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PRELIMINARY STUDIES ON THE BIOLOGY AND ECOLOGY OF *CHLAMYDATUS PULLUS* (REUTER) (HETEROPTERA: MIRIDAE) IN GREENLAND

BY

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WITH 11 FIGURES AND 3 TABLES IN THE TEXT, AND 6 PLATES

С РУССКИМ РЕЗЮМЕ

KØBENHAVN
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Abstract

Only one species of *Chlamydatus* Curt., *C. pullus* (Reut.), is found in Greenland, where it occurs in a parthenogenetic form.

The known distribution in Greenland indicates that the species is absent only in the northernmost parts. The habitat of *C. pullus* is described in detail here, and microclimatic measurements from the habitat are presented. The results of preliminary experiments on the species' relationship to humidity and temperature indicate a preference for the dry and hot conditions found in the habitat.

In Greenland *C. pullus* has only one annual generation and overwinters in the egg-stage. The species is phytophagous and polyphagous, occasionally being a predator on small insects. Important food-plants appear to be *Polygonum viviparum* and *Potentilla* spp.

РЕЗЮМЕ

Всего дишь один Вид *Chlamydatus* Curt., *C. pullus* (Reut.) был найден в Гренландии в партеногенетической форме.

Известная площадь распространения этого вида в Гренландии показывает, что он отсутствует только в самых северных частях страны. В работе дается детальное описание и приводятся микроклиматические измерения естественных условий обитания *C. pullus*. Результаты предварительных экспериментов на отношение вида к влажности и температуре указывают на предпочтительность к сухим и жаркни условиям, имеющим место в среде обитания.

В Гренландии *C. pullus* имеет лишь одно поколение в год и зимует в яйцевой стадии. Описываемый вид является фитофаговым и полифаговым, иногда нападающим на мелких насекомых. Важнымн пищевымн растениями вида являются *Polygonum viviparum* и *Potentilla* spp.

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Introduction

In spite of the fact that the Greenlandic insect-fauna has been relatively well known for a long time, very little work has been carried out on the biology and ecology of insects. Considering the huge interest and effort in this field elsewhere in the Arctic in recent years, particularly in Canada, there seems to be an urgent need for such investigations in Greenland.

Therefore, the aim of my work in Greenland is to make ecological and biological studies on insects, mainly the Hemiptera and especially Heteroptera. In this paper *Chlamydatus pullus* (Reut.) is dealt with exclusively, however, the common species, *Nysius groenlandicus* (Zett.) is to be the subject of future papers.

The present investigation was carried out during my term as scientific leader of the Arctic Station, University of Copenhagen, between 1967 and 1970. The Arctic Station is situated near Godhavn on Disko, West Greenland. Additional studies were made while taking part in the Danish biological expedition to the Kap Farvel area, South Greenland, in the summer of 1970.

Taxonomy

At present only four species of Heteroptera have been recorded in Greenland: *Nabis flavomarginatus* Scholtz, *Cimex lectularius* L., *Nysius groenlandicus* (Zett.) and *Chlamydatus pullus* (Reuter).

The latest published index of the insects of Greenland (Henriksen 1939) includes a fifth species, *Chlamydatus pulicarius* (Fallén). This is, however, erroneous and due to an incorrect identification which must originally be ascribed to O. G. Reuter. The first time the genus *Chlamydatus* Curtis is mentioned from Greenland it is under the name of "*Capsus* sp." (Lundbeck, 1891a, 1891b, 1895). In 1907 "*Chlamydatus pulicarius* Fall." was reported for the first time by Nielsen, where Hemiptera was determinated by Reuter. Henceforth this name was applied in general to the Greenlandic material of *Chlamydatus* (Nielsen, 1910; Henriksen & Lundbeck, 1918; China, 1934; Lack, 1934; Bertram, 1935; Carpenter, 1938). In 1935, however, Lindberg published the find of "*Chlamydatus pullus* REUT." in Northeast Greenland, whereupon HENRIKSEN (1939) included both *C. pulicarius* and *C. pullus* in his index.

In the Greenland collection of *Chlamydatus* (comprising more than 800 adult specimens of which about 100 originate from previous collectors), females were found exclusively. These are undoubtedly all *C. pullus* as the characteristic colouring of the hind legs is always typically and uniformly developed. Furthermore it is unlikely that the few Greenland specimens kept in England and Norway should differ in these respects. The identification could only be more positive if it had been possible to examine male genitalia. However, there is nothing at the moment to indicate the presence of more than one species of *Chlamydatus*, *C. pullus* (REUT.), in Greenland.

Distribution

C. pullus is widely distributed in the Palaearctic region (whole of Europe, North Africa, northern Asia), but apart from Greenland, it is not found in America (CARVALHO, 1958). Zoogeographically it is interesting that the species is absent from Iceland. *C. pullus* has been recorded as far north as the Jenisei Valley, 68°55′ and the Kola Peninsula, 69° in the Soviet Union (SAHLBERG, 1878, 1920), and LINDBERG (1935 a, 1935 b) found the species 1000 m above sea-level in Dovre, Norway, together with *Nysius groenlandicus*, the association which is always met with in Greenland. In his great work on the high altitude insects of the world, MANI (1968) observed the most common hypsobiont genera of Heteroptera to be *Nysius* DALL. and *Chlamydatus* CURTIS, but only one species of *Chlamydatus* (*C. pachycerus* KIRITSHENKO) was mentioned.

The records of *C. pullus* in Greenland appear in Fig. 1. The map undoubtedly shows the intensity of collection rather than the distribution, but it appears that the species is truly absent from the northernmost areas, as thorough investigations in Peary Land, for example, have not revealed it. Probably the distribution is approximately continuous from NE to NW, but on a lesser scale it is often disjointed, with the species occurring in clusters.

