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THE EURYHALINE COPEPOD GENUS EURYTEMORA IN FRESH AND BRACKISH WATERS OF THE CAPE THOMPSON REGION, CHUKCHI SEA, ALASKA

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Collections made in the vicinity of Cape Thompson, Alaska, on the coast of the Chukchi Sea during the course of biological investigations by the Atomic Energy Commission (Project Chariot), have yielded six species of the euryhaline copepod genus *Eurytemora*. These occurred in brackish waters (coastal lagoons, pools, and ponds) and in fresh waters (inland lakes, pools, ponds, and pools and ponds near the coast). Collections were made in 1959 by Douglas Hilliard and in 1950–1961 by J. C. Tash. These data partly supplement those of Johnson (1961) who collected from some of the lagoons in 1959. Additional data come from samples from other regions of Alaska accumulated by M. S. Wilson and referred to herein as the Wilson collection. Reports on other copepods and crustacean groups of the Cape Thompson collections are included in papers by Wilson and Tash (MS.) and Hilliard and Tash (1966).

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Inland Lakes, Pools, and Ponds

Only one species of *Eurytemora*, new to science, occurred in samples from 4 of 10 small, shallow, permanent, unnamed bodies of fresh water (herein termed lakes) and 7 nearby smaller, less permanent pools and ponds situated in wet *Carex* marsh and meadow. One lake (reference no. 9), located about 11 miles inland from Cape Thompson, has an outlet to a small creek draining to the Kukpuk River. The other three lakes, located near one another about 7 miles inland, have no defined inlets or outlets, the incoming water originating from drainage of the surrounding marsh during snowmelt and rains. Emergent vegetation occurs at the edges of the lakes; in the type locality (Lake 4), broad-fingered beds of *Arctophila* extend toward the center. The lakes are ice-free for about 2½–3 months of the year (from early to mid-June to early September). In 1960, the maximum temperature range recorded weekly for Lake 4 from July 1 to August 11 was 13.2–15.5° C.; by September 4, this dropped to 4° C.

Quantitative and qualitative samples were taken at regular intervals and stations from the open, deep water of Lake 4 with no. 12-mesh plankton nets on an open Clarke-Bumpus sampler. The other lakes were sampled on one or two dates by casting nets from the shore.

The existence of the new species, described below, has been known for many years from immature copepodid stages collected at Umiat (Wilson collection) but it was impossible to define until adults were collected in the Cape Thompson samples. The Umiat collection and one made by Tash in the Noatak region extend the known distribution of the species beyond the Cape Thompson region.

Family Temoridae

Eurytemora arctica, new species

Figures 1–3

Type locality.—Unnamed lake (reference no. "Lake 4"), about 7 miles inland from coast of Chukchi Sea, Cape Thompson region, Alaska, 68°11′09″ N., 165°42′05″ W.; surface area, 2.1 hectares; maximum depth, 2.4 meters.

Types.—Holotype ♀, USNM 106647; allotype ♂, USNM 106648.

Definition.—Female: Metasomal wings and genital segment not laterally expanded; caudal rami slightly longer than urosome segments 2 + 3; antennules reaching to near end of metasome. Leg 5: Exopod segment 1 with 2 outer spines; inner process directed inwards and about 4 × width of distal part of segment; inner apical spine of exopod 2 much longer than outer apical spine. Male: Antennules a little longer than metasome, with stout, long aesthetes; spines of segments 8–12 of right antennule not more developed than those of left. Leg 5 of adult: Right exopod 2 constricted near middle with basal part wider than distal; anterior proximal part of left basal segment 2 produced into spinous point; left exopod 2 without apical digitiform protrusion. Leg 5 of copepodid stage V: Inner apical spine of exopod 2 much longer than outer spine, that of left side the longer, equaling half or more of the length of its segment.

Description of female.—Total length: 1.85–2.02 mm. (metasome = total anterior division, 1.09–1.16; urosome, 0.765–0.855; measurements middorsal line, top of head to end of caudal rami, from specimens in which urosome was separated and mounted in shallow depression slide to overcome effect of ventral curvature). All segments of metasome well defined (figs. 1*a*, *b*); greatest width in second segment (thoracic somite 1) equal to about one-half total length of metasome. Cephalic segment rounded anteriorly, slightly broadened at midpoint, without pronounced cephalic depression (viewed laterally in exact midline); dorsal cuticular protuberance at distal midpoint of segment, variable in size and prominence (fig. 1*a*). Last 2 segments of metasome reduced in both width and length (fig. 1*b*); wings of last segment not expanded laterally, nearly symmetrical, produced posteriorly to near midpoint of genital segment, apices rounded and each bearing a fine, sensory setule (figs. 1*c*, *d*).

Urosome (figs. 1*d*, *e*): Genital segment rounded laterally in proximal half but without prominent protrusions either laterally or ventrally; operculum (external genital flap) broader than long, rounded distally, partially encircled by depressed cuticular ornamentation of narrow, lobed sclerotizations armed with short setules (fig. 1*e*). Segments 2 and 3 with lateral hairs that extend over distal outer portion of dorsal surface of segment 3. Caudal rami a little longer than segments 2 + 3 (about 1.13:1); widest just below base, length about 6 × this greatest width; inner and outer margins with fine hairs and dorsal surfaces with closely placed, short, scalelike hairs. Terminal caudal setae (except short, dorsally placed seta) slender, unjointed, longer than rami; lateral seta a little shorter, plumose only on inner margin; second apical seta (from outer margin) the longest.

Antennule (fig. 1*g*) reaching to about middle of metasomal wings or a little beyond; 24-segmented (counting imperfectly separated segments 8–9); beginning with 12, the segments regularly elongated;

numerical setation as common in the genus (s=seta; sp=spine; a=aesthete).

segment			segment	
1	3s, a		13	2s
2	3s, a		14	2s, a
3	2s, a		15	2s
4	1s		16	2s, a
5	2s, a		17	2s
6	1s		18	2s
7	2s, a		19	2s, a
8		sp	20	1s
9	2s, a		21	1s
10		sp	22	1s + 1s
11	2s, a		23	1s + 1s, a
12	1s, a,	sp	24	6s, a

