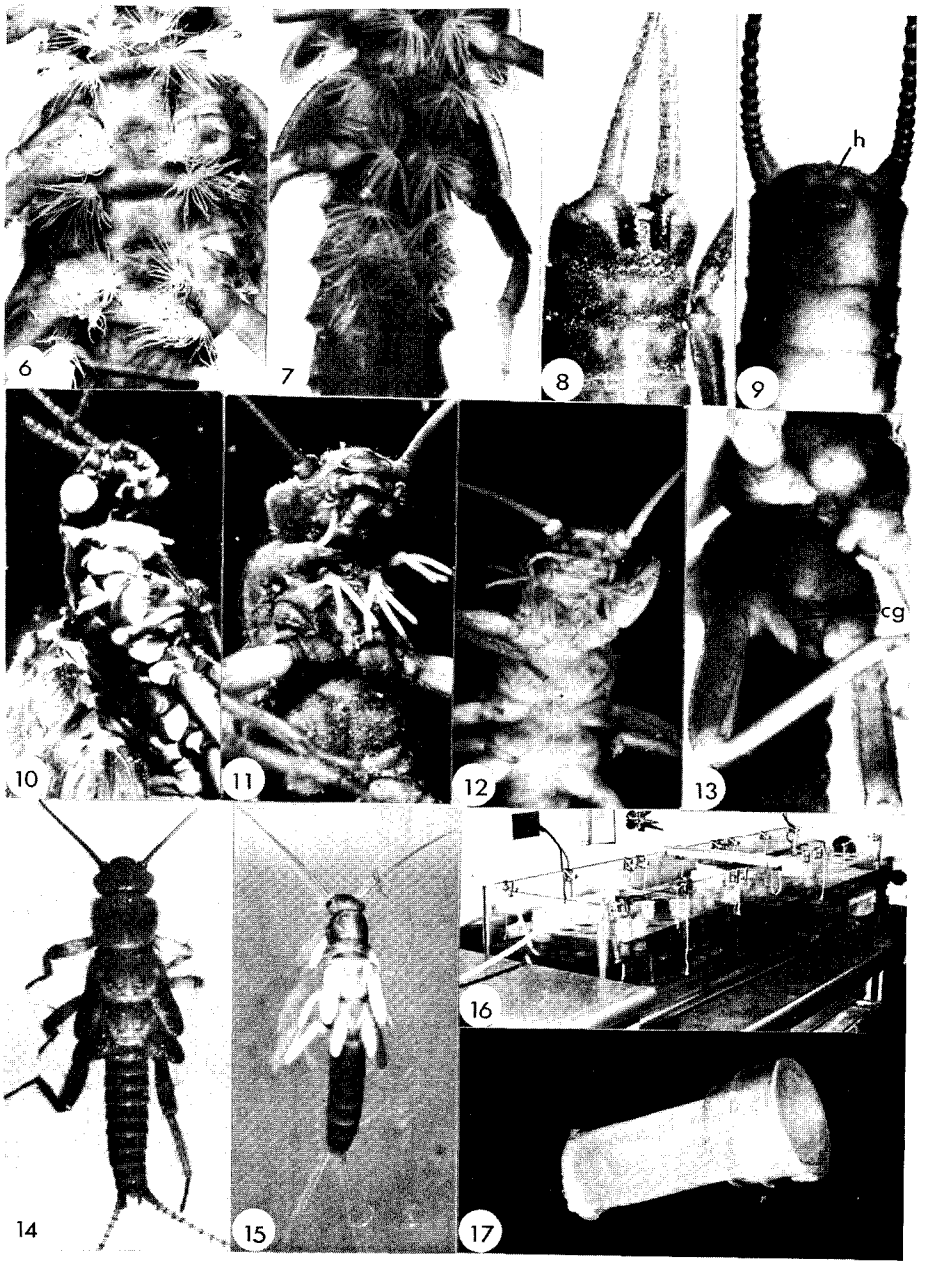
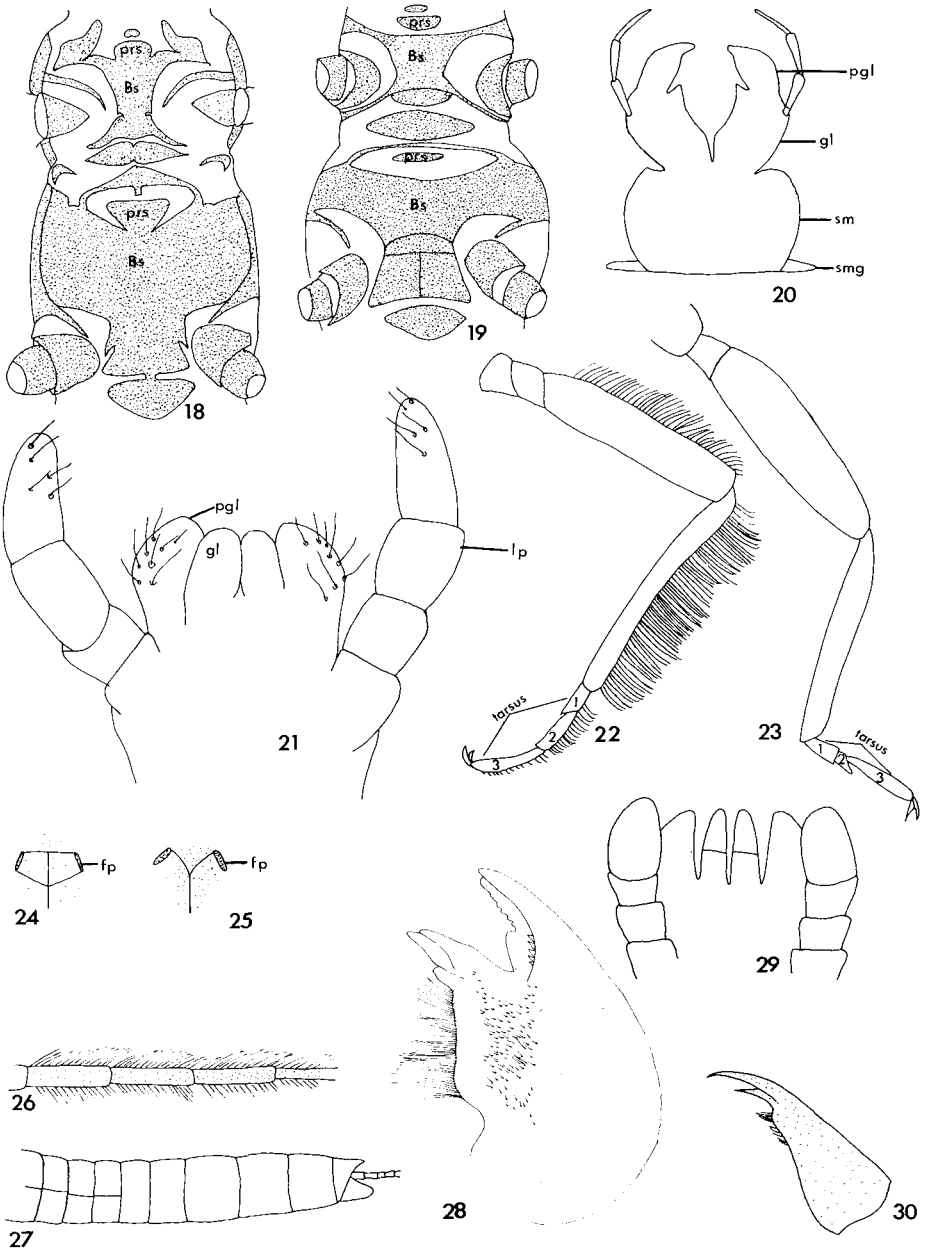
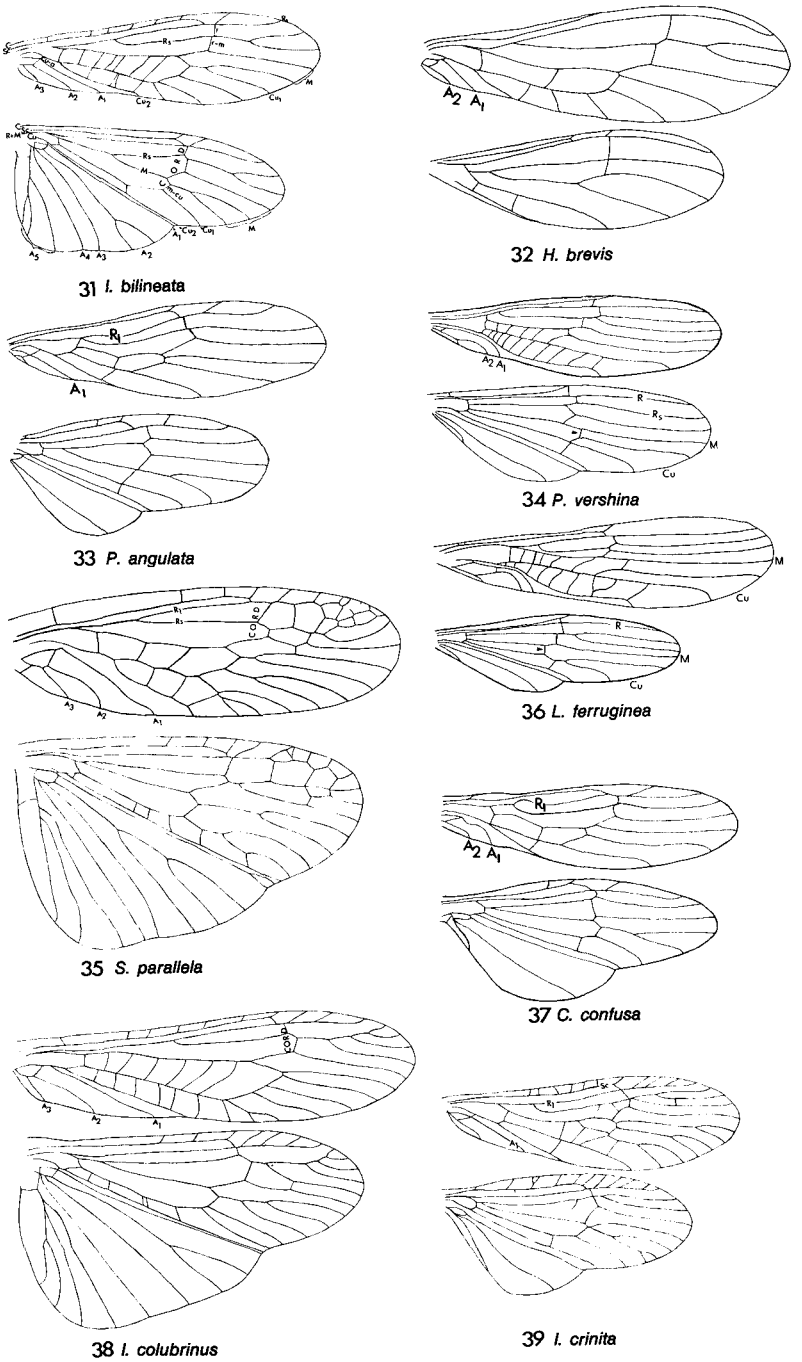


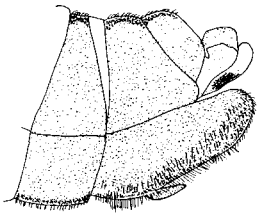
Fig. 6–17. Fig. 6, Nymph of *Pteronarcys dorsata* (ventral) showing gills on the first two abdominal segments; Fig. 7, Nymph of *Pteronarcella badia* (ventral) showing gills on the first three abdominal segments; Fig. 8, Terminal abdominal segments of *Claassenia sabulosa* (male, dorsal) showing hooks on the tenth tergite; Fig. 9, Terminal abdominal segments of *Acroneuria abnormis* (male, ventral) showing hammer (h); Fig. 10, Adult of *Zapada cinctipes* (lateral) showing cervical gill remnants; Fig. 11, Nymph of *Z. cinctipes* (ventral) showing cervical gills; Fig. 12, Nymph of *Amphinemura linda* (ventral) showing cervical gills; Fig. 13, Nymph of *Taeniopteryx nivalis* (ventral) showing coxal gill (cg); Fig. 14, Nymph of *Z. cinctipes* (dorsal); Fig. 15, Nymph of *Capnia gracilaria* (dorsal); Fig. 16, Rearing apparatus; Fig. 17, Rearing container.



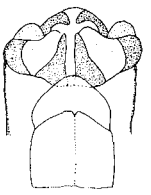
Figures 18–30. Fig. 18, Prothoracic and mesothoracic sterna of *Isocapnia crinita,* showing the basisternum (Bs) and presternum (prs); Fig. 19, Prothoracic and mesothoracic sterna of *Paracapnia angulata,* showing basisternum (Bs) and presternum (prs); Fig. 20, Nymphal labium of *Isogenoides colubrinus,* showing paraglossa (pgl), glossa (gl), submentum (sm) and submental gill (smg); Fig. 21, Nymphal labium of *Leuctra ferruginea,* showing paraglossa (pgl), glossa (gl) and labial palpus (lp); Fig. 22, Nymphal hindleg of *Oemopteryx fosketti;* Fig. 23, Nymphal hindleg of *Capnia gracilaria;* Fig. 24, Nymphal mesothoracic ridge pattern of *Isogenoides colubrinus,* showing the furcal pit (fp); Fig. 25, Nymphal mesothoracic ridge pattern of *Skwala parallela,* showing the furcal pit (fp); Fig. 26, Distal cercal segments of *Isocapnia crinita* nymph; Fig. 27, Nymphal abdomen of *Leuctra ferruginea;* Fig 28, Nymphal mandible of *Skwala parallela;* Fig. 29, Nymphal labium of *Zapada cinctipes;* Fig. 30, Nymphal maxilla of *Diura bicaudata.*



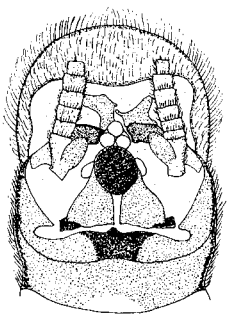
Figures 31 – 39. Wings of Plecoptera. Fig. 31, *Isoperla bilineata;* Fig. 32, *Hastaperla brevis;* Fig. 33, *Paracapnia angulata;* Fig. 34, *Paraleuctra vershina;* Fig. 35, *Skwala parallela;* Fig. 36, *Leuctra ferruginea;* Fig. 37, *Capnia confusa;* Fig. 38, *Isogenoides colubrinus;* Fig. 39, *Isocapnia crinita.*