In the immediate surroundings of Godhavn, I have, in spite of intensive searching, only encountered *C. pullus* in a very restricted area, called Østerlien, northeast of the Arctic Station (*cf.* p. 8). A single specimen was, however, found in a heath-locality 400 m NW of Østerlien. The other nearest sites were in Brededal and Disko Fjord, 18 and 22 kilometres, respectively, from Godhavn. In the Kap Farvel area *C. pullus* was only found in one locality (Anordliuitsoq, Pamiagdluk) and confined to a very small area (*cf.* p. 13). However, the species has previously been collected in the neighbourhood (Ilua, Mrs. E. LUNDHOLM leg., 1890), but apart

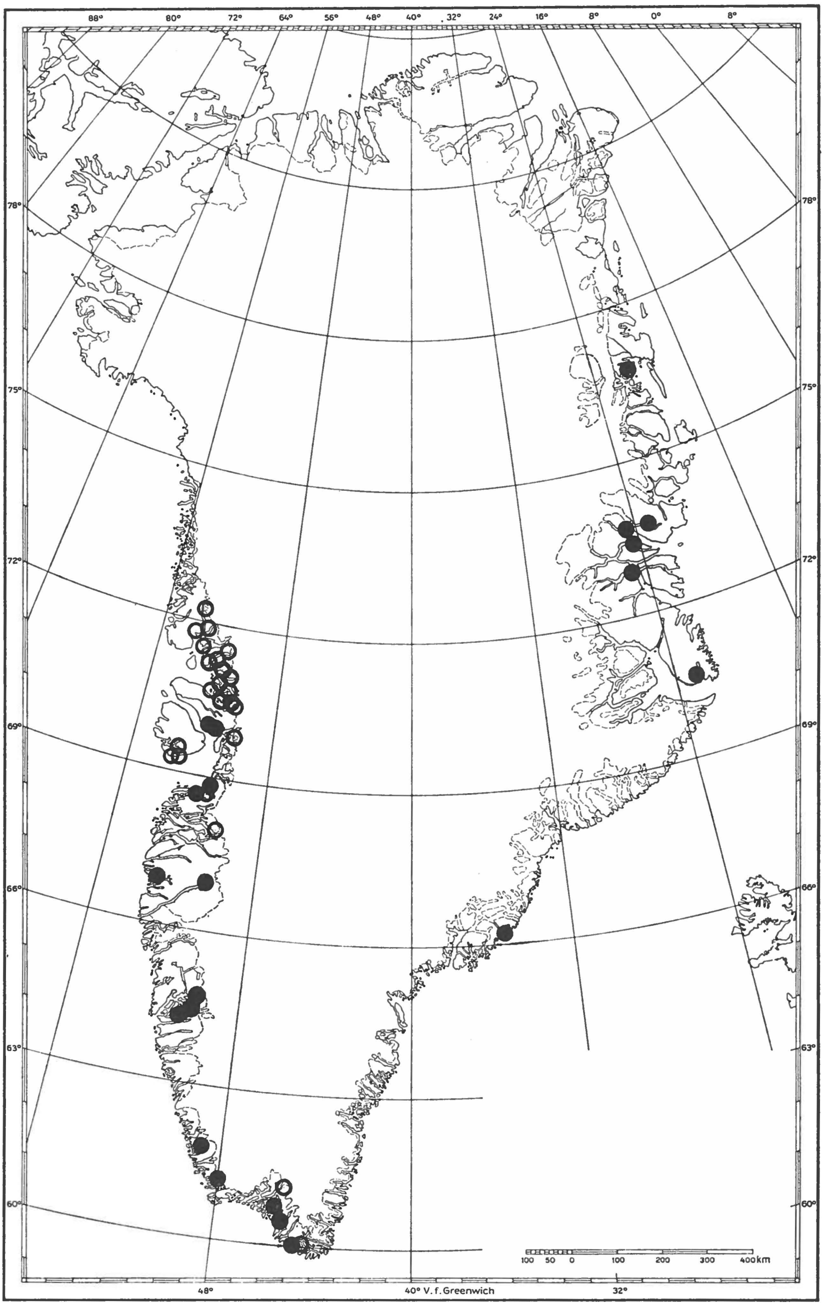

Fig. 1. The records of *Chlamydatus pullus* (Reut.) collected in Greenland. Open circles represent the author's collections.

from this, Frederiksdal, 25 km from Anordliuitsoq, is the nearest known locality (VIBE leg. 1948). In the Umanak district *C. pullus* was found in nearly all my sampling localities (*cf.* Fig. 1), appearing more frequently inland. In contrast, in the Kap Farvel area, the species was absent in the innermost part of the fjord system (*cf.* p. 26).

Habiat

The habitat of *C. pullus* in Europe has been described by several authors. KULLENBERG (1944) concluded that the species is found in open sunny places with sandy soils and low vegetation. JENSEN-HAARUP & LINDBERG (1931) collected *C. pullus* in subarctic birchwood in Swedish Lapland. According to SOUTHWOOD & LESTON (1959) the species "is found amongst low-growing plants, more especially in dry places with bare patches of ground". LINNAVUORI (1966) reported finding it in dry, sandy fields and Empetrum-heaths in Finland. These statements are accurate in describing the habitat of the species in Greenland as well.

Little information about the habitat of *C. pullus* in Greenland is to be found in the literature. LUNDBECK (in a diary note) found it under stones in Tasiussaq and (1891 a) swept it from willow scrub in Neria, Frederikshåb district. JOHANSEN (1910) wrote, in his faunistic account of the Danmark Expedition, "if we examine the fresh shoots of *Potentilla* and *Papaver* we find a number of larvae of *Trombidium* or the common, small bugs (*Chlamydatus pulicarius*?) fixing themselves in the innermost parts of the plants" (l.c. p. 44). LACK (1934) found *C. pullus* on *Salix* in Jameson Land, and the Oxford Expedition collected it under excrement and in grass near fox excrements at Qugssuk, Godthåbsfjord (CHINA, 1934). CARPENTER (1938) reported nymphs on *Betula nana*, lichens and sand, on the moorland and moraine heaths at Utorqait in Amerdloq.

At Østerlien, in the Godhavn area, the locality where I collected *C. pullus* is composed of a steep slope (a tertiary basalt-breccie) facing SW and a gently falling plain below (see Fig. 2 and Plate 2). The slope is covered with *Salix glauca*-scrub alternating with a luxuriant herb-field in the wetter regions, while the vegetation on the plain consists of different kinds of heath.