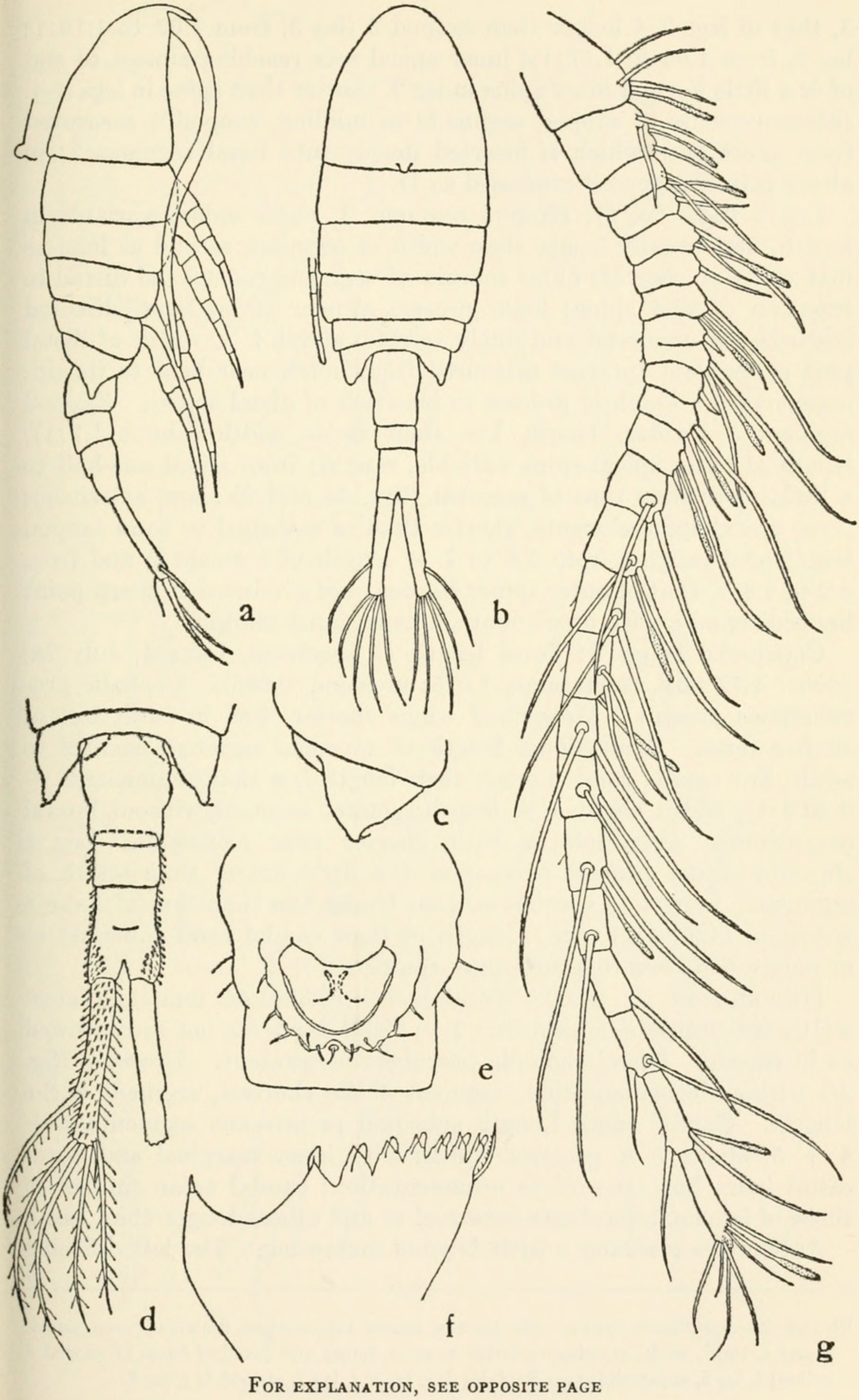
Aesthetes subequal to short setae of proximal segments but much shorter than long setae of other segments; most setae of segments 7–20 very long, reaching end of succeeding 3 segments or beyond; those of segments 17, 19, and 20 the longest; many segments with irregularly placed hairs.

Mandible blade (fig. 1*f*) with prominent, incompletely rounded gap separating first denticle from others; second denticle single, with hyaline cap; others with doubled or tripled points of which one carries a hyaline cap. Antenna and other cephalic appendages as typical for the genus.

Legs 1–4 (figs. 2*d–g*) comparatively elongate (fig. 1*a*). Segmentation and setation as typical for the genus, all setae plumose (not completely illustrated in figures). Basal segment 1 of all legs with inner seta; basal segment 2 with slender outer seta on legs 3–4. Leg 1: Exopod segment 3 only a little longer than exopod 1, with 3 spines and 4 setae, apical spines with hyaline membranes, innermost spine subequal to or a little shorter than segment, apical seta usually reaching considerably beyond apical spine; endopod 1-segmented, with 6 setae, the apical reaching to end of exopod 3 or beyond.

Legs 2–4: Exopod segment 3 with 3 spines and 5 setae; endopods 2-segmented, second segment with 6 setae in legs 2–3 and 5 setae in leg 4, all apical setae reaching beyond exopod 3. Exopod segment 3 of legs 2–3 shorter than exopod segments 1 + 2 (about 1:1.24; range 1:1.21–1.31), that of leg 4 subequal to segments 1 + 2 (1:1.08); inner apical spine of leg 2 a little shorter than or subequal to exopod

FIGURE 1.—*Eurytemora arctica*, new species, female: *a*, habitus, lateral view, leg 5 omitted (Lake 4), and variation of cephalic protuberance (Lake 8); *b*, habitus with apex of antennule, dorsal view (Lake 4); *c*, detail of right metasomal wing, lateral view; *d*, detail of metasomal wings and urosome, dorsal view; *e*, genital segment, ventral view, with detail of operculum; *f*, mandible, apex of blade; *g*, antennule.



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3, that of legs 3–4 longer than exopod 3 (leg 3, from 1.02 to 1.10:1; leg 4, from 1.08 to 1.17:1); inner apical seta reaching almost to end of or a little beyond inner spine in leg 2, shorter than spine in legs 3–4. (Measurements of exopod segments in midline, exopod 1 measured from exact base which is inserted deeply into basal segment 2; in above ratios, exopod 3 expressed as 1).

