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Aquatic Plant Communities and Invertebrates in a Prairie Pothole During Duck Brood Rearing

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AQUATIC PLANT COMMUNITIES AND INVERTEBRATES IN A PRAIRIE POTHOLE DURING DUCK BROOD REARING

BY

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IN A PRAIRIE POTHOLE DURING DUCK BROOD REARING

This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable for 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

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Abstract

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More than 1,100 samples of aquatic plants and associated invertebrates were collected in a prairie wetland. Sampling was done weekly throughout the duck brood rearing season.

Linear regression revealed a 4 to 100 ratio of animal to plant biomass (R^2 = 0.488). Comparatively high degrees of association were found between Ceratophyllum demersum and Gastropoda and between Lemna minor and most zooplankton groups.

Significant sources of variation in invertebrate biomass were plant communities, date, plants, and community by date interaction. Depth was not significant. Significant sources of variation in zooplankton numbers were date, plants, and community by date interaction. Depth and communities were not significant.

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INTRODUCTION

Although many studies have dealt with the needs of duck broods (Bartonek and Hickey 1969a, Sugden 1973, Mack and Flake 1980), waterfowl biologists do not understand why ducks select certain habitats for brood rearing. The management implications for understanding what attracts broods or rearing hens could be important.

If the quality of brood rearing habitat is definable, marsh managers may be able to create favorable brood rearing habitat by a variety of techniques such as burning, fertilizing, or drawdowns (Green et al. 1964, Meeks 1969, Kaminski and Prince 1981). Natural areas exhibiting favorable habitat would be easily identified. Also, early estimates of annual waterfowl production might be enhanced. Bartonek and Hickey (1969b), Krapu (1974), Swanson et al. (1974), Krapu and Swanson (1975), and Swanson et al. (1979) showed that breeding hens require and seek a diet high in animal proteins. Sufficient data exist to indicate that duck broods also feed heavily on aquatic invertebrates (Chura 1961, Collias and Collias 1963, Bartonek and Hickey 1969a). Protein requirements of growing ducklings and breeding hens apparently demand an animal diet. Joyner (1980) found that breeding ducks selected ponds based on the abundance of invertebrates.

Krecker (1939), Moroney (1972), Voights (1976), and others have shown that aquatic invertebrate abundance is seasonal and varies between plant communities. Obviously, aquatic plant communities are parameters that may be used to evaluate brood rearing habitat.

Another factor affecting invertebrate abundance may be water depth. Joyner (1980) noted a higher concentration of invertebrates in shallow wetlands with sloping sides as compared to wetlands with steep sides. Prairie wetlands are typically shallow and therefore more susceptible to drought. Natural droughts keep prairie wetlands in a productive state (Leitch 1964).

A comparison of invertebrate abundance to brood hatching peaks might provide insight on the demand placed on invertebrate populations by duck broods. Measurement of invertebrate abundance also might be used to evaluate the quality of brood rearing habitats.

Quantitative sampling of aquatic plant communities and their associated invertebrate populations is difficult during the brood rearing period because of dense mats of vascular plants and filamentous algae (Swanson 1978). Diurnal migration of invertebrates suggests that the entire water column should be sampled in order to obtain a complete estimate of available invertebrates. Duck broods apparently take advantage of some invertebrate migrations by feeding at night (Swanson and Sargeant 1972). Large quantitative samples have been taken by lowering a large net (Andrews and Hasler 1943, Rosine 1955) or a square tube of sheet metal (Gerking 1957) over the sample point. Due to the time involved in collecting and analyzing large samples, these techniques are not practical for detailed comparisons of brood rearing habitats since it is difficult to obtain large numbers of samples. As an alternative, an investigator could collect numerous small samples of aquatic plant communities which would provide a sufficient number of samples to utilize statistical comparison techniques.

I examined the relationships of aquatic plants to associated invertebrates by comparing biomasses from a series of sample sites over a 13 week period. The field season was timed to provide information on aquatic plant communities and associated invertebrate populations through the period of duck brood rearing. This paper also introduces a new sampler for making quantitative measurements in all densities of emerged, submerged, and floating vegetation.

The objective of this study was to test the following hypotheses:

1) Macroinvertebrate biomass is directly related to plant biomass in a prairie wetland.
2) The numbers of zooplankton are directly related to plant biomass in a prairie wetland.
3) Macroinvertebrate biomass and density of zooplankton are greater in shallow water than in deep water in a prairie wetland.
4) Peaks in biomass of macroinvertebrates and in number of zooplankton occur at the time of the greatest demand by ducklings.