Fig. 2 is a sketch of Østerlien with the habitat of *C. pullus* indicated. The species was only found where there was shelter from nearly all directions of wind (east wind is predominant, wind from the south is rare) and where the microclimatic temperature conditions were favourable. On the slope the species was not found in the willow-scrub and rarely in the rich herb-field dominated by *Taraxacum croceum* and *Alchemilla* *glomerulans* (for descriptions and analyses of these plant communities, see T. W. Böcher, 1959, pp. 22–32, and 1963, Fig. 110). However, it was common in a few small, dry patches below the herb-field areas and at the foot of the slope. A vegetation analysis of one of these patches is to be found in Table 1 a. *C. pullus* was further present in a small, relatively

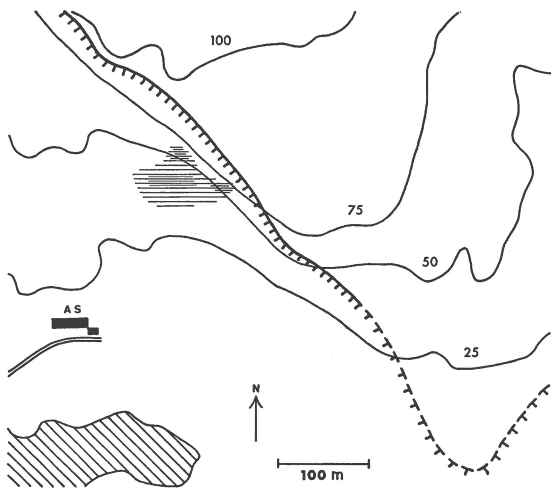

Fig. 2. Map sketch of Østerlien near the Arctic Station (AS), Godhavn. The habitat of *C. pullus* is indicated by fine horizontal lines. The basalt breccie, part of the Lagoon, and contour lines are also shown.

luxuriant portion of the heath covering the highest part of the plain near the foot of the slope (Table 1 b and Table 2: Stand 1). Towards the southeast, this heath is gradually replaced by a drier and poorer one (*Dryas-Carex*) and southward, by more humid types.

In Disko Fjord, *C. pullus* was found in a dried-up riverbed exposed to the south. In Brededal, it occurred on a slope similar to the one at Østerlien: namely a snow-bed and herb-slope with a southern exposure, about 50 m above sea-level, and protected to the north and east by a steep basalt wall (Table 2: Stand 2).

C. pullus was extremely common in the dry, southeastern part of Disko Bugt. Here it occurred particularly on the south-facing slopes which had a steppe-like vegetation (Table 2: Stand 3), but also on small islands and skerries with much different flora (*e.g.* Table 2: Stand 4). In the northeastern part of Disko Bugt it was found in a dry heath (*Dryas*) and in a steppe-like community, especially at the base of *Potentilla hookeriana* (Table 2: Stand 5).

In the Umanak district, *C. pullus* was particularly common and ubiquitous in the southeastern part of the fjord system, which has a continental type of climate. Here it was not confined to dry slopes with

Table 1. *Analyses of the vegetation in two areas inhabited by* Chlamydatus pullus *at Østerlien, Godhavn. Shoot density determination according to* T. W. BÖCHER & WEIS BENTZON (1958). *The analyses were carried out by* T. W. BÖCHER *on July 20 (b) and 29 (a), 1968.*

a) Small patch on the slope at Østerlien. About 50 m above sea-level. 30° inclination towards SW. pH 5.0.

Potentilla crantzii	21	*Salix herbacea*	26
Equisetum arvense	15	*Salix glauca*	2
Sibbaldia procumbens	11		
Euphrasia frigida	11	*Poa pratensis* coll.	19
Campanula gieseckiana	10	*Festuca rubra* coll.	10
Cerastium alpinum	10	*Poa alpina*	8
Polygonum viviparum	8	*Trisetum spicatum*	3
Taraxacum croceum	8	*Carex macloviana*	+
Veronica alpina	4		
Antennaria canescens	3	*Desmatodon latifolius*	2
Lycopodium dubium	2	*Tortula ruralis*	+
Erigeron humilis	2	*Cladonia pyxidate*	+
Stellaria monantha	1		
Draba lactea	+		
Minuartia biflora	+		

b) Dry patches on the heath covering the highest part of the plain at Østerlien (*cf.* Table 2: Stand 1). About 30 m above sea-level. 5° inclination towards S. pH 5.8.

Polygonum viviparum	24	*Carex rupestris*	20
Silene acaulis	6	*Kobresia myosuroides*	19
Dryas integrifolia	5	*Carex capillaris*	2
Pedicularis flammea	1	*Carex bigelowii*	1
Cerastium alpinum	+	*Carex scirpoidea*	1
Minuartia rubella	+	*Carex norvegica* ssp. *inserrulata*	+
Pedicularis hirsuta	+	*Luzula confusa*	+
Vaccinium uliginosum ssp. *microphyllum*	26	*Tomenthypnum nitens* / *Aulacomnium turgidum*	10
Salix glauca	1	*Bryum archangelicum*	7
Empetrum nigrum ssp. *hermaphroditum*	+	*Polytrichum* sp.	7
		Dicranum spadiceum	+
		Eucalypta rhabdocarpa	+
		Cladonia sp.	3

a southern exposure and a steppe-like vegetation (*e.g.* Qarássap nunatâ, Table 2: Stand 6; Ikerasak, Table 2: Stand 7; Magdlak, Alfred Wegeners Halvø; Umanak; Sãtut; *cf.* Plate 4), but was also found in *Betula nana*-scrub (*e.g.* Qarássap nunatâ; Itivdliarssuk), and mixed scrub composed of *Betula nana*, *Salix glauca* and *Vaccinium uliginosum* ssp. *microphyllum* (Tasiussaq, Perdlerfiup kangerdlua; Qalatôq, Upernivik Ø; Kangiussap qíngua, Svartenhuk SE; Pangnertôq, Uvkusigssat Fjord;

Table 2. *Plant communities in habitats of* Chlamydatus pullus. *Mosses and lichens are only occasionally included.* !! *and* ! *indicate more or less dominating species.*

Stand 1.
Østerlien, Godhavn. Plain.