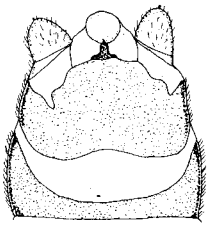
40 *T. nivalis*



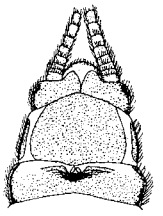
41 *T. nivalis*



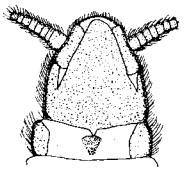
42 *O. fosketti*



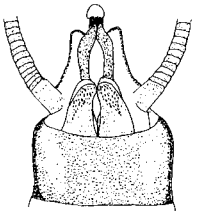
43 *T. nivalis*



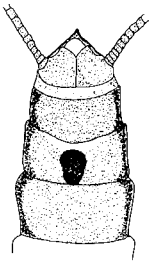
44 *T. nivalis*



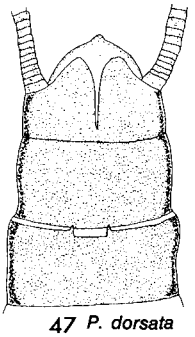
45 *O. fosketti*



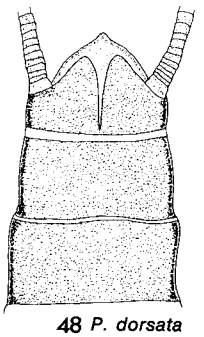
46 *P. dorsata*



49 *P. badia*

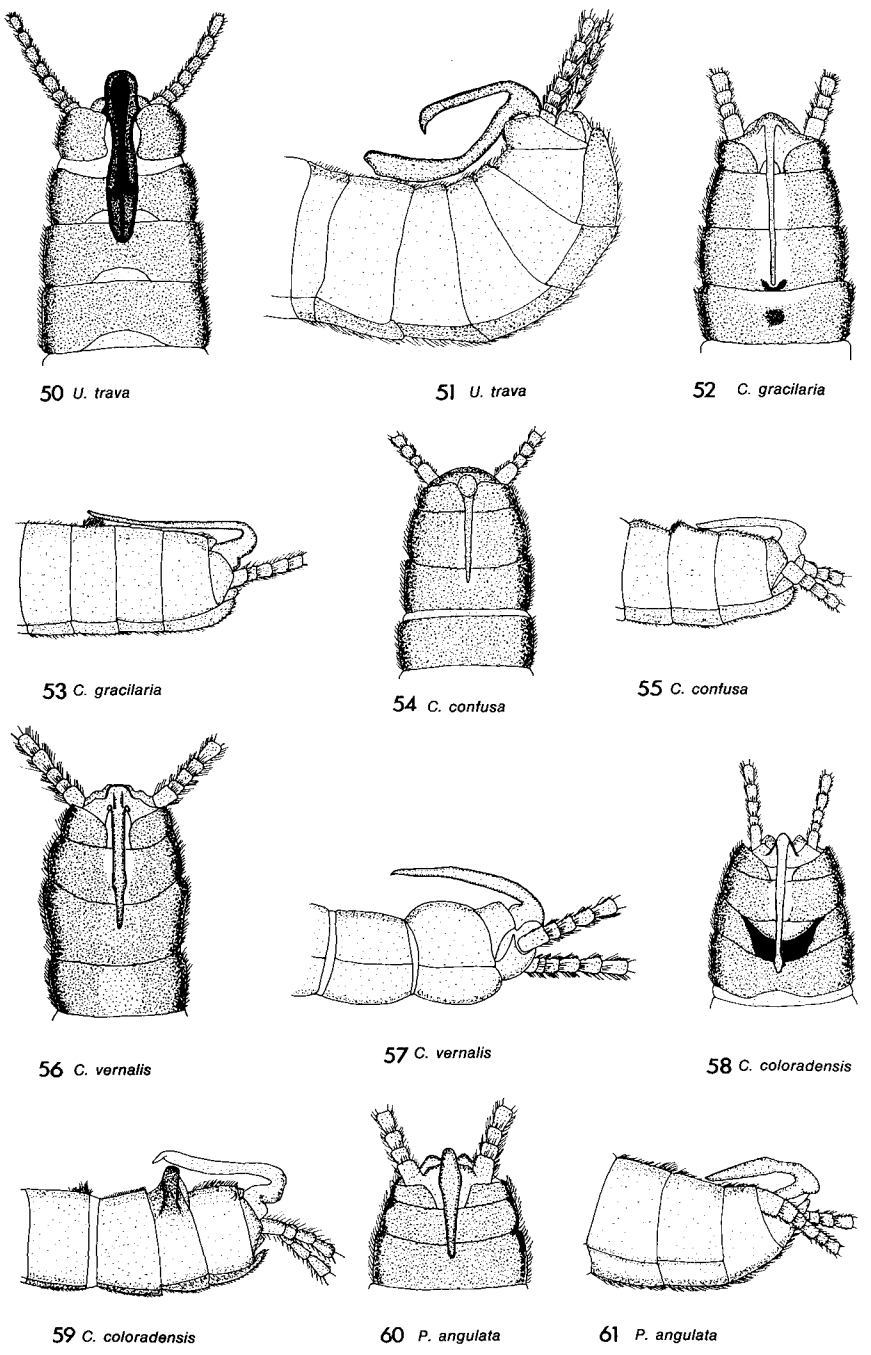


47 *P. dorsata*

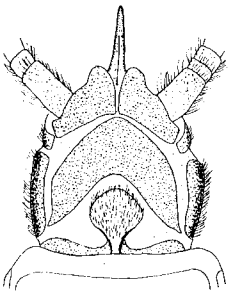


48 *P. dorsata*

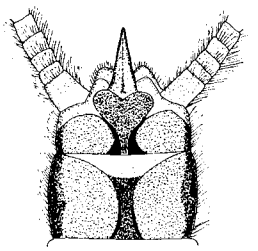
Figures 40 – 49. Genitalia of Taeniopterygidae and Pteronarcidae. Fig. 40, *Taeniopteryx nivalis* (male, lateral); Fig. 41, *T. nivalis* (male, ventral with 9th sternite removed to show aedeagus and subanal lobes); Fig. 42, *Oemopteryx fosketti* (male, dorsal); Fig. 43, *T. nivalis* (male, dorsal); Fig. 44, *T. nivalis* (female, ventral); Fig. 45, *O. fosketti* (female, ventral); Fig. 46, *Pteronarcys dorsata* (male, dorsal); Fig. 47, 48, *P. dorsata* (female, ventral showing variation in subgenital plates); Fig. 49, *Pteronarcella badia* (female, ventral).



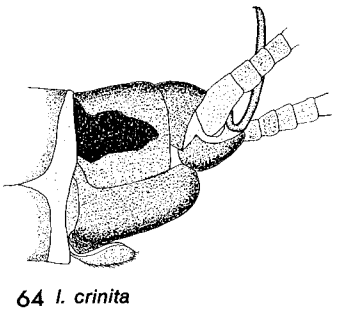
Figures 50 – 61. Male genitalia of Capniidae. Fig. 50, *Utacapnia trava* (dorsal); Fig. 51, *U. trava* (lateral); Fig. 52, *Capnia gracilaria* (dorsal); Fig. 53, *C. graciliaria* (lateral); Fig. 54, *C. confusa* (dorsal); Fig. 55, *C. confusa* (lateral); Fig. 56, *C. vernalis* (dorsal); Fig. 57, *C. vernalis* (lateral); Fig. 58, *C. coloradensis* (dorsal); Fig. 59, *C. coloradensis* (lateral); Fig. 60, *Paracapnia angulata* (dorsal); Fig. 61, *P. angulata* (lateral).



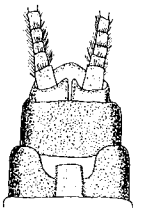
62 *I. crinita*



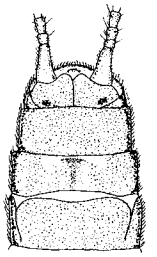
63 *I. crinita*



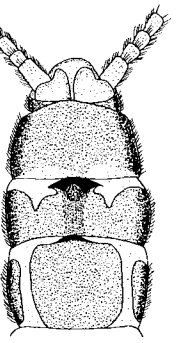
64 *I. crinita*



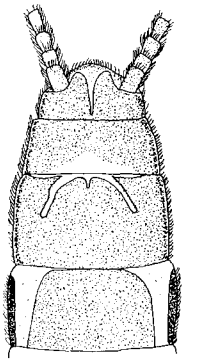
65 *I. crinita*



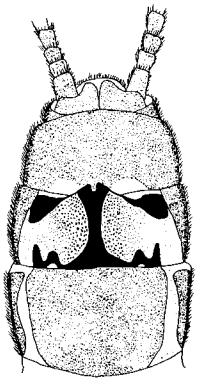
66 *I. missourii*



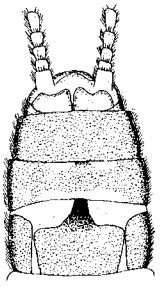
67 *C. vernalis*



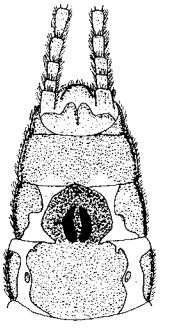
68 *P. angulata*



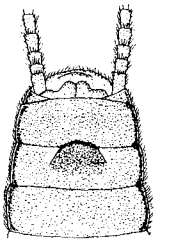
69 *U. trava*



70 *C. confusa*

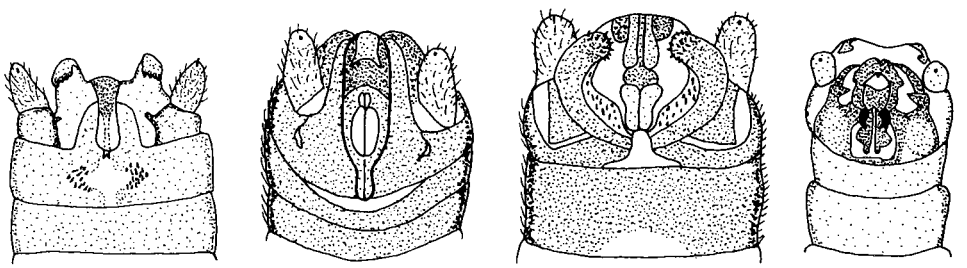


71 *C. coloradensis*

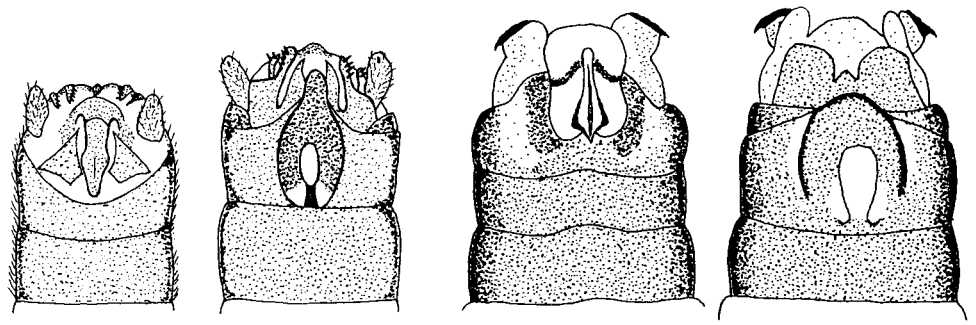


72 *C. gracilaria*

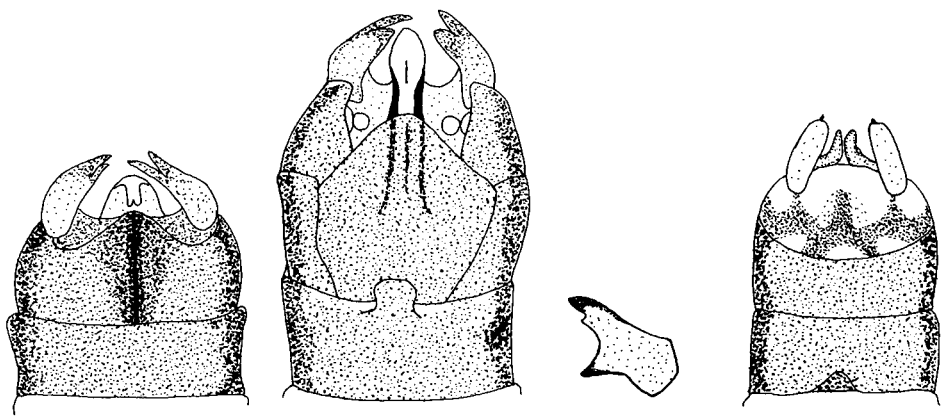
Figures 62 -- 72. Genitalia of Capniidae. Fig. 62, *Isocapnia crinita* (male, ventral); Fig. 63, *I. crinita* (male, dorsal); Fig. 64, *I. crinita* (male, lateral); Fig. 65, *I. crinita* (female, ventral); Fig. 66, *I. missourii* (female, ventral); Fig. 67, *Capnia vernalis* (female, ventral); Fig. 68, *Paracapnia angulata* (female, ventral); Fig. 69, *Utacapnia trava* (female, ventral); Fig. 70, *Capnia confusa* (female, ventral); Fig. 71, *C. coloradensis* (female, ventral), Fig. 72, *C. gracilaria* (female, ventral).



73 *M. californica* 74 *Z. cinctipes* 75 *S. rotunda* 76 *P. delicatula*

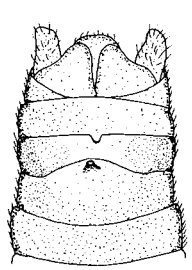


77 *A. linda* 78 *A. linda* 79 *N. rickeri* 80 *N. rickeri*

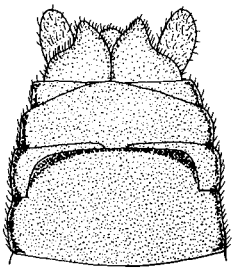


81 *P. vershina* 82 *P. vershina* 83 *P. vershina* 84 *L. ferruginea*

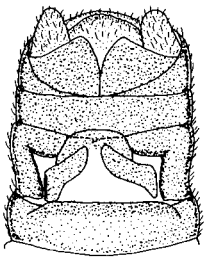
Figures 73 – 84. Male genitalia of Nemouridae and Leuctridae. Fig. 73, *Malenka californica* (dorsal); Fig. 74, *Zapada cinctipes* (dorsal); Fig. 75, *Shipsa rotunda* (dorsal); Fig. 76, *Podmosta delicatula* (dorsal); Fig. 77, *Amphinemura linda* (dorsal); Fig. 78, *A. linda* (ventral); Fig. 79, *Nemoura rickeri* (dorsal); Fig. 80, *N. rickeri* (ventral); Fig. 81, *Paraleuctra vershina* (dorsal); Fig. 82, *P. vershina* (ventral); Fig. 83, *P. vershina* cercus (lateral); Fig. 84, *Leuctra ferruginea* (dorsal).



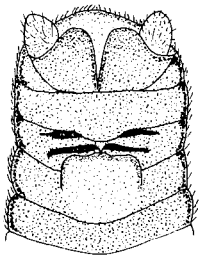
85 *M. californica*



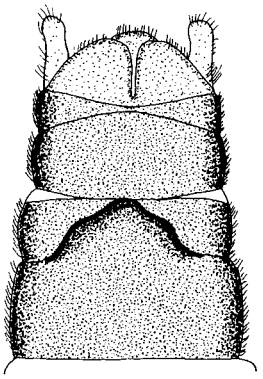
86 *Z. cinctipes*



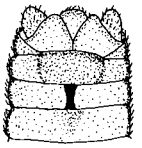
87 *S. rotunda*



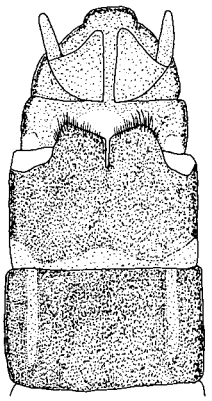
88 *A. linda*



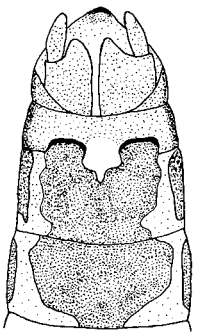
89 *N. rickeri*



90 *P. delicatula*

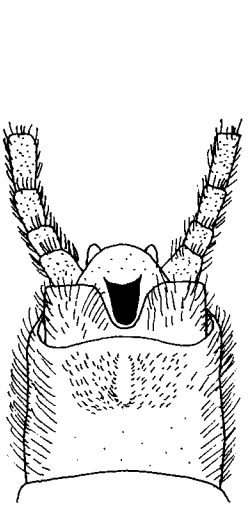


91 *P. vershina*

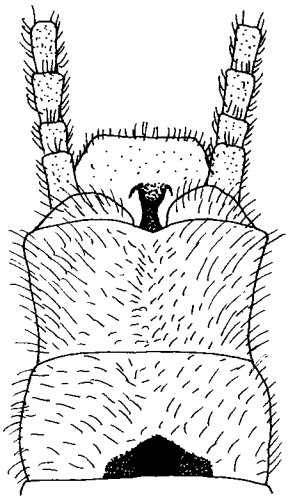


92 *L. ferruginea*

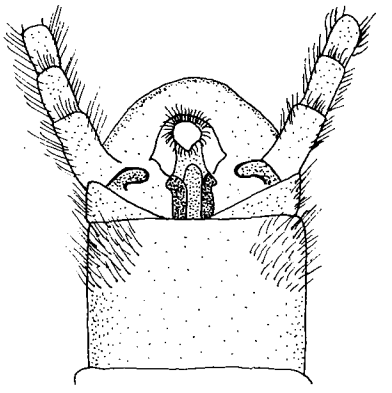
Figures 85 – 92. Female genitalia of Nemouridae and Leuctridae. Fig. 85, *Malenka californica* (ventral); Fig. 86, *Zapada cinctipes* (ventral); Fig. 87, *Shipsa rotunda* (ventral); Fig. 88, *Amphinemura linda* (ventral); Fig. 89, *Nemoura rickeri* (ventral); Fig. 90, *Podmosta delicatula* (ventral); Fig. 91, *Paraleuctra vershina* (ventral); Fig. 92, *Leuctra ferruginea* (ventral).