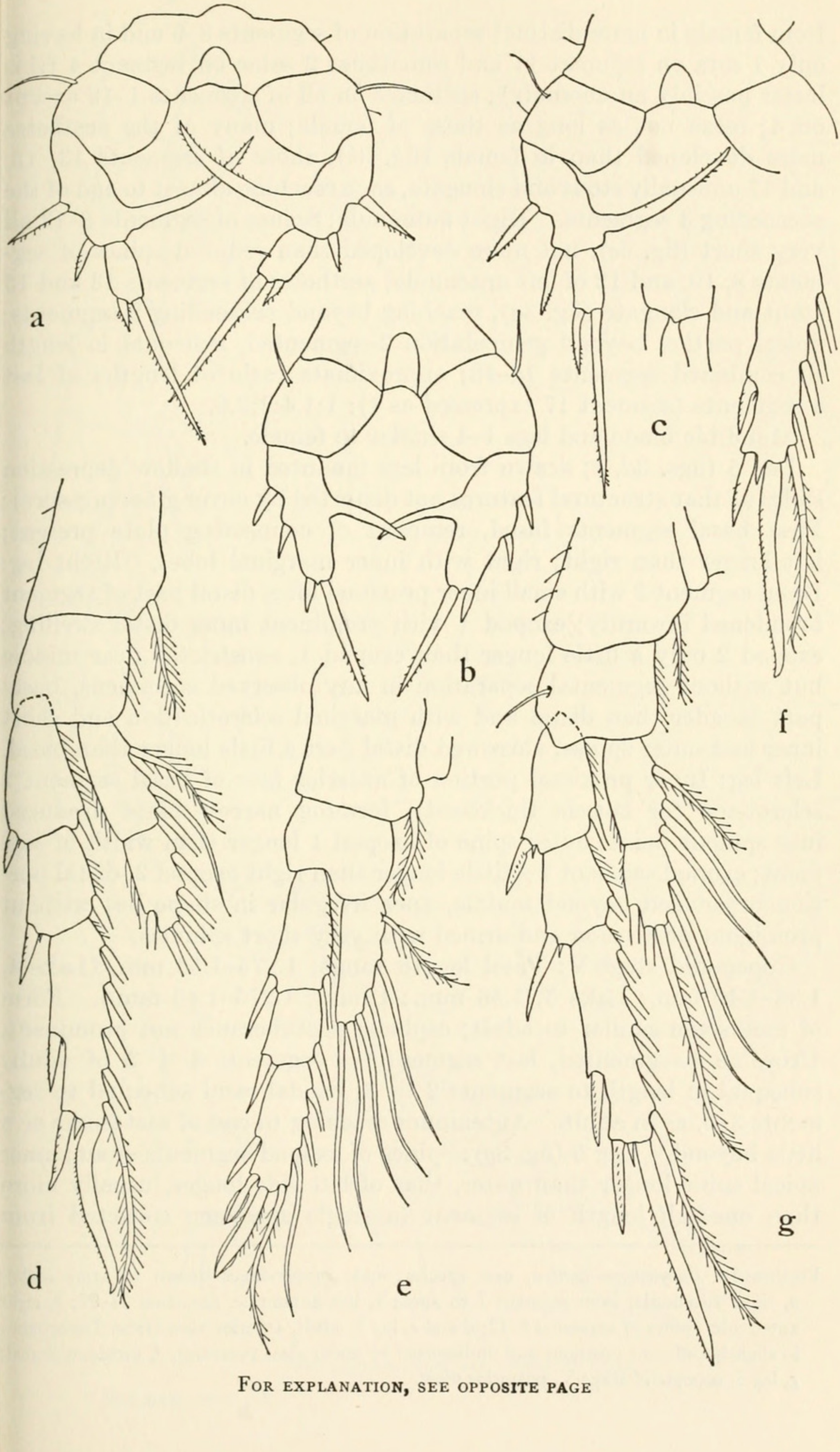
Leg 5 (figs. 2*a*, *b*): Exopod segment 1, outer spines variable in length, first usually longer than width of segment, second as long as first spine or shorter; outer margin of segment constricted distad to insertion of first spine; inner process slender throughout, directed inwards, tip upcurved and finely serrate, about 4 × width of distal part of segment (process measured from notch near base to its tip; segment from notch of process to insertion of distal spine). Exopod segment 2 slender, length less than twice width (about 1.7:1); length of outer apical spine variable, ranging from about one-half to a little more than that of segment (figs. 2*a* and 2*b* show extremes); inner apical spine elongate, shorter than or subequal to total exopod length and ranging from 5.6 to 7 × length of segment 2 and from 3.2 to 4.8 × that of outer spine; segment not produced to sharp point between spines, with or without setule on inner margin.

Copepodid stage V: Total length (1 specimen, Lake 4, July 28, 1960): 1.72 mm. (metasome, 1.025; urosome, 0.695). Cephalic protuberance present. Metasomal wings shorter than in adult but of similar form. Proportional length of urosome segments similar to adult, but caudal rami shorter, their length less than segments 2 + 3 (0.8:1), width about 4 × length; genital segment without lateral protrusions. Antennules a little shorter than metasome. Leg 5 (fig. 2*b*): Inner process of exopod 1 a little longer than width of segment. Length of specimens from Umiat less than that of Lake 4 specimen (1.32–1.43 mm.); length of their caudal rami subequal to or only a little less than urosome segments 2 + 3.

Description of male.—Total length: 1.56–1.65 mm. Greatest width of metasome in segments 2–3; distal segments not so narrowed as in female. Distal cephalic protuberance present. Urosome (fig. 3*f*) without ornamentation; segment 4 the shortest, segment 5 the longest. Caudal rami: Length subequal to urosome segments 3 + 4 + 5, about 7 × greatest width; with inner marginal and outer distal hairs but no surface ornamentation; caudal setae similar to those of female, lateral seta subequal to and others longer than rami.

Antennules reaching a little beyond metasome. The left differing

Figure 2.—*Eurytemora arctica*, new species, female (appendages drawn to same scale): *a* and *c*, leg 5, adult, showing variation in outer spines and detail of bases of exopod 3 spines; *b*, leg 5, copepodid stage V; *d*, leg 2; *e*, leg 1; *f*, leg 3, exopod 3; *g*, leg 4.



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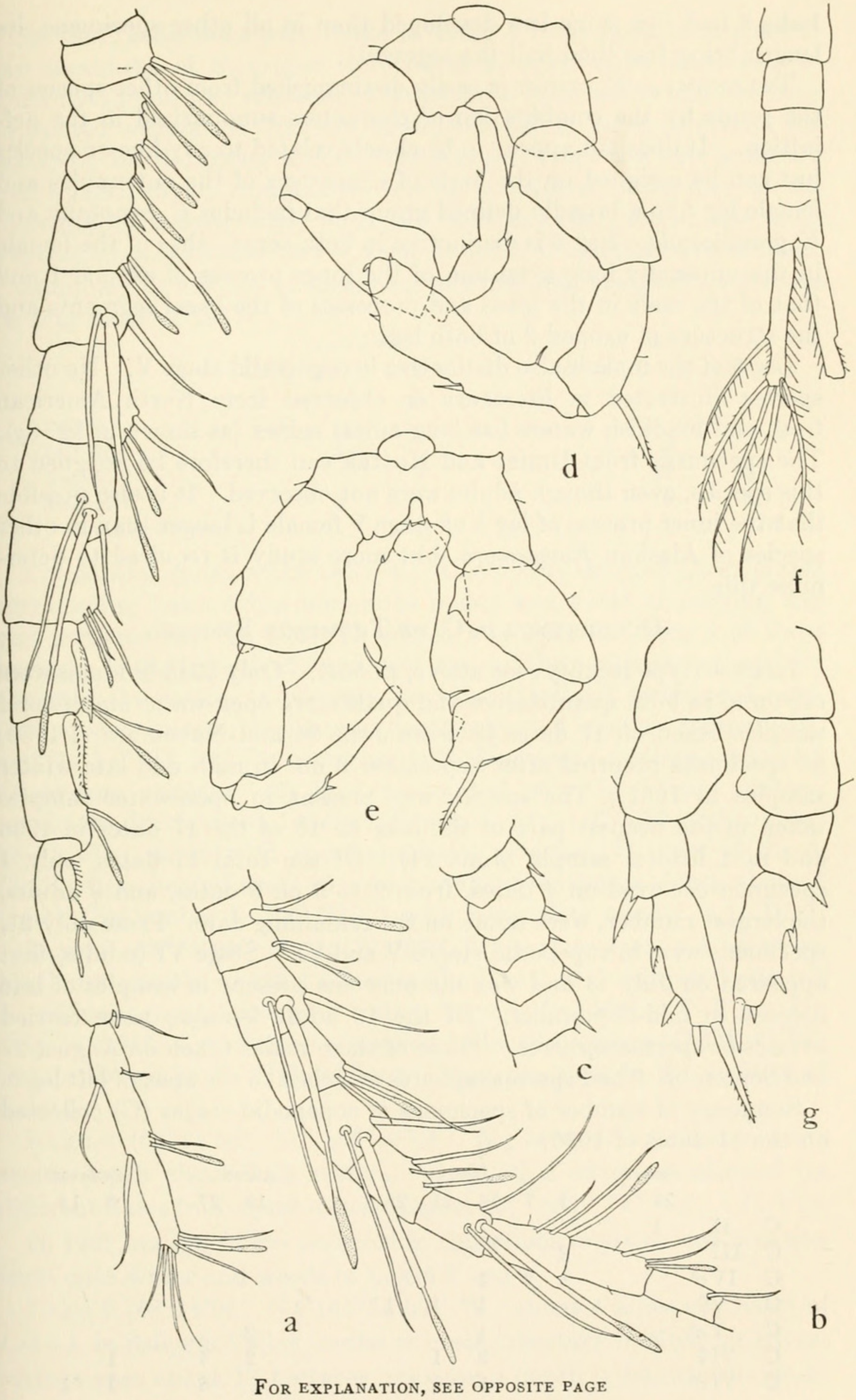
from female in more distinct separation of segments 8–9 and in having only 1 seta on segment 11 and sometimes 2 setae on segment 4 (this latter possibly an anomaly); aesthetes on all of segments 1–19 except on 4; setae not as long as those of female; many of the aesthetes more developed than in female (fig. 3*b*), those of segments 13, 15, and 17 unusually stout and elongate, each reaching almost to end of the succeeding 3 segments. Right antennule: Spines of segments 8–12 all very short (fig. 3*c*), not more developed than reduced spines of segments 8, 10, and 12 of left antennule; aesthetes of segments 13 and 15 stout and elongate (fig. 3*a*), reaching beyond succeeding 2 segments; apical portion beyond geniculation 2-segmented, subequal in length to combined segments 15–18; approximate ratio of lengths of last 4 segments (segment 17 expressed as 1): 1:1.4:2:2.6.

