FRESHWATER PLANKTON CRUSTACEA OF THE COLVILLE RIVER AREA, NORTHERN ALASKA*

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Introduction

THE distribution of plants and animals has occupied the interest of biologists for many years. Rawson (1953) and Wilson (1953a) called attention to the paucity of information about the freshwater plankton organisms in the American Arctic, and both authors pointed out the importance of North American species in holarctic and circumarctic zoogeographical problems. The present paper is a contribution to the faunistics of a poorly known area, the Arctic Slope of northern Alaska. In addition to the plankton collections, limnological observations of physical conditions and chemical analyses of water were made.

The author, assisted by F. W. Jackson of Pinedale, Wyoming, collected Microcrustacea in lakes and ponds along the Colville River, Alaska, from June 10 to August 25, 1955. The field party was flown to a small lake near the junction of the Kiligwa and Colville Rivers (Fig. 1); from this point a pneumatic raft (Fig. 2) was used to float down-river to the Beaufort Sea. From camps established along the way an attempt was made to collect in as many different aquatic habitats as could be found. Collecting gear, including a small pneumatic raft, was packed to lakes and ponds at varying distances from the temporary camps. Anyone who has examined even a moderately detailed map of northern Alaska will realize the impossibility of collecting in all the numerous lakes and ponds of this vast area; however, it is felt that the collections from some 200 lakes and ponds represent most of the major freshwater habitats in the area. Locations of camps make convenient points of reference and are named after major landmarks of the immediate vicinity (Fig. 1). General remarks concerning the river and birds and mammals observed were given previously (Reed 1956).

The Colville, rising in the De Long Mountains of the Brooks Range, is the largest river in Alaska draining into the Arctic Ocean. From headwaters to Harrison Bay the Colville passes through the Southern and Northern Sections of the Foothills Province, and finally crosses the Arctic Coastal Plain Province. Payne, *et al.* (1951) characterize the geology of these areas as follows: the Southern Foothills are of irregular and rather

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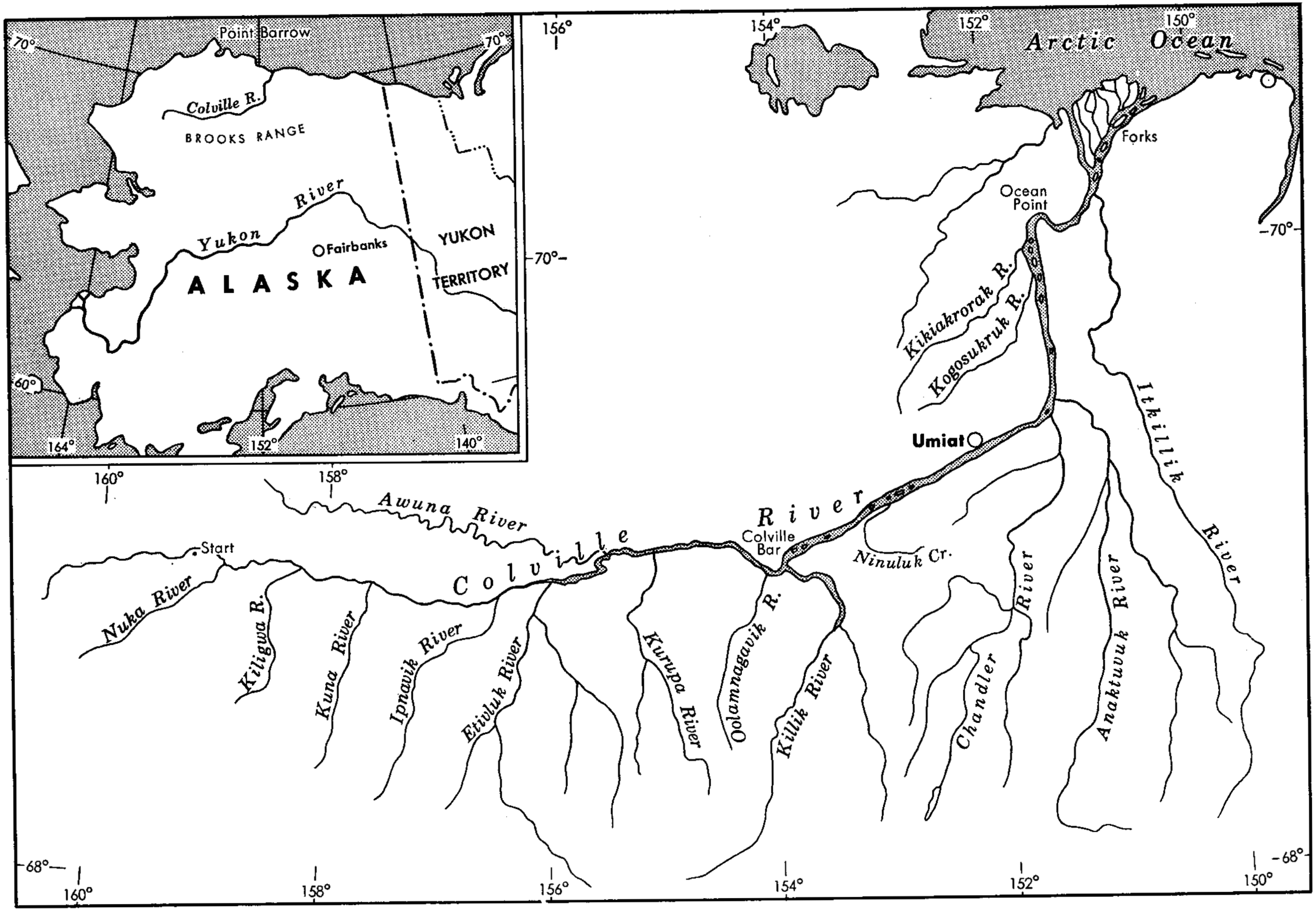

Fig. 1. Map of the Colville River area, northern Alaska.

well-drained topography; the less complex structural geology of the Northern Foothills results in low, rolling hills and more impeded drainage. The Coastal Plain is of very low relief and is covered by hundreds of water bodies, which range in size from a few square feet to several square miles.

The various bodies of water sampled during this investigation can be characterized as:

1. Lakes associated with fluviatile action, chiefly oxbow lakes and other remnants of former drainages, and sloughs and backwaters connected to present rivers and streams.
2. Basins in some way associated with ice, thaw or cave-in lakes. Some small, irregularly shaped, and steep-sided basins appear to have been formed by differential thawing along cracks in the permafrost.
3. Ponds occupying hollows in low-centre polygons.
4. Seeps — very small and very shallow bodies of water that do not appear to fit into any of the above categories; these occurred frequently on hilltops and bluffs along the river.
5. Meltwater ponds resulting from the thawing of snow and not persisting until freeze up.

