MACROINVERTEBRATES IN THE GREEN RIVER BELOW FLAMING GORGE DAM, 1964-65[1] AND 1967

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INTRODUCTION

Two months before Flaming Gorge Dam on the Green River was closed in 1962, 700-800 km of the river and its tributaries were treated with rotenone to suppress rough-fish populations (Binns et al., 1964). Effects of the rotenone treatment and of the dam's subsequent operation upon downstream invertebrates were largely speculative. This paper reports postimpoundment observations made during two studies conducted on the Green River below Flaming Gorge Dam. The first was done by Pearson and Franklin in 1964 and 1965. Their major objectives were to describe the changes in river environment after closure of the dam and to determine the postimpoundment distribution of macroinvertebrates and compare it with that reported before the dam was built. The second set of observations was made by Pearson and Kramer in 1967 during an attempt to investigate *Baetis* population-dynamics immediately below Flaming Gorge Dam. Though unsuccessful in its major objective, this study provided information on unexpected effects of Flaming Gorge Dam upon downstream invertebrates. Both studies document some changes which have occurred below Flaming Gorge Dam, and the findings should be useful for future comparative purposes.

METHODS AND MATERIALS

Collections were made from June 1, 1964, to September 1, 1965, and from June 18 to October 14 in 1967. During 1964 and 1965, samples were taken every 2-4 weeks in the summer at four stations (Figure 1): Little Hole (11.7 km below Flaming Gorge Dam = 11.7 KBD), Carr Ranch (68.7 KBD), Echo Park – above the mouth of the Yampa River (103.9 KBD), and Island Park (125.5 KBD). One or two summer collections were also made at nine supplementary stations. Weekend collecting trips were made

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each month to Island Park from October, 1964, to May, 1965. In 1967, weekly collecting trips were made between the dam and Little Hole. Two collecting trips were made from the dam to Taylor Flat (25.9 KBD) in August and October, 1967.

