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# Corixidae (Water Boatmen) Abundance and Contribution to Littoral Zone Fish Forage in Lake Poinsett, South Dakota

Richard Lee Applegate

# CORIXIDAE (WATER BOATMEN) ABUNDANCE AND CONTRIBUTION TO LITTORAL ZONE FISH FORAGE IN LAKE POINSETT, SOUTH DAKOTA

BY

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This thesis is approved as a creditable and independent investigation by a candidate for the degree, Doctor of Philosophy, and is acceptable as meeting the thesis requirements for this degree. Acceptance of this thesis does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

Thesis Adviser                                        Date

Head, Entom                   nt                      Date

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Corixidae (Water Boatmen) Abundance and Contribution to Littoral Zone Fish Forage in Lake Poinsett, South Dakota

Abstract

Richard L. Applegate

Corixids were sampled each week in littoral zone areas of Lake Poinsett during the open water seasons, April-October, in 1970, 1971, and 1972. Fish were sampled each week in littoral zone areas in 1970 and food habits studies were conducted to determine if fish predation would influence corixid population dynamics.

Seven genera and 15 species of the family Corixidae were collected. Major indigenous species were Palmarcorixa buenoi Abbott, Trichocorixa borealis Sailer, Cenocorixa dakotensis (Hungerford), and Sigara conocephala (Hungerford). Species migrating to Lake Poinsett in the fall to overwinter were Sigara alternata (Say), S. solensis (Hungerford), S. bicoloripennis (Walley), Hesperocorixa vulgaris (Hungerford), and Callicorixa audeni Hungerford.

Corixid population density increased from a mean annual standing crop of $4.9/m^2$ in 1970 to $17.6/m^2$ in 1971 and $56.9/m^2$ in 1972. The mean density of P. buenoi ($19.8/m^2$) was approximately five fold greater than that of T. borealis ($3.8/m^2$), the second most abundant species, and in combination with T. borealis represented 95 percent

of the three year mean standing crop ($24.7/m^2$) of Corixidae in Lake Poinsett. Both P. buenoi and T. borealis produced two generations each year, but P. buenoi overwintered as primarily fourth instar nymphs and T. borealis overwintered as adults.

Food habits analysis of littoral zone fishes, Pimephales promelas Rafinesque, Etheostoma nigrum Rafinesque, Ictiobus cyprinellus (Valenciennes), Percopsis omiscomaycus (Walbaum), Notropis hudsonius (Clinton), N. stramineus (Cope), and N. lutrensis (Baired and Girard), indicated that corixids were not prey species and that littoral zone fish predation had no significant effects on corixid population dynamics. The lack of predation of littoral zone fishes on corixids appeared to be primarily related to the fish species composition and to the high densities of more vulnerable prey.

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# INTRODUCTION

Trophic ecology, the science of the feeding of animals, is essential to the understanding of predator-prey relationships and of population cycles in aquatic ecosystems. Aquatic ecosystems are composed of consuming and consumed animals interrelated in a strife-torn association dominated by mutually contradictory goals of predation and evasion. Various adaptations have evolved on each side to achieve these goals. Selective predation by fishes or a lack of it has profound effects on invertebrate population structure and cycles (Hrbacek 1960; Hrbacek, et al. 1961; Brooks and Dodson 1965; Hurlbert et al. 1972). The degree of food selectivity by fishes is largely dependent on size and mobility of food organisms. Selectivity is accomplished by either picking organisms of a desired size or by indiscriminate filtering, in which case the morphology of the gill-rakers determine the size of organisms captured.

Corixidae occupies a link in the food chain between the particulate organic matter and filamentous algae of a lake bottom and the predatory fishes that feed upon them. Corixids, therefore, play an important role in aquatic communities because they are primary and secondary consumers and may serve as a basic link in the food chain leading to predatory vertebrates. Food habit studies of fishes have shown corixids to be preferred food by some species (Forbes 1888) and studies by Popham (1941) have shown that the protective coloration of corixids is owing to selective predation by fishes.

There are about 115 known species of Corixidae in the United States, 23 of which occur in South Dakota (Hungerford 1948; Sailer 1948). Nine genera and 18 species are represented in the Eastern South Dakota Lake District and 7 of these species commonly occur in lakes of the District (Applegate 1972). The majority of corixids winter as adults, but some species have been reported as passing the winter as eggs or nymphs. Corixids undergo five nymphal instars and there may be one or two generations a year, depending upon the species or climate (Hungerford 1948). Objectives of this study were to describe corixid species composition, relative abundance and annual cycles in Lake Poinsett, South Dakota, and to determine if littoral zone fish predation influenced corixid population dynamics.

## STUDY AREA

Lake Poinsett, the largest natural lake in South Dakota, is located in the east central part of the state. The lake was formed by the partial blockage of a stream valley by glacial drift approximately 20,000 years ago during the Wisconsin ice age (Flint 1955). Thermal stratification never develops in the summer and ice-cover is present from November through March. Shifting sand, gravel, and rubble substrates in shore-line areas intergrade with muck substrates in the lake basin. Higher aquatic vegetation is lacking, but the filamentous green alga, *Cladophora* sp., dominates the sand, gravel, and rubble substrate of the littoral zone and provides a food source for corixid populations.

Lake Poinsett is a hardwater lake with high dissolved solid and organic matter content (Table 1). The lake is located in the cultivated plains of Eastern South Dakota and receives nutrient-rich inflow from ground and surface waters (Applegate 1971). The two major drainages into the lake have mean annual total $PO_4$ concentrations of 0.6 and 1.9 mg/liter. Lake Poinsett receives by surface flow about 1.66 x $10^4$ kg $PO_4$ and 1.28 x $10^4$ kg $NO_3$ annually. An estimated 70 percent of the phosphorus load is retained (Skille 1971). Dissolved inorganic phosphorus and nitrate nitrogen are seven and two times, respectively, the levels considered necessary for dense algal blooms (Sawyer 1966). The lake is characterized by late winter and early spring maxima of unicellular phytoplankton under ice and summer blooms of blue-green algae. Unicellular algae provide a food base for the rapid development

Table 1. Hydrographic, chemical and organic matter characteristics of Lake Poinsett, South Dakota

| | |
|---|---|
| Hydrographic features | |
| Elevation, msl | 503 m |
| Area | 3157 ha |
| Length | 8.9 km |
| Width | 4.8 km |
| Mean Depth | 1.8 m |
| Maximum Depth | 5.5 m |
| Shore Development | 1.6 |
| Chemical features* | |
| pH | 7.9-9.6 |
| Specific conductance (micromhos/cm at 25° C) | 620 - 1350 |
| Bicarbonate alkalinity as $CaCO_3$ (mg/1) | 100 - 258 |
| Carbonate alkalinity as $CaCO_3$ (mg/1) | 0 - 90 |
| Calcium-magnesium hardness as $CaCO_3$ (mg/1) | 192 - 500 |
| Noncarbonate hardness as $CaCO_3$ (mg/1) | 3 - 230 |
| Sulfate $SO_4$ (mg/1) | 116 - 290 |
| Chloride Cl (mg/1) | 29 - 59 |
| Calcium Ca (mg/1) | 17 - 43 |
| Magnesium Mg (mg/1) | 46 - 98 |
| Sodium Na (mg/1) | 15 - 74 |
| Potassium K (mg/1) | 19 - 24 |
| Orthophosphate ($mgPO_4$/1) | 0.04 - 0.22 |
| Poly and meta phosphate ($mgPO_4$/1) | 0.00 - 0.24 |
| Sestonic phosphate ($mgPO_4$/1) | 0.01 - 0.43 |
| Nitrate nitrogen $NO_3$ (mg/1) | 0.10 - 1.40 |
| Ammonia $NH_3$ (mg/1) | 0.00 - 1.93 |
| Iron Fe (mg/1) | 0.02 - 0.58 |
| Silica $SiO_2$ (mg/1) | 14.8 -27.0 |
| Aluminum Al (mg/1) | 0.00 - 0.03 |
| Barium Ba (mg/1) | 0.00 - 1.00 |
| Boron B (mg/1) | 0.00 - 0.20 |
| Copper Cu (mg/1) | 0.03 - 0.70 |
| Manganese Mn (mg/1) | 0.09 - 0.80 |
| Organic matter features** | |
| Dissolved organic matter (mg/1) | 35.0 -50.0 |
| Seston (mg/1) | 4.2 -15.5 |
| Zooplankton (mg/1) | 0.2 - 2.3 |

* Data from Schmidt (1967), Skille (1971), Smith (1971)
** Data from Applegate et al. (1973)

of planktonic herbivore populations in the spring (Applegate et al. 1973). The high particulate organic matter concentrations in addition to the substrate growths of *Cladophora* provide a rich food base for Corixidae and for the benthic detritivores and herbivores.

The macroscopic benthose population of the sand substrate is comprised of about 18 genera of invertebrates (Smith 1971). Species of the family Chironomidae are most abundant, followed by Oligochaeta, Ephemeroptera and Acari. The fish population of Lake Poinsett is comprised of about 18 species (Congdon 1968). Dominant species are black bullhead, *Ictalurus melas* Rafinesque; carp, *Cyprinus carpio* Linnaeus; bigmouth buffalo, *Ictiobus cyprinellus* Valenciennes; white crappie, *Pomoxis annularis* Rafinesque; black crappie, *P. nigramaculatus* Le Sueur. The dominant species of the littoral zone is the fathead minnow, *Pimephales promelas* Rafinesque.

# METHODS

Corixids were sampled each week at four areas representing the north, south, east, and west littoral zone portion of Lake Poinsett during the open water seasons, April-October, in 1970, 1971, and 1972. Duplicate samples were taken during the morning hours, 8:00 a.m. - 11:00 a.m., on each sampling date from each area with a 45 x 20 cm rectangular dip net. Samples were taken by pushing the net approximately 1m/sec. over the substrate. Each transect was from 9.15 m from the shore line back to the shore line. Each transect (=sample) represented 4.1 $m^2$ of substrate sampled. Corixids were captured in the net from the substrate or in the water above the substrate when attempting to avoid the net as it approached them. Collections were preserved in 20 percent formalin and were sorted to species and sex using the keys and descriptions of Hungerford (1948) and Sailer (1948). Species were counted and their density, No./$m^2$, estimated.