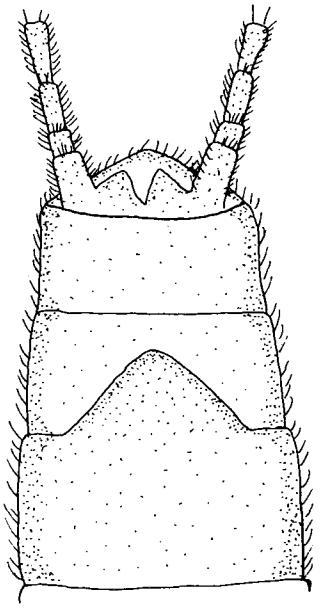
93 *H. brevis*



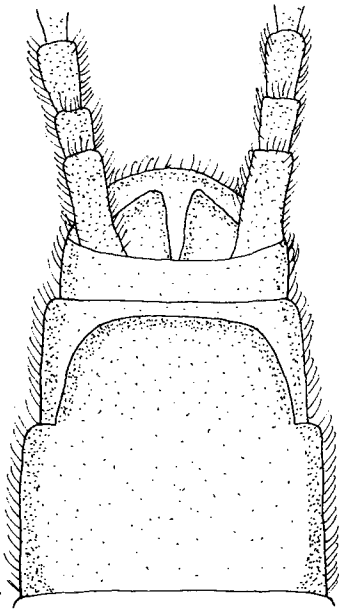
94 *T. signata*



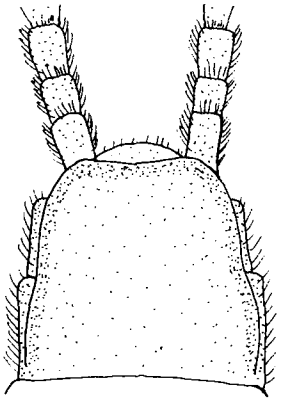
95 *S. lineosa*



96 *H. brevis*

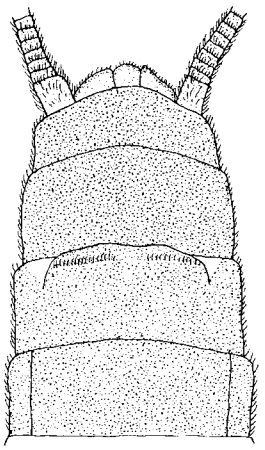


97 *T. signata*

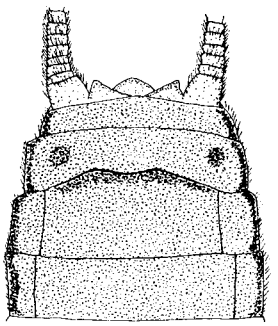


98 *S. lineosa*

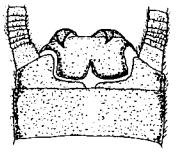
Figures 93 – 98. Genitalia of Chloroperlidae. Fig. 93, *Hastaperla brevis* (male, dorsal); Fig. 94, *Triznaka signata* (male, dorsal) Fig. 95, *Suwallia lineosa* (male, dorsal); Fig. 96, *H. brevis* (female, ventral); Fig. 97, *T. signata* (female, ventral); Fig. 98, *S. lineosa* (female, ventral).



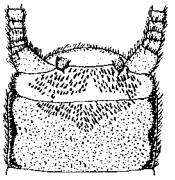
99 *A. abnormis*



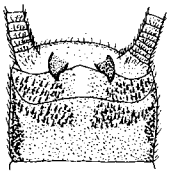
100 *A. lycorias*



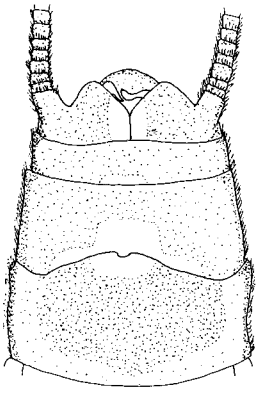
101 *H. pacifica*



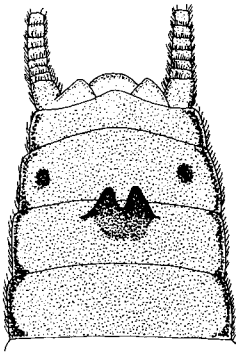
102 *A. lycorias*



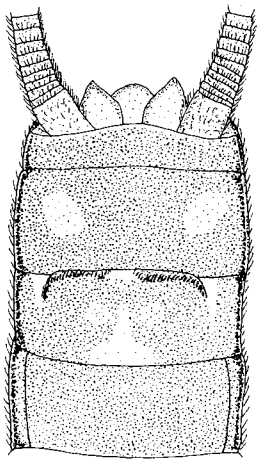
103 *A. abnormis*



104 *H. pacifica*

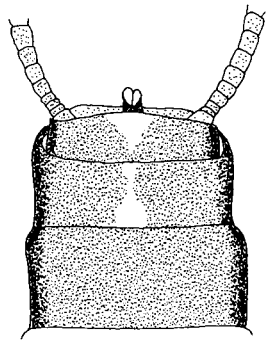


105 *P. media*

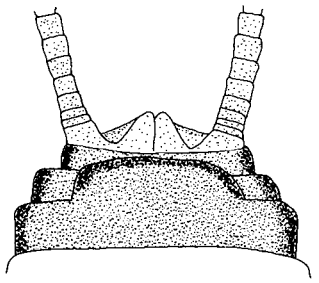


106 *C. sabulosa*

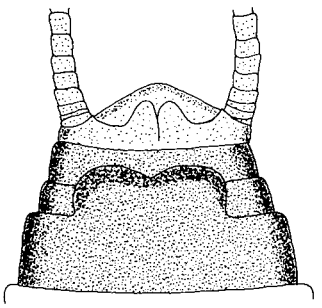
Figures 99 – 106. Genitalia of Perlidae. Fig. 99, *Acroneuria abnormis* (female, ventral); Fig. 100, *A. lycorias* (female, ventral); Fig. 101, *Hesperoperla pacifica* (male, dorsal); Fig. 102, *A. lycorias* (male, dorsal); Fig. 103, *A. abnormis* (male, dorsal); Fig. 104, *H. pacifica* (female, ventral); Fig. 105, *Paragnetina media* (female, ventral); Fig. 106, *Claassenia sabulosa* (female, ventral).



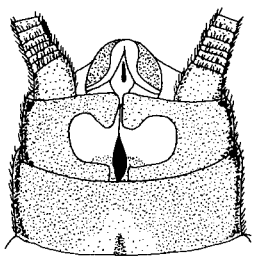
107 *D. bicaudata*



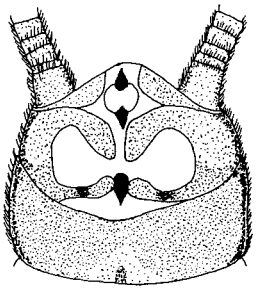
108 *D. bicaudata*



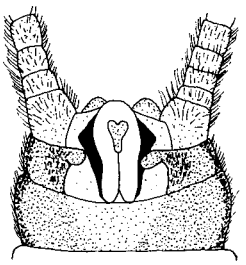
109 *D. bicaudata*



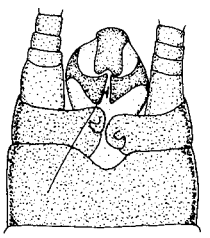
110 *I. colubrinus*



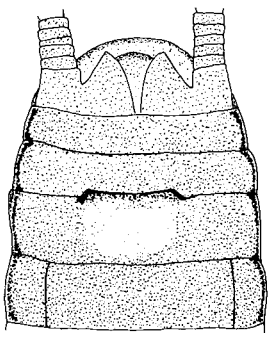
111 *I. frontalis*



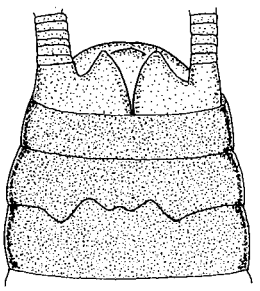
112 *S. parallela*



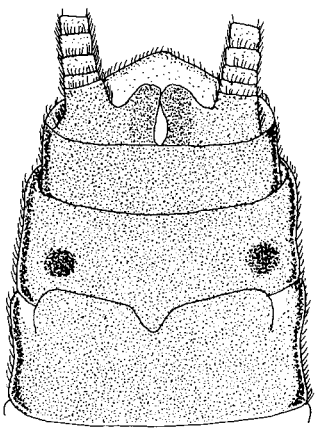
113 *A. compacta*



114 *S. parallela*

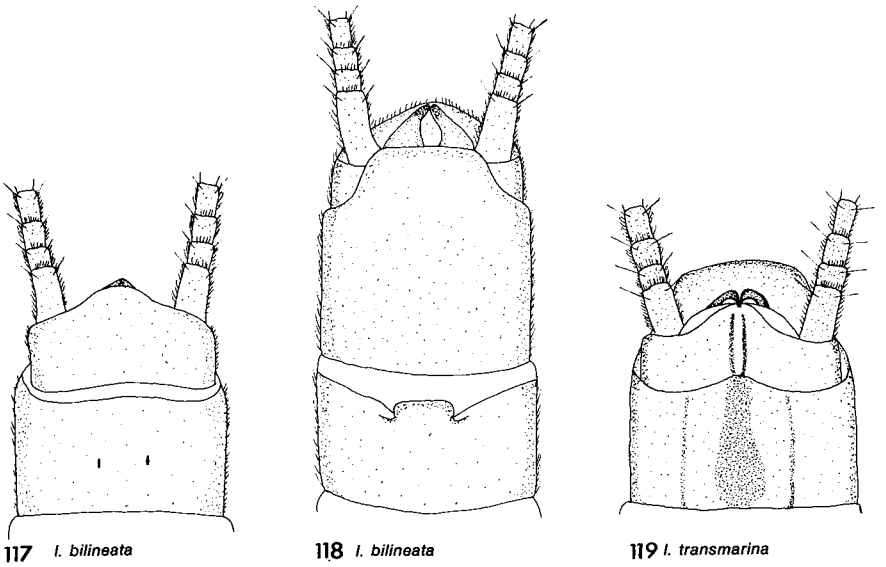


115 *A. compacta*



116 *I. colubrinus*

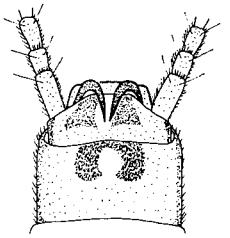
Figures 107 – 116. Genitalia of Perlodinae and Isogeninae. Fig. 107, *Diura bicaudata* (male, dorsal); Fig. 108, 109, *D. bicaudata* (female, ventral, showing variation in subgenital plates); Fig. 110, *Isogenoides colubrinus* (male, dorsal); Fig. 111, *I. frontalis* (male, dorsal); Fig. 112, *Skwala parallela* (male, dorsal); Fig. 113, *Arcynopteryx compacta* (male, dorsal); Fig. 114, *S. parallela* (female, ventral); Fig. 115, *A. compacta* (female, ventral); Fig. 116, *I. colubrinus* (female, ventral).



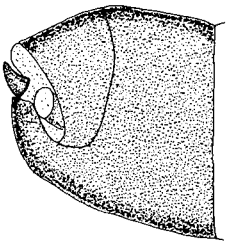
117 *I. bilineata*

118 *I. bilineata*

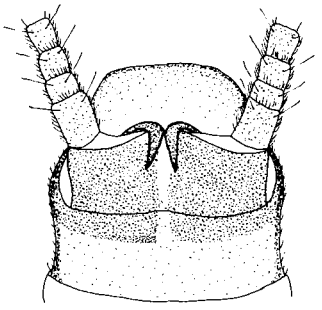
119 *I. transmarina*



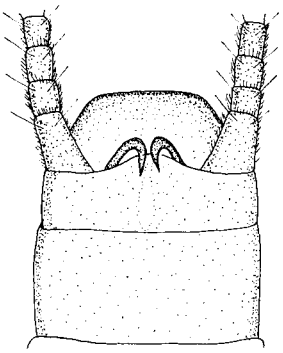
120 *I. longiseta*



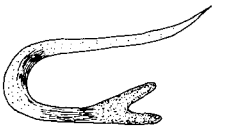
121 *I. decolorata*



122 *I. patricia*

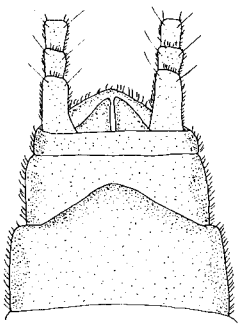


123 *I. petersoni*

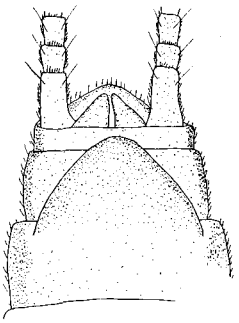


124 *I. petersoni*

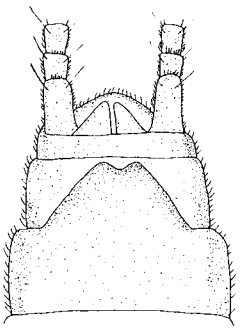
Figures 117 – 124. Male genitalia of Isoperlinae. Fig. 117, *Isoperla bilineata* (dorsal); Fig. 118, *I. bilineata* (ventral); Fig. 119, *I. transmarina* (dorsal); Fig. 120, *I. longiseta* (dorsal); Fig. 121, *I. decolorata* (lateral, cerci removed); Fig. 122, *I. patricia* (dorsal); Fig. 123, *I. petersoni* (dorsal); Fig. 124, Aedeagal process of *I. petersoni* (lateral).



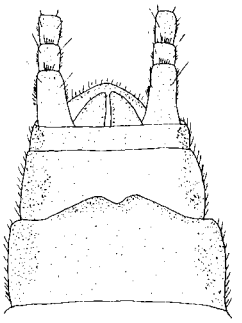
125 *I. bilineata*



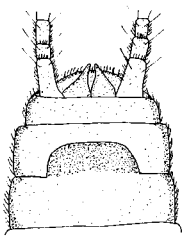
126 *I. bilineata*



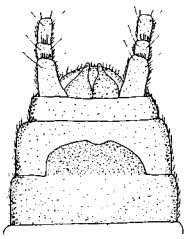
127 *I. bilineata*



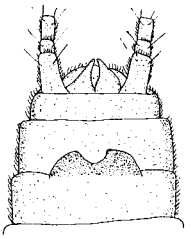
128 *I. bilineata*



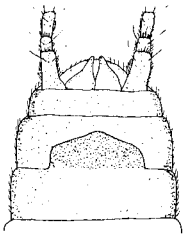
129 *I. longiseta*



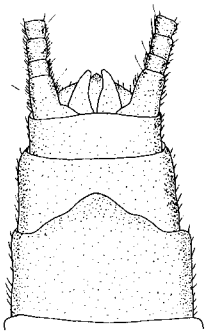
130 *I. longiseta*



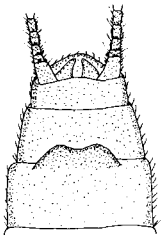
131 *I. longiseta*



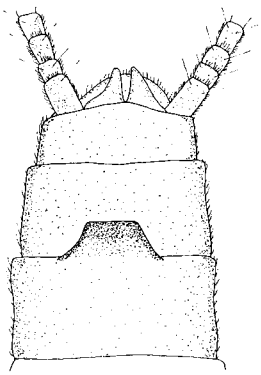
132 *I. longiseta*



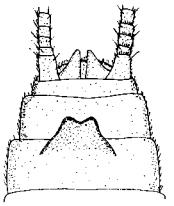
133 *I. decolorata*



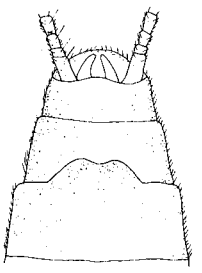
134 *I. petersoni*



135 *I. transmarina*

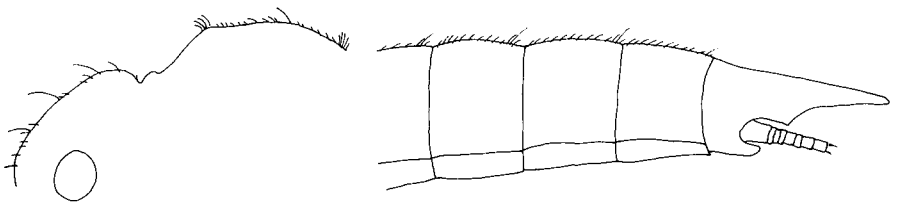


136 *I. patricia*

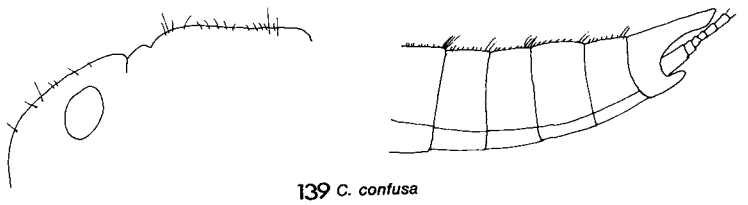


137 *I. marlynia*

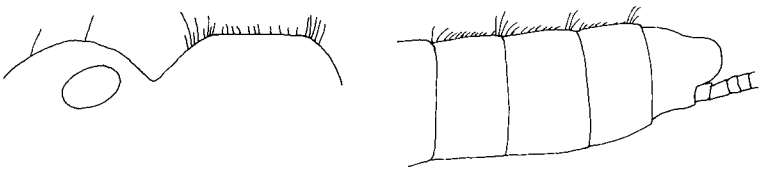
Figures 125 – 137. Female genitalia of Isoperlinae. Fig. 125 – 128, *Isoperla bilineata* (ventral, showing variation in subgenital plates); Fig. 129 – 132, *I. longiseta* (ventral, showing variation in subgenital plates); Fig. 133, *I. decolorata* (ventral); Fig. 134, *I. petersoni* (ventral); Fig. 135, *I. transmarina* (ventral); Fig. 136, *I. patricia* (ventral); Fig. 137, *I. marlynia* (ventral).



