MEDDELELSER OM GRØNLAND
UDGIVNE AF
KOMMISSIONEN FOR VIDENSKABELIGE UNDERSØGELSER I GRØNLAND
Bd. 131 · Nr. 1

BIOLOGICAL REMARKS ON *LEPIDURUS ARCTICUS* PALLAS, *DAPHNIA PULEX* DE GEER AND *CHYDORUS SPHAERICUS* O. F. M. IN EAST GREENLAND

BY

ERIK M. POULSEN

WITH 10 FIGURES IN THE TEXT

KØBENHAVN
C. A. REITZELS FORLAG
BIANCO LUNOS BOGTRYKKERI A/S
1940

CONTENTS

INTRODUCTION

During "Treaars Ekspeditionen til Christian d. X's Land" under the leadership of Dr. phil. Lauge Koch a large material of freshwater-entomostraceans was collected along the north-eastern coast of Greenland. This material together with some material from former expeditions, an English expedition (C. C. Bertram) 1933, the "Godthaab" expedition 1930, the "Danmark" expedition 1906—08 and the "Amdrup" expedition 1901—02 has been subjected to a mainly systematic and zoo-geographical study by the present author1). However, for some of the species (*Lepidurus arcticus* Pallas, *Daphnia pulex* de Geer and *Chydorus sphaericus* O. F. M.) the material yielded a lot of special observations regarding development, propagation and seasonal variation. It is the scope of the present paper to deal with these observations.

Lepidurus arcticus Pallas.

Lepidurus arcticus is very common in East Greenland; it is found both along the beach of the lakes and in the ponds (cfr. Erik M. Poulsen 1940).

Regarding the development the following observations were made. In Langsø, Ellaø, where fortnightly investigations have been carried out, no specimens were observed from the beginning of September and until the end of June. On June the 29th a number of larvae with a total length (without the caudal filaments) of 1.4—1.9 mm were found, and on July the 1st (in Bjørnesø on Ellaø) some few larvae with a total length of 1.5—2.9 mm were found. These larvae fall as the following measurements show in 2 separate size groups:

mm	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9
No. of larvae	1	1	3	2	4	2	..	..	..	..	..	1	..	2	..	1

As no larvae were found in the samples until June 29th the smallest of these two size groups must be composed of the newly hatched larvae,

---

1) Erik M. Poulsen: Freshwater Entomostraca. The Zoology of East Greenland, Meddelelser om Grønland, Bd. 121, 4. København 1940.

the 1st larval stage, whereas the larvae of the next size group belong to the second larval stage. The second larval stage has been described and figured by G. O. Sars (1896) from Norwegian freshwaters. V. Brehm (1912) has in the "Danmark" material from East Greenland observed larvae which resemble those described by Sars; as however, their caudal filaments are shorter and of a somewhat other form, Brehm mentiones the possibility that these larvae are younger than those of Sars; he does not give any further description of these larvae. O. Olofsson (1918) has observed two planctonic larval stages in Spitzbergen, the smallest stage correspond as to the form of the last segment and the length of the caudal filaments with Brehm's specimens from East Greenland; any further description of the stages is not given. Fr. Johansen (1922) has figured the last segment and caudal filaments of a larva of 3 mm from North-West Canada, it resembles the stage figured by Sars rather closely.

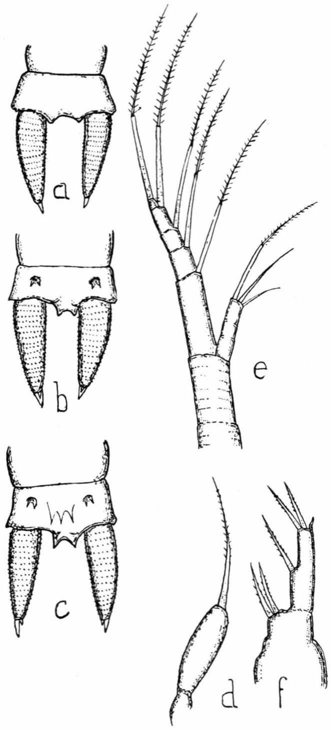

Fig. 1. *Lepidurus arcticus*, 1st larval stage, Bjørnesø, $^1/_7$-1934, a. posterior part of body with caudal lamella and filaments seen from below; b. the same seen from above; c. the same of another specimen seen from above; d. 1st antenna; e. second antenna; f. mandible.

As the first two larval stages have been separated from one another by the varying form of the last segment and the length of the caudal filaments only, I shall on the basis of the present material from East Greenland give some further morphological details regarding these larval forms.

1st larval stage. Mean total length (without the caudal filaments) 1.7 mm (1.4—1.9). The carapace is rather flattened and the sinus of the hind margin is of little depth only; the spines of the hind margin are not developed yet, only some few minute teeth are present. The carapace is comparatively short, its length amounting in mean to 38 % of the total length. In fig. 1, a, b, c, is shown the end of the body. The last segment is without spines; the last but one segments are not separated from one another and completely devoid of spines; spines are however found on the more anterior segments; the caudal lamella is short and its hind margin is produced in two short, broad spines. The caudal filaments are short too, their length being in mean 15 % of the total length of the individual; they are conical of form with a slight inwards bending, at the end they carry a large and a minute tooth (as mentioned by Olofsson), their surface is covered with small and

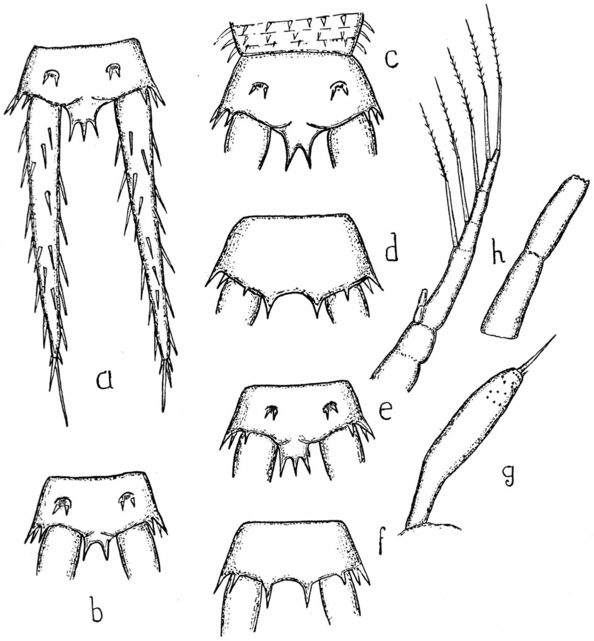

Fig. 2. *Lepidurus arcticus*, 2nd larval stage, Bjørnesø, $^1/_7$-1934. a. posterior part of body with caudal lamella and filaments seen from above; b. the same of another specimen; c and d, e and f. the same of two other spec. seen from above and below; g. 1st antenna; h. 2nd antenna, to the right its inner ramus drawn to a larger scale. a, g and h from an individual with a total length of 2.7 mm, b. 2.5 mm, c and d. 2.7 mm, e and f. 2.6 mm.

very short spines. In fig. 1 c the caudal lamella of the next stage is seen below the integument of the last segment. The first pair of antennae (fig. 1 d) consist of a narrow scape and an oblong, fusiform, terminal part carrying at its end a stout ciliated hair, exceeding in length the antenna itself. The antenna is rather long projecting considerably over the frontal margin of the carapace. The second pair of antennae (fig. 1 e) are developed as powerful organs of locomotion, the end of their bristles reach nearly the last segment of the body. The scape of the antennae is indistinctly divided in joints. It carries two rami; the inner ramus is small in length, only little more than $^1/_3$ of the big outer ramus, it is composed apparently of 2—3 joints and terminates in 3 bristles of which one is jointed with the distal part ciliated; the two other bristles are simple—not ciliated—hairs. The outer ramus is composed apparently of 5 joints, the proximal one being about as large as the 4 distal ones together; from the end of each of the 5 joints arises a strong jointed bristle, ciliated in the distal part. The mandibles (fig. 1 f) consist of a stout basal part and a slender distal one (the palp); at the end of the basal part are two stout spines; the distal part carries in the middle (probably at the end of joint) a similar spine and at its end two such spines more besides a small curved spine.

2nd larval stage. Whereas the 1st larval stage has a mean total length of 1.7 mm only, the total length of the 2nd stage (without the caudal filaments) is 2.7 mm (2.5—2.9 mm). The carapace is more arched and has a deeper sinus than that of the 1st stage, its hind margin is furnished with a row of strong spines; taken as a whole the carapace is very much like that of the grown up specimens. It is comparatively longer than in the 1st stage, its length amounting to 55 $^0/_0$ of the total length against 38 $^0/_0$ in the 1st stage. The end of the body (fig. 2 a-f) has about the same form as in the larvae described by Sars. The segmentation is still indistinct, but indicated by rows of strong spines (fig. 2 c) absent in the 1st stage. The caudal lamella is somewhat larger than in the 1st stage, and terminates generally in 3, more rarely only in 2 spines, in a single case a minute fourth spine has been observed (fig. 2 e). The spines are longer and better developed than those of the 1st stage. The caudal filaments (fig. 2 a) are (as mentioned by Olofsson) now long being 31 $^0/_0$ of the total length against only 15 $^0/_0$ in the first stage; they are furnished with long adpressed and irregularly arranged spines, at their extremity are two longer and two shorter spines. The 1st pair of antennae (fig. 2 g) are of the same form as those of the 1st stage but the terminal bristle is far shorter only about $^1/_3$ of the antenna itself, at the base of the terminal bristle is found a short spine; the distal part of the antenna is furnished with a number of small teeth. These are no doubt the still not fully developed sensory papillæ, found in older stages. The second pair of antennae (fig. 2 h) are still organs of locomotion, but they are rather reduced in comparison with those of the 1st stage; the inner ramus is very small, in length only $^1/_5$—$^1/_6$ of the outer ramus, it has no bristles only a number of small teeth on its terminal edge. The outer ramus is—as in the 1st larval stage—apparently 5-jointed, carrying at the end of each segment a long jointed and in the distal part ciliated bristle. The mandibles have now the same form as in the grown-up animal and there is no mandibular palp. This description coincides with Sars' description of his larvae save regarding the inner ramus of the 2nd antenna; Sars figures and describes an inner ramus with 3 strong ciliated bristles whereas the individuals of the 2nd stage from East Greenland as mentioned have no bristles at all on the inner ramus. Thus the larva described by Sars resembles in this respect the 1st larval stage from East Greenland, the caudal filaments of Sars' larvae do however clearly show that they belong to the second and not to the 1st larval stage. I think that this difference as to the form of the 2nd antenna can be explained only by a different mode of the postembryonic development in the two areas of distribution. It should here be borne in mind that also in other respects there are differences between the *L. arcticus* from Norway and those from East Greenland; the caudal lamella is linguiform in the Norwegian specimens but triangular in the Greenlandic specimens (Erik M. Poulsen, 1940). Also the habitat is different: the Norwegian *L. arcticus* living in fairly deep water (in lakes) whereas the Greenlandic and other arctic *L. arcticus* are living in shallow waters and often in small ponds. The fact that the reduction of the 2nd antennae is more advanced in the Greenlandic than in the Norwegian larvae shows that the duration of the postembryonic larval development is shorter in Greenland than in Norway. This is in good accordance with the generally observed tendency among arctic animals to shorten the postembryonic larval development. This shortening is obtained as a rule by a further development within the egg; as we do not know at what stage the Norwegian *L. arcticus* are hatched we cannot decide if this mode is used in *L. arcticus* also. In this connection it is however of interest to consider that the Central European species *Apus cancriformis* is hatched at an earlier stage than *L. arcticus* viz. as a metanauplius.

Later than July the 1st larvae have not been observed in the plankton samples, no doubt due to the fact that the larvae from the 3rd stage and upwards live at the bottom. Fairly young individuals are however present in the material from the "Danmark" expedition (lake at Danmarkshavn, end of July 1907). From this material I have measured specimens with a total length varying from 4.7—10.0 mm. All these specimens were dark coloured and had obviously lived at the bottom.

When the measurements of these specimens are arranged together with those of the larvae from the end of June and the beginning of July the following dispersion of the length is found:

mm.........	1	$1^1/_2$	2	$2^1/_2$	3	$3^1/_2$	4	$4^1/_2$	5	$5^1/_2$	6	$6^1/_2$	7	$7^1/_2$	8	$8^1/_2$	9	$9^1/_2$	10
No. of spec...	1	12	0	5	0	0	0	2	1	0	0	1	1	2	2	0	0	1	1

The individuals of $1^1/_2$ and $2^1/_2$ mm are those of the two first stages—as already mentioned; although the measurements of the larger specimens are rather few the mode of dispersion of the sizes seems to indicate that there are 3 further stages represented in the material viz. at $4^1/_2$—5, at $6^1/_2$—8 and at 9—10 mm. In the 3rd stage the carapace has nearly reached the same size as in the grown up individuals. The length of the carapace in per cent of the total length is in the various stages of development as follows (no of spec. measured in ()):

1st stage.......	38 $^0/_0$	(13 spec.)	
2nd —	55 $^0/_0$	(5 —)	
3rd —	61 $^0/_0$	(3 —)	
4th —	57 $^0/_0$	(6 —)	
9—16 mm tot. l.	67 $^0/_0$	(81 —)	Material from ponds near Hurry Fjord and Langsø on Ellaø, 4th.—24th. August 1933.
17—29 mm tot. l.	66 $^0/_0$	(25 —)	

Thus the strongest growth of the carapace takes place between the 1st and the second stage; after the 2nd stage the growth of the carapace is only little stronger than that of the whole body, and in specimens of more than ca. 10 mm total length the carapace grows proportionally with the body itself.

Even in the youngest of the bottom stages (3rd stage) the caudal filaments have reached their full length, 55—70 $^0/_0$ of the total length, also the spines of the filaments are now arranged regularly in rings as in the grown-up specimens. The caudal lamella in the first three bottom stages has about the same form as in the grown-up specimens (cfr. fig. 3), being however comparatively a little broader; its number of spines is still small, in the third stage 4—6, in the 4th ca. 7—8, in the 5th ca. 9—10, against in the grown up individuals c. 20. The 1st antennae (see fig. 6, d, e, and f) gradually develop as a sensory organ, their terminal bristle becomes shorter; in the 5 first stages its length amounts to the following percents of the length of the antenna without the scape: 1st stage—142 $^0/_0$, 2nd stage—50 $^0/_0$, 3rd stage—39 $^0/_0$, 4th stage—28 $^0/_0$, 5th stage—18 $^0/_0$. In the 3rd stage the sensory papillae are still only present as small teeth, in the 4th and 5th stage they are however well developed ressembling those of the adult stage. The reduction of the 2nd pair of antenna continues. It does not grow at all from the 3rd to the 5th stage (see fig. 3, d, e, and f, where all the figures are drawn to the same scale); in the 3rd stage (fig. 3 d) the inner ramus is still present as a slender short appendage, in the 4th stage (e) it is only a budformed rudiment, and in the 5th stage it has completely disappeared. The bristles of the outer ramus which in the 2nd stage were full developed are in the 3rd stage only present as small simple hairs or spines; in the 4th stage they have completely disappeared.