Mandible blade and legs 1–4 similar to female.

Leg 5 (figs. 3*d*, *e*; drawn from legs mounted in shallow depression slides so that structural features not distorted by cover glass pressure): First basal segments fused, remnant of connecting plate present; left longer than right; right with inner marginal lobes. Right leg: Basal segment 2 with small inner proximal lobe, distal part of segment broadened inwardly; exopod 1 with prominent inner distal swelling; exopod 2 only a little longer than exopod 1, constricted near middle but without segmental separation in any observed specimens, basal part broader than distal and with marginal sclerotization and short inner and outer spines, narrowed distal part a little longer than basal. Left leg: Inner proximal portion of anterior face of basal segment 2 sclerotized (or cuticle thickened), forming narrow plate produced into spinous point; outer spine of exopod 1 longer than width of segment; exopod segment 2 a little longer than right exopod 2, distal portion broadened beyond middle, apex irregular in shape but without prominent protrusion and armed with very short spinules.

Copepodid stage V: Total length range: 1.275–1.56 mm. (Lake 4, 1.38–1.46 mm.; Lake 3, 1.56 mm.; Umiat, 1.275–1.40 mm.). Form of metasome similar to adult; cephalic protuberance not prominent. Urosome 4-segmented, last segment (= segments 4 + 5 of adult) subequal in length to segments 2 + 3; caudal rami subequal to segments 3–5, as in adult. Antennules reaching to end of metasome or a little beyond. Leg 5 (fig. 3*g*): Spines of exopod segments stout; inner apical spine longer than outer, that of left side longer, usually more than one-half length of segment (a single specimen collected from

FIGURE 3.—*Eurytemora arctica*, new species, male (appendages drawn to same scale): *a*, right antennule, from segment 7 to apex; *b*, left antennule, segments 11–20; *c*, right antennule, spines of segments 8–12; *d* and *e*, leg 5, adult, anterior view (from 2 specimens in slightly different positions and undistorted by cover glass pressure); *f*, urosome, dorsal; *g*, leg 5, copepodid stage V, posterior view.



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Lake 8 had this spine less developed than in all other specimens, its length being less than half the segment).

Taxonomy.—*E. arctica* is easily distinguished from other species of the genus by the combination of characters summarized in the definition. It does not appear to be closely related to any known species but can be assigned on the basis of characters of the antennules and female leg 5 to a broadly defined group that includes *E. composita* and *E. gracilicauda*. Leg 5 is distinctive in both sexes—that of the female in the unusually long extension of the inner process of exopod 1 and that of the male in the lobes and processes of the basal segments and the structure of exopod 2 of both legs.

Leg 5 of the male is also distinctive in copepodid stage V. No other species illustrated in literature or observed from North American fresh and brackish waters has long apical spines (as shown in fig. 3*g*). The specimens from Umiat and Noatak can therefore be assigned to this species, even though adults were not observed. It is also possible that the inner process of leg 5 of stage V female is longer than in other species of Alaskan *Eurytemora*, but more study is required to determine this.

Occurrence in Cape Thompson Region

Lake 4 (type locality; see above, p. 554).—Only 33 individuals were captured in both quantitative and qualitative open-water and littoral samples taken on 17 dates between June 24 and November 7, 1960; no specimens occurred after September 8 nor in mid- and late winter samples in 1961. The species was present in open-water samples taken in the deepest part of the lake on 10 of the 17 dates in 1960 and in 1 littoral sample (June 24). Of the total 11 dates, only 1 specimen occurred on 4 dates, from 2 to 6 on 6 dates, and 9 adults, the largest number, were taken on the remaining date. From July 21, specimens were in copepodid stages V and VI. Stage VI (adults) first appeared on July 14 and was the only one present in samples of late August to mid-September. Of the 10 adult females, none carried ovisacs or spermatophores. Three of the 6 males taken on August 27 and September 8 had spermatophores attached to the apex of left leg 5.

Summary of number of specimens of copepodid stages (C) collected on the 11 dates of 1960:

	June	*July*					*August*			*September*	
	24	1	7	14	21	28	4	19	27	8	14
C II	1										
C III		2									
C IV♂		1	2	1							
C V♀				1	1	1	1				
C V♂				1				2			
C VI♀				2	1			2	4	1	
C VI♂				1	1				5	1	1

In 1961, collections were made in Lake 4 from April to August 7. No specimens of *E. arctica* were taken in open water until July 6. On July 13 and two subsequent dates, both open water and the beds of rooted vegetation (mostly *Arctophila fulva*) were sampled, the latter by hand-dipping a net. The samples from the two areas are not quantitatively comparable, but it is believed that due to the difficulty of maneuvering both the boat and the net in the thick vegetation, only a small part of the population of the latter was sampled.

