THE CADDISFLIES (INSECTA: TRICHOPTERA) OF THE LAKE ITASCA REGION, MINNESOTA, AND A PRELIMINARY ASSESSMENT OF THE CONSERVATION STATUS OF MINNESOTA TRICHOPTERA

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TABLE OF CONTENTS

PART II

PART III

LIST OF TABLES

PART I

PART III

LIST OF FIGURES

PART I

PART II

ABSTRACT

Objectives of this survey and subsequent study were to prepare an annotated species list of the caddisflies from the Lake Itasca region, to record relative abundance and seasonal distribution for these species, and to compare the diversity and similarity among the caddisfly communities at each site. A companion study was initiated to make a preliminary assessment of the conservation status of all Trichoptera species known from Minnesota at this time.

Annotated records are presented for 126 species of caddisflies representing 37 genera in 13 families. Records are based on 73 light trap collections of over 95,000 adult caddisflies from four sites in the Lake Itasca region of northern Minnesota: LaSalle Creek, Nicollet Creek, Sucker Creek, and Beaver Lake. Caddisflies were collected from June-October 1988, and May-October, 1989. Rank abundance graphs are used to present relative abundance data for the most common species; among these, *Cheumatopsyche pettiti, C. oxa, Hydropsyche morosa, H. slossonae* (Hydropsychidae), *Leptocerus americanus, Ceraclea alagma, C. cancellata, C. excisa, Oecetis inconspicua, O. avara, O. cinerascens, Triaenodes marginatus, T. tardus* (Leptoceridae), *Lepidostoma bryanti* (Lepidostomatidae), and *Pycnopsyche guttifer* (Limnephilidae), include the five most abundant species from each site. The families Leptoceridae and Hydropsychidae represent 90% of the total individuals reported.

Differences in species richness, relative abundance, and sex ratios are discussed for each site each year. There were generally more species and individuals collected in 1989 than 1988, and among the most common species, females frequently outnumbered males. The Brillouin and Shannon indices and an evenness formula were used to determine that all sites have moderate species diversity. Sorensen's index of similarity is employed to describe beta diversity; based on quantitative information, the degree of similarity is high for Nicollet Creek, Sucker Creek, and Beaver Lake.

Seasonal distribution is recorded for all species for 1988 and 1989. The first flight activity is reported near the end of May for several *Cheumatosyche* and *Hydropsyche* (Hydropsychidae) and *Oxyethira* (Hydroptilidae) species, and for *Limnephilus parvulus* and *Nemotaulius hostilis* (Limnephilidae). The last flight activity of the year is recorded during the second week of October for *P. guttifer* and *Neophylax concinnus* (Uenoidae). Considering all sites collectively, species found to be most common over the two-year period were generally active over the entire season, from late spring to mid-autumn; *C. pettiti, O. inconspicua, O. avara, T. marginatus,* and *H. morosa* are among these species.

In comparison, certain species were encountered only for limited periods, such as *Fabria inornata* (Phryganeidae) and *Hesperophylax designatus* (Limnephilidae), collected only in June, and *Glossosoma intermedium* and *Protoptila tenebrosa* (Glossosomatidae), found only from late July through mid-August.

A new species, *Oxyethira itascae* Monson and Holzenthal, was discovered at Nicollet Creek during the study; in addition, *Oxyethira verna*, *Hydroptila wyomia*, *H. xera*, *Polycentropus clinei*, *P. iculus*, *Pycnospyche limbata*, *Ceraclea vertreesi*, *Oecetis nocturna*, and *Triaenodes ignitis*, collected during this study, are new records for Minnesota, and *O. ecornuta* is a new record for Minnesota and the United States. Other new State records were encountered during examination of museum specimens and include *Hydroptila angusta*, *Hydroptila antennopedia*, *Diplectrona modesta*, *Oligostomis ocelligera*, *Micrasema gelidum*, *Ironoquia lyrata*, *Onocosmoecus quadrinotatus*, *Pycnopsyche aglona*, *Goera stylata*, *Lepidostoma sackeni*, and *Ylodes frontalis*.

The conservation status of Minnesota Trichoptera is discussed and species are classified as endemic, disjunct, regionally restricted, range limited, or widely distributed. Recommendations are made for future study of the endemic, disjunct, and regionally restricted species. Endemic species are *Protoptila talola* (Glossosomatidae), *Oxyethira itascae* (Hydroptilidae), *Polycentropus milaca* (Polycentropodidae), *Chilostigma itascae* (Limnephilidae), and *Ceraclea brevis* (Leptoceridae); disjunct species are *Agapetus tomus* (Glossosomatidae), *Hydroptila metoeca*, *H. novicola*, *H. tortosa* (Hydroptilidae), *Ceraclea vertreesi*, and *Setodes guttatus* (Leptoceridae); regionally restricted species are *Oxyethira ecornuta* (Hydroptilidae) and *Limnephilus rossi* (Limnephilidae). Special emphasis is placed on recommendations for Nicollet Creek, the type locality for both *Chilostigma itascae* and *Oxyethira itascae*. An annotated list for all species recorded from Minnesota is presented.

PART I

INTRODUCTION

INTRODUCTION

The abundance of lakes, rivers, streams, and wetlands in Minnesota creates an ideal setting for research on the Trichoptera, or caddisflies, a diverse order of aquatic insects best known for the cases built by their aquatic larvae. A variety of aquatic habitats are found throughout the Lake Itasca region, which is located near the confluence of the State's three major biomes (Tallgrass Prairie, Eastern Deciduous Forest, and Northern Coniferous Forest). A survey of the caddisflies of this area was initiated in 1988. The objectives of this survey and subsequent study were to prepare an annotated species list of the caddisflies from the Lake Itasca region, to record relative abundance and seasonal distribution for these species, and to compare the diversity and similarity among the caddisfly communities at each site. A companion study was initiated to make a preliminary assessment of the conservation status of all Trichoptera species known from Minnesota at this time.

The Trichoptera of Minnesota have been reported in the literature since Elkins' (1936) descriptions of the immature stages of several species and Denning's (1937, 1943, 1947) research on the biology of some immature caddisflies and descriptions of adults. Since that time there have been many species of caddisflies reported from Minnesota, such as in the comprehensive work by Ross (1944), in annotated species lists by Etnier (1965, 1968) and in a report by Lager et al. (1979). The life cycles and drift of several species from a Minnesota woodland stream were described by Krueger and Cook (1984). Other authors have provided descriptions and records of Minnesota caddisflies as a result of research on specific taxa (Flint 1959, 1984, Haddock 1977, Holzenthal 1982, Holzenthal and Harris 1985, Lago and Harris 1987, Morse 1972, Resh 1976, Yamamoto and Wiggins, 1964, among others). This research spanning nearly 50 years has provided records for about 260 species of caddisflies in Minnesota collected from many localities in several counties.

Knowledge of the presence of certain species in a region or habitat is important for many reasons. The geographical distribution of caddisflies is of interest to systematists, for along with phylogenetic hypotheses, they use this information when considering patterns of distribution among species. For some caddisfly taxa distributional and phylogenetic data have been correlated with dispersal patterns of other taxa sharing an ecological relationship with them (Ross 1956, 1965, 1967). Quantifying caddisfly species richness and relative abundance provides basic information useful to those interested in secondary production in aquatic systems. Invertebrates make up a major part of the food web as they provide food for many organisms at higher trophic levels. Trichoptera themselves are important secondary consumers of both living and decaying organic material, and, therefore, are vital components of nutrient cycling and processing. Since most Trichoptera species exist primarily upon decomposing plant and animal material and the larvae are found in nearly all fresh-water systems, their role in affecting water quality is of major significance. The wide diversification of species within different types of habitats is evidence of this importance and has led to the recognition of their usefulness to scientists as bioindicators of water quality (Hilsenhoff 1987, Resh and Unzicker 1975, Resh and Grodhaus 1983, Rosenberg and Resh 1993, Wiggins 1977). Early assessments of water quality were commonly dependent on chemical and physical analyses, but they only reflected the conditions that were present at the time the water sample was taken. The refinement of techniques using macroinvertebrates as bioindicators in a monitoring program adds an important temporal dimension, since the manner in which organisms colonize each habitat offers evidence for their tolerance of a range of environmental conditions (Resh and Grodhaus 1983).

Phenological data for adult caddisflies is important in understanding species' life cycles and aids in making predictions about timing of events such as oviposition, aestivation, diapause, pupation, and activity periods for adults and larvae. Life history patterns of aquatic invertebrates have been described as the result of the complex relationship between such environmental factors as temperature (Vannote and Sweeney 1980), oxygen (Jonasson 1972), water level (Wiggins et al.1980), photoperiod (Sweeney 1984), food (Wallace and Merritt 1980), and the populations of predators and competitors (Butler 1984). Synchrony, which may take place during any stage in a life cycle but has been most frequently reported for adult emergence, occurs more markedly as one moves from tropical to north temperate populations (McElravy et al. 1982). There is speculation as to the adaptive significance of the high frequency of population synchrony for some taxa (Danks and Oliver 1972, Welch 1973) . The value is obvious for short-lived species and those with small populations that have a limited period of time and opportunities to find a mate (McCafferty 1981). Those species which occur in restricted environments, such as temporary pools or intermittent streams, must synchronize their life histories with the annual aquatic cycle (Wiggins et al. 1980); others may be dependent upon specific thermal regimes and are able to emerge only during periods when water temperatures are optimal (Vannote and Sweeney 1980).

There have been numerous publications reporting seasonal distribution of adult caddisflies in North America, including Alabama (Harris et al. 1991), California (Erman 1989), Alberta (Richardson and Clifford 1986), Kentucky (Floyd and Schuster 1990), Manitoba (Flannagan 1977), Ohio (MacLean and MacLean 1984, Marshall 1939, Usis and

MacLean 1986), Ontario (Singh et al.1984), South Carolina (Floyd et al. 1993), and others. Phenological information has not been reported for the emergence of adult caddisflies in Minnesota, however.

There has been lengthly discussion concerning the meaning of diversity and its application, and many different diversity indices have been proposed (Pielou 1966, Whittaker 1972). In simplest form diversity has been defined as species richness (McIntosh 1967), or alpha diversity (Whittaker 1972), the number of species within a community or habitat. The term beta diversity was introduced to describe the extent of change in species between communities along habitat gradients; gamma diversity describes the total diversity of a geographic area, representing the product of the alpha diversity of its communities and the amount of beta differentiation within these communities (Whittaker 1972). Because natural communities support species that differ in numbers of individuals, some workers have chosen to define diversity as a measure of species richness and relative abundance (Lloyd and Ghelardi 1964, Margalef 1958, Whittaker 1972). Diversity indices have been employed in the measurement of environmental stress in communities, which often indicates the state of health of an ecosystem; high diversity is associated with healthy communities. In addition, diversity indices may be used in comparing the state of health of communities for the purposes of conservation management (Magurran 1988). Diversity indices have not been used in studies of Minnesota Trichoptera.

Species' records are useful to those documenting the diversity of plants and animals, which includes species richness and relative abundance. It is necessary to know the commonness or rarity of species in order to implement appropriate conservation strategies (Rabinowitz et al. 1986). The Minnesota Department of Natural Resources through the Natural Heritage Program has been conducting a county-by-county biological survey, with the intention of completing it for as many organisms as possible in each county in the State, and it has created a comprehensive database on all state and federally listed endangered species. Among Minnesota insects only a very few families of Lepidoptera and the Cicindelidae (Coleoptera) have been assessed as to their conservation status (Coffin and Pfannmuller 1988). Such assessments have been completed for Trichoptera in Florida and South Carolina (Morse 1976, 1982).

Trichoptera

Trichoptera represent one of the largest orders of aquatic insects. The origin of the common name, caddisfly, can be traced to the 1400's where "cadaz" and "cadace" were terms used originally for cotton or silk and worsted yarn (Hickin 1967). In 1611 in *The Winter's Tale* Shakespeare wrote "He hath Ribbons... Inckles, Caddysses", referring in the latter cases to broad linen tape, and garters of worsted tape, respectively (Hinman 1968). It is thought an association was made between the insect larvae which attach pieces of plant material to their cases and the traveling vendors who pinned pieces of ribbon and other cloth or worsted to their clothing and came to be called cadice men. The term caddis is again found in the early writings of Izaak Walton, where in 1653 in *The Compleat Angler* he mistakenly makes reference to the mayfly being "bred of the cod-worm or Caddis" (Hickin 1967).

Morphology. The most distinguishing feature of adult Trichoptera is the presence of modified setae, in the form of hairs, covering both pairs of wings, hence the derivation of the ordinal name, from the Greek *trichos* (hair) *pteron* (wing). The head and thorax also bear numerous hairs. Trichoptera are most closely related to Lepidoptera, butterflies and moths, which have modified setae in the form of scales covering their wings. Caddisflies are often mistaken for their sister order because they are somewhat mothlike in appearance, but hold their wings rooflike at rest, while most moths spread their wings. Adult caddisflies, ranging in length from 1.5-40 mm, are also characterized by the possession of long antennae, vestigial mandibles, and distinct maxillary and labial palpi. Females of one Minnesota species may be wingless, and in some families there are patches of scales present on body and wings. The morphological structures of the adults that are diagnostically useful in familial and generic identification include color, shape, size, and texture of setal warts of the head and thorax, presence or absence of ocelli, number and form of the segments of the maxillary palpi, arrangement and number of tibial spurs, presence or absence of glands on the abdominal sternum, and wing shape and venation (Ross 1956, Wiggins 1984). The structures of the male genitalia are the most useful in identifying species, while females are less easily determined to species, and are unidentifiable in many cases. Ross (1944) illustrates examples of genitalic structures for most North American families.

Caddisfly larvae are recognized by their well-developed, sclerotized head capsule, often with distinct markings, a peg or rodlike single-segmented antenna, and prominent mandibles. The paired eyes are arranged in groups of ocelli. The larval thorax is distinguished by a pronotum with a distinctly sclerotized plate, a meso and metathorax which may be membranous or with sclerotization, and three pairs of legs. In some families the larval fore legs are morphologically different than the mid and hind legs, which is related to their methods of feeding and locomotion. The abdomen has 10 segments, is generally membranous, and, in some families bears humps on the first segment and small sclerites on the first and last segments. The humps are thought to create space within the case for the purpose of channeling water to aid in respiration. In addition, some families have filamentous abdominal gills which increase the surface area available for oxygen uptake. All larvae bear anal prolegs with claws on the 10th segment (Wiggins 1977).

The exarate pupae are decticous (bear sclerotized articulated mandibles used to cut their way out of the pupal case), possess long antennae, and hold their wings close to their abdomen. The middle tarsi possess a dense fringe of natatorial hairs, enabling them to swim to the surface after escaping the pupal case. The pupal abdomen is characterized by paired dorsal sclerites, or hook plates, on several segments, which help maintain the attachment of the abdomen to the silk lining of the pupal cocoon, allowing the insect to move within, and aid in its exit from the pupal case. In many families paired anal processes are located on the last abdominal segment of the pupa (Wiggins 1984).

Biology. The order Trichoptera is a holometabolous taxon. The adults, generally nocturnal or crepuscular, are most often encountered near the aquatic habitat of the larvae, and may be observed flying just above the surface of the water, dropping into the water or alighting on overhanging vegetation to oviposit, or swarming in mating behavior. They are not so easily found during daylight hours, since they are usually resting on foliage or in crevices near the water, but they may be disturbed and collected by sweeping and beating the vegetation with a net. Although reported to have been found several miles from an aquatic habitat, adults are most effectively collected at night near water, where they are readily attracted to an artificial light source (Crichton 1960, Nimmo 1966).

Adults are considered to be nonfeeding, though some ingest fluids with a modification of the hypopharynx called the haustellum, and may live 1-3 months (Crichton 1957). Adult females generally enter the water to oviposit, though there are exceptions in some families where eggs are laid on vegetation overhanging the water, on substrate near the water, or in the vicinity of temporary pools. In these instances the eggs are encased in a gelatinous matrix which prevents desiccation until rain washes them into the water or melting snow creates a vernal pool (Ross 1944). Females deposit eggs singly, in an irregular mass, or in strings arranged into a definite shape, such as the flat oval of *Triaenodes* (Leptoceridae). In temperate climates caddisflies are commonly univoltine, with five larval instars, a pupal stage, and a winged adult stage. North American species may complete their life cycle in less than a year or take up to two years. Although most species are actively feeding as larvae during winter months, in regions with extremely cold temperatures, development may be slowed for some species, and they pass the season as quiescent 5th-instar larvae. These species enter diapause in the spring until conditions are most conducive to continued development (when adequate food becomes available or to synchronize adult emergence following dissimilar growth of larvae). Resumption of development is triggered by an external stimulus such as temperature, photoperiod, or snow melt. *Neophylax oligius* (Uenoidae) and *Pycnopsyche guttifer* (Limnephilidae) are Minnesota species that emerge as adults in the autumn. Larvae of the next generation feed on the abundant autumn leaf-fall which enters the water, and it is thought they enter diapause as 5th-instar larvae during the spring or early summer the following year and pupate in late summer or autumn (Wiggins 1977). Diapause was studied in adults of *Limnephilus indivisus* (Limnephilidae) from Ontario, also recorded from Minnesota, which is associated with temporary pools. For this species sexual maturity is delayed until the advent of autumn. Eggs are laid near the soil, under wood or bark, where they are somewhat protected from sun and wind. The soil moisture gradually replenishes the pools after summer dry periods and larvae emerge (Wiggins 1973).

Case and Retreat-making Behavior. Caddisflies are probably most frequently recognized in their larval stages because of the construction of truly unusual nets, retreats, and portable cases, upon which familial classification is partially based (Ross 1956). These structures are created with silk produced by the silk gland, a modified salivary gland, and released in a fine thread from an opening in the tip of the labium. It is used alone in the nets and retreats and laid down as a dragline by free-living forms. More commonly, however, the silk is used to make a case in which the larvae incorporate a variety of objects such as sand, gravel, wood, leaves, grasses, and other plant and animal materials. These tubular cases are of different shapes and generally genus specific (Wiggins 1984). They are thought to enhance respiratory efficiency (Dodds and Hisaw 1924, Milne 1938) by serving as a conduit which directs water flowing in the anterior opening, over the abdomen and gills, and out the posterior end. Larval undulations also aide in drawing the water into the case, increasing the rate of flow of water bathing the cuticle, thereby augmenting the available oxygen. In addition, tube-cases offer the larva some protection from physical injury when being swept in fast-flowing waters, as well as from predation. Due to remarkable camouflage, larvae often elude all but the experienced observer.

The manner in which the larvae use silk correlates with the ecological niches in which they exist (Wiggins 1984). Data from stream surveys calls attention to the large number of species of Trichoptera, which far outnumber the species of Ephemeroptera, Plecoptera, and Odonata combined. Caddisfly success in adapting to a great variety of aquatic habitats and in evolving a large number of species has been attributed to their ability to use silk in many different ways (Mackay and Wiggins 1979).

Phylogenies have been proposed based on comparative morphology of adults, larvae, and pupae, ecological information, and on the use of silk. There has been much debate on the relationship between certain families (Martynov 1924, Ross 1944, 1956, 1967, Schmid 1980, Weaver 1984, 1992a, 1992b, Weaver and Morse 1986, Wiggins 1977, 1984, 1992, Wiggins and Wichard 1989). All authors generally agree that there are three major lineages in the order, the suborders Spicipalpia, Annulipalpia, and Integripalpia (Fig.1). The relationship of these suborders to each other, however, is still a matter of contention. A useful method for organizing Trichoptera into families is, in part, based on these phylogenies (taken from Wiggins 1977, 1984):

Free-living forms are represented by a single family in Minnesota, Rhyacophilidae (suborder Spicipalpia). These caddisflies, most frequently associated with cool lotic habitats (some with temporary streams), are primarily predaceous, and a few are herbivorous. These larvae are campodeiform, bearing prognathous head and mouthparts and well-developed leg musculature. They do not build any type of retreat or case. Instead, they lay a silk thread on the substrate as they move about, which acts as a safety line should they become dislodged. At the time of pupation a strong brown silk cocoon is constructed within a rough dome-shaped covering made of pieces of rock glued together with silk and attached to the substrate.

The saddle-case makers, represented by a single family in Minnesota, Glossosomatidae (suborder Spicipalpia), are found in brisk running water or along wave-swept shores. The larvae are completely concealed from above by their cases, which are made with tiny rocks incorporated into the dorsum, and are likened to tortoise shells in appearance; there is a wide strap made of mineral fragments on the ventral surface. Though not visible dorsally, the head, legs, and abdominal tip protrude through openings at each end of the case as the larva moves about feeding on diatoms and fine particulate organic

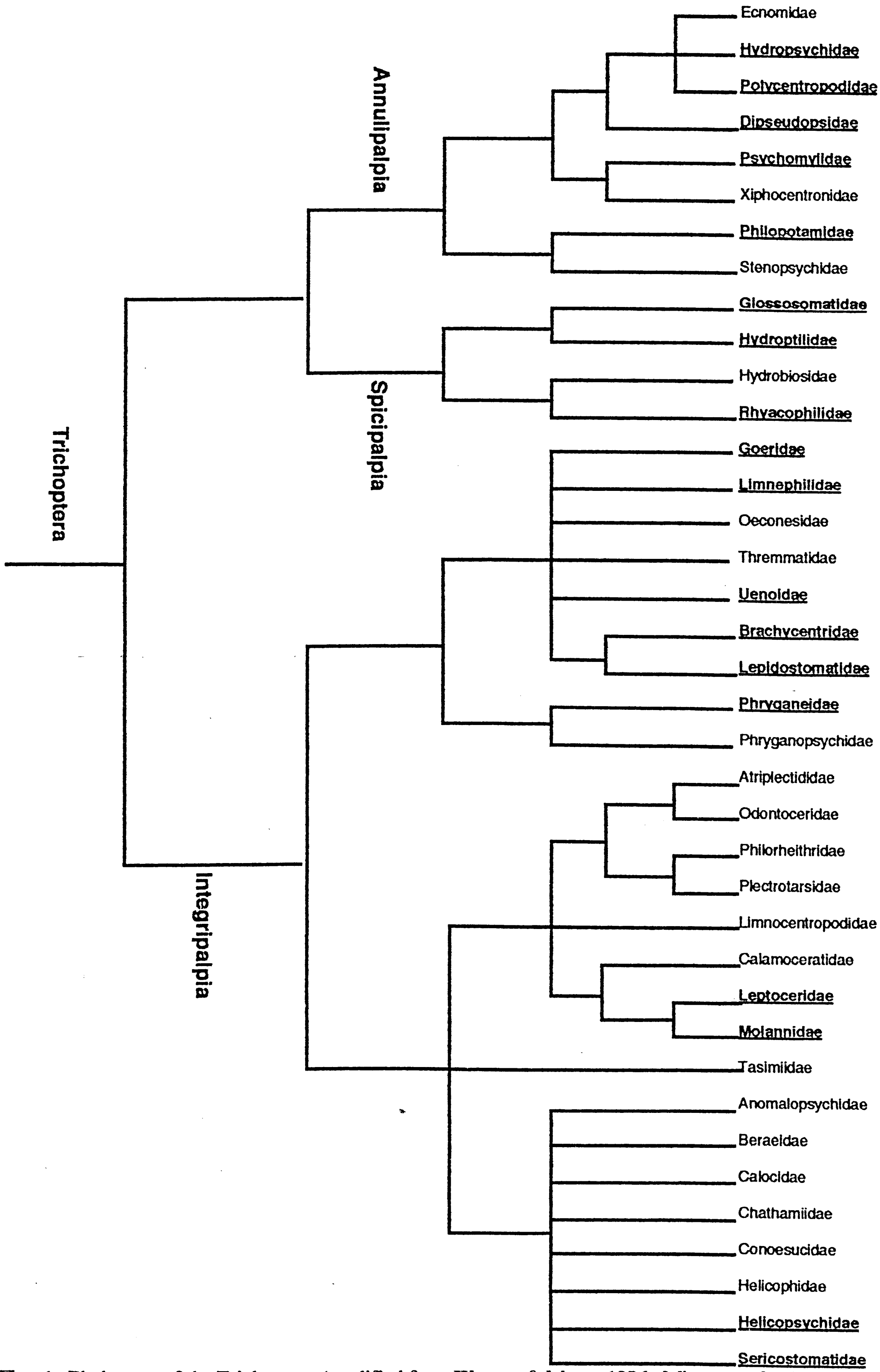


Fig. 1. Phylogeny of the Trichoptera (modified from Weaver & Morse 1986, Minnesota families underlined bold).

matter on exposed rock surfaces. At the time of pupation the larva removes the ventral strap, secures the case to the substrate with silk, and spins a silk cocoon beneath the domed case.

The purse-case makers are represented by a single family in Minnesota, Hydroptilidae (suborder Spicipalpia), often called the microcaddisflies, because this family includes the smallest species of all adult caddisflies (1.5-5 mm). The larvae of this family are free-living during the first four instars, and most differ morphologically from the fifth instar, which inhabits a case. The cases are constructed variously in barrel, bottle, and bivalve or purse shapes and are found in all types of permanent aquatic habitats. The larvae of some genera extrude the distal portion of the abdomen, or only the anal prolegs, through the posterior opening in the case, which enables contact with the substrate. Their diet consists mainly of the cellular contents of filamentous algae and diatoms. In preparation for pupation both ends of the larval case are closed off, it is affixed to the substrate, and the larva spins a silk lining within the case. Ross (1956) did not find evidence of a fibrous inner cocoon, but Wiggins and Wichard (1989) state that in some genera the pupal case is constructed entirely of silk.

The net-spinning caddisflies are found among the following families in Minnesota: Philopotamidae, Arctopsychidae, Hydropsychidae, Polycentropodidae, Dipseudopsidae, and Psychomyiidae (suborder Annulipalpia). These larvae, recognizable by their unique fixed nets and retreats, are sedentary in comparison to those of other families because they primarily move within the limits of these structures. They are dependent on currents or the action of water on wave-swept shores to enable them to use their nets for filtering food. Their diet ranges from algae and small particles of plant or animal detritus which they gather from the net, to whole animals which are caught in the mesh, and upon which they prey. During pupation the larva may spin a sacklike cocoon covered with stones and open anteriorly, or it may construct an ovoid cocoon inside a crude covering of stones and debris which is attached to the substrate.

The tube-case makers include the following families in Minnesota: Phryganeidae, Brachycentridae, Limnephilidae, Goeridae, Uenoidae, Lepidostomatidae, Sericostomatidae, Molannidae, Helicopsychidae, and Leptoceridae (suborder Integripalpia). Found in all types of aquatic habitats, the larvae construct a great variety of differently shaped portable tubular cases that offer camouflage as they move about, and in some families, are thought to provide a respiratory advantage. Some workers believe larval undulations within the case create a current, which increases the flow of water bathing the larval cuticle, thereby maximizing oxygen uptake (Dodds and Hisaw 1924). Others suggest that the cases allow larvae to optimize, rather than maximize, oxygen consumption, by facilitating a decrease in rates of oxygen consumption and metabolism (Williams et al. 1987). With their head and legs extended from the anterior opening of the case, the larvae crawl about in search of food, adding on to their cases as they develop to accommodate increase in size. Larvae are primarily detritivorous, but there are some herbivores and predators. In most families, at the time of pupation the anterior end of the case is closed with a silken sieve membrane and the ends of the case are secured to the substrate. Pupation occurs within the unmodified larval case.

There are differing theories on the evolution of case-making behavior in Trichoptera. Martynov (1924) and Schmid (1980) divided the order into suborders Annulipalpia (free-living and net-spinning forms) and Integripalpia (tube-case makers). Ross (1967) constructed his phylogeny so as to place the free-living, saddle-case, and purse-case making forms in Integripalpia, along with the tube-case makers, leaving only the retreat and net-spinners in Annulipalpia. Based on many morphological homologies of larvae, pupae, and adults, Weaver and Morse (1986) expanded on Martynov's arrangement (Fig. 1), proposing that tube-dwellers were likely the ancestral caddisflies. They suggested that ancestral larvae were detritivores, which constructed fixed tubular chambers strengthened with silken secretions within the moist soil or detritus found near lentic or lotic-depositional habitats. From this early larval behavior, some evolved into retreat-makers, primitive Annulipalpia, and others into tube-case makers, primitive Integripalpia; free-living, saddle-case making, and purse-case making probably evolved independently. They predicted that further study will reveal that saddle- and purse-case making likely were derived from pupation activities, which are very different from tube-case making.

Trophic Relations. With a few exceptions, the majority of caddisfly larvae whose biology is known are detritivores. They have evolved to utilize decaying organic matter, especially plant material, as their primary food source and have many morphological adaptations for this purpose. Aquatic insects are commonly organized into trophic groups based on feeding mechanisms (Cummins 1973, Cummins and Klug 1979, Wiggins 1977, 1984):

Shredders feed upon living vascular plant tissue as herbivores and upon large particles (>1mm) of coarse particulate organic matter (CPOM), primarily decomposing vascular plant tissue, as detritivores. Fungi and bacteria cover the surface of decaying plant material, and studies have shown an increase in rates of consumption as this material becomes colonized by these microorganisms (Anderson and Grafius 1975). Many genera in

Limnephilidae and Lepidostomatidae are considered quite dependent on plant material heavily covered with fungi and bacteria (Wiggins 1977), and the amount and kind of microfloras affect the nutritional value of these food resources (Sweeney 1984). Species in such genera as *Agrypnia, Banksiola, Fabria, Phryganea, Ptilostomis (Phryganeidae,* early instars), *Micrasema* (Brachycentridae), *Lepidostoma* (Lepidostomatidae), *Anabolia, Limnephilus, Pycnopsyche* (Limnephilidae), and *Leptocerus, Triaenodes* (Leptoceridae) are among the shredders. The larvae of shredders generally have toothed mandibles shaped for that purpose and play an important role in reducing large pieces of organic material to smaller sizes, thus making them available as food for collectors.

Collector-filterers feed upon living algal cells as herbivores and upon small particles (<1 mm) of fine-ultrafine particulate organic matter (FPOM-UPOM) in suspension as detritivores. Larvae of this group are primarily retreat makers and net spinners as found in all genera of Philopotamidae, Dipseudopsidae, and Hydropsychidae, as well as in *Cyrnellus, Neureclipsis, Nyctiophylax,* and *Polycentropus* (Polycentropodidae) in Minnesota. An unusual T-shaped labrum edged with fine setae is an adaptation found in the Philopotamidae which is used to clean particulate matter from their very fine meshed nets. The abundance of setae associated with the mouthparts of most Hydropsychidae may be a similar adaptation for procuring food. There has been debate about the significance of mesh size in net construction. Wallace (1975) suggested a correlation between placement of caddisfly families phylogenetically and net complexity. Primitive net-making larvae constructed simple nets with large mesh sizes. As caddisflies evolved, capture nets increased in complexity and mesh sizes decreased. Alstad (1982) acknowledged this association but proposed a causal relationship between the current speed and concentration of particulate food, and the complexity of net construction: primitive taxa found in fast-flowing upstream habitats less rich in nutrients construct simple nets with large mesh sizes; current is slower at lower elevations downstream, the particulate matter in suspension increases, and the more derived taxa are found associated with complex filtering nets with small mesh sizes. Collector-filterers also include some tube-case makers whose legs are adapted for filtering by means of the arrangement of setae and spines, as in *Brachycentrus* (Brachycentridae)

Collector-gatherers are detritivores and they consume decomposing UPOM-FPOM that has been deposited often as sediment-related detritus. They include saddle-case makers, net spinners, purse-case makers, and several families of tube-case makers. They may clean it from their retreats, tubes, or rock surfaces with such adaptations as flexible brushlike setae on mouthparts and fore legs, as found in *Lype, Psychomyia* (Psychomyiidae) and

Agapetus (Glossosomatidae). There are several families of tube-case makers with genera that contain collector-gatherers in Minnesota, including *Micrasema* (Brachycentridae), *Anabolia, Hesperophylax, Hydatophylax, Lenarchus, Limnephilus* (Limnephilidae), *Agarodes* (Sericostomatidae), *Molanna* (Molannidae), and *Ceraclea, Mystacides, Nectopsyche, Setodes* (Leptoceridae).

Scrapers feed upon algae and small particles of associated periphyton on rocks or other substrate and possess smooth mandibles shaped for this purpose. In Minnesota they are represented primarily by the retreat makers *Lype and Psychomyia* (Psychomyiidae), the saddle-case makers *Agapetus, Glossosoma,* and *Protoptila* (Glossosomatidae), the purse-case makers *Hydroptila, Ithytrichia, Neotrichia,* and *Mayatrichia* (Hydroptilidae), and the tube-case makers, *Apatania, Hesperophylax* (Limnephilidae), *Goera* (Goeridae), *Neophylax* (Uenoidae), and *Helicopsyche* (Helicopsychidae).

Predators feed on whole animals or their parts and include members of the free-living caddisflies, retreat and net makers, and tube-case makers. *Rhyacophila* (Rhyacophilidae) engulf animal parts, while other genera rely on silken retreats, specially shaped nets, and tubes to capture food, as in *Nyctiophylax, Neureclipsis,* and *Polycentropus* (Polycentropodidae). Predators among tube-case makers include *Banksiola, Oligostomis,* (Phryganeidae), *Molanna* (Molannidae), and *Oecetis*, *Ceraclea* (Leptoceridae). Some species of *Ceraclea* (Leptoceridae) found in Minnesota feed exclusively on fresh-water sponges (Resh 1976, Resh et al. 1976).

Piercers ingest plant tissue fluids, primarily filamentous algae and diatoms, and are found only among the purse-case making caddisflies, Hydroptilidae. Among the Minnesota genera *Agraylea*, *Hydroptila*, and *Oxyethira*, there is a larval adaptation for securing plant material. Seta-bearing processes on the fore tibiae are used in chelate fashion, in conjunction with the tarsal claw, to manipulate pieces of algae (Nielsen 1948). Larvae of *Mayatrichia* have an attenuate head, also thought to be an adaptation for feeding, and *Orthotrichia* spp. have an asymmetrical labrum, with a sclerotized point along the midline, which is thought to assist the larva in piercing algal filaments (Wiggins 1977).

It should be noted that many caddisfly species are omnivorous, utilizing different resources as the seasons change, and larger pieces of material with maturity. This is true for most genera of several families of tube-case makers. For example, *Banksiola crotchi* , a Minnesota species known to be detritivorous in its early instars, becomes entirely predaceous by the final instar (Wiggins 1977).

