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Biological Features of an Aestival Pond in Western Canada

by

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ABSTRACT

The seasonal changes in flora and fauna in an aestival pond in central Alberta, Canada, were studied through a complete annual cycle during which an exceptional decrease in water volume occurred in response to lower than normal rainfall. Substantial changes took place between successive summers in the species composition of the phytoplankton, Rotifera, Oligochaeta, Copepoda and Zygoptera. Some of the incoming species, particularly *Chaetogaster diaphanus* (Oligochaeta) and three species of *Lestes* (Zygoptera) are often associated with more temporary habitats of the region. The instability of species composition and productivity of the community is discussed in terms of the trophic position of aestival lakes and ponds.

INTRODUCTION

In recent years interest in the use of shallow inland waters for raising rainbow trout and other game fish has emphasised our basic ignorance of the dynamics of ecological succession and the relationship between the productivity of a senescent aquatic habitat and its seral status. From his study of Cedar Bog Lake LINDEMAN (1941; 1942) proposed that characteristic features of late lake senescence were: a general decline in productivity and an increasing influence of climatic factors over the level of production. Such inherent instability places strict limitations on the type of shallow water body that would be suitable for the establishment of, for example, a fish-farming industry.

A study of the physical and chemical features of an aestival pond near Edmonton, Alberta, Canada, (53° 31′ N; 113° 07′ W) showed that the annual cycle consisted basically of summer and winter sea-

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sons with very short transitional periods between them (DABORN & CLIFFORD, this issue). During the summer the water volume of the pond diminished steadily from a high spring level resulting from snow run-off, and in winter all water in the basin remained frozen for about three months. Thus, the establishment of perennial populations of any species in an aestival pond depends upon tolerance of the changes associated with rapidly falling water levels in summer and a means of avoiding or adjusting to total freezing of the surrounding water in winter.

METHODS

For the examination of plankton, ten litres of water collected in a beaker from just below the water surface in the centre of the pond were poured through a Wisconsin plankton net lined with # 20 bolting silk. Estimates of phytoplankton numbers were obtained by examination of ten 1.0 ml subsamples under 600X magnification, and of zooplankton numbers by total counts of 5.0 ml subsamples allowed to settle in the chamber of a Wild M40 inverted microscope. Both techniques are semi-quantitative at best (KUTKUHN, 1958) but are sufficiently reliable to indicate major seasonal trends.

In order to sample simultaneously the invertebrates of both the mud and water, a new sampler was devised. It consisted of a hollow metal cylinder one metre in length, with a diameter of 11.45 cm, the lower end of which could be sealed by a pair of moveable plates. The cylinder was thrust as deeply as possible into the bottom mud, the plates closed, and the enclosed sample, consisting of a complete column of water and a variable thickness of mud, was emptied into a bucket. Samples thus obtained were fixed with formalin to which a small quantity of rose bengal had been added to facilitate sorting, and in the laboratory were washed through Canadian Standard sieves # 20 (0.841 mm) and # 30 (0.595 mm) before sorting by hand. Five such vertical samples were taken each month of the open water seasons. Comparison with samples taken with an Ekman grab have indicated that this vertical sampler is a reasonably semi-quantitative method. Dipnet collections made at the same time were used to supplement vertical samples and indicated that certain fast-swimming species, particularly the phyllopods and mites, were underestimated by the cylinder method.

Emergence of aquatic insects was monitored using floating box-frame traps (MORGAN, WADDELL & HALL, 1963). Each trap enclosed an area of 0.093 m^2 (1.0 ft^2) and was emptied at intervals of two to five days. Destruction of the traps by muskrats prevented data being obtained during the latter part of August, 1967.

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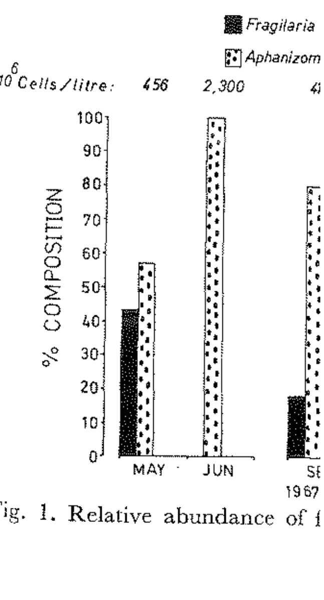