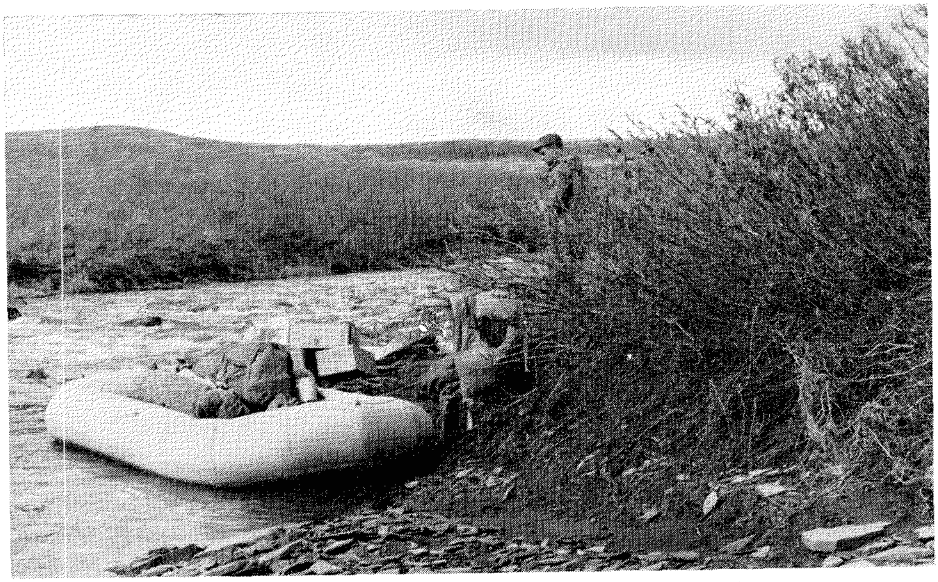

Fig. 2. The pneumatic raft in an unnamed tributary of the Colville River near the Kiligwa River.

Detailed discussions of the origin and development of lake basins in northern Alaska have been provided by Wallace (1948), Black and Barksdale (1949), Hopkins (1949), Livingstone (1954) and Livingstone, *et al.* (1958). The precise designation of water bodies of various sizes has plagued aquatic biologists for many years. Frequently size and depth have been used in classification, e.g., Olofsson (1918), Johansen (1922), Elton and Miller (1954). On the basis of depth and area, the Colville water bodies can be divided into three general categories; moreover, certain biological features support this division which is as follows:

1. Lakes — Usually more than 1 km. in greatest dimension and more than 1.5 metres in depth. The emergent vegetation, if any, is confined to the margin (Fig. 3) and is usually a grass or sedge, rarely *Polygonum*. There is usually evidence of considerable wave erosion somewhere on the perimeter (Fig. 4).
2. Ponds — Variable in extent but between 0.3 to 1.5 metres in depth. Emergent vegetation varies from little to nearly complete cover and is frequently *Polygonum;* there is little or no wave erosion (Figs. 5 and 6).
3. Pools — Usually of small surface and less than 0.3 metre in depth. Emergent vegetation is frequently quite thick but is rarely *Polygonum,* usually *Carex* and similar species (Fig. 7). There is no wave erosion.

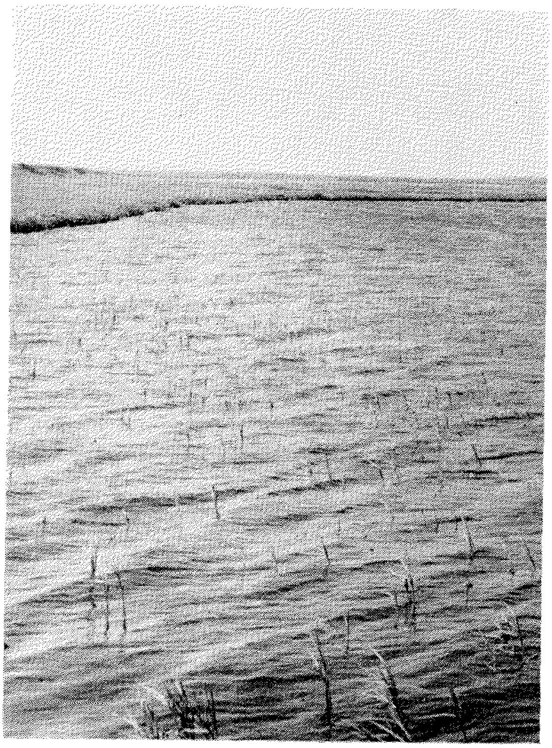

Fig. 3. Lake near the confluence of the Kikiakrorak and Colville rivers, northern Alaska. The emergent vegetation of grass or sedge and the large area distinguish lakes from ponds as defined in this study.

Basins resulting from melting along frost cracks were classed as pools because of the small surface and freedom from wave action; however, these pools had usually a depth considerably greater than 0.3 metre, frequently reaching 1 to 2 metres (Fig. 8).

Physical conditions

All water bodies sampled were quite shallow; the deepest, a lake in an old river channel near Ocean Point, was 3.6 metres (12 feet) deep; lakes deeper than 2.5 metres were unusual. The water was in general free from suspended material. A Secchi disc, a white metal disc 20 cm. in diameter, could be seen resting on the bottom in all lakes in which the transparency was measured with this device. As a group the lakes contained the clearest water. Ponds and pools were variable; some were clear and others, the shallow polygon pools, and the frost crack pools in particular, contained water that was stained a deep brown presumably from humic material leached from the surrounding tundra vegetation.

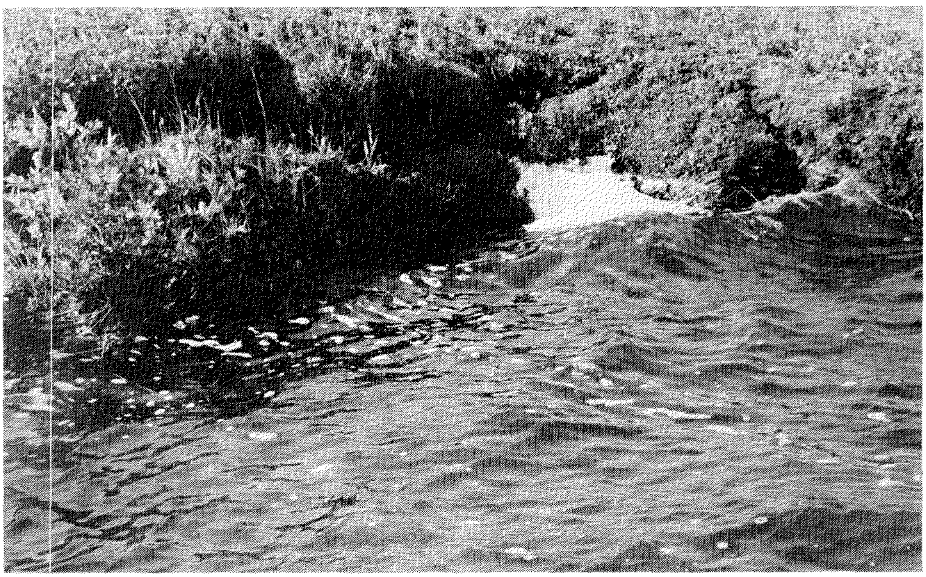

Fig. 4. Shore erosion on a lake near the junction of the Itkillik and Colville rivers, northern Alaska.

The shores of most lakes examined were notably abrupt; sloping bottom profiles were uncommon, and beaches rare (Figs. 3 and 4). One outstanding exception was observed at Kikiakrorak where a lake about 2 km. long by 1 km. wide was surrounded by a sandy, gently sloping beach approximately 30 m. wide. Wave erosion on the lake shores was manifested in two ways: where the ground surface was only a foot or so above the water surface, irregular small inlets were eroded into the tundra; where the banks were more than 2 or 3 feet above the water-level, undercutting followed by slumping occurred (Fig. 4).

The bottoms of most lakes and ponds were of fine silt or mud with variable amounts of organic material. A few lakes in the Kikiakrorak area had hard sand bottoms; gravel composed the bottom of one lake near Umiat. At several localities, especially at Kurupa, Kikiakrorak, and Ocean Point, the hard smooth surface of the permafrost could be detected below the superficial bottom deposits of the shallower ponds and pools. Using chest high waders it was possible to wade in a series of oxbow ponds at Kurupa in which the water was about 2 feet deep and the "bottom" composed of a little silt and nearly 18 inches of partly decayed organic matter under which the permafrost could be felt. Some polygon pools and seeps at Kikiakrorak and Ocean Point contained 3 or 4 inches of water over silt and organic muck deposits about 10 inches deep. By breaking through the organic material the smooth surface of the permafrost could be felt. Irregularly cracked depressions were observed in the bottoms of several of the larger lakes in the upper Colville delta area.