Vaccinium uliginosum ssp. *microphyllum* !!
Polygonum viviparum !
Salix glauca !
Carex rupestris
Kobresia myosuroides
Dryas integrifolia
Equisetum arvense
Luzula confusa
Pedicularis flammea
P. lanata
Poa pratensis coll.
Rhododendron lapponicum
Silene acaulis

Stand 2.
Brededal, Disko. S facing snow-bed.

Equisetum arvense !
mosses !
Oxyria digyna !
Poa alpina !
Polygonum viviparum !
Salix herbacea !
Sibbaldia procumbens !
Alchemilla glomerulans
Angelica archangelica
Antennaria canescens
Carex brunescens
Cerastium alpinum
Erigeron humilis
Gnaphalium norvegicum
Minuartia biflora
Salix glauca
Taraxacum sp.
Trisetum spicatum
Veronica alpina

Stand 3.
Akugdlît. S facing slope.

Artemisia borealis
Campanula gieseckiana
Cerastium alpinum
Draba sp.
Luzula spicata
Poa glauca
Potentilla hookeriana
Saxifraga tricuspidata
Sedum rosea
Viscaria alpina

Stand 4.
Small island near Akugdlît.

Plantago maritima !
Puccinellia sp. !
Stellaria longipes !
Cochlearia groenlandica
Empetrum nigrum ssp. *hermaphroditum*
Salix glauca
Sedum rosea

Stand 5.
Qapiarfît, Disko Bugt. S facing slope

Dryas integrifolia !
Potentilla hookeriana !
Artemisia borealis
Campanula gieseckiana
Hierochloe alpina
Saxifraga tricuspidata

Stand 6.
Qarássap nunatâ. S facing slope.

Carex rupestris !
Cerastium alpinum !
Poa glauca !
Saxifraga tricuspidata !
Arnica alpina
Calamagrostis purpurascens
Campanula gieseckiana
Draba sp.
Melandrium triflorum
Papaver radicatum
Phleum commutatum
Potentilla hookeriana
Salix glauca
Stellaria longipes

Table 2. (Continued).

Stand 7.
Ikerasak. Rock crevices.

Arnica alpina
Cerastium alpinum
Melandrium triflorum
Poa glauca
Potentilla hookeriana

Stand 8.
Sagdliaruseq, Inukavsait. Beach.

Cerastium alpinum
Elymus arenarius ssp. *mollis*
mosses
Phleum commutatum
Poa pratensis coll.
Puccinellia sp.

Stand 9.
Anordliuitsoq, Pamiagdluk. Small plain.

Agrostis canina ssp. *montana* !
"*Cladonetum*" !
Potentilla tridentata !
Campanula gieseckiana
Empetrum nigrum ssp. *hermaphroditum*
Juncus trifidus
Juniperus communis
Luzula confusa
Salix glauca
Tortula sp.
Viscaria alpina

Stands 10–12.
Anordliuitsoq, Pamiagdluk.
Old settlement.

Stand 10.
12 m above sea-level.

Deschampsia flexuosa !
Empetrum nigrum ssp. *hermaphroditum* !
mosses and lichens !
Alchemilla alpina
Carex bigelowii
Juncus trifidus
Juniperus communis
Luzula spicata
Potentilla tridentata

Stand 11.
10 m above sea level.

Alchemilla alpina !
mosses !
Nardus stricta !
Betula glandulosa
Carex bigelowii
Deschampsia flexuosa
Elymus arenarius ssp. *mollis*
Juniperus communis
Luzula spicata
Phleum commutatum
Polygonum viviparum
Potentilla tridentata
Salix glauca
S. herbacea
Sedum rosea
Taraxacum sp.

Stand 12.
2–3 m above sea-level.

Poa pratensis coll. ! !
Elymus arenarius ssp. *mollis* !
Festuca rubra coll. !
mosses !
Taraxacum sp. !
Carex canescens
Deschampsia flexuosa
Polygonum viviparum
Sedum rosea

cf. Plate 3, Fig. 2). In addition, the species was found in a highly unusual location — that of a beach, on humid ground among stones, near the outlet of a brook (Sagdliaruseq, Inukavsait; Table 2: Stand 8).

In the Kap Farvel district *C. pullus* was exclusively found in one locality, Anordliuitsoq on Pamiagdluk. The habitat was characteristic

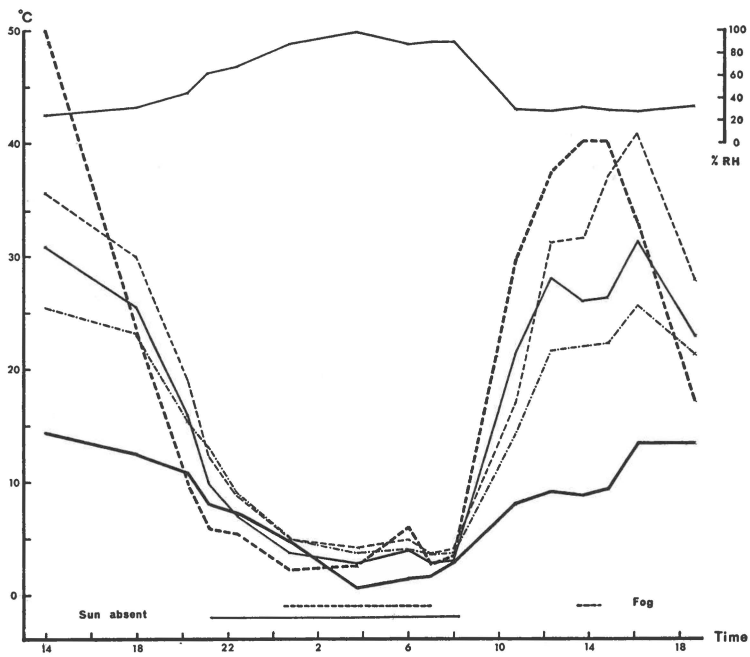

Fig. 3. Graph with relative humidity at ground level, temperature, and sun and fog periods on the slope at Østerlien, Godhavn, on June 24 and 25, 1969. Readings were taken at irregular intervals. Temperatures were recorded in the following positions. Heavy solid line: 100 cm above ground. Heavy broken line: on ground surface beneath *Salix-glauca*-scrub (about 50 cm high). Thin solid line: on ground surface in an exposed patch. Thin broken line: on the surface of litter. Thin dot/dash line: on ground surface beneath *Sibbaldia procumbens* (about 4 cm high).

and well separated from the surrounding landscape, which was generally humid. The main site was a small plain (about 100 m^2), sloping gently to the south on the northern side of a river outlet (Plate 5). The soil was well-drained and consisted of fine gravel. The vegetation was sparse and steppe-like, dominated by *Potentilla tridentata* (Table 2: Stand 9). Furthermore, several *C. pullus* were collected in *P. tridentata* stands in rock crevices south of the river outlet. Finally, some specimens were caught in pitfalls in an old settlement about 200 m further south. The traps were placed in three series: 10 in dry soil, 20 in slightly moister soil, and 10 in moist soil (Table 2: Stands 10–12). The catch from August 20 to 29 was 11, 5 and 0 specimens, respectively.