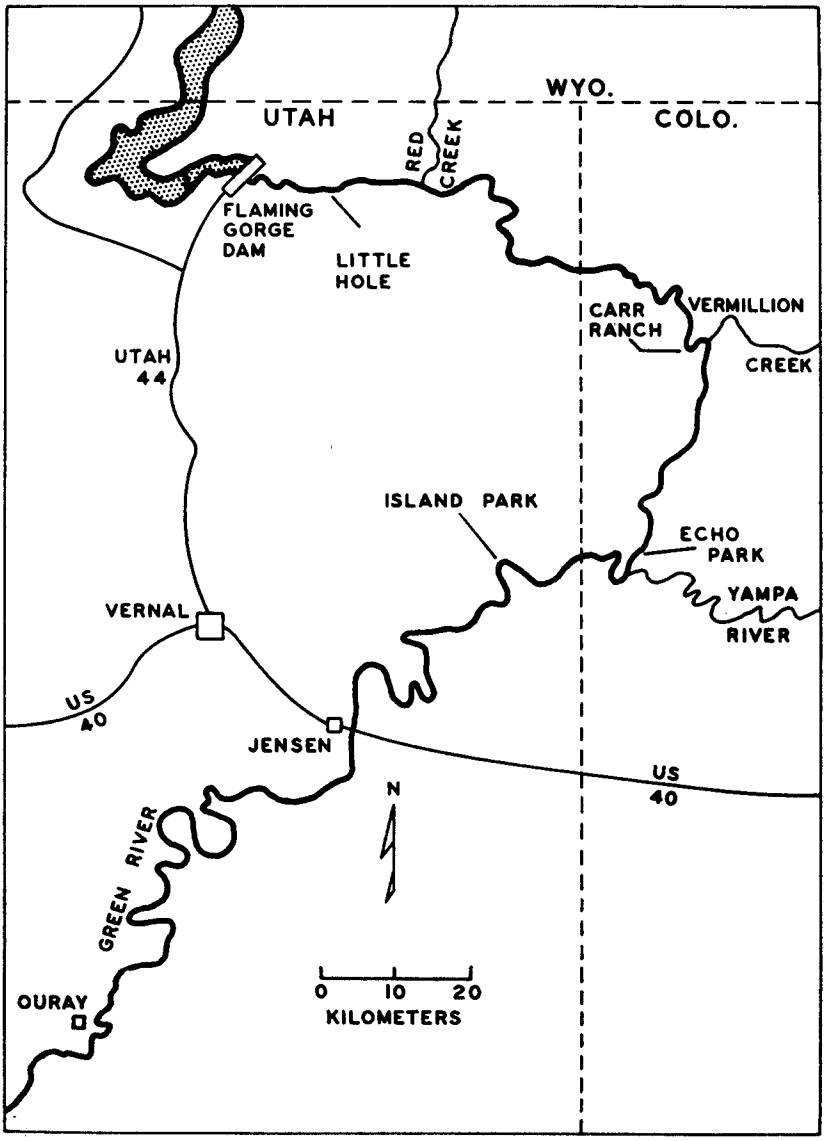

FIGURE 1. Location of sampling stations on the Green River, Utah-Colorado.

Recording thermometers were maintained in the river at Little Hole, Echo Park, and Island Park in 1964-65, and at Little Hole and 0.8 km below Flaming Gorge Dam in 1967. Determinations of water temperature, turbidity, dissolved oxygen, pH, and alkalinity were made when bottom or drift samples were taken. Additional records on stream flow, water temperature, and water chemistry were obtained from the U. S. Geological Survey and the Utah Department of Fish and Game for the 1963-67 period.

Bottom samples on hard substrates were taken with a wire-mesh device similar to that described by Waters and Knapp (1961). Ninety-five, 87, and 64 such samples were collected in 1964, 1965, and 1967, respectively. Samples on soft bottoms were taken with a 15.2-cm-square Ekman dredge. Sixteen and 36 samples were collected with the dredge in 1964 and 1965, respectively. Drift organisms were sampled with a conical nylon-mesh net (Nitex #423) mounted on a 29.2-cm-diameter hoop (Pearson and Franklin, 1968). Seventy-three and 321 drift-net samples were collected in 1964 and 1965, respectively. In 1967, drift organisms were collected at Little Hole with an automatic sampling device powered by a water-wheel anchored in the river. Results obtained with the automatic sampler were comparable to those obtained with the drift net since both devices filtered known volumes of water.

RIVER ENVIRONMENT

Stream Flow

Seasonal variations in flow have been greatly reduced since closure of the dam. In general, summer, fall, and winter flows have increased and spring flow has decreased. The lowest annual mean discharge observed at Greendale (0.8 KBD) was 6.7 m^3/sec in 1963 and the highest was 76.1 m^3/sec in 1967. Mean annual discharges were 44.3, 63.1, and 46.2 m^3/sec in 1964, 1965, and 1966, respectively. Mean May-October postimpoundment flows were lowest in 1963 (2.8-3.7 m^3/sec) and highest in 1967 (54.3-91.4 m^3/sec; Table 1).

Power demands on Flaming Gorge Dam often caused a diurnal fluctuation in flow. Maximum power production (and high flows) usually occurred during the daytime with a sharp drop in output in late afternoon. Reductions in flow from 70 to 10 m^3/sec within an hour were common.

TABLE 1
MEAN MONTHLY DISCHARGE OF THE GREEN RIVER BEFORE AND AFTER CLOSURE OF FLAMING GORGE DAM, GREENDALE, MAY-OCTOBER, EXPRESSED IN M^3/SEC.