Table 1. Air and surface temperatures in degrees Centigrade for some lakes, ponds, and pools of the Colville River drainage.

Date	*Air*	*Lake*	*Pond*	*Pool*
June 17	7	4	9.5	6—10.5
18	7—9	4.5	7.5	10—11.5
19	9		8	
21	13.5	4		13.5—14.5
24	12.5		15	
July 1	15.5		12.5	18
3	19	15.5	15.5	19—20.5
6	14.5	17	20.5	20
10	10—14	16.5	13.5—17	7—15.5
15	20.5	18		
26	14—18	19	16.5	15.5
28	7	13.5	10	11
Aug. 1	11.5	12.5		
2	9	13	12	
8	5	9	6.5	5—7
11	7	9.5	9	10.5
14	12	11.5	9—11	10
15	8	8—10	10—12	7.5—10.5
19	5.5	7	6	8
24	2—4	7	6—7	7
25	5	4	2.5	

Surface temperatures varied from 0.5 to 20.5°C. (Table 1). Water temperatures in pools followed changes in air temperature more rapidly than those of either ponds or lakes. Usually lake surface temperatures were lower than air temperatures until about mid-July, from then until the end of August the water tended to be warmer than the air. The inter-relationships of depth, area, and surface temperature are evident from the following series taken June 17 near Umiat:

Umiat Lake, about one half ice covered	3.3°C.
Nearby ice-free lake	7.8
Meltwater pool 8 inches in depth	10.6
Slough 5 inches deep with bare mud bottom	14.4

No instances of thermal stratification were observed. Differences in surface temperatures at various places within one lake were noted, e.g., in an oxbow lake at Ocean Point the surface temperature was 9.4°C. above the deep water (3.6 m.) near the centre; close to shore the surface temperature in 0.6 m. was 11.1°C. Cooling can occur rapidly; during a period of stormy weather on August 24 and 25 at Oliktok Point the water temperature of a rather large lake dropped from 6.7 to 3.3°C. in 24 hours.

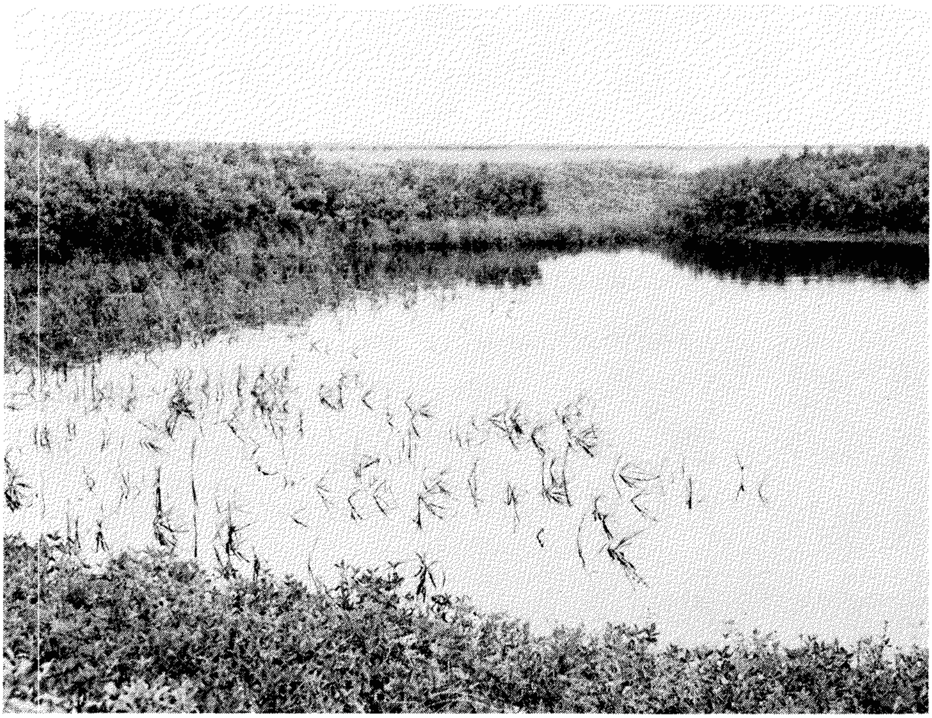

Fig. 5. Pond at Ocean Point, Colville River, northern Alaska.

It is possible that the lakes as far inland as Umiat and Anaktuvuk reach higher temperatures than the more coastal lakes. The maximum temperature recorded by Edmondson (1955) in two summers of study of Imikpuk Lake near Barrow was 12.5°C. At Umiak a lake temperature of 17°C. was recorded on July 15. A surface temperature of 18°C. was noted on July 27 at Anaktuvuk; no temperature above 13°C. was recorded after this date.

Chemical conditions

Chemical analyses were confined to those determinations that could be performed in the field with modest equipment. Dissolved oxygen was measured by the unmodified Winkler method. Alkalinity titrations and volumetric analyses for calcium, chloride, and sulphate were made by procedures given in Theroux, *et al.* (1943). Water hardness was measured by a compleximetric chelation method (Versene water test kit). Observations were made on 48 bodies of water (Table 2).

Table 2. Ionic composition in parts per million of some lakes, ponds, and pools of the Colville River drainage.

Locality	*Type*	*Versene hardness as* $CaCO_3$	HCO_3^-	SO_4^{--}	Cl^-	Ca^{--}
Umiat	Pond	34	33.0	11.5	7.0	19.0
"	Lake	17	17.0	13.5	9.0	20.0
"	Pool	34	30.0	17.3	10.0	16.0
Ipnavik	Pond	51	63.0	14.4	4.0	34.0
"	"	25	33.0	17.3	1.0	23.0
"	"	8	8.0	24.0	4.0	24.0
Kurupa	Lake	34	40.0	8.8	3.0	19.0
"	Pool	17	6.0	10.6	7.0	18.0
"	Lake	12	6.0	9.6	6.0	23.0
"	Pond	17	9.0	10.6	8.0	18.0
"	"	17	9.0	9.6	6.0	20.0
Colville Bar	Pool	17	9.0	12.5	7.0	14.0
" "	Lake	17	13.0	7.7	6.0	15.0
" "	"	17	10.0	8.6	7.0	21.0
Ninuluk	"	17	33.0	19.2	6.0	19.0
"	Pond	34	18.0	10.6	4.0	15.0
"	Lake	34	19.0	4.8	4.0	13.0
Anaktuvuk	Pond	34	38.0	7.7	5.0	18.0
"	Pool	17	15.0	17.3	5.0	13.0
"	Pond	34	20.0	7.7	6.0	18.0
"	"	51	29.0	8.6	5.0	16.0
"	Lake	51	34.0	11.5	5.0	15.0
Kikiakrorak	"	85	89.0	7.7	13.0	20.0
"	"	68	75.0	7.7	13.0	20.0
"	Pond	102	100.0	5.8	13.0	20.0
"	Lake	51	39.0	12.5	9.0	18.0
"	"	51	35.0	7.7	10.0	18.0
"	Pond	34	18.0	9.6	10.0	17.0
"	Stream	34	24.0	7.7	8.0	20.0
Ocean Point	Pool	170	180.0	11.5	23.0	27.0
" "	Pond	34	33.0	8.6	9.0	15.0
" "	"	68	49.0	7.7	14.0	17.0
" "	Lake	51	30.0	9.6	9.0	14.0
" "	"	68	62.0	12.5	14.0	—
Itkillik	Pond	68	60.0	—	12.0	—
"	Lake	51	40.0	—	7.0	—
"	"	51	40.0	—	5.0	—
"	Pond	68	52.0	—	11.0	—
"	"	68	61.0	—	9.0	—
"	Pool	85	70.0	—	19.0	34.0
"	Lake	51	44.0	—	9.0	18.0
"	Pond	119	100.0*	—	21.0	24.0
"	"	68	52.0	—	12.0	21.0
"	"	—	93.0*	—	17.0	20.0
Oliktok Point	"	72	36.0	9.6	49.0	16.0
" "	Pool	60	28.0	17.3	28.0	16.0
" "	Lake	90	61.0	6.7	23.0	20.0
" "	"	90	61.0	7.7	20.0	20.0