Considering the relation between the habitats of *C. pullus* and the other common Heteropteran, *Nysius groenlandicus*, it appears true that *Nysius* is always present where *Chlamydatus* is found; however, the converse is by no means valid, as *Nysius* is practically ubiquitous in Greenland, and *Chlamydatus* is not.

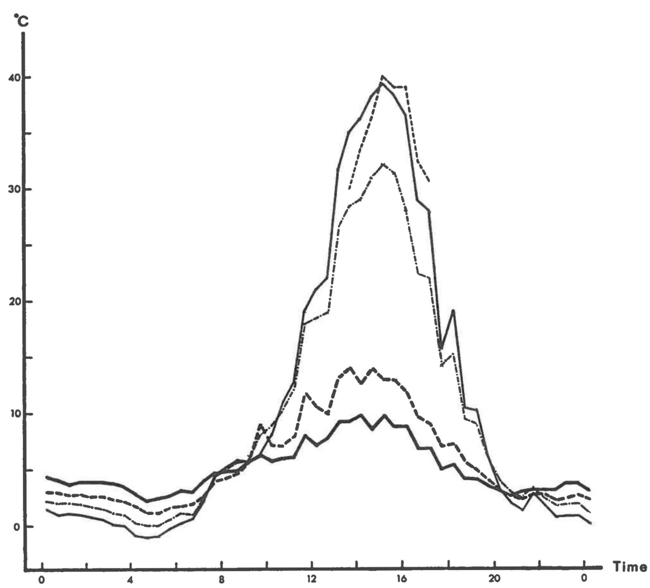

Fig. 4. Temperature records on the slope at Østerlien (exactly the same place as in Fig. 3), on August 30, 1969. Automatic recording taken every $^1/_2$ hour in the following positions. Heavy solid line: 100 cm above ground. Heavy broken line: on ground surface beneath *Salix glauca*-scrub (about 50 cm high). Thin solid line: on ground surface in an exposed patch. Thin broken line: on ground surface in a protected spot (only part of the curve is drawn since it, apart from the section shown, closely coincides with the following curve). Thin dot/dash line: on ground surface beneath vegetation, about 2 cm high (*Polygonum viviparum*, *Potentilla crantzii*, *Salix herbacea*).

Microclimatic measurements

Observations indicate that *C. pullus* is found in places with a warm and dry microclimate. Measurements were taken with thermistors (in most cases a Grant miniature temperature recorder) and simple hair-hygrometers (Fischer and Lambrecht) placed on the ground.

Figs. 3–6 give some examples of temperature recordings taken in *C. pullus*-habitats during clear weather spells and consequently fairly extreme climatic conditions.

Fig. 3 shows some measurements from the slope at Østerlien, Godhavn (*cf.* pp. 8–9; Plate 3, Fig. 1 and Table 1 a) about the time *C. pullus* was hatching from the eggs. Weather conditions on June 24 were generally excellent with clear skies and no wind, but this favourable situation was interrupted twice on June 25 by cold fog from the sea — a common occurrence in early summer in Disko Bugt. A surprisingly high temperature (50° C) was measured on the dry ground below the willow-scrub (at that time still without leaves). In the habitat proper of *C. pullus* the earth was rather humid due to melting snow still present higher on the slope, and this made surface temperatures relatively low. In dry litter, however, much warmer conditions prevailed.

Fig. 4 shows some automatic recordings in exactly the same place on a sunny day when the life-cycle of *C. pullus* was about to be com-

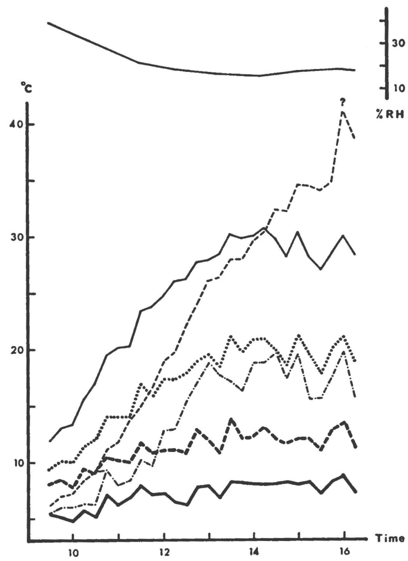

Fig. 5. Temperature and relative humidity at ground level in a steppe-locality at Qarássap nunatâ, in the Umanak district, on July 19, 1969. Automatic recording taken every $^1/_4$ hour in the following positions. Heavy solid line: 100 cm above ground. Heavy broken line: 10 cm above ground. Heavy dotted line: 1 cm above ground. Thin solid line: on ground surface in an exposed patch. Thin broken line: on ground surface in a protected spot with a vegetation of *Carex rupestris*. Thin dot/dash line: on ground surface at the base of a plant of *Potentilla hookeriana* (about 30 cm high). The question mark indicates that the maximum value is indefinite, as the apparatus was not prepared to measure above 45° C.

pleted. Night frost occurred on the bare ground, but not in the low vegetation or in other sheltered places. The "canopies" formed by the willow-scrub moderated the temperature fluctuations on the ground below.

Fig. 5 shows temperature development in a steppe-locality in the driest part of the Umanak district (Qarássap nunatâ; Table 2: Stand 6, Plate 4, Fig. 2) during a typical summer day. The locality studied was less than three kilometres from the margin of the inland ice. Fairly strong gusts of dry wind from the ice-cap, especially during the forenoon and late afternoon, impeded maximal temperatures, except in sheltered places. The large population of *C. pullus* was extremely active throughout the period.