Summary of number of specimens of copepodid stages (C) collected on four dates of 1961:

	open water			*vegetation*		
	C IV	C V♀	C V♂	C IV	C V♀	C V♂
July 6	1			not collected		
July 13		1		1	2	5
August 2			1		29	22
August 7	1	3			6	5
Total specimens			7			70

Ponds and pools near lake 4.—The poorly drained *Carex* marsh surrounding Lake 4 has numerous ponds and pools of varying size and permanence. In 1960, *E. arctica* was collected from 3 of those having a heavy growth of vegetation around the perimeter or partially covering the water. Collection records: (1) Pond (estimated area, 500 square meters; maximum depth about 1 meter; permanent), July 7: 1 C III, 2 C V♀; occurring with *Heterocope septentrionalis* and *Diaptomus arcticus*. (2) Pool (estimated area, 83 square meters; maximum depth about 1 meter), September 8: 1 C VI♀ with ovisac, 15 C VI♂, some with spermatophores attached to apex of leg 5. (3) Pool (estimated area, 10 square meters; maximum depth about 1 meter), September 8: 2 C VI♀ (1 with incomplete ovisac), 6 C VI♂.

Lake 3 (68°11′09″ N., 165°42′02″ W.; surface area, 1.8 hectares; maximum depth, about 1.52 meters).—In 1 of 2 samples collected on different dates from open water, August 19, 1960: 2 C V♂. On July 17, 1959, 4 specimens presumed to be this species (C III, C IV) were collected by D. Hilliard from 2 separate pools in the vicinity of Lake 3.

Lake 8 (68°11′06″ N., 165°42′04″ W.; area 0.03 hectares; maximum depth about 1.52 meters).—In 1 of 2 samples collected on different dates from open water, August 19, 1960: 1 C V♂, 1 C VI♀.

In 1961, no specimens occurred in collections made on one occasion from open water and weeds of Lakes 3 and 8.

Lake 9 (68°14′06″ N., 165°34′09″ W.; about 4 miles northeast of Lake 4, in Saligvik Valley; outlet to creek tributary to Kukpuk River; surface area about 12 hectares; maximum depth unknown but probably not over 3 meters).—The single collection from this lake, August 21, 1960, contained 7 adults: 6 ♀ (5 with ovisacs), 1 ♂.

Ponds and pools near lake 9.—(1) Pool (about 1 mile northwest; estimated area, 25 square meters; maximum depth about 1 meter; vegetation largely *Carex* and *Sphagnum*), August 23, 1960: 1 C VI ♀, 1 C VI ♂. (2) Pond (about 1 mile southwest; estimated area, 627 square meters; maximum depth about 1.5 meters; vegetation largely *Hipperus*, *Arctophila*, *Sphagnum*), August 21, 1960: 1 C V ♀.

Coastal region south of cape thompson.—One or two specimens were collected from each of four more or less brackish pools near Singoalik Lagoon in 1960 (table 1). Large numbers of *E. gracilicauda* of similar size and habitus (see p. 567), occurred in two of these samples and early copepodid stages (C II–C III) that were present might be either of the two species. In 1961, recognizable stages of *E. arctica* were not collected in any coastal pools that were sampled.

Occurrence in Noatak River Watershed

Locality about 58 miles inland from Chukchi Sea, near junction of Kelly and Noatak Rivers, about 67°58′ N., 162°20′ W. Tash collection: 12 C V ♀♂; permanent freshwater pond, area about 0.2 hectares, depth about 1.8 meters, from weedy margin (*Carex* dominant), July 29, 1961; occurring with *Diaptomus gracilis*. This region is a part of the Brooks Range physiographic province southeast of Cape Thompson; the Noatak River and its tributaries drain a considerable part of the western portion of the northern mountains of Alaska. *Eurytemora yukonensis*, not yet known from the Arctic Slope province, also occurred in shallow bodies of water of the Noatak region with *D. gracilis*.

Occurrence at Umiat

Locality on Colville River in northern Alaska, in foothills of Brooks Range, about 65 miles inland from Beaufort Sea, about 69°24′ N., 152°15′ W. Wilson collection: 41 specimens (9 C IV♀♂; 32 C V♀♂) taken by casting small net an unknown distance from shore in shallow, freshwater permanent pond, estimated area about 0.2 hectares, July 29, 1949, collector, C. S. Wilson; occurring with a few specimens of *Heterocope septentrionalis* (C VI) and *Diaptomus pribilofensis* (C IV–VI).

Bionomics

Restriction to either brackish or fresh water cannot be assumed for species of *Eurytemora*, but some occur much more commonly in one than in the other. *E. arctica* was rare in brackish coastal pools and was not found in the lagoons at Cape Thompson, although all other

Arctic Slope species that range from brackish into fresh water were collected in them. As presently known the species occurs commonly in small, shallow freshwater tundra lakes, pools, and ponds, and rarely in coastal brackish pools. Its distributional range is in the Arctic Slope and Brooks Range physiographic provinces, from the coastal region of Cape Thompson east to Umiat and south to the Noatak River watershed, between about 67°–70° N. latitude and 152°–166° W. longitude.

The species of *Eurytemora* found in fresh water occur in a variety of bodies of water, ranging in size from shallow pools to large, deep lakes. Although some species appear environmentally restricted, others seem ubiquitous, and it is difficult to judge from distributional data what habitats are marginal for such species. For instance, in Alaska *E. yukonensis* occurs in the largest and deepest lakes of the State (those of the Bristol Bay region) but is also found in shallow lakes and ponds along the lower Yukon and Noatak Rivers, where it has been collected from both open waters and submerged vegetation. Other species of *Eurytemora* have been found abundantly in the rooted vegetation of small, shallow lakes and ponds; for example, *E. gracilicauda* was collected in large numbers from grassy margins and from beds of *Arctophila* of small, shallow lakes and ponds on eastern Saint Matthew Island in the Bering Sea, about 60°30′ N., 173°30′ W. (Wilson collection: August 1954, R. and R. Rausch, collectors; a few *Diaptomus pribilofensis* occurred in some of the weed collections). There are records in the literature of other species of *Eurytemora* associated with weeds. Willey (1923a, p. 331; 1923b, p. 6) records a reproducing population of *E. affinis* "amongst dwarf weeds in the littoral zone of a swampy shore" of Lake St. John, Quebec, and Lowndes (1935) reports *E. velox* as not only common among weeds but as being found "attached to algae." From these observations it appears that studies of freshwater calanoid copepods in geographic regions in which *Eurytemora* is expected to occur must include exploration of more than the open waters of lakes and ponds, usually considered as the typical habitat for calanoids.

Eurytemora arctica in the Cape Thompson region represents an example of this need for detailed examination of weed beds. In the open waters of Lake 4 (depth, 2.4 meters) large numbers of three other calanoid copepods (*Heterocope septentrionalis*, *Diaptomus arcticus* and *D. pribilofensis*) were collected throughout the season in 1960 in noticeable contrast to the small numbers of *E. arctica*. This erratic occurrence of *E. arctica* in open-water samples suggested a population localized within the lake and from which occasional individuals wandered into the selected areas being routinely sampled. Therefore, in 1961, other areas of the lake were investigated and larger numbers of *E. arctica* were captured from the thick beds of *Arctophila* that extend out into the lake (water depth, 1.0–1.5 meters) than in open water (see above, p. 563)—in contrast to relatively few individuals of the other calanoid copepods. Although the data are not as exhaustive as is desirable, we believe it reasonable to assume that the population of this lake is localized in the *Arctophila* beds. In the Noatak River pond, the species was likewise collected among weeds but not from open water. Other records of occurrence contribute little to the question of localization in weed beds. The vegetation of the pond at Umiat, from which fairly large numbers were taken, is unknown, but the method of collecting precluded sampling of both the deepest open water and thick weed beds, while not excluding thinly developed littoral growths. Excepting Lake 4, none of the bodies of water in the Cape Thompson region were sampled adequately or frequently enough to determine the absence or the preferences of a highly localized or rare species.