Fig. 1. Relative abundance of f

Results

A morphometric account of the pond and its seasonal and between-years changes in physical and chemical features has been given elsewhere (DABORN & CLIFFORD – this issue). The pond was surrounded by a mixed band of semi-terrestrial macrophytes including *Carex rostrata* STOKES, *Glyceria grandis* S. WATS. and *Eleocharis palustris* L. Although no quantitative surveys were conducted, distinct changes were noted in the relative abundance of these species during the study. In 1967 the association was dominated by *Carex*, while *Eleocharis* occurred in scattered patches, but with a marked reduction in volume of the pond, the latter species was by far the most abundant in 1968. The truly aquatic flora consisted of one floating form, *Lemna minor* L., and two submerged species, *Lemna trisulca* L. and *Myriophyllum exalbescens* FERN. All three were abundant in 1967, *L. minor* forming an extensive mat over the surface of the south-eastern (i.e. downwind) portion of the pond, but the following year *L. minor* was very scarce and development of both *L. trisulca* and *M. exalbescens* was comparatively poor.

Phytoplankton Association

During the course of the study 35 species, predominantly diatoms, blue-green and green algae, formed the phytoplankton association, but only four species were ever in abundance. The relative abundance of these species is given in Figure 1 together with an approxi-

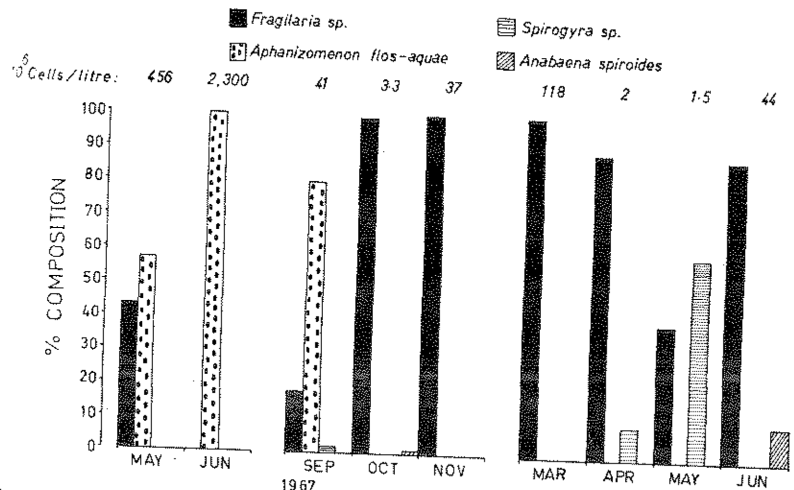

Fig. 1. Relative abundance of four major species of phytoplankton.

mation of the total number of cells per liter at that time. In June 1967 *Aphanizomenon flos-aquae* (L.) formed a dense green bloom throughout the water column, and this persisted through the first week in July. On July 4 and 5 dissolved oxygen saturation varied from 138% in mid-afternoon to a low of 65% just before dawn. Concurrent light and dark bottle experiments provided estimates of gross production of 45 and 30 mg C/m³ per hour over periods of six hours. The bloom disappeared between 16 and 19 July and thereafter total phytoplankton abundance amounted to less than 5% of that occurring in June. Subsequent oxygen measurements gave no evidence of a biogenic diel cycle, and light and dark bottle experiments indicated little or no primary production. During the autumn and early winter *Aphanizomenon* was succeeded by the pennate diatom *Fragilaria* sp. which remained the dominant species until the end of May 1968, at which time filaments of *Spirogyra* sp. were extremely abundant. There was no sign of *Aphanizomenon* in 1968.

Zooplankton Association

Of 11 rotifer species collected during the study four were common and their relative numbers varied considerably (Fig. 2). The apparent reversal of dominance of *Keratella cochlearis* (GOSSE) and *K. quadrata* (MÜLLER) from 1967 to 1968 seems to indicate a major change in the community comparable with that occurring within the phytoplankton. A similar congeneric succession occurred among the copepods; *Diaptomus leptopus* FORBES was extremely abundant in June 1967, but the next year a much smaller population consisted largely of *Diaptomus franciscanus* LILLJEBORG (Fig. 2). It should be noted, however, that *D. leptopus* is characteristically a mid-summer species (KENK, 1949; HAMMER & SAWCHYN, 1968) and therefore its absence in June 1968 may be more apparent than real, the juveniles being indistinguishable. Breeding of *D. franciscanus* occurred in May 1968, but one month later the adults had completely disappeared.