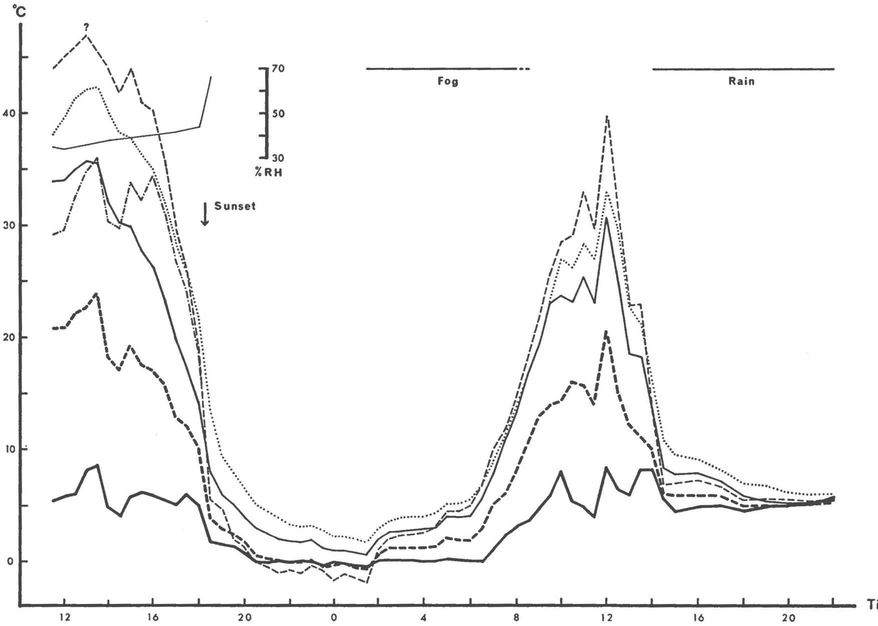

Fig. 6. Temperatures and a few measurements of relative humidity at ground level from a "*Potentilla tridentata*-steppe" at Anordliuitsoq, Pamiagdluk, in the Kap Farvel area, on August 1 and 2, 1970. Fog and rain periods are also indicated. Automatic recording taken every $^1/_2$ hour in the following positions. Heavy solid line: 100 cm above ground. Heavy broken line: 1 cm above ground. Thin solid line: on ground surface in an exposed patch. Thin broken line: on the surface of a lichen-cover (1 to 2 cm thick). Thin dotted line: on ground surface in a protected spot. Thin dot/dash line: on ground surface at the base of a plant of *Potentilla tridentata* (about 8 cm high). Only part of this curve is drawn since it, apart from the section shown, closely coincides with the thin solid line curve. The question mark indicates indefinite values above 45° C.

Fig. 6 shows a typical example of the changing weather conditions in the Kap Farvel area. The measurements were recorded in a "*Potentilla tridentata*-steppe" (see p. 13, Table 2: Stand 9, and Plate 5). Apart from a light cloud-cover about 2 P.M., August 1 was a clear day with maximal insolation. At the same time a light wind from the south brought with it the low tempeartures of the sound, which was at that time completely packed with old floating ice. The low air-temperatures prevented the flight activity of insects such as the annoying *Simulium vittatum* Zett., but on the ground *C. pullus* and *Nysius groenlandicus* were very active (*Nysius* was able to fly) until shortly before sunset (6.15 P.M.). After that all insect-activity suddenly stopped. During the night very different climatic conditions in the micro-landscape were recorded. The warming up of the soil during day resulted in the surface being warmer than the air at night, especially in a protected place. The surface of the insulated

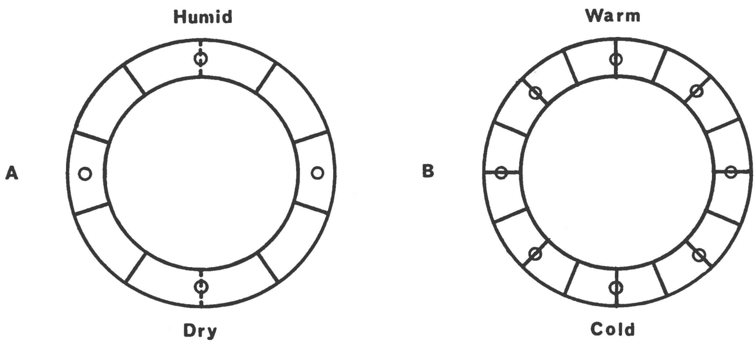

Fig. 7. Division of the floor in the humidity (A) and temperature (B) organs. Small circles mark the position of holes in the lid.

lichen-cover was the "active surface" showing the largest amplitude in temperatures (about 50° C). A fog after midnight hindered the outgoing radiation and caused the microclimate to be 2°–4° C warmer. The fog and light clouds later on delayed the warming up on August 2; *C. pullus* was active from about 8 A.M. until the rain stopped all activity and wiped out every difference in the microclimate.

Experiments on relations to humidity and temperature

Habitat and microclimatic measurements indicate that *C. pullus* prefers dry and warm conditions. In order to test the reactions of the population at Østerlien to a gradient of humidity or temperature, a number of choice experiments were carried out, using circular "organs".

The apparatus used were constructed in close accordance with LANDIN (1968, Figs. 2 and 3). Apart from the "floors", on which the insects moved, they were nearly identical for both the humidity and temperature experiments. The floor (in the form of a circle-ring, 4 cm in width, 30 cm in diameter) consisted of brass wire netting in the humidity experiments and a perforated, thin copper plate with two extensions opposite each other, in the temperature experiments. The rest of the apparatus was made of thick plastic. The "basement" below the floor (4 cm high) was divided into a number of compartments for chemicals regulating the humidity of the air space above. The apparatus was tightly sealed by a transparent lid onto which the transparent, circular walls (2 cm high) were fixed. The lid was provided with holes, which allowed for the introduction of insects, thermistor probes, etc., and which could be closed with rubber stoppers. During experiments the apparatus was lit by a single bulb placed centrally 50 cm above it.