Year	*Month*					
	May	*June*	*July*	*Aug.*	*Sept.*	*Oct.*
Preimpoundment (1950-1960 mean)	129.8	206.9	98.4	48.5	26.3	26.1
Postimpoundment						
1963	3.7	3.5	2.9	2.9	3.2	3.6
1964	41.8	40.9	69.1	56.4	62.3	73.1
1965	30.5	40.7	13.4	14.1	20.8	36.2
1966	38.3	45.0	47.9	54.4	58.8	62.3
1967	54.3	91.4	77.9	85.3	85.6	88.2

TABLE 2
MAXIMUM WATER TEMPERATURES RECORDED AT LITTLE HOLE, GREEN RIVER, MAY-OCTOBER, 1963-1967, EXPRESSED IN °C

Year	*Month*					
	May	*June*	*July*	*Aug.*	*Sept.*	*Oct.*
1963[1]	....	....	16.0	15.5	15.5	16.5
1964[1]	9.5	7.0	8.0	14.5	10.0	11.0
1965	....	11.0	15.0	16.0	13.5	12.0
1966[1]	6.0	10.0	11.5	11.0	12.5	11.5
1967	....	6.0	6.5	8.5	9.5	10.0

[1]Data from Utah Fish & Game records.

Water Temperature

The general effect of the dam has been to increase river temperatures during the winter and decrease them during the summer, compared to preimpoundment years. Mean monthly preimpoundment water temperatures ranged from 0.5° C to 21.0° C at Greendale, and mean monthly postimpoundment temperatures have ranged from 2.0° to 12.5° C. At Little Hole, maximum summer water temperatures are now inversely related to stream flow, and the lowest temperatures during the June-October period were recorded in 1967, the year of highest summer flows (Tables 1 and 2).

Near Jensen, Utah (150.3 KBD), seasonal changes in water temperature were affected little by the dam in 1963, but summer temperatures during 1964-67 were 1.0° to 3.5° C lower than the preimpoundment average. Winter temperatures at Jensen have been similar to those during preimpoundment years (0-1° C in December, January, and February).

Turbidity

Water released from the reservoir was clear during 1964-67, but three major tributaries discharged turbid waters into the Green River within the study area. These were Red Creek (18.0 KBD), Vermillion Creek (70.2 KBD), and the Yampa River (105.9 KBD). Red and Vermillion creeks are small (0-0.6 m^3/sec in summer) while the Yampa River nearly equals the Green (mean annual flow during 1963-67 = 49.1 m^3/sec). Maximum turbidities recorded at Little Hole, Carr Ranch, Echo Park, and Island Park in 1964-65 were 62, 700, 5000, and 5000 JTU (Jackson Turbidity Units), respectively.

Water Chemistry

Dissolved-oxygen concentrations were 6.0 ppm or higher at all stations. Highest levels were observed at Little Hole (13.0 ppm), where summer water temperatures were low, the water was clear, and algal growths on the bottom were extensive.

The pH at all stations combined varied from 7.7 to 8.9 and no seasonal trends were apparent. Records from the U. S. Geological Survey indicate that the mean hydrogen-ion concentration of the Green River at Greendale has remained at 7.8 during pre- and postimpoundment years.

Total alkalinity was 125-180 ppm between the dam and Echo Park during 1964-65. Alkalinity of the Yampa River was lower than that of the Green during these years (52-155 ppm), particularly during the spring-runoff period. As a result, alkalinity at Island Park was lower (65-155 ppm) than that observed above Echo Park.

MACROINVERTEBRATE DISTRIBUTION: 1964-1965 (FLAMING GORGE DAM TO ISLAND PARK)

During 1964-1965, 69 different invertebrate forms were collected in the study area (Table 3). Included were 28 species of Ephemeroptera, 4 genera of Plecoptera, 7 genera of Trichoptera, 10 families of Diptera, and 5 families of Coleoptera. The number of taxonomic groups collected at each station increased and the density of bottom fauna on each type of substrate decreased progressively downstream from Flaming Gorge Dam. Detailed analyses of the bottom-sample data are contained in Pearson (1967).