Unlike the characteristically mono- or di-specific occurrence of Copepoda in ponds (COLE, 1967; HUTCHINSON, 1967), the Cladocera were represented by a total of nine species during the study, several occurring in the pond at the same time. Five of these were collected in several months or were numerous (Fig. 2). The consistency of the two June samples provides a sharp contrast with between-years changes in other taxa. During May 1968 *Daphnia pulex* LEYDIG females were already producing ephippia; early production of resistant eggs is common in astatic waters and in this pond may reflect the unusually low water levels of that summer.

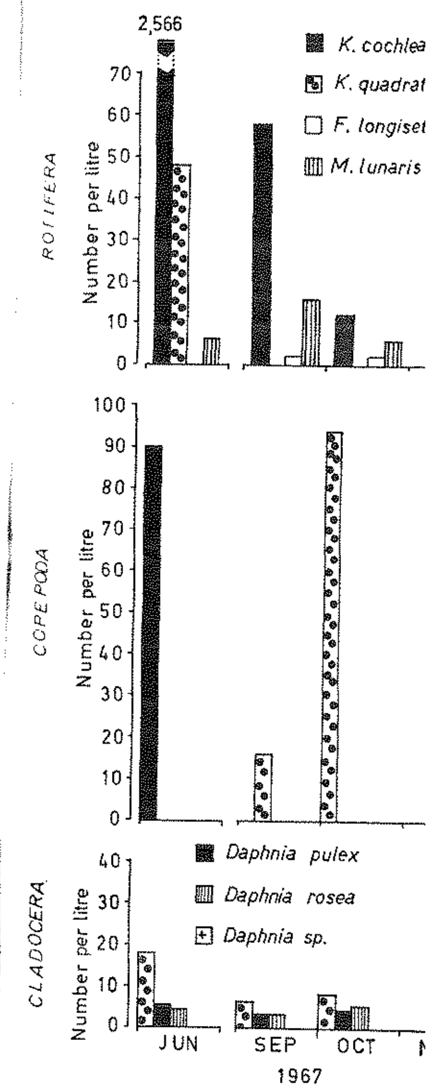

Fig. 2. Abundance of Rotifera, Cope
F. = *Filinia*; *M.* = *Monostyla*.

Macroinvertebrates

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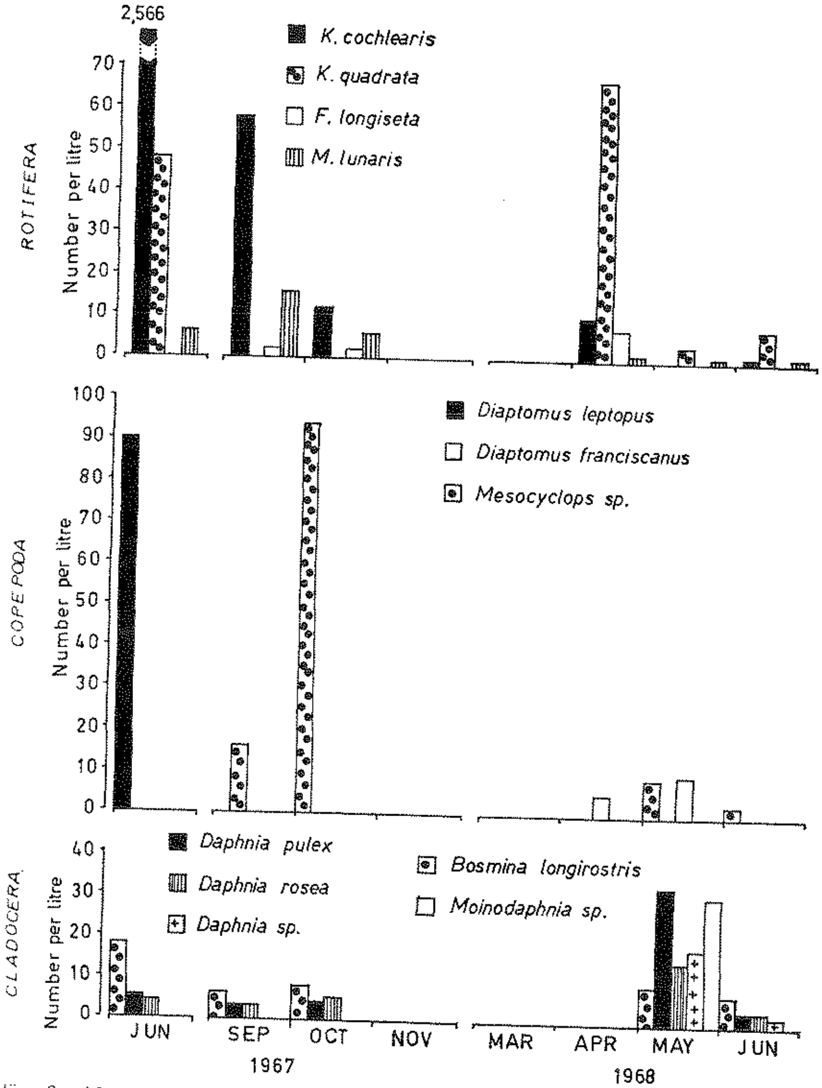