In the humidity experiments a gradient of 5 % RH to about 95 % RH was produced by means of NaOH and water. The room temperature was kept constant at about 20° C. The gradient was tested with cobalt thiocyanate paper (*cf.* SOLOMON 1958) and remained stable for weeks. The floor was divided into ten sections, corresponding two by two (Fig. 7).

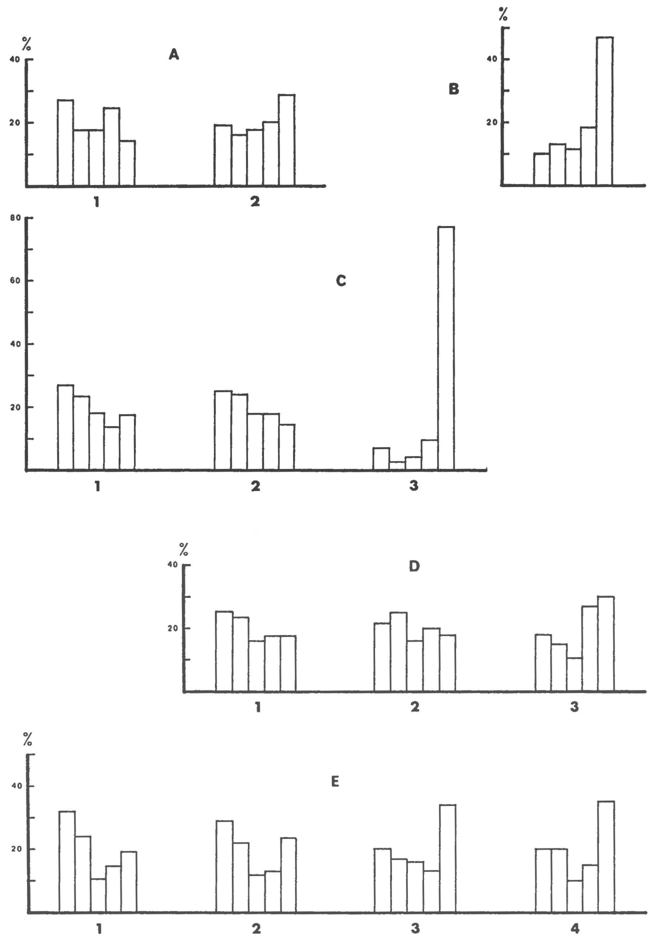

Fig. 8. Results of five experiments on the reaction of *C. pullus* to a humidity gradient. From left to right in the histograms relative humidity increases from about 5 % to about 95 %. Percentages are given for recorded positions (R. P.) of the given number of bugs, which were all placed in the apparatus at the same time.

A. July 29, 1968. 10 nymphs (IV and V).
1) 16 R. P. from $1^1/_4$ to $3^1/_4$ hrs.
2) 31 R. P. from $8^1/_2$ to $9^3/_4$ hrs.

B. August 22, 1967. 10 adults. 20 R. P. from $5^3/_4$ to $6^1/_4$ hrs.

C. August 7, 1969. 20 adults.
1) 8 R. P. from $^1/_2$ to $1^1/_4$ hrs.
2) 13 R. P. from $2^1/_2$ to 4 hrs.
3) 19 R. P. from 19 to 21 hrs.

D. August 15, 1969. 22 adults.
1) 17 R. P. from 2 to $3^1/_4$ hrs.
2) 10 R. P. from 5 to $5^3/_4$ hrs.
3) 22 R. P. from $7^1/_2$ to 9 hrs.

E. August 22, 1969. 12 adults.
1) 12 R. P. from $2^3/_4$ to 4 hrs.
2) 12 R. P. from $5^1/_4$ to $6^1/_4$ hrs.
3) 22 R. P. from $8^1/_4$ to $10^1/_4$ hrs.
4) 20 R. P. from 11 to 12 hrs.

The temperature gradient was achieved by cooling one of the copper-extensions in a freezing mixture (ice and NaCl) while heating the other electrically. It was, however, difficult to maintain a stable gradient. Temperature was measured with a termistor at eight points on the floor, but the bugs often climbed the walls or the probes, where temperature conditions differed from those measured. The difference amounted to a maximum of 5° C (negative) in the warmest point and 3° C (positive) in the coldest. The inevitable simultaneous gradient in humidity was counteracted by placing NaOH and water below the cold and warm parts of the floor. The floor was divided in sixteen sections, corresponding two by two (Fig. 7).

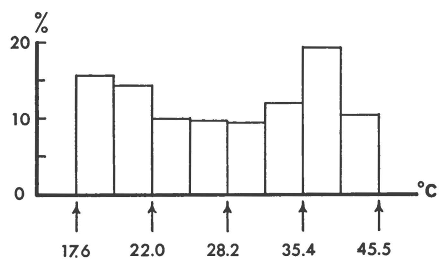

Fig. 9. Results of a single experiment on the reaction of *C. pullus* to a temperature gradient. 26 adults were introduced. 40 positions and 19 series of temperature were recorded. Duration of the experiment was 50 minutes. The temperature gradient varied as follows:
17.6° C ±0.6 (16.7 to 18.5° C), 22.0° C±0.6 (20.4 to 23.3° C), 28.2° C ±0.9 (26.2 to 29.3° C), 35.4° C ±0.9 (33.5 to 36.5° C), 45.5° C ±1.1 (42.9 to 47.0° C).

A varying number of freshly caught bugs was used. The timidity and vivacity of this species made counting and recording positions difficult.

The results appear in Figs. 8–9 which also give detailed information about the experimental conditions. The humidity experiments clearly showed an initial, rather weak xerophily which, after six to eight hours in the apparatus (without access to water and food), was gradually converted to a hygrophily. This became pronounced after twenty hours' exposure. Only one experiment using the temperature organ is quoted (Fig. 9), in which *C. pullus* seemed to prefer temperatures in the interval 35° to 40° C. The high percentages in the coldest sections may have been caused by the slower motion of the insect there. The temperature in the warmest section proved to be lethal, as no less than ten specimens of the original twenty-six died there during the last half of the experiment.

Table 3 gives the results of five experiments concerning temperature relations for individual specimens.