As larval stages have been found in June and the beginning of July only, and never together with grown up, mature specimens it is obvious that one generation only is reared yearly. In Langsø, where fortnightly samplings have been carried out during all seasons of the year, *L. a.* has been found in the summer only, but not in the winter, the autumn or the spring. This tends to show that *L. a.* does not hibernate; the fact that larvae but not grown up specimens were observed in the beginning of the summer gives evidence to the same effect. In the material from the "Danmark" expedition, however, F. Johansen (1912) has found grown up specimens from the end of June; he writes "these are animals which hibernated instead of dying off like many of their fellows in the autumn". F. Johansen doesn't, however, state the length of the "full grown" specimens, but V. Brehm (1912) writes concerning the "Danmark" material, that larvae were very common in the end of June, and that "young animals" resembling the grown up in all respects but size were found mostly in July and further that "die im spätere August gefangenen Tiere erreichen enorme Grösse". From these observations it seems to be evident that the full grown

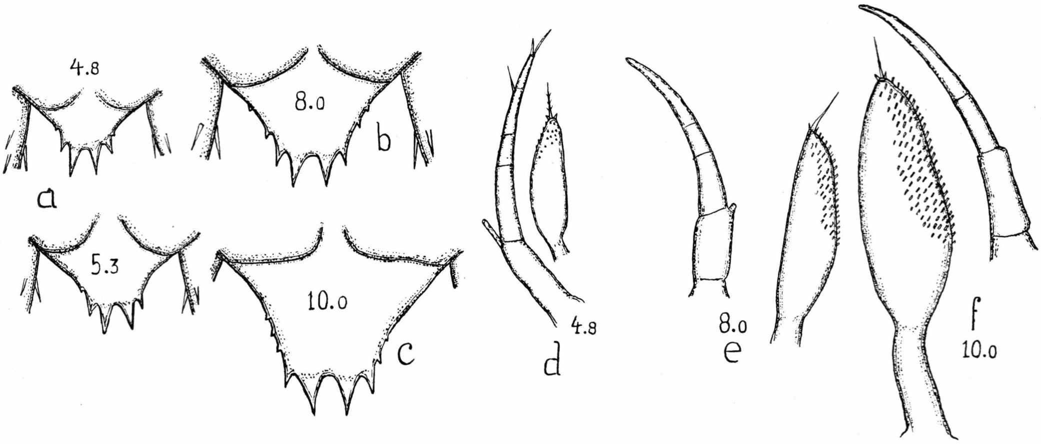

Fig. 3. *Lepidurus arcticus*, 3rd, 4th and 5th stage of development, lake at Danmarkshavn, end of July 1907. Caudal lamella of 3rd stage (a), 4th stage (b), and 5th stage (c). 1st and 2nd antenna of 3rd stage (d), 4th stage (e), 5th stage (f). The numbers indicate the total length of the specimens in mm. All figures are drawn to the same scale.

specimens from the early part of the summer are not as large as the specimens found later in the summer. Thus there is some reason to assume that the "full grown" specimens from the early summer are those hatched earliest in the summer.

Daphnia pulex de Geer.

Daphnia pulex is one of the most common entomostraca of East Greenland. It has been found through the whole of the area investigated and very often in large quantities. In Langsø on Ellaø where fortnightly samplings have been carried out it is very numerous, and the following observations regarding its propagation and seasonal variations are mainly based on the material from this lake.

The material on which the present investigation is based is given in the following notes containing statements concerning the mode of propagation as well as measurements of the specimens investigated.

Notes.

Bjørnesø, Ellaø, 72°50′ N. Lat. $^{18}/_{8}$-1933: Empty ♀, T1) 2.20 mm (1.93—2.53), S. 0.21 mm (0.20—0.27); 12 spec. — $^{25}/_{10}$ (Ice cover 30 cm thick): Empty ♀ T. 2.25 mm (2.07—2.60), S. 0.30 mm (0.27—0.33); 6 spec., Eph. ♀, T. 2.24 mm (2.13—2.33), S. 0.32 mm (0.27—0.33); 4 spec., Cast ephippia. — $^{1}/_{7}$-34: Only 2 sub. ♀ found with 4—6 eggs or young in the brood pouch, size 1.93 + 0.20 and 2.13 + 0.27 mm2).

Ulvesø, Ellaø, $^{15}/_{8}$-1933: No spec. observed. — $^{14}/_{9}$: Empty ♀, T. 2.47 mm (2.20—2.67), S. 0.23 mm (0.20—0.27); 3 spec. — $^{1}/_{11}$: Empty ♀, T. 2.44 mm (2.13—2.67), S. 0.22 mm (0.13—0.33); 9 spec. — $^{21}/_{11}$: Empty ♀ in decreasing numbers, 2.47 + 0.33 and 2.67 + 0.27 mm. — $^{23}/_{3}$-1934: Rather many empty ♀, T. 2.56 mm (2.33—2.80), S. 0.14 mm (0.13—0.20); 13 spec. One ♀ with 4—5 eggs in the brood pouch, 2.53 + 0.20 mm. — $^{18}/_{4}$: Empty ♀, T. 2.46 mm (2.13—2.86), S. 0.12 mm (0.07—0.13); 15 spec. — $^{15}/_{5}$: Empty ♀, T. 2.64 mm (2.40—2.93), S. 0.12 (0.07—0.13); 11 spec. — $^{7}/_{6}$: Empty ♀, decreasing numbers, T. 2.58 mm (2.20—2.75), S. 0.09 (0.07—0.13); 4 spec. — $^{17}/_{7}$: Few young, T. 1.40 mm (1.20—1.60), S. 0.37 mm (0.33—0.40); 2 spec.

Langsø, Ellaø, $^{8}/_{8}$-1933: Young ♀, T. 1.29 mm (1.00—1.47), S. 0.31 mm (0.27—0.40); 15 spec. Empty ♀, T. 2.53 mm (2.20—2.86), S. 0.16 mm (0.13—0.20); 13 spec. — $^{22}/_{8}$: Young ♀, T. 1.52 mm (1.33—1.93), S. 0.25 mm (0.20—0.33); 33 spec. Empty ♀, T. 2.51 mm (2.33—2.60), S. 0.14 mm (0.13—0.20); 8 spec. — $^{15}/_{9}$: Empty ♀, T. 1.97 mm (1.47—2.80), S. 0.18 mm (0.07—0.27); 14 spec. Eph. ♀, T. 2.30 mm (1.93—2.60), S. 0.13 mm (0.07—0.20); 4 spec. — $^{19}/_{9}$: Empty ♀, decreasing numbers, T. 2.07 mm (1.67—2.47), S. 0.23 mm (0.07—0.20); 5 spec., Eph. ♀, increasing numbers, T. 2.06 mm (1.80—2.53), S. 0.17

---

1) T = Total length from the front margin of the head to the base of the spine of the carapace; S = length of the spine of the carapace.

2) The 1st figure gives the T.-, the 2nd the S.-length.

mm (0.07—0.27); 10 spec. — $^{3}/_{10}$: A few empty ♀, T. 1.84 mm (1.80—1.87), S. 0.17 mm (0.13—0.20); 4 spec., Eph. ♀, T. 1.88 mm (1.80—2.00), S. 0.17 mm (0.13—0.20); 4 spec., as the dorsal margin of the carapace of the empty ♀ is quite smooth these have apparently cast their ephippia[1]. — $^{19}/_{10}$: A single empty ♀, 2.00 + 0.13 mm. Several eph. ♀, T. 2.01 mm (1.80—2.20), S. 0.21 mm (0.13—0.27); 11 spec. — $^{31}/_{10}$: Few empty ♀. Large numbers of eph. ♀, T. 1.98 mm (1.80—2.40), S. 0.11 mm (0.07—0.20); 19 spec. Many cast ephippia. — $^{14}/_{11}$: Empty ♀, T. 2.16 mm (2.07—2.33), S. 0.13 mm (0.07—0.20); 5 spec. Eph. ♀, T. 2.17 mm (2.07—2.33), S. 0.12 mm (0.07—0.13); 10 spec. — $^{30}/_{11}$: A few empty ♀, T. 2.17 mm (2.00—2.33), S. 0.13 mm; 2 spec. Many eph. ♀, T. 2.16 mm (1.93—2.33), S. 0.15 mm (0.07—0.20); 19 spec. — $^{13}/_{12}$: Empty ♀, increasing numbers, T. 2.21 mm (2.00—2.33), S. 0.09 mm (0.07—0.13); 22 spec. Eph. ♀, decreasing numbers, T. 2.14 mm (1.93—2.33), S. 0.13 mm (0.07—0.20); 28 spec. — $^{27}/_{12}$: Empty ♀, increasing numbers, T. 2.27 mm (2.07—2.60), S. 0.09 mm (0.07—0.13); 16 spec. Eph. ♀, decreasing numbers, T. 2.30 mm (2.13—2.53), S. 0.12 mm (0.07—0.20); 11 spec. — $^{12}/_{1}$-1934: Rather few empty ♀, T. 2.16 mm (2.00—2.27), S. 0.12 mm (0.07—0.13); 5 spec. Eph. ♀, increasing numbers, T. 2.15 mm (2.00—2.40), S. 0.13 mm (0.07—0.20); 2 spec. — $^{23}/_{1}$: Many empty ♀, T. 2.16 mm (2.00—2.33), S. 0.08 mm (0.07—0.13); 29 spec. A few eph. ♀, T. 2.20 mm (2.00—2.47), S. 0.09 mm (0.07—0.13); 20 spec. — $^{7}/_{2}$: Empty ♀, T. 2.21 mm (2.00—2.33), S. 0.09 mm (0.07—0.13); 16 spec. Eph. ♀ T. 2.19 mm (1.93—2.27), S. 0.09 mm (0.07—0.13); 9 spec. — $^{24}/_{2}$: Empty ♀ T. 2.14 mm (2.00—2.27), S. 0.07 mm; 17 spec. Few eph. ♀, T. 2.20 mm (2.13—2.27), S. 0.07 mm; 3 spec. — $^{5}/_{3}$: Empty ♀, decreasing numbers, T. 2.23 mm (2.13—2.33), S. 0.08 mm (0.07—0.13); 14 spec. Only one eph. ♀, 2.20 + 0.07 mm. — $^{20}/_{3}$: Only few empty ♀, T. 2.26 mm (2.13—2.40), S. 0.07 mm; 11 spec. — $^{17}/_{4}$, $^{3}/_{5}$, $^{14}/_{5}$, $^{29}/_{5}$, and $^{12}/_{6}$: no specimens found $^{29}/_{6}$: Large numbers of young, still empty ♀, T. 0.83 mm (0.77—1.09), S. 0.27 mm (0.20—0.31); 16 spec. A few larger but still empty ♀, T. 1.85 mm (1.80—1.93), S. 0.31 mm (0.27—0.33); 5 spec. — $^{10}/_{7}$: The population is now very dense with as well young as sub. ♀. Young, T. 0.85 mm (0.73—1.50), S. 0.42 mm (0.33—0.60); 16 spec. Sub. ♀, T. 2.40 mm (2.13—2.60), S. 0.36 mm (0.27—0.47), mean number of eggs or young in the brood pouch 6.5; 51 spec. — $^{23}/_{7}$: Sub. ♀, decreasing numbers, T. 2.19 mm (1.93—2.47), S. 0.16 mm (0.13—0.20), mean number of eggs or young in the brood pouch 3.5; 6 spec. Empty ♀, T. 2.26 mm (1.93—2.60), S. 0.21 mm (0.13—0.27); 22 spec. Considerable numbers of young, T. 0.80—1.07 mm, S. 0.33—0.47 mm; 12 spec. — $^{12}/_{8}$: A few sub. ♀, T. 2.37 mm (2.13—2.53), S. 0.13 mm, mean number of eggs or young in the brood pouch 2.0; 10 spec. Empty ♀, T. 2.40 mm (2.27—2.67), S. 0.13 mm; 8 spec. — Decreasing numbers of young, T. 1.47 mm (1.27—1.60), S. 0.23 mm (0.20—0.27); 11 spec.

Freshwater at Kap Stosch, 74° N. Lat., $^{3}/_{4}$ m depth, $^{1}/_{8}$-1930[2]: Empty ♀, eph. ♀, T. 2.01 mm (1.47—2.73), S. 0.24 mm (0.07—0.47); 126 spec. A number of young from 1.27—1.80 mm.

Sandøen, Tyrolerfjord, 74°30′ N. Lat., $^{1}/_{4}$—$^{3}/_{4}$ m depth, $^{17}/_{7}$-1930: Young, empty and eph. ♀

---

[1] This is generally the case with the empty females through the rest of the autumn and the winter.

[2] The samples from 1930 were taken by the "Godthaab" Expedition.

Small lake, Moskusoksefjorden, 73°40′ N. Lat., $^1/_4$ m depth, $^{17}/_8$-1930: Eph. ♀ T. 1.89 mm (1.53—2.20); 41 spec.; some few empty ♀, but no young.
Small lake at Kap Stosch, $^3/_4$ m deep, $^3/_8$-1930: Empty ♀, T. 2.11 cm (1.60—2.80), S. 0.29 mm (0.20—0.33); 23 spec.
Freshwater at Knudshoved, 73°30′ N. Lat., 1 m depth, $^5/_8$-1930: 3 eph. ♀, 2.27 + 0.27 mm, 2.40 + 0.33 mm, 2.47 + 0.20 mm. Some empty ♀, T. 2.49 mm (2.13—2.93), S. 0.28 mm (0.20—0.33); 8 spec. Youngs, T. 1.32 mm (1.00—1.67), S. 0.49 mm (0.40—0.60); 24 spec.
Small lake, Moskusoksefjorden, 73°40′ N. Lat., $^{15}/_8$-1930: Eph. ♀, T. 1.97 mm (1.67—2.13), S. 0.15 mm (0.13—0.20); 20 spec. A few empty ♀.
Pond at Kap Stosch, $^3/_4$ m depth, $^3/_8$-1930: Young from 1.27—1.80 mm; 20 spec. Empty ♀, T. 1.80—2.27 mm; 24 spec. Eph. ♀, T. 2.41 mm (1.80—2.73), S. 0.21 mm (0.07—0.47); 126 spec.
Lake at Danmarkshavn, 76°40′ N. Lat., end of July 1907[1]): Empty females. Few eph. ♀, T. 2.31 mm (2.20—2.40), S. 0.23 mm (0.20—0.27); 3 spec. Many ♀ with sub. eggs, T. 2.38 mm (2.00—2.67), S. 0.24 mm (0.20—0.27), mean number of sub. eggs or young = 4; 20 spec.
Lake at 2nd "tent-locality", ca. 76°40′ N. Lat., 250 feet ab. s. l., icefree, $^{20}/_8$-1906: Youngs and eph. ♀, cast ephippia.
Lake at Stormkap, ca. 76°40′ N. Lat., $^3/_9$-1906: Empty ♀. Eph. ♀, T. 2.28 mm (1.87—2.67), S. 0.10 mm, (0—0.20); 22 spec.
Pond on Maroussia Island, 76°40′ N. Lat., $^{30}/_7$-1907: Youngs and eph. ♀.
Pond A.[2]) Hurry Fjord, Scoresby Sund, 70°30′ N. Lat., $^4/_8$-1933: A few eph. ♀.
Pond C. $^6/_8$-1933: A few eph. ♀.
Pond D. $^7/_8$-1933: Empty ♀. A few ♀ with sub. eggs, T. 2.60 mm (2.33—2.86), S. 0.43 mm (0.33—0.47); 4 spec. Many eph. ♀, two size-groups one from 1.53—2.00 mm another from 2.27—3.00 mm.
Pond I, $^{14}/_8$-1933: A few young, T. from 1.07 mm. Empty ♀. Several eph. ♀. 2 size-groups, one with T. 1.60—1.87 mm, another with T. 2.47—2.53 mm; the smallest group has S. 0.24 mm (0.20—0.27); 22 spec. the largest S. 0.17 mm (0.13—0.20); 4 spec.
Pond J, $^{14}/_8$-1933: Empty ♀, one ♀ with sub. eggs (2.00 + 0.40 mm). Many eph. ♀, T. 1.75—2.20 mm, S. 0.20—0.40 mm.
Northern part of Storø, 70°50′ N. Lat., $^2/_8$-1933: Many empty and eph. ♀, few sub. ♀, young.
Freshwater at Nordfjord, 73°40′ N. Lat., 32 m a. s. l. $^2/_8$-1932. Eph. ♀.
Freshwater on Ellaø, 72°50′ N. Lat., $^{25}/_8$-1932: Few empty ♀.
Small lake at Nordfjord, 73°40′ N. Lat., 34 m a. s. l. $^2/_8$-1932: Few eph. ♀.
Lake on Ellaø, 72°50′ N. Lat., $^{25}/_8$-1932: A few dark empty ♀.
Uglesø, Ymerø, 73°20′ N. Lat., 75 m a. s. l., $^1/_2$ m deep, $^{10}/_8$-1932: A few empty ♀.