TABLE 3
AQUATIC INVERTEBRATES REPORTED FROM THE GREEN RIVER ABOVE OURAY, UTAH, BEFORE AND AFTER SEPTEMBER, 1962

Organism	*Reported before Sept. 1962*	*Found above Flaming Gorge Dam after Sept. 1962*	*Found below Flaming Gorge Dam after Sept. 1962*[1]	*Old groups not found by Sept. 1965*	*New groups not reported before Sept. 1962*
Nematoda	X	X	1,4		
Oligochaeta	X	X	1,2,3,4,		
Hirudinea	X	X	5		
Amphipoda					
Hyalella			2		X
Gammarus	X	X			
Hydracarina	X	X	1,2,3,4		
Plecoptera					
Isoperla	X		1,2,3,4		
Isogenus	X		3,4		
Arcynopteryx			1		X
Acroneuria	X		1,3,4		
Claassenia	X			X	
Perlesta	X			X	
Pteronarcidae	X	X			
Nemouridae	X	X			
Ephemeroptera					
Siphlonurus	X	X			
Genus et species novum	X			X	
Isonychia	X	X			
Lachlania powelli	X		4		

TABLE 3
(Continued)

Organism	*Reported before Sept. 1962*	*Found above Flaming Gorge Dam after Sept. 1962*	*Found below Flaming Gorge Dam after Sept. 1962*[1]	*Old groups not found by Sept. 1965*	*New groups not reported before Sept. 1962*
Heptagenia elegantula	X	X	1,2,3,4		
Heptagenia sp. II	X		4		
Rhithrogena undulata	X	X	2,3,4		
Epeorus albertae[2]	X	X	4		
Pseudiron sp.	X			X	
Ametropus albrighti	X		5		
Callibaetis sp.	X		2		
Baetis insignificans	X			X	
Baetis sp. I	X	X	1,2,3,4		
Baetis sp. II			4		X
Baetis sp. III			4		X
Baetis sp. IV			1,2,3,4		X
Baetis sp. V			1,2,3,4		X
Baetis sp. VI			4		X
Baetis sp. VII	X		2,3,4		
Baetis sp. VIII			2,3,4		X
Baetis sp. XI			3,4		X
Baetis sp. XII			4		X
Baetis sp. XIV			2,4		X
Brachycercus sp.	X	X	2		

Tricorythodes minutus	X	X	2,3,4		
Tricorythodes sp.	X		3,4		
Ephemerella inermis	X	X	1,3,4		
Leptophlebia gravastella	X	X			
Paraleptophlebia pallipes		X	1,3,4		X
Choroterpes albiannulata	X	X	2,3,4		
Traverella albertana	X	X	2,3,4		
Caenis	X	X			
Pentagenia	X			X	
Ephemera sp.	X	X			
Hexagenia limbata	X		5		
Ephoron album	X	X	2,3,4		
Odonata					
Gomphus	X		5		
Ophiogomphus	X		1,3		
Argia	X			X	
Hemiptera					
Gerridae	X		1,2,3,4		
Notonectidae	X		1		
Naucoridae					
Ambrysus			3		X
Corixidae	X	X	2,4		
Megaloptera					
Corydalus	X		3,4		
Sialidae		X			X

TABLE 3
(Continued)

Organism	*Reported before Sept. 1962*	*Found above Flaming Gorge Dam after Sept. 1962*	*Found below Flaming Gorge Dam after Sept. 1962*[1]	*Old groups not found by Sept. 1965*	*New groups not reported before Sept. 1962*
Trichoptera					
Cheumatopsyche	X		2,3,4		
Hydropsyche	X	X	3,4		
Agraylea			1,2,3,4		X
Hydroptila	X		2,3,4		
Leptocerus	X		4		
Leptocella	X	X	2,3,4		
Brachycentrus	X	X	2,3,4		
Lepidoptera					
Pyralidae	X	X			
Coleoptera					
Haliplidae	X	X	2		
Dytiscidae	X	X	2,3,4		
Gyrinidae	X			X	
Hydrophilidae	X	X			
Hydraenidae	X	X			
Dryopidae	X	X	2		
Elmidae	X	X	2,3,4		