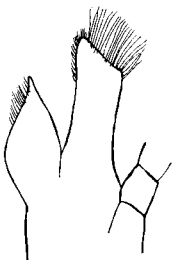
138 *C. gracilaria*



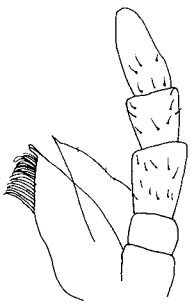
139 *C. confusa*



140 *C. coloradensis*

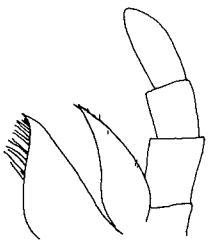


141 *C. vernalis*



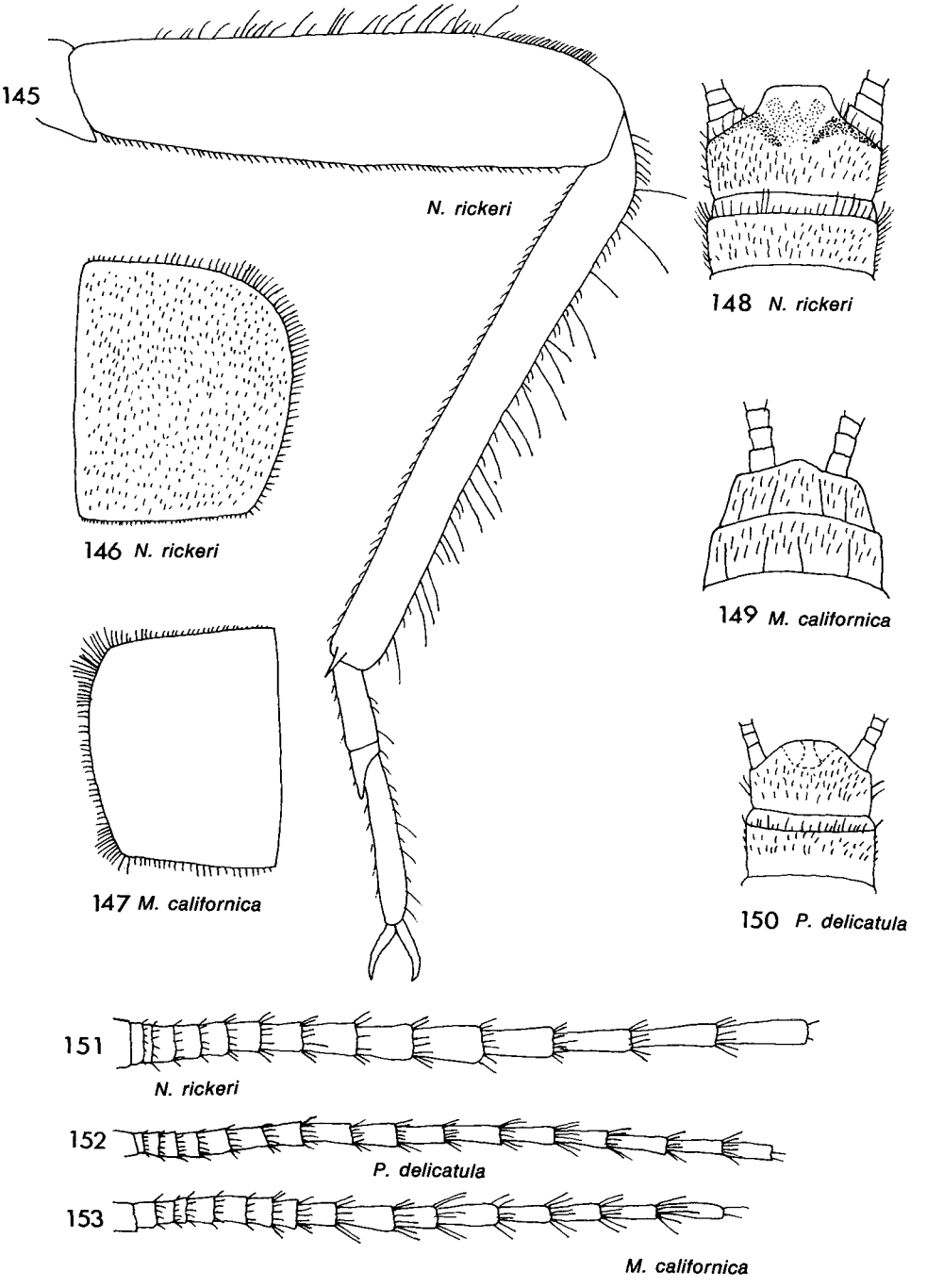
143 *C. gracilaria*

142 *C. confusa*

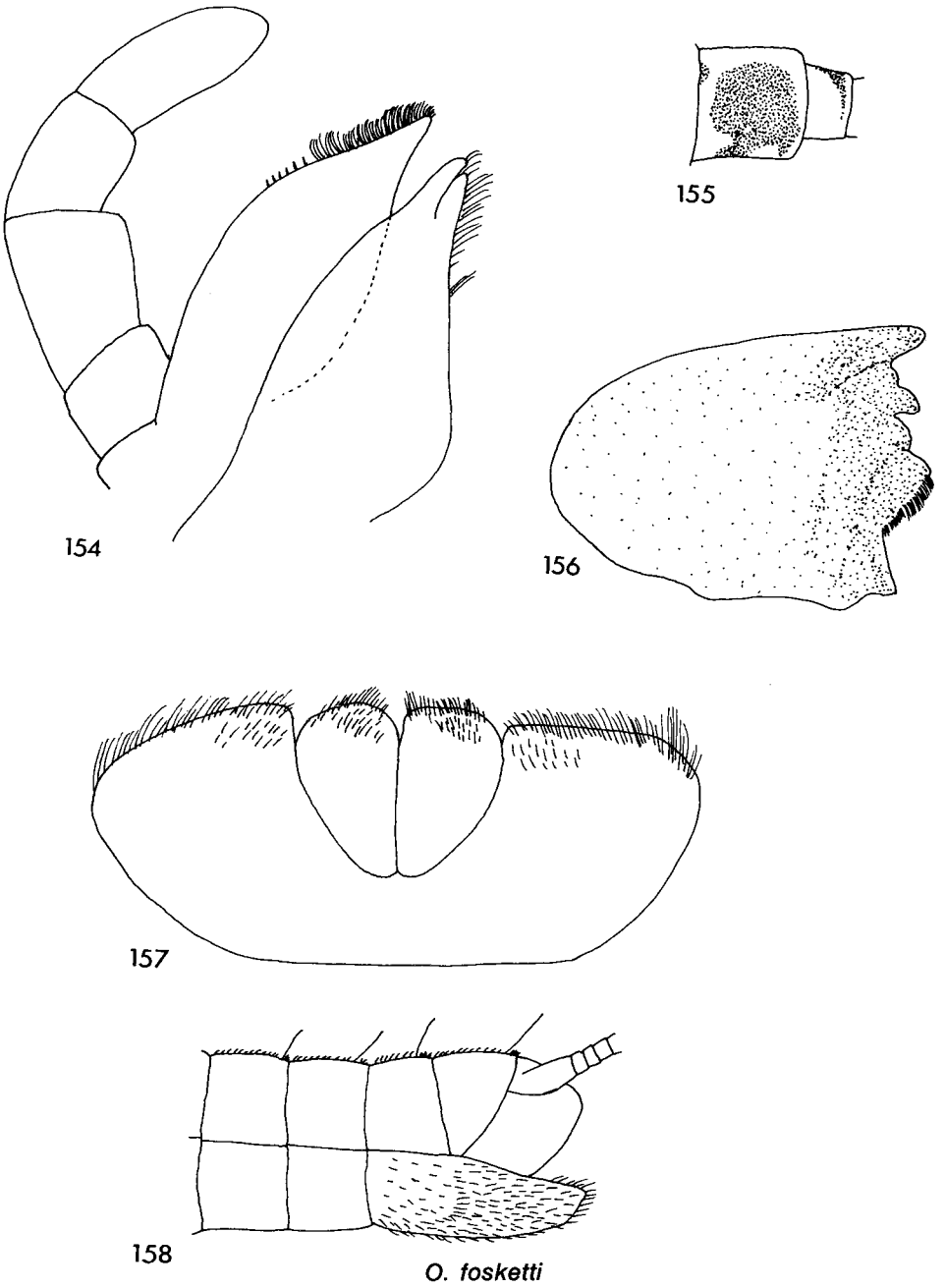


144 *C. coloradensis*

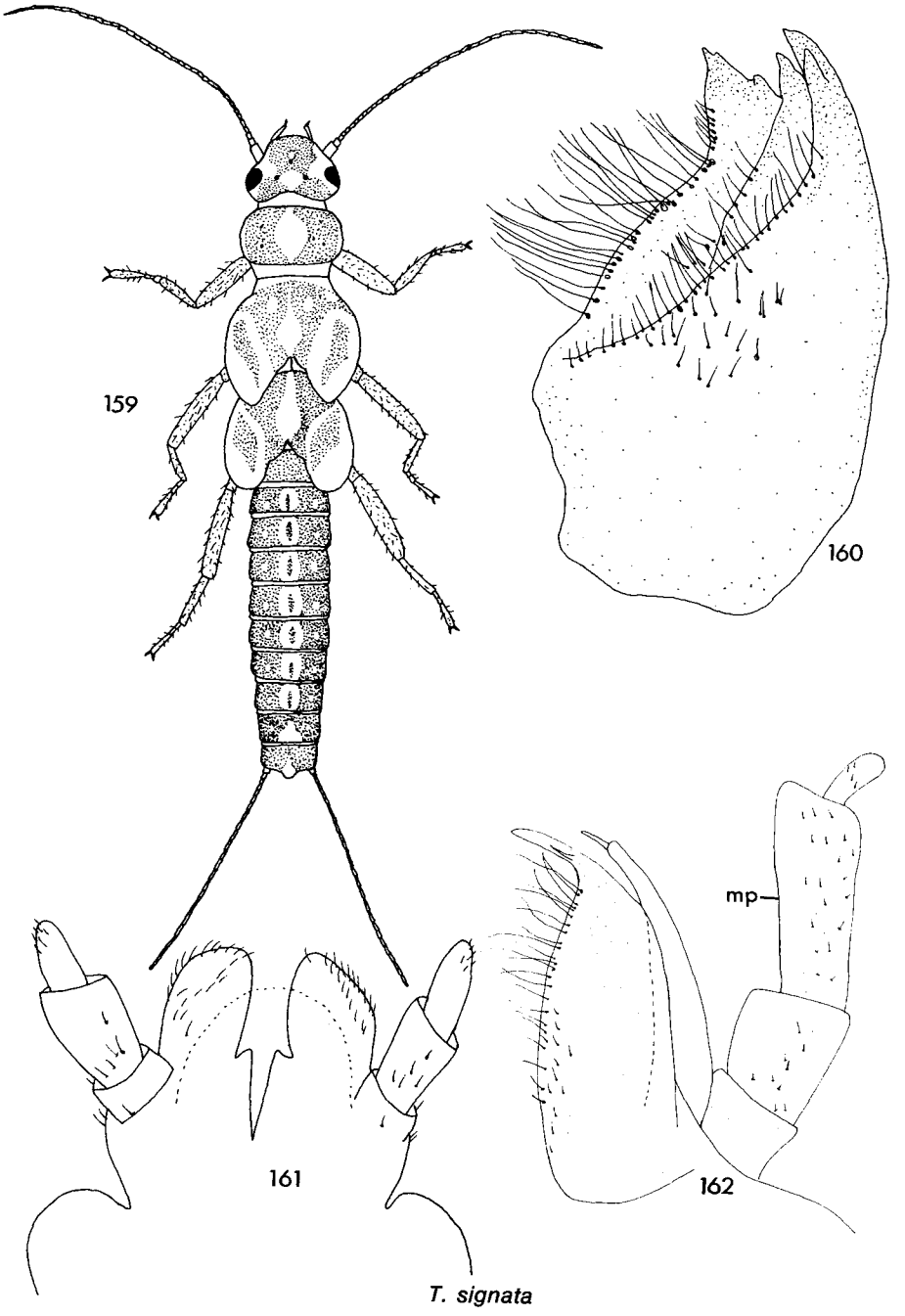
Figures 138 – 144. Nymphal setation and maxillae of Capniidae. Only the setae which can be seen in profile on the top of the head, on the pronotum and on the abdomen have been indicated; the eye is outlined as a point of reference. Fig. 138, *Capnia gracilaria* (male); Fig. 139, *C. confusa* (male); Fig. 140, *C. coloradensis* (female); Fig. 141, Maxilla of *C. vernalis;* Fig. 142, Maxilla of *C. confusa;* Fig. 143, Maxilla of *C. gracilaria;* Fig. 144, Maxilla of *C. coloradensis.*



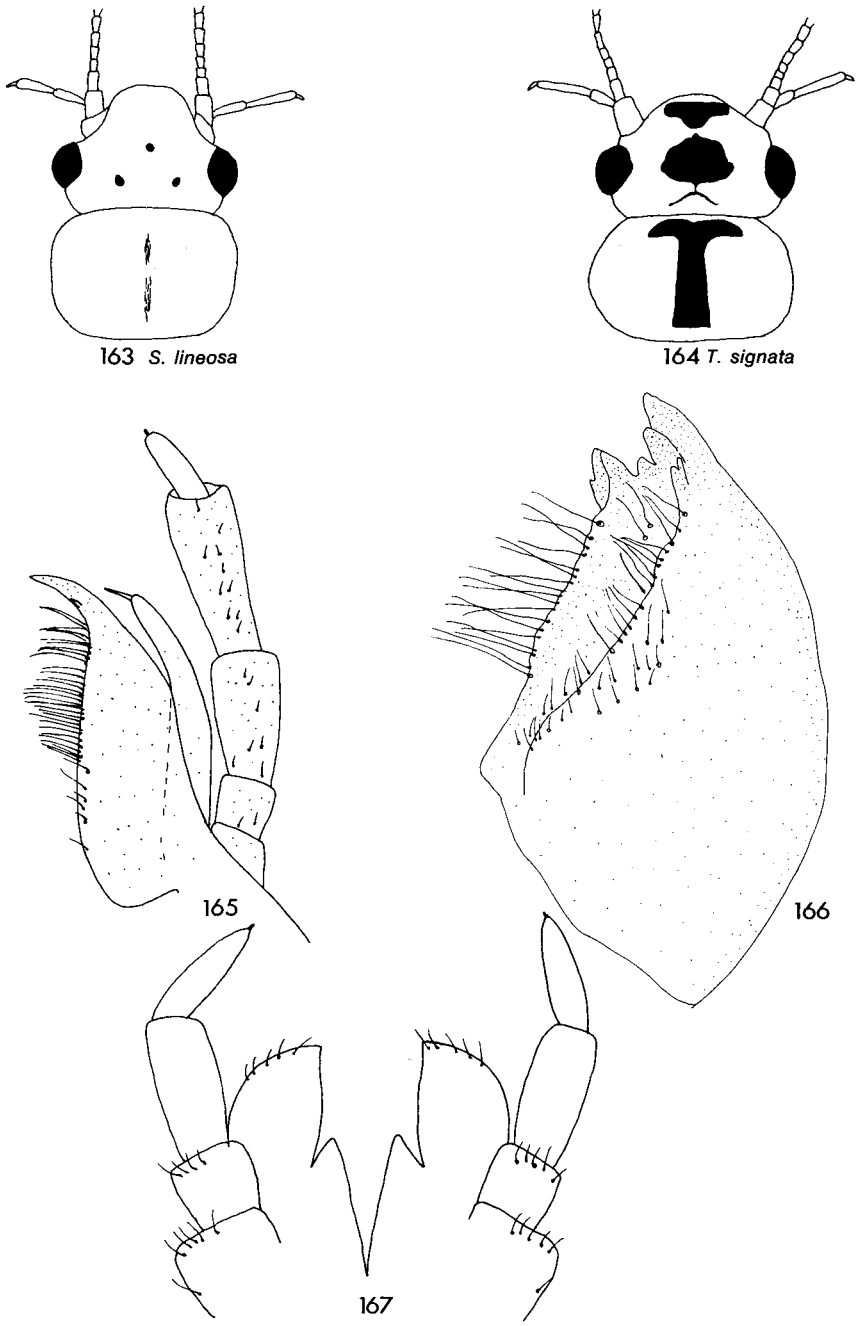
Figures 145 – 153. Setation of Nemouridae nymphs. Fig. 145, Hindleg of *Nemoura rickeri;* Fig. 146, Right half of pronotum of *N. rickeri;* Fig. 147, Left half of pronotum of *Malenka californica;* Fig. 148, Terminal abdominal tergites of *N. rickeri* (male); Fig. 149, Terminal abdominal tergites of *M. californica* (female); Fig. 150, Terminal abdominal tergites of *Podmosta delicatula* (male); Fig. 151, Cercus of *N. rickeri* (lateral); Fig. 152, Cercus of *P. delicatula* (lateral) ; Fig. 153, Cercus of *M. californica* (lateral).