It is reasonable to suggest from the available data that the population of *E. arctica* in Lake 4 is monocyclic and overwinters as resting eggs, rather than as adults or late copepodid stages, as is probably true for many other calanoid copepods in shallow bodies of fresh water on the Arctic Slope of Alaska (Wilson and Tash, MS.). Data are not conclusive because the localized habitat was not adequately sampled for a critical study of the life cycle, and the suggestion originates from these observations: (1) littoral and open-water samples of late spring-early summer in 1960 and 1961, during and after thawing, had neither adults nor late copepodid stages; (2) copepodid stages found in 1960 showed seasonal progression from early to adult stage, and developmental stages were not collected after adults had become established; (3) samples from the deep, open waters taken under ice in January 1961 (ice depth, 1.22 meters) and in April when ice depth was greatest (1.75 meters) contained no *Eurytemora* of any stage.

The weedy portion of the lake in which the population is presumably established is of such depth (1.0–1.5 meters) that it freezes to the bottom by the end of winter (April) so that copepodid stages would not survive during the winter. It should be noted also that no specimens were collected in open water after September 14, 1960, although other calanoids were present in samples taken until November 7. Presumably, reproduction takes place in the *Arctophila* bed, and overwintering resting eggs would be deposited there. The only indications of dates of breeding and egg production were late in the season (August 21, 27, and September 8) when males with spermatophores on leg 5 and females with ovisacs were taken in Lake 4 and nearby pools, and in Lake 9.

Field studies on coastal pool populations were too few to supply evidence for the bionomics of *E. arctica*, and only some speculative points that might have value in future studies can be offered. Presumably development in some pools is both earlier and more rapid than in other pools and in Lake 4. The appearance of adults of *E. arctica* in one pool and of *E. gracilicauda* in two pools as early as June 29, 1960, cannot be accounted for by overwintering of live specimens, because the pools are so shallow they would freeze to the bottom before thawing. It is more reasonable to assume that the populations of these two species developed from overwintering resting eggs in bodies of water that not only melted early (as was observed in the coastal area for some bodies of water in May) but had a high enough temperature to permit a comparatively rapid development of some of the population to the adult stage. If such bodies of water did not dry out during the summer season there would be time for development of a second generation as Oloffson (1918) postulated for *E. raboti* in Spitzbergen and as may be true for some Alaskan *Eurytemora*. On the other hand, adults of a monocyclic population that developed rapidly might not persist long after egg production in a shallow pool with fluctuating water level where it is associated with a related and more dominant species. Successful collection of a short-lived, monocyclic species would be dependent upon an element of chance in sampling the body of water at the particular short period of time when identifiable copepodid stages were present. Such factors might account in part for failure to collect more specimens of *E. arctica* in the coastal pools. An additional factor that might be very important but difficult to assess until more of the numerous bodies of water along the coast of Alaska are investigated, is that brackish water even of very low salinity is a marginal habitat for *E. arctica*, it being dominantly a freshwater species.

Coastal Pools and Ponds

Three species of *Eurytemora* were collected in pools and ponds on the coast (table 1). Of these, precisely identifiable copepodid stages of *E. arctica* occurred only as one or two specimens in four pools in 1960, so that its importance as part of the coastal brackish fauna is not known. The other two species, *E. canadensis* and *E. gracilicauda*, occurred in large numbers and frequently enough to be considered characteristic elements of both fresh and brackish coastal bodies of water. They were associated with one another in brackish pools or occasionally with *Limnocalanus johanseni*, a dominant associate of *Eurytemora* in nearby lagoons and the only other calanoid copepod found in the brackish pools. In freshwater pools, *E. gracilicauda* occurred with the freshwater calanoid *Heterocope septentrionalis*.

Samples reported here represent only a small part of such habitats in the entire Cape Thompson region. Most are from the marshy area near Singoalik Lagoon and are characterized as pools because of their intermittent nature and small size. Many are shallow, ranging from only 15 to 30 cm. in depth but some have a maximum depth of about 1 meter. Those near Singoalik and Mapsorak Lagoons are considered as more or less brackish; precise salinity records associated with the collections are not available but other records indicate that they are not continuously fresh. Salinity undoubtedly varies with the fluctuating water level which may be considerable both during a season and from one year to another.

Records are summarized by year of collection in table 1. Excepting Pool 1, the pools from which collections were made in 1961 were not correlated with any of the previous year, and it is not known which correspond to the pools listed for 1960. Copepodid stages are listed for each date. In no instance do the collections furnish adequate data for life cycle studies, but they do emphasize the value of the locale for such studies. Of particular interest is the question of whether such populations of *Eurytemora*, unlike most other calanoids of continental bodies of water on the Arctic Slope, produce more than one generation a year (Wilson and Tash, MS.). The copepodid stages present in the series of 1960 collections in Pool 1 (table 1) suggest two generations of *E. gracilicauda*. Absence of any specimens in the middle of the season may have been due to the presence of the species only as naupliar stages which collecting gear failed to sample. Production of two generations in a season would undoubtedly be dependent upon early melting of snow and ice in the region, as probably happened in 1960 when adults bearing ovisacs were collected as early as June 29 (see discussion under *E. arctica*, p. 567). As with *E. gracilicauda*, the records of *E. canadensis* in shallow pools that freeze to the bottom, not only in the Cape Thompson region but in other parts of its distributional range, suggest overwintering of the species as resting eggs.

Coastal Lagoons

Including those studied by Johnson in 1959, a total of 11 lagoons has been surveyed. As Johnson (1961) indicated, they group naturally into those lying north and south of Cape Thompson, and they are summarized here by these geographic subdivisions (table 2). They are dish shaped in profile, range in length from 3.2 to 8.0 km., are shallow (maximum depth, 3 meters), and are free of ice cover for about 2½–3 months. Most do not now have direct connections with the sea. Maximum temperatures recorded in 1960 were 13.7° C. on July 18 for Mapsorak Lagoon and 16.2° C. for Pusigrak Lagoon.