Hypotheses 1 and 2 are to be tested by simple linear regression in which plant biomass is an independent variable and zooplankton numbers and invertebrate biomass are dependent variables. In addition, associations of plant species and invertebrate groups are to be identified by multiple regression. A factorial analysis of variance will be used to determine the amount of variation in invertebrate

abundance explained by plant species, time of season, depth of water, and the plant communities.

STUDY AREA

The study area, Paul L. Errington Memorial Marsh, (Figure 1) is a glacially derived "pothole" wetland in the Prairie Coteau of eastern South Dakota. It is a semipermanent prairie wetland of approximately 300 surface acres (classified Type IVB according to Stewart and Kantrud 1971). Part of Errington Marsh and surrounding uplands is owned by the United States Fish and Wildlife Service and is maintained as a Waterfowl Production Area. The remainder of the marsh and surrounding uplands is a Game Production Area owned by the South Dakota Department of Game, Fish and Parks. The marsh is located in the southern half of section 25, T112N, R52W, in Brookings County.

Figure 1. Paul Errington Memorial Marsh.

METHODS

Tessman (1979) indicated that the average hatching dates for 7 common species of ducks in South Dakota fall between June 1 and mid July. My 13 week field season began on June 1, 1980. It was terminated on August 30, 1980, which included the rearing period of late-hatching broods.

Sample sites were randomly established on the study area using a numbered grid overlay placed over an aerial photograph of the marsh. A random numbers table was used to select the 32 intersection points that served as sampling stations. Station sites were located in the marsh by using a range finder and compass. Each station was marked with an anchored float. Three quantitative samples of the water column were taken at each station each week through the field season.

Sampling was conducted within a 5 meter radius around the station. A random numbers table was used to determine the location of each sample within a station. Care was taken to prevent the boat from drifting over areas yet to be sampled on that day.

The sampler (Figure 2) consisted of a 20 cm long cylinder of #10 nylon plankton net with a 50.8 cm circumference opening and a canvas border sewn around the opening. The opposite end was sewn shut. A bow saw blade with evenly spaced teeth was formed to a 12.7 cm square. A 0.64 cm diameter metal rod was welded around the inside for support. Rivets secured the canvas opening of the net around the outside of the saw blade so that the teeth pointed upward