Chrysomelidae	X	X	1,2		
Heteroceridae	X	X			
Helodidae	X			X	
Diptera					
Blephariceridae			4		X
Tipulidae	X	X	1,2,3,4,		
Psychodidae	X	X			
Culicidae	X	X	4		
Simuliidae	X	X	1,2,3,4		
Chironomidae	X	X	1,2,3,4		
Ceratopogonidae	X	X	1,2,3,4		
Stratiomyidae			1		X
Tabanidae	X		2		
Rhagionidae	X	X	1,3		
Anthomyiidae			1,2		X
Empididae	X	X			
Gastropoda					
Physidae	X	X	1		
Lymnaeidae	X	X			
Pelecypoda			1		X

[1]1=Little Hole, 2=Carr Ranch, 3=Echo Park, 4=Island Park, 5=supplementary stations only.
[2]Reported as *Iron* by Binns (1965).

TABLE 4

ABUNDANCE OF BENTHIC INVERTEBRATES ON RUBBLE-GRAVEL SUBSTRATES, LITTLE HOLE, GREEN RIVER, 1965 AND 1967 – EXPRESSED AS MEAN NUMBER PER M^2

	1965						*1967*						
Organism	*June 14*	*July 9*	*Aug. 7*	*Aug. 26*	*Sept. 19*	*Nov. 4*	*July 8*	*July 22*	*July 29*	*Aug. 5*	*Aug 12*	*Aug. 19*	*Oct. 14*
Nematoda					11								
Oligochaeta	3206	118	2378	829	3217	215	462	172	172	108	269	1625	1657
Hydracarina		11	22	32	11	43							
Plecoptera													
Isoperla						11							
Arcynopteryx					11	11							
Ephemeroptera													
Baetis sp. I	839	721	40124	19465	1754	6811	409	129	161	581	1033	592	75
Baetis sp. V					11	22							
Paraleptophlebia pallipes					11	11							
Trichoptera													
Agraylea					11								
Diptera													
Tipulidae		11	11									11	
Simuliidae		3271	20261	12460	1022	16355	22	43	32	86	990	839	183
Chironomidae	4390	7306	5219	9006	7123	7995	8511	7081	7091	4143	3239	2733	4089

Ceratopogonidae	11	22			11								
Tabanidae								11	11		11		
Rhagionidae						43				22			
Anthomyiidae				43	11								11
Pupae (all families)	226	613	280	570	829	409	1603	334	850	2819	603	280	291
Gastropoda						32							
Number of samples	2	2	2	2	2	2	2	1	2	2	2	2	2

Little Hole

The substrate at Little Hole was composed primarily of compacted rubble with sand and gravel in the interstices. Because seasonal flooding was reduced, the import of sand and silt from upstream was reduced and the substrate was relatively stable. Soft sand-silt bottoms were found in the deeper pools.

Twenty-six groups of organisms were collected at Little Hole (Table 3), but four groups were dominant: *Baetis* sp. I, Simuliidae, Oligochaeta, and Chironomidae. Numbers of *Baetis* sp. I nymphs and Simuliidae larvae reached 40,124 and 20,261/m^2 on rubble-gravel substrates, respectively (Table 4). Oligochaetes and Chironomidae larvae reached densities of 35,680 and 27,675/m^2, respectively, on sand-silt bottoms.

Carr Ranch

The river at Carr Ranch was characterized by a low gradient and shifting bottom with few silt-free patches of gravel or rubble. Submerged woody and herbaceous plant debris was abundant, however, and the clinging and sprawling forms of benthic invertebrates inhabited this substrate.

Thirty-six groups of organisms were collected at this station (Table 3). The four most abundant organisms on debris substrates were Chironomidae, Oligochaeta, *Baetis* sp IV, and *Baetis* sp. I. Maximum observed densities of these forms were 2,970; 2,518; 1,141; and 624/m^2, respectively. On silt-sand substrates, maximum numbers of chironomids reached 5,650/m^2 and oligochaetes reached 1,355/m^2.

Echo Park

This station was located on the Green River 0.8 km above its confluence with the Yampa. The substrate was largely rubble and gravel with some silt-sand deposited near shore and inside bends of the river.