Mode of reproduction. The most striking features in the mode of reproduction of the East Greenlandic *Daphnia pulex* is that males are totally lacking. Among the several thousands of specimens investigated from various localities and from different seasons of the year as well as from different years not one single male has been observed. None

---

[1]) The samples from 1906—07 were taken by the "Danmark" Expedition.

[2]) The samples A—J were taken by C. C. BERTRAM, England, all near Hurry Fjord.

of the previous investigators of the East Greenlandic *D. p.* colonies (C. Wesenberg-Lund and V. Brehm) have observed males. It is thus evident that the *D. pulex* of East Greenland propagates without males, producing as well subitaneous eggs as resting-eggs parthenogenetically. In this case the mode of reproduction is just the same as in Spitzbergen where Olofsson did not—in spite of his large material—find males. From this fact he drew the conclusion that the arctic colonies produced the resting-eggs parthenogenetically. As males have neither been found in the large material from East Greenland it is obvious that the total lacking of sexual propagation must be regarded as a characteristic biological feature for the colonies of *D. p.* living under extreme arctic conditions. In this connection it is of interest that P. Haberbosch has found males in West Greenland (where the conditions are not quite as extreme arctic as in North East Greenland) but he did find very few males only, and in one sample only. Obviously there is no doubt that the general mode of reproduction in West Greenland is purely parthenogenetically too, but that in some cases males may be produced and, perhaps, take part in the reproduction. Olofsson is of the opinion that this pure parthenogenetic propagation under extreme arctic conditions is forced on the colonies by the short life cyclus (only two months or even less). It is however doubtful if this explanation is the right one. In colonies in temperate countries even a shorter life cyclus can be found. K. Berg (1931) thus mentions a colony of *D. pulex* from Denmark, which starts its life cyclus from resting eggs in the end of March (no specimens having hibernated) and which already in the end of April has produced males. According to this a colony living two months in the arctic summer should have "time enough" to produce males, and the more so as the water of the arctic shallow ponds during the summer may be quite as warm as that of the ponds of more temperate regions in spring. Also the fact, stated by v. Scharffenberg (1914), that even ex-ephippio females of *D. p.* are able to produce males, shows that the arctic colonies of *D. p.* have "time enough" to produce males. Thus the short life cyclus of the arctic *D. p.* colonies cannot be regarded as the cause of the pure parthenogenetic propagation of these colonies. On the basis of extensive investigations on the mode of reproduction in temperate countries it is now generally accepted (see f. i. K. Berg 1931, pag. 197 ff.) that the production of males and the formation of resting-eggs and ephippia is caused by unfavourable external conditions. This conclusion may be true, but the fact that the unfavourable external conditions at the close of the arctic summer does not induce the colonies to produce males, although resting eggs are produced, tends to show that unfavourable conditions are not the only cause of the production of males and that the production of males and the formation of resting-

Tab. 1. *Daphnia pulex*, Langsø, Ellaø. Measurements (in units of micrometer scale) of total
empty females, s = females with subitaneous eggs or

Dato		$^{8}/_{8}$-33	$^{22}/_{8}$-33	$^{5}/_{9}$-33	$^{19}/_{9}$-33	$^{3}/_{10}$-33	$^{19}/_{10}$-33	$^{31}/_{10}$-33	$^{14}/_{11}$-33	$^{30}/_{11}$-33	$^{13}/_{12}$-33	$^{27}/_{12}$-33	$^{12}/_{1}$-34
Units	mm												
11	..	...	...	..	..	..	..	..	..	...	...	..	...
12	0.80	...	...	..	..	..	..	..	..	...	...	..	...
13	..	...	...	..	..	..	..	..	..	...	...	..	...
14	0.93	...	...	..	..	..	..	..	..	...	...	..	...
15	..	y	...	..	..	..	..	..	..	...	...	..	...
16	1.07	y	...	..	..	..	..	..	..	...	...	..	...
17	..	yyyyyy	...	..	..	..	..	..	..	...	...	..	...
18	1.20	yyyyyy	...	..	..	..	..	..	..	...	...	..	...
19	..	yyyyyyyyy	...	..	..	..	..	..	..	...	...	..	...
20	1.33	yy	yyy	..	..	..	..	..	..	...	...	..	...
21	..	y	yyyyyy	..	..	..	..	..	..	...	...	..	...
22	1.47	yyy	yyyyyyyy	y	..	..	..	..	..	...	...	..	...
23	..	yy	yyyyyyy	..	..	..	..	..	..	...	...	..	...
24	1.60	yyy	yyy	yy	..	..	..	..	..	...	...	..	...
25	..	...	yy	..	y	..	..	..	..	...	...	..	...
26	1.75	yy	y	yy	..	..	..	..	..	...	...	..	...
27	..	...	yy	yy	e	ye	e	e	..	...	...	..	...
28	1.87	...	...	yy	yeeee	ye	yee	yeeee	..	...	...	..	...
29	..	y	y	ye	e	e	e	yeeee	..	e	e	..	...
30	2.00	...	...	..	yyeee	e	ee	yeee	y	...	ee	...	yeeee
31	..	y	...	..	..	..	ee	eeee	yyee	ee	yyeeeee	yy	eeeee
32	2.13	yy	...	..	..	..	ee	ee	yyee	yeeeeeeee	yyyeeeeeeeee	yee	yeeeeeeeeeee
33	..	yy	...	e	y	..	e	..	ye	eeee	yyyyyyyyyyeeeeeeee	yyyye	yyeeeeee
34	2.27	...	...	..	..	..	..	..	eeee	ye	yyyyyyee	yyyee	yeeeee
35	..	y	y	..	e	..	..	..	yye	ee	yye	yyyeee	e
36	2.40	...	yy	..	y	..	..	e	..	...	...	yyee	e
37	..	y	yy	yee	yee	..	..	..	..	...	...	..	...
38	2.53	yyy	yy	yy	..	..	..	..	..	...	...	..	...
39	..	...	y	e	ye	..	..	..	..	...	...	..	...
40	2.67	...	...	..	..	..	..	..	..	...	...	..	...
41	..	yy	...	..	..	..	..	..	..	...	...	..	...
42	2.80	y	...	y	..	..	..	..	..	...	...	..	...
43	..	yy	...	..	..	..	..	..	..	...	...	..	...

length without the spine. Each individual measured is indicated by a letter; y = youngs or young in the brood pouch, e = ephippial females.

$^{23}/_{1}$-34	$^{7}/_{2}$-34	$^{24}/_{2}$-34	$^{5}/_{3}$-34	$^{20}/_{3}$ -34	$^{4}/_{4}$ -34		$^{29}/_{6}$-34	$^{10}/_{7}$-34	$^{23}/_{7}$-34	$^{12}/_{8}$ -34
...	...	..	..	..	..	From $^{17}/_{4}$—$^{12}/_{6}$ no specimens observed	yyyyy	yy	..	..
...	...	..	..	..	..		yyyyyyyyy	yy	y	..
...	...	..	..	..	..		yy	yyyyy	yyyy	..
...	...	..	..	..	..		...	yyy	y	..
...	...	..	..	..	..		y	y	y	..
...	...	..	..	..	..		y	y	yy	..
...	...	..	..	..	..		...	...	...	..
...	...	..	..	..	..		...	...	...	..
...	...	..	..	..	..		...	...	...	yy
...	...	..	..	..	..		...	...	...	y
...	...	..	..	..	..		...	...	y	yy
...	...	..	..	..	..		...	y	...	yy
...	...	..	..	..	..		...	...	y	yyy
...	...	..	..	..	..		...	y	...	y
...	...	..	..	..	..		...	...	...	..
...	...	..	..	..	..		...	...	...	..
...	...	..	..	..	..		yy	...	...	..
...	...	..	..	..	..		yy	yyyy	...	..
...	e	..	..	..	..		y	yyy	ys	..
yyyye	y	yy	..	..	..		...	yyyys	yy	..
yyyee	...	yyyy	..	..	..		...	y	yyys	..
yyyyyyyyeeeeee	yyye	yyyye	yyy	yy	..		...	ss	yyyyyys	s
yyyyyyyyyyeeeeee	yyyyyyyyyyeeee	yyyye	yyyyye	yy	..		...	ssss	yyyyyys	..
yyyyee	yeee	yyye	yyy	yyy	y		...	ssss	yy	y
yyee	yy	..	yyy	yyy	..		...	ssssssssss	yyyys	yyys
e	...	..	..	y	..		...	ssssssssssss	yy	ys
e	...	..	..	..	..		...	sssssssss	yyys	yys
...	...	..	..	..	..		...	sssssssssss	yy	s
...	...	..	..	..	..		...	ssss	yyy	..
...	...	..	..	..	..		...	...	y	y
...	...	..	..	..	..		...	...	...	..
...	...	..	..	..	..		...	...	...	..
...	...	..	..	..	..		...	...	...	..

eggs must not necessary be caused by one and the same factor; K. Berg (1931) by means of experimental research has come to the same supposition: "These facts would seem to indicate that there is a difference between the conditions causing the production of male eggs and those which induce the formation of resting eggs". It is perhaps a question if—in temperate zones—the relation between the presence of males and the formation of resting eggs and ephippia is so strong as generally supposed.

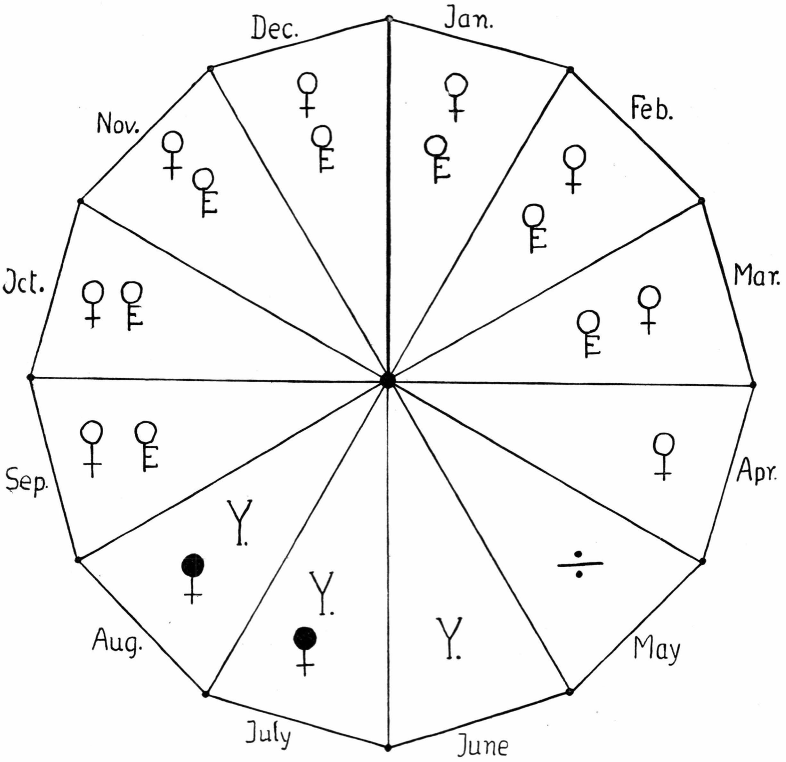

Fig. 4. The life-cyclus of *Daphnia pulex* in Langsø, Ellaø, according to the results of the fortnightly observations from August 1933 until August 1934.

The life cyclus of the North-East Greenlandic *Daphnia pulex* is seen most clearly from the fortnightly investigation of Langsø (Tab. 1). The first sample of this investigation was taken on August 8th, 1933 and the sampling was continued fortnightly for a whole year until August 12th, 1934. During the time when the lake was ice free horizontal hauls were made generally, whereas during the ice-bound period vertical hauls were taken through a hole in the ice. In fig. 4 is given a general survey of the varying mode of reproduction throughout the year. In May when the long arctic winter is nearing its end, but the lake still ice-bound, no individuals at all were observed; the samples taken on April 17th, May 3rd, 14th and 29th and on June the 12th (on the last mentioned date the lake was nearly ice free) contained no specimens of *D. p.*, only a few ephippia. The colony thus has a resting period of nearly 2 months, from the middle of April to the middle of June. On June the 29th young occur for the first time; the main part of these are small (abt. 0.8 mm) and obviously newly hatched. A few are larger (abt. 1.8 mm) and evidently nearly mature. In July (10th and 27th) the life of the colony is in full swing. The population is dense consisting of both females with subitaneous eggs and young of varying sizes. In August (8th, 12th and 22nd) the colony still propagates exclusively by means of sub. eggs, but the numbers of females with sub. eggs are much smaller than in July (only found in the sample from August the 12th), also the number of eggs is smaller than in July (ca. 1—3 in August against up to 11 in July); a large number of empty females of varying sizes is now found whereas the number of young is by far not so large as in the preceeding two months; it is obvious that the period of reproduction with sub. eggs is ending already in the beginning of August. In September females with subitaneous eggs or newly hatched young are not found at all, but now the propagation with resting eggs has begun; on Sept. 5th some few ephippial females are observed, and on Sept. 19th their number has increased considerably. There are no males. Thus there is a certain resting period between the closing of the period of production of sub. eggs and the beginning of the reproduction by means of resting eggs. In October when the lake already is ice-bound many ephippial females are still found; there are neither males nor young. The colony consists of either ephippial females or empty females. In the empty females the dorsal margin is quite smooth just as OLOFSSON has found it to be the case with females which have cast an ephippium. This is the state of the colony in the following months. On November 30th by far the larger part of the females are carrying ephippia. In the course of December and January however the number of the empty females increases whereas the number of the ephippial females decreases rapidly. In February the number of individuals in the colony is strongly decreasing, but still besides the empty females a few ephippial females are found. In the beginning of March only very few ephippial females are observed, and in the latter half of the month (the 20th) only few individuals at all are present and among these no females carrying ephippia. In the course of April the colony dies away; on the 4th only very few empty females are observed¹). On the 17th, however,

---

¹) According to information received from Mag. SØGAARD ANDERSEN who has taken the samples, the few specimens observed in the sample were dead and the water of the lake had a strong smell of H_2S.

no specimens were found. It is obvious that the colony in question is monocyclic with a rather short period of reproduction with subitaneous eggs preceeding a very long lasting period (6—7 months) of reproduction with resting eggs and ephippia. Already WESENBERG-LUND (1895) arrived to the result that *D. pulex* (as the other Greenlandic Cladocera) was monocyclic. The most interesting fact by the present material is that it shows that the colony lives under the ice throughout the larger part of the arctic winter and that it produces ephippia right from September through the autumn and winter until the beginning of March; the resting period of this arctic colony is very short lasting abt. $1^1/_2$ month only (during April and May). It is evident that it is not the cold of the arctic winter that makes the individuals die; if this had been the case the individuals would have disappeared earlier in the winter. The dying of the individuals is either caused by internal factors, by hunger, or by lacking of oxygen in the water (cfr. the foot note p. 19).