Fig. 2. Abundance of Rotifera, Copepoda and Cladocera. *K.* = *Keratella;* *F.* = *Filinia;* *M.* = *Monostyla.*

Macroinvertebrates

Lumbriculus variegatus (MÜLLER) (Oligochaeta) was present in vertical samples throughout the study (Fig.3) at all points on the pond bottom, although it was more abundant toward the edges than in the centre. In 1968 the predaceous naid *Chaetogaster diaphanus*

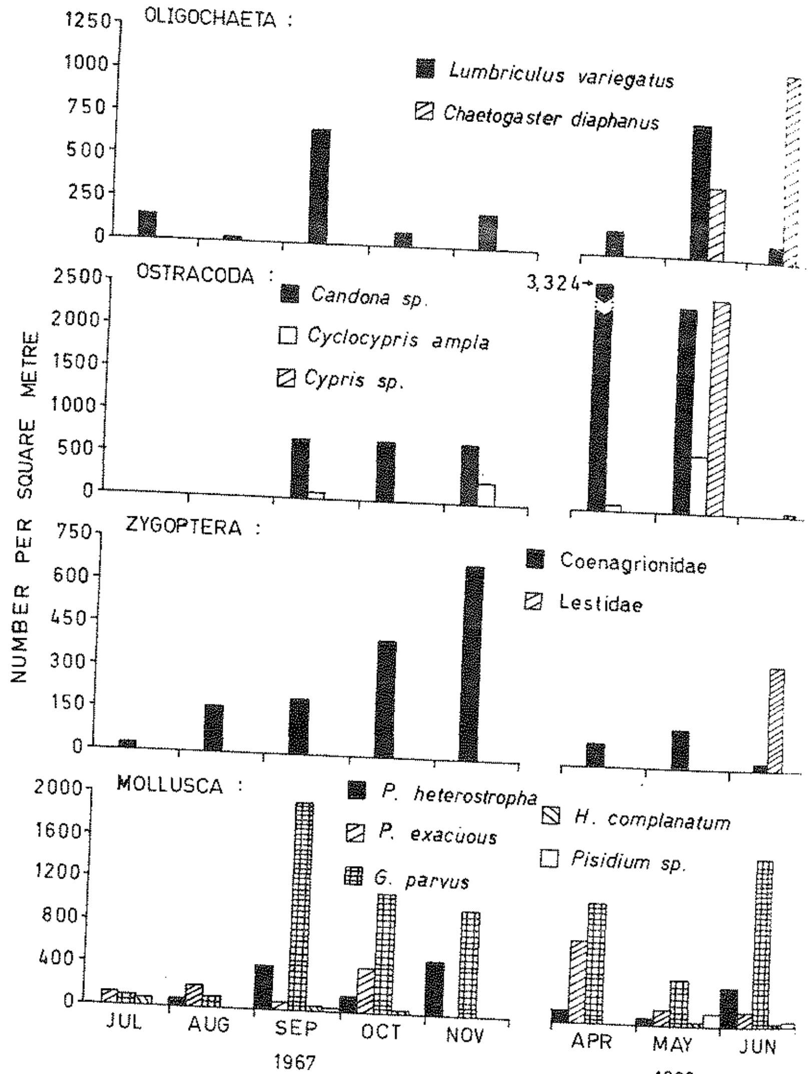

Fig. 3. Abundance of Oligochaeta, Ostracoda, Zygoptera and Mollusca. *P.* = *Physa*; *Pr.* = *Promenetus*; *G.* = *Gyraulus*; *H.* = *Helisoma*.