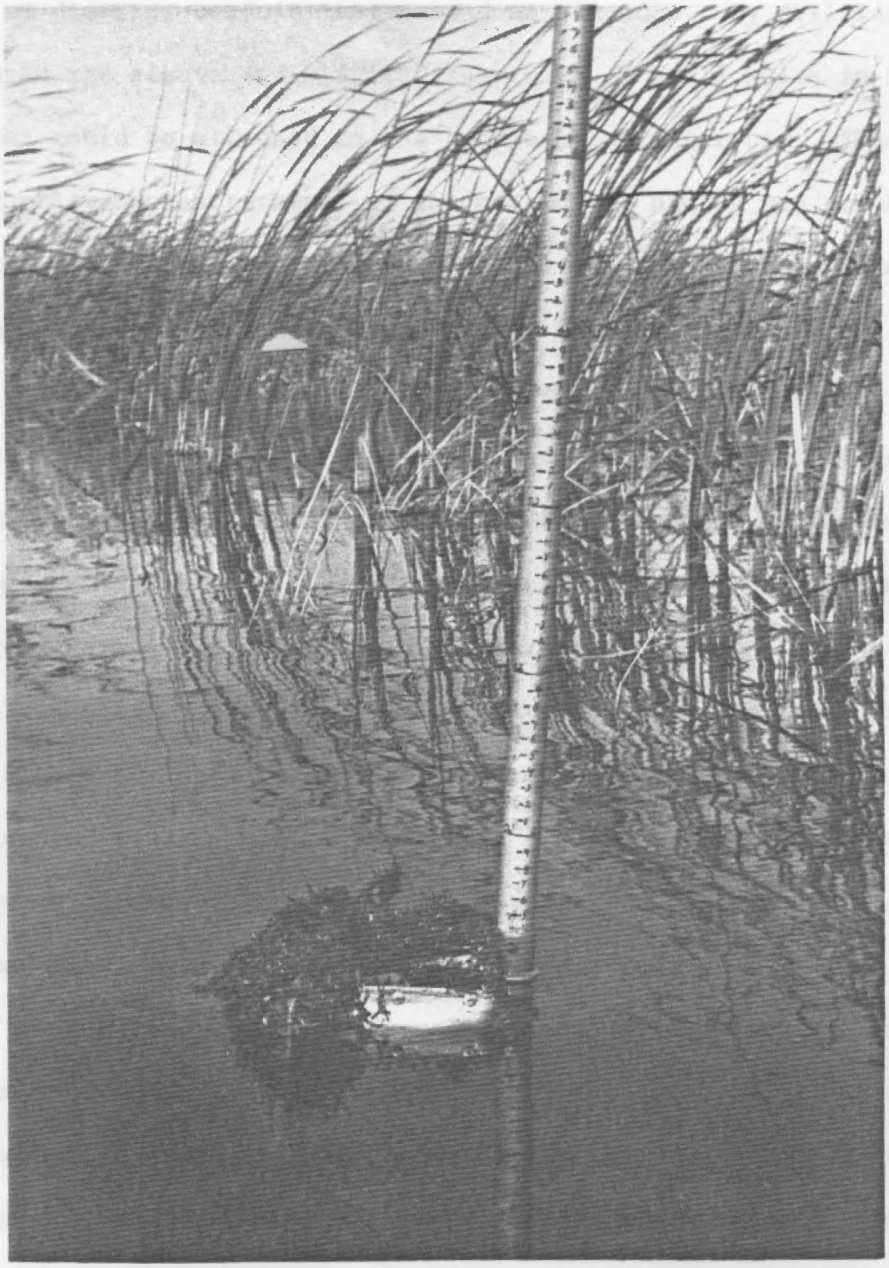

Figure 2. A sampler used to collect quantitative samples of aquatic plant communities and associated invertebrates.

from the net. A 2.54 cm diameter conduit sleeve was welded to the outside of the saw blade. The net could then be fitted to a length of 2.54 cm diameter conduit that served as a handle. By drilling 2 small holes in the sleeve and aligning them with 2 small holes in the conduit, the net could be attached to the handle by a cotter pin. Thus, detachment and reattachment of the net to the handle was quick and easy. A waterproof marker was used to graduate the handle in centimeters so depth of water at the sample site could be measured.

Upon arrival at a sample site, the net was lowered to the marsh bottom until it was resting on the substrate with the teeth pointing upward. Rotating the handle 180^{o} moved the net a short distance along the marsh bottom to an undisturbed water column. The entire water column was sampled by retrieving the net in a vertical line from the marsh bottom. The product of the water depth and the area within the saw blade yielded the volume of water sampled. Those portions of aquatic plants protruding outside the saw blade were severed with a sharp knife. Only those portions of the plants within the saw blade were considered part of the sample.

This sampler provided smaller samples than those taken by Andrews and Hasler (1943) and Gerking (1957). It was a more accurate and versatile sampler of the water column than the Ekman or Peterson dredge. It could also be operated in dense stands of emergent vegetation. Observations during sampling indicated that invertebrates and even some vertebrates such as fathead minnow (Pimephales promelas), were not disturbed during sampling.

After collecting a sample, the net was detached from the handle. Contents of the net were deposited in a plastic wash pan. The net was inverted and washed over the pan with tap water to remove material adhering to the net. Contents of the wash pan were stored in jars. The addition of a small amount of formalin and rose bengal mixture stained and killed the invertebrates. Samples were strained through #10 nylon plankton netting in the laboratory to remove excess water and were preserved in 100% ethyl alcohol within 24 hours of collection.

Samples were placed in enamel dissecting pans for analysis. Separation of invertebrates and aquatic plants was accomplished by hand picking with forceps. Plants were separated according to species (Fasset 1957) and invertebrates according to order or family (Pennak 1978). Each plant fragment was rinsed with tap water over the dissecting pan to remove small adhering invertebrates. After removal of the plants, the remaining material in the sample was placed in a petri dish with a grid on the bottom. A 10X dissecting scope mounted on a movable arm provided a systematic method for picking macroinvertebrates from the petri dish. Water was added to the sample until a volume of 100 ml was reached. A Hensen-Stemple pipette was used to obtain a 1% subsample of the zooplankton.

All invertebrates, except zooplankton, and all the plants were dried for a minimum of 2 days at 60 C (Welch 1948). These subjects were then weighed to the nearest 0.0001 gram on a Mettler balance. Zooplankton subsamples were separated under 25X scope and counted.

Due to their size and abundance, Chironomidae and Culicidae were separated from other Diptera during analysis. Therefore, in the following pages, Diptera refers to all Diptera except Chironomidae and Culicidae. Copepoda were separated into the suborders Calanoida and Cyclopoida. Bosmina, due to its small size, was separated from the rest of the Cladocera. All plants and groups of invertebrates analyzed are listed in Table 1.