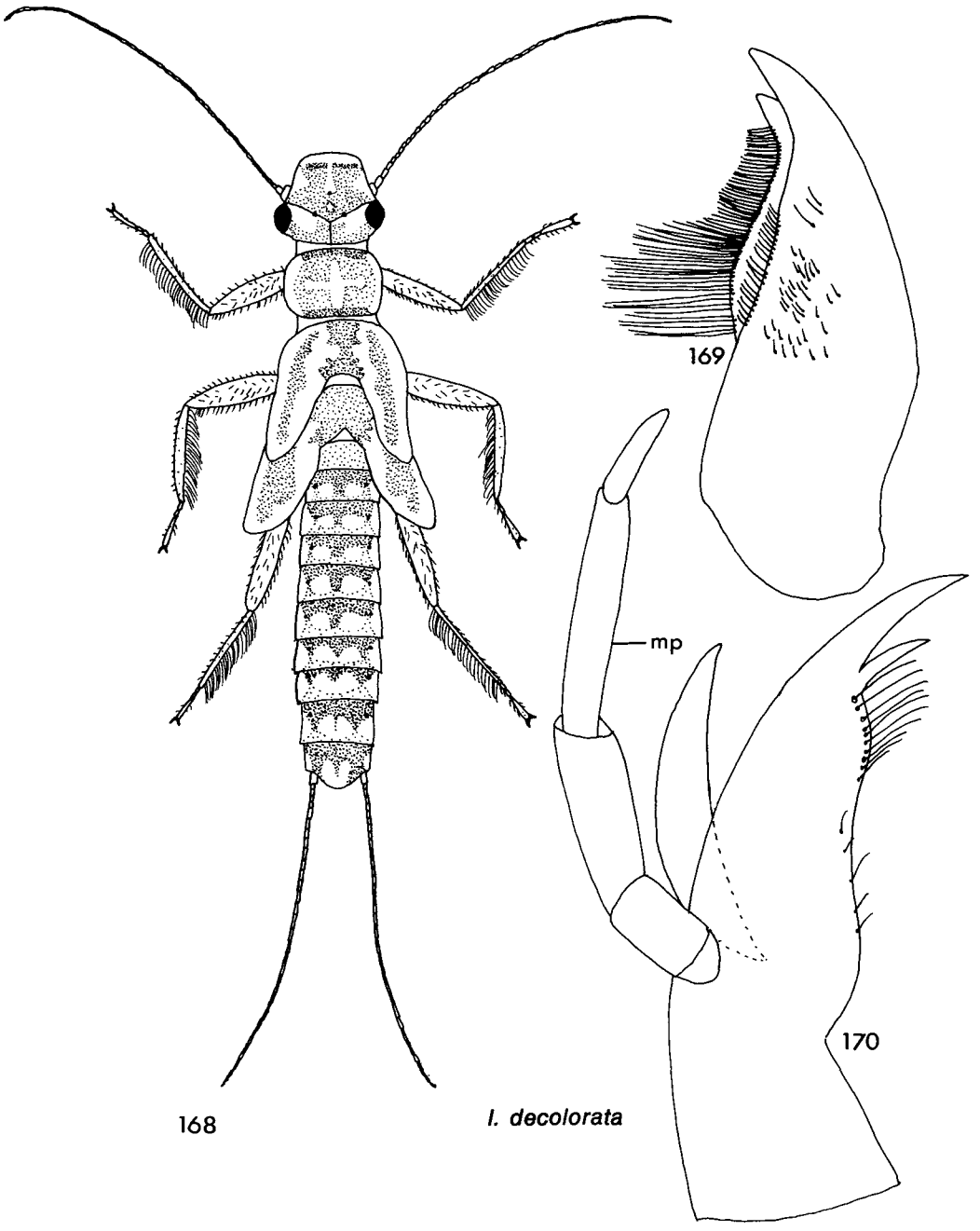
Figures 154 – 158. Nymphal mouthparts, basal antennal segments and abdominal setation of *Oemopteryx fosketti.* Fig. 154, Maxilla; Fig. 155, Color pattern on basal antennal segments; Fig. 156, Mandible; Fig. 157, Labium; Fig. 158, Terminal abdominal segments indicating bristles seen in profile (male).



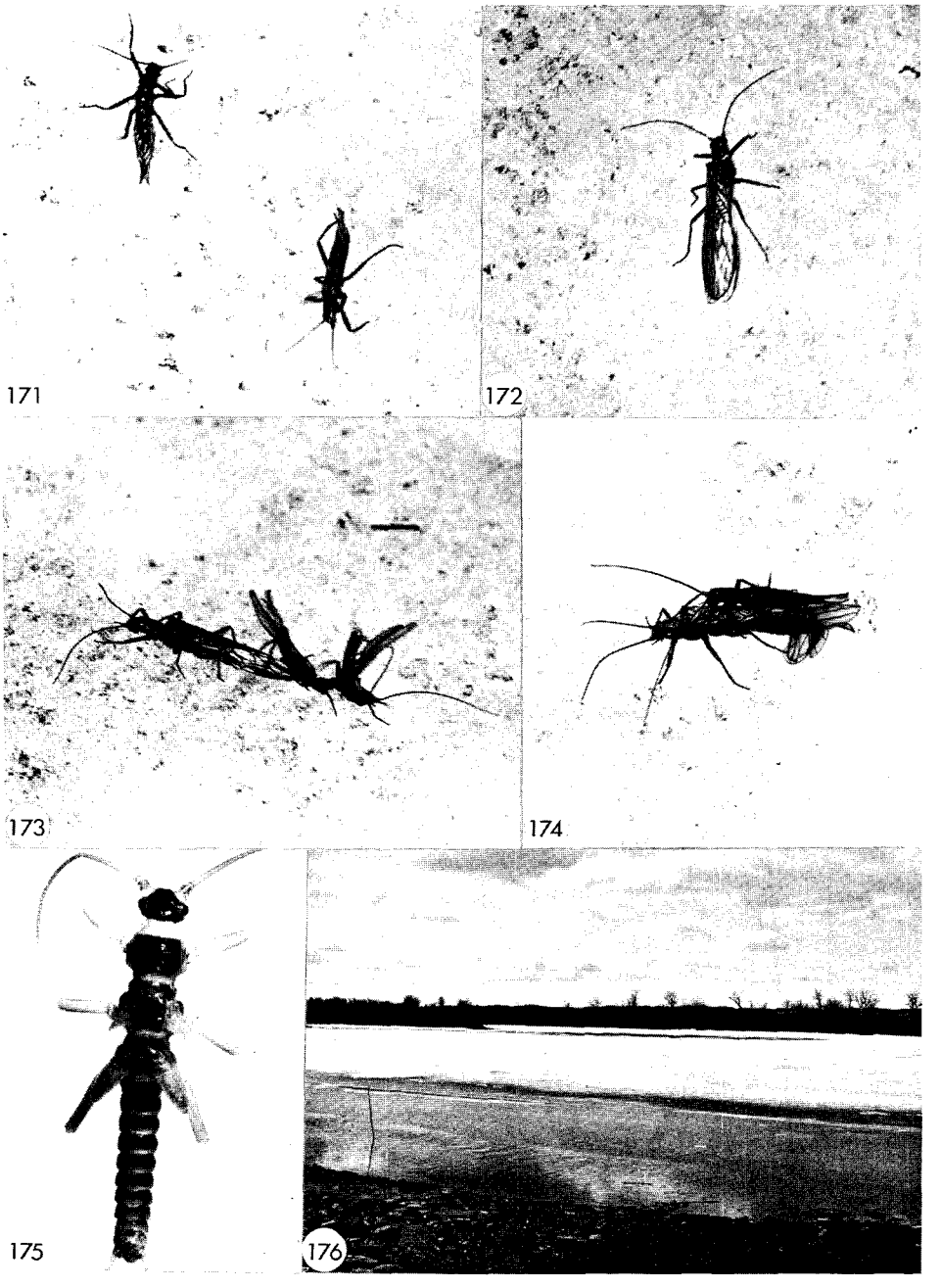
Figures 159 – 162. Nymphal color pattern and mouthparts of *Triznaka signata*. Fig. 159, Mature nymph showing color pattern; Fig. 160, Mandible; Fig. 161, Labium; Fig. 162, Maxilla and maxillary palpus (mp).



Figures 163 – 167. Adult head patterns and nymphal mouthparts of Chloroperlidae. Fig. 163, Head pattern of *Suwallia lineosa;* Fig. 164, Head pattern of *Triznaka signata;* Fig. 165, Maxilla of *S. lineosa;* Fig. 166, Mandible of *S. lineosa;* Fig. 167; Labium of *S. lineosa.*



Figures 168 – 170. Nymphal color pattern and mouthparts of *Isoperla decolorata.* Fig. 168, Mature nymph showing color pattern; Fig. 169, Mandible; Fig. 170, Maxilla with maxillary palpus (mp).



Figures 171 – 176. Adults, nymph and habitat of *Oemopteryx fosketti* under field conditions. Fig. 171, Two males actively searching out females on the snow near the North Saskatchewan River; Fig. 172, Female; Fig. 173, Two males competing for a female; the male nearest the female had begun mating, and upon the arrival of the second male, a struggle ensued until one was driven away; Fig. 174, Mating pair; Fig. 175, Mature male nymph; Fig. 176, North Saskatchewan River partially ice-covered near Borden Bridge (Hwy. 5) at emergence time of *O. fosketti.*

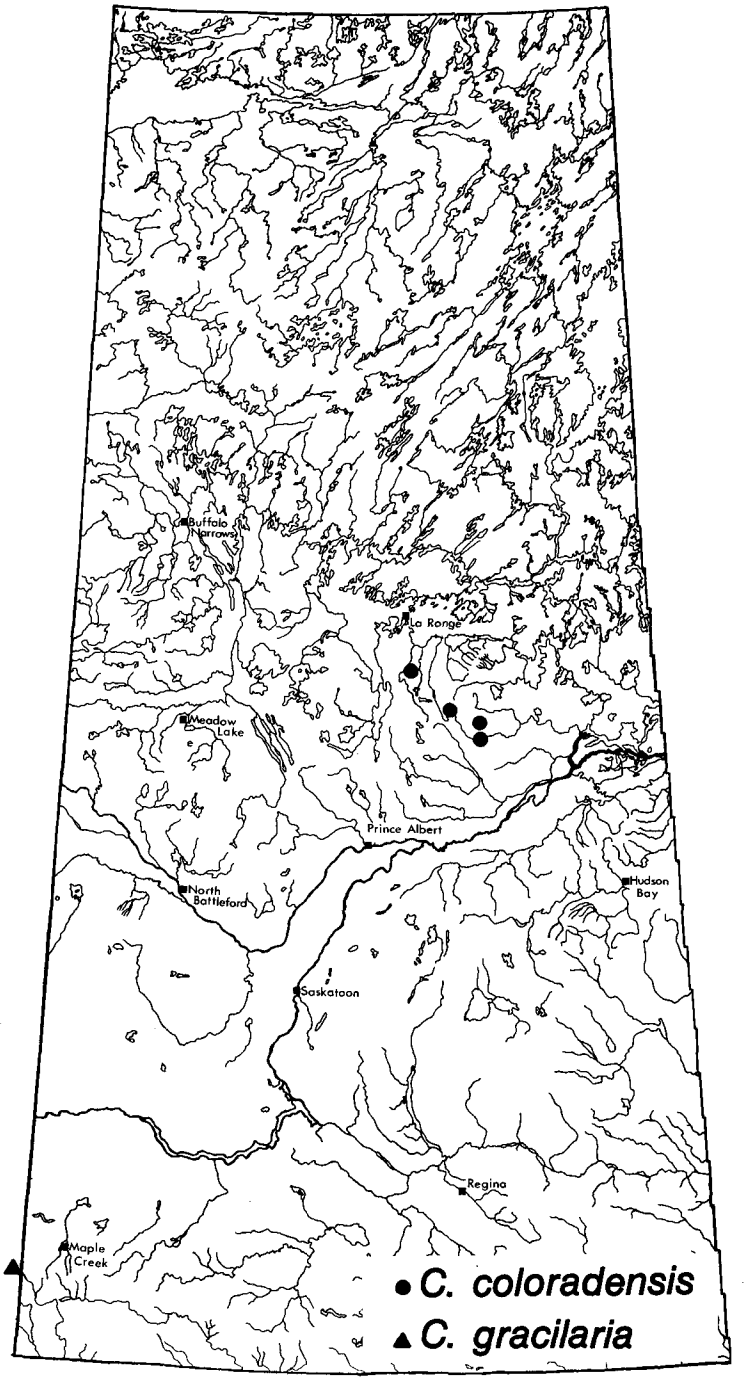


Fig. 177, Saskatchewan records for *Capnia coloradensis* and *C. gracilaria*.

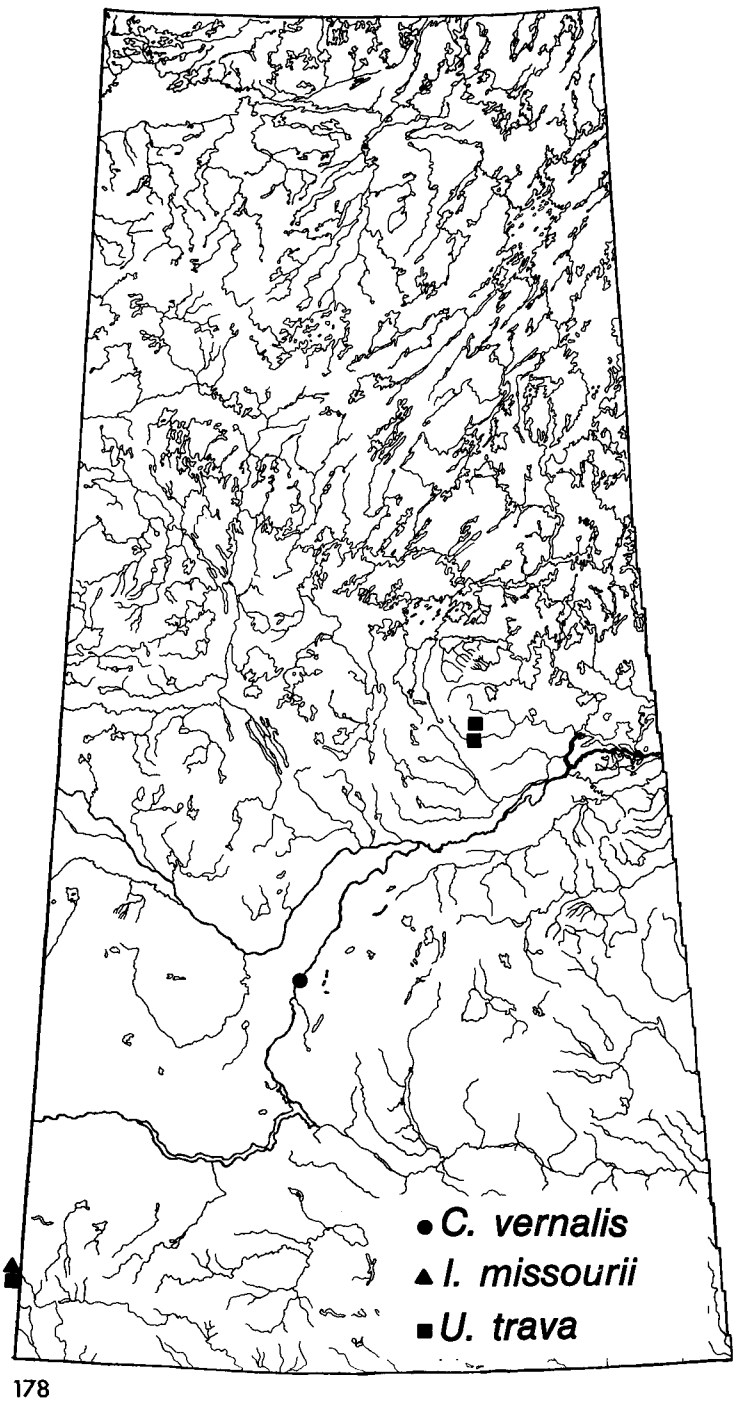


Fig. 178, Saskatchewan records for *Capnia vernalis, Isocapnia missourii* and *Utacapnia trava.*