That the East Greenlandic *Daphnia pulex* can live not only through the larger part of the winter but even through the whole of it appears from the samples taken in Ulvesø, Ellaø. From Ulvesø only empty females have been recorded; this may be due to the fact that the number of individuals in the various samples are rather small, this especially holds good for the samples from the early autumn when ephippial females should be sure to occur. The records from Ulvesø are as follows:

Sept. 14th (1933) — one newly hatched young and 4 empty, grown up females,
Nov. 1st (1933) — 12 empty females,
Nov. 21st (1933) — 15 empty females,
April 18th (1934) — 14 empty females,
May 15th (1934) — 11 empty females,
June 7th (1934) — 4 empty females,
July 17th (1934) — 2 young.

It appears that empty females occur throughout the whole of the winter, and still in May in not inconsiderable numbers; in June, however, the number has decreased strongly. On July 17th none of the wintering specimens were present, only a few young were found. That the specimens found in May and June belong to the wintering population cannot be doubted. They were of about the same size as those found in April (and in November). The length of the spine (in June) was a little shorter than in the preceeding samples; but as the spine has grown shorter through the whole of the winter this fact makes it the more evident that the specimens found in June have wintered. The size of the individuals and the length of the spine are shown in the following table:

	Tot. length mm	length of spine mm	length of spine in °/₀ of total length	No. of spec.
Sept. 14th.....	2.07	0.27	13.0	4
Nov. 1st.....	2.38	0.22	9.0	12
Nov. 21st.....	2.54	0.15	5.8	15
April 18th.....	2.51	0.11	4.4	18
May 15th.....	2.54	0.11	4.3	11
June 7th.....	2.53	0.07	2.8	3

On June 7th when the wintering specimens were observed for the last time the lake was still ice-bound. There were no eggs to be seen in the ovaries of the specimens, this indicates that these wintering specimens were not about to produce subitaneous eggs, as it is the case with wintering specimens in more southern localities. The fact that only young were found in July and no larger individuals seems to indicate that the wintering females had died without producing subitaneous eggs, as it should be supposed that in case the wintering females had produced sub. eggs at least some of them should have lived in July still. Also the rapid decrease in the number of the wintering females during April, May and June tends to show that they are about to die. Thus the evidence at hand seems to show that the wintering females do not live to produce new broods.

The mode of reproduction found in the colonies in Langsø and Ulvesø is no doubt typical for the North East Greenlandic *D. p.* The observations from other freshwaters only investigated once or twice during the summer season are in good accordance with those from the regular investigations of the above mentioned two lakes.

In Bjørnesø, also on Ellaø, on July 7th (1934) only a few females with subitaneous eggs were observed. On August 18th (1933) only empty females were present in the sample, whereas on October 25th (below the ice) several ephippial females as well as empty ones were found. The colony thus propagates by means of subitaneous eggs in July, there seems to be a stop in the propagation during August and later—at any rate in October—the propagation by resting eggs is in full swing.

We shall now proceed to consider some freshwaters investigated only once during the season. From ponds near Hurry Fjord in Scoresby Sound (on 70°30′ N. Lat.) some samples from August 1933 are at hand. The following observations were made. Pond D, August 7th (Tab. 2). There are three size groups viz.: 1) young, hatched from summer eggs with a mean length of 0.85 mm (0.73—1.00), 17 spec.; 2) females both ephippial and empty ones of a mean length of 1.75 mm (1.53—2.07), 107 spec., and 3) females, both empty, with subitaneous eggs, or with

Tab. 2. Various Colonies of *Daphnia pulex*. Measurements (in units of micrometer scale) of the total length without the spine. Each individual measured is indicated by a letter: y = youngs or empty females, s = females with subitaneous eggs or youngs in the brood pouch, e = ephippial females.

Locality		Pond near Kap Stosch	Pond near Kap Stosch	Pond D Hurry Fjord	Pond I Hurry Fjord
Data		$^1/_8$-1930	$^3/_8$-1930	$^7/_8$-1933	$^{14}/_8$-1933
Units	mm				
11	..	...	...	yy	...
12	0.80	...	...	yyyyyyyy	....
13	..	yy	...	yyy	...
14	0.93	yy	...	yy	...
15	..	...	...	yy	...
16	1.07	...	...	...	y
17	..	...	...	...	y
18	1.20	...	...	...	yyy
19	..	y	yy	...	yyyyyy
20	1.33	y	yyyyy	...	yyyyyyyyyyy
21	..	yy	yy	...	yyyyyy
22	1.47	yyyyyeeeeee	yyyyyyyy	...	yyyyyyyyyyyyyy
23	..	yyyyyeeeeeeeeeeeee	y	yye	yyyy
24	1.60	eeeeeeeeeeeee	y	yyyeeeeeee	yyyyyee
25	..	yeeeeeeee	...	yyyyyeeeeee	yyyyyyyyeeeee
26	1.73	yeeeeee	...	yyyyyyyyyyyyyyyeeeeeeeeee	yyyyyyyyeeeeee
27	..	yeeeeeee	ye	yyyyyyyyyyyyyyyyyyyyyeeeeeeee	yyyyyyyyyyeeeeeeeeee
28	1.87	eee	yyyee	yyyyyyyyyyyyye	yyyeee
29	..	e	yyyyyyeeee	yyyyyyeee	y
30	2.00	eeee	yyyyyyye	yyyye	...
31	..	ee	yyyyyye	ye	...
32	2.13	ee	eeeeee	...	...
33	..	eeeee	eeeeeeeeeeee	yy	...
34	2.27	eeee	yeeeeeeeeee	e	yy
35	..	eee	eeeeeeeeee	sse	y
36	2.40	eeeeeeeeee	eeeeeeeeeeeeeee	see	yys
37	..	eeeeeeeee	eeeeeeeeeeeeeeeeeeee	e	e
38	2.53	eeeeeeeeeeeeeee	eeeeeeeeeeeeeeeeeee	yye	yyyeee
39	..	eeeeeeeeee	eeeeeeeeeeeee	yye	yy
40	2.67	eeee	eeeee	eeeee	...
41	..	eee	ee	eee	yy
42	2.80	...	...	sseee	y
43	..	...	...	yyssse	...
44	2.93	...	...	yys	...
45	..	...	...	ee	...

ephippia of a mean length of 2.70 mm (2.20—3.00), 40 spec. Whereas 59 ephippial females were found, only 9 females with summer eggs were present. It is thus evident that the propagation by means of summer eggs is about to end, just as it was the case in Langsø in the beginning of August. The 2nd size group (mean l. 1.75 mm) represent no doubt the 1st subitaneous broad; as no females with sub. eggs are found in this group it seems evident that the 1st sub. brood does not produce sub. eggs at all, but resting eggs only. The 3rd size group—exephippio ♀—produces first sub. eggs and then ephippia. The population in pond I, Hurry Fjord on August 14th (see Tab. 2) is in much the same state;

Y.-youngs, ♀-empty females, ♀-fem. w. sub.-eggs, ♀-ephip. fem., ÷-no spec. obs.

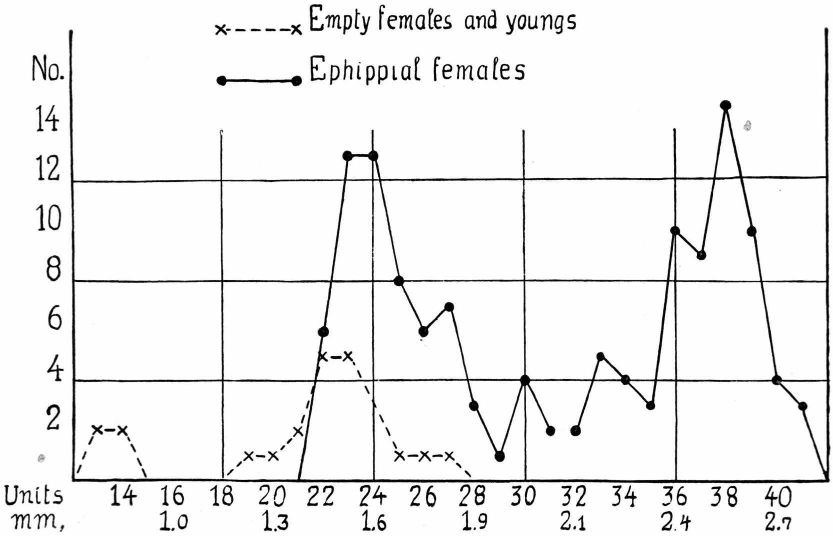

Fig. 5. The size of youngs, empty, and ephippial females. Pond at Kap Stosch, $^1/_8$-1930.

here only one female with sub. eggs—in the ex-ephippio group—was observed among a large number of empty or ephippial females. Among the 1st sub. brood ephippial ♀ only were found. In pond J. Hurry Fjord, August 14th no females with sub. eggs were observed, in all other respects the colony was in the same state of reproduction as the colonies in pond D and I: A number of young and two size-groups of older specimens, both groups containing ephippial females.

Another series of samples (Tab. 2) taken in the beginning of August 1930 in the neighbourhood of Kap Stosch (ca. 74° N. Lat.) show quite the same as to the mode of reproduction. In a shallow pond on August 1st (see fig. 5) young and two size-groups of older specimens were observed, in the two older size-groups ephippial (or empty) females were present; no females with sub. eggs were found. In another pond, from which a sample was taken on August 3rd, the case was just the same: Young and two—not clearly seperated—size-groups of older individuals; in the smaller of these size-groups both empty and ephippial females were found, in the larger one, however, ephippial females only. The above mentioned samples from the first half of August show that the propagation by means of sub. eggs does not last further than to the beginning of August. This observation is in good accordance with the results of the fortnightly samplings in Langsø.

The main observations concerning the mode of reproduction are as follows: 1. Males do not occur, and thus the propagation is purely parthenogenetical. 2. The propagation is monocyclic. Sub. eggs are produced in July and in a far lesser degree in the first half of August. The production of resting eggs and ephippia may begin in the latter half of July, but as a rule it does not occur until August, and sometimes not before September, in that case there seems to be a period in August where neither sub. eggs nor resting eggs are produced; the individuals found during this time all being empty. 3. The propagation by means of resting eggs may last for a very long time through the whole of the winter until the beginning of March. 4. The number of sub. eggs is generally small, up till 11 in the beginning of July and only 1—3 in the beginning of August. 5. Only the ex-ephippio-generation produces sub. eggs. All other generations and broods produce resting eggs only. 6. The wintering females may live until the spring (April—June).

Size and Growth. Neither P. Haberbosch nor Wesenberg-Lund have published anything about the size of the Greenlandic *D. pulex*. According to the present material (see fig. 5 and 6) the mature specimens generally have a size (total length ÷ the spine) of 2.0 mm. The largest specimens observed (an ephippial female) had a tot. l. of 3.00 mm (including the spine 3.27 mm). Olofsson in Spitzbergen has found a tot. l. up to 3.29 mm; as means of the total length he gives sizes from 2.0—3.0 mm. Thus it seems as if the Spitzbergen *D. pulex* reaches a somewhat larger size than those from N. E. Greenland. Brehm (1912) however mentions that *D. pulex* in Greenland may reach a size of 5.0 mm. As in the present, large material specimens larger than 3.3 mm never have been observed, it must be very exceptionally only that the Greenlandic specimens reach a size of 5 mm. Kaj Berg (1931) found in spring in Denmark some individuals of a size between 3 and 4 mm. He further gives some measurements of *D. pulex* from the winter months. In the following survey I have given his figures together with the measurements from East Greenland (the measurements are in mm, the spine excluded):

	March	April
Denmark........	2.46	2.85
E. Greenland	2.23	2.27

The spring specimens from Denmark is thus somewhat larger than those from East Greenland; this is no doubt due to the fact that the conditions of nourishment is better during the winter in Denmark than in North East Greenland. In the autumn, however, the usual size of the species in Denmark is 2.0 mm i.e. just the same as in North East Greenland. Thus there is hardly any difference at all as to the rate of growth of *D. pulex* in the temperate Denmark and the arctic Greenland.

In early summer when the colony awakes to the new life the growth is very rapid. This appears clearly from the fortnightly samplings in Langsø (see Tab. 1). In the period from April 17th to June 12th no specimens at all were found in the samples. On the June 29th however two size-groups are represented in the sample. The smallest size-group had a mean length (without the spine) of 0.85 mm (0.73—1.07), the larger 1.90 mm (1.87—2.00). The specimens of the smaller size group were light coloured, only very few were slightly dark tinted; the specimens of the larger size group were, however dark coloured especially on the neck and the dorsal part of the carapace. As no females with eggs or young in the brood pouch were observed the individuals of both these size groups must have been hatched from the ephippia. The smallest are those newly hatched, the others have obviously already passed through one moulding. On July 10th we still have a size group of newly hatched individuals of a mean length of 0.89 mm (0.73—1.07), besides there is a size group of empty females of about 1.9 mm and another of females with eggs or young in the brood pouch and with a mean length of 2.42 mm (2.00—2.67). The smallest size group consists obviously partly of young hatched from the ephippia and partly of young hatched from the sub. eggs of the largest size group. The young can be separated in these two groups by their colour: the lightcoloured hatched from the ephippia and the dark coloured hatched from the sub. eggs. That there besides the various colouration is a real difference between these two groups appears from a consideration of the length of the spine (see the table below):

July 10th, 1934 (measurements in units of micrometer-scale):

light coloured young:				dark coloured young:			
Tot. l.	sp. l.	mean sp. l.	sp. l. in % of tot. l.	Tot. l.	sp. l.	mean sp. l.	%
13	4-5-6	5.0	38.5	11	7-8	7.5	68.2
14	5-5-6	5.3	37.9	12	7-7	7.0	58.3
				13	8-9	8.5	65.4
16	6	6.0	37.5	15	7	7.0	46.7
mean of all specimens........			38.2 %	mean of all specimens			60.9 %

In the lightcoloured ones the spine is 38.2 % of the total length, in the dark coloured ones however no less than 60.9 %. The young from June 29th were lightcoloured, and although some of them had a slight dark tint no truly dark coloured young were observed; the length of the spine in these young was as follows:

Tot. l.	sp. l.	mean sp. l.	sp. l. in % of tot. l.
11	3-4-4-4-4	3.8	34.5
12	4-4-4-4-4-4-5-5-5	4.3	35.8
13	4-4	4.0	30.8
14	..	..	..
15	5	5.0	33.3
16	5	5.0	31.3
mean of all specimens			35.3 %

Thus the lightcoloured young from July 10th have about the same percentic spine length (38.2 %) as those caught on June 29th and undoubtedly hatched from ephippia (35.3 %). It is therefore resonably to suppose that of the young from July 10th the lightcoloured ones are hatched from ephippia whereas the dark coloured ones are hatched from the summer eggs. In the same direction points the fact that later on in the season when the production of sub. young is in full swing, f.i. on July the 23rd (1934) and August 8th (1933), dark coloured young are found only. Further observations concerning the question of the light- and dark coloured spec. are given elsewhere (ERIK M. POULSEN 1940).