*includes CO_3^{--}

Chloride content ranged from 1 to 49 p.p.m.; however, in only six samples were chlorides present as 20 p.p.m. or more (Table 2). There was a slight tendency for chloride content to increase in a downstream direction. At Oliktok Point the pond containing 49 p.p.m. Cl^- was situated a short distance from the ocean. Driftwood on the beach and along the edge of the pond indicated that during onshore storms waves entered the pond from the sea. Although the chloride content was rather high, the fauna of the pond was definitely freshwater in character, containing such species as *Diaptomus sicilis, D. glacialis* and *Heterocope septentrionalis*. The presence of *Saduria* sp., *Pseudalibrotus litoralis* and the harpacticoids *Ectinosoma* sp. and *Tachidius* sp., which are all brackish or at least euryhaline species,

Fig. 6. Ponds on the tundra at Oliktok Point, northern Alaska. Note the abrupt nature of the banks.

in one pond at Oliktok Point suggested that some of the ponds were brackish. The water in the pond containing these species had a hardness of 240 p.p.m., the highest value recorded. Gorham (1955) has noted that surface waters nearer the sea-coast often contain greater amounts of chloride than do those farther inland, presumably due to chloride passing into the atmosphere from sea spray and later being washed out by rains and mists. There is an indication in the present data that for any one area the lakes contained less chlorides than did the ponds or pools. The Kikiakrorak samples exhibit an interesting situation. The two lakes and one pond which each had 13 p.p.m. Cl^- (Table 2), were connected and were drained by a stream different from that draining the other two lakes and pond. Moreover, the first group occupied basins on the highest level above the

Colville River; whereas the second group was located on a lower terrace and therefore may be younger than the first.

Normal carbonates contributed to the alkalinity of only two of 48 samples, a lake and a pond at Itkillik. In general, alkalinity appeared to increase from Ipnavik to Itkillik; however, considerable variation within localities was observed. No consistent relationship between size of water body and HCO_3^- content was found. In regard to HCO_3^- the ponds and lakes at Kikiakrorak showed a condition similar to that of Cl^-, i.e., a distinct subdivision within one area. The waters examined were soft, only three testing over 100 p.p.m. hardness as $CaCO_3$ (Table 2). Bicarbonate was the dominant anion, carbonate hardness being greater than non-carbonate in all but two cases.

Fig. 7. Pool on the river bluff near the junction of the Kurupa and Colville rivers, northern Alaska.

Forty-two calcium determinations varied from 13 to 34 p.p.m. Calcium content appeared to be unrelated to type of water body and no trend with respect to locality was noted.

The results of 21 determinations of dissolved oxygen are given in Table 3. Amounts varied from 4.3 to 10.5 p.p.m. and percentages of saturation ranged from 49 to 100, with the majority of readings between 60 and 68 per cent. The rather low percentages of saturation are probably a reflection of the high humic content of the water since this is known to reduce oxygen content. Dissolved oxygen in surface and bottom waters was compared in a lake at Ocean Point on August 9. A sample taken just above the lake bottom in 12 feet of water contained 7.0 p.p.m. while one from the surface contained 7.7 p.p.m.

Table 3. Quantity of dissolved oxygen in parts per million for some lakes, ponds, and pools of the Colville River drainage.

Area	*Type*	O_2 *p.p.m.*	*Sample temperature* °*F.*	°*C.*	*Percentage saturation*
Umiat	Pond	7.1	44	6.5	59
"	Lake	9.0	38	3.2	70
"	Pool	6.1	51	10.3	56
Ipnavik	Pond	6.4	54	12.2	63
"	"	6.4			63
"	"	7.0			68
Kurupa	Lake	10.5	54	12.2	100
"	"	6.6	60	15.7	68
"	Pond	5.6	64	17.7	62
"	"	7.3			
Colville Bar	Pool	4.3	68	20	49
" "	Lake	4.9	63	17.2	53
" "	"	5.7	63	17.2	60
Ninuluk	Lake	6.2	62	16.6	65
"	Pond	6.2	60	15.5	63
"	Lake	6.5	59	14.4	64
Anaktuvuk	Pond	6.4	56	13.3	62
"	Lake	6.4	56	13.3	62
Ocean Point	Lake	7.7 (sur.) 7.0 (bot.)	49	9.5	67
Ocean Point	Pond	8.3	52	11.1	75

Biological observations

Crustaceans were qualitatively sampled by means of Wisconsin plankton nets of Number 10 and 20 silk bolting cloth and a large dip net made of nylon parachute material. Collections were made by dipping among the littoral vegetation and by tossing a plankton net attached to a line out into a pond and then pulling the net slowly to shore. On occasion both vertical and horizontal sampling was done from the raft. Catches were transferred to small vials and preserved with formaldehyde.

Twenty-two species of Cladocera, 29 species of Copepoda and six species of larger Crustacea were collected. The number of occurrences and type of water body from which each species was collected are given in the following annotated species lists. Ostracods occurred in many of the collections, but were not identified. Residues of samples and all specimens except the cyclopoids, which have been retained for further study, have been deposited in the United States National Museum.

Fig. 8. Pool on the tundra near Colville Bar, Colville River, northern Alaska. This type of pool is thought to originate from differential thawing along cracks in the permafrost.

Cladocera

Dr. John L. Brooks, Yale University, kindly identified the *Daphnia* and Dr. David G. Frey, Indiana University, verified identification of most of the other cladocerans. Nomenclature is according to Brooks (1959).

Holopedium gibberum Zaddach. This occurred in 13 lakes and ponds from Kurupa to Ocean Point. Young animals made up the early collections at Kurupa and Colville Bar; females carrying subitaneous eggs were collected at Ocean Point on August 9.

Daphnia middendorffiana Fischer and *Daphnia pulex* Leydig x *D. middendorffiana*. Typical *D. middendorffiana* were collected at Ninuluk, Kikiakrorak, Ocean Point, Itkillik, Forks, and Oliktok Point. Apparent hybrid populations occurred at Bison Creek, Ipnavik, Kurupa, Colville Bar, Umiat, and Anaktuvuk.

Daphnia longiremis (Sars). This species occurred in 13 ponds or lakes.

Simocephalus vetulus (O. F. Müller). This occurred in 8 collections: Bison Creek, Ipnavik, Umiat, Forks, and Ocean Point. Females with subitaneous eggs were collected on June 24; on August 9 ephippial females and those with subitaneous eggs occurred together.