Thirty-seven forms of invertebrates were collected (Table 3). The four most abundant forms on rubble-gravel substrates were *Baetis* sp. I., *Hydropsyche,* Chironomidae, and *Isoperla,* with maximum densities of 6,510; 1,786; 764; and 441/m^2, respectively. Oligochaetes and chironomids were the most abundant forms on silt-sand, reaching densities of 430 and 334/m^2, respectively.

Island Park

The gradient at this station was relatively low, and the substrate was mostly gravel with numerous clumps and snags of plant debris. Seasonal water-level fluctuations were great and bank erosion was severe which greatly reduced the stability of the sand-silt areas.

Forty-seven forms of bottom fauna were collected (Table 3). The four most abundant organisms on rubble-debris substrates were Chironomidae, *Baetis* sp. I, *Ephemerella inermis*, and *Trichorythodes minutus*. Maximum observed numbers were 3,949; 1,840; 829; and 334/m^2, respectively. On sand-silt bottoms, Chironomidae larvae, Ceratopogonidae larvae, and Oligochaeta were the most abundant forms, reaching maximum densities of 237, 215, and 129/m^2.

MACROINVERTEBRATE DISTRIBUTION: 1967 (FLAMING GORGE DAM TO TAYLOR FLAT)

The bottom-fauna community on rubble-gravel substrates at Little Hole was again dominated by Oligochaeta, Chironomidae, Simuliidae, and *Baetis* sp. I in 1967 (Table 4). Numbers of oligochaetes and chironomids were slightly lower in 1967 than in 1965, but numbers of Simuliidae and *Baetis* were greatly reduced. Density of Simuliidae was 1,022-20,261/m^2 in 1965 and 22-990/m^2 in 1967 (Table 4). Numbers of *Baetis* per square meter were reduced from 721-40,124 in 1965 to 75-1,033 in 1967.

Baetis sp. I had two generations per year in this stretch of the Green River. The winter generation hatched in the fall, overwintered as nymphs, and emerged in June-July of the following year. The summer generation hatched in July, matured rapidly, and emerged in September to lay eggs which hatched and became the winter generation. Mature nymphs of the winter generation were longer (6.1-6.3 mm) than mature nymphs of the summer generation (5.0-5.3 mm). This size dimorphism between generations is common in Baetidae and provided a means of distinguishing mature nymphs of the two generations.

Early in the summer of 1967, numbers of mature winter-generation nymphs were nearly equal to those estimated in 1965. Emergence, mating, and oviposition were observed in 1967, but it soon became apparent that very few eggs had hatched by late August. Nearly all nymphs taken in August were stragglers

from the winter generation. Collecting trips were made from the dam to Taylor Flat on August 19 and October 14, 1967, and no summer-generation nymphs were found within 9.5 km of the dam (Figure 2). Ninety percent of the *Baetis* nymphs in samples