Distribution. Trichoptera are represented by nearly 1400 Nearctic species (Morse unpub. 1992). Caddisflies in Minnesota are found in virtually all aquatic habitats, from lakes, rivers, and vernal springs, to marshes, temporary pools, bogs, and seepages. The larvae of some species may be found in moist semiaquatic environments, such as the wet leaf litter found near temporary pools, which allows them to survive dry periods (Wiggins 1973, Williams and Williams 1975). Caddisflies are most commonly associated with lotic habitats and representatives of all 19 Minnesota families are found in them. Seven of these families have also successfully adapted to lentic habitats, including three found in temporary pools (Wiggins 1977). Ross (1956) refers to the ancestral characters of those families occurring in cool lotic waters and to the derived characters of those found in warm lentic habitats. These include various morphological adaptations and the net, retreat, or case-making behavior necessary to larval food gathering and survival. As oxygen content steadily decreases from cool lotic to warm lentic habitats, there is an increased need for larval respiratory capability. The fact that most families found in lentic waters are those which build portable tube cases is offered as support for the hypothesis that tube-case makers are able to increase the oxygen content within their cases by undulation. This has led to the belief that the evolution of tube-case making has allowed caddisflies to exploit lentic habitats where there is less dissolved oxygen than in lotic waters (Milne 1938, Wiggins 1984), and this adaptation is the direct result of the ability of caddisflies to produce silk (Wiggins 1977). More recent research has shown that some caddisfly larvae that do not build tube-cases generally have higher rates of oxygen consumption than tube-case makers, which probably also indicates higher rates of metabolism (Williams et al. 1987). Weaver (1992a) applies these data to the theory that ancestors of tube-case making caddisflies lived in moist soil or detritus near lentic habitats (Weaver and Morse 1986), and suggests that they must have had low rates of oxygen consumption and metabolism. Weaver (1992a) then proposed that caddisfly ancestors were able to functionally adapt their rate of metabolism and oxygen consumption to environmental changes in oxygen concentration and this may have been the key to their success in moving into aquatic habitats.

MATERIALS AND METHODS

Study Area

This study, undertaken in the Lake Itasca region of Minnesota, involved making regular collections from four sites: Nicollet Creek, Beaver Lake, Sucker Creek, and LaSalle Creek (Fig. 2). Collections were made from June-October, 1988, and May-October, 1989. Lake Itasca, in Clearwater County, is the headwaters of the Mississippi River and is located in the region of Minnesota where the Eastern Deciduous Forest, the Northern Coniferous Forest, and the Tallgrass Prairie Biomes converge (Coffin and Pfannmuller 1988). This area has numerous lakes, marshes, bogs, and temporary pools, as well as several creeks, many of which empty into the Mississippi River. The Itasca region is not heavily populated by humans and is without heavy industry. The Mississippi River is monitored by the Mississippi Headwaters Board, which regulates use of the first 400 miles of this river. Some surrounding areas are designated as Scientific and Natural Areas, which have been established to protect and perpetuate Minnesota's rare and unique natural resources for nature observation, education, and research.

Collection Sites

<u>Nicollet Creek</u>, Clearwater County (47.194°N, 95.230°W), flows within Itasca State Park between Nicollet Lake and Lake Itasca on Wilderness Drive (Fig. 3). It has a silty bottom, some woody debris and leaf packs, and tall grasses overhanging its banks, obscuring it from view in many places. This creek, often with particulate matter in suspension, follows a tortuous course through a wetland meadow surrounded primarily by conifers, before joining the west arm of Lake Itasca. There are many seepage areas in the meadow that enter into the creek, and springs keep at least two small pools open year round. Creek depth was 30-60 cm at the collection site. Water temperatures ranged from 12-29°C during the collection period (n=20), and pH ranged from 7.68-8.50 (n=6). Mean flow was 0.22 ± 0.11 SD m/sec (n=7), mean conductivity was 494 ± 34 SD micromhos/cm (n=5), and mean alkalinity was 244 ± 6 SD ppm $CaCO_3$ (n=5).

<u>Beaver Lake</u>, Clearwater County (47.200°N, 95.243°W), is located west of the west arm of Lake Itasca on Wilderness Drive in Itasca State Park (Fig. 3). This small, still

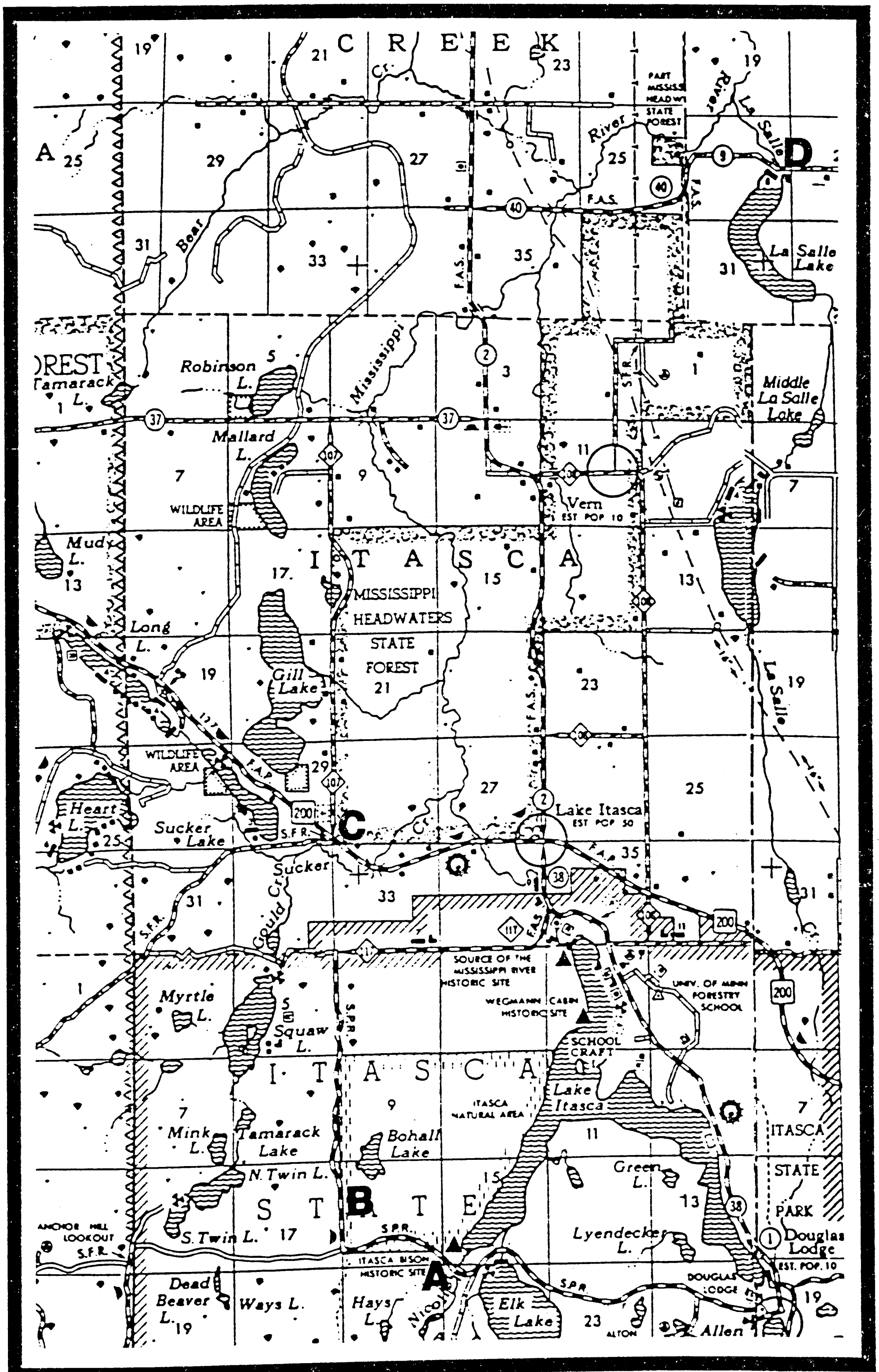


Fig. 2. Collection sites for Trichoptera in the Lake Itasca region in northern Minnesota A. Nicollet Creek; B. Beaver Lake; C. Sucker Creek; D. LaSalle Creek.

A

B

Fig. 3. Collection sites. A. Nicollet Creek; B. Beaver Lake.

lake is not clear, has an ill-defined shore with abundant littoral and lentic vegetation, woody debris, and a muddy bottom. It is situated in a clearing, and coniferous and deciduous trees are at some distance from the shoreline. Depth at the collection site was 60 cm. Water temperatures ranged from 18-30°C during the collecting period (n=9), and pH ranged from 6.95-8.4 (n=2). Conductivity ranged from 38-69 micromhos/cm (n=2), and alkalinity ranged from 20-22 ppm $CaCO_3$ (n=2).

Sucker Creek, Clearwater County (47.253°N, 95.242°W), flows through Iron Springs Bog Scientific and Natural Area, north of Highway 200, approximately 3 km northeast of the headwaters of the Mississippi River (Fig. 4). This clear creek has a sandy bottom, some aquatic macrophytes, and tall grasses extending over its bank; there are many Tamarack and Black Spruce trees at some distance from the edge. There is little woody or other allochthonous debris in the water. Small pools with silty bottoms are found along its course. Creek depth was 45 cm at the collection site. Water temperatures ranged from 10-26°C during the collecting period (n=20), and pH ranged from 8.05-8.65 (n=6). Mean flow was 0.36 ± 0.07 SD m/sec (n=7), mean conductivity was 557 ± 103 SD micromhos/cm (n=5), and mean alkalinity was 279 ± 52 SD ppm $CaCO_3$ (n=5).

LaSalle Creek, Hubbard County (47.349°N, 95.165°W), is located 9.6 km north and 3.2 km east of the headwaters of the Mississippi River where it leaves LaSalle Lake at County Road 40 (Fig. 4). This clear creek has riffles, some aquatic macrophytes, and a sand and pebble bottom; a large partially submerged log caused many leaf packs and other debris to collect at a bend in the creek and remained at the collection site for the duration of this study. There are tall grasses along its course and deciduous and coniferous trees near its edge. Just beyond the collection site the creek widens into a large shallow pool. Depth at the collection site was 20-45 cm. Water temperatures ranged from 16-29°C during the collecting period (n=20), and pH ranged from 8.25-8.89 (n=6). Mean flow was 0.56 ± 0.16 SD m/sec (n=7), mean conductivity was 378 ± 19 SD micromhos/cm (n=5), and mean alkalinity was 185 ± 1 SD ppm $CaCO_3$ (n=5).

Collection Techniques and Equipment

Light Traps. Adult caddisflies were attracted with 15-watt black lights (ultraviolet collecting light, model 2805; BioQuip Products, 17803 LaSalle Avenue, Gardena, California 90248-3602) operated from a 12-volt DC battery, suspended across white pans

A

B

Fig. 4. Collection sites. A. Sucker Creek; B. LaSalle Creek.

(28x38x10cm) containing 750 ml 80% ethanol (Fig. 5). At each site the pans were placed at water's edge, at the same location each collection date, and lights were set on timers to run simultaneously from one hour before to 1 1/2 hours after sunset, at least every two weeks from June to October 1988, and May to October 1989. These dates were used because I did not receive all of my equipment before June 1988, and adult caddisflies were not flying to lights before May and after October 1989, due to low temperatures. Caddisflies are not commonly encountered at lights when ambient temperatures fall below 13°C. The insects were attracted to the light and fell into the pan, were preserved, and pan contents removed the next morning. The caddisflies were transferred from the collecting pans to containers for transport to the laboratory, where they were placed in fresh 80% ethanol and stored in Nalgene bottles until identified. In 1988 traps were set at each of the three lotic sites, Nicollet Creek, Sucker Creek, and LaSalle Creek, and in 1989 the lentic site, Beaver Lake, was added.

Malaise Traps. A malaise trap (Fig. 5) (Townes model; Golden Owl Publishers, 182 Chestnut Road, Lexington Park, Maryland 20653) was set up at Nicollet Creek on January 1, 1988, for the purpose of collecting caddisflies known to emerge as adults in the winter and spring. This site was selected because it is the type locality for *Chilostigma itascae*, an endemic species which was collected from this locality in 1974 and has not been encountered since that time. The rectangular trap was constructed with polyesther marquisette netting, 12 mesh to the cm, arranged on two ends with a center baffle. Insects were collected in a 500 ml jar which contained a 17:1 ratio of 80% ethanol and glycerin. The trap was monitored from January - May 1988, November 1988 - May 1989, and November 1989 - May 1990.

Water Measurements. At each site quantitative measurements were taken for water temperature, pH, flow (m/sec), conductivity (micromhos/cm), and alkalinity (ppm $CaCO_3$). The flow meter and pH, conductivity, and alkalinity kits were borrowed from the Department of Fisheries and Wildlife at the University of Minnesota. Measurements were taken only when this equipment was available for my use.

At each collection site a qualitative assessment was made for water clarity. Water was clear if I could see the bottom of the lake or creek and was not clear if there was noticeable particulate matter in suspension or I could not see the bottom.

A

B

Fig. 5. A. Light trap; B. Malaise trap.

Collecting Permits. An annual collecting permit was required for material taken from Sucker Creek, Iron Springs Bog, because it flows within a Scientific and Natural Area and is protected by the Minnesota Department of Natural Resources. Permits No. 8R-1988 & No. 5R-1989 were obtained from Robert Djupstrom, Supervisor, Scientific and Natural Areas. Although collection permits were not necessary, permission for work done within Itasca State Park at Nicollet Creek and Beaver Lake was granted annually by Jon Ross, resident biologist at the Lake Itasca Forestry and Biological Station. I made a verbal agreement with the property owner to establish a collection site at LaSalle Creek.

Species Determinations and Depositions

Genitalic Preparations. In the laboratory specimens were sorted to genus by external morphology and sexed. Abdomens were removed, placed in 10% KOH solution, and heated on a hotplate to near boiling for clearing (in the case of the Hydroptilidae the entire insect was cleared). Clearing time varied from a few minutes to 10 minutes, depending on specimen size and degree of sclerotization. In some cases specimens were placed in a cold 10% KOH solution for 8-12 hours. When the viscera within the abdominal cuticle were softened the abdomen was transferred to a container of distilled water. A syringe was placed in the anterior end and used to force a stream of water into the abdomen, flushing out the softened viscera. This left a clear intact abdominal exoskeleton, through which it was easy to distinguish structures of the genitalia (Ross 1944). Most specimens were examined under an Aus Jena Dissecting Microscope, model GSZ, magnification 50X. For specimens that were very small (Hydroptilidae), the specimen or genitalia was placed in glycerin in a United States Bureau of Plant Industries (USBPI) watch glass and examined under an Olympus Stereomicroscope, model SCH, magnification 192X.

Subsamples. For the insects collected at Nicollet Creek, Sucker Creek, and Beaver Lake, each specimen was identified and counted individually. For collections made at LaSalle Creek, specimens of Hydroptilidae, Hydropsychidae, and the genera *Ceraclea*, *Oecetis*, and *Triaenodes* (Leptoceridae) were subsampled when numbers exceeded 150 individuals. Specimens were placed in a pan and subdivided using a grid divided into 16 equal rectangles. When numbers of individuals were between ca. 150-500, one-half of the specimens were counted; when numbers were between ca. 501-1000, one-fourth of the specimens were counted; when numbers were between ca. 1001-3500, one-eighth of the specimens were counted, and when numbers were greater than 3500, one-sixteenth of the specimens were counted.

Undetermined Specimens. Female specimens of *Hydropsyche* and *Cheumatopsyche* (Hydropsychidae) and *Hydroptila* and *Oxyethira* (Hydroptilidae) were not individually identified to species due to the difficulty of making positive identifications of females in these genera. *Hydroptila* and *Oxyethira* females were also not counted due to their small size and large numbers. Therefore, males as well as females from these genera were not included in rank abundance curves and similarity and diversity calculations; females were also not recorded in the annotated species list. *Hydropsyche* and *Cheumatopsyche* species females were counted; when reporting the abundances of *Hydropsyche* and *Cheumatopsyche* female species, I determined the number of females from the proportion of males identified from each species; the number of males of each species was divided by the total number of males identified in its genus, and this amount was multiplied by the total number of females collected in the same genus. The resultant figure was used as the corresponding number of females for each species of *Hydropsyche* and *Cheumatopsyche*.

Keys and Other References. Species identifications were based on males, unless positive determinations could be made using females. All specimens were identified to species by me through the use of keys and illustrations of genitalia taken from the literature (Armitage 1991, Armitage and Hamilton 1990, Betten 1950, Betten and Mosely 1940, Blickle 1979, Blickle and Morse 1954, 1955, Denning 1943, 1947, Haddock 1977, Kelley 1985, 1986, Kingsolver and Ross 1961, Lago and Harris 1987, Leonard and Leonard 1949, Milne 1931, Morse 1972, 1975, Nimmo 1971, 1986, 1987, Parker and Wiggins 1985, Ross 1938, 1941, 1944, 1966, Ross and Merkley 1952, Roy and Harper 1979, Schefter et al. 1986, Schmid 1950, 1952, 1980, 1982, 1983, Weaver 1988, Wiggins 1956, Yamamoto and Wiggins 1964). Some verifications were also made by comparison with specimens from the University of Minnesota Insect Collection. In the case of specimens of questionable identification, there was consultation with Dr. R.W. Holzenthal, Dr. S.C. Harris, and R.J. Blahnik for verification.

In the Results section, North American distributional references include northern Mexico and Greenland. Nearctic species records are taken from Morse (1992, unpublished).

Deposition of Specimens. After positive determinations were made, genitalia were placed in 80% ethanol, stored in genitalia vials, and placed, with the remainder of the specimen, and locality and determination labels, in 11-ml patent lip vials with neoprene stoppers. Reference collections are deposited in the University of Minnesota Insect Collection.

Diversity and Similarity Indices

Brillouin's Diversity Index. I chose to include species richness, or alpha diversity, and relative abundance in describing the diversity of each site to reflect the fact that all species in a community are not represented by equal numbers of individuals. Beta diversity was calculated using Sorensen's similarity indices (see below); gamma diversity was not calculated. The Brillouin index was chosen to estimate diversity, in part because it is based on species richness and relative abundance; it is also recommended for non-random samples and collections where members are identified and counted (Pielou 1966). It is calculated using the formula $HB= \ln N! - \sum \ln n_i ! / N$; N= total number of individuals; n_i = number of individuals in each species; values usually range between 1.5 and 3.5, rarely exceeding 4.5.

Shannon's Diversity Index. The Shannon index takes species richness and relative abundance into account, assuming that individuals are randomly sampled from an infinitely large population and all species are represented in the sample (Pielou 1966). Although not the formula of choice, I used it to compare to the values obtained with the Brillouin formula, to see how much they differed. The Shannon index is calculated using the formula $H'= -\sum p_i \ln p_i$; p_i = the proportional abundance of each species; values usually range between 1.5 and 3.5, rarely exceeding 4.5.

Evenness. In order to be able to compare values between sites as to how equally abundant the species are, evenness (E) was calculated, $E = HB / HB_{max}$. Evenness is the ratio of observed diversity to maximum diversity on a scale from 0 - 1.0 (1.0 represents the equal abundance of all species). HB_{max} is calculated using the formula $HB_{max} = 1 / N \ln (N! / \{[N/S]!\}^{s-r} \{([N/S]+1)!\}^{r})$; N = total number of individuals, S = total number of species, [N/S] = the integer of N/S, r = N - S[N/S] (Magurran 1988).

Sorensen's Similarity Indices. These indices were used evaluate the degree of association or similarity of habitats by measuring the extent to which pairs of sites have species in common. In cases of complete similarity (identical species composition at each site) the index equals one; in cases of complete dissimilarity (no species in common) the index equals zero. Qualitative and quantitative indices were compared.

Sorensen's index based on qualitative data does not take species abundance into account. It is calculated using the formula $C_s = 2_j /(a+b)$; $_j$ = the number of species (S) in common between sites A and B; a = the number of species in site A; b = the number of species in site B (Southwood 1978).

Sorensen's index based on quantitative data (Bray and Curtis 1957) is based on species abundance. It is calculated using the formula $C_N = 2\ _{jN} / (aN+bN)$; $_{jN}$ = the number that represents the sum of the lower of the two abundances recorded for species found in both sites; aN = the number of individuals (N) in site A; bN = the number of individuals in site B (Southwood 1978).

RESULTS

This section includes records of caddisflies collected during this study in the form of an annotated species list and table. Relative abundance, including sex ratios, and similarity and diversity indices are presented for each of four localities. Seasonal distribution is also reported. All records are from light trap collections; malaise trap collections did not include caddisflies.

Annotated Species List

In the following section families are arranged phylogenetically; genera and species are listed alphabetically. Of the 19 families of caddisflies reported from Minnesota members of 13 were found during this study. They are Glossosomatidae, Hydroptilidae, Philopotamidae, Hydropsychidae, Polycentropodidae, Psychomyiidae, Phryganeidae, Limnephilidae, Uenoidae, Lepidostomatidae, Molannidae, Helicopsychidae, and Leptoceridae. All of these families were encountered at LaSalle Creek; 11 families were found at Sucker Creek; 10 families were found at Nicollet Creek; 8 families were found at Beaver Lake. One hundred and twenty-six species were identified from over 95,000 specimens (Table 1).

Family Glossosomatidae. Glossosomatidae, or saddle-case makers, are found in all faunal regions, and each of the subfamilies, Agapetinae, Glossosomatinae, and Protoptilinae, has representatives in North America. Six genera have a Nearctic distribution and contain approximately 80 species. Larvae are most frequently encountered in flowing water, but some species have been also collected from wave-washed lake shores. They are generally found grazing on diatoms, green algae, and fine particulate organic matter (FPOM) from upper, often exposed, rock surfaces. Larval mandibles possess a smooth scraping edge, thought to be an adaptation for this feeding behavior. Concealed from above, larvae move about with head, legs, and abdominal tip extended from each end of the case. These cases are distinctive for the family, resembling tiny tortoise shells, dome-shaped, with a ventral strap across a flat bottom. Larvae do not add to their case with growth but make a new one with each instar, which is attached to the existing case until it is completed. The old case is then abandoned. Particular features of these cases may be associated with each genus (Wiggins 1977). The three genera found in Minnesota are *Agapetus*, *Glossosoma*, and *Protoptila*.

Table 1. All caddisfly species and their abundances in collections from four sites in Minnesota during 1988 and 1989. (Hydroptila and Oxyethira spp., males only)

Species	Family	Nic Cr '88	Nic Cr '89	LaSal Cr '88	LaSal Cr '89	Suc Cr '88	Suc Cr '89	Beav L '89	Total
G. intermedium	Glossosomatidae					2			2
P. tenebrosa	Glossosomatidae			3					3
A. multipunctata	Hydroptilidae	30	6	130	1007	15	85	23	1296
H. albicornis	Hydroptilidae				1				1
H. amoena	Hydroptilidae				1				1
H. armata	Hydroptilidae	13	2	153	77	2	6		253
H. grandiosa	Hydroptilidae			6					6
H. perdita	Hydroptilidae			2	1				3
H. spatulata	Hydroptilidae			2					2
H. waubesiana	Hydroptilidae		1	79	8				88
H. wyomia *	Hydroptilidae			6	13				19
H. xera *	Hydroptilidae	1	10	304	34	13	21		383
O. aegerfasciella	Hydroptilidae	4	4	42	85	1	1	3	140
O. baldufi	Hydroptilidae		1	1	36		2		40
O. cristata	Hydroptilidae	1		3	123				127
O. aeola	Hydroptilidae		2						2
O. araya	Hydroptilidae			3	4			1	8
O. coercens	Hydroptilidae			1	4				5
O. ecornuta **	Hydroptilidae			1					1
O. forcipata	Hydroptilidae				4				4
O. itascae *	Hydroptilidae	1		70	28				99
O. michiganensis	Hydroptilidae	1	2	10	11			12	36
O. obtatus	Hydroptilidae				2			1	3
O. rivicola	Hydroptilidae		3	116	89				208
O. serrata	Hydroptilidae		3	2	12				17
O. verna*	Hydroptilidae			6	6				12
O. zeronia	Hydroptilidae			2				1	3
C. obscura	Philopotamidae			10	43				53
C. campyla	Hydropsychidae		35						35
C. gracilis	Hydropsychidae	30			2		13		45
C. oxa	Hydropsychidae	50	68	48	31	144	748	3	1092
C. pettiti	Hydropsychidae	141	217	7678	5848	4	15		13902
C. speciosa	Hydropsychidae			5					5
H. alhedra	Hydropsychidae	7	3	21	8		3		42
H. alternans	Hydropsychidae				3				3
H. betteni	Hydropsychidae	194	178	2194	367	30	2	5	2969
H. bronta	Hydropsychidae	4		15	11		3	11	44

Table 1. Continued.

Species	Family	Nic Cr '88	Nic Cr '89	LaSal Cr '88	LaSal Cr '89	Suc Cr '88	Suc Cr '89	Beav L '89	Total
H. morosa	Hydropsychidae		6	3049	5370				8425
H. slossonae	Hydropsychidae	104	333	62	11	369	392		1271
H. vexa	Hydropsychidae		17	107	94				218
N. crepuscularis	Polycentropodidae			2					2
N. affinis	Polycentropodidae		32	1	332		57	45	467
N. moestus	Polycentropodidae			2	7	68	33	1	111
P. albipunctus	Polycentropodidae				2				2
P. aureolus	Polycentropodidae			1					1
P. cinereus	Polycentropodidae	1	2	94	118	9	3	2	229
P. clinei *	Polycentropodidae		2						2
P. flavus	Polycentropodidae				5			1	6
P. iculus *	Polycentropodidae						2		2
P. interruptus	Polycentropodidae	7	234	40	200		64	183	728
P. melanae	Polycentropodidae							11	11
P. pentus	Polycentropodidae	1	6			5	1		13
P. remotus	Polycentropodidae				2	4	3	7	16
P. weedi	Polycentropodidae		4		1	4	15		24
L. diversa	Psychomyiidae		2						2
P. flavida	Psychomyiidae		1	65	108				174
A. improba	Phryganeidae						1	15	16
A. straminea	Phryganeidae		1		1			1	3
A. vestita	Phryganeidae	4	2	3	1	20	19	29	78
B. crotchi	Phryganeidae	6	10	9	9	2	8	110	154
F. inornata	Phryganeidae							4	4
H. canadensis	Phryganeidae		1	1			3	1	6
P. cinerea	Phryganeidae	4	18	7	3		2	36	70
P. ocellifera	Phryganeidae	2	13	13	12	2	8		50
P. semifasciata	Phryganeidae	3	12	36	26	1	11	15	104
A. bimaculata	Limnephilidae		1				2	4	7
A. consocia	Limnephilidae			3		5			8
H. designatus	Limnephilidae						2		2
H. argus	Limnephilidae				1		1		2
L. infernalis	Limnephilidae			2				3	5
L. moestus	Limnephilidae					1	2		3
L. ornatus	Limnephilidae		1			1	2		4
L. parvulus	Limnephilidae		3						3
L. perpusillus	Limnephilidae	1	1						2

Table 1. Continued.

Species	Family	Nic Cr '88	Nic Cr '89	LaSal Cr '88	LaSal Cr '89	Suc Cr '88	Suc Cr '89	Beav L '89	Total
L. rhombicus	Limnephilidae			1					1
L. sericeus	Limnephilidae				1	1			2
N. hostilis	Limnephilidae	2	1	6				2	11
P. amicus	Limnephilidae	9	17	3	34		1		64
P. radiatus	Limnephilidae							4	4
P. guttifer	Limnephilidae	187	35	58	93	56	67		496
P. lepida	Limnephilidae			15	12		1		28
P. limbata *	Limnephilidae				1	9	1		11
P. subfasciata	Limnephilidae			1	6		1	1	9
N. concinnus	Uenoidae			6	6	6	2		20
N. oligius	Uenoidae			9	38				47
L. bryanti	Lepidostomatidae		18			6	458	1	483
L. costale	Lepidostomatidae					63	18		81
L. togatum	Lepidostomatidae		2	34	80			2	118
M. flavicornis	Molannidae		4					21	25
M. tryphena	Molannidae	1	12	22	14		2		51
M. uniophila	Molannidae			39	10	1	1	2	53
H. borealis	Helicopsychidae		2	890	1362	5	1		2260
C. alagma	Leptoceridae	11	51	26	85	1	10	462	646
C. ancylus	Leptoceridae			1					1
C. arielles	Leptoceridae			29	104			1	134
C. cancellata	Leptoceridae	1	10	2	40	1	13	477	544
C. diluta	Leptoceridae			144	248			3	395
C. excisa	Leptoceridae	39	627	115	768	13	5		1567
C. maculata	Leptoceridae			1					1
C. resurgens	Leptoceridae		15	47	16				78
C. tarsipunctata	Leptoceridae	1		434	990		7	107	1539
C. transversa	Leptoceridae	3	8	621	1256	1			1889
C. vertreesi *	Leptoceridae		3						3
L. americanus	Leptoceridae	108	625	28	750	2	1417	402	3332
M. interjecta	Leptoceridae				1			2	3
M. sepulchralis	Leptoceridae			107	92		1	1	201
N. albida	Leptoceridae		19	13	39			23	94
N. candida	Leptoceridae							2	2
N. diarina	Leptoceridae			215	66		3	2	286
N. exquisita	Leptoceridae	5			1	2			8
O. avara	Leptoceridae			2320	6176	1	1		8498

Table 1. Continued.

Species	Family	Nic Cr '88	Nic Cr '89	LaSal Cr '88	LaSal Cr '89	Suc Cr '88	Suc Cr '89	Beav L '89	Total
O. cinerascens	Leptoceridae	57	348	613	641	4	93	86	1842
O. inconspicua	Leptoceridae	264	620	5755	7033	48	379	3089	17188
O. nocturna *	Leptoceridae		1	164	36		2	1	204
O. ochracea	Leptoceridae						38		38
O. osteni	Leptoceridae	8	14	325	1082	1	9	308	1747
O. persimilis	Leptoceridae			12	68				80
T. abus	Leptoceridae			1					1
T. baris	Leptoceridae				360				360
T. dipsius	Leptoceridae		27	14			10		51
T. flavescens	Leptoceridae					3			3
T. ignitus *	Leptoceridae			1					1
T. injustus	Leptoceridae	11	14	27	111		38	24	225
T. marginatus	Leptoceridae	694	1607	1683	2822	36	1499	89	8430
T. nox	Leptoceridae		5				2	71	78
T. tardus	Leptoceridae	41	84	49	317	6	100	491	1088

*** New state record**

****New United States record**

Glossosoma Curtis 1834

This genus occurs in Nearctic, Palaearctic, and Oriental faunal regions. Twenty-two North American species are recorded, primarily from western montane regions, with only three species having been found from central and northeastern parts of the continent. Members of this genus are typically most abundant in cold, fast-flowing streams (Wiggins 1977). Larvae may be found in large numbers on rock surfaces; adults are often only infrequently encountered (Ross 1944). Two species from this genus occur in Minnesota; one species was collected during this study.

Glossosoma intermedium (Klapalek) 1892

Sucker Creek, 1988; 1♂, 1♀

Protoptila Banks 1904

Members of this genus are widely distributed throughout and restricted to the New World, with about 15 species being recorded from North America. Larvae are known to be associated with slower, warmer streams of the central continent, but due to their small size are frequently missed by collectors. Adults are often attracted to lights in large numbers (Ross 1944, Wiggins 1977). Four species from this genus occur in Minnesota; one species was collected during this study.

Protoptila tenebrosa (Walker) 1852

LaSalle Creek, 1988; 3 ♀.

Family Hydroptilidae. Hydroptilidae include the smallest of caddisflies (2-3 mm) and are referred to as the purse-case makers and the microcaddisflies. Found in all faunal regions, the 19 Nearctic genera are divided among the subfamilies Hydroptilinae, Leucotrichiinae, Orthotrichiinae, and Ptilocolepinae, and contain about 240 species. Larvae are associated with all types of permanent lentic and lotic habitats, feeding on filamentous algae and diatoms (Wiggins 1977). Some genera have adaptations of the fore femora and tibiae allowing them to grasp algal filaments, and others a pointed labrum or narrowed head capsule, enabling them to puncture and feed on the cellular contents of filamentous algae (Nielsen 1948). The life cycle is atypical in that larvae are free-living during the first four instars and build a case only during the last instar. It appears most larvae accommodate to the often dramatic increase in size during the 5th instar by adding to the original case. Although cases are diverse in form, the bivalve cases are characteristic for the family (Wiggins 1977). The genera found in Minnesota are *Agraylea, Hydroptila, Ithytrichia, Leucotrichia, Mayatrichia, Neotrichia, Ochrotrichia, Orthotrichia, Oxyethira*, and *Stactobiella*..

Agraylea Curtis 1834

This Holarctic genus has three widely distributed North American species. Larvae are found in lakes, ponds, and in the slow reaches of large rivers. The bivalve cases reveal a concentric arrangement of algal filaments on the exterior surface (Wiggins 1977). The single species from this genus which occurs in Minnesota was collected during this study.

Agraylea multipunctata Curtis 1834

Nicollet Creek, 1988; 1 ♂, 29 ♀. 1989; 1 ♂, 5 ♀.

LaSalle Creek, 1988; 16 ♂, 114 ♀. 1989; 10 ♂, 997♀.

Sucker Creek, 1988; 1 ♂, 14 ♀. 1989; 1 ♂, 84 ♀.

Beaver Lake, 1989; 3 ♂, 20 ♀.

Hydroptila Dalman 1819

This genus is reported from all faunal regions, and approximately 95 species are widely distributed in North America. Larvae are found in lentic and lotic habitats and construct a bivalve case covered with grains of sand, algae, or diatoms (Wiggins 1977). Adults are often attracted to lights in large numbers. Twenty-seven species from this genus occur in Minnesota; nine species were collected during this study. Due to the difficulty of verifying female examples of species in this genus, only males were identified.

Hydroptila albicornis Hagen 1861

LaSalle Creek, 1989; 1 ♂.

Hydroptila amoena Ross 1938

LaSalle Creek, 1989; 1 ♂.

Hydroptila armata Ross 1938

Nicollet Creek, 1988; 13 ♂. 1989; 2 ♂.

LaSalle Creek, 1988; 153 ♂. 1989; 77 ♂.

Sucker Creek, 1988; 2 ♂. 1989; 6 ♂.

Hydroptila grandiosa Ross 1938

LaSalle Creek, 1988; 6 ♂.

Hydroptila perdita Morton 1905

LaSalle Creek, 1988; 2 ♂. 1989; 1 ♂.

Hydroptila spatulata Morton 1905

LaSalle Creek, 1988; 2 ♂.

Hydroptila waubesiana Betten 1934

Nicollet Creek, 1989; 1 ♂.

LaSalle Creek, 1988; 79 ♂. 1989; 8 ♂.

Hydroptila wyomia Denning 1947

LaSalle Creek, 1988; 6 ♂. 1989; 13 ♂.

Hydroptila xera Ross 1938

Nicollet Creek, 1988; 1 ♂. 1989; 10 ♂.

LaSalle Creek, 1988; 304 ♂. 1989; 34 ♂.

Sucker Creek, 1988; 13 ♂. 1989; 21 ♂.

Orthotrichia Eaton 1873

This small genus, reported from the Holarctic, Oriental, and Ethiopian faunal regions, has six species recorded from North America. All but one have a distribution restricted to the eastern half of the continent. Larvae, found along lake shores and in the slow reaches of rivers, build purse-shaped cases exclusively of silk during the last instar. Cases bear dorsolateral ridges on each side of and parallel to the mid-dorsal line, distinguishing them from all others in North America (Wiggins 1977). The three species which occur in Minnesota were collected during this study.

Orthotrichia aegerfasciella (Chambers) 1873

Nicollet Creek, 1988; 4 ♀. 1989; 2 ♂, 2 ♀.

LaSalle Creek, 1988; 42 ♀. 1989; 9 ♂, 76 ♀.

Sucker Creek, 1988; 1 ♀. 1989; 1 ♀.

Beaver Lake 1989; 3 ♀.

Orthotrichia baldufi Kingsolver & Ross 1961

Nicollet Creek, 1989; 1 ♀.

LaSalle Creek, 1988; 1 ♂. 1989; 36 ♀.

