Wayne A. Hubert
William J. Lavoie IV
Lawrence D. Debray

Aquatic Macroinvertebrates in Young Beaver Ponds on a Small Prairie Stream, Wyoming

Abstract

We describe aquatic macroinvertebrates in 10 beaver ponds less than 10 years old on a small prairie stream in southwestern Wyoming. A greater diversity of taxa were obtained from sweep net samples through the water column than from Ekman dredge samples of the bottom substrate. Densities of benthic macroinvertebrates did not differ significantly among the 10 ponds, but the mean density was relatively low compared to values reported for beaver ponds studied in woodland and montane systems. Aquatic macroinvertebrate densities may be low in beaver ponds on prairie streams due to the relatively small amounts of leaf litter that accumulate in ponds and the frequent destruction of ponds by floods.

Key Words: macroinvertebrates, benthos, ponds, beaver, *Castor canadensis*, Great Plains, Wyoming.

Ponds constructed by beaver (*Castor canadensis*) on streams are important components of both woodland and prairie ecosystems, but there is limited information on the aquatic macroinvertebrates that inhabit beaver ponds. Previous studies on macroinvertebrates in beaver ponds have focused on woodland (Keiper 1966, Naiman *et al*. 1986, McDowell and Naiman 1986) or montane (Gard 1961, Hodkinson 1975a and 1975b, Smith *et al*. 1991) stream systems. We know of no studies of aquatic macroinvertebrates in beaver ponds on small prairie streams on the Great Plains.

Much of the previous research on aquatic macroinvertebrates in stream systems with beaver ponds has focused on comparisons of the structure and function of macroinvertebrate assemblages in beaver ponds and unimpounded stream reaches (McDowell and Naiman 1986, Naiman *et al*. 1986, Smith *et al*. 1991) or the effect of ecological succession of beaver ponds on macroinvertebrates assemblages in the ponds (Keiper 1966, Hodkinson 1975a and 1975b). No studies are known to us that evaluate variation in benthic macroinvertebrate densities among beaver ponds of similar age within a complex of ponds. A complex of beaver ponds is usually composed of a primary pond built to impound water around a lodge and to cover the winter food cache, as well as several secondary ponds built to improve transportation of food and extend the swimming range of beaver (Grasse and Putnam 1955).

The purpose of this study was to describe aquatic macroinvertebrates in a complex of young beaver ponds (< 10 years old) on a small prairie stream on the Great Plains in southwestern Wyoming. We evaluated differences in aquatic macroinvertebrate densities in

Wayne A. Hubert, William J. Lavoie IV, and Lawrence D. Debray, Wyoming Cooperative Fish and Wildlife Research Unit[1], University of Wyoming Laramie, WY 82071-3166

[1] The Unit is jointly supported by the University of Wyoming, Wyoming Game and Fish Department, Wildlife Management Institute, and U.S. Geological Survey.

benthic samples among the 10 ponds and described the relative abundance of aquatic macroinvertebrates in sweep net samples through the water column and in benthic samples.

Study Area

The study was conducted on Crow Creek, Laramie County, Wyoming, where it flows onto F. E. Warren Air Force Base near the City of Cheyenne. A complex of 10 ponds with an active colony of beaver was present at this location. The ponds had no stream segments with water flowing in the original stream channel between them and they were long and narrow (< 10 m wetted width) with water extending across the high-water stream channel. Surface area of the ponds ranged from 40 to 1,190 m^2 with maximum water depths of 0.6-1.2 m during late summer. The ponds were constructed in the mid-1980s following a severe flood and were 8-10 years old when sampled. Bottom substrates were primarily sand with some areas of silt and fine gravel. The ponds were colonized by aquatic macrophytes, primarily *Chara*, *Carex*, *Potomogeton*, and *Scirpus*. Minnows (Cyprinidae) and suckers (Catostomidae) were present in the stream and ponds. The riparian zone was dominated by willows (*Salix*), which were the dominant material used in construction of the dams.