TABLE 1.—*Calanoid copepod species composition (genera* Eurytemora *and* Limnocalanus) *of Cape Thompson coastal pools and ponds, 1960–1961*

Body of water	Location (see table 2 for location of lagoons)	Brackish water	Fresh water	Date	Copepodid stages (I–VI): *E. arctica*	*E. gracilicauda*	*E.* imms.†	*E. canadensis*	*L. johanseni*
				1960					
pool	near Akoviknak Lagoon		X	July 13				IV–VI	
pool	E. end Mapsorak Lagoon	X		July 26				IV	
pothole	dry creekbed near Mapsorak Lagoon	?		July 26				•I–VI	
Pool 1	near Singoalik Lagoon	X		June 29		•IV–VI	III		
				July 4		•V–VI		•V–VI	
				July 11		V–VI	I–II	•VI	
				July 18	V (1 ♂)	•IV–VI	I–III		
				July 25		•VI	III		
				Aug. 1, 8					
				Aug. 17			I–II		
				Aug. 22		VI			
				Aug. 29		V–VI		II–V	
pool	near Singoalik Lagoon	X		June 29	VI (1 ♀)	IV–VI			
				July 12		IV–V			V–VI
3 pools	near Singoalik Lagoon	X		July 12		•IV–VI	III	•IV–VI	
pool	near Singoalik Lagoon	X		Aug. 23		IV–V	II–III		VI (1♀)
2 pools	near Singoalik Lagoon	X		Aug. 23		•IV–VI	II–III		
pond	near Singoalik Lagoon	X		July 12				V–VI	VI
2 pools	near above pond	X		Aug. 29	VI (2♀, 1♂)				
pool	E. bank Singoalik Creek, 1 mi. N. Singoalik Lagoon		X	Aug. 6		IV–VI			
pool	near above		X	Aug. 6		VI	with *Heterocope septentrionalis*		
pool	near Singoalik Creek, 2 mi. inland		X	Aug. 6		•IV–VI			
pool	E. bank Ogotoruk Creek, 1 mi. N. Chariot site		X	July 28				V	
				1961					
Pool 1	near Singoalik Lagoon	X		July 10		•IV–VI	II–III		
pool	near Singoalik Lagoon	X		July 10		IV–VI		IV–V	
pool	near Singoalik Lagoon	X		July 10		•VI		•III–VI	VI
pool	near Singoalik Lagoon	X		July 10				II–V	
pool	near Singoalik Lagoon	X		July 10		IV–V	I–III	III–V	
pool	at Chariot site (68°06′ N., 165°45′ W.)		X	July 16		IV–VI	with *Heterocope septentrionalis*		

•Females with attached ovisacs present in sample.

†Stages I–III of *E. arctica* and *E. gracilicauda* cannot be distinguished from one another with precision; probably most, if not all, specimens listed in this column are *E. gracilicauda*; none are *E. canadensis*.

With a few exceptions during the observed periods, salinity was relatively low (table 2). It seems logical to expect, however, that the salinity of all the lagoons may be subject to greater or lesser variation both throughout the season and from one year to another because of physical factors influenced by the weather and climate of this high latitude region. Strong winds are frequent even in the summer months, resulting in practically no thermal or haline stratification and contributing also to an erratic sampling of plankton organisms. Thus, data from one week or year to another are not necessarily sufficient to estimate accurately the quantitative abundance of a species or to assume that its absence from a sample means that it was also absent from the lagoon. Records in table 2 should be viewed on the basis of these considerations.

Johnson found four species of *Eurytemora* in nine of the lagoons in 1959. Two of these (*E. herdmani, E. pacifica*) were not found in our collections, but three additional species (*E. composita, E. raboti, E. gracilicauda*) occurred. *E. arctica* was not present in the lagoons but was collected in pools, so that eight species of *Eurytemora* occur in the coastal area. In order to indicate what is known of the continuity of species composition shown by three years of collecting, Johnson's records for August 1959 are combined here with our records of July 1959 and of 1960–1961 (table 2).

With two exceptions, collections from the eight lagoons south of Cape Thompson yielded only *E. canadensis*, usually in association with and in smaller numbers than *Limnocalanus johanseni*. Both of these species in Alaska occur along the coast in waters ranging from low salinity to fresh, but there are more known records of *E. canadensis* than of *L. johanseni* in fresh water with associated freshwater calanoid genera such as *Heterocope* and *Diaptomus* (literature and Wilson collection).

Mapsorak Lagoon (Johnson no. 2S) presents a striking example of the temporal nature of the copepod communities that may at times be collected. In 1959, Johnson found nine marine species that he considered as having been "probably only recently recruited from the sea." He describes the lagoon as having "a narrow above-sea-outlet that probably floods with sea water during high storms." That this large assemblage of species probably had been washed into the lagoon from the sea is suggested by the high salinity and by the fact that none of the species was found in series of samples taken weekly in 1960 and 1961. The difference in the species of *Eurytemora* found in the three years is noteworthy. *E. herdmani* and *E. pacifica*, occurring only during the period of high salinity in 1959, are typical of inshore waters of the Alaskan coast but are not known from fresh waters nor from waters of extremely low salinity. In 1960, relatively low salinity was recorded and four other species of *Eurytemora* were found (table 2), all of which range from brackish to fresh waters. Of these, *E. composita* and *E. raboti* were not collected again in Cape Thompson samples, but since they are known to be widely distributed in diverse bodies of water along the northwestern Alaskan coast, they may well occur in unsampled ponds or pools of the area. Whether populations are established in inshore-offshore waters is unknown but both have been recorded from coastal continental bodies of water of high salinity (Mohr et al, 1961; Holmquist, 1963; Heron, 1964). Since ovigerous females and developmental stages of both species were found in the lagoon in 1960 on several dates, it was surprising not to find them in 1961 samples. The other two species of 1960 samples, *E. canadensis* and *E. gracilicauda*, are both highly characteristic of waters of very low salinity and commonly range into fresh waters. *E. gracilicauda* occurred in very small numbers on only two different dates in 1960, and its absence in 1961 suggests it may have been a straggler washed into the lagoon from nearby pools.

The sparsity of numbers of individuals of species such as *E. canadensis*, and the lack of knowledge of occurrence of other species throughout the season, did not make the collections of value for life cycle studies. However, observations of the populations of *E. foveola* from the lagoons north of Cape Thompson indicated that they were reproducing. Collections in July contained ovigerous females with developing ova, accompanied by all copepodid stages, suggesting the possibility that this species could produce two generations during favorable seasons. Aiautak Lagoon is very large (about 8 km. in length), and the single collection, a littoral tow from the south end, may give an incomplete indication of its calanoid species composition. *E. foveola* has not yet been found in fresh water (Wilson collection), but its occurrence in lagoons of low, variable salinity and association with other species of *Eurytemora* that are known to range from brackish to fresh waters, suggest a greater euryhalinity than indicated by the presently known occurrences.

Crustaceans other than calanoid copepods were at times abundant in the lagoons, especially *Cyclops* spp. and *Daphnia* spp. (Johnson, 1961; Hilliard and Tash, 1966). Both of these freshwater genera are recorded throughout literature from brackish waters along seacoasts (examples can be found in Gurney, 1933; C. B. Wilson, 1932; Lagerspetz, 1958; Carpelan, 1964). Some species are tolerant of low salinities and of changing conditions throughout the season. The almost universal tendency to consider them as genera confined to fresh water may be misleading when attempting to characterize coastal bodies of water by their faunal elements. In some regions, the absence of freshwater calanoid genera is probably more significant

Table 2.—*Calanoid copepod species composition of Cape Thompson lagoons, 1959–1961, based on data for August 1959 from Johnson (1961), collections by D. Hilliard in July 1959 and J. C. Tash in 1960 and 1961* (+ = less than 10 specimens, usually 1–5; + + = 10 or more specimens)