Sucker Creek, 1989; 1 ♂ 1 ♀.

Orthotrichia cristata Morton 1905

Nicollet Creek, 1988; 1 ♂.

LaSalle Creek, 1988; 3 ♂. 1989; 26, ♂, 97 ♀.

Oxyethira Eaton 1873

This genus, found in all faunal regions, has 40 species widely distributed throughout North America. Larvae are found in lentic habitats and slow-flowing portions of rivers. Their cases are distinctive because they are bottle-shaped, somewhat flattened, and made entirely of silk (Wiggins 1977). Adults are often attracted to lights in large numbers. Sixteen species of this genus occur in Minnesota. Twelve species were collected during this study, including, *Oxyethira itascae* Monson & Holzenthal, newly discovered and described herein. Due to the difficulty of verifying female examples of species in this genus, only males were identified.

Oxyethira aeola Ross 1938

Nicollet Creek, 1989; 2 ♂.

Oxyethira araya Ross 1941

LaSalle Creek, 1988; 3 ♂. 1989; 4 ♂.

Beaver Lake, 1989; 1 ♂.

Oxyethira coercens Morton 1905

LaSalle Creek, 1988; 1 ♂. 1989; 4 ♂.

Oxyethira ecornuta Morton 1893

LaSalle Creek, 1988; 1 ♂.

Oxyethira forcipata Mosely 1934

LaSalle Creek, 1989; 4 ♂.

Oxyethira itascae Monson & Holzenthal 1993

Nicollet Creek, 1988; 1 ♂.

LaSalle Creek, 1988; 70 ♂. 1989; 28 ♂.

Oxyethira michiganensis Mosely 1934

Nicollet Creek, 1988; 1 ♂. 1989; 2 ♂.

LaSalle Creek, 1988; 10 ♂. 1989; 11 ♂.

Beaver Lake, 1989; 12 ♂.

Oxyethira obtatus Denning 1947

LaSalle Creek, 1989; 2 ♂.

Beaver Lake, 1989; 1 ♂.

Oxyethira rivicola Blickle & Morse 1954

Nicollet Creek, 1989 3 ♂.

LaSalle Creek, 1988; 116 ♂. 1989; 89 ♂.

Oxyethira serrata Ross 1938

Nicollet Creek, 1989; 3 ♂.

LaSalle Creek, 1988; 2♂. 1989; 12 ♂.

Oxyethira verna Ross 1938

LaSalle Creek, 1988; 6 ♂. 1989; 6 ♂.

Oxyethira žeronia Ross 1941

LaSalle Creek, 1988; 2 ♂.

Beaver Lake, 1989; 1 ♂.

Family Philopotamidae. Philopotamidae, or fingernet caddisflies, are found in all faunal regions and live exclusively in lotic waters. The three North American genera are divided between two subfamilies, Philopotaminae and Chimarrinae, containing about 50 species. Larvae construct long, narrow finger-shaped nets, attaching them to the underside of rocks so that they are distended by the current. These nets provide shelter and filter organic material from the water. A membranous T-shaped labrum, characteristic for the family, is a specialized adaptation for cleaning FPOM off their nets. Species from this family are able to make use of smaller pieces of particulate matter than any other filter-feeding caddisflies because of the minute dimension of the mesh making up the nets (Wiggins 1977). The three genera known from Minnesota are *Chimarra, Dolophilodes*, and *Wormaldia.*

Chimarra Stephens 1829

This genus is found in all faunal regions, with about 25 species recorded from North America. Larvae usually construct their nets in rows, and they often are irregular in appearance in comparison to nets of other genera in the family. Although they are commonly found in riffle areas, they are also known to move to submerged roots of riparian plants during warm weather and to deeper water in winter (Williams & Hynes 1973). Four species from this genus occur in Minnesota; one species was collected during this study.

Chimarra obscura (Walker) 1852

LaSalle Creek, 1988; 6 ♂, 4 ♀. 1989; 21 ♂, 22 ♀.

Family Hydropsychidae. Hydropsychidae, or common netspinners, are very often dominant in running water habitats worldwide, and some species are found along wave-washed lake shores. All the subfamilies, Arctopsychinae, Diplectroninae, Hydropsychinae, and Macronematinae and twelve genera, containing about 150 species, are known from North America. Larvae are easily collected because they are readily found in the shelter of the intricate silken nets they construct to filter food particles. All larvae possess toothed mandibles which they use to ingest small aquatic invertebrates and algae; they also consume FPOM (Wiggins 1977). Nets may be quite noticeable on rocks or submerged wood because they often cover extensive surface areas. Adults are frequently attracted to lights in large numbers. The genera found in Minnesota are *Cheumatopsyche,* *Diplectrona, Hydropsyche, Macrostemum*, and *Potamyia*. Due to the difficulty of verifying female examples of species in this family, only males were identified.

Cheumatopsyche Wallengren 1891

This genus, found in all but the Neotropical faunal region, has 45 widely distributed North American species. Larvae are known to be more tolerant of stream pollution than other caddisfly species (Ross 1944). Some species build nets that are lacking the structural supports common in other genera in the family, and these larvae are frequently encountered in waters with gentle to moderate currents (Fremling 1960). Some larvae have also been found as deep as 20 cm in interstitial habitats of stream substrates (Williams & Hynes 1974). Eleven species from this genus occur in Minnesota; five species were collected during this study.

Cheumatopsyche campyla Ross 1938

Nicollet Creek, 1989; 1 ♂, 34 ♀.

Cheumatopsyche gracilis (Banks) 1899

Nicollet Creek, 1988; 2 ♂, 28 ♀.

LaSalle Creek, 1989; 1 ♂, 1 ♀.

Sucker Creek, 1989; 2 ♂, 11 ♀.

Cheumatopsyche oxa Ross 1938

Nicollet Creek, 1988; 7 ♂, 43 ♀. 1989; 7 ♂, 61 ♀.

LaSalle Creek, 1988; 22 ♂, 26 ♀. 1989; 4 ♂, 27 ♀ .

Sucker Creek, 1988; 20 ♂, 124 ♀. 1989; 117 ♂, 631 ♀ .

Beaver Lake, 1989; 1 ♂, 2 ♀ .

Cheumatopsyche pettiti (Banks) 1908

Nicollet Creek, 1988; 28 ♂, 113 ♀ . 1989; 24 ♂, 193 ♀ .

LaSalle Creek, 1988; 3040 ♂, 4638 ♀. 1989; 1192 ♂, 4656 ♀ .

Sucker Creek, 1988; 1 ♂, 3 ♀ . 1989; 2 ♂, 13 ♀.

Cheumatopsyche speciosa (Banks) 1904

LaSalle Creek, 1988; 2 ♂, 3 ♀.

Hydropsyche Pictet 1834

This genus is found in all but the Neotropical faunal region and is the largest in the family, with over 70 species widely distributed throughout the continent. Nielsen (1981) assigned certain North American species of the *Hydropsyche morosa* group along with two Palaearctic species to the genus *Ceratopsyche*. Nielsen's study was not based on a phylogenetic analysis which included all species in the *H. morosa* group, many of which are among Old World genera, nor was it based on evidence from all developmental stages in the life cycle of these insects. Schefter et al. (1986) proposed the assignment of *Ceratopsyche* as a subgenus of *Hydropsyche*. I have chosen to keep the original assignment of species from the *morosa* group in *Hydropsyche sensu lato*.

Larvae are commonly found in all types of permanent lotic systems, from large rivers to small spring-fed streams; they have also been found along the shores of large lakes (Wiggins 1977). The nets of some species are structurally supported by silk strands that act as guy-lines enabling them to withstand strong currents (Fremling 1960). Twenty-five species from this genus occur in Minnesota; seven species were collected during this study.

Hydropsyche alhedra Ross 1939

Nicollet Creek, 1988; 2 ♂, 5 ♀. 1989; 1 ♂, 2 ♀.

LaSalle Creek, 1988; 10 ♂, 11 ♀. 1989; 1 ♂, 7 ♀.

Sucker Creek, 1989; 1 ♂, 2 ♀.

Hydropsyche alternans (Walker) 1852

LaSalle Creek, 1989; 2 ♂, 1 ♀.

Hydropsyche betteni Ross 1938

Nicollet Creek, 1988; 35 ♂, 159 ♀. 1989; 31 ♂, 147 ♀.

LaSalle Creek, 1988; 972 ♂, 1222 ♀. 1989; 183 ♂, 184 ♀.

Sucker Creek, 1988; 11 ♂, 19 ♀. 1989; 1 ♂, 1 ♀.

Beaver Lake, 1989; 1♂, 4 ♀.

Hydropsyche bronta Ross 1938

Nicollet Creek, 1988; 1 ♂, 3 ♀.

LaSalle Creek, 1988; 10 ♂, 5 ♀. 1989; 6 ♂, 5 ♀.

Sucker Creek, 1989; 1 ♂, 2 ♀.

Beaver Lake, 1989; 2 ♂, 9.

Hydropsyche morosa Hagen 1861

Nicollet Creek, 1989; 1 ♂, 5 ♀.

LaSalle Creek, 1988; 1472 ♂, 1577 ♀. 1989; 2563 ♂, 2807 ♀.

Hydropsyche slossonae Banks 1905

Nicollet Creek, 1988; 27 ♂, 77 ♀. 1989; 31 ♂, 302 ♀ .

LaSalle Creek, 1988; 28 ♂, 34 ♀. 1989; 6 ♂, 5 ♀ .

Sucker Creek, 1988; 99 ♂, 270 ♀. 1989; 130 ♂, 262 ♀ .

Hydropsyche vexa Ross 1938

Nicollet Creek, 1989; 1 ♂, 16 ♀ .

LaSalle Creek, 1988; 49 ♂, 58 ♀. 1989; 48 ♂, 46 ♀ .

Family Polycentropodidae. Polycentropodidae, or trumpetnet caddisflies, are found in all faunal regions and contain five genera within the subfamily Polycentropodinae in North America. There are 75 species widely distributed throughout the continent. Larvae are found in lentic and lotic waters where they construct fixed nets that are diverse in shape. Some larvae are concealed in the tip of trumpet-shaped nets, distended by gentle currents, where they filter organic material. Some are predaceous and build retreats that are short tubes, open at each end. Others take advantage of depressions or crevices in rocks by covering them with silk and organic debris, creating a concealed chamber, which is also lined with silk, within which they can move freely (Wiggins 1977). The genera found in Minnesota are *Cyrnellus, Neureclipsis, Nyctiophylax*, and *Polycentropus*.

Neureclipsis McLachlan 1864

This genus is Holarctic in distribution and contains five species recorded from North America. Four species are restricted to the eastern half of the continent, and one has been found as far west as British Columbia in North America. Larvae, found only in flowing waters, build large trumpet-shaped nets, supported at the wide open end by silk strands attached to submerged vegetation. They are positioned so that a gentle current flows into this opening and distends it. Nets may be encountered just beneath the surface as well as attached to the bottom substrate, and they are often in close proximity throughout the water column. The larva retreats to the narrow tube at the unattached end of the net and feeds upon plant and animal material that is filtered out of the water (Wiggins 1977). Three species from this genus occur in Minnesota; one species was collected during this study.

Neureclipsis crepuscularis (Walker) 1852

LaSalle Creek, 1988; 2 ♀.

Nyctiophylax Brauer 1865

This genus is known from all faunal regions except the European Palaearctic area. Approximately 10 species have been recorded from North America; some are widely distributed. Larvae are primarily carnivorous and live in lakes and in areas of streams with gentle currents. They spin a silk roof across a depression in wood or rock, under which is a tubular retreat open at each end; it is disguised with silt and diatoms. Silk strands, which are sensitive to movement, extend beyond the openings and serve to alert the concealed larva to prey activity (Wiggins 1977). Four species from this genus occur in Minnesota; two species were collected during this study.

Nyctiophylax affinis (Banks) 1897

Nicollet Creek, 1989; 16 ♂, 16 ♀.

LaSalle Creek, 1988; 1 ♂. 1989; 45 ♂, 287 ♀.

Sucker Creek, 1989; 23 ♂, 34 ♀.

Beaver Lake, 1989; 24 ♂, 21 ♀.

Nyctiophylax moestus Banks 1911

LaSalle Creek, 1988; 2 ♂. 1989; 5 ♂, 2 ♀.

Sucker Creek, 1988; 18 ♂, 50 ♀. 1989; 6 ♂, 27 ♀.

Beaver Lake, 1989; 1 ♂.

Polycentropus Curtis 1835

This genus occurs in all but the Australian faunal region. There are 46 species recorded from North America which are widely distributed throughout most of the continent. Larvae have been found in a great variety of aquatic habitats including lake sediments as deep as 5 m. Within the family they are considered the genus best adapted to warm lentic waters, and among retreat-makers, the only genus occurring in temporary spring pools. Larvae are primarily predaceous and generally are encountered in association with one of two types of retreats: one consists of a flexible silk tube surrounded by an irregular network of silk strands, which serve to alert the larvae to prey; the other retreat, loose, baglike, and distended by the current, filters out invertebrates upon which the larva feeds (Wiggins 1973, 1977). Sixteen species from this genus occur in Minnesota; eleven species were collected during this study.

Polycentropus albipunctus (Banks) 1930

LaSalle Creek, 1989; 2 ♂.

Polycentropus aureolus (Banks) 1930

LaSalle Creek, 1988; 1 ♂.

Polycentropus cinereus (Hagen) 1861

Nicollet Creek, 1988; 1 ♂. 1989; 2 ♂.

LaSalle Creek, 1988; 42 ♂, 52 ♀. 1989; 22 ♂, 96 ♀.

Sucker Creek, 1988; 7 ♂, 2 ♀. 1989; 2 ♂, 1 ♀.

Beaver Lake, 1989; 1 ♂, 1♀.

Polycentropus clinei (Milne) 1936

Nicollet Creek, 1989; 2 ♂.

Polycentropus flavus (Banks) 1908

LaSalle Creek, 1989; 1 ♂, 4 ♀.

Beaver Lake, 1989; 1 ♂.

Polycentropus iculus Ross 1941

Sucker Creek, 1989; 2 ♂.

Polycentropus interruptus (Banks) 1914

Nicollet Creek, 1988; 4 ♂, 3 ♀. 1989; 103 ♂, 131 ♀.

LaSalle Creek, 1988; 28 ♂, 12 ♀. 1989; 101 ♂, 99 ♀.

Sucker Creek, 1989; 45 ♂, 19 ♀.

Beaver Lake, 1989; 121 ♂, 62 ♀.

Polycentropus melanae (Ross) 1938

Beaver Lake, 1989; 5 ♂, 6 ♀.

Polycentropus pentus Ross 1941

Nicollet Creek, 1988; 1 ♂. 1989; 4 ♂, 2 ♀.

Sucker Creek, 1988; 2 ♂, 3 ♀. 1989; 1 ♂.

Polycentropus remotus Banks 1911

LaSalle Creek 1989; 1 ♂, 1 ♀.

Sucker Creek, 1988; 2 ♂, 2 ♀. 1989; 3 ♀.

Beaver Lake, 1989; 7 ♀.

Polycentropus weedi Blickle & Morse 1955

Nicollet Creek, 1989; 4 ♂.

LaSalle Creek, 1989; 1 ♂.

Sucker Creek, 1988; 4 ♂. 1989; 7 ♂, 8 ♀.

Family Psychomyiidae. Psychomyiidae, or net-tube caddisflies, are found in all but the Neotropical and Australian faunal regions. The subfamilies Psychomyiinae and Paduniellinae, are found in North America, and include 4 genera containing about 18 species on this continent. Larvae are usually found in cool lotic habitats, though some are associated with the calmer waters of stream depositional areas. They build silk tubes on rock and wood surfaces, covering them with sand and debris. Larvae feed on detritus, algae and microflora (Lepneva 1964, cited in Wiggins 1977). Two genera, *Lype* and *Psychomyia*, occur in Minnesota.

Lype McLachlan 1879

This genus occurs in the Palaearctic, Ethiopian, Oriental, and Nearctic faunal regions. Larvae, typically encountered in small cool running waters, build a retreat by spinning a silk cover over a naturally occurring groove in submerged wood, or burrowing into soft wood, creating a hidden chamber with openings at each end. Retreats also have been found incorporated into the wood used in the cases of larger caddisfly species (Flint 1959, Wiggins 1977). The single species known from North America, occurring only in the eastern half of the continent, was collected during this study.

Lype diversa (Banks) 1914

Nicollet Creek, 1989; 2 ♀.

Psychomyia Latreille 1829

This genus is found in Holarctic and Oriental faunal regions and contains three species known from North America. Larval retreats appear as a maze of silk tubes up to several centimeters in length, found on surfaces of rocks, and disguised with sand grains (Wiggins 1977). Larvae are usually encountered in lotic systems, feeding primarily on algae (Coffman et al. 1971). The single species occurring in Minnesota was collected during this study.

Psychomyia flavida Hagen 1861

Nicollet Creek, 1989; 1 ♀.

LaSalle Creek, 1988; 65 ♀. 1989; 108 ♀.

Family Phryganeidae. This family has a Holarctic distribution and is divided into two subfamilies, Yphriinae and Phryganeinae. There are 10 genera in North America, containing about 28 species, which are found primarily in northern latitudes. Among Phryganeidae are some of the largest case-makers in the order; case lengths up to 60 mm. have been recorded (Wiggins 1977). Larvae have been encountered in a variety of habitats, from vernal streams and pools to lakes at depths of 100 m. Larvae of Phryganeinae build cases of spiral or ring construction, commonly incorporating pieces of leaves and bark. The single species of Yphriinae constructs a case of pieces of rock, bark, and twigs, without a spiral or ring arrangement, which is different than all others in the family. Larvae are described as the most physically active of all the tube-case makers, frequently abandoning their cases upon being disturbed. Although generally described as omnivorous, some exhibit predatory behavior during part of their life cycle (Wiggins 1977). *Agrypnia, Banksiola, Fabria, Hagenella, Oligostomis, Phryganea,* and *Ptilostomis* are the genera found in Minnesota.

Agrypnia Curtis 1835

This genus, found in Holarctic faunal regions, has ten species recorded from North America. Most species have a northern transcontinental distribution, but some are found in mountainous areas in the east and west, and continue to southern states. Larvae have been found in lakes, marshes, and rivers with gentle currents. Cases are usually of spiral construction, but larvae have been found within pieces of hollow stems (Wiggins 1977). Five species from this genus occur in Minnesota; three species were collected during this study.

Agrypnia improba (Hagen) 1873

Sucker Creek, 1989; 1♀.

Beaver Lake, 1989; 3♂, 12♀.

Agrypnia straminea Hagen 1873

Nicollet Creek, 1989; 1♀.

LaSalle Creek, 1989; 1♂.

Beaver Lake, 1989; 1♂.

Agrypnia vestita (Walker) 1852

Nicollet Creek, 1988; 1♂, 3♀. 1989; 1♂, 1♀.

LaSalle Creek, 1988; 1♂, 2♀. 1989; 1♂.

Sucker Creek, 1988; 4♂, 16♀. 1989; 9♂, 10♀.

Beaver Lake, 1989; 8♂, 21♀.

Banksiola Martynov 1924

This genus, found only in the Nearctic faunal region, has five recorded species. Four species are distributed in the eastern half of the continent and one is transcontinental. Larvae, typically encountered in lentic habitats and slow flowing streams, have been observed feeding on plant material during early instars and becoming entirely predaceous with maturity (Winterbourn 1971a). Cases are of plant material in spiral formation (Wiggins 1977). Three species from this genus occur in Minnesota; one species was collected during this study.

Banksiola crotchi Banks 1943

Nicollet Creek, 1988; 4♂, 2♀. 1989; 4♂, 6♀.

LaSalle Creek, 1988; 6♂, 3♀. 1989; 5♂, 4♀.

Sucker Creek, 1988; 1♂, 1♀. 1989; 6♂, 2♀.

Beaver Lake, 1989; 41♂, 69♀.

Fabria Milne 1934

This monotypic genus, found only in the Nearctic faunal region, is not frequently encountered in the adult stage. Larvae have been collected primarily from lentic and sluggish lotic waters, where they are found associated with submerged vegetation. Cases, unique to the order, are constructed with living plant material arranged in spiral formation, with pieces trailing off the posterior end. The cases are bushy in appearance, buoyant, and are often found floating near the surface of the water (Wiggins 1977).

Fabria inornata (Banks) 1907

Beaver Lake, 1989; 4♂.

Hagenella Martynov 1924

This genus is Holarctic and contains one species with a Nearctic distribution. It has been encountered only in the northern latitudes of eastern United States and eastern Canada. Larvae have not yet been associated with adults of this species (Wiggins 1977).

Hagenella canadensis (Banks) 1907

Nicollet Creek, 1989; 1♂.

LaSalle Creek, 1988; 1♂.

Sucker Creek, 1989; 3♂.

Beaver Lake, 1989; 1♂.

Phryganea Linnaeus 1758

This genus is found in the Holarctic faunal region and includes two Nearctic species. One species is found in eastern North America and the other is widely distributed throughout the continent. Larvae have been collected from marshes and lake shores as well as at depths of 100 m in Lake Superior (Selgeby 1974). The spiral cases are usually constructed of plant materials, but animal parts and live ostracods have been used when plants are scarce. Larvae are omnivorous, ingesting dead and living organisms (Neave 1933, Wiggins 1977). The single species occurring in Minnesota was collected during this study.

Phryganea cinerea Walker 1852

Nicollet Creek, 1988; 4♂. 1989; 16♂, 2♀.

LaSalle Creek, 1988; 4♂, 3♀. 1989; 1♂, 2♀.

Sucker Creek, 1989; 1♂, 1♀.

Beaver Lake, 1989; 31♂, 5♀.

Ptilostomis Kolenati 1859

This genus, found in the Nearctic faunal region, contains four species. Two species are transcontinental and two occur in the eastern portion of the continent. Larvae have been collected from a variety of lentic and lotic habitats and build cases in ringlike sections with rectangular leaf pieces. Some final-instar larvae are predaceous (Wiggins 1977). The two species from this genus that occur in Minnesota were collected during this study.

Ptilostomis ocellifera (Walker) 1852

Nicollet Creek, 1988; 2♀. 1989; 1♂, 12♀.

LaSalle Creek, 1988; 9♂, 4♀. 1989; 12♀.

Sucker Creek, 1988; 1♂, 1♀. 1989; 8♀.

Ptilostomis semifasciata (Say) 1828

Nicollet Creek, 1988; 1♂, 2♀. 1989; 6♂, 6♀.

LaSalle Creek, 1988; 26♂, 10♀. 1989; 7♂, 19♀.

Sucker Creek, 1988; 1♂. 1989; 5♂, 6♀.

Beaver Lake, 1989; 11♂, 4♀.

Family Limnephilidae. Limnephilidae are found in all but the Ethiopian faunal region and are the largest North American family of Trichoptera. The Nearctic subfamilies are Apataniinae, Dicosmoecinae, Limnephilinae, Neophylacinae, and Pseudostenophylacinae. There are about 45 genera containing over 280 species in North America. Among all caddisfly families the larvae have adapted to the widest range of aquatic habitats, including some mesic terrestrial environments. They feed primarily on plant materials and the microflora and fungi associated with decaying organisms. Some have toothed mandibles allowing them to tear large plant pieces into smaller particles; others possess mandibles with a smooth edge formed by fused teeth enabling them to feed by scraping periphyton and FPOM from rocks and other surfaces. Cases are constructed from a variety of materials, and are diverse in form. Generally, larvae inhabiting lotic waters use sand and rock materials, and those in lentic waters use plant materials to construct their cases (Wiggins 1977). The genera found in Minnesota are *Anabolia, Apatania, Arctopora, Asynarchus, Chilostigma, Frenesia, Glyphopsyche, Grammotaulius, Hesperophylax, Hydatophylax, Ironoquia, Lenarchus, Leptophylax, Limnephilus, Nemotaulius, Onocosmoecus, Philarctus, Platycentropus, Pseudostenophylax*, and *Pycnopsyche*.

Anabolia Stephens 1837

This genus occurs in the Holarctic faunal region and contains two northern transcontinental and two northeastern Nearctic species. Larvae have been found in marshes and temporary pools, as well as slow-flowing streams. Cases are either cylindrical and made of pieces of wood and stems arranged longitudinally or three-sided and made of leaf fragments (Flint 1960, Wiggins 1973). Larvae are detritivorous, primarily upon vascular plant materials (Wiggins 1977). Four species from this genus are found in Minnesota; two species were collected during this study.

Anabolia bimaculata (Walker) 1852

Nicollet Creek, 1989; 1♀.

Sucker Creek, 1989; 2♂.

Beaver Lake, 1989; 1♂, 3♀.

Anabolia consocia (Walker) 1852

LaSalle Creek, 1988; 3♂.

Sucker Creek, 1988; 5♂.

Hesperophylax Banks 1916

This Nearctic genus has six species, five with a western distribution and one with a central transcontinental range. Larvae build cylindrical cases of rock or wood fragments, usually curved and tapered. They often occur in large numbers, and have been found in permanent and temporary streams, as well as lentic waters to a depth of 20 m. Their diet includes diatoms, filamentous algae, and vascular plants (Parker and Wiggins 1985, Wiggins 1977). The single species occurring in Minnesota was collected during this study.

Hesperophylax designatus (Walker) 1852

Sucker Creek, 1989; 2♂.

Hydatophylax Wallengren 1891

This Holarctic genus contains four North American species, two with an eastern distribution and two known from the west. Larvae occur in streams, and are usually found feeding on plant materials within debris or shoreline vegetation. They construct irregular cases of wood or leaves that are among the largest (76 mm in length) of all in North America (Wiggins 1977). The single species found in Minnesota was collected during this study. It is considered the most showy of Minnesota caddisflies because of its size and distinct wing coloration.

Hydatophylax argus (Harris) 1869

LaSalle Creek, 1989; 1♀.

Sucker Creek, 1989; 1♂.

Limnephilus Leach 1815

This Holarctic genus contains about 104 species widely distributed in North America. Larvae are detritivores and most frequently found associated with lentic habitats, but some have been found in streams and springs. The diverse cases are constructed of sand and pieces of rock as well as leaves and bark (Wiggins 1977). There are 21 species from this genus found in Minnesota; seven species were collected during this study.

Limnephilus infernalis (Banks) 1914

LaSalle Creek, 1988; 2♂.

Beaver Lake, 1989; 3♂.

Limnephilus moestus Banks 1908

Sucker Creek, 1988; 1♀. 1989; 1♂, 1♀.

Limnephilus ornatus Banks 1897

Nicollet Creek, 1989; 1♀.

Sucker Creek, 1988; 1♀. 1989; 1♂, 1♀.

Limnephilus parvulus (Banks) 1905

Nicollet Creek, 1989; 3♂.

Limnephilus perpusillus Walker 1852

Nicollet Creek, 1988; 1♂. 1989; 1♀.

Limnephilus rhombicus (Linnaeus) 1758

LaSalle Creek, 1988; 1♀.

Limnephilus sericeus (Say) 1824

LaSalle Creek, 1989; 1♂.

Sucker Creek, 1988; 1♀.

Nemotaulius Banks 1906

This Holarctic genus contains a single Nearctic species with a transcontinental distribution. Larvae are found in lentic waters, typically associated with areas of thick plant growth. Cases are usually somewhat flattened and made of leaves and twigs arranged transversely. Just before pupation, the cases are sometimes altered so that leaves are attached longitudinally (Flint 1960, Wiggins 1977).

Nemotaulius hostilis (Hagen) 1873

Nicollet Creek, 1988; 2♂. 1989; 1♂.

LaSalle Creek, 1988; 2♂, 4♀.

Beaver Lake, 1989; 1♂, 1♀.

Platycentropus Ulmer 1905

This Nearctic genus contains three species, with a distribution over the eastern half of the continent. Larvae, found in lentic and lotic waters, are especially tolerant of the warm waters at the edges of streams and lake shores where there is heavy plant growth. Their cases are most commonly in the form of a straight fibrous tube made with a transverse arrangement of grasses and sedges (Wiggins 1977). Three species from this genus occur in Minnesota; two species were collected during this study.

Platycentropus amicus (Hagen) 1861

Nicollet Creek, 1988; 9♂. 1989; 15♂, 2♀.

LaSalle Creek, 1988; 3♂. 1989; 31♂, 3♀.

Sucker Creek, 1989; 1♂.

Platycentropus radiatus (Say) 1824

Beaver Lake, 1989; 4♀.

Pycnopsyche Banks 1905

This Nearctic genus contains 17 species found primarily over the eastern half of the continent; two species have a range that extends west to the Rocky Mountains. Larvae are known primarily from streams and small rivers in deciduous forests, and are important as detritivores, especially in the breaking down of large amounts of leaf material. Therefore, early instars are encountered in the fall when allochthonous input is the greatest. Cases are initially made of leaves or bark and twigs; in the final instar, they are made of bark or pieces of rock (Wiggins 1977). Six species in this genus occur in Minnesota; four species were collected during this study.

Pycnopsyche guttifer (Walker) 1852

Nicollet Creek, 1988; 126♂, 61♀. 1989; 6♂, 29♀.

LaSalle Creek, 1988; 24♂, 34♀. 1989; 62♂, 31♀.

Sucker Creek, 1988; 44♂, 12♀. 1989; 57♂, 10♀.

Pycnopsyche lepida (Hagen) 1861

LaSalle Creek, 1988; 8♂, 7♀. 1989; 7♂, 5♀.

Sucker Creek, 1989; 1♂.

Pycnopsyche limbata (MacLachlan) 1871

LaSalle Creek, 1989; 1♀.

Sucker Creek, 1988; 8♂, 1♀. 1989; 1♂.

Pycnopsyche subfasciata (Say) 1828

LaSalle Creek, 1988; 1♂. 1989; 6♂.

Sucker Creek, 1989; 1♂.

Beaver Lake, 1989; 1♂.

Family Uenoidae. Uenoidae are found in the Holarctic and Oriental faunal regions and contain subfamilies Uenoinae and Thremmatinae (Vineyard & Wiggins 1988). Five genera have a Nearctic distribution and include about 47 species. Larvae are found in lotic waters, most frequently springs and streams in mountainous regions. Their diet consists of FPOM, diatoms, and algae. Larval mandibles bear fused teeth which create a smooth edge for scraping food material, much of which is taken from rock surfaces. Cases are diverse, from the very long and slender, made primarily of silk, to the irregular, made of rock fragments (Wiggins 1977). *Neophylax* is the only genus occurring in Minnesota. Four species occur in Minnesota; two species were collected during this study.

Neophylax concinnus McLachlan 1871

LaSalle Creek, 1988; 6♂. 1989; 5♂, 1♀.

Sucker Creek, 1988; 6♂. 1989; 2♂.

Neophylax oligius Ross 1938

LaSalle Creek, 1988; 6♂, 3♀. 1989; 34♂, 4♀.

Family Lepidostomatidae. Lepidostomatidae occur in all faunal regions and contains two North American genera, *Lepidostoma* and *Theliopsyche*, with about 66 species. Most larvae are found in small streams or slow reaches of large rivers; some are found along lake shores. They are thought to be detritivorous and are usually encountered among vegetation. Larvae have been described as bearing mandibles with separate teeth (Wiggins (1977) and also as possessing mandibles with scraperlike edges (Weaver 1988). In most species larval cases of early instars are made of small stones; as larvae mature some species make four-sided cases of bark or leaves, while others make cases of small slender pieces of plants arranged in whorls. Some larvae construct cases with characteristics unique to certain species groups. *Lepidostoma* is the single genus found in Minnesota.

Lepidostoma Rambur 1842

This genus is Holarctic in distribution and contains about 61 species in North America. Although species are widely distributed, most are found in the western part of the continent. Larvae are most frequently encountered in springs and streams where the current is slow but have also been found in lakes and temporary streams (Denning 1958, Mackay 1969). Detritus, especially decaying leaves, makes up the major portion of the larval diet (Anderson & Grafius 1975, Winterbourn 1971b). Cases of early instar larvae are commonly cylindrical and made of sand grains. With maturity, many species change the case to a four-sided structure composed of pieces of leaves cut into hexagonal shapes, which are fitted tightly together and arranged in panels (Sattler 1957, cited in Weaver 1988); others may be whorls of small slender plant pieces arranged transversely. Certain species groups build slender tapered cases of fine sand grains, and others make short robust cases of small stones. One species forms a spiral case (Weaver 1988). Five species of this genus occur in Minnesota; three species were collected during this study.

Lepidostoma bryanti (Banks) 1908

Nicollet Creek, 1989; 2♂, 16♀.

Sucker Creek, 1988; 1♂, 5♀. 1989; 19♂, 439♀.

Beaver Lake, 1989; 1♀.

Lepidostoma costale (Banks) 1914

Sucker Creek, 1988; 13♂, 50♀. 1989; 2♂, 16♀.

Lepidostoma togatum (Hagen) 1861

Nicollet Creek, 1989; 2♀.

LaSalle Creek, 1988; 7♂, 27♀. 1989; 16♂, 64♀.

Beaver Lake, 1989; 1♂, 1♀.

Family Molannidae. Molannidae, or hood-case makers, are found in the Holarctic and Oriental faunal regions. There are two Nearctic genera, *Molanna* and *Molannodes*, containing seven species. The omnivorous larvae live in a variety of lentic and lotic waters and are usually encountered in the sand or mud bottoms of these habitats. The flattened larval cases are constructed primarily of sand and rock pieces, with lateral flanges and a dorsal hood (Wiggins 1977). The larvae are not visible from above and are often difficult to detect in the substrate. *Molanna* is the single genus found in Minnesota.

Molanna Curtis 1834

This genus is found in the Holarctic and Oriental faunal regions and contains six species in North America. Five species are distributed in the eastern half of North America; one species' range extends west to Colorado and British Columbia (Wiggins 1977). Larvae inhabit rivers and streams, where the current is slow, and lakes, to a depth of 20 m. Their diet includes diatoms, filamentous algae, vascular plants, and invertebrates (Neave

1933). Four species from this genus occur in Minnesota; three species were collected during this study.

Molanna flavicornis Banks 1914

Nicollet Creek, 1989; 4♂.

Beaver Lake, 1989; 21♂.

Molanna tryphena Betten 1934

Nicollet Creek, 1988; 1♂. 1989; 12♂.

LaSalle Creek, 1988; 22♂. 1989; 13♂, 1♀.

Sucker Creek, 1989; 2♂.

Molanna uniophila Vorhies 1909

LaSalle Creek, 1988; 38♂, 1♀. 1989; 9♂, 1♀.

Sucker Creek, 1988; 1♂. 1989; 1♂.

Beaver Lake, 1989; 2♂.

Family Helicopsychidae. Helicopsychidae, or snail-case makers, are found in all faunal regions. *Helicopsyche* is the single Nearctic genus and contains nine species. They are best known for their helical larval cases made of sand and small pieces of rock, which were originally described as snail shells (Lea 1834). Larvae are frequently encountered on rock surfaces in lotic waters but also occur in hyporheic interstices and lakes (Williams & Hynes 1974). Algae and detritus make up much of their diet (Wiggins 1977).