Depth distribution of Corixidae in the littoral zone was estimated by making 6.1 m transects parallel to shore at 30 cm depth intervals. Qualitative samples were taken in the profundal zone with a bottom trawl and Miller tow net sampler to determine if corixids inhabited deep areas of the lake not in the littoral zone habitat. Substrate samples were taken by the use of SCUBA to determine the substrate types and areas used for ovipositing. Water temperature was monitored in the littoral zone with a hand thermometer at 30 cm below the surface.

Three major species of corixids from Lake Poinsett were reared in temperature control and temperature fluctuating aquaria to determine embryonic development time and approximate time between generations. Temperatures were monitored in temperature fluctuating aquaria with a recording thermometer.

Fish were sampled each week from the four littoral zone sampling areas of Lake Poinsett during the open water season in 1970. Collections were taken with a 6.1 m length beach seine and dip net and preserved in 20 percent formalin. The anterior portions of the digestive system of fish, from the mouth to the pyloric caeca or from the mouth to the first major curve of the intestine for species not having pyloric caeca, were removed from fish. Each digestive tract portion was teased apart on a microscope slide and food items were identified at a magnification of 20x, 40x, and 100x.

# RESULTS AND DISCUSSION

## Corixidae Species Composition and Relative Abundance

Seven genera and 15 species of the family Corixidae were collected from Lake Poinsett. The species composition represented approximately 68 percent of the species occurring in the Eastern South Dakota Glacial Lake District (Table 2). The species composition of Lake Poinsett consisted of indigenous species and migrant species.

The major indigenous species were P. buenoi, T. borealis, C. dakotensis, and S. conocephala (Table 3). These species have been reported to be lake inhabiting forms in South Dakota (Applegate 1973). Palmacorixa buenoi, the most abundant species in Lake Poinsett, has reduced and nonfunctional flight wings and is restricted to permanent bodies of water (Hungerford 1948). The mean density of P. buenoi ($19.84/m^2$) was approximately five fold greater than that of T. borealis ($3.81/m^2$), the second most abundant species, and made up 80 percent of the three year mean standing crop ($24.71/m^2$) of Corixidae in Lake Poinsett. Palmacorixa buenoi attained estimated densities of $597/m^2$ at the south area of Lake Poinsett on August 15, 1972 and had an average density of $124/m^2$ in June 1972.

Trichocorixa borealis, one of the most abundant lake dwelling species in Eastern South Dakota, seldom attained densities as great as those of P. buenoi. The mean density of T. borealis ($3.81/m^2$) made up 15 percent of the three year mean standing crop and in combination with P. buenoi represented 95 percent of the three year mean standing crop of Corixidae in Lake Poinsett.

Table 2. Corixidae species composition of Eastern South Dakota

| | |
|---|---|
| Cymatia americana Hussey | Cenocorixa utahensis (Hungerford)* |
| Palmacorixa buenoi Abbott* | C. sp.* |
| P. gilletti Abbott | Sigara alternata (Say)* |
| Trichocorixa verticalis (Fieber)* | S. bicoloripennis (Walley)* |
| T. naias (Kirkaldy)* | S. decoratella (Hungerford) |
| T. borealis Sailer* | S. conocephala (Hungerford)* |
| T. calva (Say) | S. grossolineata (Hungerford)* |
| T. kanza Sailer | S. solensis (Hungerford)* |
| Callicorixa audeni Hungerford* | S. compressoidea (Hungerford) |
| Hesperocorixa vulgaris (Hungerford)* | Ramphocorixa acuminata (Uhler) |
| Cenocorixa dakotensis (Hungerford)* | Corisella tarsalis (Fieber)* |

*Species collected from Lake Poinsett

Table 3. Mean density (No./m$^2$) of adult Corixidae at four littoral zone areas of Lake Poinsett, South Dakota

| Species | 1970 | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | A | M | J | J | A | S | O | Annual Mean |
| *P. buenoi* | - | 0.19 | 6.19 | 11.12 | 6.36 | 1.31 | 0.03 | 4.02 |
| *T. borealis* | - | 0.17 | 0.04 | 0.37 | 0.15 | 0.15 | 0.10 | 0.16 |
| *T. verticalis* | - | - | - | 0.02 | - | - | - | <.01 |
| *T. naias* | - | - | - | - | - | 0.01 | - | <.01 |
| *C. dakotensis* | 0.24 | 0.34 | 0.07 | 0.62 | - | 0.02 | 0.07 | 0.18 |
| *C. utahensis* | - | - | - | - | - | - | 0.05 | 0.01 |
| *C.* sp. | - | - | - | - | - | - | - | - |
| *S. alternata* | 0.20 | 0.11 | 0.01 | - | - | 0.04 | 0.23 | 0.06 |
| *S. conocephala* | 0.07 | 0.06 | 0.04 | - | - | 0.01 | 0.01 | 0.02 |
| *S. solensis* | - | - | - | - | - | 0.06 | 1.90 | 0.22 |
| *S. bicoloripennis* | - | - | - | - | - | - | 0.02 | <.01 |
| *S. grossolineata* | - | - | - | - | - | - | - | - |
| *C. tarsalis* | - | - | - | - | - | - | - | - |
| *H. vulgaris* | - | - | - | - | - | 0.01 | - | <01 |
| *C. audeni* | - | - | - | - | - | - | - | - |
| Total | 0.51 | 0.87 | 6.34 | 12.13 | 6.51 | 1.61 | 2.41 | 4.67 |

Table 3. Continued. Mean density (No./$m^2$) of adult Corixidae at four littoral zone areas of Lake Poinsett, South Dakota

| Species | 1971 | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | A | M | J | J | A | S | O | Annual Mean |
| P. buenoi | 0.00 | 4.19 | 5.07 | 3.86 | 15.11 | 32.87 | 27.97 | 10.95 |
| T. borealis | 0.11 | 0.64 | 0.52 | 3.33 | 7.88 | 5.80 | 43.58 | 4.62 |
| T. verticalis | - | - | 0.30 | 0.02 | 0.01 | - | - | 0.08 |
| T. naias | - | - | 0.02 | 0.01 | 0.02 | - | - | 0.01 |
| C. dakotensis | 0.04 | 0.03 | 0.03 | 0.01 | 0.06 | 0.04 | 0.65 | 0.06 |
| C. utahensis | - | - | - | 0.01 | - | - | - | <.01 |
| C. sp. | - | - | 0.01 | 0.01 | 0.02 | - | 0.41 | 0.03 |
| S. alternata | - | - | - | - | 0.13 | - | 0.41 | 0.03 |
| S. conocephala | 0.17 | 0.04 | 0.08 | - | 0.03 | 0.06 | 1.67 | 0.10 |
| S. solensis | 0.38 | - | 0.01 | - | 0.03 | 0.02 | 30.12 | 1.11 |
| S. bicoloripennis | - | - | - | - | 0.04 | - | 16.50 | 0.60 |
| S. grossolineata | - | - | - | 0.01 | - | - | - | <.01 |
| C. tarsalis | - | - | - | - | - | - | - | - |
| H. vulgaris | - | - | - | - | 0.01 | - | - | <.01 |
| C. audeni | - | - | - | - | - | - | 0.16 | 0.01 |
| Total | 0.70 | 4.90 | 6.04 | 7.26 | 23.34 | 38.79 | 121.47 | 17.60 |

Table 3. Continued. Mean density (No./$m^2$) of adult Corixidae at four littoral zone areas of Lake Poinsett, South Dakota

| Species | 1972 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | A | M | J | J | A | S | O | Annual Mean | 3 Year Mean |
| *P. buenoi* | - | 0.16 | 124.06 | 33.62 | 97.04 | 15.09 | 4.33 | 49.24 | 19.84 |
| *T. borealis* | 0.27 | 4.40 | 3.51 | 31.96 | 6.34 | 1.14 | 0.12 | 7.11 | 3.81 |
| *T. verticalis* | - | - | - | - | - | - | - | - | 0.03 |
| *T. naias* | - | - | - | - | - | - | - | - | <.01 |
| *C. dakotensis* | 0.03 | 0.26 | 0.12 | 1.51 | 0.17 | 0.04 | - | 0.31 | 0.18 |
| *C. utahensis* | - | - | - | - | - | - | - | - | <.01 |
| *C.* sp. | - | - | - | 0.02 | - | 0.02 | 0.06 | 0.01 | 0.01 |
| *S. alternata* | - | - | - | - | - | - | - | - | 0.04 |
| *S. conocephala* | - | 0.17 | 0.01 | - | 0.02 | - | - | 0.05 | 0.06 |
| *S. solensis* | 0.41 | 0.04 | - | - | - | - | 2.32 | 0.16 | 0.52 |
| *S. bicoloripennis* | 0.01 | 0.02 | 0.06 | - | - | - | 0.06 | 0.02 | 0.22 |
| *S. grossolineata* | - | - | - | - | - | - | - | - | <.01 |
| *C. tarsalis* | - | - | - | - | 0.01 | - | - | <.01 | <.01 |
| *H. vulgaris* | 0.01 | - | - | - | 0.01 | - | - | <.01 | <.01 |
| *C. audeni* | - | - | - | - | - | - | - | - | <.01 |
| Total | 0.73 | 5.05 | 127.76 | 67.11 | 103.59 | 16.29 | 6.89 | 56.90 | 24.71 |

The indigenous species, C. dakotensis, S. conocephela, T. verticalis and T. naias, maintained subdominant populations each year and in combination had an estimated three year mean density of 0.27/$m^2$. These same four species occurred as subdominants in a survey of 43 Eastern South Dakota Lakes in August 1970 (Applegate 1972).