Occasionally small particles of plants made it impossible to pick all plant tissue from the sample. In those cases, subsamples of the remaining plant material were taken by picking all the plant tissue from 1 randomly selected grid. These subsamples were dried and weighed. Their weights were multiplied by a constant that yielded an estimate of the remaining plant weights. This estimate was added to the weight of plants that were picked to provide a dry weight value for all plants in the sample.

Of the 1,248 possible samples, 1,180 were analyzed. Two of the stations were not sampled during the first week. Occasionally samples were not analyzed in the laboratory due to filamentous algae in the sample that could not be separated from the plants and animals. Some samples were lost due to accidental breakage of the storage vials.

Table 1. Biological variables as grouped in analysis.

Plants	Macroinvertebrates	Zooplankton
Ceratophyllum demersum	Culicidae and Chironomidae	Cyclopoida
Lemna minor	Gastropoda	Calanoida
Lemna trisulca	Hemiptera	Cladocera
Potamogeton pectinatus	Amphipoda	Bosmina
Utricularia vulgaris	Ephemeroptera	Ostracoda
	Hirudinea	
	Hydracarina	
	Odonata	
	Coleoptera	
	Other Diptera	
	Miscellaneous[a]	

[a]Miscellaneous includes Lepidoptera, Megaloptera, Trichoptera, Collembola, Nematomorpha, and unknown.

RESULTS AND DISCUSSION

Plant and Animal Associations

Linear regression comparisons indicated a positive relationship (R^2 = 0.488, P = < 0.05) with plant biomass as the independent variable and total macroinvertebrate biomass as the dependent variable. This comparison indicates that 48.8% of the difference in invertebrate biomass between samples was explained by differences in plant biomass. The Y intercept was 0.004, near the origin as expected, and the slope was 0.040.

Sample weights were also tested on the basis of weights per liter of water to remove bias associated with water depth. With this change in expression of the data, a linear regression comparison, with the same variables as above, produced an R^2 value of 0.467 and a slope of 0.040. Both analyses indicated that each 4 grams of animal biomass were associated with 100 grams of plant biomass. Krull (1970) using wet weights found 1 gram of invertebrates per 100 grams of plant matter. Gerking (1957) using air-dried weights of plants and oven-dried weights of invertebrates found an even smaller animal to plant ratio in most cases.

A high level of productivity was expected in prairie potholes. The highly fertile waters of prairie wetlands may be responsible for the high ratio of invertebrate biomass to plant biomass.

Multiple regression revealed the degree of association between particular groups of animals and plant species. Several significant associations were identified. However, the large number of degrees of

freedom in these comparisons have caused some rather weak associations to be identified as significant. Forty-nine percent of the variation of Gastropoda biomass between samples can be explained by Ceratophyllum demersum biomass (Table 2). This relationship is probably responsible for the high degree of association found between C. demersum and total invertebrate biomass. Gastropoda biomass included the shells and this group had a much higher total biomass than any other group. Correspondingly, C. demersum was much more abundant than any other plant species. Andrews and Hasler (1943) reported a higher biomass of invertebrates in association with C. demersum than any of the other 6 species of submergent vegetation that they tested. Krull (1970) found that C. demersum was second only to Lemna trisulca in supporting invertebrate biomass. Apparently the high amount of surface area produced by the finely dissected leaves of C. demersum is a contributing factor to its association with macroinvertebrates (Krecker 1939, Andrews and Hasler 1943, Rosine 1955).

Generally, higher degrees of association were found between plant species and zooplankton than between plant species and macroinvertebrates. Higher degrees of association were found between zooplankton groups and Lemna minor than other plant species (Table 3). Since L. minor is a small, floating plant, it is not found in open, wind-swept areas of a marsh. Likewise, zooplankton are not as often found in wind-swept and turbulent waters. Therefore, if zooplankton do seek associations with aquatic vegetation, then L. minor is probably more readily available because of the physical properties of the wetland. Lemna trisulca is the plant most highly associated with all

Table 2. Signficant associations of aquatic plants with macroinvertebrates tested by stepwise multiple regression at 95% confidence[a]. Independent variables are plant biomasses. Dependent variables are macroinvertebrate biomasses.