Discharge in the stream channel immediately downstream from the complex of ponds was 0.0083 m^3/second on August 10, 1993. Discharge during spring and summer occasionally exceeds 1.0 m^3/s when melting snow or thunderstorms enhance flow. The beaver ponds were at about 1,880 m above mean sea level.

Methods

Sampling was conducted on August 10, 1993. Four samples of benthic macroinvertebrates were taken from each pond with an Ekman dredge (23 x 23 cm), one on each side of the pond in water less than 0.5 m deep and one at each end in the deepest locations. Two samples were taken with a 0.2-m-diameter sweep net (363 um openings) passed along the bottom of each pond in water less than 0.5 m deep and through any aquatic vegetation that may have been present. Samples were preserved in formalin and returned to the laboratory where macroinvertebrates were removed from debris with the aid of a dissecting microscope. Mollusks and insects of the orders Ephemeroptera, Plecoptera, Trichoptera, and Odonata were identified to species when possible, while other macroinvertebrates were identified to family or genus.

Mean densities of the 13 most abundant taxa of benthic macroinvertebrates were assessed among the 10 study ponds for samples taken with the Ekman dredge. We recognized that a multivariate analysis of variance (MANOVA) could be used to assess differences in mean densities among ponds, but interpretation of significant differences with a large number of variables (taxa) is difficult and we were not interested in relations among different taxa (Bray and Maxwell 1985). A one-way analysis of variance was used to assess differences in mean densities of each abundant taxon among the 10 ponds. The Bonferroni pairwise comparison of means was used to make comparisons among ponds if significance was determined with ANOVA. Statistical analyses were conducted using STATISTIX 4.1 (Analytical Software 1994). Significance was determined at $P < 0.05$ for all tests.

Results

The most abundant macroinvertebrate taxa in bottom substrate sampled with the Ekman dredge were Oligochaeta, Chironomidae, *Pisidium compressum* and Pulmonata (Table 1). The most

Table 1. *Proportions (percent) of aquatic macroinvertebrate taxa in samples from beaver ponds on a Great Plains stream during August 1993 using two different sampling methods.*

Taxa		Ekman dredge	Sweep net
Ephemeroptera			
	Tricorythodes minutus		1.4
	Baetis tricaudatus		0.2
Trichoptera			
	Hydroptila sp.		0.3
Odonata			
	Aeshna palmata		0.1
	Amphiagrion sp		0.2
	Argia sp		0.1
	Coengrion sp.		3.3
Diptera			
	Chironomidae	31.5	13.1
	Ceratopogonidae		0.1
	Chrysops sp.	0.6	0.5
Coleoptera			
	Dubiraphia sp	2.0	2.1
Hemiptera			
	Corisella sp.		1.3
Collembola			
	Isotomidae		0.2
Amphipoda			
	Hyallela azteca	2.3	21.7
Decapoda			
	Orconectes neglectus		0.4
Hirudinea		0.3	0.1
Oligochaeta			
	Naididae	41.0	3.5
Turbullaria			
	Tricladida	0.1	
Pulmonata			
	Physa gyrina	0.9	7.1
	Gyraulus parvus	0.1	2.1
	Helisoma anceps	5.2	10.0
	Ferrissia rivularis	2.1	0.3
Bivalvia			
	Pisidium compressum	13.6	27.2
	Anodontoides ferrusacianus	0.3	

Table 2. *Densities (number/square meter) of benthic macroinvertebrates in samples taken with an Ekman dredge from beaver ponds on a Great Plains stream during August 1993.*

Taxa	Mean	Standard error
Chironomidae	391.1*	57.9
Chrysops	7.3	4.1
Dubiraphia	24.8	6.1
Hyallela azteca	28.5	21.9
Hirudinea	4.2	2.7
Nadidae	508.0	166.2
Tricladida	1.2	1.2
Physa gyrina	11.4	5.0
Gyraulus parvus	1.2	0.8
Helisoma anceps	63.8	17.0
Ferrissia rivulari	25.3	10.3
Pisidium compressum	167.8	40.7
Anodontoides ferrusacianus	3.6	2.0
TOTAL	1,238.2	227.0