Helicopsyche Hagen 1866

This genus occurs in all faunal regions. Four species have a southern distribution, four are western, and one is widely distributed across North America. Larvae are often encountered in large numbers on the downstream side or protected areas of rocks in fast flowing water or on exposed surfaces in gentle currents. They are also known from the littoral zone of lakes and interstitial regions, to depths of 30 cm. The helical case design is thought to protect the larva from being crushed if dislodged in the current, and the spherical shape may facilitate movement within stream-bed interstices (Vaughn 1985, Williams and Hynes 1974, Williams et al. 1983). The anal claw terminates in a comblike structure which is unique to North American larvae (Wiggins 1977). The single species from this genus occurring in Minnesota was collected during this study.

Helicopsyche borealis (Hagen) 1861

Nicollet Creek, 1989; 2♂.

LaSalle Creek, 1988; 373♂, 517♀. 1989; 323♂, 1039♀.

Sucker Creek, 1988; 5♂. 1989; 1♂.

Family Leptoceridae. Leptoceridae, or longhorned case makers, are known from all faunal regions and are divided into two subfamilies, Triplectidinae and Leptocerinae. Only Leptocerinae has a Nearctic distribution, containing eight genera with about 117 species. This family is large and widely distributed, and larvae are often abundant and diverse in cool lotic as well as warm lentic habitats. Larvae are generally considered omnivorous, but some are strictly predaceous and possess mandibles specialized for this feeding behavior. Most Nearctic larvae bear prominent antennae, six times longer than wide, a characteristic unique to the family. The cases are commonly constructed of sand, pieces of rock, and plant material, or are entirely of silk, and bear characteristic generic features (Wiggins 1977). The genera found in Minnesota are *Ceraclea, Leptocerus, Mystacides, Nectopsyche, Oecetis, Setodes, Triaenodes*, and *Ylodes*.

Ceraclea Stephens 1829

This genus is common throughout the Holarctic faunal region and contains about 36 widely distributed Nearctic species. Larvae are found in lentic and lotic waters, often on bottom substrates. Many species are detritivores, and a few are specialists, feeding on freshwater sponges (Resh 1976, Resh et al. 1976). Cases, usually constructed of sand grains, are wide anteriorly and sharply tapered posteriorly; some have a dorsal hooded flange, concealing the larva from above. Cases of spongivorous species are made primarily of silk; some use pieces of sponge in addition to silk (Wiggins 1977). Eighteen species from this genus occur in Minnesota; eleven were collected during this study.

Ceraclea alagma (Ross) 1938

Nicollet Creek, 1988; 5♂, 6♀. 1989; 14♂, 37♀.

LaSalle Creek, 1988; 20♂, 6♀. 1989; 66♂, 19♀.

Sucker Creek, 1988; 1♂. 1989; 8♂, 2♀.

Beaver Lake, 1989; 79♂, 383♀.

Ceraclea ancylus (Vorhies) 1909

LaSalle Creek, 1988; 1♀.

Ceraclea arielles (Denning) 1942

LaSalle Creek, 1988; 12♂, 17♀. 1989; 40♂, 64♀.

Beaver Lake, 1989; 1♂.

Ceraclea cancellata (Betten) 1934

Nicollet Creek, 1988; 1♀. 1989; 6♂, 4♀.

LaSalle Creek 1988; 1♂, 1♀. 1989; 4♂, 36♀.

Sucker Creek, 1988; 1♀. 1989; 12♂, 1♀.

Beaver Lake, 1989; 286♂, 191♀.

Ceraclea diluta (Hagen) 1861

LaSalle Creek, 1988; 60♂, 84♀. 1989; 16♂, 232♀.

Beaver Lake, 1989; 2♂, 1♀.

Ceraclea excisa (Morton) 1941

Nicollet Creek, 1988; 23♂, 16♀. 1989; 244♂, 383♀.

LaSalle Creek, 1988; 44♂, 71♀. 1989; 368♂, 400♀.

Sucker Creek, 1988; 2♂, 11♀. 1989; 2♂, 3♀.

Ceraclea maculata (Banks) 1899

LaSalle Creek, 1988; 1♀.

Ceraclea resurgens (Walker) 1852

Nicollet Creek, 1989; 15♀.

LaSalle, Creek, 1988; 10♂, 37♀. 1989; 12♂, 4♀.

Ceraclea tarsipunctata (Vorhies) 1909

Nicollet Creek, 1988; 1♀.

LaSalle Creek, 1988; 309♂, 125♀. 1989; 653♂, 337♀.

Sucker Creek, 1989; 5♂, 2♀.

Beaver Lake, 1989; 43♂, 64♀.

Ceraclea transversa (Hagen) 1861

Nicollet Creek, 1988, 2♂, 1♀. 1989; 6♂, 2♀.

LaSalle Creek, 1988; 108♂, 513♀. 1989; 220♂, 1036♀.

Sucker Creek, 1988; 1♂.

Ceraclea vertreesi (Denning) 1966

Nicollet Creek, 1989; 3♂.

Leptocerus Leach 1815

This genus is known from the Holarctic and Oriental faunal regions. The single Nearctic species has primarily an eastern distribution in North America. Larvae, commonly found in lentic habitats, use natatorial hind legs to swim briskly within aquatic vegetation; middle legs bear a tarsal claw modified into a hook shape that is characteristic for the genus. Larval diet consists primarily of FPOM. Cases, constructed entirely of silk, are long and gently tapered (Wiggins 1977).

Leptocerus americanus (Banks) 1899

Nicollet Creek, 1988; 27♂, 81♀. 1989; 145♂, 480♀.

LaSalle Creek, 1988; 14♂, 14♀. 1989; 309♂, 441♀.

Sucker Creek, 1988; 1♂, 1♀. 1989; 587♂, 830♀.

Beaver Lake, 1989; 254♂, 148♀.

Mystacides Berthold 1827

This genus is known from the Holarctic and Oriental faunal regions. Three species occur in North America; one has a western distribution and two are transcontinental. Larvae are often abundant in shallow, lentic habitats and in slow reaches of rivers, where they feed on fine particles of plant and animal material. Larval cases are straight, made of fragments of rocks, shells, or plants, and include small twigs or conifer needles which extend anteriorly beyond the end of the case (Wiggins 1977). Adults are crepuscular and have been observed flying back and forth a few inches above the surface of the water. Two species of this genus occur in Minnesota; both species were collected during this study.

Mystacides interjecta (Banks) 1914

LaSalle Creek, 1989; 1♀.

Beaver Lake, 1989; 2♂.

Mystacides sepulchralis (Walker) 1852

LaSalle Creek, 1988; 42♂, 65♀. 1989; 28♂, 64♀.

Sucker Creek, 1989; 1♀.

Beaver Lake, 1989; 1♂.

Nectopsyche Muller 1879

This genus is found only in the Nearctic and Neotropical faunal regions. There are 16 widely distributed species occurring in North America. Larvae have been found in lakes and slow-flowing areas of rivers, on the substrate and on vegetation; some species are swimmers. Their diet includes FPOM, vascular plant tissue, and animals. Larval cases are long, slender, gently tapered, and made of small pieces of rocks and plants, with twigs or conifer needles protruding beyond the anterior end (Wiggins 1977). Five species occur in Minnesota; four were collected during this study.

Nectopsyche albida (Walker) 1852

Nicollet Creek, 1989; 3♂, 16♀.

LaSalle Creek, 1988; 8♂, 5♀. 1989; 4♂, 35♀.

Beaver Lake, 1989; 3♂, 20♀.

Nectopsyche candida (Hagen) 1861

Beaver Lake, 1989; 1♂, 1♀.

Nectopsyche diarina (Ross) 1944

LaSalle Creek, 1988; 71♂, 144♀. 1989; 9♂, 57♀.

Sucker Creek, 1989; 2♂, 1♀.

Beaver Lake, 1989; 1♂, 1♀.

Nectopsyche exquisita (Walker) 1852

Nicollet Creek, 1988; 2♂, 3♀.

LaSalle Creek, 1989; 1♂.

Sucker Creek, 1988; 1♂, 1♀.

Oecetis McLachlan 1877

This genus is found in all faunal regions and contains about 22 widely distributed Nearctic species. Larvae are found on bottom substrates of lentic and lotic habitats; some early instars are swimmers. The cylindrical larval cases are diverse in shape, being made of pieces of rock and/or leaves and bark, or a transverse arrangement of short stems and twigs. All larvae possess long bladelike mandibles, thought to be an adaptation for predatory behavior (Wiggins 1977). Eight species of this genus occur in Minnesota; seven species were collected during this study.

Oecetis avara (Banks) 1895

LaSalle Creek, 1988; 1318♂, 1002♀. 1989; 4022♂, 2154♀.

Sucker Creek, 1988; 1♂. 1989; 1♀.

Oecetis cinerascens (Hagen) 1861

Nicollet Creek, 1988; 18♂, 39♀. 1989; 183♂, 165♀.

LaSalle Creek, 1988; 465♂, 148♀. 1989; 203♂, 438♀.

Sucker Creek, 1988; 3♂, 1♀. 1989; 51♂, 42♀.

Beaver Lake, 1989; 39♂, 47♀.

Oecetis inconspicua (Walker) 1852

Nicollet Creek, 1988; 147♂, 117♀. 1989; 449♂, 171♀.

LaSalle Creek, 1988; 3022♂, 2733♀. 1989; 4282♂, 2751♀.

Sucker Creek, 1988; 32♂, 16♀. 1989; 186♂, 193♀.

Beaver Lake, 1989; 1573♂, 1516♀.

Oecetis nocturna Ross 1966

Nicollet Creek, 1989; 1♂.

LaSalle Creek, 1988; 156♂, 8♀. 1989; 36♂.

Sucker Creek, 1989; 2♂.

Beaver Lake, 1989; 1♂.

Oecetis ochracea Curtis 1825

Sucker Creek, 1989; 1♂, 37♀.

Oecetis osteni Milne 1934

Nicollet Creek, 1988; 3♂, 5♀. 1989; 9♂, 5♀.

LaSalle Creek, 1988; 197♂, 128♀. 1989; 562♂, 520♀.

Sucker Creek, 1988; 1♂. 1989; 7♂, 2♀.

Beaver Lake, 1989; 193♂, 115♀.

Oecetis persimilis (Banks) 1907

LaSalle Creek, 1988; 12♀. 1989; 40♂, 28♀.

Triaenodes McLachlan 1865

This genus is found in the Holarctic, Ethiopian, Oriental, and Neotropical faunal regions and contains about 26 widely distributed Nearctic species. Larvae are found among submerged aquatic plants in lotic and lentic waters. Their natatorial hind legs enable them to be strong swimmers within beds of thick vegetation. Larval diet consists primarily of FPOM and vascular plant tissue. Cases are long, slender, and gently tapered; they are constructed with pieces of green plants arranged spirally, a characteristic of North American species of the genus (Wiggins 1977). Ten species of this genus occur in Minnesota; nine species were collected during this study.

Triaenodes abus Milne 1935

LaSalle Creek, 1988; 1♂.

Triaenodes baris Ross 1938

LaSalle Creek, 1989; 28♂, 332♀.

Triaenodes dipsius Ross 1938

Nicollet Creek, 1989; 5♂, 22♀.

LaSalle Creek, 1988; 6♂, 8♀.

Sucker Creek, 1989; 3♂, 7♀.

Triaenodes flavescens Banks 1900

Sucker Creek, 1988; 1♂, 2♀.

Triaenodes ignitus (Walker) 1852

LaSalle Creek, 1988; 1♂.

Triaenodes injustus (Hagen) 1861

Nicollet Creek, 1988; 5♂, 6♀. 1989; 5♂, 9♀.

LaSalle Creek, 1988; 6♂, 21♀. 1989; 14♂, 97♀.

Sucker Creek, 1989; 7♂, 31♀.

Beaver Lake, 1989; 11♂, 13♀.

Triaenodes marginatus Sibley 1926

Nicollet Creek, 1988; 18♂, 676♀. 1989; 117♂, 1490♀.

LaSalle Creek, 1988; 144♂, 1539♀. 1989; 301♂, 2521♀.

Sucker Creek, 1988; 7♂, 29♀. 1989; 535♂, 964♀.

Beaver Lake 1989; 18♂, 71♀.

Triaenodes nox Ross 1941

Nicollet Creek, 1989; 5♀.

Sucker Creek, 1989; 1♂, 1♀.

Beaver Lake 1989; 2♂, 69♀.

Triaenodes tardus Milne 1934

Nicollet Creek 1988; 14♂, 27♀. 1989; 42♂, 42♀.

LaSalle Creek, 1988; 12♂, 37♀. 1989; 85♂, 232♀.

Sucker Creek, 1988; 1♂, 5♀. 1989; 52♂, 48♀.

Beaver Lake, 1989; 111♂, 380♀.

Species Richness and Relative Abundance

Total species richness, or number of species present, at each site is shown in Table 2. Although the difference of one between the numbers of species collected at LaSalle Creek in 1988 and 1989 was minimal, there were much greater differences, 19-22, between years at Nicollet and Sucker Creeks.

Relative abundance of the species collected during this study is depicted with rank/abundance curves (Figs. 6-10). Figure 6 depicts the rank abundance for the 25 most common species for all sites taken together in 1988 and 1989, showing the relationship between the few very abundant and the many less common species. Out of the 126 species collected from all four sites, one species, *Oecetis inconspicua*, was most abundant, numbering nearly 17,200 individuals, followed by *Cheumatopsyche pettiti* with about 13,900 individuals. *Oecetis avara, Triaenodes marginatus*, and *Hydropsyche morosa* were more moderately abundant, each with between 8400-8500 individuals. From the next most frequently encountered species, *Leptocerus americanus,* the numbers decrease more gradually. Thirty species were represented by 5 or fewer individuals; six, *Polycentropus aureolus*, *Limnephilus rhombicus*, *Ceraclea ancylus*, *C. maculata*, *Triaenodes abus*, and *T. ignitus*, were recorded from only one specimen.

The relative abundance of the 15 most common species at each site is shown in Figs. 7-10. Table 3 lists these species, unranked, indicating those in common from each site. Most of these species were collected in greater numbers in 1989 than in 1988. At Nicollet Creek *T. marginatus* was the most common species in 1988 and 1989 (Fig. 11), representing 31% of the total number of individuals collected from this location over both years. The family Leptoceridae was dominant at this site, with 72% of all the individuals found here, followed by Hydrosychidae spp. with 19%. Among all the species reported from Nicollet Creek, seven were encountered only at this site. At LaSalle Creek *C. pettiti* and *O. inconspicua* were the most common species in 1988 and 1989, respectively (Fig. 12); *C. pettiti* was the most abundant considering both years together, with 20% of the total number of individuals. The family Leptoceridae comprised 54% of all the individuals collected here, followed by Hydropsychidae with 38%. Among all the species reported from LaSalle Creek, 25 were found only at this site. At Sucker Creek *Hydropsyche slossonae* and *T. marginatus* were the most common species in 1988 and 1989, respectively (Fig. 13); *T. marginatus* was the most abundant considering both years together, with 23% of the total number of individuals. Leptoceridae contained 56% of all

Table 2. Species richness, diversity, and evenness.

	Species richness			Diversity			Evenness
	1988	1989	Total	Brillouin		Shannon	
LaSalle Creek	84	83	101	2.545	-	2.549	0.58
Nicollet Creek	40	62	68	2.464	-	2.481	0.606
Sucker Creek	42	61	67	2.377	-	2.397	0.574
Beaver Lake		52	52	1.966	-	1.982	0.511

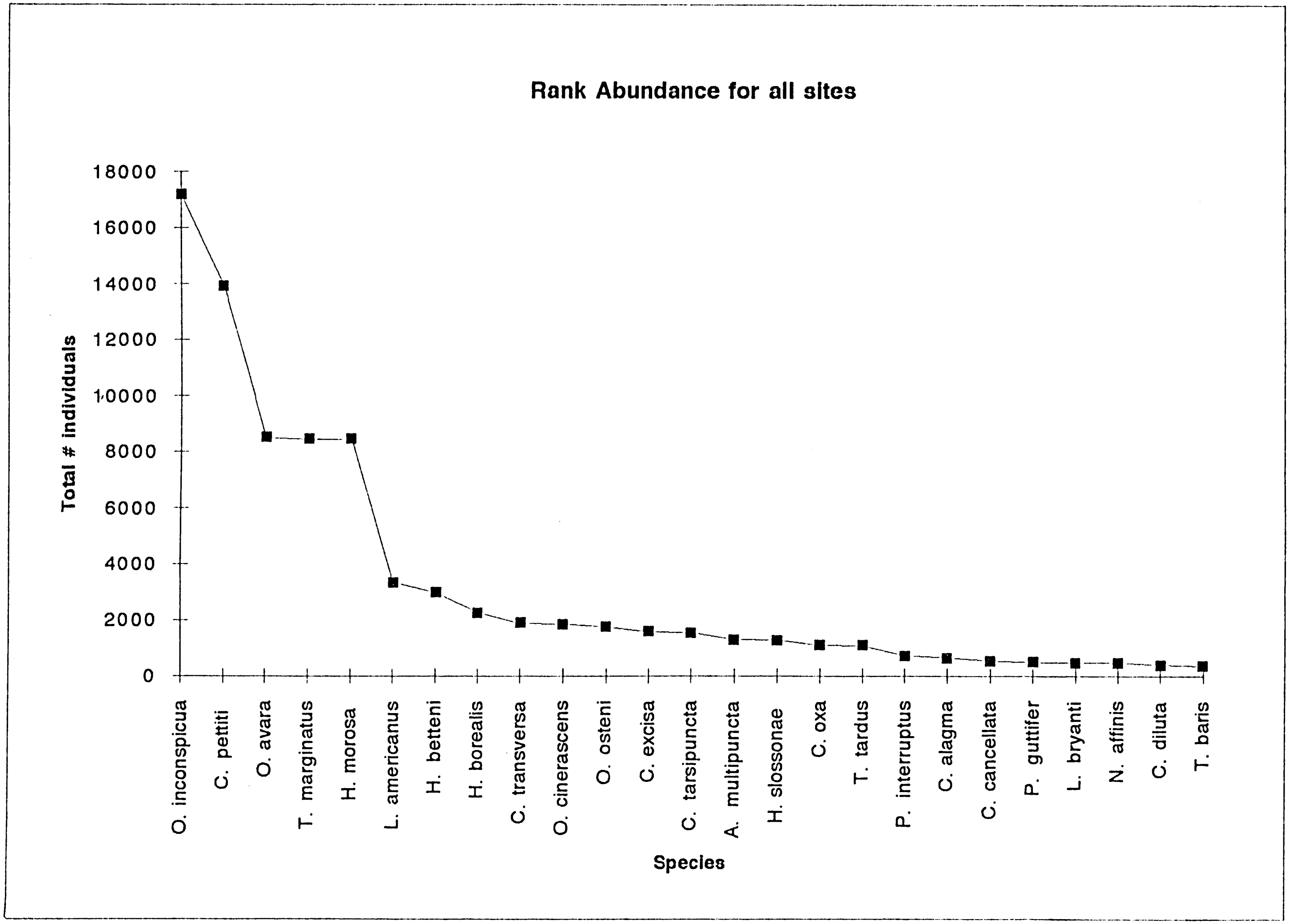


Fig. 6. Rank abundance for the 25 most common species from all sites, 1988-1989.

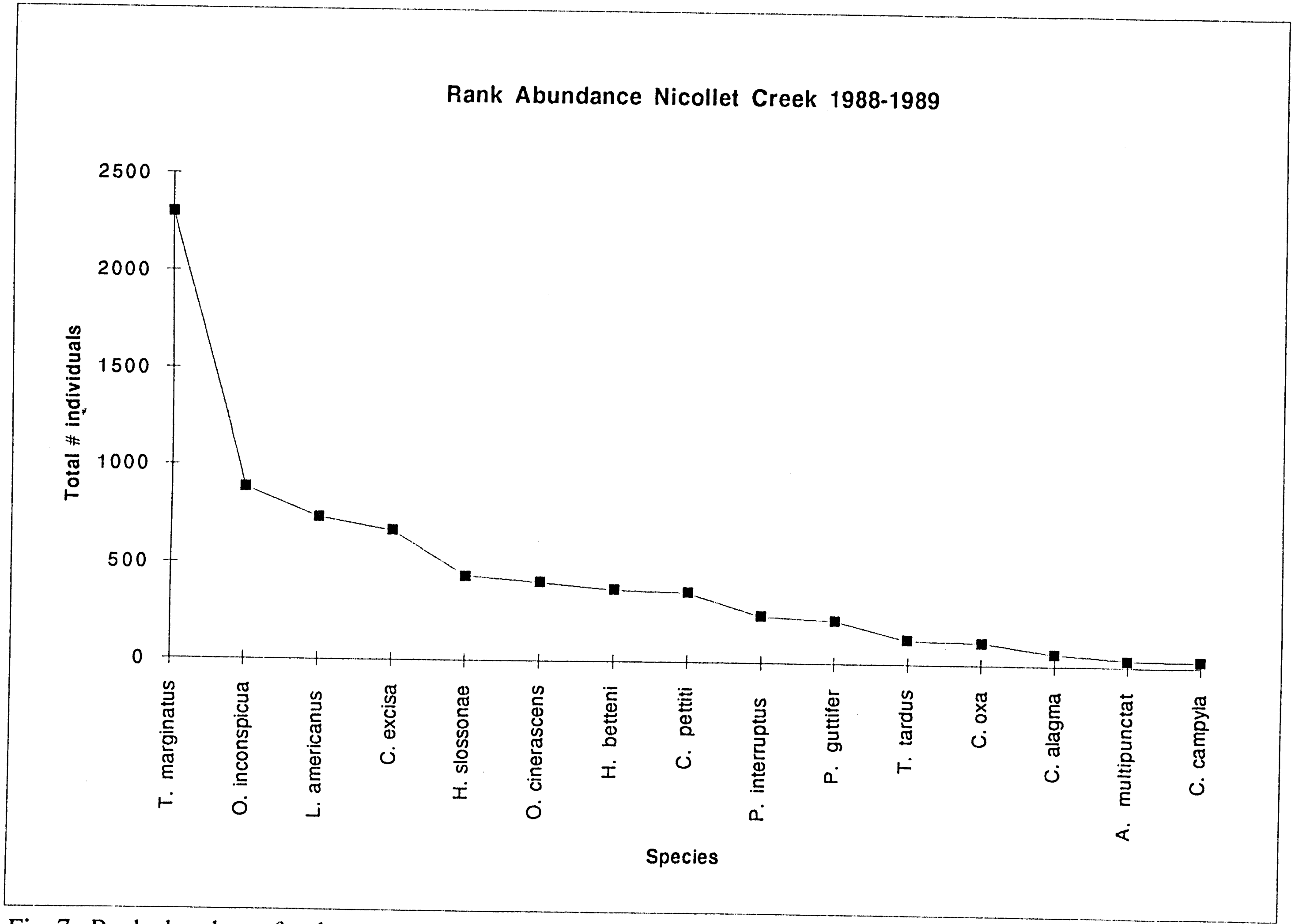


Fig. 7. Rank abundance for the most common species at Nicollet Creek, 1988-1989.

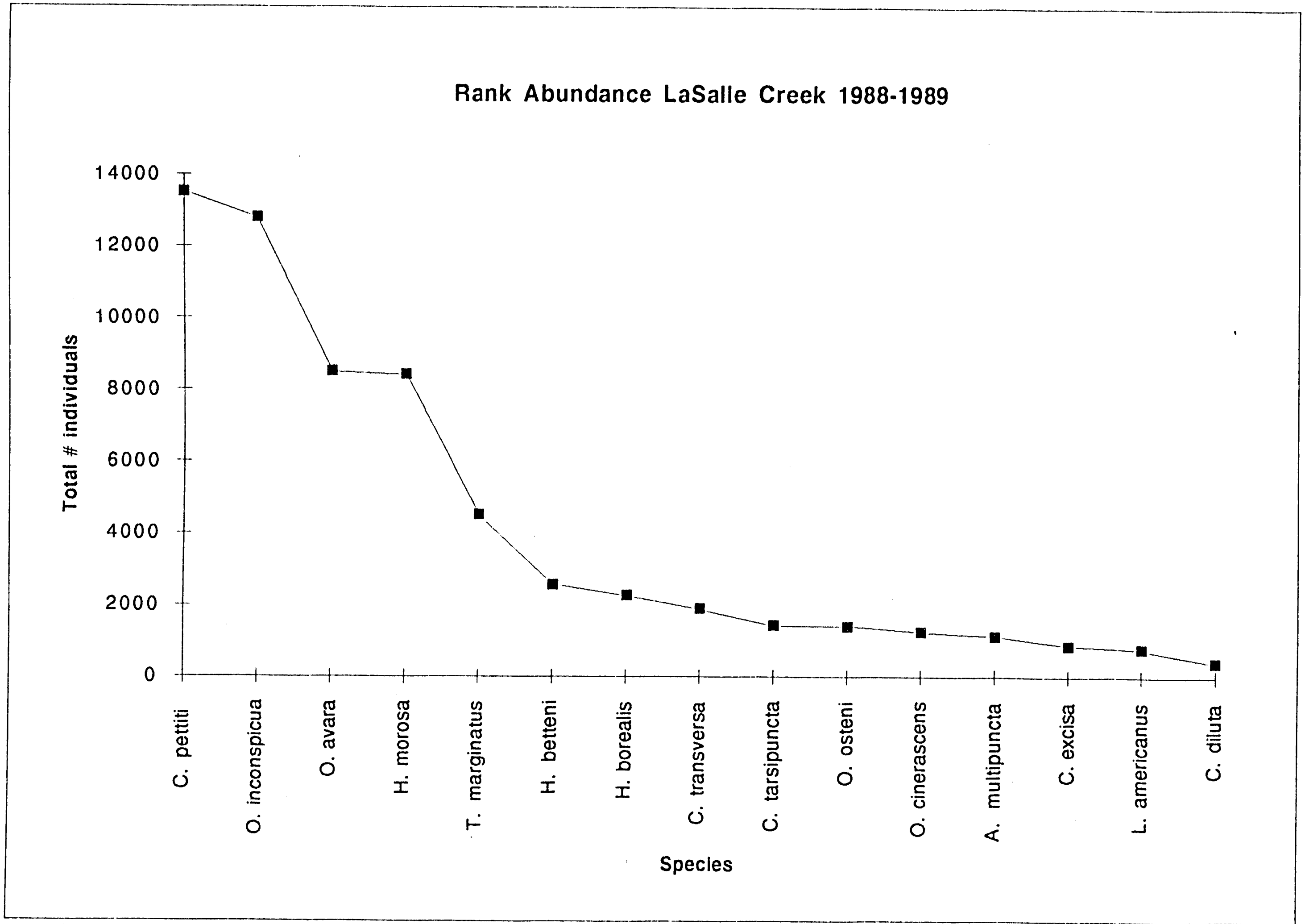


Fig. 8. Rank abundance for the most common species at LaSalle Creek, 1988-1989.

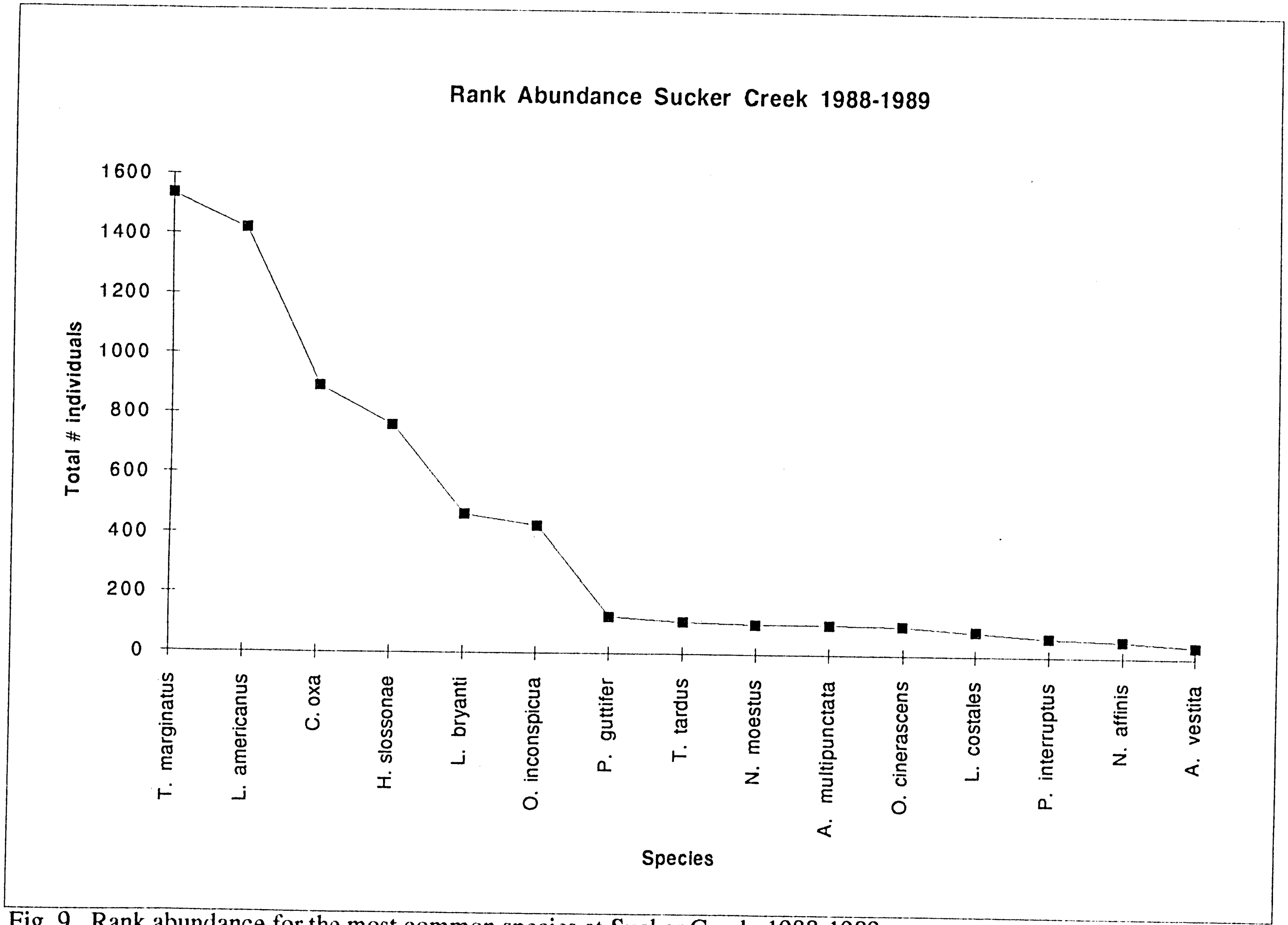


Fig. 9. Rank abundance for the most common species at Sucker Creek, 1988-1989.

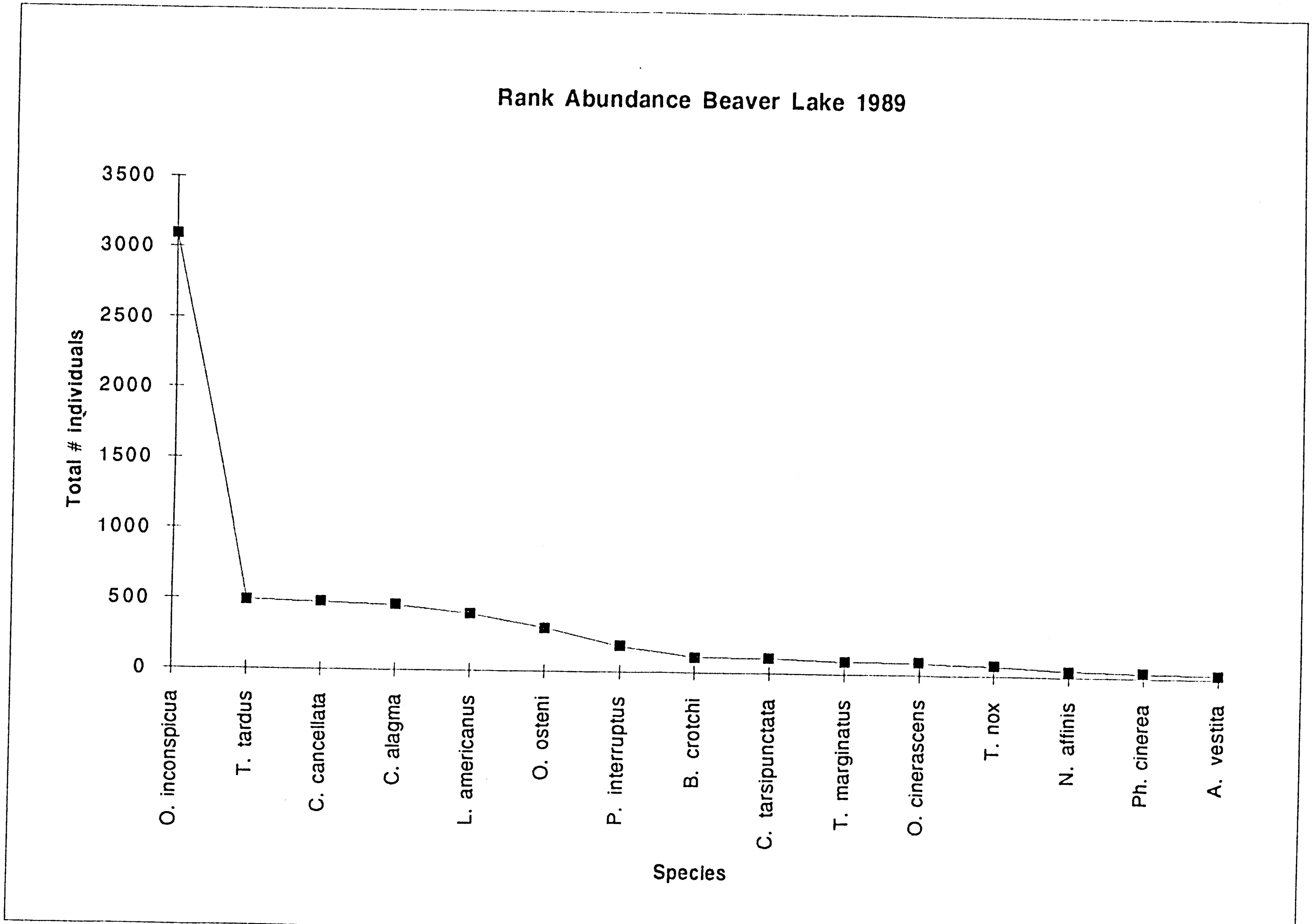


Fig. 10. Rank abundance for the most common species at Beaver Lake, 1989.

Table 3. The 15 most abundant species collected at each site.