Returning to the question of the growth it is obvious that at any rate not earlier than in the beginning of June the ephippia are hatched, and that already on July the 10th, in the course of about 3—4 weeks the ex-ephippio young have grown up to a mean size of 2.4 mm (and to a maximum size of 2.7 mm) and are now propagating by means of sub. eggs. When we look upon the samples from July (Tab. 1) it is clear that we have in the main two size groups: the young of which the main part is hatched from sub. eggs and a smaller part only from ephippia, and the older ones hatched from ephippia and now propagating by means of sub. eggs; besides there are very few specimens of an intermediate size (hatched either from ephippia or summer eggs). In August there are two size groups, a smaller one with a mean length of 1.3 mm (1.0—1.8) and a larger one of 2.5 mm (2.1—2.9). The size group of smaller specimens is apparently made up of the young hatched from the summer eggs during July (the 2nd generation), whereas the larger size group consists of the individuals hatched from the ephippia in June (the 1st generation). The measurements (see Tab. 1) do not show any growth of the specimens of the 1st generation during the latter part of the summer (August—September), this may however be caused by the dying away of the older and larger ones during this season. In the course of September the 1st generation disappears completely and the colony now consists of individuals hatched from the sub. eggs (the 2nd and perhaps 3rd generation). The specimens hatched from the sub. eggs (see fig. 6) grow considerably through the months July-November (also after the beginning of the production of ephippia). For the various months the following mean lengths were observed:

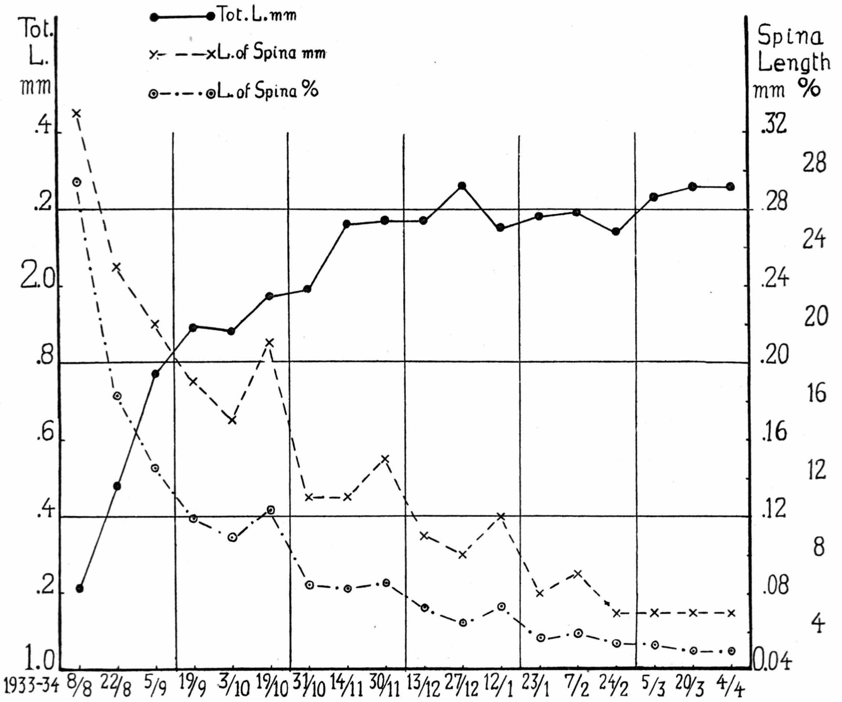

Fig. 6. Langsø, Ellaø, growth of the 2nd generation; the varying length of the spine, actual and in percent of the total length.

July	($^{23}/_{7}$-1934)	0.91 mm	(9 spec.)
Aug.	(1933)	1.42 mm	(70 —)
Sept.	(1933)	1.83 mm	(22 —)
Oct.	(1933)	1.97 mm	(40 —)
Nov.	(1933)	2.15 mm	(38 —)
Dec.	(1933)	2.21 mm	(78 —)
Jan.	(1934)	2.17 mm	(90 —)
Febr.	(1934)	2.18 mm	(45 —)
March	(1934)	2.22 mm	(26 —)

From these measurements it is further clear that—as already mentioned—there is no growth during the winter (December—March).

The observations from Langsø can be supplemented with some few from another lake on Ellaø viz. Ulvesø, from where samples have been taken in September, November, April, May and June. The population in this lake is rather scarce, and only empty females have been observed (see p. 20), the mean length for the various months were as follows:

14th Sept. (1933)	2.07 mm (4 spec.)[1]
1st and 21st Nov. (1933)	2.47 mm (15 —)
18th April (1934)	2.51 mm (18 —)
15th May (1934)	2.54 mm (11 —)
7th June (1934)	2.53 mm (3 —)

Also in this water *D. p.* grows rather well during the autumn from September to November, whereas there is no growth—or at any rate—only a very little one from November and right until June when the wintering females die away. The figures further show that *D. p.* in this lake attains a considerably larger size than in Langsø.

From the above mentioned measurements it is seen firstly that the arctic *D. p.* of East Greenland has the same growth and during the summer reaches the same size as the *D. p.* of more southern latitudes, and secondly that the wintering specimens in Greenland do not grow during the last part of the winter, this being however the case with the wintering specimens of the more southern localities. Finally it is of interest to note that a not inconsiderable growth takes place during the first half of the winter from September to December, at a time when the waters are ice- and snowcovered.

Through the measurements of the size of the individuals from various samples it should be possible to investigate how many generations and broods the colonies produce yearly. In Langsø (Tab. 1) thus the ex-ephippio generation propagates by means of subitaneous eggs producing a 2nd generation comprising 1 or 2 broods. As the period of sub. propagation is very short-lasting, and never two distinct size groups of females hatched from sub. eggs are observed it seems to be obvious that a 3rd generation is not produced; the resting eggs are produced partly by the 1st and partly by the 2nd generation, this generation producing resting eggs only (cfr. the samples from September the 5th and the 19th). As the propagation by means of ephippia lasts for a long time it must be assumed that several broods of resting eggs are produced; the course of the reproduction is shown in fig. 7. The measurements from Kap Stosch (August 1st) and from waters at Hurry Fjord in the beginning of August, with two size groups of eph. ♀ seem to

---

[1] The length of these specimens were: 1.00, 2.20, 2.47 and 2.67 mm.

indicate the same course of the production which no doubt must be assumed to be the rule in East Greenland. The course of the production is thus about the same as that prevailing in Spitzbergen, where (after OLOFSSON) as a rule 2 generations are produced both producing ephippia towards the end of the season.

OLOFSSON has shown that in the ephippia from Spitzbergen the ventral edge of the valves remains upon the ephippia when these are thrown off; this phenomenon is not known from any southern countries. To a certain degree it is however the case with the ephippia from East Greenland. In the samples from the autumn from Langsø the ventral edges of the valves are as a rule attached to the loose ephippia and often parts of the shell too. The edges of the valves form two strings which are attached to the ephippium at the base of the spine; to the free ends of these strings is often attached a triangular piece formed by that part of the shell which is situated just in front of the ephippium. In the autumn the ephippia often form small clusters in which the single ephippia are hold together by their strings. In spring and early summer ephippia may be found still with such strings attached to their hind margin, but as a rule the ephippia found in this season of the year has no strings. It must therefore be assumed that such ephippia have lost their strings during the intervening period.

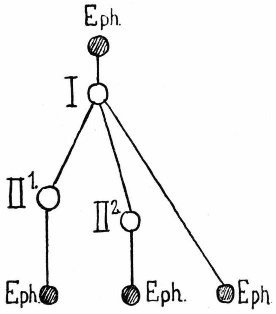

Fig. 7. The course of the reproduction of the East Greenlandic *Daphnia pulex.*

Seasonal variation. Seasonal variation in colonies of *Daphnia pulex* is a well known fact; the length of the rostrum and the convexity of the lower margin of the head may vary, but the most pronounced seasonal variation occurs as to the length of the spine of the carapace. O. OLOFSSON (1918) in his studies of the *D. pulex* of Spitzbergen has treated the seasonal variation in the length of the spine very thoroughly. For his investigation, however, material was at hand from the summer season only, the months July and August. Due to the samplings carried out by the Three Years Expedition to Kong Christian X's Land we have now got a material not only from a couple of months during the summer season but from every month of the year. Therefore we are able to investigate the seasonal variations of the arctic colonies of *D. pulex* throughout the whole year. As the most conspicuous seasonal variation is found regarding the length of the spine this form of seasonal variation shall be dealt with firstly, and as the samplings were carried out most regularly, i.e. every fortnight, in the lake Langsø we shall begin with the colony of this lake.

During spring—from April 17th—June 12th—no specimens were observed in the samples. On June 29th (1934) *D. p.* had reappeared; on this day a number of young hatched from ephippia (see p. 25) were found. The length of the spine of these young of which a few were somewhat larger than the main bulk appears from the following table:

Tot. length		length of spine of the single individuals, units	mean length of spine		
units	mm		units	mm	$^0/_0$ of tot. l.
11	0.73	3-4-4-4-4	3.8	0.25	34.5
12	0.80	4-4-4-4-4-4-5-5	4.3	0.29	35.8
13	0.87	4-4	4.0	0.27	30.8
15	1.00	5	5.0	0.33	33.3
16	1.07	5	5.0	0.33	31.3
27	1.80	4-4	4.0	0.27	14.8
28	1.87	5-5	5.0	0.33	17.9
29	1.93	5	5.0	0.33	17.2

It appears from the table that the newly hatched ex-ephippio young have a spine which in length is abt. 35 $^0/_0$ of the total length. The few larger and older young have a spine only little larger than that of the smaller and younger ones; the percentic length of the spine is only 15—18. On July the 10th the propagation by means of subitaneous eggs has begun and we find, as already mentioned (p. 25), two forms of young, one light coloured just as the ex-ephippio young from June 29th and another dark coloured; the length of the spine is quite different in these two forms:

Tot. length		Light coloured young				dark coloured young			
		sp. l.	sp. l. mean		sp. l. in $^0/_0$ of tot. l.	sp. l.	sp. l. mean		sp. l. in $^0/_0$ of tot. l.
units	mm	units	units	mm		units	units	mm	
11	0.73	..	..	..	..	7-8	7.5	0.50	68.2
12	0.80	..	..	..	..	7-7	7.0	0.47	58.3
13	0.87	4-5-6	5.0	0.33	38.5	8-9	8.5	0.56	65.4
14	0.93	5-5-6	5.3	0.35	37.9	..	..	..	..
15	1.00	..	..	..	..	7	7.0	0.47	46.7
16	1.07	6	6.0	0.40	37.5	..	..	..	..

We shall first consider the lightcoloured, ex-ephippio, young. The sp. l. varies between 4 and 6 units, its percentic length between 37.5 and 38.5. The spine is thus a little longer than in the ex-ephippio young from June 29th (31—36 $^0/_0$). In the dark coloured—ex-sub. egg—young the spine is considerably longer than in the ex-ephippio young; in the former 47—68 $^0/_0$, in the latter 38—39 $^0/_0$ only.

Still considering only the young the sample from July the 23rd contains dark young only, i.e. only young hatched from the sub. eggs. The spine lengths of these young were as follows:

Tot. length		sp. l.	mean sp. l.		sp. l. in $^0/_0$ of tot. l.
units	mm		units	mm	
12	0.80	5	5.0	0.33	41.7
13	0.87	6-6-7-7	6.5	0.37	50.0
14	0.93	7	7.0	0.47	50.0
15	1.00	6	6.0	0.40	40.0
16	1.07	6-7	6.5	0.37	41.9

The percentic length of the spine varies between 40 and 50 $^0/_0$; thus the spine is little shorter than on July 10th. On August 8th (1933) there is in the sample some young a little larger than those from July (1934), their mean $^0/_0$ sp. l. varies between 31 and 33 $^0/_0$; the actual sp. l. is 0.33 mm or somewhat smaller than in the specimens from July. When we compare these observations regarding the sp. l. of newly hatched young from June—August we get the following survey:

	$^{29}/_{6}$-1934	$^{10}/_{7}$-1934	$^{23}/_{7}$-1934	$^{8}/_{8}$-1934
	Ex-ephippio (17 spec.)	Ex-ephippio (7 spec.)		
tot. l. mm . .	0.81 (0.73—1.07)	0.93 (0.87—1.07)		
sp. l. mm. . .	0.27 (0.20—0.33)	0.35 (0.27—0.40)		
sp. l. in $^0/_0$ of tot. l.	33.3	37.6		
		Ex-sub. eggs (7 spec.)	Ex-sub. eggs (9 spec.)	Ex-sub. eggs (8 spec.)
tot. l. mm . .		0.82 (0.73—1.00)	0.91 (0.80—1.07)	1.10 (1.00—1.13)
sp. l. mm. . .		0.50 (0.47—0.60)	0.42 (0.33—0.47)	0.33 (0.27—0.47)
sp. l. in $^0/_0$ of tot. l.		60.9	46.1	31.8

In the ex-ephippio young the sp. l. increases a little from June 29th to July 10th. As the temperature is rising from June 29th to July 10th this observations tends to show that the young hatched when the temperature is low have a shorter spine than those hatched at comparatively high temperatures. A comparison between the ex-ephippio and ex-sub. egg young from July 10th shows—as already mentioned—that the sp. l. is much greater in the latter than in the former ones. As there is every reason to suppose that of the young hatched at the same time, those hatched from ephippia have had a more long lasting development than those hatched from sub. eggs and, therefore—at this season—have developed partly at a lower temperature than the latter, this observation also bears evidence to the fact that the length of the spine increases by increasing temperatures during the development. Comparing the measurements of the ex-sub. egg young from various dates it is seen that the total length of the young increases during the season (July 10th 0.82 mm, 23rd 0.91 mm and August 8th 1.10 mm), but simultaneously the (actual) length of the spine decreases from 0.50 mm on July 10th to 0.42 on July the 23rd and to 0.35 mm on August 8th. The percentic figures for the 3 data are: 60.9, 46.1 and 31.8. The increase of the length (size) of the newly hatched young from July 10th—August 8th is no doubt connected with the decrease in number of eggs in each brood during the same period as it must be supposed that the nourishment available for each egg is in negative correlation with the number of eggs in the broods. On July 10th the mean number of eggs or youngs in the brood pouch is 6.2 (varying between 2 and 11), on July 23rd it is 2.5 (1-5) and on August 12th 2.0 (1-4). The samples from Hurry Fjord 1933 shows just the same; here pond D is investigated on August 8th and pond J on August 14th. The size and spine length of the young were as follows:

	$^{8}/_{8}$ (9 spec.)	$^{14}/_{8}$ (11 spec.)
Tot. length	0.88 mm (0.80—1.00)	0.96 mm (0.73—1.13)
sp. l.	0.40 mm (0.33—0.53)	0.32 mm (0.27—0.40)
sp. l. % of tot. l.	45.5 %	33.3 %

Thus there is in this case a clear increase in the size of the young and a decrease in the spine length from August 7th to August 14th. As the temperature is falling from July to August the decrease in the length of the spine shows that at falling temperatures also the length of the spine is in positive correlation with the temperature.