Fifteen specimens of a Cenocorixa sp. were collected in 1971 and 1972 and may be considered a new species. The new form most closely resembled C. expleta (Uhler), a species described from two females collected in Colorado and also having a distribution in North Dakota and in Saskatchewan and Manitoba, Canada (Hungerford 1948). Cenocorixa expleta is unique in that the male pala of this species has a spinose tumescene at its base and a broken peg row with 12 pegs in the upper apical row and 10 pegs in the lower basal row with two pegs spaced wide apart in between. The female pala has 14 to 16 lower palmar hairs. Hungerford described this species as ranging from 6.5 mm to 7.1 mm in length. The specimens from Lake Poinsett range from 7.9 mm to 9.0 mm in length. Like C. expleta, the male pala has a spinose tumescene at its base, but the broken peg row has 13-15 pegs in the upper apical row and 11-13 pegs in the lower basal row with one peg spaced in between. The new form is also unique in that the female pala has 11 long lower palmar hairs and the male pala has 12-13 long lower palmar hairs. The number and characteristics of the lower palmar hairs are of particular interest in that they are a key character used by Hungerford to separate the tribes of the subfamily Corixinae. Not more than 12 to 14 long lower palmar hairs is a key character of the tribe Glaenocorisini, a tribe not found represented in Lake Poinsett in this study. The character of fewer than 14 long lower palmar hairs observed in the new form would make the form unique within the tribe Corixini, the tribe containing the majority of North American species and the tribe containing all of the species observed in Lake Poinsett.

Migrant species of corixids appeared in late fall and early spring samples. *Sigara alternata*, *S. solensis*, *S. bicoloripennis*, *H. vulgaris*, and *C. audeni* are species that predominate in marshes of Eastern South Dakota and migrated to Lake Poinsett to winter. Hungerford (1948) pointed out that many species of Corixidae exhibit a life history where young are produced in temporary pools and ponds and adults winter in more stable aquatic systems. Hilsenhoff (1970), while conducting a taxonomic study of the corixids of Wisconsin, observed these migratory habits and placed special emphasis on collecting from large streams in October and November when both indigenous and migratory species were concentrated together. Likewise, the greatest species diversity in Lake Poinsett normally occurred in late summer and fall. Migratory species attained a mean density of $47.19/m^2$ in October 1971 and comprised 39 percent of the mean standing crop during that month. The three year mean density of migratory species was $0.78/m^2$ or only three percent of the three year mean standing crop of Corixidae in Lake Poinsett.

## Corixidae Annual Cycles

Corixids exhibited bimodal annual cycles and a progressive population density increase during the three years of study. Population density was usually greatest in the spring, May-June, and late summer and fall, August-September (Fig. 1). Population density increased from a mean annual standing crop of $4.9/m^2$ in 1970 to $17.6/m^2$ in 1971 and $56.9/m^2$ in 1972. The annual cycle of corixids was primarily influenced by the dominant species, P. buenoi and T. borealis.

Palmacorixa buenoi produced two generations each year. The species wintered in the profundal zone as primarily fourth instar nymphs. Three third instar and two fifth instar nymphs were collected in the early spring of 1971, but all other nymphs collected in the winter or early spring were fourth instars. Nymphs were collected in the muck substrate of the profundal zone with a bottom trawl and Miller sampler in November and early April. Fourth instar nymphs appeared at low densities in the littoral zone in April and molted to fifth instar nymphs in May (Fig. 2) when water temperature was 14 C - 21 C (Fig. 3). Fifth instar nymphs concentrated on the sand and gravel substrate in water depth of 15 cm - 30 cm and molted to first generation adults in June when water temperature was 14 C - 25 C. All nymphs had molted to adults by mid June each year and only adults were present during the latter part of June. Ovipositing occurred in June and egg deposition was concentrated on rubble 2.7 m - 12.2 m from the shore line in water depths of 0.6 m - 0.9 m. The egg incubation period and duration between molts was approximately 10 days each at the water temperatures of 19 C - 25 C recorded in the littoral zone areas of Lake Poinsett. Second generation adults appeared in August and the first part of

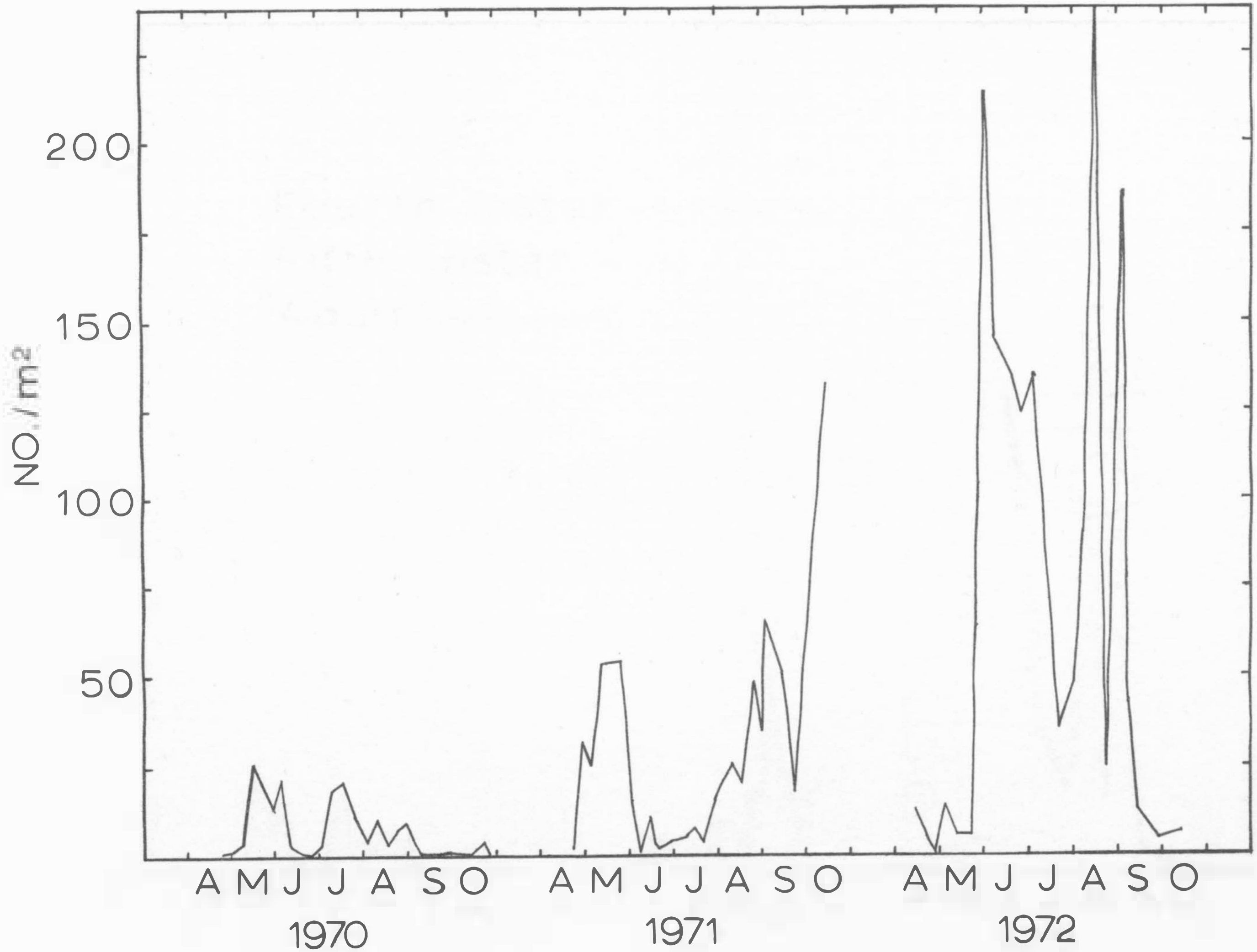


Figure 1. Average density of corixids in the littoral zone of Lake Poinsett, South Dakota.