Scapholeberis kingi Sars. This occurred in 4 ponds and pools at Anaktuvuk and Ocean Point. Two pool collections at Kurupa and one at Ocean Point contained the "horned" form, which bears a frontal spine on the head. Klugh (1926) and Bardach (1954) have reported the horned form from Ontario and the Thelon area, N.W.T. Horned and non-horned animals occurred together at Ocean Point.

Ceriodaphnia quadrangula (O. F. Müller). This was collected at Ipnavik, Itkillik, and Ocean Point.

Bosmina longirostris (O. F. Müller). There were 8 occurrences, at Ninuluk, Itkillik, and Forks.

Bosmina coregoni Baird. There were 7 occurrences: Kurupa, Colville Bar, Ninuluk, Umiat, Ocean Point, and Itkillik. None were taken in pools.

Lathonura rectirostris (O. F. Müller). This species was collected once, in a pond at Ocean Point.

Eurycercus lamellatus (O. F. Müller). This occurred in all localities for a total of 41 times. In the Colville collections all animals examined have antennule characters that agree with those given by Frey (1958) for *E. lamellatus;* viz., the sensory hair is at mid-length or slightly proximal on the antennules. Brooks (1959, 634-635) stated that *E. glacialis* Lilljeborg is the form occurring in the far north, i.e., northern Alaska and Canada. Juday (1920) reported *E. glacialis* from Teller, Alaska; Herschel Island, Yukon Territory, and two localities in Northwest Territories, Bernard Harbour and Cape Bathurst. Juday further stated that *glacialis* had been reported from Bering Island (Lilljeborg 1887) and St. Paul Island (Juday and Muttkowski 1915) in the Bering Sea.

The author has examined *Eurycercus* in several collections from various localities in the Canadian Arctic and they were all *glacialis.* Only *E. lamellatus* was present in the collections from Saint Matthew Island, Bering Sea that were made available by Dr. Robert Rausch and Mrs. Mildred S. Wilson, Arctic Health Research Center, Anchorage, Alaska.

Camptocercus rectirostris Schødler. This occurred in 7 ponds and one lake at Ipnavik, Kurupa, Colville Bar, Anaktuvuk, Kikiakrorak, and Ocean Point.

Acroperus harpae Baird. This was collected at Colville Bar, Umiat, Anaktuvuk, Kikiakrorak, and Ocean Point in 4 ponds, one pool, and one stream.

Alona affinis (Leydig). This occurred in one pond at Ninuluk and 3 ponds at Kikiakrorak.

Alona guttata Sars. This occurred 5 times at Kurupa, Anaktuvuk, Ocean Point, and Itkillik.

Alona quadrangularis (O. F. Müller). This species was collected twice, at Anaktuvuk and Ocean Point.

Alona rectangula Sars. This was collected once at Ninuluk and once at Ocean Point.

Alonella excisa (Fischer). This was collected twice at Ocean Point.

Alonella nana (Baird). This was found in one pond at Anaktuvuk.

Graptoleberis testudinaria (Fischer). This was collected twice at Ocean Point.

Pleuroxus denticulatus Birge. This was found in one pond at Anaktuvuk.

Chydorus sphaericus (O. F. Müller). This was collected 45 times in all localities. Females with subitaneous eggs were present from June 24 to August 19.

Polyphemus pediculus (Linneaus). This appeared in 19 collections at Kurupa, Colville Bar, Ninuluk, Anaktuvuk, Kikiakrorak, Ocean Point, and Itkillik.

Copepoda

The nomenclature of Calanoida follows Wilson (1959) and that of Cyclopoida Yeatman (1959). Mrs. Mildred S. Wilson, Arctic Health Research Center, Anchorage, Alaska, identified the harpacticoids and verified determinations of the calanoids. Dr. H. C. Yeatman, University of the South, Sewanee, Tennessee, checked identifications of some cyclopoids. The records are based on the examination of adult animals.

Cyclops (Cyclops) scutifer Sars. This occurred 32 times and in all localities. It is definitely a species of lakes and ponds. Ovigerous females were first collected on June 27.

Cyclops (Cyclops) strenuus Fischer. This occurred 29 times and in all areas. Ovigerous females were first found on June 18 at Umiat. Along the Colville River *C. strenuus* inhabits small and weedy waters; 19 occurrences were in pools, 9 in ponds, and 1 in a lake.

Cyclops (Acanthocyclops) vernalis Fischer. The work of Price (1958) strongly suggests that what has often been called a highly variable species may be in fact a group of sibling species. Pending further information, it is perhaps best to designate the Colville River animals as belonging to the *vernalis* group. This form occurred in all areas in a total of 33 samples.

Cyclops (Acanthocyclops) venustoides Coker. This occurred in 11 collections from the starting point to Oliktok Point.

Cyclops (Acanthocyclops) capillatus Sars. This was collected at all localities except Colville Bar, most of the 31 occurrences were in ponds.

Cyclops (Diacyclops) languidoides Lilljeborg. This appeared erratically and only in small numbers.

Cyclops (Megacyclops) magnus Marsh. This occurred in 17 collections from all localities. Ovigerous females were numerous in meltwater puddles between snow banks on the tundra at Point Barrow on June 10.

Microcyclops rubellus (Lilljeborg). This appeared irregularly, usually in collections from pools.

Eucyclops agilis (Koch). This was collected on 14 occasions from Ipnavik to Oliktok Point. The first ovigerous females were captured on June 27.

Calanoida

Eurytemora canadensis Marsh. Eighteen collections from ponds and lakes at Anaktuvuk, Itkillik, Ocean Point, Forks, and Oliktok Point contained *E. canadensis.* At least one and perhaps two undescribed species of *Eurytemora* occurred in some of the samples. The new species are being described by Mrs. Mildred S. Wilson.

Heterocope septentrionalis Juday and Muttkowski. This occurred 63 times in all localities, 6 times in pools.

Diaptomus (Nordodiaptomus) alaskaensis M. S. Wilson. This was collected on 10 occasions at Kurupa, Ninuluk, Anaktuvuk, Kikiakrorak, and Ocean Point. Adult males and females with attached spermatophores were found on July 1. It is predominantly a pool form.

Diaptomus (Hesperodiaptomus) arcticus Marsh. This occurred in 18 ponds and lakes from Anaktuvuk to Oliktok Point. Ovigerous females were first collected on August 15.

Diaptomus (Arctodiaptomus) bacillifer Købel. This was collected in a pool at Kikiakrorak and in three ponds at Oliktok Point.

Diaptomus (Diaptomus) glacialis Lilljeborg. This was found three times at Kikiakrorak and Oliktok Point.

Diaptomus (Eudiaptomus) gracilis Sars. This appeared in eight collections from Ocean Point, Itkillik, and Forks.

Diaptomus (Leptodiaptomus) pribilofensis Juday and Muttkowski. This was the most frequently collected diaptomid; it occurred in 21 ponds, 9 lakes, and 5 pools from Anaktuvuk to Oliktok Point. Females bearing spermatophores were first collected on August 9.

Diaptomus (Leptodiaptomus) sicilis S. A. Forbes. This was collected in two ponds at Oliktok Point.

Diaptomus (Mixodiaptomus) theeli Lilljeborg. This was found in a collection from one pool at Itkillik and is the only record for the species from North America (Reed 1958).

Harpacticoida

Canthocamptus assimilis Kiefer. This occurred in seven ponds at Ipnavik and in one lake at Umiat.

Attheyella dentata (Poggenpol). This was collected in a pond at Ipnavik, and in a pool and a lake at Umiat.

Attheyella dogieli (Rylov). This was found in one pond at Umiat.

Attheyella nordenskioldii (Lilljeborg). This occurred in collections from nine pools at Ipnavik, Kurupa, Umiat, Oliktok Point, and Point Barrow.