(GRUITHUISEN) was collected in large numbers although it had not been recorded at all the year before. This is a common species in temporary ponds of the area and in reedy portions of larger lakes, and its sudden appearance in quantity reflects the changes recorded in other taxa.

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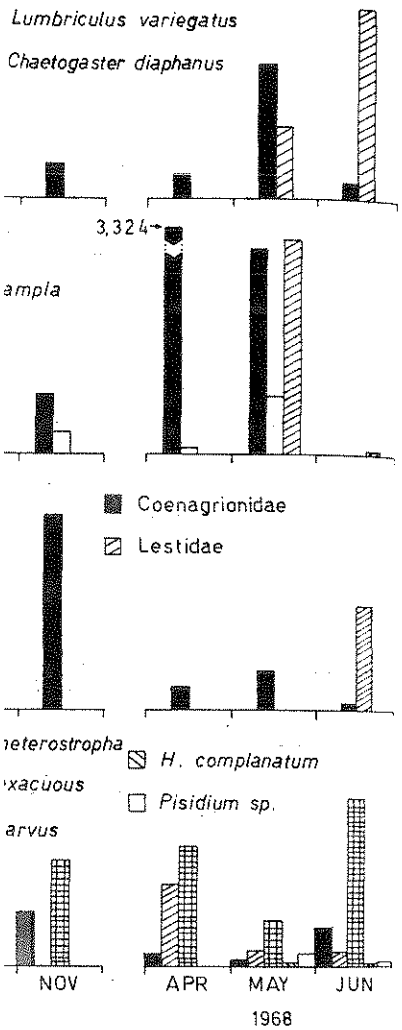

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a lucida MEYER & MOORE, *Glossi-* *phonia heteroclita* (L.) and *Helobdella fusca* (CASTLE) were collected during the study, mostly by dip-net. All three species are abundant in a larger slough about 175 m west of the pond, but they appeared to be a minor component of the pond community. No evidence was obtained to indicate that the first two species reproduced in the pond during 1967, but a single, ovigorous *G. heteroclita* was collected in May 1968.

Large numbers of the fairy shrimp *Eubranchipus bundyi* (FORBES) were collected by dip-net in April 1968 and by the end of the first week in May the adults had successfully completed reproduction and died. In Alberta the life cycle of this species takes between three and four weeks for completion, the eggs hatching as soon as the ground thaws. Another phyllopod, *Lynceus brachyurus* MÜLLER, was abundant in the early summer in both years. Hatching took place in April (1968) and numerous metanauplii were obtained in plankton samples at an average density of 18 per litre. Transformation to the adult form occurred when the metanauplii reached 1.25 mm in length and growth to the full adult size of 3.5—4.0 mm took three or four weeks. A few specimens of *L. mucronatus* (PACKARD) were also present in 1968.

When the pond was first visited in February 1967 fragments of ice were collected and allowed to thaw in an aquarium. A large population of two ostracods, *Candona* sp. and *Cyclocypris ampla* FURTOS, were obtained alive from the melt. No ostracods were collected during the summer by any means, but the same two species reappeared in September (Fig. 3). Many *Candona* occurred in ice samples during the winter (almost all of them survived thawing) and estimates of population density based upon ice collections (691/m^2) compared favourably with results from vertical samples during September, October and November (680/m^2). *Candona* was extremely abundant during the following April and May, the population presumably having survived the winter in the ice (DABORN, 1971) but had vanished again by the end of June, A vernal species of *Cypris* was also abundant in May 1968 and had declined sharply by the end of the next month.

Damselfly nymphs were a conspicuous component of the pond fauna in 1967, the density rising from 25/m^2 in July to 680/m^2 in November as more young hatched and pond volume decreased (Fig. 3). Emergence trap collections (Fig. 4) indicated that three species of Coenagrionidae were present: *Coenagrion angulatum* WALKER, *C. resolutum* HAGEN and *Enallagma boreale* SELYS in the proportions 14:3:1 respectively. During the following winter a steady die-off occurred of nymphs enclosed in the pond ice so that by spring break-up less than 20% of the population had survived (DABORN, 1971). Vertical samples and emergence trap results during 1968 indicated a