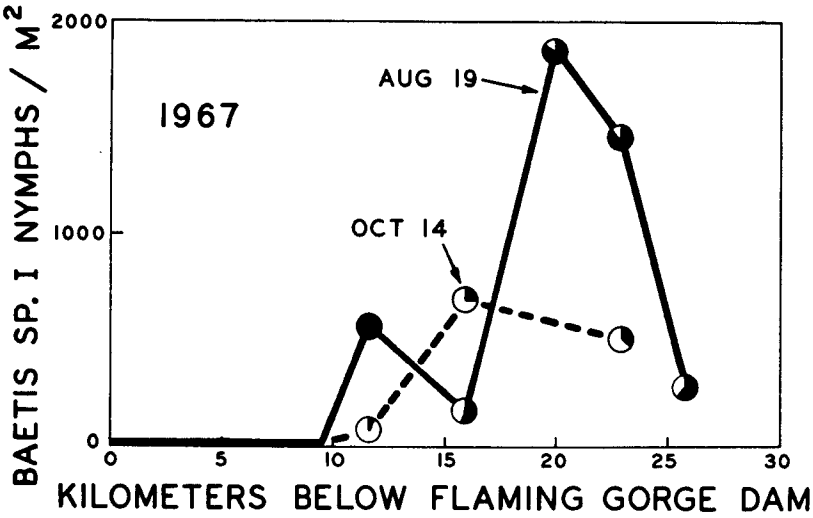

FIGURE 2. Longitudinal distribution of *Baetis* nymphs in the Green River between Flaming Gorge Dam and Taylor Flat, on two dates in 1967. The circles represent the age distribution of nymphs. The percentage of nearly mature numphs is represented by the solid portion of the circle, the immature nymphs (<4.5 mm body length) by the open portion.

at Little Hole on October 14 were newly hatched. The highest standing crop of *Baetis* nymphs (1,850/m²) was found 6 km below Little Hole (13 KBD), but numbers were substantially lower than was observed at Little Hole in 1965.

Drift-net catches reflected this reduction in *Baetis* populations. The mean 24-hr catch of *Baetis* nymphs at Little Hole in 1967 was 11/28m³, whereas this catch was 3,161/28m³ in 1965. The mean 24-hr catch of Simuliidae decreased from 340/28m³ in 1965 to 9/28m³ in 1967.

COMPARISON OF PRE- AND POSTIMPOUNDMENT MACROINVERTEBRATE FAUNAS

Information from several sources was used to compare the invertebrate fauna of the study area in 1964-65 with preimpoundment fauna. Data on invertebrate forms present in the Green

River proper before closure of the dam were taken from Edmunds and Musser (1960), Sessions and Gaufin (1960), Bosley (1960), Woodbury et al. (1963), and Binns (1965). Records from tributaries, ponds, seeps, and cutoff channels along the mainstem Green River were not included in the list of invertebrates present before September, 1962. In the few cases where it was not clear whether collections were from the Green River proper, the species in question were included. Data on macroinvertebrate fauna found after September, 1962, were derived from the present study and from Binns (1965), who studied the Green River above Flaming Gorge Dam.

Nine invertebrate forms reported from the area prior to September, 1962, were not collected during the present study nor by Binns (Table 3). Three were mayflies (*Pentagenia,*[2] *Pseudiron,* and *Genus et species novum*), which were apparently rare before impoundment (Edmunds and Musser, 1960; Binns, 1965). A fourth mayfly, *Baetis insignificans,* may have been among the 11 unidentified forms of *Baetis* nymphs collected during the present study since complete taxonomic keys to Ephemeroptera nymphs in the Green River are lacking. The genus *Baetis* is a particularly poorly-known group. *Claassenia sabulosa* (Plecoptera) was formerly common but was not taken in the present study. *Perlesta* (also Plecoptera) was not found, but it was apparently rare prior to impoundment (Sessions and Gaufin, 1960). Nymphs of *Argia* were not collected during the present study, possibly because most of the sampling was done in moving water, and they were overlooked in backwaters and cutoff pools. Adult Zygoptera were frequently observed and collected at all stations, however. Beetles of the family Helodidae were not found in the present study but one specimen was taken in the preimpoundment collection made by Bosley (1960) on the upper Green River in Wyoming. This family had not been reported below the Flaming Gorge Dam site. Beetles of the family Gyrinidae were observed often but were not collected with the devices used in this study.

On the other hand, 10 groups of invertebrate forms not previously reported in the area were collected during the present study (Table 3). *Hyalella, Arcynopteryx,* and *Paraleptophlebia pallipes* probably existed previously in cool tributaries and found suitable living conditions in the Green River after the dam was closed.

[2]Reported by Binns (1965). The record of this genus in Wyoming needs to be confirmed (G. F. Edmunds, personal communication).