Dependent variable (biomass)	Step	Independent variables (biomass)	R^2 Improvement
Total Invertebrates	1	Ceratophyllum demersum	0.487
	2	C. demersum Lemna trisulca	0.520
	3	C. demersum L. minor Potamogeton pectinatus	0.534
	4	C. demersum L. minor L. trisulca P. pectinatus	0.537
Chironomidae and Culicidae	1	P. pectinatus	0.164
	2	C. demersum P. pectinatus	0.220
Gastropoda	1	C. demersum	0.488
	2	C. demersum P. pectinatus	0.493
Amphipoda	1	L. minor	0.555
	2	L. minor L. trisulca	0.582
	3	L. minor L. trisulca Utricularia vulgaris	0.600

Table 2. Continued

Dependent variable (biomass)	Step	Independent variables (biomass)	R^2 Improvement
Amphipoda (continued)	4	C. demersum L. minor L. trisulca U. vulgaris	0.611

[a]Invertebrate groups exhibiting an R^2 value less than 0.164 are not presented.

Table 3. Significant associations of aquatic plants with zooplankton tested by stepwise multiple regression at 95% confidence. Independent variables are aquatic plant biomasses. Dependent variables are numbers of zooplankton.

Dependent variable	Step	Independent variables (biomass)	R^2 Improvement
Total zooplankton	1	Lemna minor	0.670
	2	L. minor L. trisulca	0.679
	3	L. minor L. trisulca Potamogeton pectinatus	0.682
	4	L. minor L. trisulca P. pectinatus Utricularia vulgaris	0.684
Cyclopoida	1	L. minor	0.593
	2	L. minor P. pectinatus	0.601
	3	L. minor L. trisulca P. pectinatus	0.609
	4	Ceratophyllum demersum L. minor L. trisulca P. pectinatus	0.614
Calanoida	1	L. minor	0.364
	2	L. minor L. trisulca	0.384
Cladocera	1	L. trisulca	0.048
	2	L. trisulca U. vulgaris	0.077
	3	L. minor L. trisulca U. vulgaris	0.091

Table 3. Continued

Dependent variable	Step	Independent variables (biomass)	R^2 Improvement
Cladocera (continued)	4	L. minor L. trisulca P. pectinatus U. vulgaris	0.102
Bosmina	1	L. minor	0.670
	2	L. minor L. trisulca	0.688
	3	L. minor L. trisulca P. pectinatus	0.689
Ostracoda	1	L. trisulca	0.133
	2	L. trisulca U. vulgaris	0.157
	3	C. demersum L. trisulca U. vulgaris	0.175

zooplankton that are not highly associated with L. minor (Table 3). Since L. trisulca often occurs below the water surface and has larger, more angular leaves it is not as easily manipulated by the wind.

There appears to be an intrinsic relationship between zooplankton and those aquatic plants that are also controlled by wind and waves in the marsh. One obvious unanswered question now appears--is the association between Lemna spp. and zooplankton a result of searching by the zooplankton or a result of both being pushed to the same sheltered areas due to physical properties of the marsh? Regardless of the reason for the association, a very definite relationship occurred between Lemna spp. and zooplankton.

Community Comparisons

The 32 sample stations were grouped into 9 separate communities according to dominant vegetation of the area. Community 1 was a mixture of L. trisulca and C. demersum, community 2 was dominated by Potamogeton pectinatus, community 3 was sparingly inhabited by Typha spp., community 4 was in a dense stand of Typha spp., and community 5 was open water. A more detailed description is given in Table 4. The number of sample stations in each of these communities was 2, 3, 4, 3, and 15, respectively. Community 6 consisted of 2 stations at the edge of a dense bed of Typha spp. Sampling of these stations was conducted in open water and among the Typha spp. Therefore, community 6 was not included in the community comparisons by ANOVA.

Community 7 was in a bed of Scirpus validus, community 8 was situated in a bed of dead Typha spp., and community 9 was located in

Table 4. Communities in Errington Marsh based upon classification by Cowardin et al. (1979).

Classification	Community 1	Community 2	Community 3	Community 4	Community 5
System	Palustrine	Palustrine	Palustrine	Palustrine	Lacustrine (littoral)
Class	Aquatic bed	Aquatic bed	Aquatic bed	Emergent	Unconsolidated bottom
Subclass	Rooted vascular floating	Rooted vascular	Rooted vascular emergent	Persistent	Organic
Dominance type	C. demersum L. trisulca	P. pectinatus	C. demursum Typha spp.	Typha spp.	Annelids

a stand of Scholochloa festucacea. Communities 7, 8, and 9 were represented by only 1 sample station each. These communities were also excluded from the community comparisons to eliminate bias from inadequate repetition. In addition, community 1 was not sampled during the first week. Observations in the ANOVA testing totaled 993 and were adjusted to express value per liter of water.