Concerning the *Daphnia pulex* on Spitzbergen O. OLOFSSON (l.c.) has found that: "Die Individuen, die ihre Embryonalentwicklung bei einer niedrigen Temperatur durchgemacht haben, haben eine kürzere, die welche sie bei einer höheren Temperatur durchgemacht haben, eine längere Spina." This conclusion is based on investigation of the spina length in grown up specimens not in young. The present investigation based directly on the newly hatched young confirms OLOFSSON's view as far as there is observed an increase in the spine length in the newly hatched young from June to the middle of July and a decrease during July and August.

Before proceeding to consider the seasonal variation of the spine on a whole we shall try to elucidate the variation of the spine length during the life of the individual. As of course in a material as the present it is impossible to follow one and the same individual through its life time we shall try to single out a certain brood and consider this brood from one sample to another of the Langsø material. From tab. 1 (p. 16) it is clear that the newly hatched brood of sub. young with a length of 1.1—1.3 mm from August 8th 1933 can be followed through the rest of the year and until the end of March next year. In fig. 6 (p. 27) are given curves showing the variation of the total length, the actual spine length and the spine length in $^0/_0$ of the total length of this brood from August 8th 1933—April 4th 1934. The figure shows clearly that not only the percentic but also the actual length of the spine decrease steadily through the whole period both in the season (August—November) when the individuals are growing and in the season (November—April) when no growth takes place. The decrease in the spine length is most rapid at the time (August—September) when the individual growth is strongest. The young from the beginning of August have a mean sp. l. of 0.33 mm. In the end of September and the beginning of October when the propagation by means of resting eggs is in full swing the mean sp. l. is 0.19 mm. In the middle of November when the individual growth has stopped the sp. l. is reduced to 0.14 mm. Finally in March next year, at the end of the life of the said brood the sp. l. is 0.07 mm only; at this time of the year specimens can be found which have no spine at all. During the season in question (August—March) the mean percentic spine length falls from 27 to 3 $^0/_0$. These observations from Langsø can be supplemented with the following observations from Ulvesø, where the hibernating individuals were observed right until the beginning of June:

	Tot. l. mm	length of spine		No. of spec.
		mm	$^0/_0$	
$^{14}/_{9}$ -1933........	2.07	0.27	13.0	4
$^{1}/_{11}$ -1933........	2.33	0.21	9.0	12
$^{21}/_{11}$ -1933........	2.53	0.15	5.9	15
$^{18}/_{4}$ -1934........	2.47	0.12	4.9	14
$^{15}/_{5}$ -1934........	2.60	0.12	4.7	11
$^{7}/_{6}$ -1934........	2.53	0.08	3.2	3

In this case too a gradual decrease of the spine length is found through the whole of the period from September to June; it is of special interest to note that a clearly pronounced decrease is found during the spring (April—June), when a fall in the temperature of the water cannot be expected.

Before discussing the results of these observations regarding the variation of the spine length in specimens hatched from sub. eggs (the 2nd generation), the variations in the spine length of the ex-ephippio specimens (the 1st generation) shall be dealt with. From the table below it is seen that the newly hatched ex-ephippio young (June 29th 1934) have a mean sp. l. of abt. 0.28 mm, the percentic sp. l. being abt. 31—35 $^0/_0$. On July 10th these young have grown up to a mean size of 2.33 mm (var. 1.87—2.60), the mean sp. l. is now 0.31 mm or 13.3 $^0/_0$. On July 23rd the mean tot. l. is 2.27 mm (1.93—2.67), the mean sp. l. is 0.18 mm or 7.9 $^0/_0$. On August 12th the mean tot. l. is 2.39 mm (2.13—2.67) the mean sp. l. is 0.13 mm or 5.4 $^0/_0$. In order to follow these ex-ephippio individuals further in the season we must go back to the preceding year when the fortnightly investigations started on August 8th. For the four samples taken until the ex-ephippio specimens disappear towards the end of September the following figures are found; for the sake of comparison the above cited figures for the year 1934 are set down too.

Date..........	$^{29}/_{6}$-1934	$^{10}/_{7}$-1934 1)	$^{23}/_{7}$-1934 1)	$^{8}/_{8}$-1933
Tot. l. mm.....	0.81 (0.73—1.07)	2.33 (1.87—2.60)	2.27 (1.93—2.67)	2.41 (1.93—2.86)
sp. l. mm......	0.28 (0.20—0.33)	0.31 (0.13—0.53)	0.18 (0.13—0.27)	0.15 (0.13—0.20)
sp. l. in $^0/_0$ of tot. l.	34.6	13.3	7.9	6.2
No. of spec....	18	70	40	17

Date..........	$^{12}/_{8}$-1934	$^{22}/_{8}$-1933	$^{5}/_{9}$-1933	$^{19}/_{9}$-1933
Tot. l. mm.....	2.39 (2.13—2.67)	2.47 (2.33—2.60)	2.50 (2.20—2.80)	2.42 (2.20—2.60)
sp. l. mm......	0.13 (0.13)	0.13 (0.13—0.20)	0.12 (0.07—0.20)	0.11 (0.07—0.20)
sp. l. in $^0/_0$ of tot. l.	5.4	5.2	4.8	4.5
No. of spec....	13	8	8	8

It is of interest to note that the sp. l. of the ex-eph. generation is reducted almost as much as that of the sub. generation, to 0.11 mm (4.5 $^0/_0$) in the former against to 0.07 mm (3 $^0/_0$) in the latter. On the same date September 19th the sp. l. of the two generations is differing considerably: Ex-eph. gen. tot. l. 2.42 mm, sp. l. 0.11 mm (4.5 $^0/_0$), ex-sub. gen. tot. l. 1.90 mm, sp. l. 0.19 mm (12 $^0/_0$). As the two generations must be assumed to require the same floating capacity the different sp. l. tends to show that the spine is of little importance only as a floating organ (see p. 41).

According to the figures the actual sp. l. of the ex-ephippio specimens does not—as it is the case with the ex-sub.-eggs spec.—decrease in the

---

1) The young excluded.

Tab. 3. Total length and length of spine of *Daphnia pulex* from a pond at Kap Stosch on August 1st, 1930 (15 units = 1 mm).

Total length units	Spine length of the single individuals, units	Mean of sp. l. units		
19	6	6.0	youngs	
20	5	5.0		
21	5-5	5.0		
22	3-3-4-4-4-4-4-5-5-5	4.1	small spec.	
23	3-3-3-3-3-3-3-3-4-4-4-4-4-4-5-5-6-6	3.9		of 1. size-gr.
24	3-3-3-3-3-4-4-4-4-4-4-4-4	3.6		
25	3-3-4-4-4-4-4-5-7	4.1		
26	3-3-4-5-5-5-8	4.9	large spec.	
27	5-5-5-6-6-7-7-7	6.0		
28	4-5-6	5.0		
29	6	6.0		
30	1-2-2-3	2.0	small spec.	
31	1-2	1.5		
32	2-2	2.0		
33	2-2-2-2-3	2.2		of 2. size-gr.
34	2-2-2-3	2.3		
35	2-3-3	2.7		
36	1-2-2-2-3-3-3-3-3-3	2.5	large spec.	
37	2-2-2-3-3-3-3-3-3	2.7		
38	1-2-2-2-2-2-2-3-3-3-3-3-3-3-3	2.5		
39	2-2-2-3-3-3-3-3-4	2.8		
40	2-3-3-3-3	2.8		
41	3-3-3	3.0		

time when the individual growth is the strongest, the mature spec. have the same sp. l. as the young; but from the latter half of July and onwards until the end of September, when the ex-ephippio individuals disappear the actual sp. l. decreases rapidly (from 0.3 to 0.1 mm). The percentic sp. l. of course decreases through the whole of the period.

From the preceding it is apparent that within the same population on the same date the youngest individuals have the longest spine, i.e. the older the individual is the smaller is the spine, thus the variation of the spine length is in correlation with age; in this connection however the question arises it the variation of sp. l. is in correlation with size too, i.e. if within specimens of the same age there is any correlation between the total length and the spine length; this question can be answered by an examination of the spine length of individuals within the same size group.

In tab. 3 is shown the total length (units) and the corresponding sp. l. (units) of the specimens from Kap Stosch, August 1st. The specimens

Tab. 4. Length of spina of *Daphnia pulex* from various colonies. (The large figures denote the mean spina length, the small figures the number of specimens from which the mean has been calculated.)

Tot. length of individuals, units	11-13	14-16	17-19	20-22	23-25	26-28	29-31	32-34	35-37	38-40	41-43	44-46	No. of spec.
Kap Stosch, $^{1}/_{8}$-1930	..	..	6.0 1	4.4 14	3.9 49	5.3 18	2.4 7	2.2 11	2.6 22	2.4 33	3.0 3	..	158
Kap Stosch, lake, $^{3}/_{8}$-1930	..	..	..	..	4.0 1	5.0 2	4.4 12	3.5 2	3.5 4	..	4.0 2	..	23
Kap Stosch, pond, $^{3}/_{8}$-1930	..	..	5.0 2	5.3 16	5.5 2	1.2 5	1.0 21	1.6 29	2.1 45	2.5 36	2.5 2	..	158
Pond D, Hurry Fjord, $^{7}/_{8}$-1933	6.0 5	6.0 4	..	..	5.5 24	5.8 68	6.7 15	4.3 3	4.2 5	3.5 11	4.0 12	4.0 4	153
Langsø, $^{8}/_{8}$-1933 ...	..	5.0 1	5.0 22	4.5 6	4.0 5	2.5 2	3.0 2	2.0 4	2.0 2	2.3 3	2.4 5	..	52
Langsø, $^{12}/_{8}$-1934...	..	..	3.5 2	3.6 5	3.0 4	..	..	2.0 2	2.0 2	2.0 2	..	..	17
Pond I, Hurry Fjord, $^{14}/_{8}$-1933	..	3.0 1	3.8 10	3.5 27	3.9 21	3.7 34	6.0 1	..	2.7 3	2.7 8	2.7 3	..	108
Pond J, Hurry Fjord, $^{14}/_{8}$-1933	4.9 10	4.8 8	5.0 1	5.9 7	5.9 25	5.4 80	5.6 9	3.3 9	3.8 6	3.5 2	..	..	157
Moskusoksefjorden, lake, $^{15}/_{8}$-$^{17}/_{8}$-1930	..	..	..	5.0 2	4.5 9	2.3 20	2.4 32	3.0 1	..	..	..	..	64
Bjørnesø, $^{18}/_{8}$-1933 .	..	..	..	..	..	..	..	2.9 9	4.0 1	3.0 1	..	..	11

fall in two size groups (a part from the newly hatched ones); it is clear from the table that within each size group the smaller individuals have the shortest spine and the larger individuals the longest spine. Of some other samples, from which a large number of spec. were measured the measurements have been set down in the same way; the results (in units, 15 units = 1 mm) were as follows, no. of spec. in ():

	1st size group		2nd size group		3rd size group	
	small	large	small	large	small	large
Kap Stosch, $^{1}/_{8}$ (see the table)	3.8 (47)	—5.5 (18)	2.2 (20)	—2.6 (51)		
Kap Stosch, $^{3}/_{8}$	5.1 (10)	—5.5 (10)	1.4 (63)	—2.5 (75)		
Pond D, Hurry Fjord, $^{7}/_{8}$...	6.0 (5)	—6.0 (4)	5.7 (50)	—6.2 (59)	3.1 (16)	—3.6 (16)
Pond J. Hurry Fjord, $^{14}/_{8}$ ..	4.9 (10)	—4.8 (9)	5.6 (53)	—5.5 (67)	3.2 (11)	—4.1 (7)

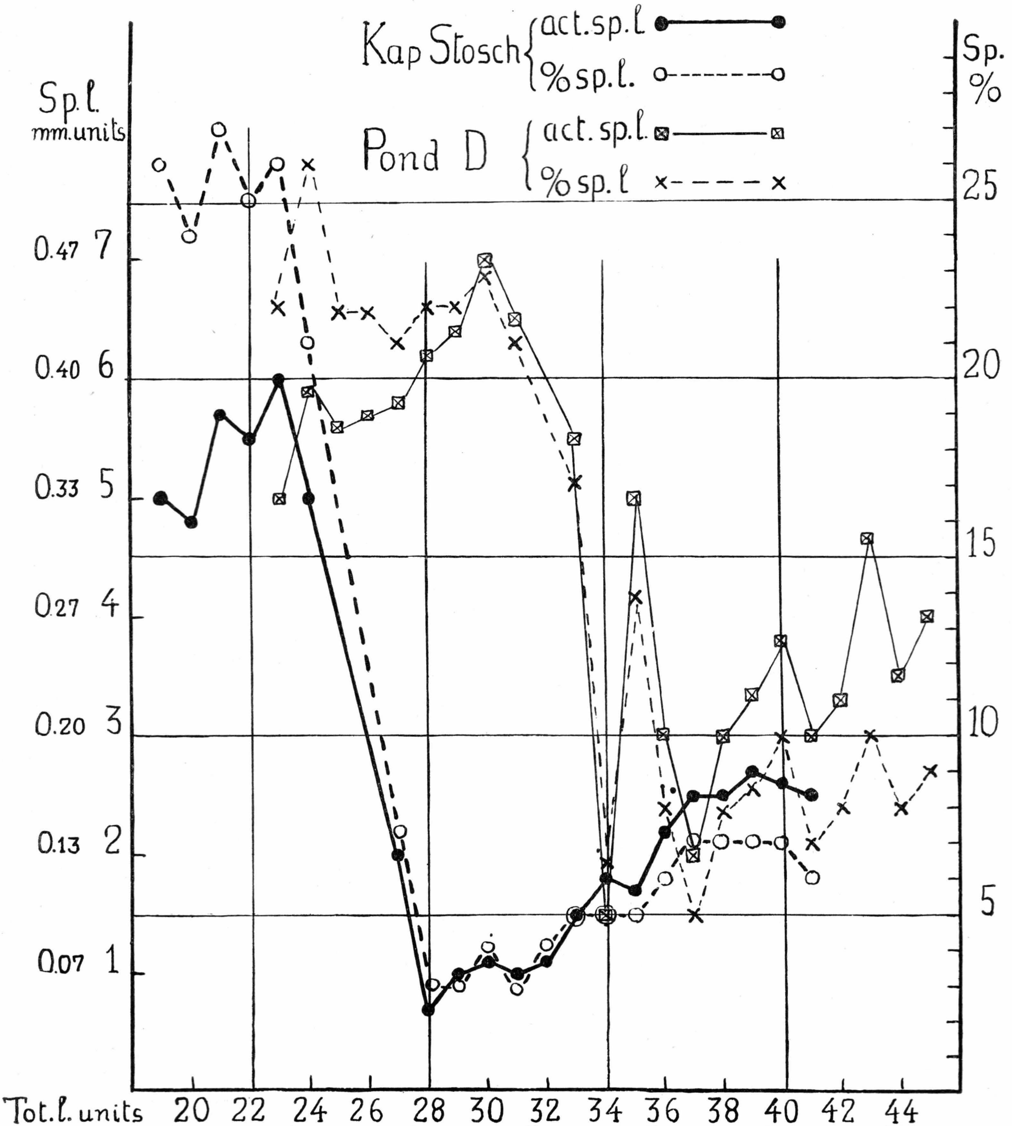

Fig. 8. The actual and percentic length of the spine of specimens from pond D, Hurry Fjord, 7/8-1933 and pond at Kap Stosch, 3/8-1930.