Bryocamptus tikchikensis M. S. Wilson. This occurred in two ponds at Itkillik.

Bryocamptus umiatensis M. S. Wilson. There were four occurrences at Umiat and Kurupa.

Bryocamptus vejdovskyi (Mrazek). This was found in three collections from pools at Umiat and Ipnavik.

Moraria duthiei (T. and A. Scott). This was found in four ponds at Umiat, the starting point, and Ipnavik.

Moraria mrazeki T. Scott. This was found in two ponds at Ipnavik and Kurupa, and in one pool at Umiat.

Tachidius spitzbergensis Oloffson. This occurred together with the preceding species.

Ectinosomidae. Two specimens of this family occurred in a brackish beach pond at Oliktok Point.

Larger Crustacea

Notostraca

Lepidurus arcticus (Pallas). There are three collections from a lake at Kikiakrorak and from a lake and a pond at Oliktok Point.

Anostraca

Polyartemiella hazeni (Murdoch). This was collected in all localities except Ipnavik and Umiat and occurred in thirteen ponds, six pools, and four lakes. Ovigerous females were first collected on July 10.

Branchinecta paludosa (O. F. Müller). This was collected in two lakes at Kikiakrorak and Oliktok Point, and in six ponds at Itkillik, Forks, and Oliktok Point.

Amphipoda

Gammarus lacustris Sars. This occurred in two ponds at Ninuluk and Kikiakrorak, and in one lake at Kikiakrorak.

Pseudalibrotus litoralis Sars. This was found in a brackish beach pond at Oliktok Point. Amphipoda were identified by the late Mr. Clarence Shoemaker, United States National Museum.

Isopoda

Saduria sp. One juvenile specimen came from the same pond as the preceding species. It was determined by Dr. Thomas Bowman, United States National Museum.

Table 4. The number of occurrences of different species of copepods in three habitats of the Colville River drainage.

Species	*Total occurrences*	*Pool*		*Pond*		*Lake*	
		No. occur.	*% of total occur.*	*No. occur.*	*% of total occur.*	*No. occur.*	*% of total occur.*
Cyclops scutifer	32	1	3	16	50	15	47
C. strenuus	28	18	65	9	32	1	3
C. vernalis	33	10	30	20	61	3	9
C. venustoides	11	4	36	4	36	3	27
C. capillatus	31	6	20	21	68	4	13
C. magnus	17	10	59	5	29	2	12
Eucyclops agilis	14	1	7	9	64	4	29
Eurytemora canadensis	18	2	11	9	50	7	39
Heterocope septentrionalis	63	6	9	30	48	27	43
Diaptomus alaskaensis	10	8	80	2	20	0	0
D. arcticus	18	1	6	9	50	8	45
D. bacillifer	4	1	25	3	75	0	0
D. glacialis	3	1	33	2	67	0	0
D. gracilis	8	0	0	1	13	7	87
D. pribilofensis	35	5	14	21	60	9	26
D. sicilis	2	0	0	2	100	0	0
D. theeli	1	1	100	0	0	0	0
Canthocamptus assimilis	8	0	0	7	87	1	13
Attheyella dentata	3	1	33	1	33	1	34
A. dogieli	1	0	0	1	100	0	0
A. nordenskioldii	9	9	100	0	0	0	0
Bryocamptus tikchikensis	2	0	0	2	100	0	0
B. umiatensis							
B. vejdovskyi	3	3	100	0	0	0	0
Moraria duthiei	4	0	0	4	100	0	0
M. mrazeki	3	1	33	2	67	0	0

Copepod communities

The smaller and warmer bodies of water usually contained relatively more species of zooplankton than did the larger, colder lakes. Mature, ovigerous cyclopoid copepods were present in the earliest samples. Nauplii of calanoid copepods began to appear in numbers in the collections made in late June. Ovigerous calanoids did not, in general, appear until late July or early August. Samples taken in August were characterized by the presence of adult calanoids, and nauplii or young copepodite stages of cyclopoids, the reverse of the situation in the early season. Cladocera bearing subitaneous eggs appeared about mid-June. Ostracods and harpacticoid copepods were collected in considerable numbers in June and in early July, but appeared irregularly in later samples.

Occurrence of the species of Copepoda in relation to habitat is given in Table 4. Some species, e.g., *Cyclops strenuus, Cyclops magnus, Diaptomus alaskaensis,* and *Attheyella nordenskioldii* appear to show a distinct preference for pools. *Diaptomus gracilis, Diaptomus arcticus, Heterocope septentrionalis,* and *Cyclops scutifer* occurred mainly in lakes. As the environment of the ponds is intermediate between the other two, it might be expected to contain a large percentage of species; this is confirmed by Table 4. However, when occurrences in pools and ponds are compared with those in ponds and lakes, the preferences for large or small water bodies are emphasized. For example, 97 per cent of *Cyclops scutifer* occurred in pond or lake habitats and 97 per cent of *Cyclops strenuus* were in pool or pond habitats. *Cyclops venustoides* occurred with about equal frequency in pools, ponds, and lakes. Still other species, e.g., *Cyclops capillatus* and *Diaptomus pribilofensis* were most frequently collected in habitats of intermediate size.

Pools, ponds, and lakes were not sampled an equal number of times, and therefore the data may be biased in favor of the pond collections, which

Table 5. The number of occurrences of different species of copepods in different habitats along the Colville River expressed as percentage of the total number of collections from each habitat.

Species	*Pool* 39 *collections*		*Pond* 77 *collections*		*Lake* 49 *collections*	
	Number occur.	*% occur.*	*Number occur.*	*% occur.*	*Number occur.*	*% occur.*
Cyclops scutifer	1	3	16	21	15	31
C. strenuus	18	46	9	12	1	2
C. vernalis	10	26	20	26	3	6
C. venustoides	4	10	4	5	3	6
C. capillatus	6	15	21	27	4	8
C. magnus	10	26	5	7	2	4
Eucyclops agilis	1	3	9	12	4	8
Eurytemora canadensis	2	5	9	12	7	15
Heterocope septentrionalis	6	15	30	39	27	55
Diaptomus alaskaensis	8	21	2	3	0	0
D. arcticus	1	3	9	12	8	17
D. bacillifer	1	3	3	4	0	0
D. glacialis	1	3	2	3	0	0
D. gracilis	0	0	1	1	7	15
D. pribilofensis	5	13	21	27	9	19
D. sicilis	0	0	2	3	0	0
D. theeli	1	3	0	0	0	0
Canthocamptus assimilis	0	0	7	9	1	2
Attheyella dentata	1	3	1	1	1	2
A. dogieli	0	0	1	1	0	0
A. nordenskioldii	9	23	0	0	0	0
Bryocamptus tikchikensis	0	0	2	3	0	0
B. umiatensis						
B. vejdovskyi	3	8	0	0	0	0
Moraria duthiei	0	0	4	5	0	0
M. mrazeki	1	3	2	3	0	0

were the most numerous (Table 4). To compensate for the inequalities of representation of the different habitats in the samples, Table 5 was prepared, showing the occurrence of the species in the different habitats as a percentage of the total number of each habitat sampled. *Heterocope septentrionalis* was found in 55 per cent of the lakes and 39 per cent of the ponds sampled, and *Cyclops strenuus* was found in 46 per cent of the pools sampled; for others, the frequency in any type of habitat for any given species was 30 per cent or less. It is interesting that an animal such as *Cyclops scutifer,* which appeared to show a strong preference for pond-lake habitats, was found in only 21 and 30 per cent of these habitats respectively. In most instances, the values of Table 5 tend to corroborate those of Table 4 in regard to habitat preferences. For instance, *Cyclops strenuus* occurred in 46 and 12 per cent of the pools and ponds sampled, and 97 per cent of the total occurrences were in these two habitats.