* significant difference ($P < 0.05$) in mean densities among the 10 study ponds

numerous organisms in sweep net samples were *Pisidium compressum*, *Hyallela azteca*, Pulmonata, and Chironomidae. Sweep net samples had a greater diversity of organisms than did Ekman dredge samples (Table 1). Most insect taxa were found exclusively in sweep net samples, with the exception of Chironomidae, Tabanidae, and *Dubiraphia*.

The mean density of all macroinvertebrate taxa among the 10 ponds in samples taken with the Ekman dredge was 1,238/m^2. Densities of individual taxa did not differ significantly among the 10 beaver ponds (Table 2), with the exception of Chironomidae ($P < 0.0001$). The fourth pond in progression downstream had a significantly higher density (mean = 1,205/m^2) of Chironomidae than the other nine ponds (mean = 344/m^2).

Discussion

The greater diversity of aquatic macroinvertebrates found in samples taken with the sweep net was likely a result of the sweep net sampling a more diverse array of microhabitats (water column, aquatic vegetation and surface of bottom substrate) than the Ekman dredge. Numerous studies have shown a greater diversity of aquatic macroinvertebrates among aquatic macrophytes than in bottom substrates of lakes and streams (Gilinsky 1984, Gregg and Rose 1985, Schramm and Jirka 1989, Wollheim 1994).

Longitudinal trends in abundance and diversity of aquatic macroinvertebrates were not observed among the 10 ponds in the complex that we studied. We noted that sand dominated the substrate in samples from all 10 ponds with no observable change with downstream progression. Previous studies have demonstrated substantial variation in both abundance and diversity of benthic macroinvertebrates associated with different sizes of particles composing bottom substrate (Cummins and Lauff 1969, Ward 1975, Hubert et al. 1984). The relatively homogeneous bottom substrates among the ponds probably contributed to the lack of significant variation in benthic macroinvertebrate densities among ponds.

The mean density of benthic macroinvertebrates in these Great Plains beaver ponds (mean = 1,238/m^2) was far less than has been observed in beaver ponds on small woodland streams in Quebec (24,000-72,700/m^2, McDowell and Naiman 1986) or on a montane stream in California (21,300/m^2, Gard 1961). Crow Creek was bordered by prairie with occasional patches of willow. It is likely that there is substantially less leaf litter in this prairie system and, consequently, lower food resources for aquatic macroinvertebrates than in woodland or montane streams (Minshall 1988, Naiman et al. 1988).

The macroinvertebrates in these prairie beaver ponds were composed of an array of functional feeding groups (Cummins 1973, Cummins and Klug 1979) dominated by collectors, scrapers, and predators with few shredders. Shredders use decomposing vascular plant material or coarse particulate organic matter primarily, and such material may be sparse in the prairie system. McDowell and Naiman (1986) also noted a lack of shredders in the beaver ponds they studied.

The dynamics of beaver ponds on prairie streams are likely to differ from woodland and montane systems. The ponds that we studied were relatively young (8-10 years), small (< 1.1 ha surface area), narrow (< 10 m wetted width), and on a creek that experiences large variation in discharge (frequently > 100 fold). Such beaver ponds are common among prairie streams of the Great Plains. It is likely that the aging of beaver ponds on Great Plains streams leads to accumulation of silt and fine particulate matter with faunal succession (Kieper 1966, Hodkinson 1975a and 1975b). However, long-term succession may be truncated by more frequent pond destruction than in woodland or montane systems due to the small-diameter building materials, willow branches, used in dam construction and wide fluctuations in discharge, especially associated with summer thunderstorms.