Beaver Lake	LaSalle Creek	Nicollet Creek	Sucker Creek
Oecetis inconspicua	Oecetis inconspicua	Oecetis inconspicua	Oecetis inconspicua
Leptocerus americanus	Leptocerus americanus	Leptocerus americanus	Leptocerus americanus
Triaenodes marginatus	Triaenodes marginatus	Triaenodes marginatus	Triaenodes marginatus
Oecetis cinerascens	Oecetis cinerascens	Oecetis cinerascens	Oecetis cinerascens
Triaenodes tardus		Triaenodes tardus	Triaenodes tardus
Polycentropus interruptus		Polycentropus interruptus	Polycentropus interruptus
Nyctiophylax affinis			Nyctiophylax affinis
Ceraclea alagma		Ceraclea alagma	
Agrypnia vestita			Agrypnia vestita
Oecetis osteni	Oecetis osteni		
Ceraclea tarsipunctata	Ceraclea tarsipunctata		
Ceraclea cancellata			
Banksiola crotchi			
Triaenodes nox			
Phryganea cinerea			
	Agraylea multipunctata	Agraylea multipunctata	Agraylea multipunctata
	Hydropsyche betteni	Hydropsyche betteni	
	Cheumatopsyche pettiti	Cheumatopsyche pettiti	
	Ceraclea excisa	Ceraclea excisa	
	Helicopsyche borealis		
	Ceraclea transversa		
	Ceraclea diluta		
	Hydropsyche morosa		
	Oecetis avara		
		Pycnopsyche guttifer	Pycnopsyche guttifer
		Hydropsyche slossonae	Hydropsyche slossonae
		Cheumatopsyche oxa	Cheumatopsyche oxa
		Cheumatopsyche campyla	
			Lepidostoma bryanti
			Lepidostoma costale
			Nyctiophylax moestus

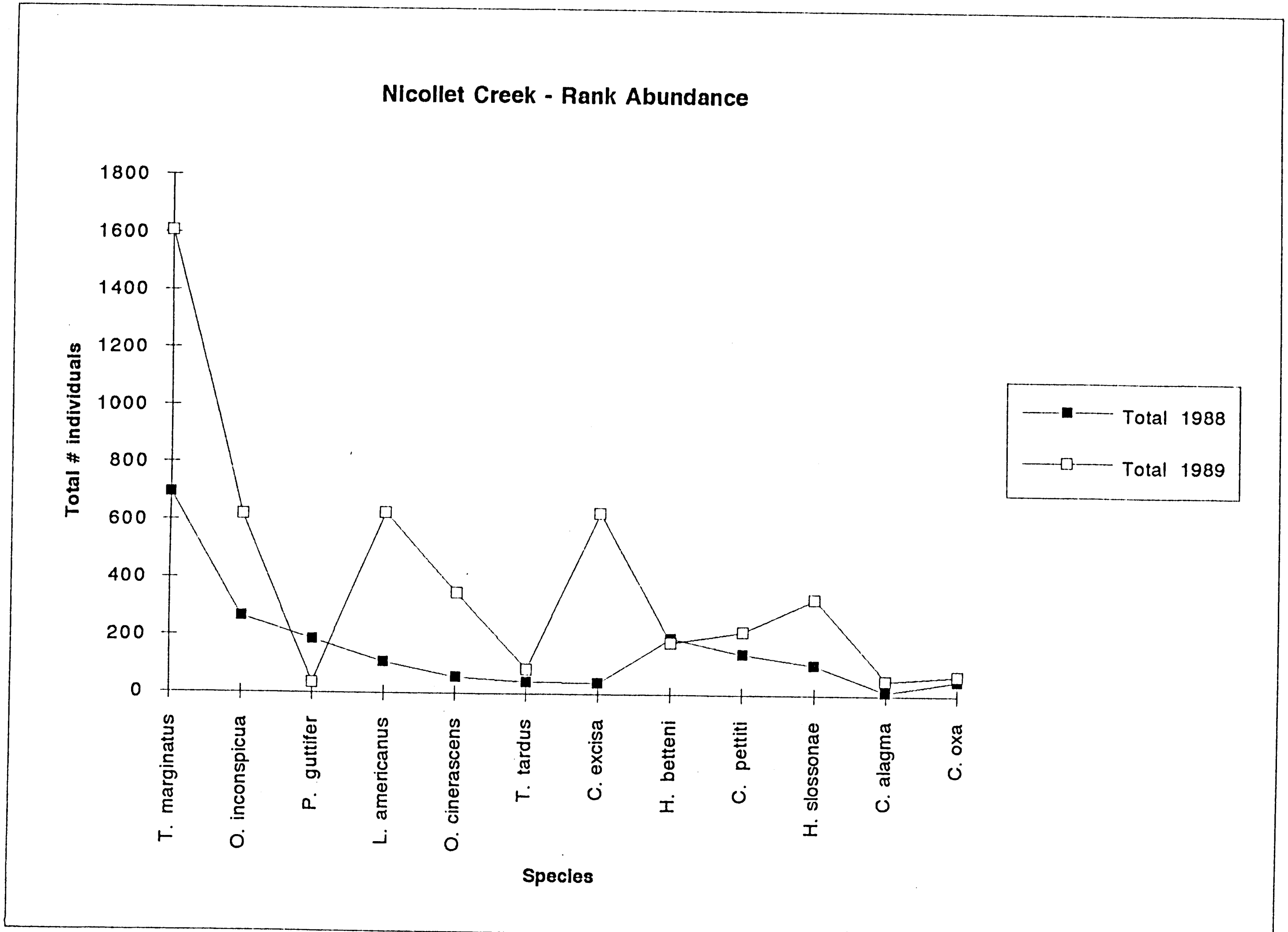


Fig. 11. A comparison of rank abundance at Nicollet Creek, 1988 and1989.

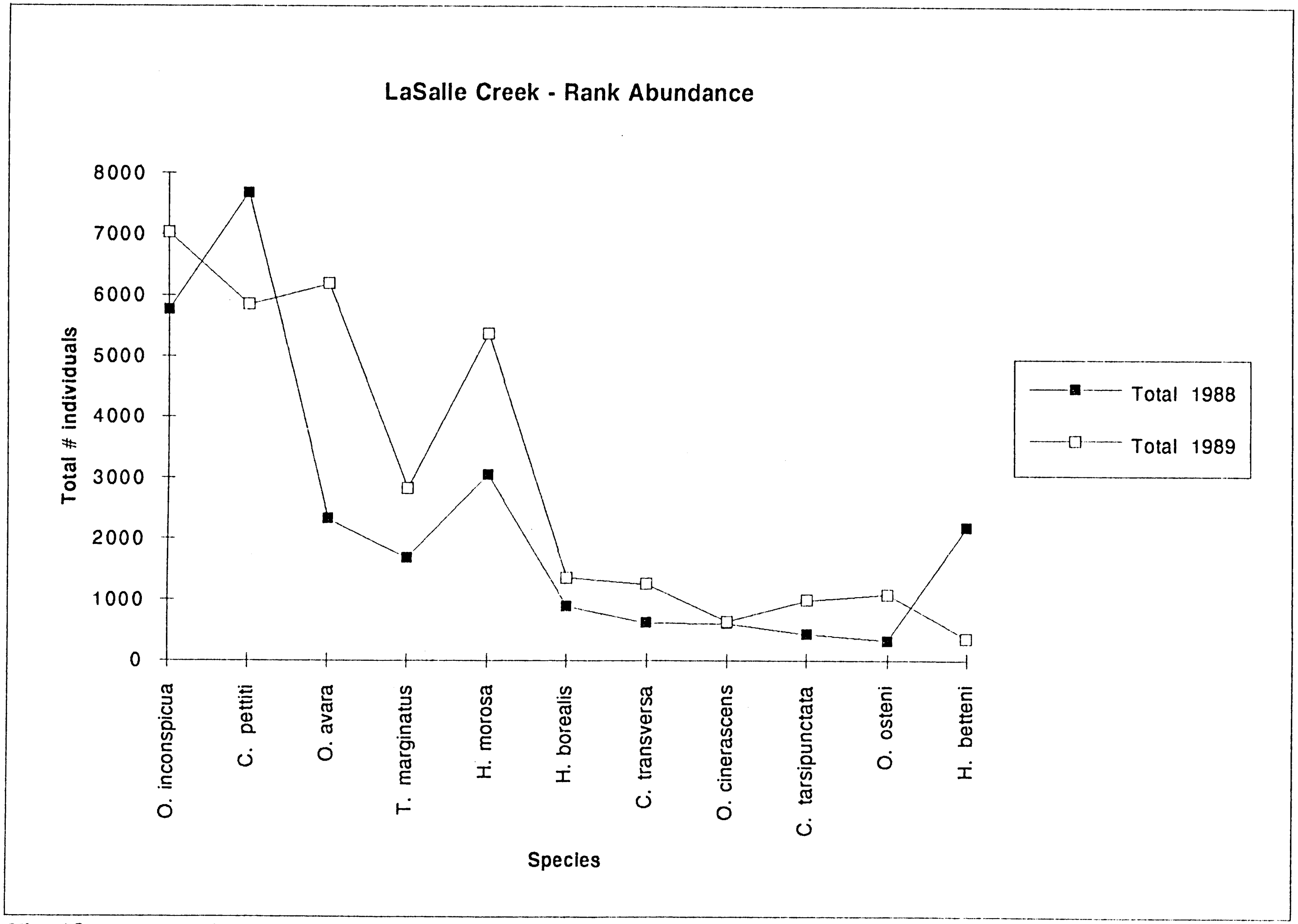


Fig. 12. A comparison of rank abundance at LaSalle Creek, 1988 and 1989.

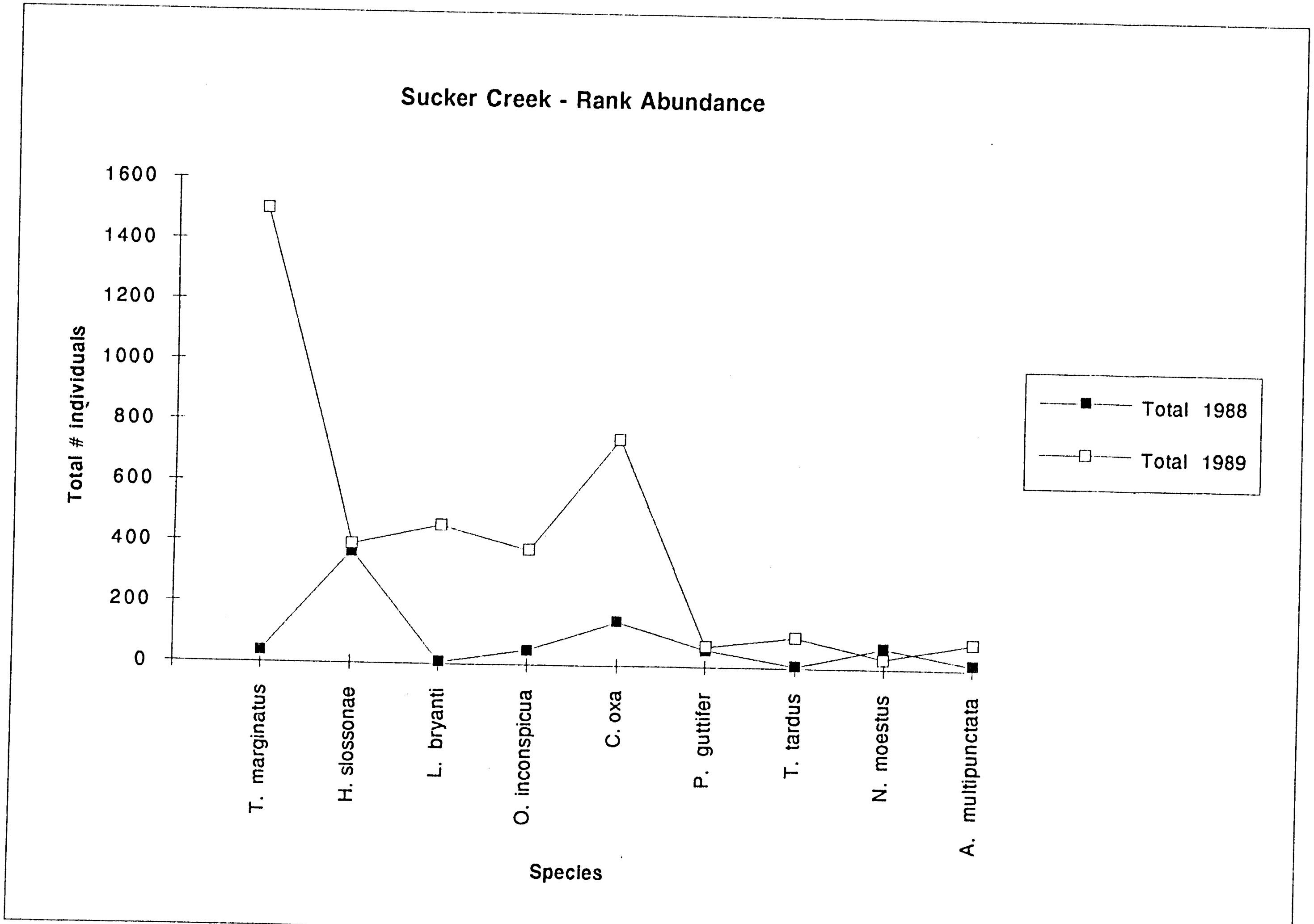


Fig. 13. A comparison of rank abundance at Sucker Creek, 1988 and 1989.

the individuals collected here, followed by Hydropsychidae with 26%. Among all the species collected from Sucker Creek, six were found only at this site. At Beaver Lake *O. inconspicua* was the most common species collected in 1989, comprising 50% of the total number of individuals (Fig. 10). Leptoceridae represented 91% of all species recorded from this site, followed by Polycentropodidae with 4%. Among the species found at Beaver Lake, four were encountered only at this site.

For those species found to be most common for 1988 and 1989 at the creek sites, collections frequently revealed larger numbers of females than males (Table 4). At LaSalle Creek, *C. pettiti,* was collected in a 1.5:1 ratio of females to males in 1988 and a 3.9:1 ratio in 1989; *Oecetis inconspicua*, however, was collected in a 0.9:1 ratio of females to males in 1988 and a 0.6:1 ratio in 1989. At Sucker Creek, *H. slossonae* was collected in approximately a 2.7:1 ratio of females to males in 1988 and a 2:1 ratio in 1989; *Triaenodes marginatus* was collected in approximately a 4.1:1 ratio of females to males in 1988 and a 1.8:1 ratio in 1989. At Nicollet Creek *T. marginatus,* the most common species at this site both years, was collected in about 37.5:1 and 12.7:1 ratios of females to males, in 1988 and 1989, respectively. *Oecetis inconspicua*, the most common species found at Beaver Lake, was collected in a 1:1 ratio of females to males; seven of the 15 most common species from this site had ratios of females to males that were at least 1.5:1.

Alpha diversity, species richness within a community or habitat (Whittaker 1972) and relative abundance of each species at all sites were used in the calculations for Brillouin's (HB) and Shannon's (H') indices (Magurran 1988); values were obtained for each site (Table 2, p. 64). LaSalle Creek had the highest diversity value (HB =2.55; H'=2.55), while Beaver Lake had the lowest (HB=1.97; H'=1.98). With these values, evenness (E), the ratio of observed diversity to the maximum possible diversity for the same number of species (Magurran 1988, Pielou 1966), was then determined (Table 2); evenness values were moderate, 0.51- 0.61, for all sites.

Beta diversity, the difference in species richness between areas of alpha diversity (Southwood 1978), was described by measuring the amount of association, or degree of similarity, between pairs of sites using similarity measures (Table 5). Sorensen coefficient values for all pairs of sites in this study were calculated (Magurran 1988). Distances between sites were as follows: Beaver Lake and Nicollet Creek, 2.0 km; Beaver Lake and LaSalle Creek, 17.6 km; Beaver Lake and Sucker Creek, 5.6 km; Nicollet Creek and LaSalle Creek, 18.0 km; Nicollet Creek and Sucker Creek, 6.8 km; LaSalle Creek and Sucker Creek, 12.6 km. Sorensen's index (Cs), based on qualitative data, revealed a moderate degree of association between all sites, ranging from 0.59 to 0.71. Sorensen's

Table 4. Ratios of females to males for those species most abundant and collected in 1988 and 1989 at each creek site, and from Beaver Lake.

LaSalle Creek	**1988**	**1989**	**Sucker Creek**	**1988**	**1989**
	females : males	females : males		females : males	females : males
O. inconspicua	0.9 : 1	0.6 : 1	H. slossonae	2.7 : 1	2.0 : 1
C. pettiti	1.5 : 1	3.9 : 1	T. marginatus	4.1 : 1	1.8 : 1
O. avara	0.8 : 1	0.5 : 1	L. bryanti	5.0 : 1	23.1 : 1
T. marginatus	10.7 : 1	8.4 : 1	O. inconspicua	0.5 : 1	1.0 : 1
H. morosa	1.1 : 1	1.1 : 1	C. oxa	6.2 : 1	5.4 : 1
H. borealis	1.4 : 1	3.2 : 1	P. guttifer	0.3 : 1	0.2 : 1
C. transversa	4.8 : 1	4.7 : 1	T. tardus	5.0 : 1	0.9 : 1
O. cinerascens	0.3 : 1	2.2 : 1	N. moestus	2.8 : 1	4.5 : 1
C. tarsipunctata	0.4 : 1	0.5 : 1	A. multipunctata	14.0 : 1	84.0 : 1
O. osteni	0.6 : 1	0.9 : 1			
H. betteni	1.3 : 1	1.0 : 1	**Beaver Lake**	**1989**	
			O. inconspicua	1.0 : 1	
Nicollet Creek	**1988**	**1989**	T. tardus	3.4 : 1	
T. marginatus	37.5 : 1	12.7 : 1	C. cancellata	0.7 : 1	
O. inconspicua	0.8 : 1	0.4 : 1	C. alagma	4.8 : 1	
P. guttifer	0.5 : 1	4.8 : 1	L. americanus	0.6 : 1	
L. americanus	3.0 : 1	3.3 : 1	O. osteni	0.6 : 1	
O. cinerascens	2.2 : 1	0.9 : 1	P. interruptus	0.5 : 1	
T. tardus	1.9 : 1	1.0 : 1	B. crotchi	1.7 : 1	
C. excisa	0.7 : 1	1.6 : 1	C. tarsipunctata	1.5 : 1	
H. betteni	4.5 : 1	4.7 : 1	T. marginatus	3.9 : 1	
C. pettiti	4.0 : 1	8.0 : 1	O. cinerascens	1.2 : 1	
H. slossonae	2.9 : 1	9.7 : 1	T. nox	34.5 : 1	
C. alagma	1.2 : 1	2.6 : 1	N. affinis	0.9 : 1	
C. oxa	6.1 : 1	8.7 : 1	Ph. cinerea	0.2 : 1	
			A. vestita	2.6 : 1	

Table 5. Similarity of caddisfly fauna between sites based on Sorensen's coefficient of similarity*

	Beaver Lake	Nicollet Creek	LaSalle Creek	Sucker Creek
Beaver Lake	XXXXXXXXXXXX	0.593 (0.91)	0.605 (0.171)	0.602 (0.965)
Nicollet Creek	XXXXXXXXXXXX	XXXXXXXXXXXXX	0.681 (0.202)	0.688 (0.944)
LaSalle Creek	XXXXXXXXXXXX	XXXXXXXXXXXXX	XXXXXXXXXXXX	0.712 (0.182)
Sucker Creek	XXXXXXXXXXXX	XXXXXXXXXXXXX	XXXXXXX XXXXX	XXXXXXXXXXX

*Numbers in parentheses are based on quantitative information; numbers without parentheses are based on qualitative information

Similarity based on Sorensen's Formula Cs = 2j / (a+b) - qualitative data

Beaver Lake, S = 48; Nicollet Creek, S = 60; LaSalle Creek, S = 81; Sucker Creek, S = 65.
Beaver L. and Nicollet C., 32 species in common; Beaver L. and LaSalle C., 39 species in common; Beaver L. and Sucker C., 34 species in common; Nicollet C. and LaSalle C., 48 species in common; Nicollet C. and Sucker C., 43 species in common; LaSalle C. and Sucker C., 52 species in common.

Similarity based on Sorensen's Formula Cn = 2 jN / (aN+bN) - (quantitative data)

Beaver Lake, N = 6187; Nicollet Creek, N = 7418; LaSalle Creek, N = 66103; Sucker Creek, N = 6636.

index (C_N), based on quantitative data, described the association between pairs of sites quite differently; when LaSalle Creek was paired with each of the other sites, there was a very low degree of association, from 0.17-0.20; all other pair combinations showed a very high degree of similarity, from 0.91-0.97.

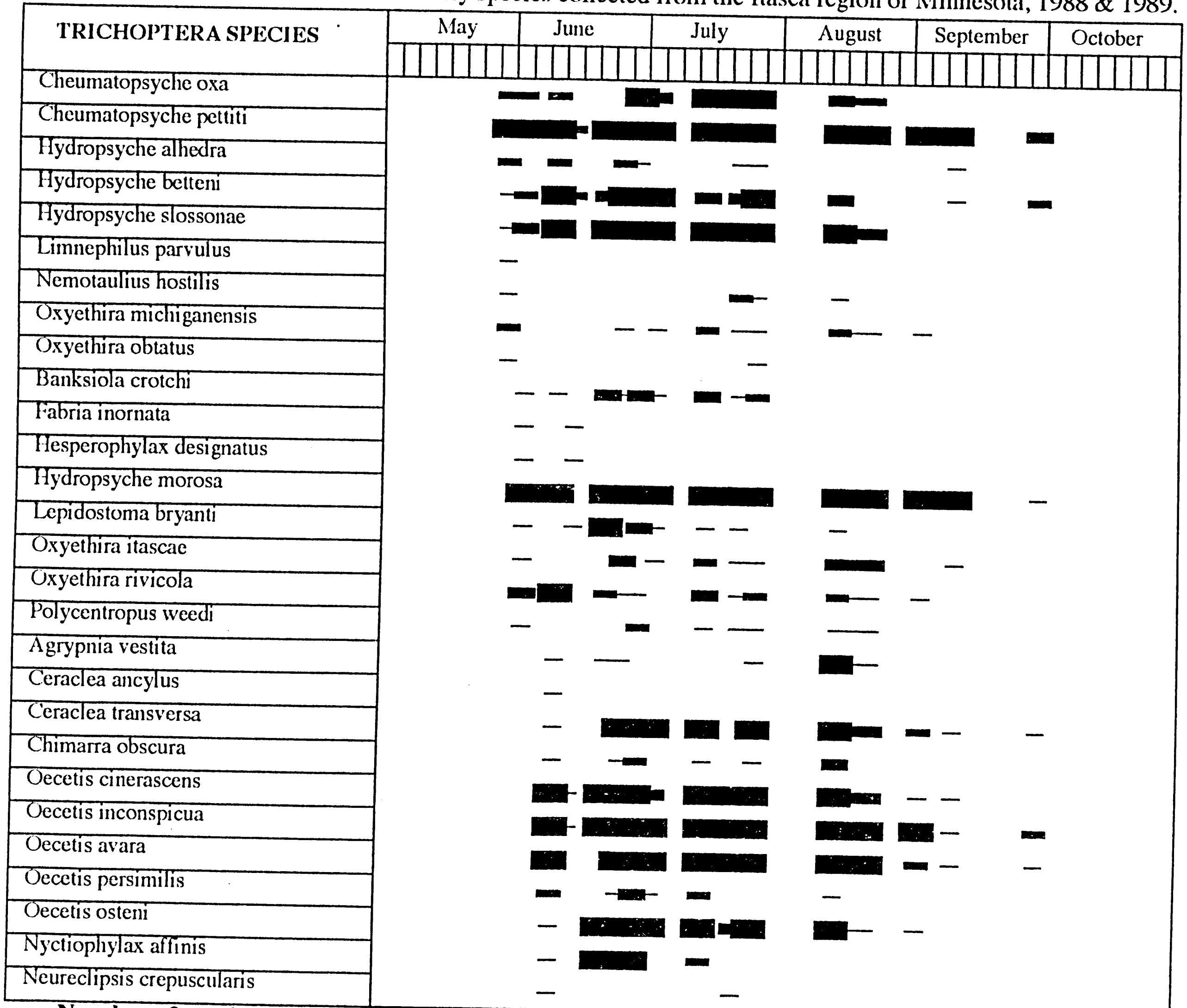
Seasonal Distribution

Seasonal distribution and abundance for all species collected during this study are shown in Table 6. The earliest flight activity was recorded at the end of May and included several *Cheumatopsyche* and *Hydropsyche* species, as well as *Oxyethira michiganensis* and *O. obtatus*, and one individual each of *Nemotaulius hostilis* and *Limnephilus parvulus*. *Neophylax concinnus* and *Pycnopsyche guttifer* were the last species to be collected the second week in October.

Species found to be most common overall were usually collected in large numbers and, generally, over the entire season; for example, *C. pettiti*, *O. inconspicua*, *T. marginatus*, *O. avara*, and *H. morosa*. Those species which were more moderate in abundance, such as *Leptocerus americanus*, *Helicopsyche borealis*, and *Hydropsyche betteni*, were collected in highest numbers from June through August. When comparing the phenology of some of the most abundant species from each collection site, I also observed that there were one-two peaks in total numbers of individuals collected during the year (Figs. 14-17).

Species in certain genera demonstrated limited periods of flight activity; *Fabria* (Phryganeidae), *Hesperophylax*, and *Hydatophylax* (Limnephilidae) were encountered only in June; *Banksiola, Hagenella*, and *Ptilostomis* (Phryganeidae) were collected from late May through July; *Glossosoma* and *Protoptila* (Glossosomatidae) were found only from late July through mid-August; *Neophylax* (Uenoidae) was collected from mid-August to the second week in October; *Pycnopysche* (Limnephilidae) was found from late July to the second week in October.

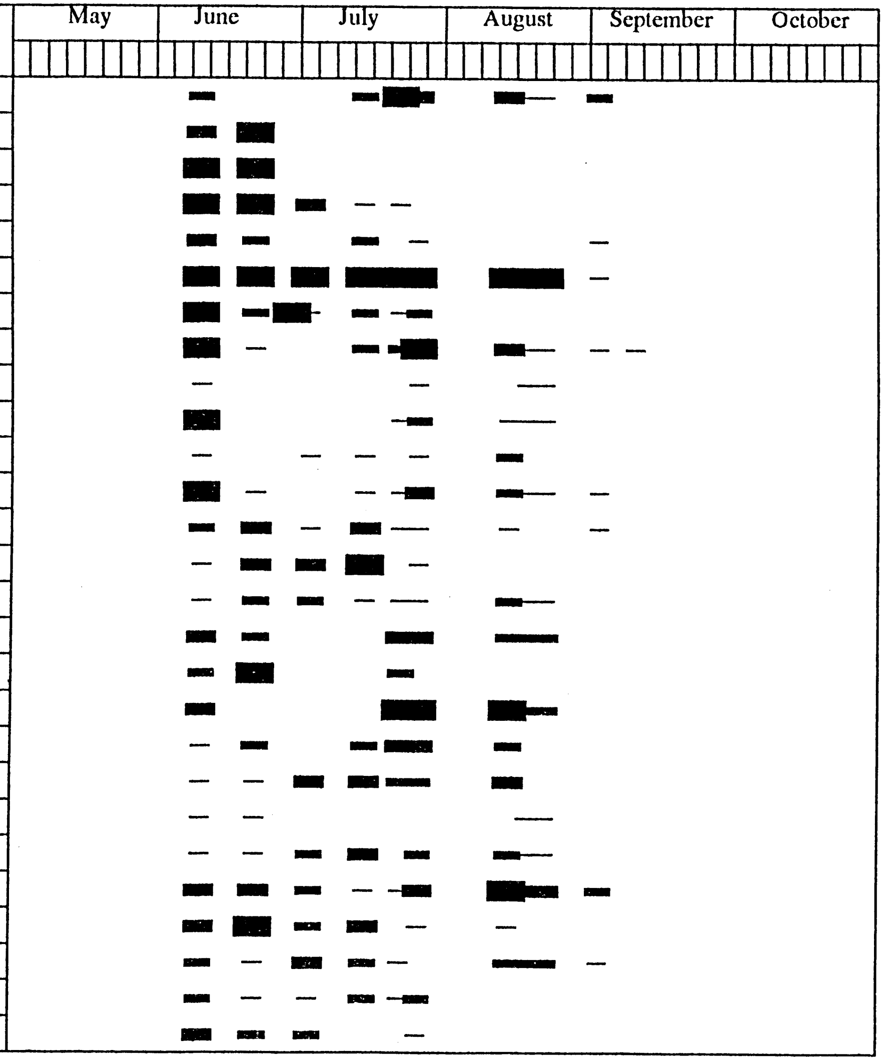
Table 6. Seasonal distribution of caddisfly species collected from the Itasca region of Minnesota, 1988 & 1989.



Number of specimens: — = 1-5; ▬ = 6-20; ■ = 21-50; █ = >50.

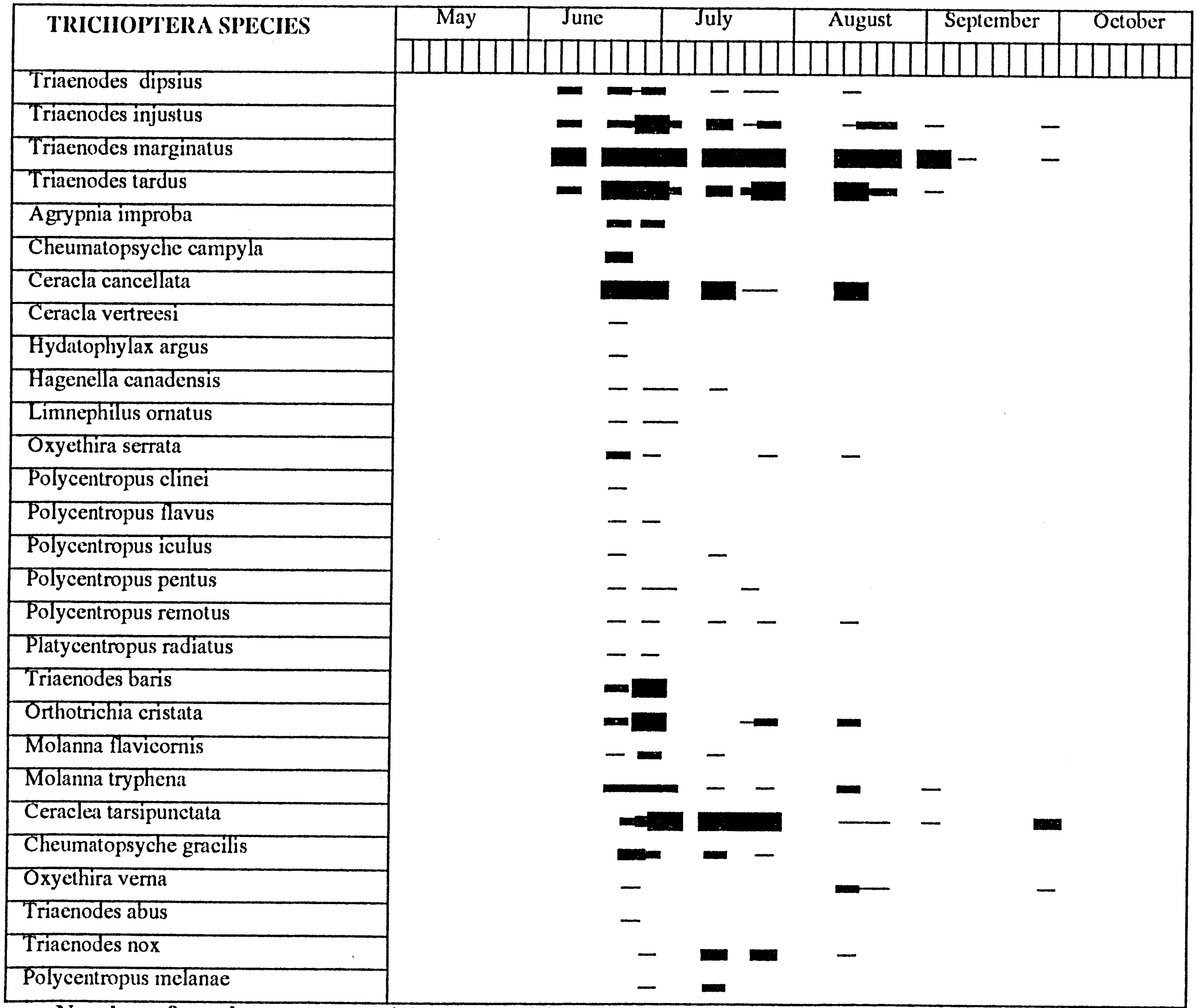
Table 6. Continued.

TRICHOPTERA SPECIES
Agraylea multipunctata
Ceraclea arielles
Ceraclea diluta
Ceraclea excisa
Ceraclea resurgens
Helicopsyche borealis
Hydropsyche vexa
Hydroptila armata
Hydroptila grandiosa
Hydroptila waubesiana
Hydroptila wyomia
Hydroptila xera
Lepidostoma togatum
Leptocerus americanus
Molanna uniophila
Mystacides sepulchralis
Nectopsyche albida
Nectopsyche diarina
Nyctiophylax moestus
Orthotrichia aegerfasciella
Oxyethira araya
Phryganea cinerea
Polycentropus cinereus
Polycentropus interruptus
Psychomyia flavida
Ptilostomis ocellifera
Ptilostomis semifasciata



Number of specimens: ___ = 1-5; ▬ = 6-20; ▬ = 21-50; ■ = >50.

Table 6. Continued.



Number of specimens: — = 1-5; ▬ = 6-20; ▬ = 21-50; ■ = >50.

Table 6 Continued.