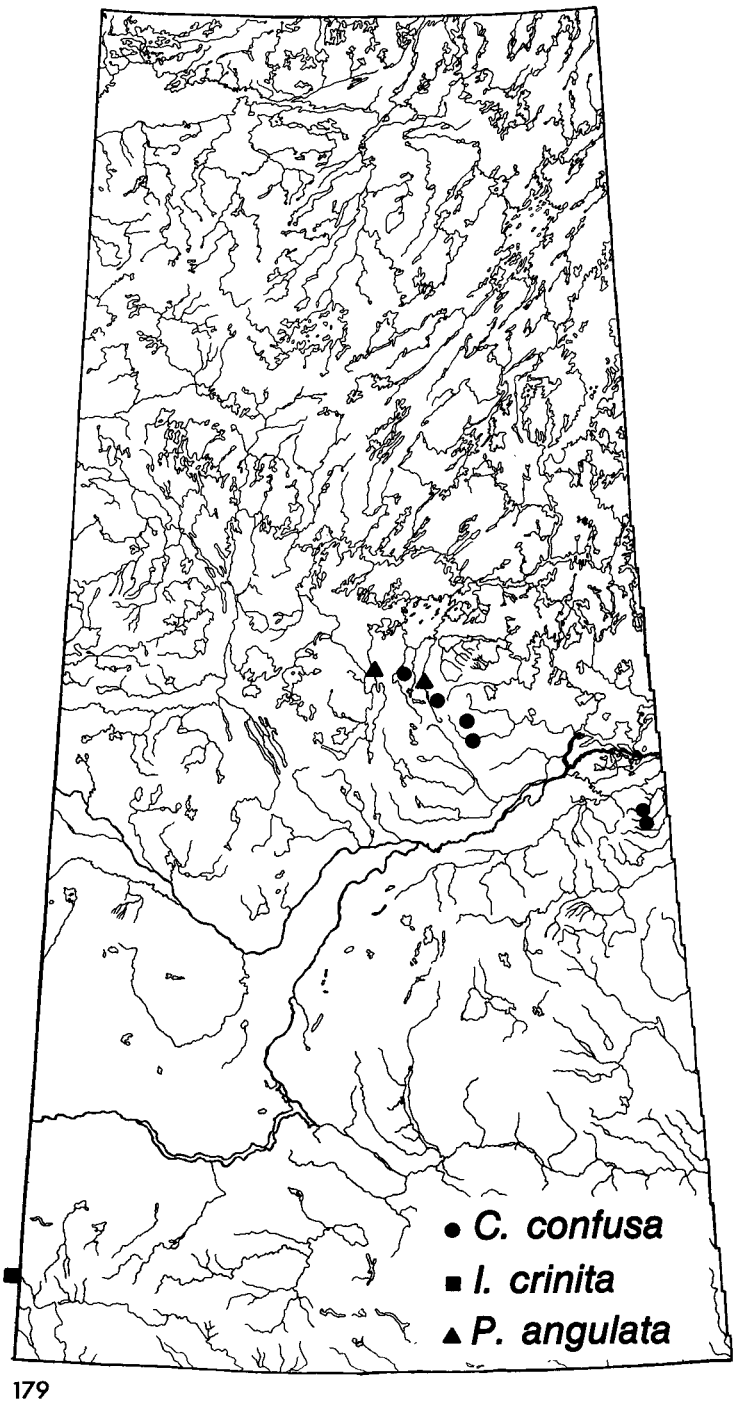


Fig. 179, Saskatchewan records for *Capnia confusa, Isocapnia crinita* and *Paracapnia angulata.*

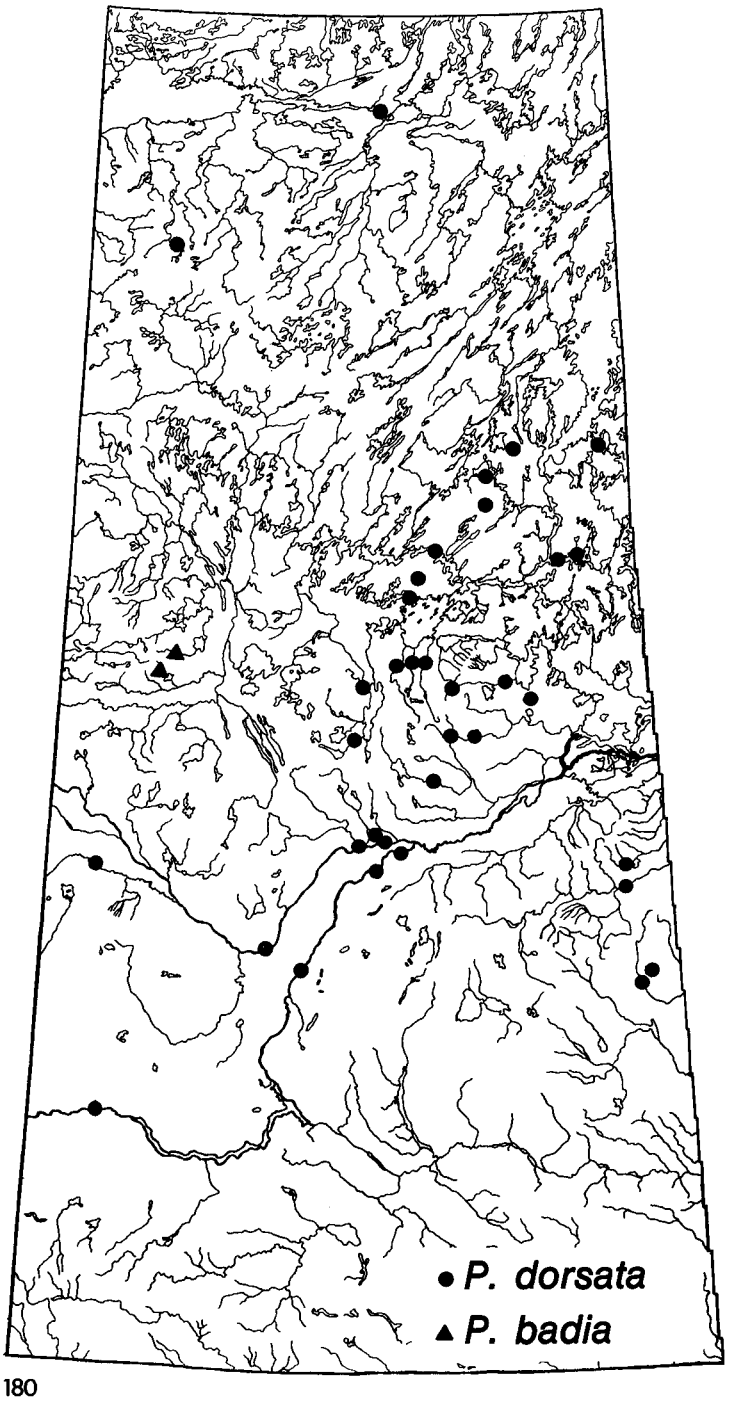


Fig. 180, Saskatchewan records for *Pteronarcys dorsata* and *Pteronarcella badia.*

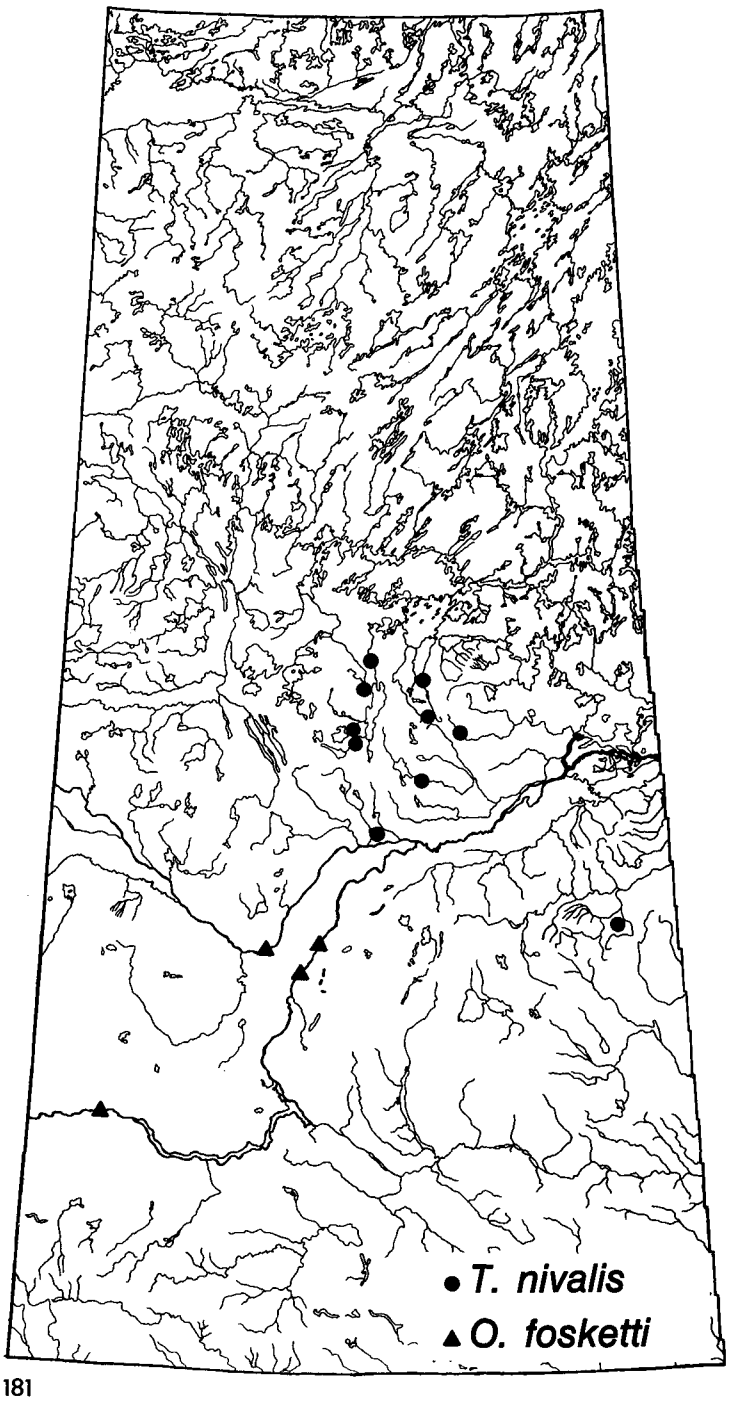


Fig. 181, Saskatchewan records for *Taeniopteryx nivalis* and *Oemopteryx fosketti*.

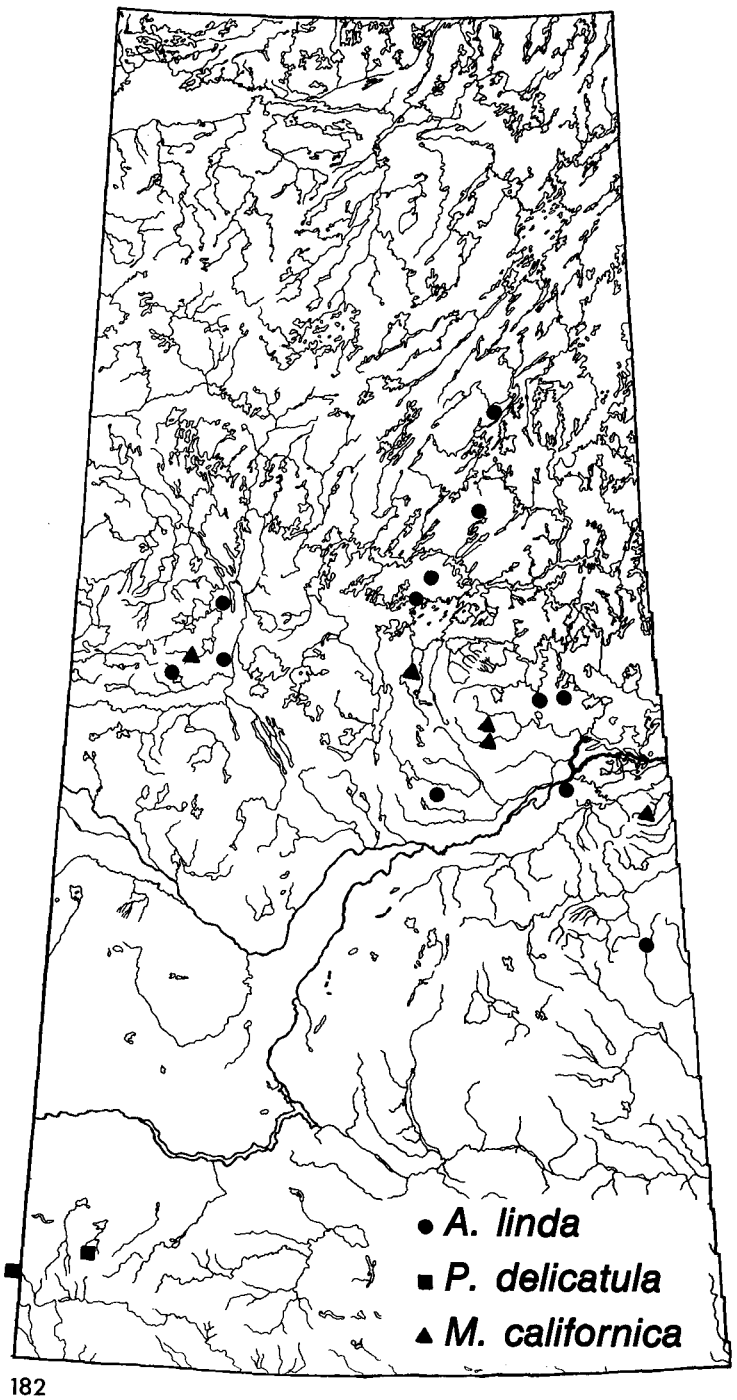


Fig. 182, Saskatchewan records for *Amphinemura linda, Podmosta delicatula* and *Malenka californica.*

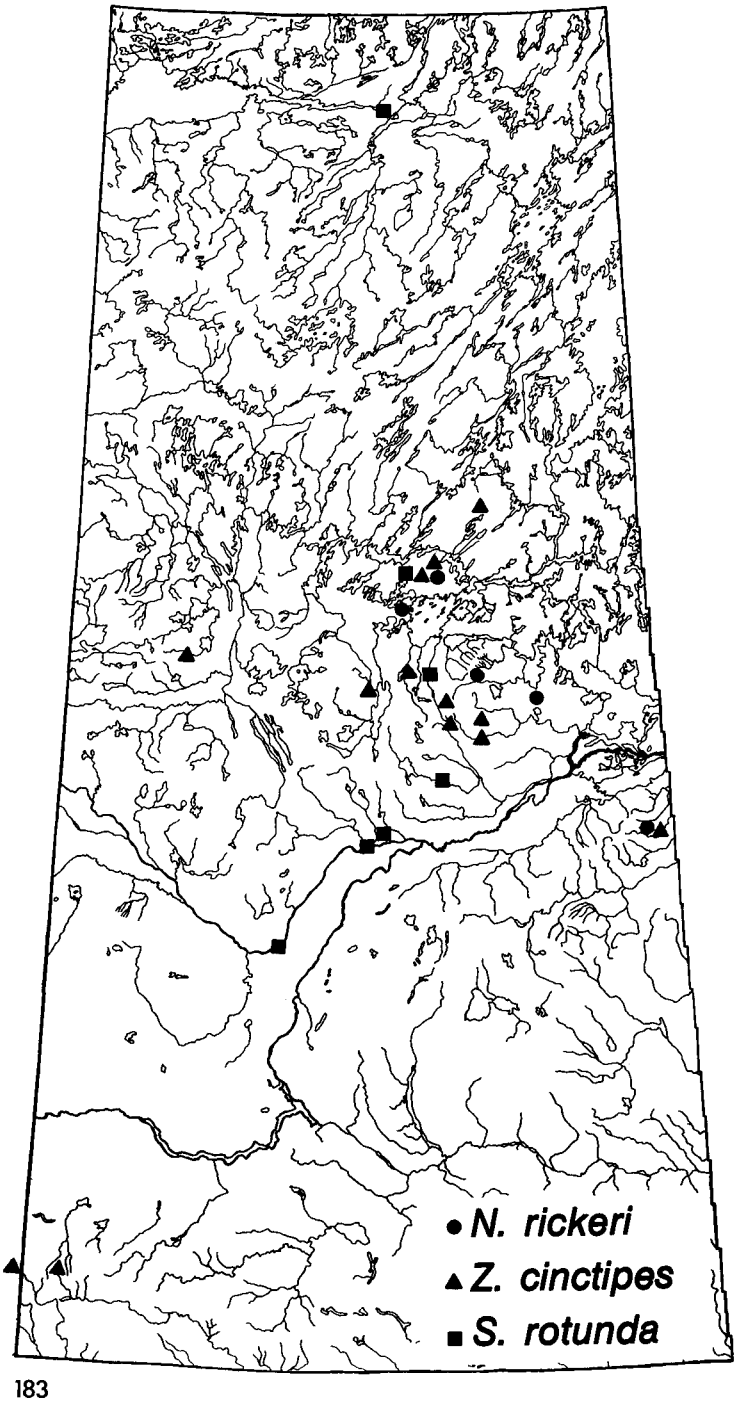


Fig. 183, Saskatchewan records for *Nemoura rickeri*, *Zapada cinctipes* and *Shipsa rotunda*.