Acknowledgments

We thank B. Kondratieff for assistance in identification of the insects; D. Beetle for help in identification of mollusks; S. Anderson, B. Rosenlund, R. Shaw, T. Smith, and J. Wright for help in project coordination; T. Elliott and T. Marwitz for critical review of the manuscript, and the Center for Ecological Management of Military Lands in the Department of Range Science at Colorado State University for funding.

Literature Cited

Analytical Software. 1994. Statistix Version 4.1 user's manual. Analytical Software, Tallahassee, FL.

Bray, J. S., and S. E. Maxwell. 1985. Multivariate analysis of variance. Sage Publications, Newbury Park, CA.

Cummins, K. W. 1973. Trophic relations of aquatic insects. Ann. Rev. Entomol. 18:183-206.

Cummins, K. W., and M. J. Klug. 1979. Feeding ecology of stream invertebrates. Ann. Rev. Ecol. Syst. 10:147-172.

Cummins, K. W., and G. H. Lauff. 1969. The influence of substrate particle size on the microdistribution of stream macrobenthos. Hydrobiologia 34:145-181.

Gard, R. 1961. Effects of beaver on trout in Sagehen Creek, California. J. Wildl. Manage. 25:221-242.

Gilinsky, E. 1984. The role of fish predation and spatial heterogeneity in determining benthic community structure. Ecology 65:455-468.

Grasse, J. E., and E. F. Putnam. 1955. Beaver management and ecology in

Wyoming. Bull. 6, Wyo. Game Fish Dept., Cheyenne, WY.

Gregg, W. W., and F. L. Rose. 1985. Influences of aquatic macrophytes on invertebrate community structure, guild structure, and microdistribution in streams. Hydrobiologia 128:45-56.

Hodkinson, I. D. 1975a. Energy flow and organic matter decomposition in an abandoned beaver pond ecosystem. Oecologia 21:131-139.

Hodkinson, I. D. 1975b. A community analysis of the benthic insect fauna of an abandoned beaver pond. J. Anim. Ecol. 44:533-552.

Hubert, W. A., G. E. Darnell, and D. E. Dolk. 1984. Late-winter abundance and substrate associations of benthos in Pool 13, Upper Mississippi River. Proc. Iowa Acad. Sci. 9:147-152.

Keiper, R. R. 1966. The distribution and faunal succession of the macroscopic bottom fauna in three different aged beaver ponds. M.S. Thesis. University of Massachusetts, Amherst, MA.

McDowell, D. M., and R. J. Naiman. 1986. Structure and function of a benthic invertebrate stream community as influenced by beaver (*Castor canadensis*). Oecologia 68:481-489.

Minshall, G. W. 1988. Stream ecosystem theory: a global perspective. J. N. Am. Benthol. Soc. 7:263-288.

Naiman, R. J., J. M. Melillo, and J. E. Hobbie. 1986. Ecosystem alteration of boreal forest streams by beaver (*Castor canadensis*). Ecology 67:1254-1269.

Naiman, R. J., H. Decamps, J. Pastor, and C. A. Johnston. 1988. The potential importance of boundaries to fluvial ecosystems. J. N. Am. Benthol. Soc. 7:289-306.

Schramm, H. L., and K. J. Jirka. 1989. Effects of aquatic macrophytes on benthic macroinvertebrates in two Florida lakes. J. Freshwater Ecol. 5:1-12.

Smith M. E., C. T. Driscoll, B. J. Wyskowski, C. M. Brooks, and C. A. Cosentini. 1991. Modification of stream ecosystem structure and function by beaver (*Castor canadensis*) in the Adirondack Mountains, New York. Can. J. Zool. 69:55-61.

Ward, J. V. 1975. Bottom fauna-substrate relationships in a northern Colorado trout stream: 1945 and 1974. Ecology 56:1424-1429.

Wollheim, W. M. 1994. Macroinvertebrate relations with salinity and macrophyte species in shallow lakes of the Wyoming high plains. M.S. Thesis. University of Wyoming, Laramie, WY.