Variation of invertebrate biomass between samples was expected. Dry weight invertebrate biomass ranged from 0 in several samples to 40.2 mg/1. A factorial analysis of variance conducted on the data explained 72% of this variation (Table 5). Communities, dates, plants, and community by date interaction were significant sources of variation. Depth was not significant.

The significant community by date interaction indicates that the order of communities with respect to concentration of invertebrate biomass changed through the summer (Table 6). Interspersion perhaps tended to stabilize the fluctuations of invertebrate biomass from week to week.

The relation of zooplankton numbers to community, date, depth, and plant biomass was tested with ANOVA (Table 7). An R^2 value of 0.244 was produced by these comparisons. Significant sources of variation were aquatic plants, date, and community by date interaction. Depth and communities were not significant. The changing order of communities with respect to zooplankton production showed no definable patterns (Table 8).

Table 5. Analysis of variance of milligrams of invertebrate biomass per liter of water.

Source	Degree of Freedom	Mean square	F Value
Total	992	13.167×10^{-6}	
Community	4	101.557×10^{-6}	26.43*
Date	12	50.927×10^{-6}	13.26*
Community X date	47	29.038×10^{-6}	7.56*
Depth of water	1	0.417×10^{-6}	0.11
Plant biomass	1	665.688×10^{-6}	173.27*
Residual	927	3.842×10^{-6}	

*Significant at 95% confidence.

Table 6. Weekly average of invertebrate biomass per liter of water for communities. Values expressed are milligrams.

Date	Community 1	2	3	4	5
Week 1		0.205	0.378	1.339	0.211
Week 2	3.554	0.044	0.177	0.468	0.058
Week 3	7.856	0.754	0.792	0.577	0.018
Week 4	16.234	0.255	0.427	1.380	0.022
Week 5	6.616	0.811	0.087	1.870	0.077
Week 6	4.975	0.431	0.197	0.596	0.004
Week 7	7.887	0.628	0.038	0.101	0.298
Week 8	5.016	0.155	0.118	1.156	0.021
Week 9	11.539	0.158	0.517	0.271	0.157
Week 10	21.842	2.249	0.132	0.231	0.191
Week 11	13.034	3.301	0.168	0.015	0.207
Week 12	6.691	1.569	0.220	0.230	0.030
Week 13	18.585	4.206	0.319	0.145	0.120

Table 7. Analysis of variance of number of zooplankton per liter of water.

Source	Degree of Freedom	Mean square	F Value
Total	992	1.9×10^{-5}	
Community	4	0.5×10^{-5}	0.32
Date	12	5.4×10^{-5}	3.51*
Community X date	47	5.0×10^{-5}	3.23*
Depth	1	0.9×10^{-5}	0.56
Plant biomass	1	27.3×10^{-5}	17.64*
Residual	927	1.5×10^{-5}	

*Significant at 95% confidence.

Table 8. Weekly average of number of zooplankton per liter of water for communities.

Date	Community 1	2	3	4	5
Week 1		64	51	37	26
Week 2	257	16	36	34	20
Week 3	301	26	10	33	6
Week 4	289	9	12	25	7
Week 5	199	15	1	12	3
Week 6	61	2	6	5	4
Week 7	230	25	14	4	6
Week 8	125	11	78	57	9
Week 9	181	31	16	31	14
Week 10	2,787	49	8	26	12
Week 11	372	275	58	35	46
Week 12	67	156	45	72	73
Week 13	121	290	29	13	133

Many authors have shown that young ducklings have a high percentage of invertebrates in their diet, with plant biomass gradually increasing in proportion to animal biomass with age of the duckling (Cottam 1939, Mendall 1949, Chura 1961, Bartonek and Hickey 1969b). The date of highest demand placed upon invertebrates by ducklings is not documented. Considering the appearance of broods from late nesting hens plus the concept that ducklings continue to utilize animals in their diet may indicate that most demand is placed on invertebrates by ducklings late in the brood rearing season. However, I did not find an increase in invertebrate biomass or zooplankton numbers that would coincide with such an increase in demand by ducklings (Figures 3 and 4). Fluctuations in abundance of invertebrate biomass and zooplankton numbers do not appear to be related to the demand placed upon them by duck broods. Swanson and Meyer (1977) believed that a drawdown due to drought increased the invertebrate abundance per liter of water in a marsh by concentrating the invertebrates in the remaining water. In this study, the water level dropped only 24 cm through the field season, which was probably not sufficient to cause a concentration of invertebrates. Depth was not a significant source of variation in invertebrate biomass or zooplankton numbers.