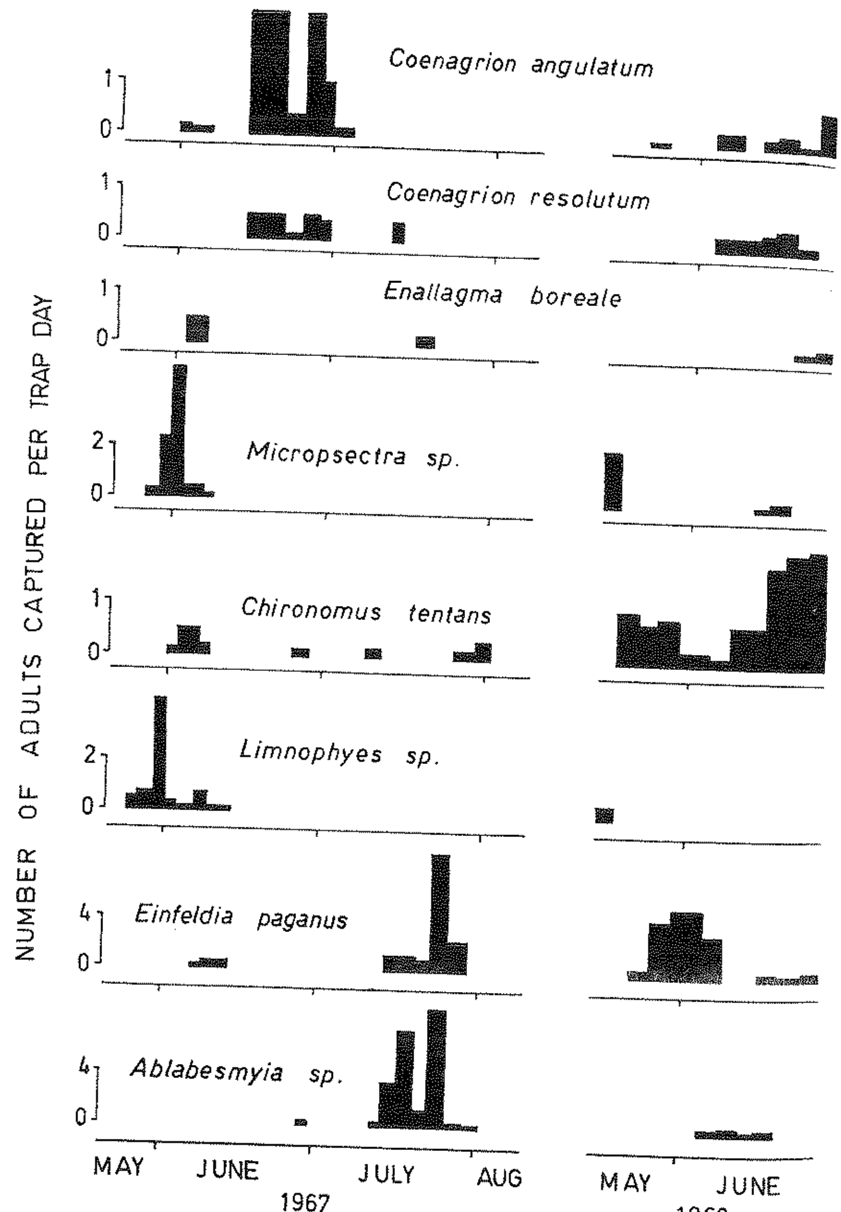

Fig. 4. Adult emergence patterns of 3 Zygoptera and 5 Chironomidae species. Hy 1425

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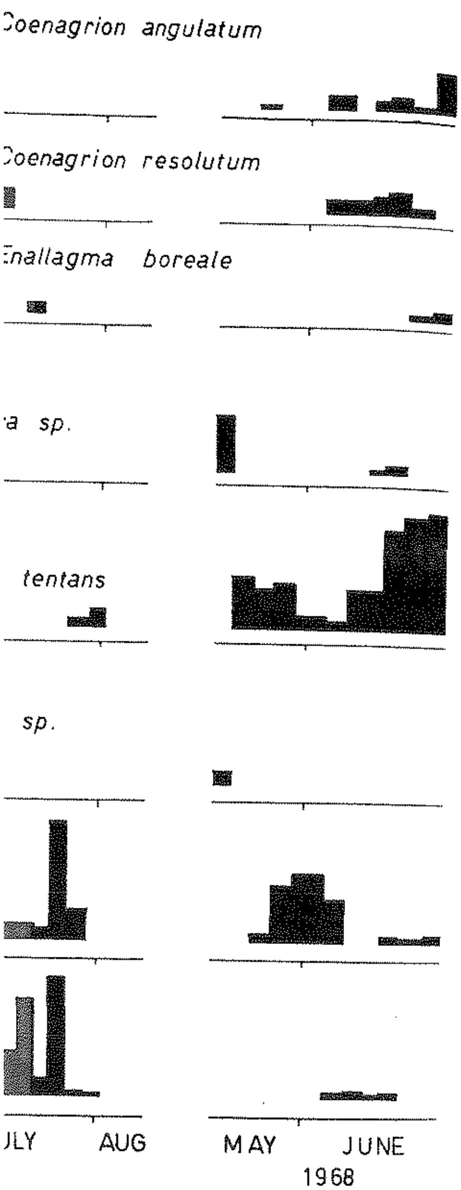