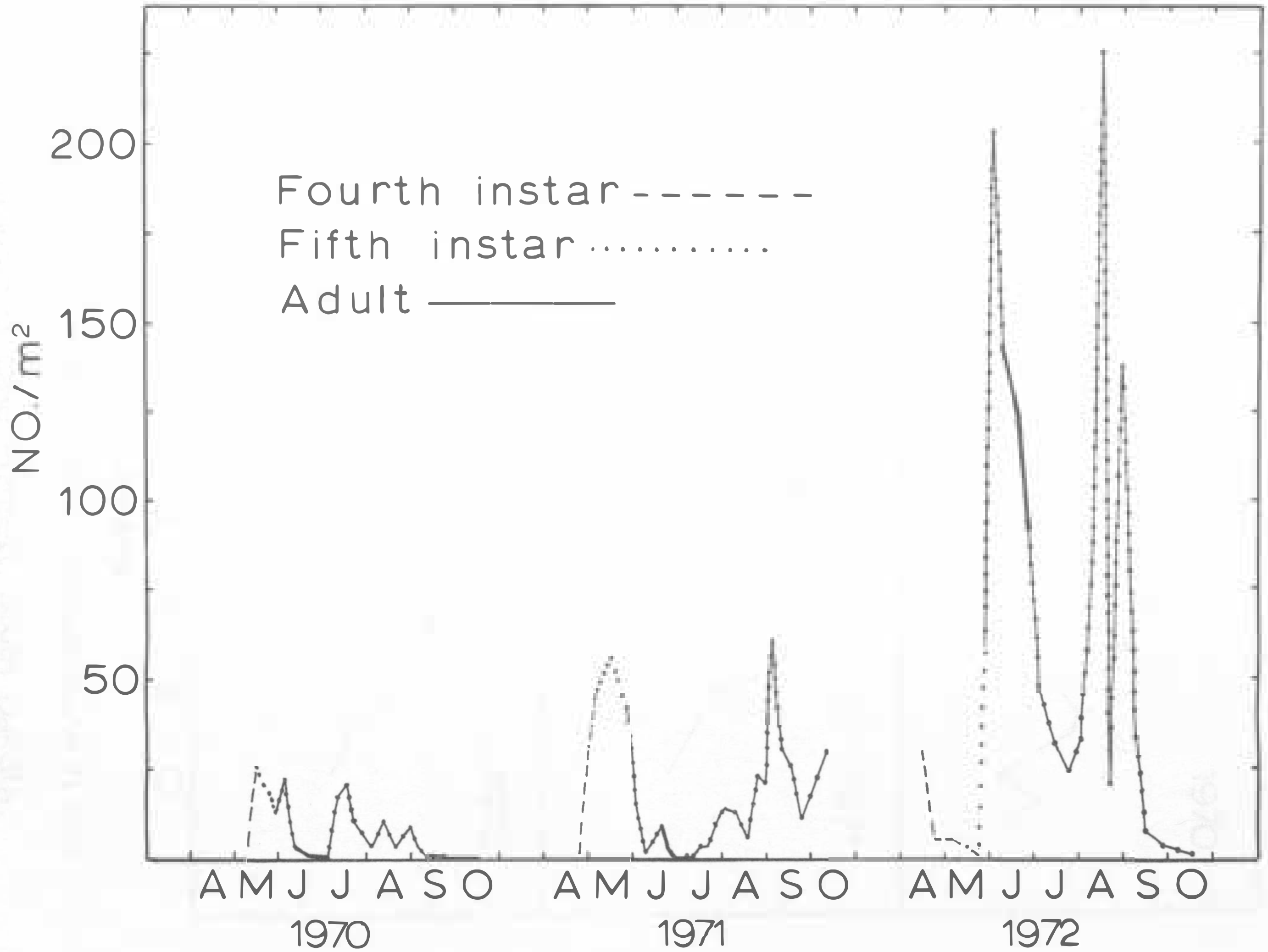


Figure 2. Population cycle of P. buenoi in Lake Poinsett, South Dakota.

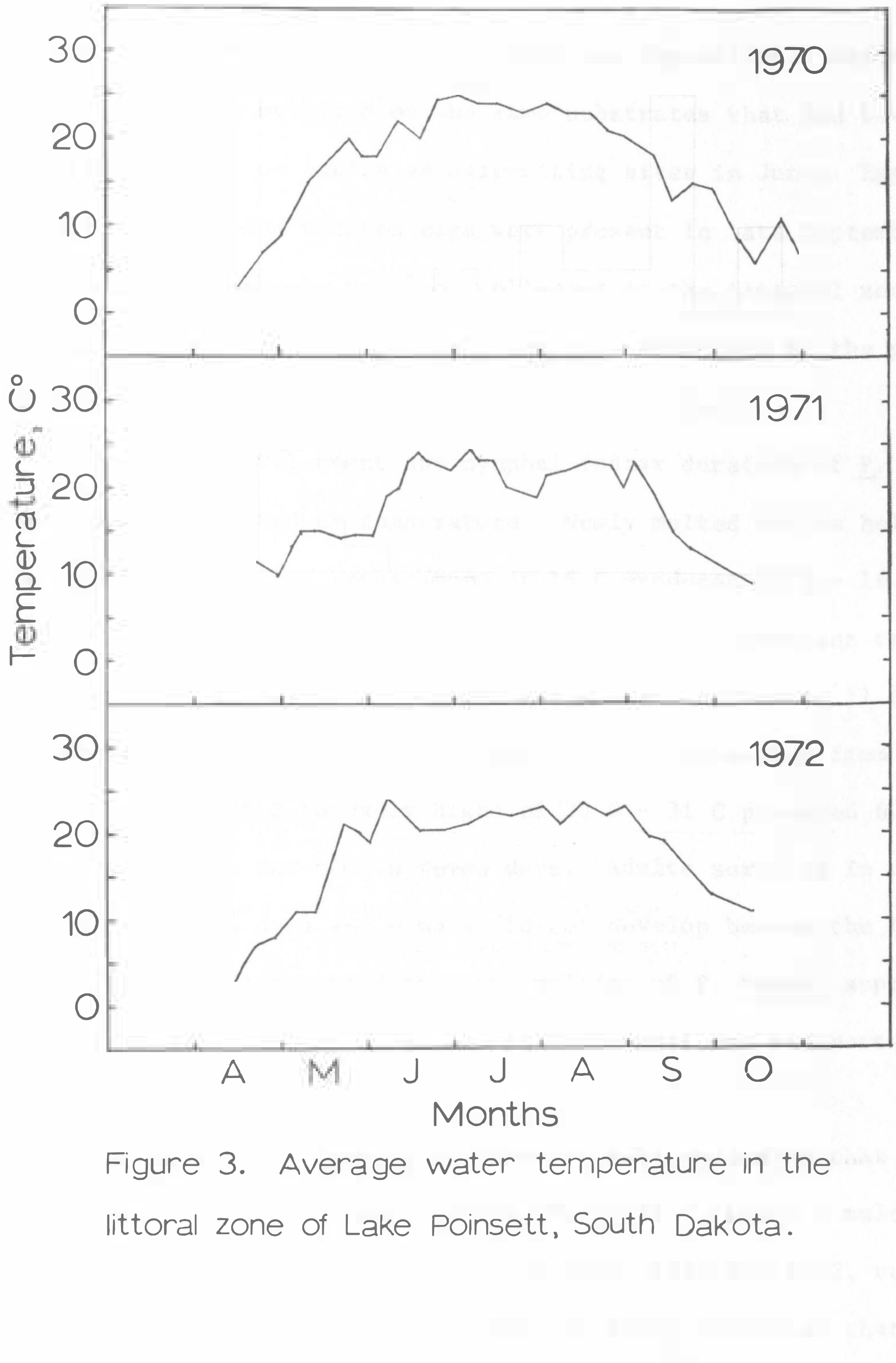


Figure 3. Average water temperature in the littoral zone of Lake Poinsett, South Dakota.

September, approximately 60 days after egg deposition. Second generation ovipositing occurred on the same substrates that had been used by first generation adults as ovipositing sites in June. Eggs containing embryos and hatched eggs were present in late September and in October, but nymphs were not collected in the littoral zone. First instar nymphs apparently moved to the muck substrate of the profundal zone and developed to the wintering fourth instars.

Embryonic development and nymphal instar duration of P. buenoi was likely regulated by temperature. Newly molted adults held in aquaria at a constant temperature of 18 C produced 16.2 - 16.4 eggs/female that hatched in 15 days. Adults held at a constant temperature of 21 C produced 15.4 - 17.5 eggs/female that hatched in 11 days. Adults held in aquaria with the temperature fluctuating from daily lows of 21 C - 25 C to daily highs of 22 C - 31 C produced 6.2 - 18.8 eggs/female that hatched in seven days. Adults survived in aquaria from seven to 14 days and nymphs did not develop beyond the first instar. Hungerford (1920) reported that the molting of P. buenoi appreared to be a precarious process under laboratory conditions and mortality was high.

Sex ratios of P. buenoi in Lake Poinsett indicated that males predominated throughout most months (Table 4). Female - male sex ratios were 1:1.5, 1:1.5 and 1:1.4 in 1970, 1971 and 1972, respectively. Chi-square values at an expected 1:1 sex ratio indicated that males occurred at significantly greater numbers each year. The 14,827 males and 10,548 females collected during the three years represented a

Table 4. Male and female densities in collections of the two dominant corixids of Lake Poinsett and chi-square values at an expected 1:1 sex ratio

| | Palmacorixa buenoi | | | Trichocorixa borealis | | |
|---|---|---|---|---|---|---|
| Year and Month | Male | Female | Chi-square Value | Male | Female | Chi-square Value |
| 1970 | | | | | | |
| April | -- | -- | -- | -- | -- | -- |
| May | 14 | 7 | 2.3 | 7 | 6 | 0.1 |
| June | 291 | 190 | 21.2** | 2 | 1 | 0.3 |
| July | 539 | 346 | 42.8** | 9 | 28 | 9.8** |
| August | 583 | 390 | 38.3** | 5 | 10 | 1.7 |
| September | 100 | 95 | 0.1 | 10 | 10 | 0.0 |
| October | 3 | 0 | 1.5 | 5 | 3 | 0.5 |
| Annual Total | 1,530 | 1,028 | 49.3** | 38 | 58 | 4.2* |
| 1971 | | | | | | |
| April | -- | -- | -- | 4 | 3 | 0.1 |
| May | 192 | 83 | 43.2** | 13 | 23 | 2.8 |
| June | 410 | 311 | 13.6** | 24 | 36 | 2.4 |
| July | 293 | 145 | 50.0** | 202 | 198 | 0.0 |
| August | 1,194 | 643 | 165.3** | 481 | 401 | 7.3** |
| September | 865 | 790 | 3.4 | 144 | 126 | 1.2 |
| October | 208 | 140 | 13.3** | 235 | 303 | 8.6** |
| Annual Total | 3,162 | 2,112 | 209.0** | 1,103 | 1,090 | 0.1 |
| 1972 | | | | | | |
| April | -- | -- | -- | 6 | 13 | 2.6 |
| May | 5 | 3 | 0.5 | 117 | 127 | 0.4 |
| June | 4,610 | 3,528 | 143.9** | 87 | 143 | 13.6** |
| July | 979 | 577 | 103.9** | 704 | 825 | 9.6** |
| August | 4,140 | 2,962 | 195.4** | 258 | 283 | 1.2 |
| September | 366 | 306 | 5.4* | 20 | 31 | 2.4 |
| October | 35 | 35 | 0.0 | 1 | 1 | 0.0 |
| Annual Total | 10,135 | 7,408 | 423.9** | 1,193 | 1,423 | 20.1** |
| Three Year Total | 14,827 | 10,548 | 721.6** | 2,334 | 2,571 | 11.5** |

*Significant difference at .05
**Significant difference at .01

female-male sex ratio of 1:1.4 that was significant at .005. Hungerford (1920) noted that 22 out of a catch of 29 first generation *P. buenoi* from a New York stream were males and suggested that males may predominate in early adults. Collections of *P. buenoi* from Lake Poinsett indicate that males may predominate throughout most months.