From this table it is seen that within the same size group in most cases (7 out of 10) the larger individuals have a longer spine than the smaller ones. Thus the variations in the spine length is not connected with the size but with the age of the specimens.

The length of the spine and its seasonal variation is about the same in the different East Greenlandic colonies. Small variations from one locality to another can however be observed. In order to investigate the question regarding local variations in the spine length I have in tab. 4 compared some samples taken at about the same season of the year, the first half of August. From the figures it is obvious that there is only little difference as to the length of the spine within the same size groups. Only the sample from pond D (and to a minor degree pond J), Hurry Fjord, shows for all size groups a longer spine than any of the other colonies; both the younger and the older specimens have the spine 1—2 units longer than in the other samples, 4—6 units against 2—5 units. On the other hand the sample from a pond at Kap Stosch August 3rd has for the intermediate size group a spine far shorter than in the other samples. In fig. 8 the spine length of these two extreme samples is shown.

The above cited observations as to variation in the spine length of the East Greenlandic *Daphnia pulex* may be summed up in the following points:

1. Within one and the same individual the length of the spine does not increase at all; the longest spine is found among the youngest individuals. In the specimens which grow up in early summer when the temperature is rising (the ex-ephippio generation) the spine has about the same actual length in the newly hatched young as in the grown up specimens; later in summer when the temperature is falling the spine length decreases. In the specimens hatched in the middle of the summer, at a time when the temperature begins to fall the actual spine length decreases steadily from the newly hatched stage and onwards through the life of the individual.
2. The length of the spine of the newly hatched young varies in accordance with the temperature prevailing during the development; the young hatched at the low temperature during the spring have a comparatively short spine, those hatched at the high temperature during mid summer have a longer spine whereas finally those hatched later in the season at falling temperature have a shorter spine.
3. Within one and the same colony the longest spine both actual and percentic is found in the young hatched in mid summer; from this season and onwards the spine length—actual as well as percentic—decreases through the whole life of the colony not only during the late summer, the autumn and the winter but also in the hibernating individuals living in the spring months under the ice.
4. Within one and the same size- or age group the larger individuals have a longer spine than the smaller ones. This tends to show that under otherwise the same conditions the spine length is in positive

correlation with the size of the individuals and obviously with the conditions of nourishment.

5. There is a certain but not very conspicous local variation in the spine length; some colonies having in the main a longer spine than others.

On the whole these observations are in accordance with the results of OLOFSSON's investigations from Spitzbergen. Only regarding the influence of the conditions of nourishment the results differ. OLOFSSON arrived to the result that the conditions of nourishment was of no importance for the variation in the spine length. However the point 4 makes it rather evident that the nourishment may have some influence on the variations in the spine length, as far as is shows that comparatively large—which obviously is the same as well nourished—individuals have a longer spine than the smaller individuals. Further the observation that the spine length of the hibernating individuals decreases in spring, when the temperature of the water cannot be expected to diminish, bears evidence to the effect that the temperature is not the only factor governing the spine length. The hibernating specimens found in spring were not lightcoloured only, but they were quite transparent too and had none or only very little food in the intestine, they were no doubt starving; therefore there is reason to suppose that the very short in some cases nearly lacking spine of these specimens is caused by starvation. The seasonal variation in the length of the spine must therefore be assumed to be governed not by the varying temperature only but by the better or worse conditions of nourishments also.

In his paper on the Spitzbergen-Entomostraca OLOFSSON discusses how far the seasonal variation of the spine is of any importance to the individuals and especially how far the buoyancy theory as it is defined by WESENBERG-LUND holds good for the arctic Daphnia colonies. According to the buoyancy theory the crista and spine of the Daphnids should act as a floating apparatus, and the seasonal variation of the development of the floating apparatus coincide with variations in the specific gravity and viscosity of the water. OLOFSSON arrived to the result that the young hatched during the warmest season, when the viscosity of the water is smallest, have a longer spine than those hatched earlier or later in the season, and that this is in accordance with the buoyancy theory as far as the longer spine should augment the floating ability of the young. In the larger individuals the swimming power is so great that there—according to OLOFSSON—is no need of any buoyancy organs and in accordance with this the spine length is reduced in the grown up specimens.

The observations made on the East Greenlandic material regarding the variations in the spine length is the same as those made on Spitzbergen, yet I cannot follow Olofsson in his conclusions regarding the purpose of the variations. The long spine should help the young to a more slow sinking by increasing the cross section resistance and by retarding the falling back to a vertical position (with the spine downwards). The spine is however only a badly designed organ for retarding this falling back, it is shaped very much like a sword with the edges in a sagittal line and therefore yields as small a resistance against the falling back to a vertical position of the individual as such an organ can possibly do; further it must be supposed that the weight of the spine will act in an opposite direction causing a more rapid falling back to the vertical position, and finally when once the vertical position is attained (with the spine pointing downwards) the spine can be of no value at all as a floating organ. Thus it seems obvious that neither for the young nor for the adult the spine can be of any value as a buoyancy organ. It is thus not possible by means of the buoyancy theory to give any reasons for the covariation between the spine length and the temperature. This does now however exclude that the temperature working on the development of the young within the mother-animal or the ephippium causes the varying spine length of the newly hatched young. It is however possible also that the cause must be sought for among the other factors acting on the individual during its development. Regarding the subitaneous young it is clear that they do not develop under the same conditions through the whole of the season. The following table gives some hints as to the conditions during the development within the maternal brood pouch:

	$^{10}/_{7}$-1934	$^{23}/_{7}$-1934	$^{12}/_{8}$-1933[1]
Mean size of the newly hatched young, mm	0.82	0.91	1.10
Actual spine length (mm)................	0.50	0.42	0.35
Sp. l. in $^0/_0$ of tot. l.	60.9	46.1	31.8
Mean no. of eggs in each brood.........	6	3	2

It is clear from the figures that the size of the newly hatched young increases during the season, whereas the number of eggs decreases. The fact that the young are larger upon hatching when the number of eggs is small and v. v. seems to indicate that the young of the small numbered broods either have got better conditions of nourishment during the development or have stayed for a longer time in the brood pouch thus being older on hatching than those of the large numbered broods. On the preceding pages it has been shown that the spine length decreases

---

[1] As no females with sub. eggs were observed during August 1934, the sample from $^{12}/_{8}$-1934 is used for the comparison.

through the whole life of the individual. Considering this in connection with the above mentioned fact that the young hatched later in the season are larger, and probably older, than those hatched earlier in the season, there seems to be reasons to suppose that the longer spine in the early hatched young are due to the fact that these are smaller and probably younger than the later hatched ones which have a shorter spine. Thus the seasonal variation of the spine length of the newly hatched young is only a consequence of the above established fact that the spine decreases through the whole of the individual life. On the present material this explanation of the seasonal variation in the spine length of the newly hatched young cannot be tested; to this effect a larger material and experimental work are needed.

At any rate it is quite clear that the spine length is longest at the time when the individual is born, then being in mean ca. 50 $^0/_0$ of the total length, and that it decreases in length through the whole life of the individual[1]), being in the oldest individuals—the hibernating females—a small protuberance of the hind margin, some few (3—4 $^0/_0$) of the total length only. If the spine is of any value to the individuals of the arctic colonies of to day, it must be assumed to be at the period when it is best developed, i.e. at the time of the hatching or immediately afterwards. We have seen that it is rather doubtful if it has any value to the young as a buoyancy organ. It could however be supposed that it serves a purpose during the act of hatching. In the resting eggs where the whole development is gone through within an egg-membrane it is possible that the straightening of the spine helps the young to break the egg-membrane. As however in the sub. eggs the membrane is very thin only and cast off early during the development the spine can be of no use in this respect. Further studies will no doubt be necessary in order to solve this question.

Chydorus sphaericus O. F. M.

Chydorus sphaericus is found through the whole of the area investigated although it does not occur in so large quantities as *Daphnia pulex*. It is in East Greenland not so abundant as in more southern countries (f.i. Denmark); this seems to indicate that the extreme arctic climate of East Greenland does not suit *Chydorus sphaericus* (cfr. Erik M. Poulsen 1940). It is obviously in accordance with this that the life cyclus of *Ch. sph.*—as it will appear from the following pages—is rather short in East Greenland, shorter than that of *Daphnia pulex*.

According to C. Wesenberg-Lund and P. Haberbosch the pro-

---

[1]) In temperate countries colonies may be found where the spine grows simultaneously with the size of the individuals (K. Berg, 1931, l. c.).

pagation of *Chydorus sphaericus* in Greenland is monocyclic. W.-L. observed (in West Greenland) in the first half of July parthenogenetic (or empty) females only; in the second half of the month, however, a few females with resting eggs were found; in August and in the beginning of September only females with resting eggs and males were present in the samples. In November empty females were found only. These observations coincide very well with the present material from East Greenland. The observations as to the propagation of *Chydorus sphaericus* in East Greenland are shown in the table below (÷ indicates that samples have been taken, the species however not being present in the samples; E = cast ephippia; ♀ empty females; e♀ = ephippial females; s♀ = females with subitaneous eggs or young in the brood pouch; ♂ = males).

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Langsø	÷	÷	E	÷	÷	÷	♀, s♀	♀, e♀	÷	÷	÷	÷
Bjørnesø	..	..	..	..	..	..	♀, s♀, e♀, ♂	♀, e♀, ♂	..	÷	..	..
Ulvesø	..	..	÷	÷	÷	÷	♀, s♀	♀, e♀, s♀, ♂	..	..	♀, ♂	..
Ponds on Ellaø.	..	..	..	..	..	..	♀	♀	..	..	..	..
Ponds near Hurry Fjord	..	..	..	..	..	..	..	♀, e♀, s♀, ♂	..	..	..	..
Other localities .	..	..	..	..	..	..	♀, s♀, e♀	♀	..	..	..	..

From these records it will be seen that the propagation only takes place during the short arctic summer, in July and August; in July the parthenogenetic propagation is prevailing, and males and ephippial females are scanty, in August however the sexual propagation dominates, ephippial females and males being common; females with subitaneous eggs are however still found in rather considerable numbers. In November, in one sample, a single empty female and a male were taken. It is thus evident that the life-cyclus of *Ch. sphaericus* is very short lasting at any rate no longer than from July to the beginning of November, in general perhaps only during July and August. The number of specimens found in the sample from November (the 1st) were only two; in Langsø where the species was well represented during July and August, no specimens at all were observed in 7 samples from the period end of August—November, and in Bjørnesø no specimens were present in a sample from October, although there were many specimens in the samples from July and August. In the first half of the year the species is not observed neither in Langsø nor in Ulvesø (see the table) in spite of extensive sampling having been carried out from January (March) to June. In Langsø the species is first recorded on July 10th, 1934, empty females and females with subitaneous eggs; on July the 23rd and August the 12th (1934) no specimens were found. On August 8th (1933) however ephippial females were found. In Ulvesø the species was first observed on July 17th, both females with subitaneous eggs and with ephippia and males. The life-cyclus of *Chydorus sphaericus* in North-East Greenland thus must be as follows: In the end of June and the beginning of July the ephippia hatch, in the course of July the young grow up and produce subitaneous eggs, but very soon, already in the course of July, males are produced and the reproduction by means of resting eggs begins. Towards the end of August the species disappears, some few individuals may however be found still in the beginning of November; however the species does not hibernate. V. Brehm in the material from the "Danmark" expedition has found the species as early as June 11th; as to the specimens observed he only mentions that they were covered by *Floscularia*; on account of this *Floscularia* covering Olofsson supposes that the specimens were not only large (grown-up) specimens, but very old too; this should further show that *Chydorus sphaericus* hibernates in East Greenland. This conclusion can hardly be true. When we consider how fast all organisms awake to new life in the beginning of the arctic summer it should not be impossible that even quite young specimens could be covered by *Floscularia*, developed during the same short period as the said *Chydorus sphaericus*. The life-cyclus of *Ch. sphaericus* in East Greenland ends no doubt in the course of the autumn, and the case is thus just the same in East Greenland as in Spitzbergen, where the species according to Olofsson disappears after the sexual period in late summer.

The number of subitaneous eggs in the brood pouch in the material at hand is 2 (or 1). In West Greenland P. Haberbosch has found the number of subitaneous eggs to be 2, whereas Wesenberg-Lund mentions that his specimens only carry one egg; he further writes that specimens with subitaneous eggs are on a whole very rare. In my material from East Greenland parthenogenetic females are however quite abundant. At Spitzbergen Olofsson always found 2 eggs in the brood pouch. The ephippial females always carry one egg only.

The size of the East Greenlandic specimens will appear from the following measurements:

Bjørnesø, $^{1}/_{7}$: Parthenogenetic females, mean 0.43 mm (0.42—0.48), 18 spec.; young and empty females 0.38 mm (0.32—0.46), 18 spec.; as no actual small young were present in this sample (as in the samples from August, Hurry Fjord) it is evident that the 2nd generation (young from subitaneous eggs) has not yet been hatched. — $^{18}/_{8}$: Ephippial females 0.44 mm (0.40—0.49), 7 spec.

Ulvesø, $^{17}/_{7}$: Parthenogenetic females 0.44 mm (0.40—0.47), 18 spec.; young and empty females 0.31 mm (0.27—0.33), 7 spec. — $^{15}/_{8}$: Parthenogenetic females

0.52 mm (0.42—0.65), 5 spec.; males 0.40 mm (0.38—0.42), 3 spec.; young and empty females 0.29 mm. (0.28—0.31), 6 spec.

Pond D, Hurry Fjord, $^{1}/_{8}$: Parthenogenetic females 0.43 mm (0.39—0.49), 7 spec.; ephippial females 0.42 mm (0.39—0.54), 10 spec.; males 0.33 (0.31—0.35), 18 spec.

Pond I, Hurry Fjord, $^{14}/_{8}$: Parthenogenetic females 0.44 (0.26—0.55), 46 spec.; males 0.33 mm (0.32—0.35), 12 spec.; ephippial females 0.41 mm (0.39—0.45), 8 spec.; young and empty females from 0.20—0.52 mm, 94 spec.

The largest specimen measured is 0.65 mm; the mean length of the grown-up females varies between 0.41 and 0.52 mm. The East Greenlandic specimens thus appear to attain about the same size as the Icelandic specimens (0.4—0.5 mm, ERIK M. POULSEN 1939) and a little larger size than those from Spitzbergen, whose mean length, according to OLOFSSON varies between 0.32 and 0.47 mm. The details of the various measurements are given in the following table 5.

It appears from the table that the smallest individuals (on August 14th) observed are 0.20 mm; that these young are newly hatched is shown by the fact that a number of developing eggs and young in the brood pouch measured from 0.19—0.26 mm. The smallest female with subitaneous eggs is only 0.26 mm; this indicates that the specimens begin to propagate rather soon after having left the brood pouch. The size of the males is rather uniform varying only from 0.31—0.35 mm; thus the males attain only little more than half the size of the females. Whereas 60 ephippial females have been recorded, 32 males were found only; when we to the number of ephippial females add the number of those having cast their ephippia or being about to prepare the ephippia and winter eggs (entered under the heading empty females or subitaneous females) it is obvious that the males are far outnumbered by the females; of the mature specimens (above 0.34 mm) 228 are females against only 32 males; the question naturally arises, are these few males sufficient to secure the fertilisation of all the resting eggs produced or is it so that the reproduction by means of resting eggs is partly sexual and partly parthenogenetical.