3 Zygoptera and 5 Chironomidae species.

substantial reduction in coenagrionid numbers and the appearance of large numbers of *Lestes* nymphs. The three Lestidae, *Lestes dryas* Kirby, *L. forcipatus* Rambur and *L. disjunctus* Selys are common in temporary ponds in Alberta and probably complete their nymphal cycle in three months or less: adult pairs were collected around the pond on July 18, 1968.

The largest single taxon in the fauna was the Chironomidae, the highest larval density recorded being in excess of 25,000/m² in November 1967. Neither larval identification nor correlation of dominant larvae with emerging adults was possible. Of 14 identified species, five occurred in abundance in emergence traps (Fig. 4) and illustrate well the apparent change in community composition between 1967 and 1968. Thus, *Chironomus tentans* Fabricius was considerably more numerous in the second year, mass synchronised emergence taking place between 9.00 and 11.00 a.m. on warm, sunny days. By contrast, numbers of *Micropsectra* sp. and *Limnophyes* sp. were much reduced in 1968.

Molluscs were a conspicuous element of the fauna in both years, being represented by eight pulmonate species and a single pelecypod. Total abundance varied from a low of 428/m² in July 1967 to nearly 2500/m² in several other months. *Physa heterostropha* Say, *Promenetus exacuous* Say and *Gyraulus parvus* Say together usually constituted two-thirds or more of the total number of molluscs. Ice samples contained the same three species with occasional *Gyraulus crista* Linné and almost all individuals were alive and active within a few hours of thawing. The average density of these four species from all ice samples was 4,912/m² but wide variation between different ice samples indicated a clumped distribution, probably in proportion with the amount of vegetation (mainly *L. trisulca*) also trapped.

Several taxa of invertebrates occurred regularly in samples throughout the study but in numbers too low for the inference of life cycles or other ecological features. Fourteen genera of Coleoptera have been identified, nine of which were represented only by adults. Limnephilid and *Triaenodes* spp. larvae were often present in vertical samples in small numbers, and emergence traps captured occasional *Triaenodes grisea* Banks (Leptoceridae), *Agrypnia pagetana* Curtis (Phryganeidae) and *Agraylea multipunctata* Cutris (Hydroptilidae) adults. In general, however, caddis flies were an inconspicuous component of the fauna. Acari, on the other hand, were numerous and varied, the genera *Eylais*, *Forelia* and *Hydrachna* being encountered frequently. Immatures were often observed on the venter of the thorax of newly-emerged Zygoptera, but could not be identified.

Discussion

At the outset of this study the question was posed: what physical, chemical and biological features are distinctive of an aestival pond? Examination of several major physical and chemical parameters indicated that only the regular occurrence of total freezing of all water in the basin could be considered a definitive characteristic (Daborn & Clifford, this issue). In contrast, several biological phenomena serve to distinguish this class of pond from other lentic habitats.

The limited primary productivity and low phytoplankton populations in this pond, represent a very different ecological situation from the succession of phytoplankton pulses typical of other shallow lakes in western Canada (Hammer, 1964; Lin, 1968). In the latter, seasonal succession of algal species results in high levels of photosynthesis being maintained throughout the summer, the ratio of maximum to minimum phytoplankton concentrations being of the order of four or five to one (Rawson, 1953). Succession of zooplankton species usually accompanies the successive development of algae (Hammer & Sawchyn, 1968) in such a way that the demands placed upon the environment *(sensu lato)* by a single taxonomic group are distributed evenly over the growing season. Such multispecies associations and successions exhibit a high degree of "order" in the sense used by Petrusewicz (1966) and Margalef (mimeographed paper) and seasonal succession of organisms may therefore be taken as an index of the stability of the community in the face of environmental instability. Furthermore, the great influence exerted by climatic factors on the productivity of the pond precisely fulfils Lindeman's predictions regarding the productivity of senescent stages of a hydrosere (Lindeman, 1942).