Seasonal occurrence may have affected the seeming use of habitats in some instances. With the exception of *Diaptomus alaskaensis,* adult calanoids were not collected until the summer was well advanced; since immature forms were not identified, a species not represented by adults would go unrecorded, although present. At no time did adult cyclopoids completely disappear from the collections. In no locality even when adults were present was any species, cyclopoid or calanoid, found in all apparently available, suitable habitats.

Probably the physical factors of the environment set the ultimate limits of the geographical distribution of a species. However, *Diaptomus sicilis, Diaptomus theeli,* and other infrequently collected species occurred in only a few of the ponds and were seemingly absent from neighbouring homogeneous ponds. To explain the presence and ostensible absence on the basis of physical environmental factors would appear to demand that the animals are susceptible to very subtle environmental differences. As far as the Colville collections are concerned, the distribution of copepod species cannot be explained on a basis of physico-chemical factors, at least not from the data at hand. The precise means by which freshwater Microcrustaceans are distributed is still in doubt. However, some manner of passive dispersal (wind, water fowl, or moving water) is usually evoked. Regardless of dispersal mechanisms for any particular species, it seems difficult to account for their distribution in the Alaskan ponds, lakes, and pools on that basis alone.

Biological interaction between species may be a factor in the distribution of copepod species in the Colville water bodies. Associations of copepods were analyzed on a cyclopoid-calanoid basis (Table 6). Harpacticoids are not included because the sampling methods were probably biased against animals that are closely associated with the substrate. A single species of cyclopoid was found in 18 samples: among these, *Cyclops strenuus* occurred alone seven times and *Cyclops scutifer* six times. A calanoid species was found singly in nine samples, in these *Diaptomus pribilofensis* occurred alone on three occasions. A combination of one calanoid with one cyclopoid occurred 19 times; among these, *Cyclops scutifer* was associated with *Heterocope septentrionalis* eight times. Two cyclopoids occurred together in 18 samples, no one association being clearly dominant. Two calanoid species were collected together on ten occasions, the combination *Diaptomus pribilofensis-Heterocope septentrionalis* accounting for five. *Cyclops vernalis* was involved in ten of the eleven collections containing three species of cyclopoids.

The four most frequently collected calanoid copepods were *H. septentrionalis, D. pribilofensis, D. arcticus,* and *E. canadensis.* The four species of cyclopoids most frequently collected were *C. vernalis, C. scutifer, C. capillatus,* and *C. strenuus.* On the basis of occurrence, these eight species may be considered the dominant copepods. The calanoids are represented by three genera, which occurred together in various combinations. Among the diaptomids, *D. arcticus* and *D. pribilofensis* were found together often. In contrast, *D. alaskaensis* was the only diaptomid in nine of the ten collections in which it was found. Similarly, *D. gracilis* occurred as the only calanoid in five samples and was associated with *E. canadensis* in three, but was not found with another diaptomid species. *D. bacillifer* and *D. glacialis* were collected four and three times respectively; twice these two diaptomids occurred together. On one occasion *H. septentrionalis* was the third calanoid present and once *E. canadensis* was collected with the two diaptomids. *D. sicilis* was also infrequently collected along the Colville River; *sicilis* occurred once with *D. glacialis, H. septentrionalis,* and *E. canadensis* and once alone. The single sample containing *D. theeli* also held *H. septentrionalis,* but no other diaptomid. Evidently the rarer species tended to occur alone or be associated with each other but not with the dominant species.

Among the cyclopoids, *C. scutifer* was the only cyclopoid in 18 samples and occurred rather frequently with *C. capillatus* and *C. vernalis. C. strenuus* occurred as the only cyclopoid in eight collections and was often associated with *C. magnus. C. vernalis* was found associated with *C. magnus* and *C. strenuus* and other pool species, or it was often found with *C. scutifer* and *C. capillatus* in ponds and lakes. *C. venustoides* also showed wide ecological valence and was frequently found associated with *C. strenuus* and other pool species, but not with *C. scutifer* and *C. capillatus* in the larger bodies of water.

Considering both calanoids and cyclopoids, the most common association of species for pools was *D. alaskaensis* with some combination of *C. strenuus, C. magnus,* or *C. vernalis.* Associations of the ponds and lakes were more complex but usually involved some combination of *H. septentrionalis, E. canadensis, D. pribilofensis, D. arcticus, C. scutifer,* or *C. capillatus.*

Zoogeography

Many faunal affinities between northern Alaska and eastern Siberia are well known. It is therefore not surprising that the Microcrustacean

Table 6. Species associations of calanoid and cyclopoid copepods in 125 lakes, pools, and ponds of the Colville River drainage.

1 cyclopoid — no calanoids, 18 occasions	
C. strenuus	7
C. scutifer	6
C. vernalis	2
C. capillatus	1
C. magnus	1
C. venustoides	1
2 cyclopoids — no calanoids, 18 occasions	
C. scutifer-C. capillatus	3
C. capillatus-C. vernalis	2
C. magnus-C. vernalis	2
C. scutifer-C. vernalis	2
C. strenuus-C. venustoides	2
C. strenuus-C. vernalis	2
C. capillatus-C. strenuus	1
C. magnus-E. agilis	1
C. scutifer-M. rubellus	1
C. scutifer-C. strenuus	1
C. strenuus-C. magnus	1
3 cyclopoids — no calanoids, 11 occasions	
C. vernalis, E. agilis, C. capillatus	2
C. vernalis, C. scutifer, C. capillatus	2
C. strenuus, C. venustoides, C. magnus	1
C. vernalis, C. capillatus, C. venustoides	1
C. vernalis, C. languidoides, C. strenuus	1
C. vernalis, C. magnus, C. strenuus	1
C. vernalis, M. rubellus, C. strenuus	1
C. vernalis, C. scutifer, E. agilis	1
C. vernalis, C. strenuus, E. agilis	1
4 cyclopoids — no calanoids, 2 occasions	
E. agilis, C. capillatus, C. vernalis, C. languidoides	1
E. agilis, C. scutifer, C. vernalis, C. languidoides	1
5 cyclopoids — no calanoids, 1 occasion	
C. magnus, C. strenuus, C. vernalis, E. agilis, C. languidoides	1
1 calanoid — no cyclopoids, 9 occasions	
D. pribilofensis	3
D. gracilis	2
H. septentrionalis	2
D. bacillifer	1
D. sicilis	1
2 calanoids — no cyclopoids, 10 occasions	
H. septentrionalis-D. pribilofensis	5
H. septentrionalis-D. arcticus	2
H. septentrionalis-E. canadensis	2
D. gracilis-E. canadensis	1
3 calanoids — no cyclopoids, 6 occasions	
H. septentrionalis, D. pribilofensis, D. arcticus	3
D. arcticus, D. pribilofensis, E. canadensis	1
D. bacillifer, D. pribilofensis, E. canadensis	1
H. septentrionalis, D. pribilofensis, E. canadensis	1
4 calanoids — no cyclopoids, 1 occasion	
H. septentrionalis, E. canadensis, D. glacialis, D. sicilis	1
1 cyclopoid — 1 calanoid, 19 occasions	
C. scutifer-H. septentrionalis	8
C. scutifer-D. gracilis	2
E. agilis-D. gracilis	1
E. agilis-H. septentrionalis	1
C. capillatus-H. septentrionalis	1
C. magnus-D. alaskaensis	1
C. magnus-D. pribilofensis	1
C. scutifer-D. arcticus	1
C. scutifer-E. canadensis	1