*Trichocorixa borealis* wintered as adults and produced two generations each year. Adults appeared in the littoral zone in April and May, and attained peak densities in mid or late May (Fig. 4). Low densities in April and high densities in May indicated that adults wintered in the profundal zone and moved to the littoral zone to oviposit. Egg deposition occurred on the rubble of the littoral zone in May and early June. The reproductive spring population appeared to have increased substantially during the three years of sampling. The average high estimated density in May 1970 was $0.4/m^2$ and had increased to $1.1/m^2$ in 1971 and $10.48/m^2$ in 1972. First generation adults appeared in July and early August approximately 60 days after egg deposition. First generation peak population density was low in 1970 ($0.7/m^2$) and increased progressively to $12.6/m^2$ in 1971 and $45.6/m^2$ in 1972. Second generation adults appeared in September and October approximately 60 days after egg deposition.

Population increase of *T. borealis* during the three years of study appeared to be due to high reproductive success of relatively low numbers of adults that overwintered in 1970 and oviposited in May and June of 1971. Two first generation cohorts were apparently produced by these overwintering adults, one in early July 1971 and the second in

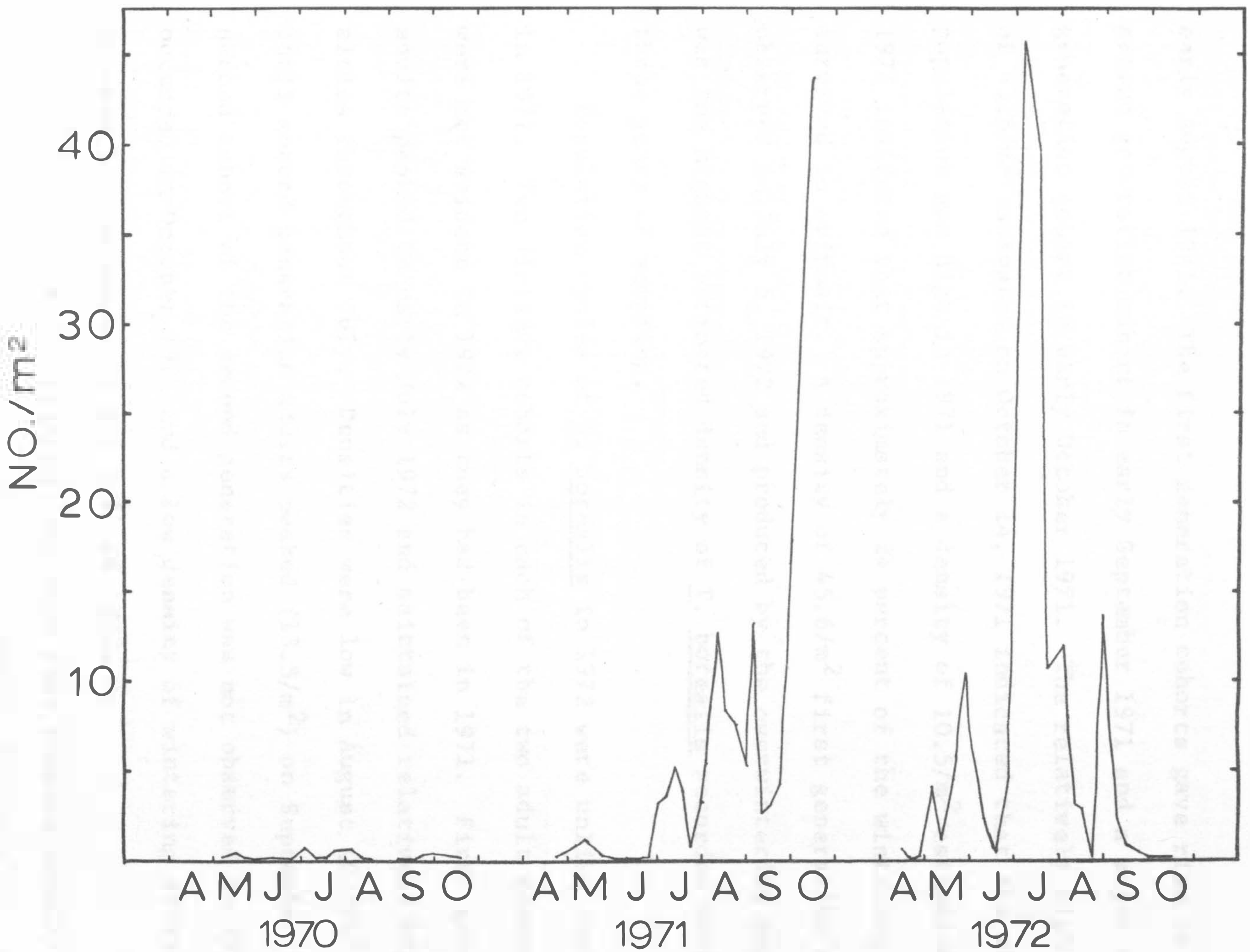


Figure 4. Population cycle of *I. borealis* in Lake Poinsett, South Dakota.

early August 1971. The first generation cohorts gave rise to a minor second generation cohort in early September 1971 and a major second generation cohort in early October 1971. The relatively high density of $43.6/m^2$ estimated on October 14, 1971 indicated that the wintering population was high in 1971 and a density of $10.5/m^2$ estimated on May 26, 1972 indicated that approximately 24 percent of the wintering population survived to oviposit. A density of $45.6/m^2$ first generation adults observed on July 5, 1972 and produced by the overwintering population was the highest estimated density of T. borealis recorded during the three years of sampling.

Population cycles of T. borealis in 1972 were unlike those observed in 1971. Two distinct cohorts in each of the two adult generations were not evident in 1972 as they had been in 1971. First generation adults peaked in early July 1972 and maintained relatively high densities throughout July. Densities were low in August ($0.2/m^2$ - $3.1/m^2$) until second generation adults peaked ($13.5/m^2$) on September 1. A second cohort of the second generation was not observed in 1972 as had occurred in October 1971 and a low density of wintering adults appeared to have been produced in the fall of 1972.

Sex ratios of T. borealis indicated that females usually occurred at slightly higher densities than males (Table 4). Male-female sex ratios were 1:1.5, 1:1.0 and 1:1.2 in 1970, 1971 and 1972, respectively. The total of 2,334 males and 2,571 females collected during the three years occurred at a male-female ratio of 1:1.1 that was significant at .005. Males occurred in significantly greater numbers only in

August 1973, the same year that male-female ratios were nearly equal.

Overwintered T. borealis placed in aquaria with temperatures fluctuating between nightly lows of 12 C - 25 C and daily highs of 14 C - 31 C produced a population cycle similar to that observed in Lake Poinsett. Eggs were deposited on the sides of aquaria beginning on May 7, two days after adults were introduced. First instar nymphs appeared 14 days after egg deposition and developed to first generation adults beginning July 5. The development time from egg to adult was 59 days. Overwintered adults survived in aquaria and fed on algae and associated fauna on the sides and bottom of aquaria until June 16, 42 days after their introduction.

The indigenous species, C. dakotensis, S. conocephala, T. verticalis and T. naias, normally occurred at trace densities and their life cycles were not defined. Cenocorixa dakotensis occurred at high enough densities in 1972 to determine that fifth instar nymphs were present on June 26 and first generation adults were present on July 5, at approximately the same time as first generation T. borealis. Overwintered adult C. dakotensis placed in aquaria, with temperatures fluctuating between nightly lows of 12 C - 25 C and daily highs of 14 C - 31 C, began ovipositing May 7, two days after adults were introduced. First instar nymphs began appearing 14 days after egg deposition and developed to first generation adults from June 16 to July 11. The development time from first eggs deposited to first adults was 40 days. The appearance of first generation adults reared in aquaria coincided with those observed in Lake Poinsett.

The depth distribution of corixids in Lake Poinsett was influenced by season and wave action. Ice thickness of 70 cm in the winter eliminated most of the littoral zone as an inhabitable area. Few, if any, species of Corixidae were collected in the littoral zone in late October and in November. The sparcity of corixids in the littoral zone in the late fall, when water temperatures were declining, suggests that the overwintering adults of indigenous species and migrant species as well as the overwintering nymphs of P. buenoi moved to the profundal zone in October and November to overwinter. Wave action in littoral zone areas also caused movements to profundal zone areas. Corixids were concentrated in shallow peripheral areas during the summer when wave action was minimal. Eleven depth profiles taken in non-turbulent littoral zone areas in July and August indicated that the majority of corixids were at 15-30 cm of depth and that densities decreased with increased depth (Table 5). Approximately 87 percent of corixids taken in the vertical depth distribution transects were in the 15 cm and 30 cm strata and densities decreased to a trace in the 120 cm strata. Littoral areas were void of or sparsely inhabited by corixids when wind produced turbulence in the shallow areas. Variance in littoral zone samples resulting from different wind velocities and directions was so great that statistical comparisons between years and between stations was not completed.