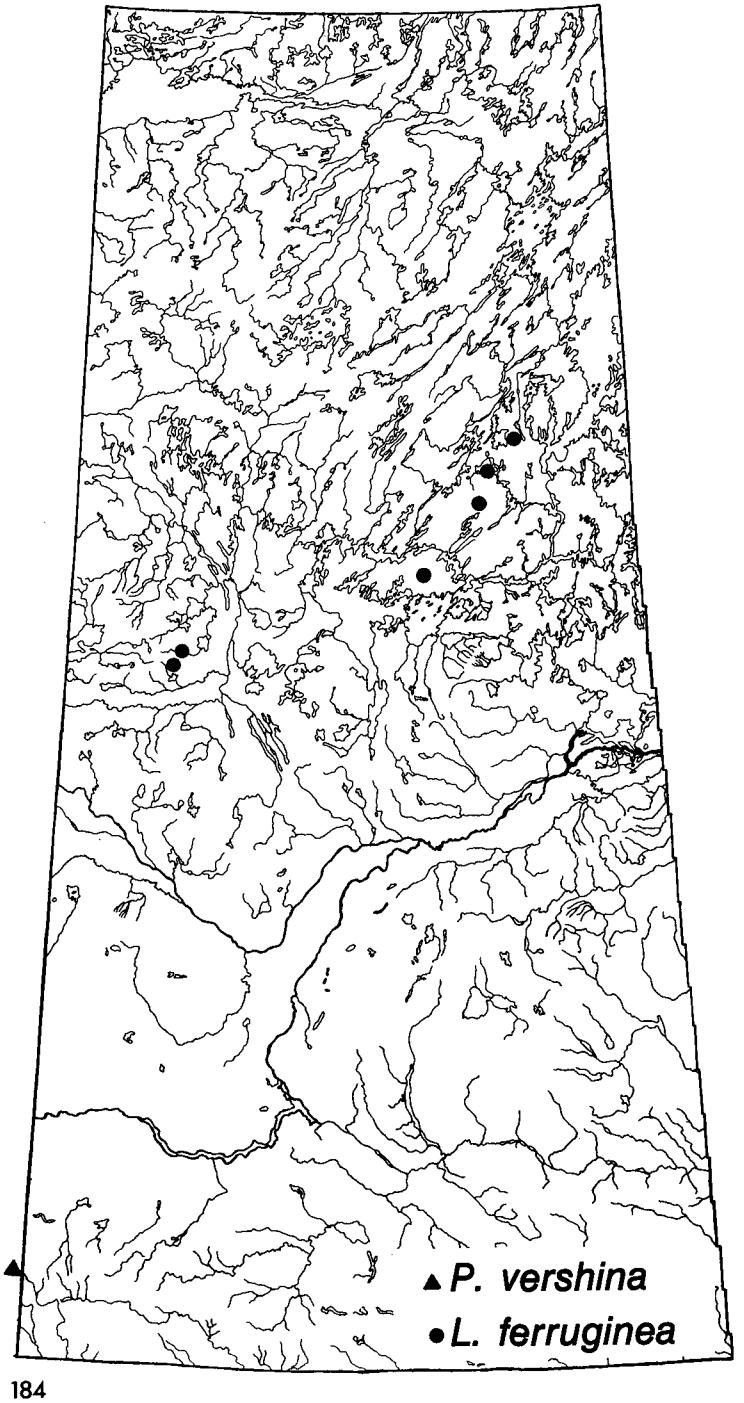


Fig. 184, Saskatchewan records for *Paraleuctra vershina* and *Leuctra ferruginea.*

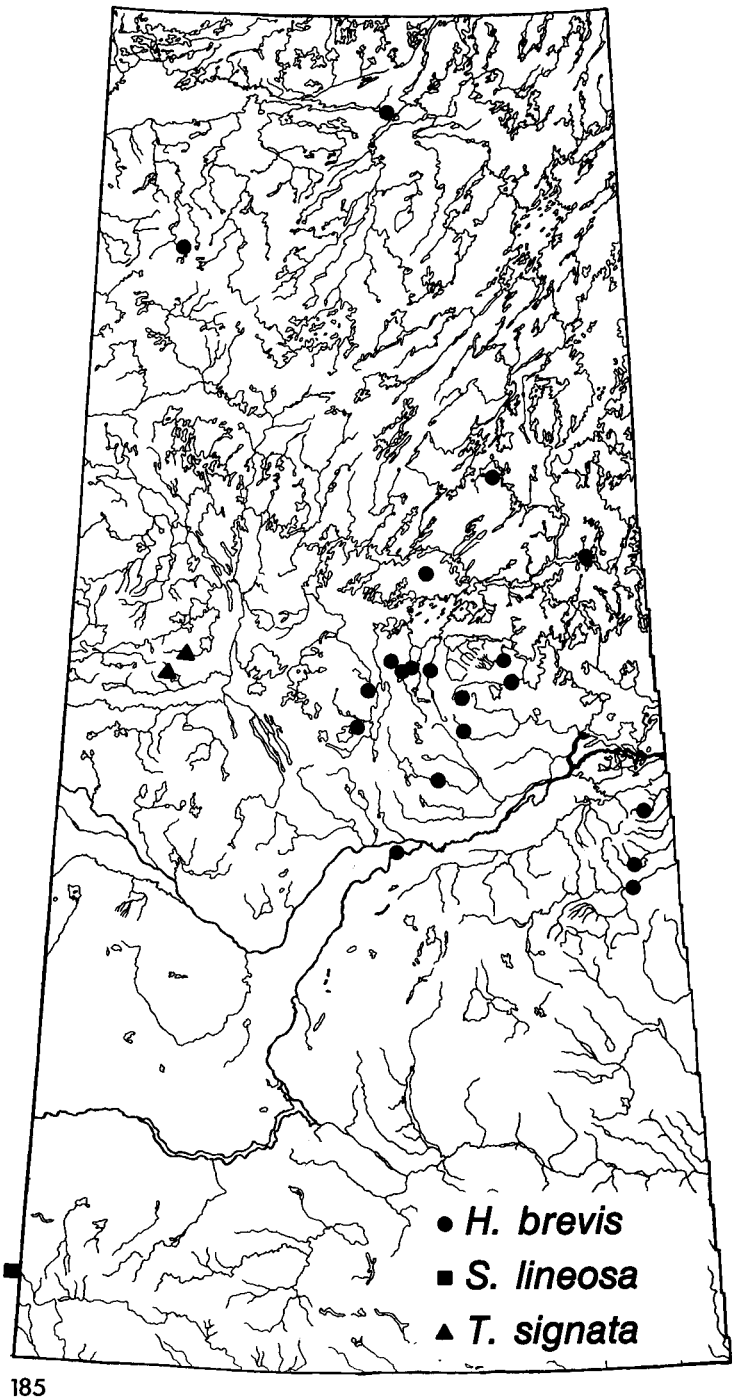


Fig. 185, Saskatchewan records for *Hastaperla brevis, Suwallia lineosa* and *Triznaka signata.*

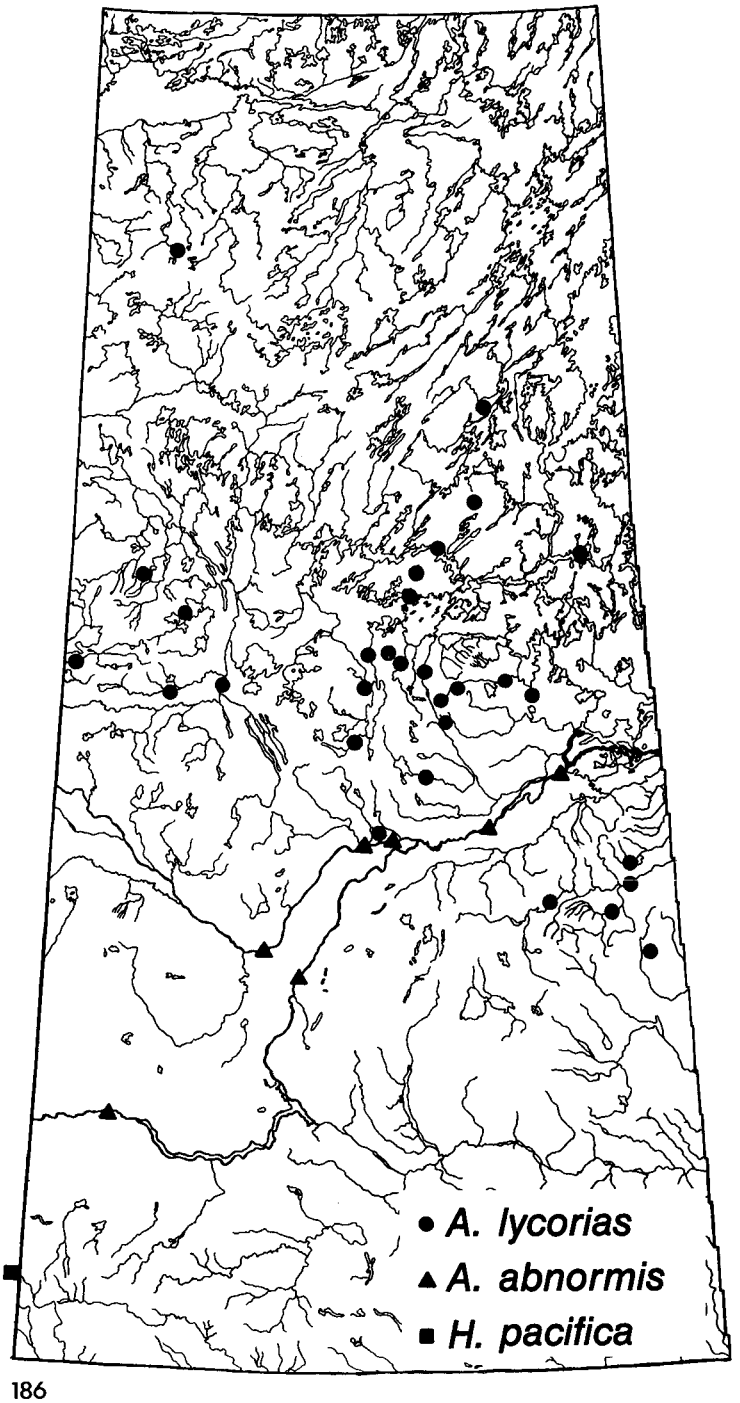


Fig. 186, Saskatchewan records for *Acroneuria lycorias, A. abnormis* and *Hesperoperla pacifica.*

Fig. 187, Saskatchewan records for *Paragnetina media, Claassenia sabulosa* and *Perlesta placida.*

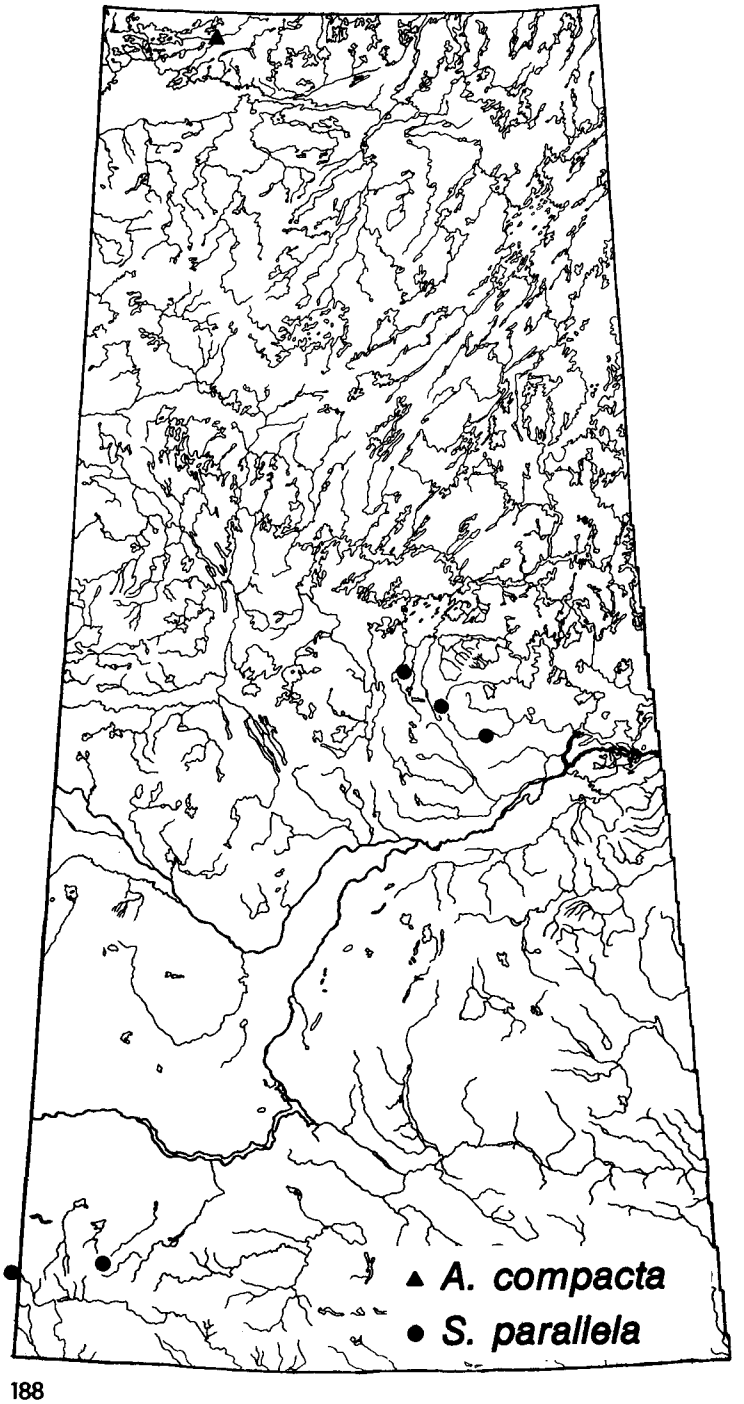


Fig. 188, Saskatchewan records for *Arcynopteryx compacta* and *Skwala parallela*.