C. strenuus-H. septentrionalis	1
C. vernalis-D. alaskaensis	1
2 cyclopoids — 1 calanoid, 8 occasions	
C. strenuus, C. magnus, D. alaskaensis	2
C. venustoides, C. magnus, D. alaskaensis	2
C. scutifer, C. capillatus, H. septentrionalis	1
C. strenuus, C. scutifer, D. pribilofensis	1
C. vernalis, C. capillatus, H. septentrionalis	1
C. vernalis, C. magnus, D. alaskaensis	1
3 cyclopoids — 1 calanoid, 5 occasions	
C. strenuus, C. vernalis, C. capillatus, H. septentrionalis	2
E. agilis, C. vernalis, C. capillatus, D. alaskaensis	1
C. scutifer, E. agilis, C. capillatus, H. septentrionalis	1
C. strenuus, C. vernalis, C. languidoides, D. alaskaensis	1
2 calanoids — 1 cyclopoid, 4 occasions	
D. arcticus, D. pribilofensis, C. vernalis	1
E. canadensis, D. gracilis, C. venustoides	1
E. canadensis, D. pribilofensis, C. capillatus	1
H. septentrionalis, D. pribilofensis, C. capillatus	1
2 calanoids — 2 cyclopoids, 1 occasion	
H. septentrionalis, D. theeli, C. vernalis, C. capillatus	1
3 calanoids — 2 cyclopoids, 2 occasions	
D. glacialis, D. bacillifer, E. canadensis, C. capillatus, C. vernalis	1
H. septentrionalis, D. pribilofensis, D. arcticus, C. capillatus, C. venustoides	1
3 calanoids — 1 cyclopoid, 5 occasions	
H. septentrionalis, D. glacialis, D. bacillifer, C. vernalis	1
H. septentrionalis, D. pribilofensis, D. arcticus, E. agilis	1
H. septentrionalis, D. pribilofensis, D. arcticus, C. scutifer	1
H. septentrionalis, D. pribilofensis, D. arcticus, C. capillatus	1
H. septentrionalis, D. pribilofensis, E. canadensis, C. capillatus	1
4 calanoids — 1 cyclopoid, 4 occasions	
H. septentrionalis, E. canadensis, D. pribilofensis, D. arcticus, C. vernalis	2
H. septentrionalis, E. canadensis, D. pribilofensis, D. alaskaensis, C. capillatus	1
H. septentrionalis, E. canadensis, D. pribilofensis, D. arcticus, E. agilis	1
5 calanoids — 1 cyclopoid, 1 occasion	
H. septentrionalis, D. pribilofensis, D. alaskaensis, E. canadensis, D. arcticus, C. scutifer	1

faunas of these adjacent areas also show relationships, not only with each other but with those of other arctic areas as well.

Daphnia middendorffiana and *D. pulex* are holarctic species (Brooks 1957). Brooks (1959) suggested that careful taxonomic and distributional studies of the Cladocera may yield interesting zoogeographical information. The cladocerans collected along the Colville River appear, according to published records, to be widely distributed species. Published records of cladocerans from Alaska are scanty and this is, of course, particularly true for a remote area such as the Colville River drainage. It is quite likely that the present report contains first records from Alaska for several of the cladocerans. This is doubtless due more to the paucity of collections than to distributional peculiarities. Lilljeborg (1887) recorded two species, *Daphnia longispina* and *Eurycercus glacialis*. Juday (1920) reported seven species, *Daphnia pulex, D. longispina, Bosmina longirostris, Eurycercus glacialis, Alona guttata, Chydorus sphaericus* and *Polyphemus pediculus*. Juday and Muttkowski (1915) recorded *Daphnia pulex, Alona rectangula* and *Chydorus sphaericus* from St. Paul Island. *Daphnia* records are given in Brooks (1957), Edmondson (1955) and Kiser (1950).

The number of species of Cladocera recorded along the Colville River is high compared to those of other areas of similar latitude. Poulsen (1940) compared the number of species of entomostracans found in Greenland with the numbers reported in the literature for other arctic and subarctic regions. The numbers of species of Cladocera were as follows:

Spitzbergen	4
Bear Island	3
East Greenland	13
West Greenland	24
Iceland	27
Northern Sweden	28

The number of species, 22, recorded in the present study is quite similar to the numbers recorded in other subarctic areas, suggesting that although the Colville River drainage is located at a high latitude the area may not be strictly arctic.

Through the studies of Mrs. Mildred S. Wilson (1951, 1953a, b, 1959) the relationships between Alaskan and Siberian species of calanoid copepods are well known. Of the species collected along the Colville River, *Diaptomus arcticus* is known from both sides of Bering Strait. *Diaptomus alaskaensis* and *D. pribilofensis* are closely related to species recorded from Siberia. *Diaptomus gracilis, D. glacialis, D. theeli,* and *D. bacillifer* are of wide distribution at high latitudes in Eurasia. *Heterocope septentrionalis,* as pointed out by Juday and Muttkowski (1915), is very similar to the widely distributed Eurasian species, *H. borealis,* and *Eurytemora canadensis* is either the same as or very close to the Siberian species, *E. tolli* Rylov (Wilson 1959). Mrs. Wilson has commented (personal correspondence) that the harpacticoid copepods exhibit similar relationships. Of the ten identified species, seven occur in Eurasia, mostly in the northern regions, and the others are more or less allied to Eurasian species or groups.

The lack of critical studies of the circumpolar forms of cyclopoid copepods makes it unwise to give more than the most generalized statements about their distribution. On the basis of published records, *Cyclops scutifer, C. capillatus,* and *C. strenuus* are all in the widest sense circumpolar. *Cyclops magnus* and *C. venustoides* are apparently North American in distribution, the other cyclopoids reported here are widely distributed.

Summary

During the summer of 1955, 200 water bodies along the Colville River, northern Alaska, were sampled for Microcrustacea and some observations of physical and chemical conditions were made.

On a basis of area and depth, the waters sampled were designated as lakes, ponds, or pools; biological observations supported this classification.

Surface temperatures ranged from 0.5 to 20.5°C.; no instance of thermal stratification was noted. The maximum depth measured was 3.6 m.

Chemical determinations were made on samples from 48 water bodies. Chloride content varied from 1 to 49 p.p.m.; calcium content ranged from 13 to 34 p.p.m. Bicarbonate, the dominant anion, exceeded 100 p.p.m. in only three lakes. Dissolved oxygen ranged from 49 to 100 per cent of saturation.

Twenty-two species of Cladocera, twenty-nine species of Copepoda and six species of larger Crustacea were identified. Early-summer collections contained adult cyclopoids and immature calanoids. In late summer, samples were characterized by adult calanoids and immature cyclopoids.

Cyclops strenuus, C. magnus, Diaptomus alaskaensis and *Attheyella nordenskioldii* were characteristic of the pools. *Diaptomus arcticus, Heterocope septentrionalis* and *Cyclops scutifer* were typical lake species. However, the typical species in the different habitats did not appear in all samples from the habitat, e.g., *H. septentrionalis* and *C. strenuus* appeared in roughly half of the lake and pool collections respectively.

D. pribilofensis, D. arcticus, Eurytemora canadensis, H. septentrionalis, Cyclops capillatus and *C. scutifer* tended to be collected in associations more complex than pairs.

The copepod fauna of the Colville River drainage shows many similarities with that of Siberia and of other high-latitude areas.

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