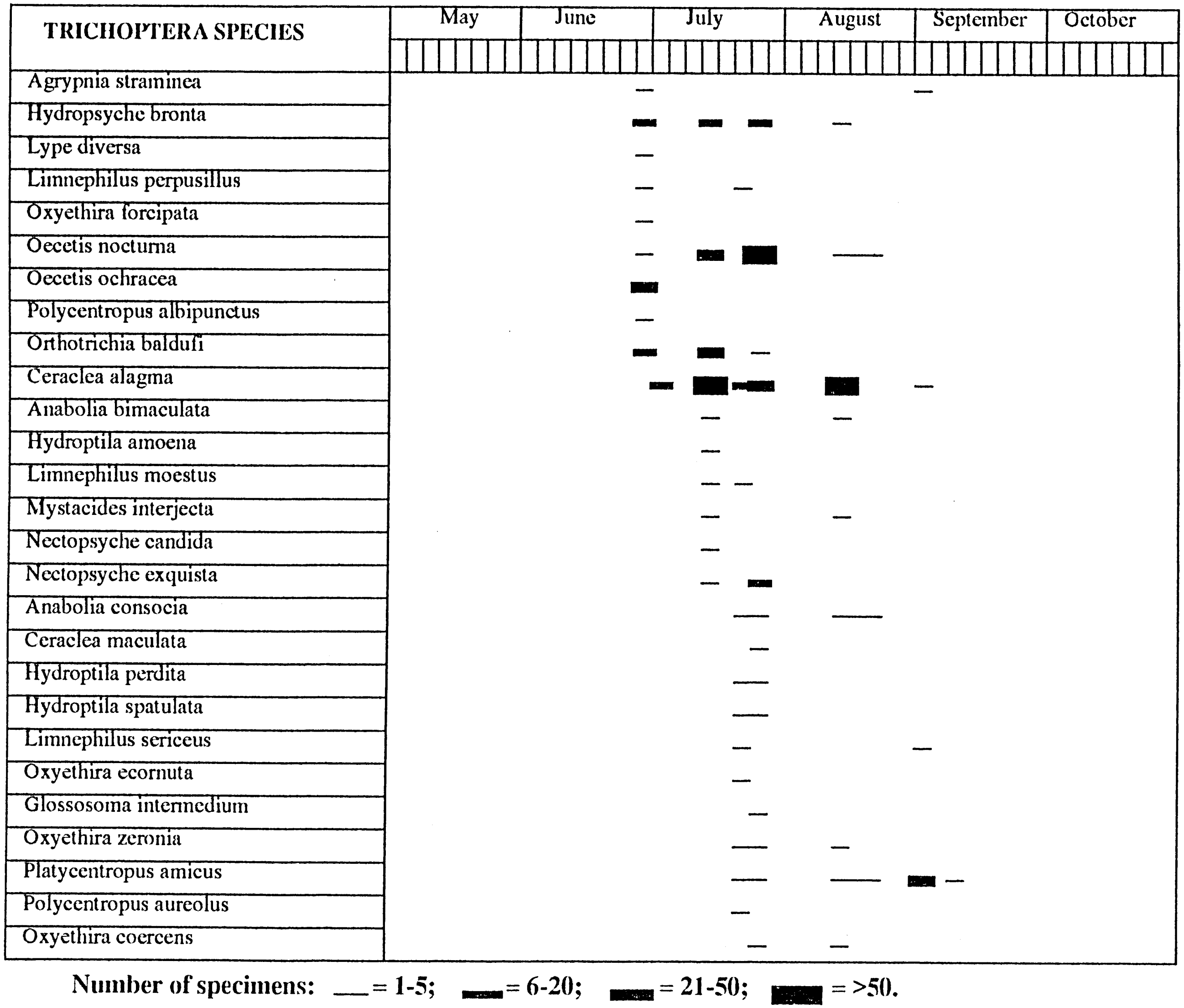
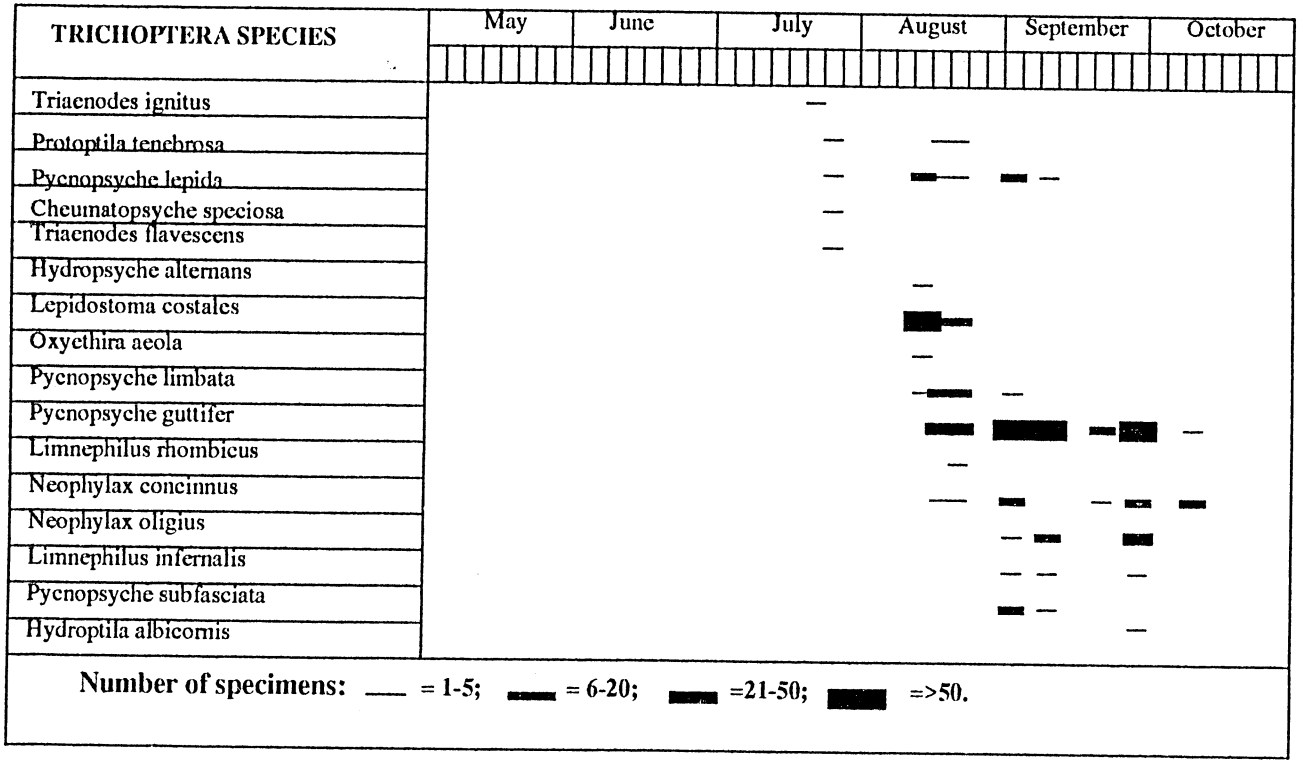


Table 6. Continued.



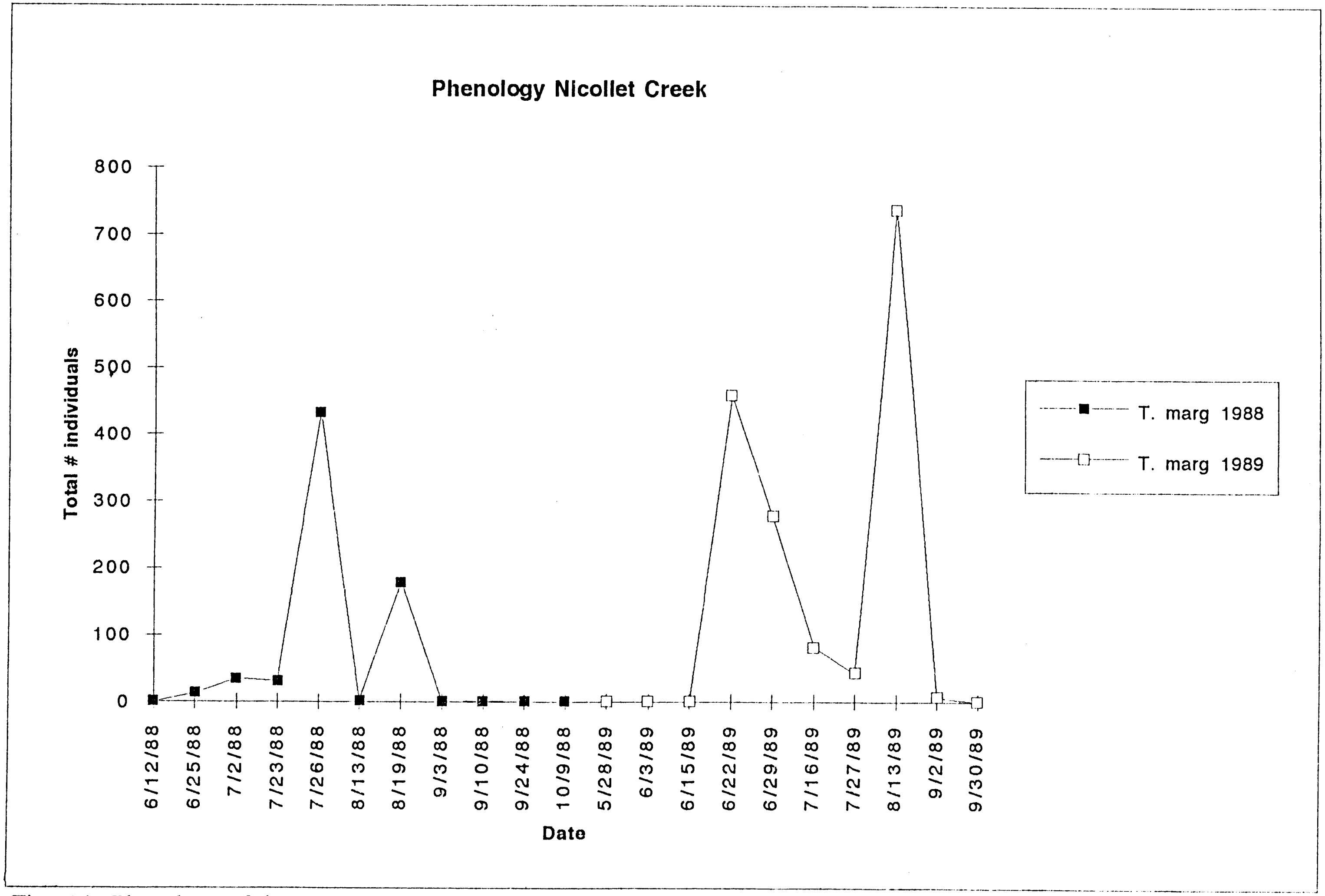


Fig. 14. Phenology of the most common species at Nicollet Creek, 1988 and1989.

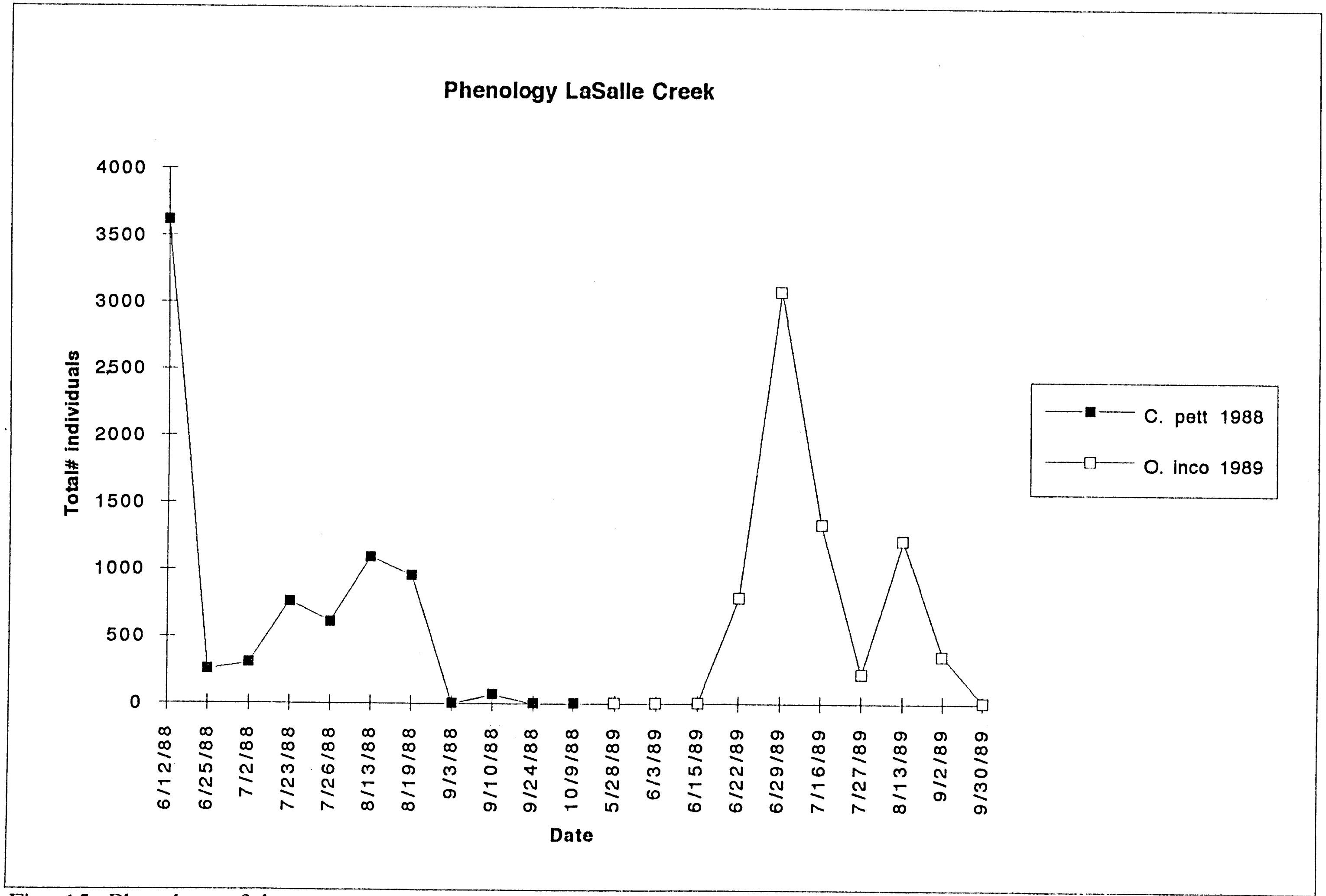


Fig. 15. Phenology of the most common species at LaSalle Creek, 1988 and 1989.

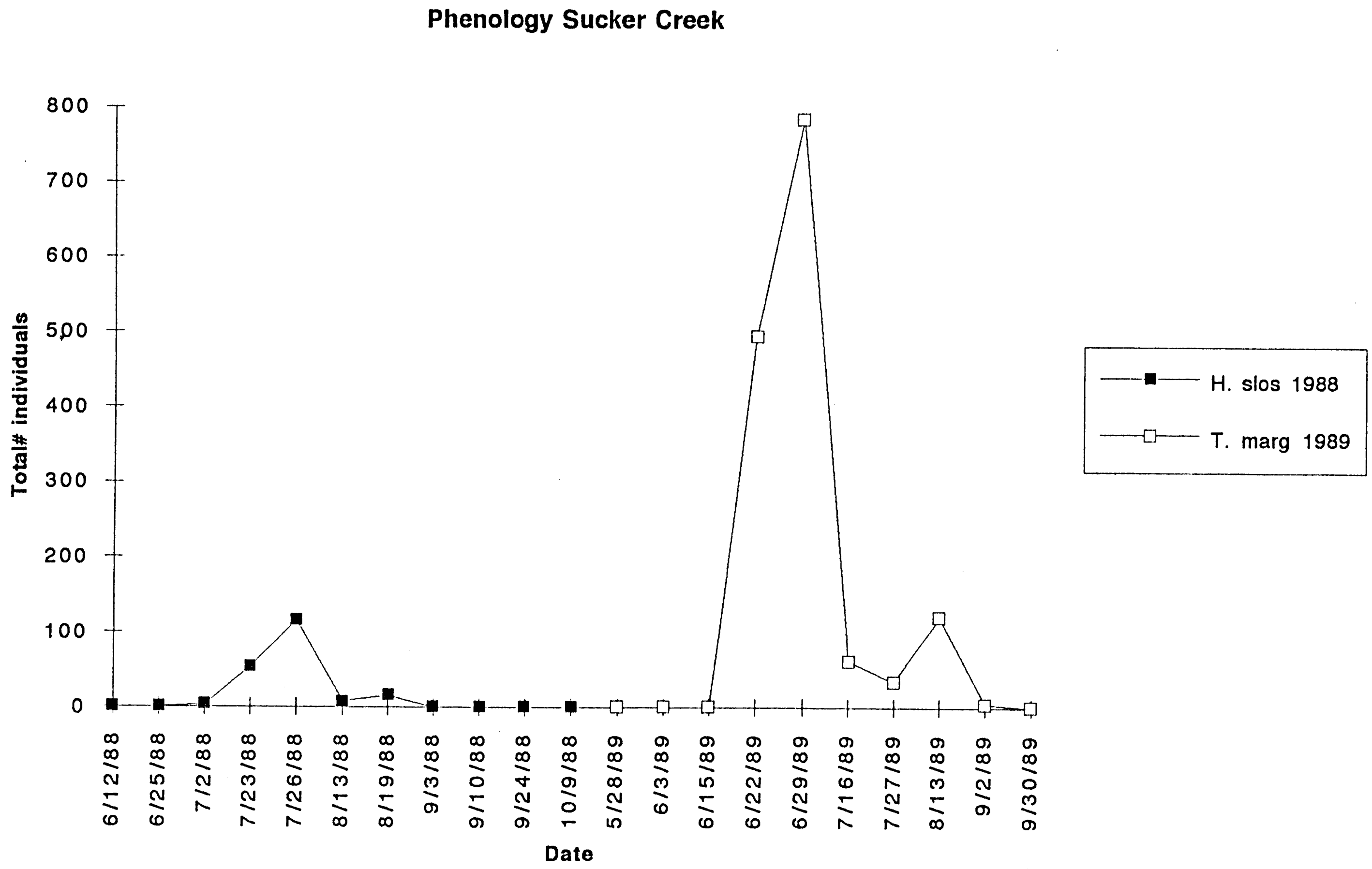


Fig. 16. Phenology of the most common species at Sucker Creek, 1988 and 1989.

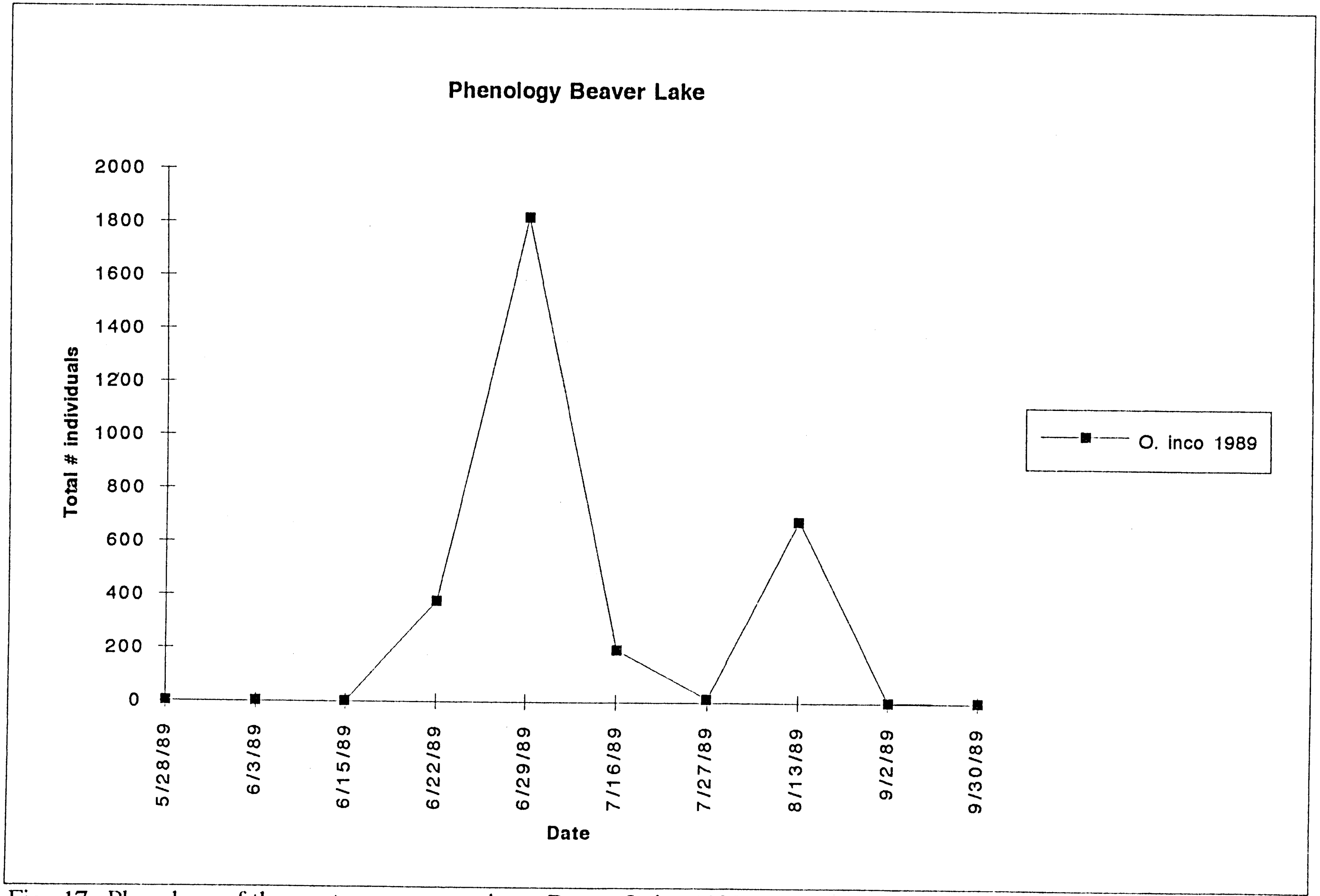


Fig. 17. Phenology of the most common species at Beaver Lake, 1989.

DISCUSSION

Species Richness. Many variables, including life histories, competition, physical and chemical properties of the habitat, dispersal, latitude, predator-prey dynamics, and geologic history, as well as collecting methods and regimes, may influence values for species richness (Coffin and Pfannmuller 1988, Peckarsky 1984, Ricklefs 1979). With the addition of 24 new state records discovered during this study (11 identified from material I collected, Table 1, Part I, pp. 29-33, and 13 from museum records, Table 1, Part III, pp. 123-133), there are currently 280 caddisfly species reported from Minnesota (Holzenthal and Monson unpub. 1994, Table 1, Part III). For comparison, the number of species recorded in some other midwestern states, North Dakota (Harris et al. 1980), Indiana (Waltz and McCafferty 1983), and Ohio (Huryn and Foote 1983, MacLean and MacLean 1984, Usis and Foote 1989), as well as states geographically removed from Minnesota, Kentucky (Floyd and Schuster 1990), South Carolina, Florida (Morse unpub. 1992), and Kansas (Hamilton et al. 1983), are included in Table 7. In comparison to the 126 species found during my study, Floyd et al. (1993) reported 93 species from two creek sites in South Carolina, Usis and MacLean (1986) reported 104 species from two swamp sites in Ohio, Floyd and Schuster (1990) recorded 79 species from 10 sites in the Buck Creek System, Kentucky, and Harris et al. (1982) found 56 species from 9 stream sites in the Florida panhandle region.

The high species richness of Trichoptera in Minnesota compared to many other states, may be due to the fact that the state has abundant and diverse aquatic resources, including the sources of three of the major drainage systems of North America within its borders, the Mississippi River, St. Lawrence/Great Lakes, and Hudson Bay. Minnesota can be geographically divided into nine watersheds, covering 4,000,000 acres and including over 15,000 lakes and 22,000 km of streams and rivers, which provide many pathways for the movement of aquatic species. There is also a history of preservation of these resources (Coffin and Pfannmller 1988). In addition there have been many caddisfly collectors working in the state for nearly 60 years, which may simply outnumber those elsewhere. The high diversity of caddisflies in the Lake Itasca region compared with other local studies may be due in part to its location at the confluence of the state's major biomes, where tallgrass prairie and eastern deciduous and northern coniferous forest species intermingle and aquatic habitats include bogs, temporary pools, ponds, and springs, together with lakes, creeks, and rivers. With little agricultural or industrial impact in this

Table 7. A comparison of caddisfly species richness at regional and local scales. (references cited in text).

	Species Richness	
	Regional (statewide)	**Local**
Minnesota	280	126
North Dakota	102	NA
Indiana	190	NA
Ohio	219	104
Kentucky	202	79
South Carolina	302	93
Florida	148	56
Kansas	104	NA

region a wide variety of natural habitats exist in an area that is in a relatively unaltered state, providing ideal habitats for caddisfly proliferation.

LaSalle Creek has the highest species richness (Table 2, p. 64) of all sites in this study, which may be attributed in part to a greater number of microhabitats available for colonization by caddisfly larvae than at the other sites, high levels of dissolved oxygen maintained by the rapid water flow at this location, and abundant nutrient resources. LaSalle Creek, with its sand and pebble bottom and aquatic macrophytes, as well as its proximity to a lake and large pool, offers diverse opportunities for retreat, net, and case-making activity and feeding; the substrate at the other sites appears to be of simpler structure. Beaver Lake has the lowest species richness of all sites in this study; fewer species would be expected at this location because lentic waters have been exploited by fewer caddisfly families due to lower levels of dissolved oxygen, the absence of flow regimes, and structural homogeneity (Wiggins 1977).

Relative Abundance. A characteristic pattern of distribution normally found in a community of plant and animal species reveals that most communities support a few very abundant species, some moderately common species, and a large number of species that are encountered rarely or in small numbers (Williams 1954). The rank abundance curve created with the data for the 25 most abundant species from all sites combined (Fig. 6, p. 65), as well as those for each site in my study (Figs. 7-10, pp. 66-69), reflect this predictable pattern of distribution. Williams (1954) demonstrated this relationship in a study of moths collected with a light trap over a four-year period, as did Crichton (1960), who collected caddisflies for the same length of time in England. Based on data from Williams (1964), Magurran (1988) examined species richness and relative abundance in communities of fresh-water algae and beetles and found the majority of species were represented by a single individual and only a few species were very common.

The preponderance of Leptoceridae species at all sites in my study is likely due in part to the fact that many of these species are able to exploit both lentic and lotic habitats and tolerate warm and cool water temperatures (Wiggins 1977). In addition, these species include predators, herbivores, and detritivores, feeding on diverse nutrient resources. Their larvae are capable of utilizing a variety of materials in the construction of their cases; *Oecetis* species are known to build cases of differing shapes out of tiny pieces of rock and/or bark, leaves, twigs, and stems. *Oecetis inconspicua* was among the most common species at three of my study sites. It is also widely distributed throughout the United States and often collected in very large numbers (Morse unpub. 1992, Ross 1944, Wiggins 1977).

The presence of *Cheumatopsyche* and *Hydropsyche* (Hydropsychidae) species in large numbers is probably due to the fact that these retreat-makers are able to colonize a variety of substrates found in flowing waters; larvae were encountered close together and densely covering the surfaces of rocks, submerged branches, leaf packs, and even a tin can. In addition, they are able to subsist on many different nutrient resources including diatoms and other algae, invertebrates, and detritus, utilizing them in differing proportions, depending on the season (Wiggins 1977, Wiggins 1984); this adaptability must also be a factor in their abundance. The highest numbers from these genera were found at LaSalle Creek (Table 1, pp. 29-30); this may have been related to the flow at this site, which was faster than at either of the other creeks. The faster the flow of water, the higher the level of dissolved oxygen, and the easier it is for the larvae to meet their respiratory requirements (Wiggins 1977).

Species abundance is influenced by complex intraspecific interactions as well as relationships between species and many other factors associated with the communities in which they live. Conditions which may affect the abundance of caddisfly species are discussed below, and include community structure, environmental factors, population fluctuations, and synchrony.

<u>Community structure</u>. Many ecological theories are based on competition (Cody and Diamond 1975). Predators represent a significant force influencing community structure because of their impact on the size of prey populations; predators in turn affect competition between prey species (Ricklefs 1979). MacArthur (1960) proposed that random partitioning of resources determined species abundance. Sugihara (1980) described a proportional relationship between the amount of niche space utilized by each species and its relative abundance. Research in tropical habitats has shown that for most taxa species richness increases as proximity to the equator increases (Dobzhansky 1950, Fischer 1960, Pianka 1978). This is thought to be related to greater structural heterogeneity and productivity occurring in these habitats, as well as to the lack of climatic fluctuations common to higher latitudes. If habitat productivity does not increase along with species richness, then species numbers may be dependent on the amount of overlap of resources or the degree of specialization (Ricklefs 1979). The relationship between resource heterogeneity and overlap, degree of specialization, and differences in species diversity, has been the subject of considerable discussion in the study of community organization (Ricklefs 1979). It seems plausible that those few species that are very abundant may be generalists, moderately abundant species may utilize some of the same resources, and the lower abundances of the many uncommon species may be related to the

specificity of their nutrient and habitat requirements. Larval habitats and specific food resources have not been described for most species. It is known, however, that the larvae of tube-case families are primarily detritivorous shredders (Wiggins 1984). Leptoceridae spp. were most common in my collections, and if larval behavior of these tube-case makers is consistent with others, they are most likely to be generalists. Hydropsychidae spp., also among the most common species I collected, are probably generalists as well; larvae are often sedentary and dependent entirely upon food particles carried into their nets (Wiggins 1984). It should be noted, that within these families, there were also some species that were very uncommon in my collections.

Environmental factors. The effect of wind, rain, ambient temperature, and moonlight on species richness and relative abundance of insects collected on any given date has been discussed for some taxa. *Mystacides interjecta* (Leptoceridae), has been commonly observed swarming on quiet evenings (Crichton 1960); they may be less likely to reach a light source under windy conditions. On the other hand, some species of Limnephilidae are capable of flying long distances and have been collected in particularly large numbers on rainy nights (Crichton 1960, Novak 1981). Waringer (1991) suggested that the effects of wind and precipitation on collection success were minimal, but peaks in collections were positively correlated with maximum night air temperatures. Although nightly air temperatures were not taken during this study, it was observed that caddisfly flight ceased below about 13° C. Variation has also been found in the extent to which individual species are attracted to light; Novak (1981) found that some *Cerclea* and *Mystacides* species were attracted weakly, or not at all. Janzen (1983) observed that moths were less attracted to artificial lights on moonlit nights; this may also be true for caddisflies.

Population fluctuations. The relative abundances of species collected during the two years of this study would most likely be different in other years due to natural fluctuations in populations. It is thought that a balance is achieved between stabilizing and unstabilizing forces in predator and prey populations, and oscillations are normal in these systems (Ricklefs 1979). The survival of species that occur in large numbers and are well distributed throughout the flight activity period in a given year may be partly due to predator satiation. Individual predators are able to consume prey only to the point of satiation (Ricklefs 1979). Perhaps less common species or those that are active as adults for shorter periods may be able to avoid some predation simply because they are less apparent. For adults that are active for limited periods, it may be because larval food resources are temporally limited; for the Nearctic genus *Pycnopsyche*, for example, it is thought that females oviposit only in the autumn, because larvae require the nutrients provided by the allochthonous input of the fall season (Wiggins 1977). Waringer (1991) and Crichton (1974), report two activity periods for single generations of *Limnephilus* spp., beginning with adult emergence during spring and early summer; both sexes are inactive in a resting stage over the summer while the female ovaries mature, and full flight activity begins in the fall.

It is not obvious why there were such large differences in abundances for many species between 1988 and 1989 (Figs. 11-13, pp. 71-73). Great variations in numbers from year to year have been reported for certain groups of stream insects, while other groups have been found to be very constant. Among Trichoptera some species of the microcaddisflies (Hydroptilidae) are quite variable from year to year, while, in general, the Limnephilidae are very stable (Crichton 1974). Depending on environmental conditions, the timing of adult emergence may be altered from year to year, and this could be a factor in the numbers collected. For example, Brittain (1976) studied the effects of artificial change in temperature and photoperiod on the emergence of adult mayflies and stoneflies and concluded that although timing of emergence was not altered by changes in photoperiod, adults emerged several weeks early when water temperatures were raised. Since most collections in my study were made about two weeks apart, this may mean that some species were not attracted at the optimal time. Therefore, these differences in abundances may again be a reflection of normal population fluctuations (Ricklefs 1979) created through the balancing of forces in the environment.

Synchrony. Synchrony, most frequently reported for adults than for other stages, often affects caddisfly abundance (McElravy et al. 1982) and is known to create sharp seasonal peaks for some temperate caddisfly species (Crichton 1960). The most obvious adaptive significance of this behavior is the increased liklihood for short-lived adults and those with small populations to find a mate. For species associated with temporary or otherwise restricted habitats, synchrony also helps to insure the reproduction of sustainable populations where opportunities may be limited. Synchrony may have been a factor in determining the numbers of individuals collected during my study in certain instances, because distinct peaks in abundance were recorded for the most common species at each site.

Sex ratios. Sex ratios for aquatic insects are generally based on adult collections, since it is usually difficult to determine the sex of immatures. The specimens collected at light traps are a measure of the relative activity of the sexes and their attraction to light, and they do not necessarily indicate natural proportions found in nature. There may not be equal numbers at adult emergence; sex ratios have shown significant variation on different nights (Crichton 1960). The results of my study indicate that the peaks in numbers of individuals for the most common species at the creek sites generally reflect the collection of greater numbers of females on those dates than on others (Table 4, p. 75). Flannagan and Lawler (1972) recorded a majority of females for most of the 19 caddisfly species collected from a lake in Manitoba. Flannagan (1977) reported a 2:1 to a 20:1 ratio of females to males for 20 out of 42 caddisfly species from a Manitoba river. A four-year study of caddisflies collected in England resulted in 38% of the species having a majority of females (Crichton 1960). It has been suggested that the occurrence of large numbers of females in a population may be a strategy that insures that males find more than one female; since one male may be able to copulate with more than one female, this increases the total number of progeny (Pianka 1978). In addition, the affect of climatic conditions (Resh and Sorg 1978) and pre-emergence differential mortality (LeSage and Harrison 1980) have been considered in attempts to explain sex ratios for aquatic insect species. Parthenogenesis is also reported for some caddisflies (Corbet 1966).

Diversity, Evenness, and Similarity. Brillouin's formula (Pielou 1966, 1969), which takes relative abundance into account, was used to calculate diversity indices for each site. Although not commonly employed due to the lengthly calculations, this method is recommended for use in collections representing non-random samples and for those for which all members can be identified and counted. Pielou (1966) suggested Brillouin's formula to estimate diversity for light trap collections. Values calculated for my study using the Brillouin formula ranged from 2.55, for LaSalle Creek, to 1.97 for Beaver Lake (Table 2, p. 64). In other studies, a Brillouin index of 1.65, was used to estimate diversity for caddisflies collected in a light trap in Illinois (Poole 1974), and a value of 1.88 was calculated for a study of moths collected in Northern Ireland (Magurran 1988). MacLean and MacLean (1984) employed Brillouin's formula in determining diversity for each date that caddisflies were collected from an Ohio marsh from spring through fall for an entire season; values ranged from 0.04-1.04. In these examples, since collections, not samples, are being compared, diversity values are significantly different from each other (Magurran 1988).

Shannon's formula (Krebs 1985, Margalef 1957) is commonly used by ecologists to estimate diversity when the populations sampled are infinitely large (Pielou 1966) and because of its computational simplicity (Magurran 1988). Out of curiosity, I also entered figures from my data into the Shannon formula and found the values to be very close to those calculated with Brillouin's formula; values ranged from 2.55 for LaSalle Creek, to 1.98 for Beaver Lake (Table 2, p. 64). Indices derived from calculations using the

Shannon and Brillouin diversity formulas were also compared by Magurran (1988), using abundance data from caddisflies collected from a stream in Illinois (Poole 1974); values were also close, 1.69 and 1.65, using the Shannon and Brillouin formulas, respectively.

The actual diversity of a collection is calculated as a percent of the maximum diversity and is known as the measure of evenness (Pielou 1966, 1969). Evenness measures how equally abundant species are in a collection, and high evenness is generally accepted as a measure of high diversity (Magurran 1988). Evenness is determined by dividing the observed diversity (value calculated using a diversity formula) by the maximum diversity (all species are equally abundant). The evenness at each site in my study was moderate, and was calculated as 0.51 at Beaver Lake, 0.57 at Sucker Creek, 0.58 at LaSalle Creek, and 0.61 at Nicollet Creek (Table 2, p. 64). The diversity at these sites may then also be considered moderate. In comparison with other arthropod studies, evenness was calculated as 0.83 for the moths collected with a light trap in Northern Ireland (Magurran 1988), 0.62 for the collection of caddisflies in Illinois (Poole 1974), and 0.85 for the fauna of beech litter in an English woodland (Lloyd and Ghelardi 1964). Values for these studies may be higher than for my study because species richness and abundances are greater in my study.