Corixids are generally described as inhabiting the shallows of ponds, lakes, and streams (Pennak 1953). Macan (1938) described corixids as being found in aquatic habitats where water depth does not exceed about one meter. The lack of corixids in the littoral zone of

Table 5. Density (No./$m^2$) and percent occurrence (in parenthesis) of corixids at different depths in the littoral zone of Lake Poinsett

| | Depth (cm) | | | | |
|---|---|---|---|---|---|
| Month | 15 | 30 | 60 | 90 | 120 |
| July | 2.2 (34.9) | 1.9 (30.2) | 1.1 (17.5) | 0.7 (11.1) | 0.4 (6.3) |
| | 3.3 (42.9) | 3.3 (42.9) | 1.1 (14.2) | 0.0 ( 0.0) | 0.0 (0.0) |
| | 6.7 ( 4.2) | 117.8 (74.1) | 31.1 (19.6) | 3.3 ( 2.1) | 0.0 (0.0) |
| | 0.4 (17.4) | 1.9 (82.6) | 0.0 ( 0.0) | 0.0 ( 0.0) | 0.0 (0.0) |
| | 1.1 ( 7.4) | 8.9 (60.1) | 3.3 (22.3) | 1.5 (10.1) | 0.0 (0.0) |
| | 0.0 ( 0.0) | 62.2 (91.2) | 5.6 ( 8.2) | 0.4 ( 0.6) | 0.0 (0.0) |
| | 0.0 ( 0.0) | 43.0 (100.0) | 0.0 ( 0.0) | 0.0 ( 0.0) | 0.0 (0.0) |
| August | 8.5 ( 6.1) | 131.9 (93.9) | 0.0 ( 0.0) | 0.0 ( 0.0) | 0.0 (0.0) |
| | 51.9 (37.7) | 85.9 (62.3) | 0.0 ( 0.0) | 0.0 ( 0.0) | 0.0 (0.0) |
| | 0.0 (0.0) | 6.7 (75.3) | 1.5 (16.9) | 0.7 ( 7.8) | 0.0 (0.0) |
| | 24.1 (37.1) | 38.9 (60.0) | 1.5 ( 2.3) | 0.4 ( 0.6) | 0.0 (0.0) |
| Mean | 8.9 (17.1) | 45.7 (70.2) | 4.1 ( 9.2) | 0.6 ( 2.9) | <0.1 (0.6) |

Lake Poinsett in the late fall, in the winter, and in the summer when water is turbulent suggests that corixids inhabited the profundal zone of Lake Poinsett during much of their life cycles. The impression that corixids inhabit primarily shallow water may be a result of inefficient sampling methods in deep water and of the ease corixids may be observed when they are present in shallow water areas. Corixids obtain oxygen by diffusion through the air - water interface of the film of air that almost completely envelops their body and the air held beneath their wings. Some authorities maintain that corixids may remain on bottom substrates indefinitely if the water is aerated (Pennak 1953). Remaining on the bottom would account for their absence in meter net and plankton tow net samples. Their agility and mobility make them capable of avoiding dredge samplers and would account for their absence in bottom samples. Smith (1971) reported capturing one nymph of P. buenoi in dredge samples from Lake Poinsett and Applegate et al. (1973) never observed corixids in plankton tow net samples from Lake Poinsett. Water visibility in Lake Poinsett was so poor that visual observations of corixid movements and habitat in the profundal zone was impossible while SCUBA diving.

Corixids in the profundal zone of Lake Huron have been observed with the use of SCUBA (personal communication from Roy F. Heberger, Jr., Great Lakes Fishery Laboratory, U. S. Fish and Wildlife Service, Ann Arbor, Michigan). Corixids were observed one mile off shore in water depths of 9.15 m to near the shore. They were associated with benthic flock composed of organic detritus and were distributed from the lakeward end of one mile transects nearly to the beach, where flock tended not to accumulate because of wave and current action. The presence of corixids in the stomachs of round whitefish, Prosopium cylindraceum (Pallas) captured lakeward of transects at water depths of 27.45 m suggested that corixids were inhabiting greater depths. Although corixids were readily observed while SCUBA diving and in the stomachs of round whitefish, they never appeared in meter plankton net tow samples or in benthic dredge samples.

## Fish Composition of the Littoral Zone

The major fishes of the littoral zone were the fathead minnow, Pimephales promelas Rafinesque; johnny darter, Etheostoma nigrum Rafinesque; and spottail shiner, Notropis hudsonius (Clinton). Young-of-the-year bigmouth buffalo, Ictiobus cyprinellus (Valenciennes) ranging between 1.8 cm and 3.7 cm total length were captured in the littoral zone on July 9, 1970. Miscellaneous species captured were one trout-perch, Percopsis omiscomaycus (Walbaum) on June 25, 1970; one sand shiner, Notropis stramineus (Cope) on July 2, 1970, and two red shiners, Notropis lutrensis (Baired and Girard) on July 2, 1970.

The fathead minnow was the most abundant species inhabiting the littoral zone throughout the summer. Schools of fathead minnows numbering several hundred individuals were common in littoral zone areas. A length-frequency histogram of fathead minnows captured in seine hauls from the littoral zone of Lake Poinsett indicated that the species had a life span of one year (Fig. 5). Adults ranging from 3.0 cm to 6.5 cm total length comprised the population in May. Spawning of fathead minnows begins in the spring when water temperatures attain 15.6 C (Prather 1957). Water temperatures in the littoral zone of Lake Poinsett attained the spawning range of the fathead minnow on May 10, 1970, and young-of-the-year fathead minnows ranging from 1.0 cm to 1.5 cm total length appeared in June samples. A second group of young-of-the-year fathead minnows ranging from 1.0 cm to 2.5 cm total length appeared in August. The two young-of-the-year groups appeared in September samples having a length frequency of 2.5 cm to 4.0 cm total length. Length frequency histograms indicated that mortality of large adult fathead minnows was high in June and that recruitment by smaller adults replaced the losses in July. Adults did not appear in August and September samples, indicating a complete mortality of adults had occurred. Hasler et al. (1946) and Prather (1957) reported that there is heavy mortality of male fathead minnows after spawning, and Carlander (1969) reported that, in most populations, fathead minnows mature and die when about one year old.

The johnny darter was a solitary species inhabiting rubble substrate in close association with corixids. Johnny darters were often captured in corixid dip net samples. Karr (1963) also noted that a dip net was an effective method of sampling johnny darters from rubble substrates. The length frequencies of johnny darters from Lake Poinsett (Fig. 6) were within the range of length frequencies reported for young-of-the-year to three year olds (Raney and Lachner 1943;

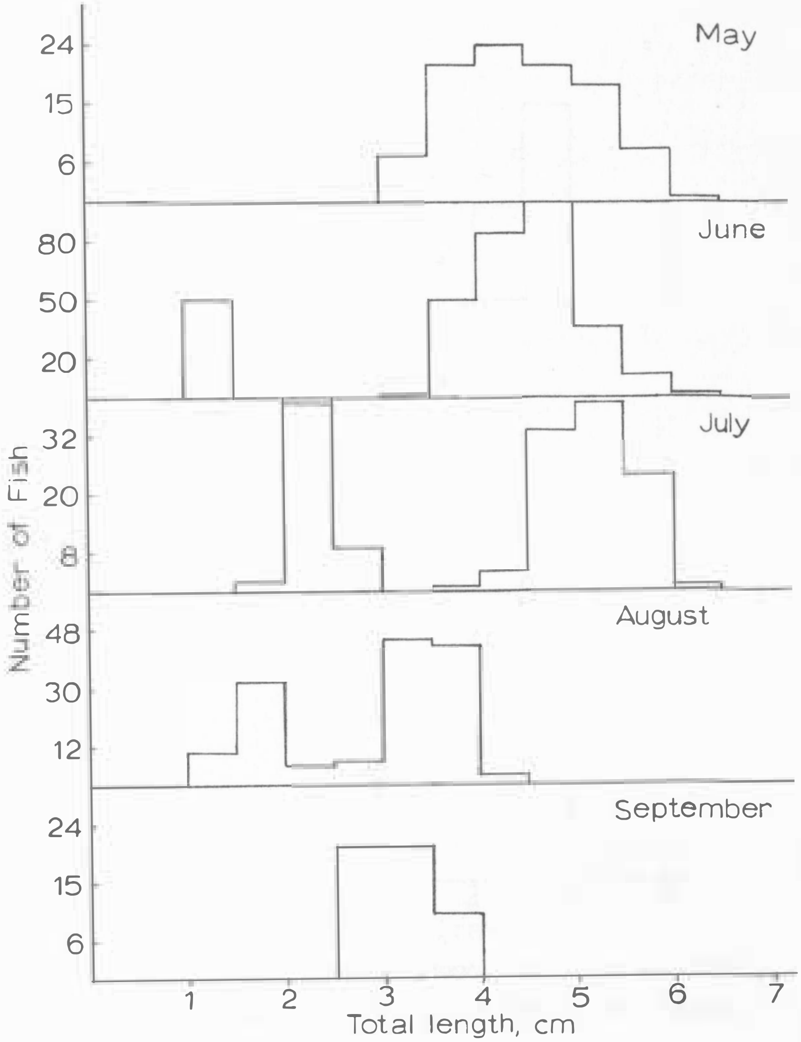


Figure 5. Length-frequency histogram of the fathead minnow, *Pimephales promelas* from the littoral zone of Lake Poinsett, 1970.

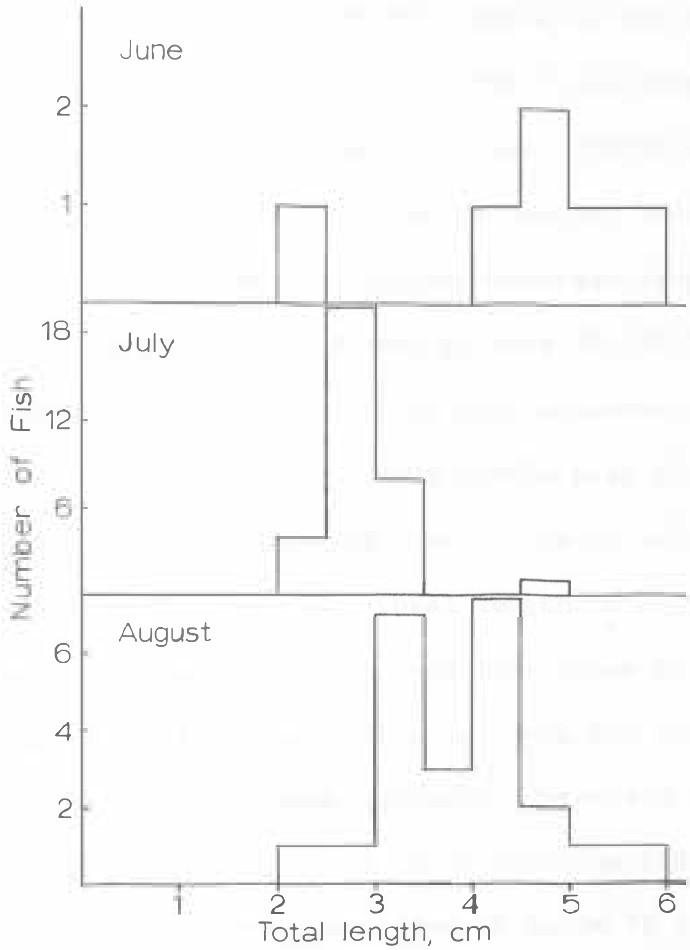


Figure 6. Length-frequency histogram of the Johnny darter, Etheostoma nigrum from the littoral zone of Lake Poinsett, 1970.