To this feature of decreasing stability of the community as a whole must be added an increase in the vulnerability of some species to replacement by immigrant species. During the present study, several species that were found in the first year were absent or uncommon in the second. Thus, *Keratella cochlearis*, abundant in the first year was infrequent in 1968, *Diaptomus leptopus* was apparently replaced by *D. franciscanus*, and *Lumbriculus variegatus* by *Chaetogaster diaphanus*. Among the insects, three species of Coenagrionidae were largely replaced by three species of *Lestes*. Several of the incoming species are more closely associated with temporary than with permanent habitats (Mozely, 1932; Kenk, 1949). It appears, therefore, that between-years changes in faunal composition should be interpreted as an example of transient ecological succession whereby the association of species more closely resembles that typical of the next stage of hydroseral succession – in this area the temporary, vernal pond. I do

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not know how often species replacement of this magnitude has occurred in previous years, but the rapid success of new dominant species suggests that the pond community is always subject to extensive immigration, and perhaps that instability of community composition may be typical of aestival ponds. Accordingly, the specific faunal and floral associations occurring each summer would be determined as a fortuitous assemblage selected from the successful immigrants or residents of the previous summer by environmental conditions during the ensuing winter and spring.

The element of chance in pond communities has been extensively discussed by Talling (1951), but more recently, much information has been gained about the ability of invertebrates to disperse or be dispersed to new habitats (Maguire, 1963; Schlichting & Milliger, 1967; Sides, 1970) and there is little reason to suppose that an organism abundant in one habitat would not be introduced into a nearby habitat within a short period of time. It remains to be seen, however, if the productivity of an ecosystem can remain constant when community composition varies considerably from year to year, or if productivity is directly influenced by the particular species present at any time. Use of aestival ponds or other senescent habitats for any purpose involving their productivity would depend very largely on the answer to this problem.

Summary

An aestival pond near Edmonton, Alberta, Canada, was studied for a period of 13 months, during which unusually low levels of precipitation resulted in an extensive reduction of the volume of water in the basin. Primary production was only detected during July 1967 when a bloom of *Aphanizomenon flos-aquae* was present. During the remainder of the study, phytoplankton populations were low and primary production negligible. Marked changes were noted in the relative abundance of different species between the two successive summers: *Aphanizomenon flos-aquae*, the most abundant phytoplankton species in 1967 was replaced by *Fragilaria* sp. in 1968; *Keratella cochlearis* (Rotifera) was replaced by *K. quadrata*, *Diaptomus leptopus* (Copepoda) by *D. franciscanus*, *Lumbriculus variegatus* (Oligochaeta) by *Chaetogaster diaphanus* and *Coenagrion angulatum*, *C. resolutum* and *Enallagma boreale* by *Lestes dryas*, *L. forcipatus* and *L. disjunctus* (Zygoptera). The association of several of the incoming species with habitats of a more temporary nature suggests that the changes should be viewed as a transient form of ecological succession that may be reversed whenever sufficient precipitation restores the pond to its previous size. The varied productivity and stability of the aestival pond community and its vulnerability to invasion are discussed in relation to its status as a distinct stage of hydroseral succession.

Resume

On a étudié les changements fauniques et floristiques dans un étang estival du centre de L'Alberta, Canada, durant un cycle annuel complet pendant qu'un décroissement exceptionnel du volume de l'eau ce soit produit par suite de précipitations plus basses que la normale. Quelques changements substantiels sont arrivé entre les deux étés successifs dans les espèces qui composants le phytoplancton, et les Rotifera, Oligochaeta, Copepoda et Zygoptera. Plusieurs des espèces immigrantes, surtout *Chaetogaster diaphanus* (Oligochaeta) et trois espèces de *Lestes* (Zygoptera), s'associent avec des habitats plus temporaires dans la region. On discute le rapport entre l'instabilité de la productivité et de la composition spécifique et la position trophique des lacs et des étangs estivaux.

Acknowledgements

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