The beta diversity of pairs of sites in my study was estimated through the use of Sorensen's similarity coefficient (Southwood 1978) (Table 5, p. 76). The pairs of sites used to assess similarity included all possible combinations (distances between sites are in parentheses): Beaver Lake/Nicollet Creek (2.0 km), Beaver Lake/LaSalle Creek (17.6 km), Beaver Lake/Sucker Creek (5.6 km), Nicollet Creek/LaSalle Creek (18 km), Nicollet Creek/Sucker Creek (6.8 km), and LaSalle Creek/Sucker Creek (12.6 km). Based on the Sorensen formula for qualitative data, which uses the species richness at each site and the number of species common to both sites in each pair, the degree of similarity between all pairs was moderate. On a scale from 0 (no species in common) to 1.0 (identical species composition), values ranged from 0.59-0.71 (Table 5). Using the Sorensen formula for quantitative data, which uses species richness and total abundance at each site, values for all pairs of sites which included LaSalle Creek ranged from 0.17-0.20. All pair combinations which did not include LaSalle Creek had values ranging from 0.91- 0.97 (Table 5). From these calculations, it appears that LaSalle Creek, together with any of the other sites, represents a pair made of less similar halves than any other combination of sites. It seems plausible that LaSalle Creek has less in common with the other sites than they do with each other. The substrate at LaSalle Creek is more variable than at the other sites, from sand and gravel to pebble and cobble, and leaf packs have formed in a log jam.

The water flow is faster at this creek than at the others, creating a well-oxygenated environment for larvae, and there are lentic waters nearby, in the form of LaSalle Lake to the south and a large shallow pool to the north. These factors may create more possibilities for colonization of microhabitats by many different species than at any other site in this study.

Distances between sites were also considered in interpreting similarity values. The pairs of sites with the highest similarity values, those that do not include LaSalle Creek, are located closer to each other than pairs including LaSalle Creek. It may be argued that this similarity is due in part to the fact that those species may be within dispersal distance of each other. The similarity values do not decrease exactly according to the increase in distances between sites, however.

The Sorensen formula was used to measure the beta diversity of birds in managed and unmanaged regions in the United Kingdom; values of 0.63 and 0.44 were reported when qualitative and quantitative data were used (Magurran 1988). Harris et al. (1991) measured the similarity of caddisfly fauna between five physiographic sections in Alabama and values ranged from 0.61-0.79 using qualitative information. Since collecting methods used in these studies were different than in mine and species richness and abundances were much lower than what I encountered, these values are intended only for general comparison.

Seasonal distribution. Many environmental factors are thought to affect the timing of the emergence of aquatic invertebrates. Vannote and Sweeney (1980) found that adult emergence for some mayflies was dependent upon the water temperature within an individual stream; results suggested that there was a temperature threshold beyond which the rate of growth of adult tissue was increased. Richardson and Clifford (1986) found a relationship between adult phenology and latitude for the caddisfly species *Helicopsyche borealis* and *Oecetis inconspicua* and suggested that temperature and photoperiod may affect their development. Malicky (1981) discovered that a change in photoperiod altered the normal emergence pattern of several caddisfly species, whereby emergence was extended over a longer part of the year. Wiggins et al. (1980) discussed ecological strategies of the insect fauna in annual temporary pools, which are thought to represent the extreme in the adaptation of life cycles according to season; the distinct seasonality in life cycles included rapid development during the wet phase. Nutrition may also play a role in the phenology of aquatic insects. Anderson and Cummins (1979) found food quality and quantity affected growth rate; they reported an increase in length of development time for limnephilid species fed a diet lower in nutrients compared to those on a diet supplemented with extra nutrients. Presumably, lengthening larval development time delays adult emergence.

Several studies have reported the seasonal distribution for caddisfly adults in North America. When comparing the seasonal distribution of some of the Minnesota species to the same species in Ohio, I found flight periods are frequently very similar. *Agraylea multipunctata*, *Cheumatopsyche oxa, C. pettiti, Oecetis cinerascens, O. inconspicua, Ptilostomis ocellifera*, and *Banksiola crotchi*, are examples (Huryn and Foote 1983, MacLean and MacLean 1984, Marshall 1939). In a comparison of species in Saskatchewan and Minnesota, *Phryganea cinerea, Helicopsyche borealis*, and *Ceraclea tarsipunctata* have shorter periods of adult activity in Saskatchewan (Milne 1943) than in Minnesota. In Kentucky, *C. pettiti, C. oxa, O. cinerascens, O. inconspicua*, and *H. borealis* had longer flight periods the same species in Minnesota (Floyd and Schuster 1990). For the species in these examples, water and ambient temperatures are probably important factors affecting adult emergence and activity periods. The climate in Ohio may be close enough to that in Minnesota to allow similar caddisfly behavior for some species, while the colder temperatures in Saskatchewan probably shorten Trichoptera flight periods in some cases. Conversely, the warm temperatures in Kentucky most likely increase the length of the activity period for many adult species. A trend toward a shorter capture period with increasing latitude was recorded for *H. borealis* and *O. inconspicua* (Richardson and Clifford 1986). It should be noted that there are also species common to Minnesota and the localities in these studies for which flight periods are quite dissimilar. For example, *Oecetis osteni* has been recorded for a three-week flight period in Ohio, compared to a three-month flight period recorded during my study in Minnesota (Huryn and Foote 1983). Adult flight was recorded from June to September for *Molanna flavicornis* in Saskatchewan (Milne 1943) but only for four weeks in Minnesota. Adults were active from mid-July to mid-September for *Hydropsyche betteni* in Kentucky (Floyd and Schuster 1990) but from late May through September in Minnesota.

The most common species in my study, *C. pettiti* (Hydropsychidae) and *O. inconspicua*, were generally found to be active as adults over the entire season in Minnesota, from late May through September (Table 6, p. 78-82); similar flight periods were also reported for these species in Indiana (Waltz and McCafferty 1983), Ohio (Huryn and Foote 1983, MacLean and MacLean 1984, Marshall 1939), Kentucky (Floyd and Schuster 1990), and Alabama (Harris et al. 1991). In many studies Hydropsychidae species and *O. inconspicua* (Leptoceridae), in particular, have been found to be common, widespread, and abundant. Hydropsychidae species are the most commonly collected caddisflies in Indiana, and *O. inconspicua* is considered the next most common species in that State (Waltz and McCafferty 1983). Hydropsychidae species are also the most frequently collected caddisflies in Idaho (Newell and Minshall 1977). *Oecetis inconspicua* is the most abundant and widely distributed *Oecetis* species in Alabama (Harris et al. 1991) and is considered one of the most common of all caddisflies in Illinois (Ross 1944).

Some of the most abundant species in my study had one-two peaks in numbers of individuals during the year (Figs. 14-17, pp. 83-86). For those species with two activity peaks, there may be more than one generation produced in the year, often with overlapping cohorts (Crichton 1974). Since larvae are in competition for niche space and food, demand for these resources is then spread out over the season. In contrast, Waringer (1991) found that larvae of species with short activity periods had clearly separated instars and fairly synchronous pupation.

Some of those genera with species exhibiting limited periods of adult flight during my study were identified with similar behavior in other parts of North America. *Glossosoma intermedium* was found to be active as an adult only during late July in Minnesota while *Pycnopsyche* spp. had eight-nine weeks of adult flight at the end of the season. In Kentucky, *Glossosoma* sp. show two short periods of activity, the first week in June and the last week in July, and *Pycnopsyche* spp. are active for four-six weeks at the season's end (Floyd and Schuster 1990). In Alabama, *Pycnopsyche* spp. are generally encountered as adults from September-November; some species have additional emergences in the spring (Harris et al. 1991), suggesting two generations each year. I collected *Hydatophylax argus* only in June, but it is recorded from January-March and again in October in Alabama (Harris et al. 1991); this may be a species with two generations per year, at least in the southern United States. Adult flight for *Neophylax concinnus* was recorded only in August and September in Minnesota during my study; records are the same in Indiana (Waltz and McCafferty 1983).

SUMMARY AND CONCLUSIONS

Of the 280 species of caddisflies known from Minnesota, 126 species from 37 genera and 13 families were collected during this study. The families Leptoceridae and Hydropsychidae accounted for 58% and 32% of the species, respectively. This was not unexpected for these are large, often abundant, and widely distributed families having species adapted to cool lotic and warm lentic habitats (Wiggins 1977). Limnephilidae, the most species-rich North American family with over 300 species, accounted for only 8% of the species; they are most common in cool waters in mountainous higher latitudes. Although Rhyacophilidae and Arctopsychidae species are reported from Minnesota, I did not expect to encounter them since they are usually associated with cool waters in high elevations. The family Sericostomatidae is rarely represented by more than a few genera and species in any faunal region and was probably not collected because it is commonly found in small springs and along wave-washed shores (Wiggins 1977). I was disappointed not to find Brachycentridae since it has been frequently found in the region, nor Dipseudopsidae, which has been reported throughout the State. Species of some genera of Brachycentridae are known to be diurnal, emerging in the early spring, and have been found crawling on sunny snow-covered surfaces (Wiggins 1977); it is possible that temperatures by nightfall during May were too low for these species to be active or they are species less attracted to artificial lights than most caddisflies. Goeridae has been recorded from the general region but is rarely encountered (Etnier 1965). Although the sites chosen for this study were somewhat physically different in substrate, vegetation, and flow regime, collections from other habitats in the region, such as small pools, large lakes, springs, and rivers, would very likely result in the discovery of additional species.

The most common species among all four sites over two years in descending order were *Oecetis inconspicua*, *Cheumatopsyche pettiti*, *Oecetis avara*, *Triaenodes marginatus*, and *Hydropsyche morosa*. *Cheumatopsyche pettiti* was most abundant at LaSalle Creek, *T. marginatus* was most common at Nicollet Creek and Sucker Creek, and *O. inconspicua* was most common at Beaver Lake.

Of the species that were rarely collected (≤5 individuals), most were members of the family Limnephilidae and included *Hesperophylax designatus*, *Hydatophylax argus*, *Limnephilus infernalis*, *L. moestus*, *L. ornatus*, *L parvulus*, *L. perpusillus*, *L. rhombicus*, *L. sericeus*, and *Platycentropus radiatus*. The others were *Glossosoma intermedium*, *Protoptila tenebrosa* (Glossosomatidae), *Cheumatopsyche speciosa*, *Hydropsyche alternans* (Hydropsychidae), *Neureclipsis crepuscularis*, *Polycentropus albipunctus*, *P.*

aureolus, P. clinei, P. iculus (Polycentropodidae), *Lype diversa* (Psychomyiidae), *Agrypnia straminea, Fabriainornata* (Phryganeidae), *Ceraclea ancylus, C. maculata, C. vertreesi, Mystacides interjecta, Nectopsyche candida, Triaenodes abus, T. flavescens,* and *T. ignitus* Leptoceridae). There were six species represented by only one individual and all were found at LaSalle Creek: *Polycentropus aureolus, Limnephilus rhombicus, Ceraclea ancylus, C. maculata, Triaenodes abus,* and *T. ignitus.*

By employing Brillouin's diversity formula and calculating evenness, values indicated all sites have moderate diversity. When beta diversity was described by measuring the association between pairs of sites, combinations including Nicollet Creek, Sucker Creek , and Beaver Lake were more similar than any pair containing LaSalle Creek.

The seasonal distribution of the most common species generally revealed the flight activity of large numbers of adults over the entire season, with one-two peaks in numbers of individuals for most of these species; peaks frequently reflected larger numbers of females than males on those dates. Those species collected in moderate numbers were actively flying for about three months. The flight period for members of certain genera was limited to only two-four weeks, including *F. inornata, H. designatus,* and *P. tenebrosa.* For those species represented by a single collection in a given year, flight periods may have been much shorter.

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PART II

A NEW SPECIES AND NEW RECORDS OF *OXYETHIRA* (TRICHOPTERA: HYDROPTILIDAE) FROM MINNESOTA

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A new species and new records of *Oxyethira* (Trichoptera:Hydroptilidae) from Minnesota

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Abstract. Males of a new species of microcaddisfly, *Oxyethira* (*Holarctotrichia*) *itascae*, (Trichoptera: Hydroptilidae) from the Lake Itasca region of northern Minnesota are described and illustrated. This represents the first new species of Trichoptera described from the State in nearly twenty years. Fifteen other *Oxyethira* species are known from the State, including *O.* (*Dampfitrichia*) *verna* Ross and *O.* (*Oxyethira*) *ecornuta* Morton, new records for Minnesota and the United States, respectively.

Key words: Oxyethira (*Holarctotrichia*) *itascae*, caddisflies, endemic, biome.

Fifty-eight of the 280 species of Trichoptera known from Minnesota are members of the family Hydroptilidae and, of these, 16 are species of *Oxyethira* Eaton. *Oxyethira* species have been reported from all the major faunal regions of the world, with species records throughout the North American continent. The larvae are typically encountered in standing waters or in lotic habitats where the current is slow. They commonly are located on submerged aquatic plants, where they feed on filamentous algae and diatoms. Some species have been discovered in faster-flowing waters on rocky, moss-covered substrates (Marshall 1979). Larvae of North American *Oxyethira* may be identified by their exceptionally long, slender meso and metathoric legs, which are at least 2 ½ times longer than their prolegs, a long distoventral lobe on the fore tibiae, and very long antennae relative to most other genera in the family. In the final instar, larvae are found within flattened, bottle-shaped cases constructed entirely of silk (Wiggins 1977).

Lake Itasca, headwaters of the Mississippi River, is in a region of Minnesota where the northern coniferous forest, eastern deciduous forest, and tallgrass prairie biomes meet (Fig. 1). During 1988 and 1989, adult caddisflies were collected at the edge of three creeks and one small lake near Lake Itasca, as part of a study on the phenology and diversity of the Trichoptera of the region. During the study, a new species of *Oxyethira* was discovered, which we describe here.

Methods

Trichoptera were trapped with 15-watt D.C. black lights suspended over pans containing 80% ethanol and placed at water's edge. Collections were made every two weeks from May to October, 1988 and 1989. Specimens were cleared in 10% KOH solution (Ross 1944). Due to their small size, they were examined under compound and dissecting microscopes for identification; illustrations were made with the aid of a drawing tube attachment on an Olympus BH-2 compound microscope. Terminology for genitalic structures follows that of Kelley (1984). Type material is deposited in the University of Minnesota Insect Collection, St. Paul (UMSP), the National Museum of Natural History, Smithsonian Institution, Washington, D.C. (NMNH), and the Illinois Natural History Survey, Champaign, Illinois (INHS), as indicated below.

Oxyethira (*Holarctotrichia*) *itascae* Monson and Holzenthal, new species Fig. 2

Diagnosis. *Oxyethira itascae* is assigned to the subgenus *Holarctotrichia* Kelley because of possession by the males of long dorsolateral processes on segment VIII, convergent but separate subgenital processes, and an elongate titillator on the phallus (Kelley 1984). *Oxyethira itascae* bears some resemblance to *O. distinctella* Mac Lachlan and *O. araya* Ross, both in the subgenus *Holarctotrichia*, in the shape of segments VIII

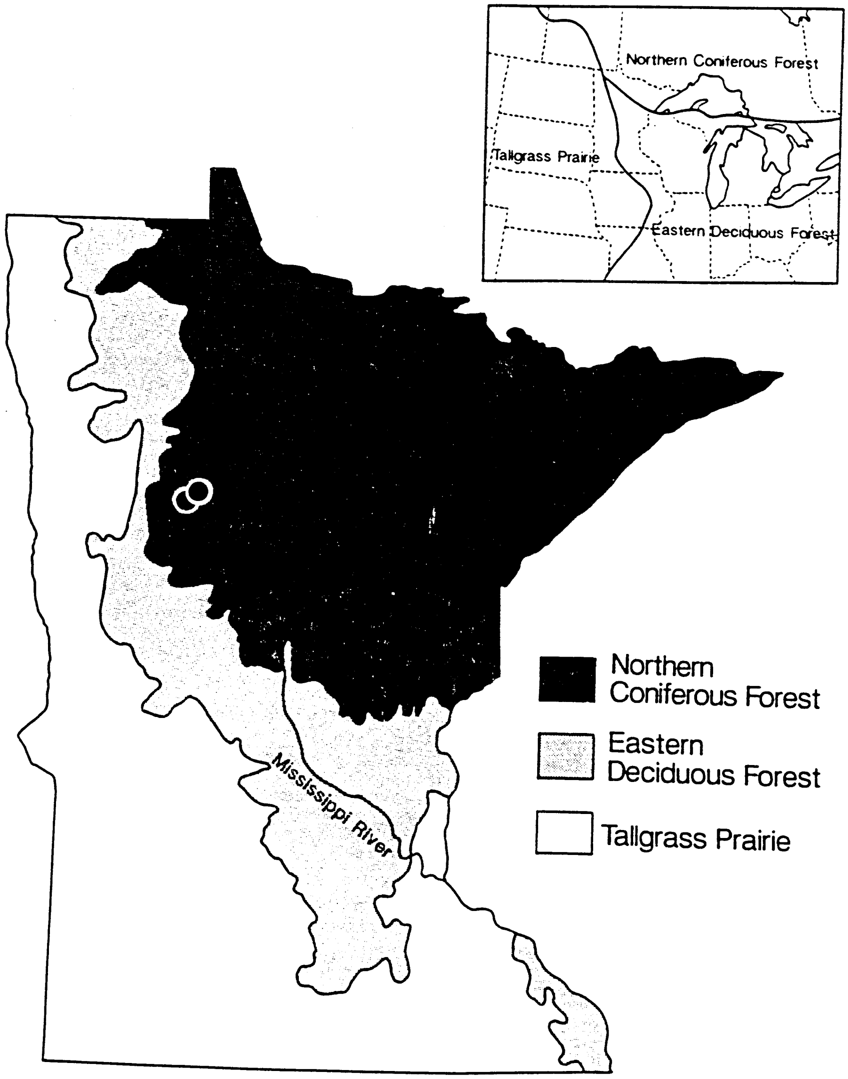

FIG. 1. The three major biomes of Minnesota and the distribution of *O. itascae*, n. sp. Inset: Approximate extent of the same biomes in the Great Lakes region.

and IX. In *O. araya* and *O. distinctella* the posterior margin of segment VIII possesses a triangular configuration similar to *O. itascae*, and the dorsolateral processes are similar to the medial pair of processes in the new species; also, in *O. araya* and *O. distinctella* the truncate dorsal margin of segment IX resembles that of *O. itascae* (Kelley 1986). The presence of two pairs of elongate dorsolateral processes on segment VIII distinguishes the new species from all others in the subgenus in North America.

The new species can be determined using Blickle's (1979) key to *Oxyethira* species with slight modifications to his first couplet and the addition of a third choice.

1. 8th tergite produced into a single process on the apicolateral margin 2
- 8th tergite not produced into processes on apicolateral margin 14
- 8th tergite produced into two processes on the apicolateral margin .. *itascae*, n. sp.

Description. Males. Length 2.8-3.0 mm. Brown in alcohol. Antennae with 25-32 seg-

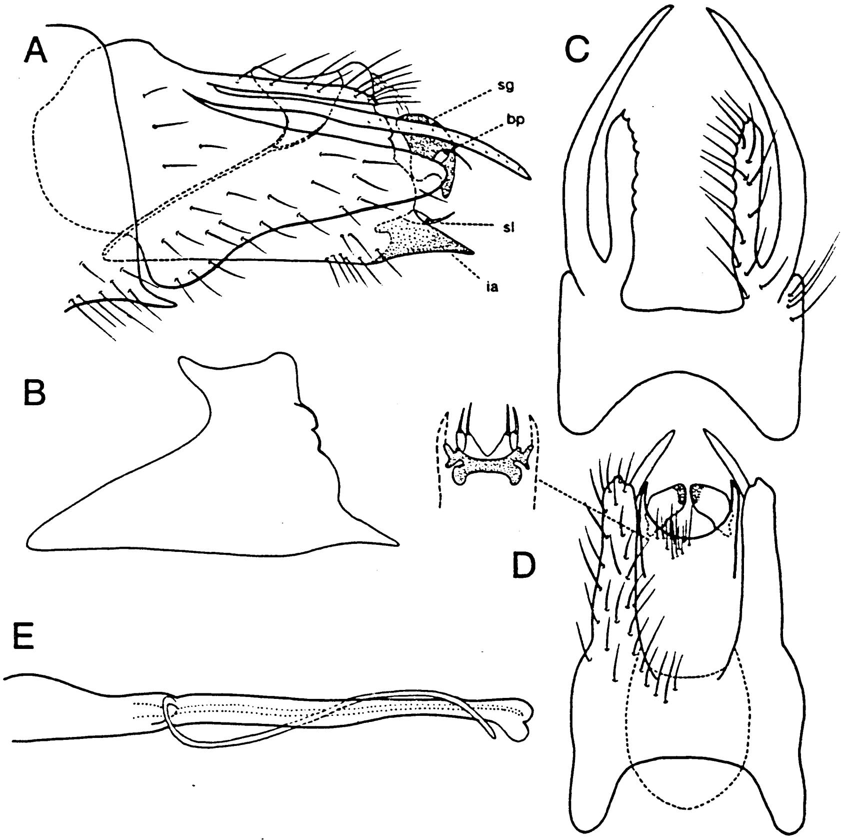

FIG. 2. *Oxyethira itascae*, new species, male genitalia. A. Segments VII–X, lateral; B. Segment IX, lateral; C. Segment VIII, dorsal; D. Segments VIII and IX, ventral, inset: details of inferior appendages, subgenital processes, and bilobed processes; E. Phallus, dorsal. Abbreviations: bp = bilobed process; ia = inferior appendage; sg = subgenital process; sl = setal lobe.

ments. Genitalia as in Figure 2. Abdominal sternum VII with apicomesal process. Segment VIII roughly triangular in lateral view, with tapering posterior margin; dorsally, with squared posteromesal excavation and two pairs of elongate dorsolateral processes: lateral pair elongate, extending beyond apex of segment IX, slender, acute apically, curved mesally; medial pair about ½ length of lateral pair, setose, with apicomesal serrations. Segment IX roughly triangular in lateral view, retracted within VIII; in lateral view, dorsal margin truncate, dorsal and lateral edges semimembranous, except for sclerotized region on posterior margin. Inferior appendages fused to IX with U-shaped configuration in ventral view, mesally setose, tapered to acute apex, slightly curved mesally. Subgenital plate prominent, sclerotized, with convergent digitate apices; setal lobes and bilobed processes each with single seta. Segment X entirely membranous. Phallus simple with spiralled titillator.

Females and immatures. Unknown.

Holotype. Male. Minnesota: Clearwater County: Itasca State Park, Nicollet Creek at Wilderness Drive, 47.194°N, 95.230°W, el. 1500 ft., 19.viii.1988, col. M. Monson (UMSP).

Paratypes. Minnesota: Hubbard County: LaSalle Creek at Co. Rd. 40, 47.349°N, 95.165°W, el. 1394 ft., 25.vi.1988, col. M. Monson, 29 males (UMSP); same, except 02.vii.1988, 2 males (INHS); same, except 24.vii.1988, 2 males (NMNH); same, except 26.vii.1988, 4 males (UMSP); same, except 13.viii.1988, 12 males (UMSP); same, except 22.viii.1988, 20 males (UMSP).

Etymology. Named for Lake Itasca, the headwaters of the Mississippi River. The name Itasca was derived from *ver(itas ca)put* after the explorer Henry R. Schoolcraft, who in 1832 found the lake to be the true source of the Mississippi River.

Distribution. Known from the type locality and the edge of LaSalle Creek, Hubbard County, in northern Minnesota; flight period is from early June through mid September.

Discussion

Oxyethira itascae is the first caddisfly to be described from Minnesota since Wiggins' (1975) description of *Chilostigma itascae* (Limnephilidae) and Etnier's (1968) descriptions of *Ceraclea brevis* (Leptoceridae, as *Athripsodes*) and *Polycentropus milaca* (Polycentropodidae), all believed to be endemic species. The discovery of *O. itascae* at the edge of Nicollet Creek in Itasca State Park is especially interesting because this is also the type locality for *Chilostigma itascae*, which is known only from adults and represents the single record for that genus outside of Scandinavia and Finland (Wiggins 1977). Nicollet Creek, with its silty bottom and many spring seepage areas, meanders through a wetland meadow surrounded by coniferous forest on its way to join Lake Itasca.

In addition to the new species, *Oxyethira ecornuta* Morton was collected during the study at LaSalle Creek, also in the Itasca region of Minnesota. This creek, running from LaSalle Lake, has a sand and gravel bottom and empties into a large pool just beyond the collection site, before entering the Mississippi River. This collection represents the first record of *O. ecornuta* in the United States. This species is Holarctic, with the only other North American record from Ontario, Canada. It is also known from Finland and Sweden (Kelley 1985). Given the distributions of *Chilostigma itascae*, *Oxyethira ecornuta*, and *Oxyethira itascae*, it appears that these are boreal species which may have a particular adaptation to the type of habitat represented in the Itasca region.

The collection of *Oxyethira verna* Ross from Becker and Hubbard Counties represents a new state record for Minnesota. This Nearctic species is known from many locations throughout the eastern half of North America. Since its occurrence in Minnesota represents a western limit of its range, it may be a species associated primarily with the eastern deciduous forest, which meets its western limit near the Itasca area.

Ross (1967) states that the ecological characteristics of many caddisflies found only in small streams are a result of the complex interrelationships with the terrestrial communities bordering them. The caddisfly faunas in these habitats are influenced by shade, leaf-fall, precipitation, the climax community, and the relationship between these variables. Correlations have been made between caddisfly phylogenetic and distributional information and the dispersal patterns of some plant groups with which caddisflies have an ecological association (Ross 1967).

The state of Minnesota is at the cross roads of three major biomes, the northern coniferous forest, the eastern deciduous forest, and the tallgrass prairie, which offer habitat variety more diverse than the surrounding states (Coffin and Pfannmuller 1988). The Itasca region in particular is even more closely associated with this merging of biomes, because the coniferous and deciduous forests intermingle in the area, gradually giving way to tallgrass prairie just west of the Itasca region. As a result of ongoing studies and the county biological survey of plants and animals being conducted by the Minnesota Department of Natural Resources, less common species, including relicts, have been found in Minnesota. The distributions of *C. itascae*, *O. ecornuta*, *O. verna*, and *O. itascae* are further indication that the Lake Itasca region may represent an important confluence in the distribution of the boreal and eastern deciduous forest Trichoptera faunas of North America.

Further evidence of the significance of Minnesota's location at the junction of these biomes is the fact that of the 280 species of caddisflies recorded from Minnesota, 79, or 28%, are those eastern species whose distribution in Minnesota represents the western limit of their range (Monson and Holzenthal unpublished). Examples include *Chimarra obscura* (Walker), *Hydroptila armata* Ross, *Hydatophylax argus* (Harris), *Lepidostoma bryanti* (Banks), and *Molanna tryphena* Betten. In addition, 30, or 11%, are those boreal species with the southern limit of their range in North America extending to Minnesota. Among these species are *Hydropsyche vexa*

Ross, *Polycentropus weedi* Blickle and Morse, *Hagenella canadensis* (Banks), and *Ceraclea excisa* (Morton). Though the analysis of the biogeography of Minnesota caddisflies is beyond the scope and intention of this paper, it will be interesting to learn if further study of the distribution of plants and animals of the Itasca region reveals other organisms unique to this area or at their range limits in North America.

It is encouraging to note that many of the forests and their watersheds in this area, including the type locality, are protected in State Parks, State Forests, and State Scientific and Natural Areas, the last being established to protect and perpetuate Minnesota's rare and unique natural resources for nature observation, education, and research. In addition, The Mississippi Headwaters Board serves to monitor use and supervise research on this portion of the Mississippi River.

Finally, in addition to the new species and new records, the following *Oxyethira* species have been recorded from Minnesota (Blickle 1979, Denning 1947, Etnier 1965, 1968): *O.* (*Oxytrichia*) *aeola* Ross, *O.* (*Oxytrichia*) *anabola* Blickle, *O.* (*Holarctotrichia*) *araya* Ross, *O.* (*Oxyethira*) *coercens* Morton, *O.* (*Holarctotrichia*) *forcipata* Mosely, *O.* (*Holarctotrichia*) *michiganensis* Mosely, *O.* (*Holarctotrichia*) *obtatus* Denning, *O.* (*Dampfitrichia*) *pallida* (Banks), *O.* (*Oxyethira*) *rivicola* Blickle and Morse, *O.* (*Oxyethira*) *rossi* Blickle and Morse, *O.* (*Holarctotrichia*) *serrata* Ross, *O.* (*Oxyethira*) *sida* Blickle and Morse, and *O.* (*Oxyethira*) *zeronia* Ross.

New state records for *Oxyethira ecornuta* and *Oxyethira verna* from Minnesota are as follows:

Oxyethira (*Oxyethira*) *ecornuta* Morton 1893: 79–80, Pl. VI, figs. 1–5, male, (Zoologiska Museum, Helsinki, Finland).

New record. MINNESOTA: Hubbard County: LaSalle Cr. at Co. Rd. 40, 47.349°N, 95.165°W, 23.vii.1988, el. 1394 ft., col. M. Monson, 1 male (UMSP).

Distribution. UNITED STATES: Minnesota; CANADA: Ontario; FINLAND; SWEDEN.

Oxyethira (*Dampfitrichia*) *verna* Ross, 1938: 118–119, fig. 27, male, (INHS).

New records. MINNESOTA: Hubbard County: LaSalle Cr. at Co. Rd. 40, 47.349°N, 95.165°W, el. 1394 ft., 25.vi.1988, col. M. Monson, 1 male; same, except 13.viii.1988, 4 males; same, except 22.viii.1988, 1 male; same, except 13.viii.1989, 4 males; same, except 30.ix.1989, 2 males; Becker County: Ottertail R. Mi 162, Hubbel Pond WMA, 16.viii.1982, col. N. Kirsch, 13 males. All specimens in UMSP.

Distribution. UNITED STATES: Alabama, Florida, Illinois, Louisiana, Maine, Michigan, Minnesota, New Hampshire, New Jersey, North Carolina, South Carolina, Tennessee, Texas, Wisconsin; CANADA: New Brunswick, Nova Scotia, Ontario.

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PART III

A PRELIMINARY ASSESSMENT OF THE CONSERVATION STATUS OF MINNESOTA TRICHOPTERA

A PRELIMINARY ASSESSMENT OF THE CONSERVATION STATUS OF MINNESOTA TRICHOPTERA

An assessment of the conservation status of Minnesota Trichoptera was based on examination of specimens in the University of Minnesota Insect Collection and the private collections of Dr. Oliver Flint and Dr. David Etnier (identifications were verified for all adult specimens examined from these collections), determinations made for those insects collected during the field work for this project, and a review of the literature. North American distributional records were studied and species were classified as follows:

1 = endemic (species native to and restricted to Minnesota)

2 = disjunct (species presence in Minnesota represents a disjunct distribution of more widespread species)

3 = regionally restricted (species whose distributions are limited to restricted regions of North America)

4 = range limited (species presence in Minnesota represents a geographical limit of the range of the species)

4N = populations in Minnesota are at the northern limit of the species' range

4S = populations in Minnesota are at the southern limit of the species' range

4E = populations in Minnesota are at the eastern limit of the species' range

4W = populations in Minnesota are at the western limit of the species' range

5 = widely distributed (species distributed over a large part of North America)

(Table 1).

Based on these categories, five species appear to be endemic: *Protoptila talola*, known only from the male holotype collected in Pine County in 1941; *Oxyethira itascae*, known from 99 males collected from Clearwater and Hubbard Counties in 1988 and 1989; *Polycentropus milaca*, known only from the male holotype collected in Itasca County in 1965; *Chilostigma itascae*, known from 17 males and 1 female collected in Clearwater County in 1974; *Ceraclea brevis*, known only from the male holotype collected in Crow Wing County in 1965.

Seven species are classified as disjunct: *Agapetus tomus*, also from Pennsylvania and southeastern United States; *Hydroptila antennopedia*, also from Pennsylvania, Maine, and New Hampshire; *H. metoeca*, also from the eastern coastal region of North America and Ohio; *H. novicola*, also from northeastern North America, Alabama and Mississippi; *H. tortosa*, also from eastern coastal states of the United States; *Ceraclea vertreesi*, also from British Columbia and Oregon; and *Setodes guttatus*, also from northeast North America and Alabama. Two species, *Oxyethira ecornuta*, known elsewhere from northern

Europe and Ontario, and *Limnephilus rossi*, also from Quebec, Michigan, and Wisconsin, were classified as regionally restricted. There were 124 species found to be at the geographical limit of their range; the remaining 143 species were classified as widely distributed. There were 24 new records for Minnesota; 11 were found among the caddisflies collected during this study; 13 were discovered during examination of museum specimens that had not previously been reported in the literature (Table 1).

Attempts were made to collect additional specimens of *P. talola, P. milaca,* and *C. brevis,* known only from holotypes and in most cases not encountered in the recent past, as well as many of the disjunct, and regionally restricted species. In 1991 J. Luedeman, a graduate student in the Department of Entomology at the University of Minnesota, placed light traps at county locations (type localities where possible) where these species were originally found; he was unsuccessful in collecting additional specimens.

Of the five species thought to be endemic, only *Chilostigma itascae* has been searched for intensively since it was first collected. Wiggins (pers. comm.) searched for immatures the summer following the original 1974 winter collection of adults. I attempted to collect adults with a Malaise trap set up from January 1988-June 1990, at the Nicollet Creek type locality. I also periodically searched for the adults during the winter months from January-March 1988-1994, and for immatures during the summer months, 1988-1992. I was unsuccessful in obtaining specimens of adults or larvae; larvae collected by Wiggins have not been determined.

Minnesota Statute 84.0895, for the protection of threatened and endangered species, Subdivision 2., states that the commissioner of natural resources "shall designate any species of wild animal or plant as: (1) Endangered, upon a showing that such species is threatened with extinction throughout all or a significant portion of its range; or (2) Threatened, upon a showing that such species is likely to become endangered within the foreseeable future throughout all or a significant portion of its range; or (3) Species of Special Concern, upon a showing that while a species is not endangered or threatened, it is extremely uncommon in Minnesota, or has unique or highly specific habitat requirements and deserves careful monitoring of its status" (Coffin & Pfannmuller 1988).

In 1989 *Chilostigma itascae* (endemic) and *Ceraclea vertreesi* (disjunct) were listed in Category 2 in the Federal Register, Part IV. The most recent issue (1991), Part VIII, makes the same assignment. This category includes "taxa for which information now in possession of the Service indicates that proposing to list as endangered or threatened is possibly appropriate, but for which conclusive data on biological vulnerability and threat are not currently available to support proposed rules....The Service hopes that this notice will encourage investigation of the status and vulnerability of these taxa, and consideration of them in the course of environmental planning." In addition, *C. vertreesi* appears on a Heritage Program inventory list maintained by Midwest Regional Office of the Nature Conservancy, which includes an assessment of the population status of caddisfly species by Heritage Programs throughout the United States. Oregon's Heritage Program ranks this species between critically imperiled because of extreme rarity (5 or fewer occurrences) or vulnerability to extirpation and rare (21 to 100 occurrences), both globally and in Oregon; *Limnephilus rossi* (regionally restricted) was placed on the same list, ranked as possibly in peril in Wisconsin and of uncertain status in Minnesota; it is also on the Heritage Program's watch list in Wisconsin.

I recommend that the type locality for *C. itascae* (Nicollet Creek and the surrounding wetland meadow area in Itasca State Park) be closely monitored for signs of habitat degradation and that further attempts be made to encounter the species. *Chilostigma itascae* should, at the very least, be a candidate for Species of Special Concern status as defined by the Minnesota state statute; it may well be appropriate as a candidate for Threatened status. In addition, I recommend that field work be continued to determine the conservation status of *Protoptila talola*, *Polycentropus milaca*, *Oxyethira itascae*, and *Ceraclea brevis*. Similarily, the conservation status and distribution of the disjunct and regionally restricted species should be investigated as well. A state-wide inventory of Minnesota Trichoptera would be appropriate to more accurately determine the distribution of these species.