Lagoon	Location		Date collected [1]	Salinity ‰ [2]	*Eurytemora* [3]							*Limnocalanus* [3]		*Acartia* [3]	Other [3]
	Lat. N.	Long. W.			*ca*	*co*	*f*	*g*	*h*	*p*	*r*	*g*	*j*	spp.	spp.
Aiautak	68°15′	166°08′	July 20, 1959	0.28–0.85			++	+							
Kemegrak	68°14′	166°06′	July 20, 1959	0.3			++						++		
			Aug. 5, 15, 1959	0.46–0.55			++						++		
			July 13, 1960	0.15			++						+		
Akoviknak	68°12′	166°02′	Aug. 14, 1959	0.18–0.18			++					++	++		
			July 13, 23, 1960	0.07			++								
Atosik	68°03′	165°26′	Aug. 6, 12, 1959	0.83–0.83	+								++		
Mapsorak	68°02′	165°21′	Aug. 6, 12, 1959	14.31–15.96					++	+				++	++
			July 4–Sept. 5, 1960	0.85–0.87	++	++		+			++		++		
			June 3–Aug. 5, 1961	0.4 (June 8)	++								++		

Pusigrak	68°01′	165°18′	July 29, 1959	0.093	+			+-imm.
			Aug. 6, 12, 1959	0.16–0.17	+		+	
			June 21–Sept. 14, 1960	0.08–0.19	+		++	
			Jan. 26, 1961	0.35				
			June 3–Aug. 5, 1961	0.09–0.12	+		++	
Singoalik	67°59′	165°14′	Aug. 6, 13, 1959	6.42–7.16	+		+	++
unnamed	67°58′	165°11′	June 21–Aug. 29, 1960	0.28–0.3	+		++	
			June 3–Aug. 5, 1961	0.17–0.2	+		++	
unnamed	67°57′	165°10′	Aug. 6, 13, 1959	0.83–0.83	+		++	++
			June 21–Aug. 1, 1960	0.33			++	
Tusikpok	67°57′	165°06′	July 29, 1959	0.35	+			
			Aug. 6, 13, 1959	0.73–0.73	+	++	+	
			June 22, 1960	0.24	early copepodid stages		+	
unnamed	67°55′	165°02′	Aug. 6, 13, 1959	3.58–3.58	++		++	

[1] 1960–1961 dates showing a seasonal range were mostly weekly collections.

[2] August 1959 records are for surface and bottom samples; single figures represent surface sample for a single date at collection point; 1960–1961 figures indicating a range are minimum-maximum records for collecting season but do not include figures for every week.

[3] *Eurytemora*: *ca*=*canadensis* Marsh, *co*=*composita* Keiser, *f*=*foveola* Johnson, *g*=*gracilicauda* Akatova, *h*=*herdmani* Thompson and A. Scott, *p*=*pacifica* Sato, *r*=*raboti* Richard; *Limnocalanus*: *g*=*grimaldii* (deGuerne), *j*=*johanseni* Marsh; *Acartia* and other species present but not distinguished as to species: *A. bifilosa* (Giesbrecht), *A. clausi* Giesbrecht, *A. longiremis* (Lilljeborg), *Calanus finmarchicus* (Gunnerus), *Centropages abdominalis* Sato, *Pseudocalanus minutus* (Krøyer), *Tortanus discaudatus* Thompson and A. Scott.

in determining brackishness in absence of other data. In the Cape Thompson lagoons of very low salinity, the common freshwater calanoid genera of the region, *Heterocope* and *Diaptomus*, have not established populations. A few specimens of *D. arcticus* were found in one lagoon in August 1960, but since none were collected at other dates, we believe them to be stragglers washed into the lagoon from a freshwater source. The few harpacticoid copepod genera that were collected are, like the calanoid genera *Eurytemora* and *Limnocalanus*, those having species with varying degrees of euryhalinity—*Danielssenia*, *Nitocra*, *Onychocamptus*.

Distribution of Cape Thompson *Eurytemora*

The group of eight species of *Eurytemora* in the relatively small area surveyed on the coast of the Chukchi Sea, ranging 39 miles north and south of Cape Thompson (from latitude 68°15′–67°55′ N. and longitude 165°02′–166°08′ W.) and about 11 miles inland (from latitude 68°11′–68°14′ N.) is the largest assemblage of species of the genus recorded from any similar-sized area of the world. This group also represents about one-half of the species known for the world and nearly all of those known for Alaska (8:10) or North America (8:11). Similar large numbers of species occur in coastal areas south of Cape Thompson, where Heron (1964) found, in a single sample, five species in Kivalina Lagoon and four species in two samples from Krusenstern Lagoon. Including those of neritic waters and continental bodies of water, five species are currently known (literature and Wilson collection) along the Beaufort seacoast from Point Barrow eastwards as well as along the coast of the Bering Sea south to the Alaska Peninsula. Similar numbers occur in nearby Asian waters so that the geographic region of northern and western Alaska and northeastern Asia is, in present-day distribution, richer in numbers of species than any other of the world. This large representation probably reflects the northern origin of both the genus and many of its species, and emphasizes how well the biological requirements of the species are met by the arctic-subarctic environment. The species of all types of habitat illustrate the strong zoogeographic affinity between the copepod faunas of Alaska and northeastern Asia, previously pointed out by M. S. Wilson (1953b).

The eight species of Cape Thompson *Eurytemora* include all but one of the total number known for landlocked bodies of water of the Arctic Slope physiographic province of Alaska, of which the Cape Thompson region is a part. In this province, comprising the Arctic coastal plain and the foothills of the Brooks Mountain Range, including the Chukchi seacoast south to about Cape Krusenstern, *Eurytemora* is known from scattered localities along the Beaufort and Chukchi seacoasts to about 65 miles inland. The nine Arctic Slope species include those of inshore-offshore waters (*E. americana, herdmani, pacifica*) which have been found at least once in a body of water on land. The species composition of the two large lagoons south of Cape Thompson at Kivalina and Cape Krusenstern, studied by Heron (1964), is similar to that of some lagoons at Cape Thompson except that *E. americana* was present and *E. canadensis* was absent from Heron's samples. Further exploration of fresh waters may add to the Arctic Slope list the tenth species known from Alaska, *E. yukonensis* M. S. Wilson (1953a). The northernmost record of this species is just southeast of Cape Thompson in the Noatak River watershed (above, p. 564).

Four Cape Thompson species are recent additions to North American fauna. In addition to *E. arctica* described above, *E foveola* was described from Cape Thompson lagoons by Johnson (1961). *E. raboti* ranges from Spitzbergen and the Siberian coast to the Barrow region, Alaska, where it has been found in collections of J. L. Mohr and associates, made in 1953 in brackish ponds (Wilson collection) and in 1960 in Nuwuk Lake (Mohr et al, 1961). It was collected in 1961 from Sinclair (or Minga) Lake, east of Barrow, by Holmquist (1963). It was first recognized in North American waters by Heron (1964) in 1959 samples from Krusenstern and Kivalina Lagoons. *E. gracilicauda*, another Asian species new to North America, was described by Akatova (1949) from freshwater Siberian lakes in the basin of the Kolyma River (about 69° N., 161° E.). The Wilson collection has several samples of *E. gracilicauda* from Alaskan fresh and brackish waters, ranging from the Arctic Slope south to the Alaska Peninsula; figures and notes are in manuscript to be published elsewhere.

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