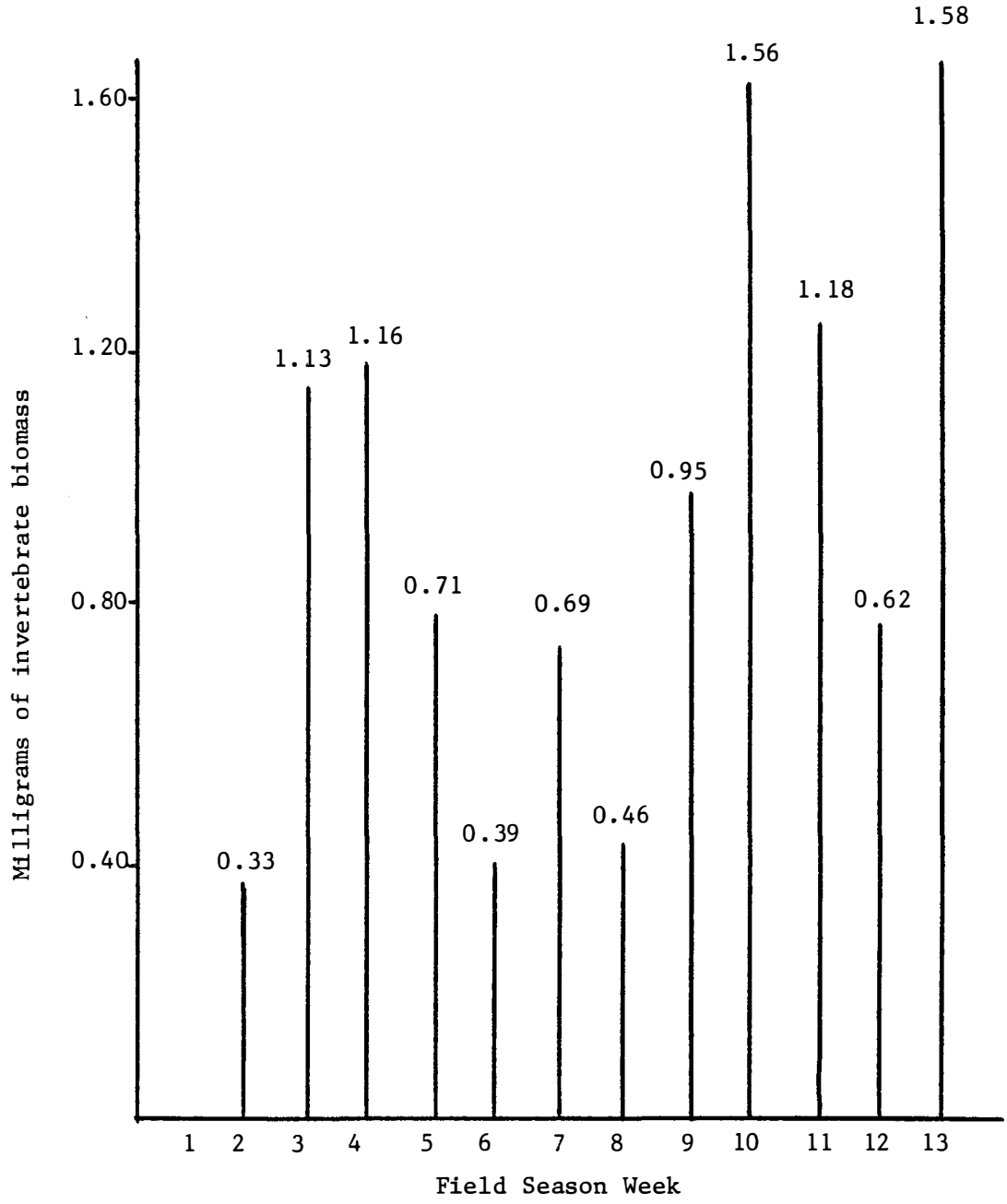

Figure 3. Average milligrams of invertebrate biomass per liter of water.