When we look upon the various series of measurements it becomes evident that the specimens measured fall in certain size-groups. This is seen more clearly from fig. 9 showing the variations in size of specimens from Hurry Fjord August 4th—14th; the fully drawn line gives the number of young + all females to each unit of the micrometer scale and the corresponding length in mm. There are three clearly defined size-groups, the first about 0.26 mm, the second about 0.33 mm and the third about 0.43 mm. As the measurements of the young in the brood pouch have shown that these have a size of about 0.19—0.26 mm there is no doubt that the first size-group represents the newly hatched young, i. e. the young hatched during the first half of August, the

Tab. 5. Measurements of total length (from the foremost point of the head to the hindmost point of the carapace) of *Chydorus sphaericus* from East-Greenland. The measurements are given in units of micrometer scale, with the corresponding lengths in mm added.

Units of micrometer	scale mm.	Pond I Hurry Fjord $^{14}/_{8}$-1933				Pond D Hurry Fjord $^{7}/_{8}$-1933				Bjørnesø Ellaø $^{1}/_{7}$ 1934			Pond I and D and other ponds on Hurry Fjord $^{4}/_{8}$—$^{14}/_{8}$-1933					Ulvesø Ellaø $^{17}/_{7}$-1934		All samples	
		Youngs and empty females	Subitaneous females	Ephippial females	Males	Youngs and empty females	Subitaneous females	Ephippial females	Males	Youngs and empty females	Subitaneous females	Males	Youngs and empty females	Subitaneous females	Ephippial females	Males	Youngs and all females	Youngs and empty females	Subitaneous females	Youngs and females	Males
13	0.200	2	..	..	..	..	..	..	..	..	..	..	2	..	..	..	2	..	..	2	..
14	0.215	2	..	..	..	..	..	..	..	..	..	..	2	..	..	..	2	..	..	2	..
15	0.231	3	..	..	..	..	..	..	..	..	..	..	3	..	..	..	3	..	..	3	..
16	0.246	6	..	..	..	2	..	..	..	..	..	..	8	..	..	..	8	..	..	8	..
17	0.262	13	1	..	..	8	..	..	..	..	..	..	21	1	..	..	22	1	..	23	..
18	0.280	7	..	..	..	4	..	..	..	..	..	..	11	..	..	..	11	2	..	13	..
19	0.292	5	..	..	..	3	..	..	..	..	..	..	8	..	..	..	8	3	..	11	..
20	0.308	6	..	..	..	4	..	..	2	..	..	..	10	..	..	2	10	2	..	12	2
21	0.323	11	..	..	4	4	..	..	5	1	..	..	16	..	..	9	16	1	..	18	9
22	0.338	8	3	..	6	7	..	..	10	1	..	..	15	3	..	17	18	3	..	22	17
23	0.354	2	..	..	2	8	..	..	1	4	..	1	10	..	..	3	10	1	..	15	4
24	0.369	2	1	..	..	..	..	1	..	5	..	..	3	1	1	..	5	1	2	13	..
25	0.385	4	2	1	..	2	1	1	..	1	..	..	6	3	2	..	11	3	5	20	..
26	0.400	4	5	2	..	1	2	3	..	2	1	..	5	7	5	..	17	..	1	21	..
27	0.415	6	1	3	..	6	..	..	..	..	6	..	12	1	3	..	16	1	2	25	..
28	0.431	1	5	1	..	3	1	3	..	1	9	..	6	6	4	..	16	..	3	29	..
29	0.446	4	7	1	..	..	1	..	..	2	6	..	5	11	1	..	17	2	5	32	..
30	0.462	3	7	..	..	..	1	1	..	1	1	..	3	8	1	..	12	1	9	24	..
31	0.477	3	6	..	..	..	..	..	..	..	1	..	3	6	..	..	9	2	9	21	..
32	0.492	1	5	..	..	..	1	..	..	..	..	..	1	6	..	..	7	..	2	9	..
33	0.508	..	2	..	..	..	..	..	..	..	..	..	..	2	..	..	2	..	2	4	..
34	0.523	1	..	..	..	..	..	..	..	..	..	..	1	..	..	..	1	..	..	1	..
35	0.538	..	..	..	..	..	..	1	..	..	..	..	..	..	1	..	1	..	..	1	..
36	0.554	..	1	..	..	..	..	..	..	..	..	..	..	1	..	..	1	..	..	1	..
37	0.569	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
38	0.585	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
39	0.600	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
40	0.615	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
41	0.631	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
42	0.646	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
No. of spec.		94	46	8	12	52	7	10	18	18	24	1	151	56	18	31	225	23	40	330	32
mean total length in mm..		0.33	0.44	0.41	0.33	0.33	0.43	0.42	0.33	0.38	0.43	0.35	0.33	0.44	0.42	0.33	..	0.36	0.43	..	0.33

third size-group (the largest specimens) must no doubt represent the individuals hatched from the ephippia during the early summer (end of June?); finally the second size-group (the specimens of an intermediate size) must represent the first brood hatched by the ex-ephippio females. Considering the sizes of the subitaneous females in the first half of August (cfr. the table) we see, that by far the largest part of these belongs to the third size-group (the ex-ephippio females and only very few to the two smaller size-groups; therefore, the largest part of the youngest size-group must be hatched from the ex-ephippio females thus representing their second brood, whereas only the minor part are hatched from the first brood of the ex-ephippio females. The size of the males (the stipulated curve) falls exclusively within the second size-group thus making it probable that the males belong to the first brood of the ex-ephippio females. Regarding the females carrying ephippia it is firstly seen that these only occur in the samples from August and not in the samples from the first half of July, and secondly that the length of the ephippial females falls within the length of the third size-group, i.e. the ex-ephippio females produce ephippia them-

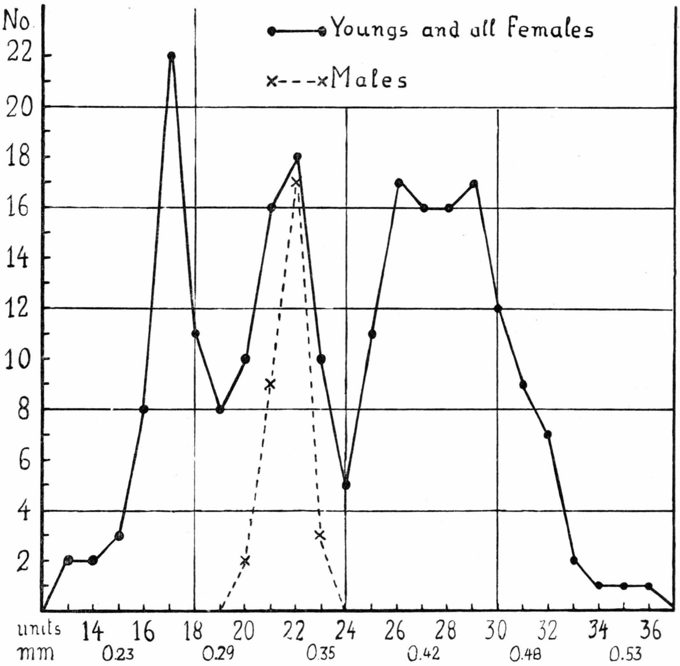

Fig. 9. Variation in size of specimens of *Chydorus sphaericus* from ponds at Hurry Fjord, 4—14th August 1933. The fully drawn line—youngs and all females, the stipulated line—the males.

selves. Of the individuals hatched from the subitaneous eggs at any rate only few have until now (beginning of August) produced ephippia.

The measurements made thus tell the following as to the life history of the colonies. The ex-ephippio females (hatched during June) produce by means of subitaneous eggs two broods of young (2nd generation) before they begin the reproduction by means of resting eggs; the males undoubtedly belong to the first of these broods only. The first subitaneous brood also produce subitaneous eggs from which the 3rd generation is hatched. The further fate of the colonies is seen from the observations from Bjørnesø, Ulvesø and Langsø later in the year: Ulvesø, August 15th, both ephippial and subitaneous females and males, September 14th no specimens observed, November 1st one single empty female. Bjørnesø, August 18th, only ephippial (and empty females) and males, only very few young and no newly hatched[1]), many empty shells, mostly with wintereggs; November 25th no specimens observed. Langsø August 27th, only a few empty females, no specimens in later samples from the fornightly investigations. From these records it is obvious that the reproduction of subitaneous eggs stops in the middle of August; how far into the autumn the production of ephippia continues cannot be stated finally from the records, but the records from August 22nd (Langsø) and September 14th (Ulvesø) makes it probable that it does not last longer than to the beginning of September. That the reproduction by means of subitaneous eggs is not continued much further than to the middle of August is evident from the fact that neither subitaneous females nor newly hatched young have been observed

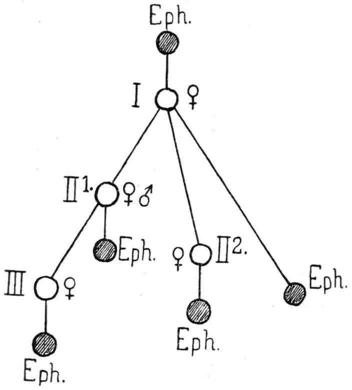

Fig. 10. The mode of reproduction of *Chydorus sphaericus* in East Greenland.

---

[1]) The measurements are the following: empty females: 0.35, 0.45 and 0.46 mm; ephippial females: 0.37, 0.39, 0.39, 0.40, 40.40, 0.3, 0.43, 0.45, 0.48 and 0.48 mm; males: 0.34 and 0.35 mm.

later than August the 14th. Gathering the above mentioned observations regarding the reproduction in a schema (see fig. 10), as those used by OLOFSSON to illustrate the life-cyclus of the Cladocera from Spitzbergen, we get the following picture of the life-cyclus of *Chydorus sphaericus* in East Greenland:

The ex-ephippio females, the 1st. generation (I), produce two broods of subitaneous young, the second generation (II^1 and II^2) and then ephippia, the 1st brood consisting of females and males the second only (?) of females; the first brood produces a 3rd generation of females only (?) and then ephippia; the 2nd brood produces only ephippia. The 3rd generation produces only ephippia.

The life-cyclus of *Ch. sphaericus* in Greenland has formerly been studied by WESENBERG-LUND (1895, pp. 135 and 144), who comes to the following conclusions: The species is monocyclic but the parthenogenetic reproduction comes to an end already in the middle of July, and the number of subitaneous females is exceedingly small; males and ephippial females continue the reproduction at any rate until the middle of September but probably far longer. That *Ch. sphaericus* is monocyclic in Greenland is confirmed by the present investigations; but the large material now at hand shows that subitaneous females are very common and there is nothing in the material that indicates that the reproduction by mean of resting eggs is continued far into the autumn. P. HABERBOSCH (1920) has found a rich reproduction by means of subitaneous eggs and further he states that intensive production of resting eggs does not take place before the second week in August and that thus *Ch. sphaericus* in this respect behaves otherwise than is normally the case with the Greenlandic Cladocera. In the material now at hand ephippial females are however found abundantly in the end of July and in the first week of August and males have been observed already in the first week of July. Thus *Ch. sphaericus* does not in this respect vary from the other Greenlandic Cladocera.

The hitherto best investigated arctic *Ch. sphaericus*-colonies are those from Spitzbergen, where OLOFSSON has found the following life-cyclus: The species is monocyclic. The ex-ephippio females produce one subitaneous brood (2nd generation) and then ephippia; this 2nd generation, consisting of females and males, produces directly ephippia; the whole cyclus lasts $1^1/_2$—2 months. The cyclus in Spitzbergen is thus much shorter than in East Greenland, where 3 generations occur and the 2nd generation produces subitaneous young before starting the reproduction by means of resting eggs. The duration of the cyclus in East Greenland is at any rate from the middle of June to the beginning of September, i.e. nearly $2^1/_2$ months. The longer cyclus of the life in East Greenland is easily explained by the comparatively long icefree period. According to the observations made during the expeditions the freshwaters in the region of Ellaø are ice free from ca. June 15th—October 1st i.e. about $3^1/_2$ months; in Spitzbergen, however, the ice free period according to Olofsson only lasts for 2—3 months. Also the temperature of the water is at any rate a little higher in East Greenland than in Spitzbergen; in the two lakes on Ellaø (Langsø and Rundsø) a water temperature of $12^1/_2$° C was measured during the first half of August; for lakes in Spitzbergen Olofsson however gives a maximum temperature of 10—12° C. It is thus obvious that the ice free period in East Greenland is about 25 % longer than in Spitzbergen and that the temperature of the water is a little higher. The longer life-cyclus of the East Greenlandic *Ch. sphaericus* is no doubt due to these more favourable conditions of nourishment.

LIST OF LITERATURE

Berg, Kaj, 1931: Studies on the Genus Daphnia with Especial Reference to the Mode of Reproduction. Vid. Med. Dansk Nat. Foren., Bd. 92.

Brehm, V., 1912: Die Entomostracen der Danmarksexpedition. Danm.-Eksp. til Grønlands Nordøstkyst 1906—08. Med. om Grønland, Bd. 45.

Ekman, S., 1904: Die Phyllopoden, Cladoceren und freilebenden Copepoden der nordschwedischen Hochgebirge. Zool. Jahrb. System., Bd. 21.

Haberbosch, P., 1920: Die Süsswasser-Entomostracen Grönlands. Zeitschr. f. Hydrologie, I.

Johansen, F., 1912: Freshwater life in north-east Greenland. Danm. Exp. til Grønlands Nordøstkyst 1906—08. Med. om Grønland, Bd. 45.

— 1922: Euphyllopoda. Rep. Canad. Arctic Exp. 1913—18. Vol. VII, Crustacea, Part G.

Lilljeborg W., 1900: Cladocera Sueciae. Uppsala.

Olofsson, O., 1918: Studien über die Süsswasserfauna Spitzbergens. Zool. Bidrag fr. Uppsala, VI.

Poulsen, Erik M., 1939: Freshwater Crustacea. Zoology of Iceland III, 35.

— 1940: Freshwater Entomostraca. The Zoology of East Greenland. Medd. om Grønland, Bd. 121.

Sars, G. O., 1896: Fauna Norvegia, Bd. I. Phyllocarida og Phyllopoda, Christiania.

v. Scharfenberg, U., 1914: Weitere Untersuchungen an Cladoceren über die experimentelle Beeinflussung des Geschlechts und der Dauereibildung. Int. Rev. d. ges. Hydrob. Biol. Suppl. III, p. 1.

Sømme, S., 1934: Contributions to the Biology of Norwegian Fish Food Animals, I., Lepidurus arcticus Pallas. Afh. Norsk Vid. Akad. Oslo, I, Mat.-naturv. Kl. 1934, Nr. 6.

Wesenberg-Lund, C., 1894: Grönlands Ferskvandsentomostraca. Vid. Med. Dansk natur. Foren. Kjöbhn. 1894.

— 1926: Contributions to the Biology and Morphology of the Genus Daphnia. Kgl. Dansk Vid. Selsk. Skr. Nat. og Math. Afh. 8. Rk. 11.

Færdig fra Trykkeriet den 14. November 1940.