The remaining seven groups are common in the Intermountain area and their discovery likely reflects the paucity of previous collection efforts in the Green River rather than recent invasion. Of the 11 different types of *Baetis* nymphs collected little can be said. Some may be invaders from cool tributaries and others may be previously reported but undescribed species. Edmunds and Musser, (1960) reported one undescribed and one unidentified species of *Baetis* in the Green River. The undescribed species has flattened, shovel-like claws and was frequently found in the present study (*Baetis* sp. VII). It is possible that the unidentified form mentioned by Edmunds and Musser (1966) was among the remaining 10 forms of *Baetis* collected during the present study.

DISCUSSION

With increasing distance below the dam, atmospheric influences and the addition of tributary waters combine to return the Green River toward a semblance of its preimpoundment state. The river environment at Little Hole was greatly altered following closure of the dam while at Carr Ranch and Echo Park the river showed signs of transition to its former state. At Island Park, the Green River appeared to be much the same in 1964-65 as it was before Flaming Gorge Dam was closed.

The bottom-fauna community at Little Hole is now a simple one in terms of number of forms present. It is, of course, difficult to say whether this was due to the fish-control project or to closure of the dam. In light of the rather complete recovery of bottom fauna above Flaming Gorge Reservoir (Binns, 1965), where the river environment had not been greatly altered, it seems likely that ecological changes due to the operation of Flaming Gorge Dam were primarily responsible for the changes observed in the bottom-fauna communities.

The nearly complete failure of the summer generation of *Baetis* sp. I in the first 11.7 km of river below Flaming Gorge Dam in 1967 was related to high flows and low water temperatures. The observation that 90 percent of the nymphs at Little Hole in October were newly-hatched supports the hypothesis that low water temperatures delayed hatching until temperatures began to rise, during fall overturn in the reservoir, to levels required to complete development. Needham et al. (1935) reported that low water temperatures delayed the hatching of *Baetis* eggs, but they did not determine minimum hatching or lethal temperatures.

The reduction in standing crop of Simuliidae larvae at Little Hole in 1967 may also have been caused by low water temperatures.

A comparison of pre- and postimpoundment data indicates that species composition of the invertebrate community of the Green River has not been noticeably altered below Echo Park, and perhaps not below the mouth of Lodore Canyon. Six of the nine forms not found during the present study but reported previously from the Green River had been collected above the Flaming Gorge Dam site. Of these six, *Perlesta, Genus et species novum* (Ephemeroptera), *Pseudiron, Pentagenia,* and Helodidae were probably rare before September, 1962, since each was represented by fewer than five specimens in preimpoundment collections. The sixth, *Baetis insignificans,* may have been collected in the present study but assigned to one of the ten unidentified categories.

Of the remaining three groups, *Argia* and Gyrinidae were frequently seen but not captured with the sampling gear used in this study. The last form, *Claassenia sabulosa,* was reportedly common in the study area before closure of the dam, and it should have been collected with the techniques used in this study. Since no specimens were found, *Claassenia sabulosa,* therefore, is the only macroinvertebrate form to have been definitely adversely affected by the fish-control project and/or the operation of Flaming Gorge Dam. *C. sabulosa* is common, however, in several other areas in the Intermountain region (Jewett, 1959).

CONCLUSIONS

The installation and operation of Flaming Gorge Dam has affected the river environment for at least 150 km downstream. Stream flows have been stabilized on a seasonal basis, but daily flows fluctuate widely. Water temperatures are now lower in summer and higher in winter than before impoundment. Invertebrate communities between the dam and Carr Ranch have been altered, probably as a response to lower summer water temperatures. *Baetis* sp. I responded spectacularly to low water temperatures in 1967 and practically disappeared from the first 9.5 km below the dam.

Species composition in the Green River below Lodore Canyon in 1964-65 appeared to be much the same as that reported in preimpoundment studies with the singular exception of *Claassenia sabulosa,* which has apparently disappeared from the fauna. As

Flaming Gorge Dam continues to operate, new extremes in flow, temperature, and perhaps in some aspects of water chemistry can be expected. As a result, the invertebrate community, particularly that in the first 20 km below the dam, may never stabilize and will continually be in stages of succession as varying conditions favor some groups then others.

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