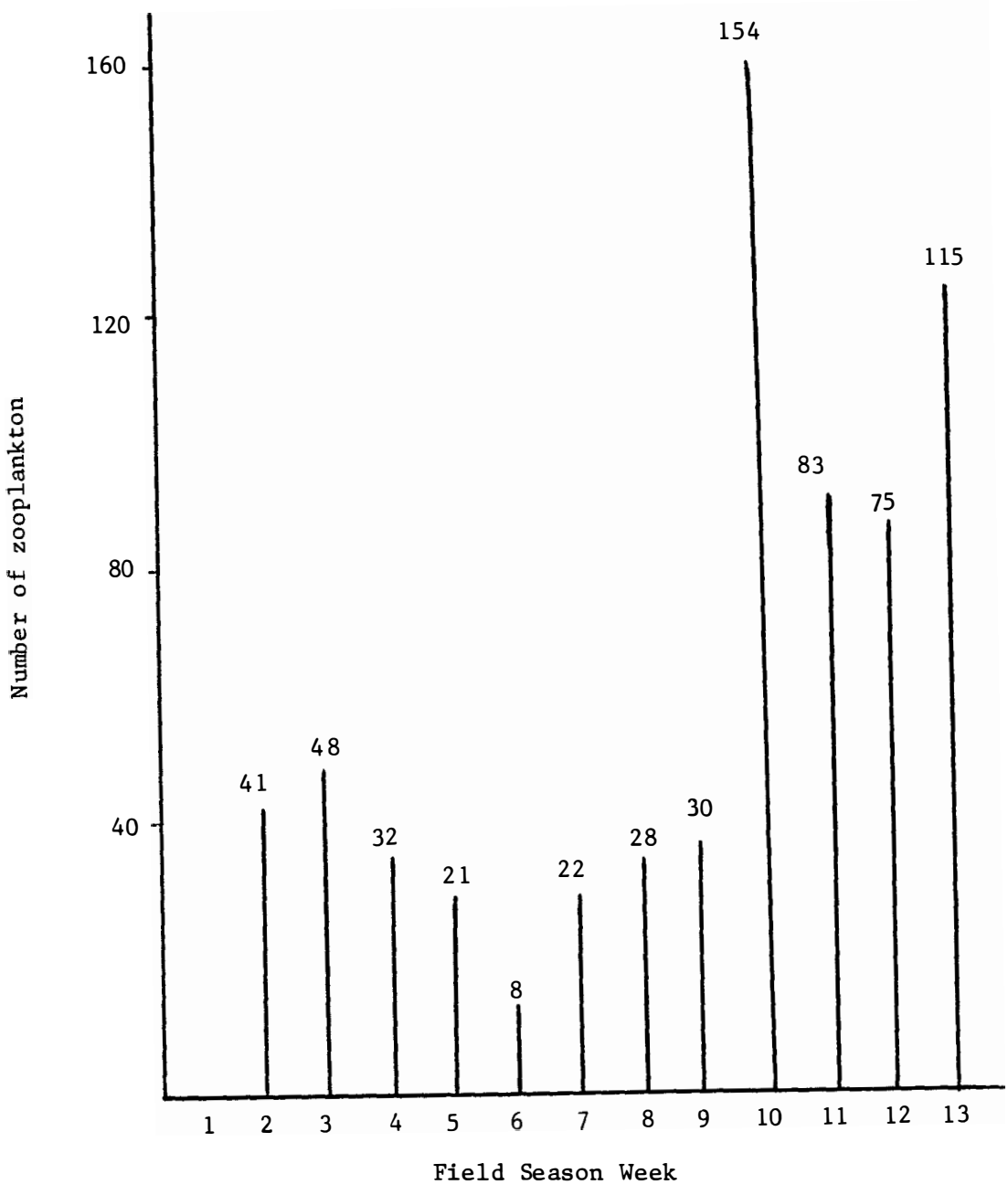

Figure 4. Average number of zooplankton per liter of water.

MANAGEMENT AND RESEARCH RECOMMENDATIONS

Community 1 produced more food for duck broods than the other communities. However, emergent vegetation probably appeals to brood rearing hens by providing cover as well as food. A high quality marsh for rearing duck broods should probably appear as dense beds of cattails with numerous openings containing a broad variety of submergent plant communities.

The best single plant indicator of good brood rearing habitat is probably L. minor. It should generally be found in or near emergent vegetation that serves as a wind break and also provides excellent cover for duck broods. In addition, L. minor was found to be highly associated with amphipoda and most zooplankton groups.

My research supports the concept that wetland diversity and interspersion of cover are important characteristics in high quality waterfowl habitat. At this time it appears that wetland managers should strive to produce a diversity of wetland plant communities in large wetlands or to promote different vegetation types when several wetland basins in a small area are being managed for waterfowl. If limited basins are available, it appears that L. minor should be encouraged for maximum high quality brood habitat potential.

Future research in this field should be directed toward a more detailed comparison of plant communities. In addition to abundance of invertebrates, availability and nutrient composition needs to be examined. The importance of emergent cover should also be considered before making more extensive recommendations for brood rearing habitat.

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