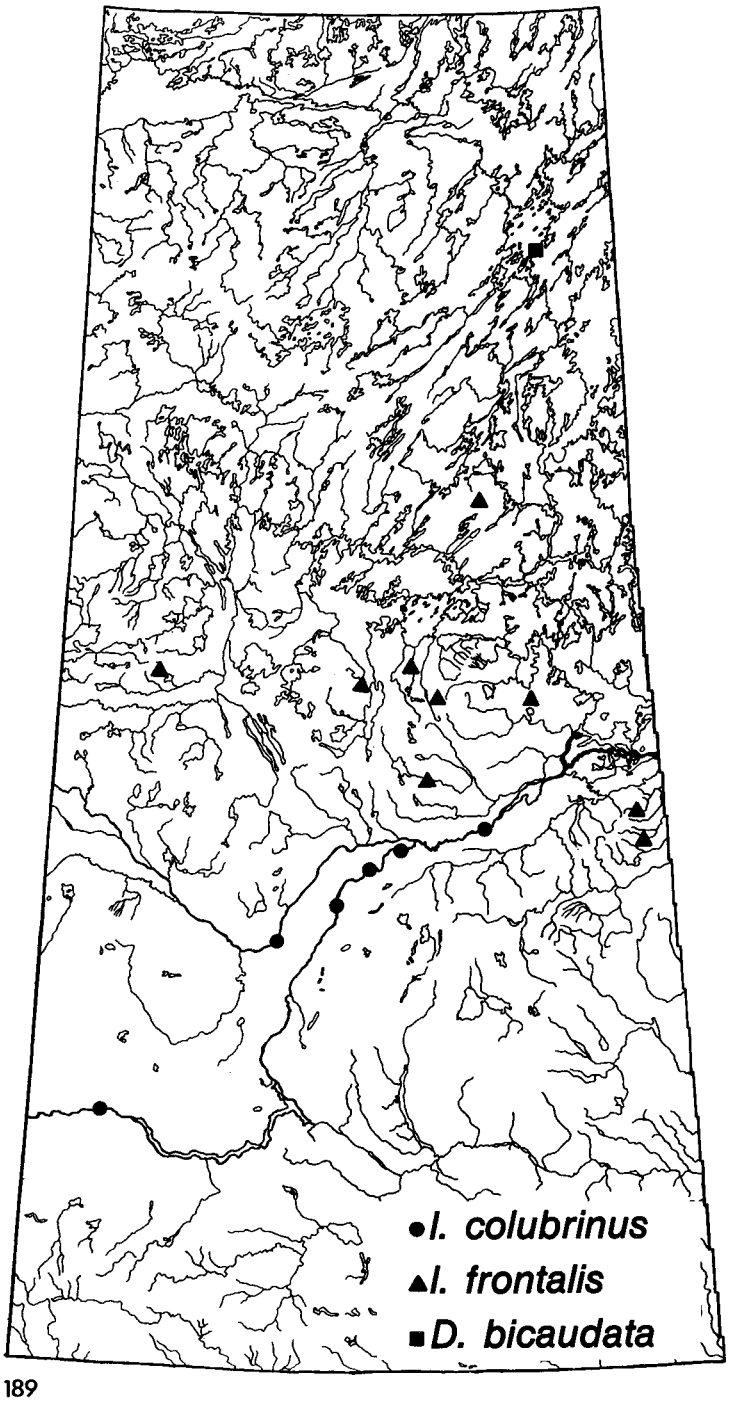


Fig. 189, Saskatchewan records for *Isogenoides colubrinus, I. frontalis* and *Diura bicaudata.*

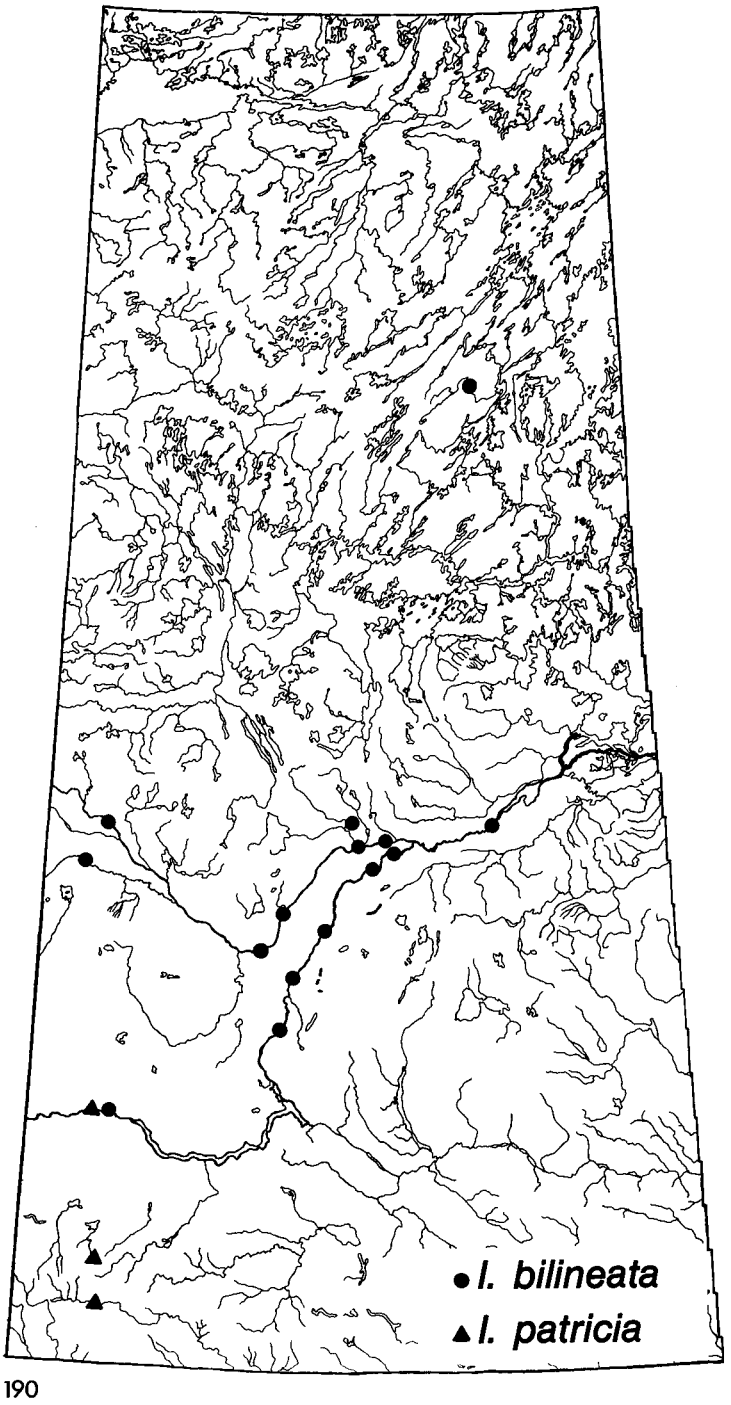


Fig. 190, Saskatchewan records for *Isoperla bilineata* and *I. patricia.*

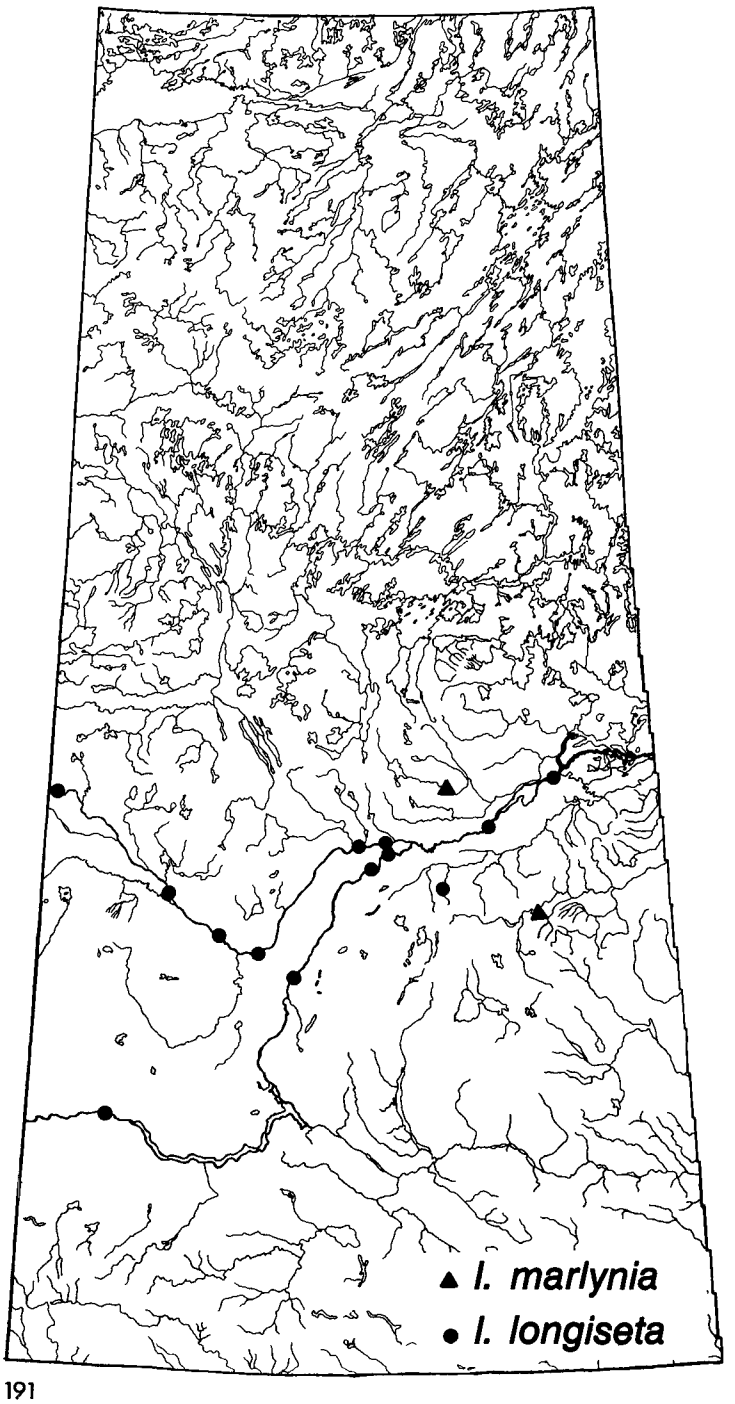


Fig. 191, Saskatchewan records for *Isoperla marlynia* and *I. longiseta*.

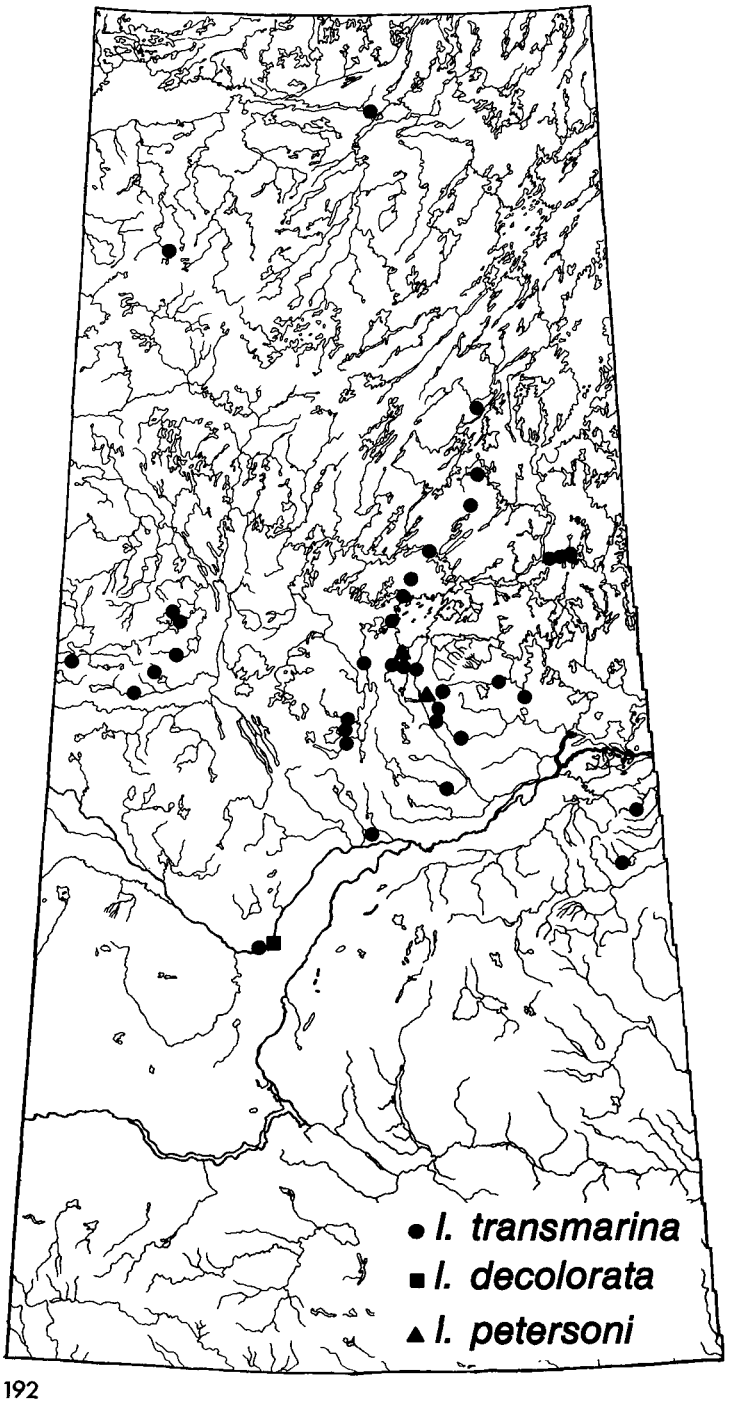


Fig. 192, Saskatchewan records for *Isoperla transmarina, I. decolorata* and *I. petersoni.*

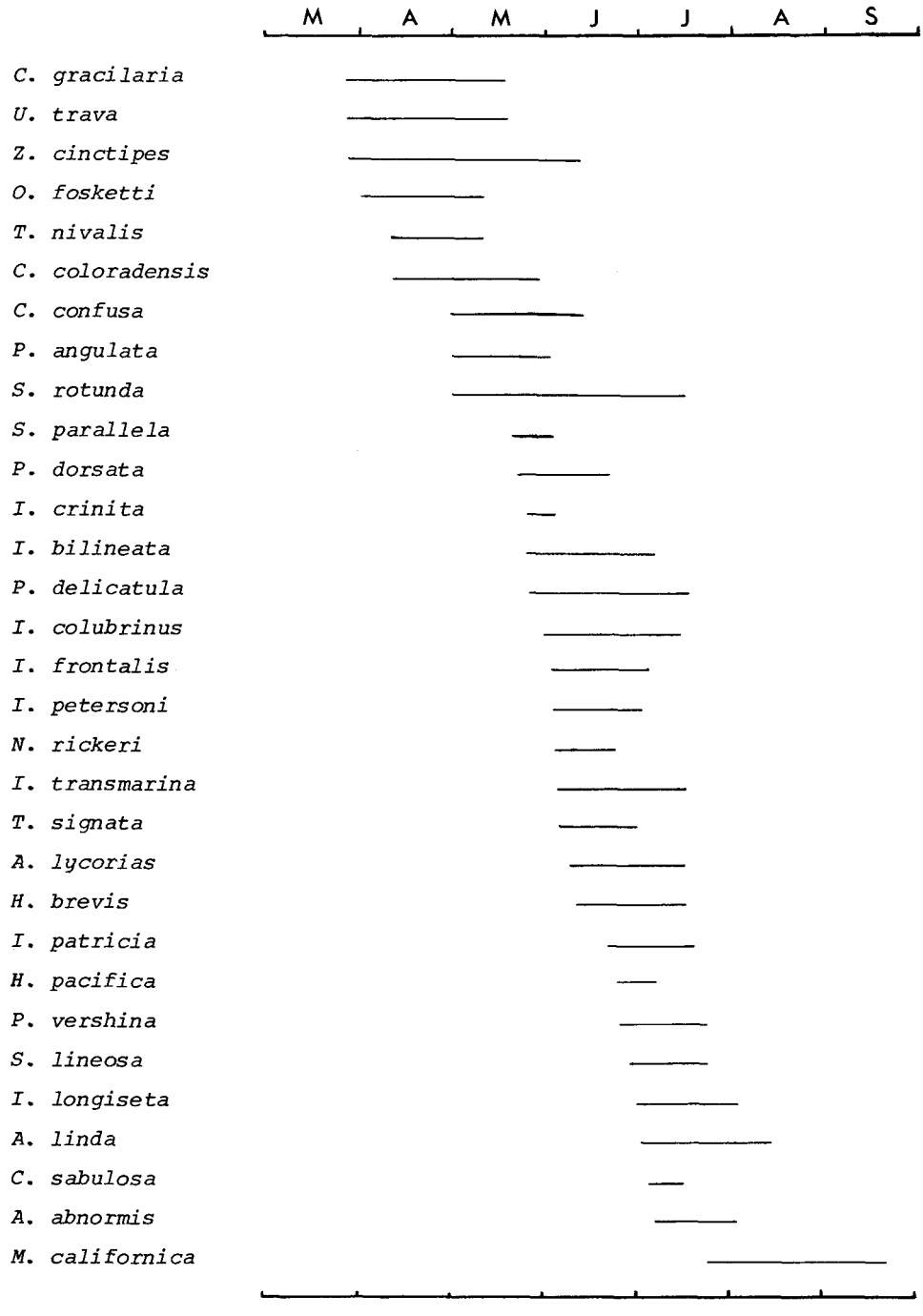


Fig. 193, Seasonal succession of adults of some species of Plecoptera in Saskatchewan. Extreme dates of capture of adults in 1974 – 1976.