Table 1.

Annotated Checklist of the Trichoptera of Minnesota

R.W. Holzenthal, M.P. Monson

	SPECIES[a]	LITERATURE CITATION	NORTH AMERICAN DISTRIBUTION[b]
	RHYACOPHILIDAE		
*	**Rhyacophila angelita** Banks 1911	Etnier 1968	5
*	**Rhyacophila fuscula** (Walker) 1852	Denning 1948, Etnier 1965, Schmid 1981	5
	Rhyacophila vibox Milne 1936	Lager et al. 1979 (larvae, unconfirmed, Lake Co.)	4W
	GLOSSOSOMATIDAE		
*	**Agapetus rossi** Denning 1941	Denning 1941, Etnier 1965, Schmid 1982	4W
	Agapetus tomus Ross 1941	Etnier 1968	2
*	**Glossosoma intermedium** (Klapálek) 1892	Etnier 1965, Nimmo 1974	5
*	**Glossosoma nigrior** Banks 1911	Denning 1942, Etnier 1965, Wiggins 1977, Schmid 1982	4W
*	**Protoptila erotica** Ross 1938	Etnier 1965, Schmid 1982	5
*	**Protoptila maculata** (Hagen) 1961	Etnier 1965	4W
*	**Protoptila talola** Denning 1947	Denning 1948, Etnier 1965	1
*	**Protoptila tenebrosa** (Walker) 1852	Etnier 1965, Nimmo 1974, Schmid 1982	5
	HYDROPTILIDAE		
*	**Agraylea multipunctata** Curtis 1834	Denning 1937, Ross 1944, Etnier 1965	5
*	**Hydroptila ajax** Ross 1938	Denning 1947, Etnier 1965, Blickle 1979	5
*	**Hydroptila albicornis** Hagen 1861	Denning 1947, Etnier 1965, Blickle 1979	4W
*	**Hydroptila amoena** Ross 1938	Denning 1947, Etnier 1965, Blickle 1979	4W
*	**Hydroptila ampoda** Ross 1941	Etnier 1968, Blickle 1979	4W
*	**Hydroptila angusta** Ross 1938	**new state record** (Monson & Holzenthal, unpub.)	5
*	**Hydroptila antennopedia** Sykora and Harris 1994	**new state record**	2
*	**Hydroptila armata** Ross 1938	Denning 1947, Etnier 1965, Hamilton & Schuster 1978, Blickle 1979	4W

Table 1. Continued.

	Hydroptila callia Denning 1948	Etnier 1968, Blickle 1979	5
*	**Hydroptila consimilis** Morton 1905	Denning 1947, Etnier 1965, Blickle 1979	5
	Hydroptila delineata Morton 1905	Etnier 1968, Blickle 1979	4W
*	**Hydroptila grandiosa** Ross 1938	Denning 1947, Etnier 1965, Hamilton & Schuster 1978, Blickle 1979	4W
*	**Hydroptila hamata** Morton 1905	Denning 1947, Etnier 1965, Blickle 1979	5
*	**Hydroptila jackmanni** Blickle 1963	Etnier 1965, Blickle 1979	4W
*	**Hydroptila metoeca** Blickle & Morse 1954	Etnier 1968, Blickle 1979	2
*	**Hydroptila novicola** Blickle & Morse 1954	Etnier 1968, Blickle 1979	2
*	**Hydroptila perdita** Morton 1905	Denning 1947, Etnier 1965, Hamilton & Schuster 1978, Blickle 1979	4W
*	**Hydroptila quinola** Ross 1947	Etnier 1968, Blickle 1979	4W
*	**Hydroptila salmo** Ross 1941	Etnier 1965, Blickle 1979	4W
*	**Hydroptila scolops** Ross 1938	Etnier 1965, Blickle 1979	5
*	**Hydroptila spatulata** Morton 1905	Denning 1947, Etnier 1965, Blickle 1979	4W
	Hydroptila tortosa Ross 1938	Etnier 1968, Blickle 1979	2
*	**Hydroptila valhalla** Denning 1947	Denning 1947, Etnier 1965, Etnier 1968, Blickle 1979	4W
	Hydroptila virgata Ross 1938	Etnier 1965, Blickle 1979 (females)	4W
*	**Hydroptila waskesia** Ross 1944	Etnier 1968, Blickle 1979	5
*	**Hydroptila waubesiana** Betten 1934	Denning 1947, Etnier 1965, Blickle 1979	5
*	**Hydroptila wyomia** Denning 1947	**new state record** (Monson, unpub.)	5
*	**Hydroptila xera** Ross 1938	**new state record** (Monson, unpub.)	5
*	**Ithytrichia clavata** Morton 1905	Denning 1947, Etnier 1965	5
*	**Leucotrichia pictipes** (Banks) 1911	Denning 1947, Etnier 1965, Flint 1970, Wiggins 1977, Blickle 1979	4N
*	**Mayatrichia ayama** Mosely 1937	Denning 1947, Etnier 1965, Lager et al. 1979	5
*	**Neotrichia halia** Denning 1948	Etnier 1965	5
*	**Neotrichia okopa** Ross 1939	Etnier 1965	5
	Neotrichia vibrans Ross 1939	Etnier 1965	4N
*	**Ochrotrichia spinosa** (Ross) 1938	Etnier 1968, Blickle 1979	4W
	Ochrotrichia stylata (Ross) 1938	Denning & Blickle 1972, Blickle & Denning 1977	4E
*	**Ochrotrichia tarsalis** (Hagen) 1861	Etnier 1965, Denning & Blickle 1972, Blickle & Denning 1977, Blickle 1979	5
	Ochrotrichia wojcickyi Blickle 1963	Denning & Blickle 1972, Blickle & Denning 1977, Blickle 1979	5
*	**Orthotrichia aegerfasciella** (Chambers) 1873	Ross 1944, Denning 1947, Etnier 1965, Blickle 1979	5
*	**Orthotrichia baldufi** Kingsolver & Ross 1961	Kingsolver and Ross 1961, Etnier 1965, Blickle 1979	4W
*	**Orthotrichia cristata** Morton 1905	Denning 1947, Etnier 1965	5

Table 1. Continued.

*	**Oxyethira aeola** Ross 1938	Blickle 1979	4S
	Oxyethira anabola Blickle 1966	Blickle 1979	4W
*	**Oxyethira araya** Ross 1941	Etnier 1965, Blickle 1979	4S
*	**Oxyethira coercens** Morton 1905	Etnier 1965, Blickle 1979	5
*	**Oxyethira ecornuta** Morton 1893	Monson & Holzenthal 1993 **new state record**	3
*	**Oxyethira forcipata** Mosely 1934	Etnier 1968, Blickle 1979	4W
*	**Oxyethira michiganensis** Mosely 1934	Etnier 1965, Blickle 1979	5
*	**Oxyethira obtatus** Denning 1947	Denning 1947, Etnier 1965, Blickle 1979	4W
	Oxyethira pallida (Banks) 1904	Etnier 1965, Blickle 1979	4N
*	**Oxyethira rivicola** Blickle and Morse 1954	Etnier 1965, Blickle 1979	4W
*	**Oxyethira rossi** Blickle and Morse 1957	Etnier 1968, Blickle 1979, Kelley 1985	4W
*	**Oxyethira serrata** Ross 1938	Denning 1947, Etnier 1965, Blickle 1979	5
*	**Oxyethira sida** Blickle and Morse 1954	Etnier 1965, Blickle 1979	4W
*	**Oxyethira verna** Ross 1938	Monson & Holzenthal 1993 **new state record**	4W
*	**Oxyethira zeronia** Ross 1941	Etnier 1968, Blickle 1979	4W
*	**Oxyethira itascae** Monson & Holzenthal 1993	**new state record**	1
*	**Stactobiella delira** (Ross) 1938	Etnier 1965	5
*	**Stactobiella palmata** (Ross) 1938	Etnier 1968	5
	PHILOPOTAMIDAE		
+	**Chimarra aterrima** Hagen 1861	Ross 1944, Etnier 1965, Armitage 1983, Armitage 1991, Lago&Harris '89	4W
*	**Chimarra feria** Ross 1941	Ross 1944, Etnier 1965, Schuster & Hamilton 1978, Lager et al. 1979, Armitage 1983, Armitage 1991	4W
*	**Chimarra obscura** (Walker) 1852	Etnier 1965, Lager et al. 1979, Armitage 1983, Armitage 1991	4W
*	**Chimarra socia** Hagen 1861	Etnier 1965, Lager et al. 1979, Armitage 1983, Lago and Harris 1987, Armitage 1991	4W
*	**Dolophilodes distinctus** (Walker) 1852	Ross 1944, Wiggins 1961, Etnier 1965, Wiggins 1977, Lager et al. 1979, Schmid 1982, Armitage 1983, Armitage 1991	4W
*	**Wormaldia moesta** (Banks) 1914	Etnier 1968, Armitage 1991	4W
	ARCTOPSYCHIDAE		
	Parapsyche sp.	Etnier 1965 (larvae)	4W

Table 1. Continued.

HYDROPSYCHIDAE

*	**Ceratopsyche alhedra** (Ross) 1939	Denning 1942, Etnier 1965, Schuster & Etnier 1978, Mackay 1986, Schefter, Wiggins, & Unzicker 1986, Schefter & Wiggins 1986, Waters 1987, Nimmo 1987	5
*	**Ceratopsyche alternans** (Walker) 1852	Denning 1943, Etnier 1965, Schuster & Etnier 1978, Sykora et al. 1981, Mackay 1986, Schefter & Wiggins 1986, Nimmo 1987	4S
*	**Ceratopsyche bronta** (Ross) 1938	Denning 1943, Etnier 1965, Schuster & Etnier 1978, Nimmo 1987	5
*	**Ceratopsyche morosa** (Hagen) 1861	Denning 1943, Etnier 1965, Schuster & Etnier 1978, Hamilton & Schuster 1979, Schefter & Unzicker 1984, Schefter & Wiggins 1986, Nimmo 1987	5
*	**Ceratopsyche oslari** (Banks) 1905	**new state record** (Monson & Holzenthal, unpub.) (female)	4E
*	**Ceratopsyche piatrix** (Ross) 1938	**new state record** (Monson & Holzenthal, unpub.) (females)	5
*	**Ceratopsyche slossonae** (Banks) 1905	Denning 1943, Etnier 1965, Schuster & Etnier 1978, Lager et al. 1979, Schefter & Wiggins 1986, Waters 1986, Nimmo 1987	4W
*	**Ceratopsyche sparna** (Ross) 1938	Denning 1943, Etnier 1965, Schuster & Etnier 1978, Schefter & Wiggins 1986, Nimmo 1987	4W
	Ceratopsyche ventura (Ross) 1941	Phillippi & Schuster 1987	4W
*	**Ceratopsyche vexa** (Ross) 1938	Denning 1943, Etnier 1965, Schefter & Wiggins 1986, Nimmo 1987	4S
*	**Ceratopsyche walkeri** (Betten & Mosely) 1940	Etnier 1965, Schuster & Etnier 1978, Schefter & Wiggins 1986, Nimmo 1987	5
*	**Cheumatopsyche aphanta** Ross 1938	Etnier 1965, Gordon 1974, Hamilton & Schuster 1979, Nimmo 1987	5
*	**Cheumatopsyche campyla** Ross 1938	Denning 1943, Etnier 1965, Gordon 1974, Nimmo 1987	5
*	**Cheumatopsyche gracilis** (Banks) 1899	Denning 1943, Etnier 1965, Nimmo 1974, Nimmo 1987, Hamilton & Schuster 1979	5
*	**Cheumatopsyche lasia** Ross 1938	Denning 1943, Etnier 1965, Gordon 1974, Hamilton & Schuster 1979, Nimmo 1987	5
*	**Cheumatopsyche minuscula** (Banks) 1907	Denning 1943, Etnier 1965, Gordon 1974, Hamilton & Schuster 1979, Nimmo 1987	5
*	**Cheumatopsyche oxa** Ross 1938	Denning 1943, Etnier 1965, Hamilton & Schuster 1979, Nimmo 1987	5
*	**Cheumatopsyche pasella** Ross 1941	Denning 1943, Etnier 1965, Nimmo 1987	5
*	**Cheumatopsyche pettiti** (Banks) 1908	Denning 1943, Etnier 1965, Gordon 1974, Mackay 1986, Waters 1987, Nimmo 1987	5
*	**Cheumatopsyche sordida** (Hagen) 1861	Denning 1943, Etnier 1965, Nimmo 1987	4W
*	**Cheumatopsyche speciosa** (Banks) 1904	Denning 1943, Etnier 1965, Gordon 1974, Nimmo 1987	5
*	**Cheumatopsyche wabasha** Denning 1947	Denning 1947, Etnier 1965, Nimmo 1987	4N
+	**Diplectrona modesta** Banks 1908	**new state record** (Monson & Holzenthal, unpub.)	5
*	**Hydropsyche betteni** Ross 1938	Denning 1943, Etnier 1965, Schuster & Etnier 1978, Lager et al. 1979, Hamilton & Schuster 1979, Nimmo 1987	5

Table 1. Continued.

*	**Hydropsyche bidens** Ross 1938	Denning 1943, Etnier 1965, Schuster & Etnier 1978, Hamilton & Schuster 1979, Nimmo 1987	5
*	**Hydropsyche californica** Banks 1899	Denning 1943, Etnier 1965, Nimmo 1987	4E
*	**Hydropsyche confusa** (Walker) 1852	Denning 1943, Etnier 1965, Sykora et al. 1981, Nimmo 1987 (females)	5
	Hydropsyche cuanis Ross 1938	Lager et al. 1979, Nimmo 1987 (larvae, unconfirmed)	4W
*	**Hydropsyche dicantha** Ross 1938	Etnier 1965, Schuster & Etnier 1978, Nimmo 1987	4W
	Hydropsyche frisoni Ross 1938	Schuster & Etnier 1978, Nimmo 1987 (larvae, unconfirmed)	4W
	Hydropsyche hageni Banks 1905	Denning 1943, Etnier 1965, Schuster & Etnier 1978, Nimmo 1987 (female)	4W
*	**Hydropsyche orris** Ross 1938	Denning 1943, Etnier 1965, Schuster & Etnier 1978, Lager et al. 1979, Hamilton & Schuster 1979, Nimmo 1987	4N
*	**Hydropsyche phalerata** (Hagen) 1861	Denning 1943, Etnier 1965, Schuster & Etnier 1978, Nimmo 1987	4W
*	**Hydropsyche placoda** Ross 1941	Ross 1941, Etnier 1965, Nimmo 1987	5
*	**Hydropsyche scalaris** Hagen 1861	Denning 1943, Etnier 1965, Schuster & Etnier 1978, Flint et al. 1979, Hamilton & Schuster 1979, Nimmo 1987	5
*	**Hydropsyche simulans** Ross 1938	Denning 1943, Etnier 1965, Schuster & Etnier 1978, Lager et al. 1979, Hamilton & Schuster 1979	5
+	**Hydropsyche valanis** Ross 1938	Ross 1944, Etnier 1965, Schuster & Etnier 1978, Nimmo 1987 (confirmed ♂, Rapidan, MN)	4N
*	**Macrostemum zebratum** (Hagen) 1861	Denning 1943, Etnier 1965, Wallace 1975, Wiggins 1977, Lager et al. 1979, Nimmo 1987	5
*	**Potamyia flava** (Hagen) 1861	Denning 1943, Etnier 1965, Wiggins 1977, Hamilton & Schuster 1979, Nimmo 1987	5
	POLYCENTROPODIDAE		
*	**Cyrnellus fraternus** (Banks) 1913	Etnier 1965, Wiggins 1977, Schmid 1980, Nimmo 1986, Armitage & Hamilton 1990	4N
*	**Neureclipsis bimaculata** (L.) 1758	Etnier 1965, Nimmo 1986, Armitage & Hamilton 1990	4S
*	**Neureclipsis crepuscularis** (Walker) 1852	Etnier 1965, Nimmo 1986, Armitage & Hamilton 1990	5
*	**Neureclipsis valida** (Walker) 1852	Etnier 1965, Nimmo 1986, Armitage & Hamilton 1990	4S
*	**Nyctiophylax affinis** (Banks) 1897	Morse 1972, Hamilton & Schuster 1980, Nimmo 1986, Armitage & Hamilton 1990	5

Table 1. Continued.

	Nyctiophylax banksi Morse 1972	Morse 1972, Nimmo 1986, Armitage & Hamilton 1990	4W
	Nyctiophylax celta Denning 1948	Lager et al. 1979, Nimmo 1986	4W
*	**Nyctiophylax moestus** Banks 1911	Morse 1972, Lager et al. 1979, Nimmo 1986, Armtigae & Hamilton 1990	5
*	**Polycentropus albipunctus** (Banks) 1930	Etnier 1965, Nimmo 1986, Armitage & Hamilton 1990	4S
*	**Polycentropus aureolus** (Banks) 1930	Ross 1944, Etnier 1965, Nimmo 1986, Armitage & Hamilton 1990	5
*	**Polycentropus centralis** Banks 1914	Etnier 1965, Lager et al. 1979, Nimmo 1986, Armitage & Hamilton 1990	4W
*	**Polycentropus cinereus** (Hagen) 1861	Banks 1930, Ross 1944, Lager et al. 1979, Nimmo 1986, Armitage & Hamilton 1990	5
*	**Polycentropus clinei** (Milne) 1936	**new state record** (Monson & Holzenthal, unpub.)	4W
*	**Polycentropus confusus** Hagen 1861	Etnier 1965, Nimmo 1986, Armitage & Hamilton 1990	4W
*	**Polycentropus crassicornis** (Walker) 1852	Etnier 1965, Nimmo 1986, Armitage & Hamilton 1990	5
*	**Polycentropus flavus** (Banks) 1908	Etnier 1965, Nimmo 1986, Armitage & Hamilton 1990	5
*	**Polycentropus iculus** Ross 1941	**new state record** (Monson & Holzenthal, unpub.)	4S
*	**Polycentropus interruptus** (Banks) 1914	Etnier 1965, Lager et al. 1979, Nimmo 1986, Armitage & Hamilton 1990	5
*	**Polycentropus melanae** (Ross) 1938	Etnier 1968, Nimmo 1986, Armitage & Hamilton 1990	4W
	Polycentropus milaca Etnier 1968	Etnier 1968, Nimmo 1986, Armitage & Hamilton 1990	1
*	**Polycentropus pentus** Ross 1941	Etnier 1965, Nimmo 1986, Armitage & Hamilton 1990	4W
	Polycentropus picicornis Stephens 1836	Nimmo 1986	4S
*	**Polycentropus remotus** Banks 1911	Ross 1944, Etnier 1965, Lager et al. 1979, Nimmo 1986, Armitage & Hamilton 1990	5
*	**Polycentropus weedi** Blickle & Morse 1955	Etnier 1968, Nimmo 1986, Armitage & Hamilton 1990	4S
	DIPSEUDOPSIDAE		
*	**Phylocentropus placidus** (Banks) 1905	Ross 1944, Etnier 1965, Lager et al. 1979, Armitage & Hamilton 1990	4W
	PSYCHOMYIIDAE		
*	**Lype diversa** (Banks) 1914	Lager et al. 1979	5
*	**Psychomyia flavida** Hagen 1861	Etnier 1965, Lager et al. 1979, Armitage & Hamilton 1990	5

Table 1. Continued.

PHRYGANEIDAE			
*	**Agrypnia glacialis** (Hagen) 1873	Etnier 1965	5
*	**Agrypnia improba** (Hagen) 1873	Etnier 1965, Lager et al. 1979	5
*	**Agrypnia macdunnoughi** (Milne) 1931	Etnier 1965	4S
*	**Agrypnia straminea** Hagen 1873	Banks 1900, Banks 1907, Elkins 1936, Etnier 1965	5
*	**Agrypnia vestita** (Walker) 1852	Etnier 1965, Hamilton & Schuster 1980	4W
*	**Banksiola crotchi** Banks 1943	Betten 1944, Wiggins 1956, Etnier 1965, Lager et al. 1979	5
*	**Banksiola dossuaria** (Say) 1828	Etnier 1968	4W
	Banksiola smithi (Banks) 1914	Etnier 1965	4S
*	**Fabria inornata** (Banks) 1907	Etnier 1965, Wiggins 1977	4S
*	**Hagenella canadensis** (Banks) 1907	Etnier 1965, Wiggins 1977	4S
+	**Oligostomis prob. ocelligera** (Walker) 1852	**new state record** (larvae)	4S
*	**Phryganea cinerea** Walker 1852	Etnier 1965, Lager et al. 1979	5
*	**Ptilostomis ocellifera** (Walker) 1852	Etnier 1965	5
*	**Ptilostomis semifasciata** (Say) 1828	Etnier 1965	5
BRACHYCENTRIDAE			
*	**Brachycentrus americanus** (Banks) 1899	Lager et al. 1979, Flint 1984	5
*	**Brachycentrus numerosus** (Say) 1823	Etnier 1965, Lager et al. 1979, Flint 1984	4W
*	**Brachycentrus occidentalis** Banks 1911	Etnier 1965, Flint 1984	5
*	**Micrasema gelidum** McLachlan 1876	**new state record** (Monson & Holzenthal, unpub.)	5
*	**Micrasema rusticum** (Hagen) 1868	Denning 1948, Etnier 1965	5
*	**Micrasema wataga** Ross 1938	Denning 1948, Etnier 1965	5
LIMNEPHILIDAE			
*	**Anabolia bimaculata** (Walker) 1852	Denning 1937, Etnier 1965, Lager et al. 1979	5
*	**Anabolia consocia** (Walker) 1852	Flint 1960, Etnier 1965, Nimmo 1971, Lager et al. 1979	5
*	**Anabolia ozburni** (Milne) 1935	Ross and Merkley 1952, Etnier 1965, Nimmo 1971	5

Table 1. Continued.

*	**Anabolia sordida** Hagen 1861	Denning 1941, Ross 1944, Etnier 1965	5
	Apatania incerta (Banks) 1897	Etnier 1964	4W
*	**Apatania zonella** (Zetterstedt) 1840	Nimmo 1971 (females)	4S
*	**Arctopora pulchella** (Banks) 1908	Etnier 1968	4S
*	**Asynarchus montanus** (Banks) 1907	Etnier 1965, Nimmo 1971	5
*	**Asynarchus mutatus** (Hagen) 1861	Etnier 1965, Nimmo 1971	4S
*	**Chilostigma itascae** Wiggins 1975	Wiggins 1975, Schmid 1980	1
*	**Frenesia missa** (Milne) 1935	Flint 1960, Etnier 1965	5
+	**Glyphopsyche irrorata** (Fabricius) 1781	Lager et al. 1979	5
*	**Grammotaulius interrogationis** (Zetterstedt) 1840	Denning 1941, Etnier 1965, Nimmo 1971	4S
*	**Hesperophylax designatus** (Walker) 1852	Elkins 1936, Etnier 1965, Parker & Wiggins 1985	5
*	**Hydatophylax argus** (Harris) 1869	Etnier 1965, Wiggins 1977, Lager et al. 1979	4W
*	**Ironoquia lyrata** (Ross) 1938	**new state record** (Monson & Holzenthal, unpub.)	4W
*	**Ironoquia punctatissima** (Walker) 1852	Lager et al. 1979 (also, confirmed male, Lyon Co.)	4W
	Lenarchus keratus (Ross) 1938	Etnier 1968, Nimmo 1977	4S
*	**Leptophylax gracilis** Banks 1900	Banks 1900, Etnier 1965, Schmid 1980	4N
*	**Limnephilus acrocurvus** Denning1942	Denning 1942, Schmid 1955, Etnier 1965	4S
	Limnephilus argenteus Banks 1914	Etnier 1968	4S
*	**Limnephilus canadensis** Banks 1908	Denning 1937, Schmid 1955, Etnier 1965, Nimmo 1971	4S
	Limnephilus dispar Mac Lachlan 1875	Nimmo 1971	4S
	Limnephilus externus Hagen 1861	Etnier 1965, Nimmo 1971	5
*	**Limnephilus hyalinus** Hagen 1861	Etnier 1965, Nimmo 1971	5
*	**Limnephilus indivisus** Walker 1852	Mickel & Milliron 1939, Etnier 1965, Nimmo 1971	5
*	**Limnephilus infernalis** (Banks) 1914	Etnier 1965, Nimmo 1971	4S
*	**Limnephilus janus** Ross 1938	Etnier 1965, Nimmo 1971	5
*	**Limnephilus moestus** Banks 1908	Etnier 1965, Nimmo 1971	5
*	**Limnephilus ornatus** Banks 1897	Etnier 1965, Nimmo 1971	5

Table 1. Continued.

*	**Limnephilus partitus** Walker 1852	Etnier 1965, Nimmo 1971	4S
*	**Limnephilus parvulus** (Banks) 1905	Etnier 1965, Nimmo 1971	4S
*	**Limnephilus perpusillus** Walker 1852	Etnier 1965, Nimmo 1971	5
*	**Limnephilus rhombicus** (Linnaeus) 1758	Elkins 1936, Flint 1960, Etnier 1965, Nimmo 1971	5
	Limnephilus rossi Leonard & Leonard 1949	Etnier 1965	3
*	**Limnephilus secludens** Banks 1914	Etnier 1965, Nimmo 1971	5
*	**Limnephilus sericeus** (Say) 1824	Ross 1944, Etnier 1965, Nimmo 1971	4S
*	**Limnephilus sublunatus** Provancher 1877	Etnier 1968	5
*	**Limnephilus submonilifer** Walker 1852	Elkins 1936, Etnier 1965	5
*	**Limnephilus tarsalis** (Banks) 1920	Etnier 1965	4E
*	**Nemotaulius hostilis** (Hagen) 1873	Etnier 1965, Nimmo 1971, Lager et al. 1979	5
+	**Onocosmoecus quadrinotatus** (Banks) 1897	**new state record** (Monson & Holzenthal, unpub.)	
*	**Philarctus quaeris** (Milne) 1935	Etnier 1965, Nimmo 1971	4E
*	**Platycentropus amicus** (Hagen) 1861	Schmid 1955, Etnier 1965, Nimmo 1977, Schmid 1980	5
	Platycentropus indistinctus (Walker) 1852	Denning 1937, Etnier 1965 (larvae)	4W
*	**Platycentropus radiatus** (Say) 1824	Ross 1944, Etnier 1965	5
*	**Pseudostenophylax uniformis** (Betten) 1934	Etnier 1965	4W
*	**Pycnopsyche aglona** Ross 1941	**new state record** (Monson & Holzenthal, unpub.)	4W
*	**Pycnopsyche guttifer** (Walker) 1852	Ross 1941, Etnier 1965, Lager et al. 1979, Wojtowicz 1982	5
*	**Pycnopsyche lepida** (Hagen) 1861	Etnier 1965, Wojtowicz 1982	5
*	**Pycnopsyche limbata** (MacLachlan) 1871	**new state record** (Monson & Holzenthal, unpub.)	4W
+	**Pycnopsyche scabripennis** (Rambur) 1852	Lager et al. 1979	5
*	**Pycnopsyche subfasciata** (Say) 1828	Elkins 1936, Etnier 1965, Wojtowicz 1982	5
	GOERIDAE		
+	**Goera stylata** Ross 1938	**new state record** (Monson & Holzenthal, unpub.)	4E

Table 1. Continued.

UENOIDAE			
*	**Neophylax concinnus** McLachlan 1871	Denning 1948, Etnier 1965	5
*	**Neophylax fuscus** Banks 1903	Ross 1944, Schmid 1955, Etnier 1965	4W
	Neophylax nacatus Denning 1941	Lager et al. 1979 (larvae)	5
*	**Neophylax oligius** Ross 1938	Denning 1948, Schmid 1955, Etnier 1965	4W
LEPIDOSTOMATIDAE			
*	**Lepidostoma bryanti** (Banks) 1908	Etnier 1965, Weaver 1988	4W
*	**Lepidostoma costale** (Banks) 1914	Etnier 1965, Weaver 1988	4W
*	**Lepidostoma sackeni** (Banks) 1936	**new state record** (Monson & Holzenthal, unpub.)	5
*	**Lepidostoma togatum** (Hagen) 1861	Etnier 1965, Weaver 1988	5
	Lepidostoma unicolor (Banks) 1911	Ross 1946, Etnier 1965, Weaver 1988	5
SERICOSTOMATIDAE			
*	**Agarodes distinctus** (Ulmer) 1905	Etnier 1968, Lager et al. 1979, Schmid 1983	4W
MOLANNIDAE			
*	**Molanna blenda** Sibley 1926	Etnier 1968, Lager et al. 1979	4W
*	**Molanna flavicornis** Banks 1914	Denning 1937, Etnier 1965	5
*	**Molanna tryphena** Betten 1934	Etnier 1968	4W
*	**Molanna uniophila** Vorhies 1909	Ross 1944, Etnier 1965, Schmid 1983	4W
HELICOPSYCHIDAE			
*	**Helicopsyche borealis** (Hagen) 1861	Elkins 1936, Ross 1944, Etnier 1965, Lager et al. 1979	5
LEPTOCERIDAE			
*	**Ceraclea alagma** (Ross) 1938	Ross 1944, Etnier 1965	4S
*	**Ceraclea ancylus** (Vorhies) 1909	Etnier 1965, Lager et al. 1979	5
*	**Ceraclea annulicornis** (Stephens) 1836	Lager et al. 1979	5

Table 1. Continued.

*	**Ceraclea arielles** (Denning) 1942	Denning 1942, Etnier 1965	5
	Ceraclea brevis (Etnier) 1968	Etnier 1968, Morse 1975	1
*	**Ceraclea cancellata** (Betten) 1934	Elkins 1936, Etnier 1965	5
*	**Ceraclea diluta** (Hagen) 1861	Ross 1944, Etnier 1965, Lager et al. 1979	5
*	**Ceraclea excisa** (Morton) 1941	Ross 1941, Etnier 1965, Lager et al. 1979	4S
	Ceraclea flava (Banks) 1904	Ross 1944, Etnier 1965, Resh 1976 (larvae)	4W
*	**Ceraclea maculata** (Banks) 1899	Ross 1944, Etnier 1965, Lager et al. 1979	5
	Ceraclea mentiea (Walker) 1852	Etnier 1965	4W
+	**Ceraclea neffi** (Resh) 1974	Lager et al. 1979	4N
	Ceraclea nepha (Ross) 1944	Etnier 1965	4N
*	**Ceraclea resurgens** (Walker) 1852	Ross 1944, Etnier 1965, Lager et al. 1979	5
*	**Ceraclea tarsipunctata** (Vorhies) 1909	Ross 1944, Etnier 1965, Harris et al. 1991	5
*	**Ceraclea transversa** (Hagen) 1861	Ross 1944, Etnier 1965, Resh 1976	5
*	**Ceraclea vertreesi** (Denning) 1966	**new state record** (Monson & Holzenthal, unpub.)	2
*	**Ceraclea wetzeli** (Ross) 1941	Etnier 1968	4W
*	**Leptocerus americanus** (Banks) 1899	Etnier 1965, Wiggins 1977	5
*	**Mystacides interjecta** (Banks) 1914	Denning 1937, Yamamoto & Wiggins 1964, Etnier 1965	5
*	**Mystacides sepulchralis** (Walker) 1852	Ross 1944, Yamamoto & Wiggins 1964, Etnier 1965, Lager et al. 1979	5
*	**Nectopsyche albida** (Walker) 1852	Etnier 1965, Haddock 1977	5
*	**Nectopsyche candida** (Hagen) 1861	Etnier 1965, Lager et al. 1979	4W
*	**Nectopsyche diarina** (Ross) 1944	Etnier 1965, Haddock 1977	5
*	**Nectopsyche exquisita** (Walker) 1852	Ross 1944, Etnier 1965, Haddock 1977	5
*	**Nectopsyche pavida** (Hagen) 1861	Etnier 1965	4W
*	**Oecetis avara** (Banks) 1895	Ross 1944, Etnier 1965, Lager et al. 1979	5
*	**Oecetis cinerascens** (Hagen) 1861	Ross 1944, Etnier 1965, Lager et al. 1979	5
*	**Oecetis immobilis** (Hagen) 1861	Etnier 1965	4S
*	**Oecetis inconspicua** (Walker) 1852	Ross 1944, Etnier 1965	5
*	**Oecetis nocturna** Ross 1966	**new state record** (Monson & Holzenthal, unpub.)	5
*	**Oecetis ochracea** Curtis 1825	Ross 1944, Etnier 1965	5
*	**Oecetis osteni** Milne 1934	Ross 1944, Etnier 1965	4W
*	**Oecetis persimilis** (Banks) 1907	Etnier 1965, Harris et al. 1991	5
*	**Setodes guttatus** (Banks) 1900	Etnier 1965	2
*	**Setodes incertus** (Walker) 1852	Etnier 1965, Holzenthal 1982	4W

Table 1. Continued.

*	**Triaenodes abus** Milne 1935	Etnier 1965, Harris et al. 1991	4W
*	**Triaenodes baris** Ross 1938	Etnier 1968	4S
	Triaenodes borealis Banks 1900	Banks 1900, Etnier 1965	
*	**Triaenodes dipsius** Ross 1938	Etnier 1965, Harris et al. 1991	4W
*	**Triaenodes flavescens** Banks 1900	Etnier 1965, Harris et al. 1991	4W
*	**Triaenodes ignitus** (Walker) 1852	**new state record** (Monson & Holzenthal, unpub.)	4W
*	**Triaenodes injustus** (Hagen) 1861	Etnier 1965, Lager et al. 1979	4W
*	**Triaenodes marginatus** Sibley 1926	Etnier 1965, Etnier 1973, Lager et al. 1979	4W
*	**Triaenodes nox** Ross 1941	Etnier 1965, Harris et al. 1991	5
*	**Triaenodes tardus** Milne 1934	Ross 1944, Etnier 1965, Lager et al. 1979	5
*	**Ylodes frontalis** (Banks) 1907	**new state record** (females) (Monson & Holzenthal, unpub.) (? **confirm**)	5
*	**Ylodes reuteri** (McLachlan) 1880	Etnier 1965	4E

Footnotes:

a) * = record confirmed by adult male (or female, if indicated) specimen(s) housed at the University of Minnesota Insect Collection
+ = same, but confirmed by larval specimen(s)

b) North American distribution of the caddisflies of Minnesota (Monson, unpub.)
1 = endemic species (native to and restricted to Minnesota)
2 = disjunct species (presence in Minnesota represents disjunct distribution of more widespread species)
3 = regionally restricted (species whose distributions are limited to restricted regions of North America)
4 = range limited (presence in Minnesota represents a geographical limit of the range of the species)
4N = populations in Minnesota are at the northern limit of the range of the species
4S = populations in Minnesota are at the southern limit of the range of the species
4E = populations in Minnesota are at the eastern limit of the range of the species
4W = populations in Minnesota are at the western limit of the range of the species
5 = species widely distributed over a large part of North America

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Re: *Permission to reproduce a published paper in a M.S. Thesis*

This letter grants permission to Ms. Margot P. Monson to include the following paper in her thesis:

"A new species and new records of *Oxyethira* (Trichoptera:Hydroptilidae) from Minnesota"

Journal of the North American Benthological Society 12(4) 438-443, 1993.

Yours sincerely,

Rosemary Mackay

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RJM/jp