Speare 1960). Three to four years is the maximum age of johnny darters. Raney and Lachner (1943) and Speare (1960) captured darters up to three years of age, and Karr (1963) considered one out of the 55 he aged to be in its fourth year of life.

Spottail shiner young-of-the-year ranging from 1.6 cm to 1.8 cm total length were captured on June 25, 1970. Older shiners having lengths of 4.0 cm to 8.0 cm also appeared in June length frequency histograms (Fig. 7). Young-of-the year shiners showed a progressive length increase ranging from 1.5 cm to 3.5 cm total length in July and from 3.5 to 5.5 cm total length in August. Older shiners were not captured in the littoral zone areas in July and August. Spottail shiner adults apparently moved from the littoral zone into the profundal zone following spawning. Spottail shiners likely do not mature until they are over 6.6 cm at the spawning season and spawn in the spring at water temperatures of about 20 C (Carlander 1969). Spottail shiners have been reported to spawn in late June and early July in Red Lake, Minnesota (Smith and Kramer 1964) and Lake Erie (Fish 1932). In Clear Lake, Iowa, they spawn in early May through mid June (McCann 1959; Griswold 1963). Length frequency for shiners and water temperatures in Lake Poinsett indicated that spawning occurred in late May and early June and that young-of-the-year shiners inhabited the littoral zone areas throughout the summer.

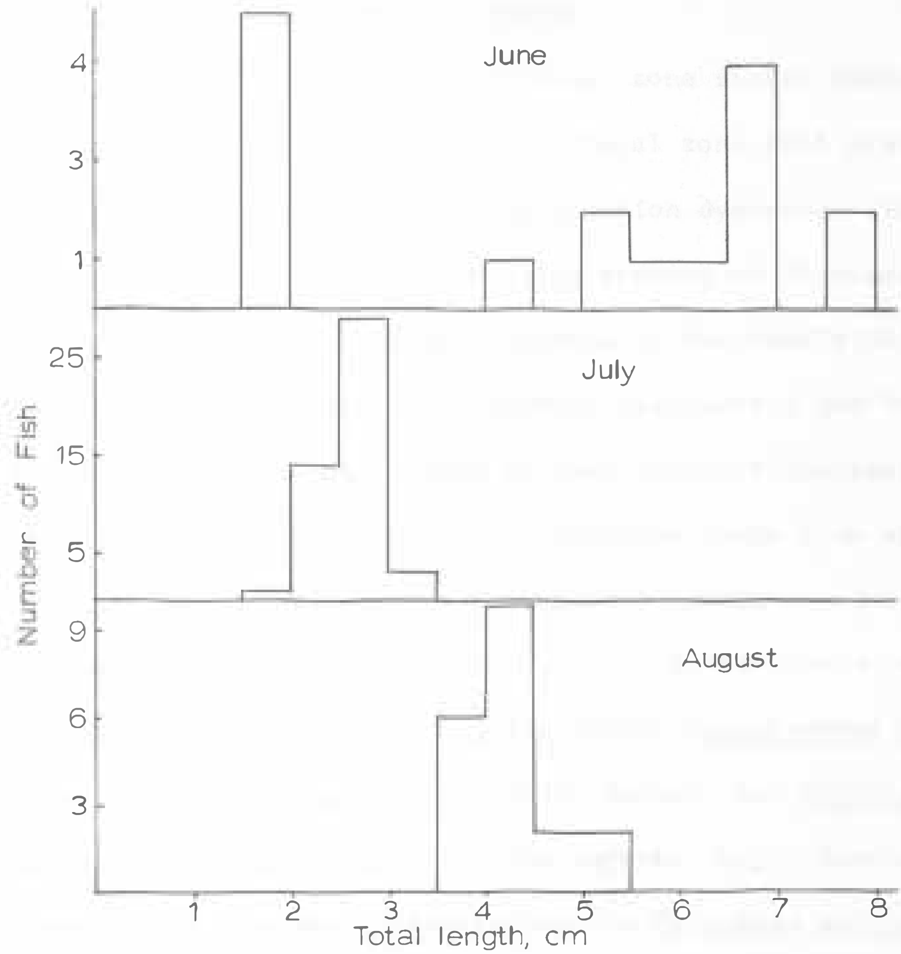


Figure 7. Length-frequency histogram of the spottail shiner, Notropis hudsonius from the littoral zone of Lake Poinsett, 1970.

Food Habits of Littoral Zone Fishes

Food habits analysis of littoral zone fishes indicated that corixids were not prey and that littoral zone fish predation had no significant effects on corixid population dynamics. The major prey organisms of the littoral zone were species of Crustacea of the order Cladocera and species of Diptra of the family Chironomidae. There are five species of planktonic cladocerans and four species of benthic cladocerans common to Lake Poinsett (Applegate et al. 1973; Repsys 1972). Cladoceran densities range from approximately 90/liter in the spring to approximately 150/liter in the summer. Daphia pulex Leydig predominates in the spring and a combination of Daphnia galeata Sars mendotae Birge, Diaphanosoma leuchtenbergianum Fisher, Bosmina longirostris (O. F. Muller) and Chydorus sphaericus (O. F. Muller) predominate in the summer. Major benthic species of Cladocera are Kurzia latissima (Kurz), Pleuroxus procurvus Birge, and P. trigonellus (O. F. Muller). Smith (1971) estimated that the mean annual density of chironomids in Lake Poinsett in 1970 was $1138/m^2$. Forty percent ($514.2/m^2$) of the mean annual density was composed of eight species of the genus Chironomus and 60 percent ($623.8/m^2$) was composed of the genera Procladius, Cryptochironomus, Polypedilum, Cladotanytarsus, and unidentified forms.

Fathead minnows fed primarily upon cladocerans and chironomid pupae and adults. These food items had the highest frequency of occurrence in intestinal tracts (Table 6). Fathead minnows lack a stomach and fragmented food items in the intestinal tracts indicated that food items were crushed by pharyngeal teeth before ingestion. An accurate numerical estimate of prey in the intestine was not possible in many adults and percent occurrence was used to evaluate feeding habits. The percent occurrence of cladocerans in the intestine of fathead minnows ranged from a high of 96 percent in August to a low of 0 percent in September. The percent occurrence of chironomids in intestinal tracts ranged from a high of 100 percent in September to a low of 1.3 percent in August. The percent occurrence of cladocerans and chironomids were more equally proportional in May, June, and July. Fathead minnows appeared to be selective for cladocerans and chironomids. Fathead minnows were observed feeding on the surface on ovipositing chironomids, and chironomid adults and eggs were the only food of the 25 minnows analyzed in September. Periphyton, rotifers, copepods, terrestrial dipterans, and the blue-green algae, Anacystis cyanea (Kutzing) Drouet and Daily occurred at a low frequency of occurrence and did not appear to be major food items. The only observed predation of fathead minnows on corixids was a single corixid egg in the intestinal tract of a 4.8 cm minnow captured on June 4.

Fathead minnows were recommended for stocking in reservoirs by Moore (1932) and in rearing ponds by Lord (1927) because they considered plankton-feeding of fathead minnows to be an important factor.

Table 6. Percent occurrence of food items in intestinal tracts of the fathead minnow, *Pimephales promelas*, from Lake Poinsett

| | 1970 | | | | |
|---|---|---|---|---|---|
| Item | May | June | July | August | September |
| Sand | 4.0 | - | - | - | - |
| Peraphyton | - | 16.0 | - | 2.7 | - |
| Cyanophyta (Anacystis cyanea) | - | - | - | 10.7 | - |
| Rotifera | - | 1.6 | - | - | - |
| Copepoda | - | 0.8 | - | - | - |
| Cladocera | 24.0 | 45.6 | 76.0 | 96.0 | - |
| Ephipia | 8.0 | 4.0 | - | - | - |
| Chironomidae | 76.0 | 66.4 | 26.0 | 1.3 | 100.0 |
| Larvae | 4.0 | 32.0 | 2.0 | - | - |
| Pupae & Adults | 72.0 | 34.4 | 26.0 | 1.3 | 100.0 |
| Terrestrial Insects | - | 0.8 | - | - | - |
| Corixidae Eggs | - | 0.8 | - | - | - |
| No. of fish examined | 25 | 125 | 50 | 75 | 25 |
| No. with food | 21 | 110 | 40 | 72 | 25 |

Fathead minnows have been described by Coyle (1930), Radcliffe (1931), Starrett (1950), and Minckley (1963) as feeding primarily on bottom algae and diatoms. Fathead minnows in Lake Poinsett appeared to be predacious upon cladocerans and chironomids.

The johnny darter fed primarily on chironomid larvae (Table 7). Copepods, cladocerans, and fish eggs were included in darter diets, but appeared to normally be minor food items. Johnny darters inhabited the bottom substrate of the littoral zone and were apparently highly selective for small chironomid larvae. The feeding responses of johnny darters have been shown to be primarily elicited by visual cues of movement (Roberts and Winn 1962). Darters in Lake Poinsett were evidently seeking out chironomid larvae and responding to their movements. Karr (1963) also noted that johnny darters in the Des Moines River, Iowa, fed primarily on chironomids and reported that chironomids in stomachs had a frequency of occurrence of 92 percent and comprised 68.5 percent of the food items ingested.

Spottail shiners fed primarily on cladocerans and chironomid larvae and pupae (Table 8). Water mites (Acari) and terrestrial insects (Cicadellidae) were included as prey in June. McCann (1959) and Griswold (1963) reported insect larvae, Cladocera, algae, and Acari as the major foods of spottail shiners in Clear Lake, Iowa. Shiners ranging between 1.0 cm and 7.0 cm from Red Lake, Minnesota, fed primarily on crustaceans (Smith and Kramer 1964).

Table 7. Average number and percent occurrence of food items in the stomachs of the Johnny darter, Etheostoma nigrum, from Lake Poinsett

| Item | 1970 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | May | | June | | July | | August | | September | |
| | Ave.No. /Fish | Percent Occurrence | Ave.No. /Fish | Percent Occurrence | Ave.No. /Fish | Percent Occurrence | Ave.No. /Fish | Percent Occurrence | Ave.No. /Fish | Percent Occurrence |
| Copepoda | 37.0 | 50.0 | - | - | 0.5 | 37.0 | - | - | 0.3 | 33.0 |
| Cladocera | - | - | - | - | 0.2 | 17.0 | 0.1 | 0.1 | - | - |
| Ephemeroptera | - | - | - | - | 0.1 | 3.0 | - | - | - | - |
| Chironomidae | 0.5 | 50.0 | 10.0 | 100.0 | 12.6 | 100.0 | 22.4 | 100.0 | 15.0 | 100.0 |
| Larvae | 0.5 | 50.0 | 10.0 | 100.0 | 12.4 | 100.0 | 22.0 | 95.0 | 15.0 | 100.0 |
| Pupae & Adults | - | - | - | - | 0.2 | 20.0 | 0.4 | 15.0 | - | - |
| Fish eggs | - | - | - | - | 0.4 | 13.0 | - | - | - | - |
| No. of fish examined | 2 | | 4 | | 30 | | 20 | | 3 | |
| No. with food | 1 | | 4 | | 30 | | 20 | | 3 | |

Table 8. Average number and percent occurrence of food items in the intestinal tracts of the spottail shiner, *Notropis hudsonius* from Lake Poinsett

| Item | 1970 | | | | | |
|---|---|---|---|---|---|---|
| | June | | July | | August | |
| | Ave.No. /Fish | Percent Occurrence | Ave.No. /Fish | Percent Occurrence | Ave.No. /Fish | Percent Occurrence |
| Cladocera | 13.3 | 60.0 | 3.0 | 100.0 | 0.2 | 5.0 |
| Acari | 0.1 | 5.0 | - | - | - | - |
| Chironomidae | 1.3 | 35.0 | 0.1 | 8.0 | 217.0 | 95.0 |
| Larvae | 0.2 | 10.0 | - | - | 198.0 | 95.0 |
| Pupae & Adults | 1.1 | 30.0 | 0.1 | 8.0 | 19.0 | 95.0 |
| Terrestrial Insects | 0.5 | 20.0 | - | - | - | - |
| No. of fish examined | 20 | | 25 | | 20 | |
| No. with food | 20 | | 25 | | 20 | |

Twenty-one young-of-the-year bigmouth buffalo captured in the littoral zone on July 9, 1970, had ingested an average 0.8 chironomid pupae and 4.4 cladocerans. One buffalo had included one Diaptomus sp. and one Cyclops sp. in its diet and one buffalo had fed upon Anacystis cyanea. The food habits of bigmouth buffalo examined were similar to those captured from Lake Poinsett in 1968 (Starostka and Applegate 1970) and similar to those reported for buffalo from other waters (Moen 1954; Johnson 1963; McComish 1967).

Two of the miscellaneous fish species in the littoral zone of Lake Poinsett were capable of a predatory influence on corixid population dynamics if they had occurred in greater numbers. The trout-perch has been described by Nurnberger (1930), Priegal (1962) and Dobie (1966) as feeding on chironomids, mayflies and other insects. The single trout-perch captured from Lake Poinsett had no food items in its stomach, but the species may have included corixids in its diet.

South Dakota is the northern-most limit of the range distribution of the red shiner (Carlander 1969). One of the two red shiners captured from Lake Poinsett contained no food items and the other shiner contained one adult Cenocorixa dakotensis. This single corixid in the intestinal tract of a red shiner was the only observed predation of fishes on adult corixids in the littoral zone. The one sand shiner captured had fed on bottom algae and on crustaceans.

The lack of predation of littoral zone fishes on corixids in Lake Poinsett appeared to be primarily related to the fish species composition and to the high densities of more vulnerable prey. Fishes such as salmonids, centrarchids, and perchids that are aggressive and selective predators are not indigenous or are not common in the shallow littoral zone of Lake Poinsett. Applegate (1973) attributed the lack of corixid populations in Lake Cochrane, South Dakota, to an abundant yellow perch population and high water transparency. Food habits studies of yellow perch, black crappie, white crappie and bluegill (Lepomis macrochirus Rafinesque) in Abbey Pond and Labolt Pond, South Dakota, demonstrated that corixids were an important food item that often made up the bulk of the diets in the fall (Unkenholz 1971; Gengerke 1972). The lack of or traces of corixids in the diets during the summer followed by high predation on corixids in the fall suggests that corixid populations were annihilated or reduced to trace densities during the summer. Migrant corixid species attempting to overwinter in the ponds were a major food item and were exposed to high mortality.

The fish composition of Lake Poinsett is representative of a shallow, eutrophic South Dakota prairie lake. Most of the major fishes are tolerant of low oxygen conditions that occur in such lakes. High densities of crustaceans in combination with chirinomids likely exerted a considerable buffering effect by providing a large and vulnerable food source for the fishes of the littoral zone of Lake Poinsett. Daphnia spp. are a primary food of planktivorous fishes (Ivlev 1961). Daphnia as well as most planktonic crustacea has few defense mechanisms against fish predation. Complete annihilation of Daphnia spp. by fish predation has been described by Brooks and Dodson (1965), Applegate and Mullan (1969) and Hurlbert et al. (1972). Daphnia populations maintain high densities during the spring in Lake Poinsett and populations decline rapidly in June when young-of-the-year fishes appear and when adult planktivorous fishes have high metabolic demands. The Daphnia populations maintain high birth rates as populations collapse and exhibit high mortality rates which Applegate et al. (1973) attributed to fish predation.

Corixids, as compared to crustaceans and chironomids, were highly adapted to avoid fish predation as long as they remained in the shallow littoral zone of Lake Poinsett. Ivlev (1961) in his classic studies on the experimental ecology of the feeding of fishes subdivided adaptive protection of prey organisms into the following basic groups: (1) toughness of outer covering and existence of defense equipment, (2) protective coloration, (3) toxicity, (4) size, and (5) speed of movement. Corixids in the littoral zone of Lake Poinsett exhibited all of the basic groups of adaptive protection Ivlev considered important. Eggs protected by outer chorions were cemented to the undersides and sides of rubble in compact masses to the extent that rubble was incursted with egg masses. Eggs were not apparently vulnerable to fish predation since only one was observed in the intestinal tract of a fathead minnow. Adult and nymphs, likewise, used the crevices provided by rubble for protection. Corixids exhibited a high degree of protective coloration and were nearly invisible when they remained motionless on gravel and rubble substrata.

Ivlev considered toxicity to mean not only the presence in the animal's body of substances of a toxic character but also the existence of products acting on the predator repulsively such as an unpleasant smell or taste. Ivlev pointed out that the action of repulsive substances is difficult to assess and mentioned the fact that water mites are normally avoided by fishes but may occupy a predominant position in the ration of fishes when other prey species are in short supply. Both nymph and adult corixids possess scent glands. Nymphal scent glands open by paired pores on the caudal margin of the third, fourth and fifth dorsal abdominal segments. In the adult, the scent glands are replaced by a metathoracid gland opening into scent gland orifices laterad of the middle coxae. Corixids collected in dip net samples from Lake Poinsett emitted a distinct odor that may have been repulsive to fishes but apparently does not eliminate them entirely as prey organisms. Collections of all the major species of Corixidae from Lake Poinsett when placed in aquaria with yellow perch, bluegill or largemouth bass, Micropterus salmoides (Lacepede) were readily ingested. Corixids may be similar to water mites in that they are repulsive but may become acceptable when preferred food items are in short supply or absent.

The size and speed of movement of corixids was a distinct survival advantage in the littoral zone of Lake Poinsett. Adult corixids exceeded the size of ingestable prey or were at least larger than the crustaceans and chironomids that comprised the major prey groups. Both nymphs and adults were capable of rapid movement. Nymphs and adults, when disturbed, would dart to a new location and remain motionless. Rapid movement combined with protective coloration provided efficient escape adaptations particularly suitable in Lake Poinsett where dense phytoplankton blooms obscured visibility during most of the summer months.

The lack of appreciable fish predation on corixids in the littoral zone of Lake Poinsett suggests that other factors, such as physical and climatic, may be directly or indirectly more responsible in affecting corixid densities and cycles. A lack of precipitation resulting in a low lake level would drastically reduce the area of rubble zone available for ovipositing sites. Turbulance in littoral zone areas created by high winds would be detrimental, in that eggs and nymphs may be destroyed by the grinding action of shifting substrata and adults are forced to move to the profundal zone where they are exposed to fish predation. Repsys(1972) reported that 220 young-of-the-year black bullheads from the profundal zone of Lake Poinsett in 1970 contained 13 corixids. Food habits studies of the yellow perch and crappies of the profundal zone of Lake Poinsett have not been reported, but they would be expected to prey on corixids since they have been reported to be predacious in other South Dakota waters.

Ross (1967) pointed out that the bulk of the aquatic insects are each restricted to a narrow range of at least some ecological conditions and that many aquatic communities are composed of far fewer species than terrestrial communities. Macan (1954) found that particular corixid species complexes had evolved and were indicative of habitat types in Briton. The corixid species composition and cycles in Lake Poinsett are likely indicative of a South Dakota prairie lake.

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