Fig. 10 shows the experimental arrangement. The bug was placed in a small glass tube in which space was restricted to about 1 cm³ by a cork, which was penetrated by a thermistor probe to the bottom of the tube. The tube was immersed in an ice/water mixture in a larger glass tube. This was heated from below and the spontaneous reactions of the bug were observed through a magnifying glass. For each change of behaviour the temperature was noted. From the start of heating to the last movement of the bug there was a time lapse of from 32 to 55 minutes. No attempt to control the change in humidity in the experimental chamber during warming was made.

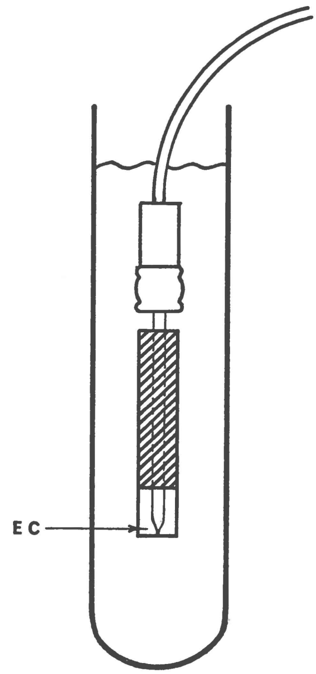

Fig. 10. Experimental arrangement for studying the temperature-activity relationship of *C. pullus*. EC is the experimental chamber.

Table 3.

	A	B	C	D	E	
Date of collection	22. VIII	22. VIII	25. VIII	25. VIII	31. VIII	
Date of experiment	23. VIII	24. VIII	26. VIII	26. VIII	16. IX	
Chill coma						$\bar{X}$
First movement......	7.6° (2.1°)	3.3°	10.7°	7.2°	10.7° (3.3°)	
Weak activity						
	9.2°	4.6°	10.9°	7.2°	18.3°	
Normal activity......						
	40.2°	44.2°	44.2°	44.5°	43.4°	43.3°
Excessive activity....						± 1.6°
Heat stupor.........	46.7°	46.7°	45.6°	45.6°	46.9°	46.3° ± 0.6°
Death	49.4°	49.6°	49.4°	48.7°	49.2°	49.3° ± 0.3°

At low temperatures the five individuals behaved quite differently. The "chill coma"* (cold rigor) was replaced by the first weak movements at temperatures from 3.3° to 10.7° C. This "weak activity" was then succeeded by "normal activity" (that is, the insect was upright and able to walk) at temperatures from 4.6° to 18.3° C. This last temperature (18.3° C) was very high and probably due to the fact that it was measured in the case of an individual (E) which had spent more than two weeks in the laboratory, so that adaptation was possible.

During the investigation of the low temperature limit of insects in the Scoresbysund area, Northeast Greenland, Bertram (1935) found the points of cold rigor and normal activity for a single specimen of "*Chlamydatus pulicarius*" to be 4.0° and 6.0° C, respectively. In Bertram's experiments the insects were forced ("by tapping the cage against the side of the chamber as a stimulus") to show whether they were able to move or not; a similar procedure would probably have produced more uniform results in my experiments. In two cases (A and E) some dubious, extremely weak movements were observed at considerably lower temperatures than the "real" first movements; they were regarded as passive movements, but this interpretation may be incorrect.

In the field I have often seen *C. pullus* fairly active and able to jump at temperatures of about 5° C — a temperature at which *Nysius groenlandicus* is almost inactive. The following example gives the relative catch (by searching for 15 minutes) of the two species in the same place (the heath at Østerlien) on two occasions with different weather.

Date	Time	Air temperature	RH	*Chlamydatus*	*Nysius*
August 9 (-69)	15.15	12.5° C (sun)	47 %	6	49
August 13 (-69)	17.30	6° C (no sun)	70 %	11	5

On September 8 and 10, 1967, the temperature in the air at 10 A.M. was meaured at 3° C and on the ground surface at 5° C on the slope of Østerlien. Each time *C. pullus* was lively and jumping.

In the experiments the measurements of the higher temperature limits showed, however, a remarkable degree of homogeneity. As the temperatur rose, "normal activity" covered a range of from 25.1° (E) to 39.6° C (B). While normally active the bugs were mostly occupied with cleaning movements; otherwise, they were rather passive. However, when the temperature reached 43° C, after a short period of violent beating of the antennae, this passivity was suddenly replaced by successively more pronounced "excessive activity", which is in fact an escape activity. This became convulsive, and ultimately the insects were lying on their

* The terms used are in accordance with Wigglesworth (1965).

backs unable to turn, when "heat stupor" set in at 46° C. Movements of the legs and antennae became progressively weaker and stopped. Death occurred at 49.3° C ± 0.3 in the five specimens tested.

Life cycle

In Europe *C. pullus* has two generations a year and winters in the egg-stage (KULLENBERG, 1944; SOUTHWOOD & LESTON 1959). In Greenland, too, the eggs hibernate, but there is only one annual generation. Even in the southernmost part (the Kap Farvel area), where the whole population is adult by early July, there is no indication of a second generation.

In 1968 the slope-localities at Østerlien, Godhavn, were snow-free by June 11 and the first nymphs appeared here about July 6. The first adults were found on August 4. That year breeding was late due to unusually large quantities of snow. In 1969 the population on the heath was detected. The snow disappeared from this part of the plain by May 14, when the slope and the lower lying parts of the heath were still covered. On June 30, nymphs in instars III to V were present on the heath, the first adults appearing in mid-July. The slope remained snow-covered until June 7, and by July 15, the population here consisted of nymphs in instars I to V, with most in III and IV. By August 7, adults constituted 96 % of a sample.

A single population estimate using a simple Lincoln-index ("Petersen Method", LE CREN, 1965) was carried out on August 21, 1969, in a small area on the slope (Plate 3, Fig. 1; Table 1). This triangular patch, measuring about 13 m^2, was particular well delimited in being on all sides surrounded by willow-scrub. The adult population was assessed as 11 per m^2 (one nymph V was caught).

Late in the season it was still possible to find a few immature stages of *C. pullus* on the slope of Østerlien. One nymph V was caught on September 8, 1967, and another IV on August 21, 1969. In Brededal a fifth instar was found on September 12, 1967; that summer was rather cold and humid.

There is a tendency for *C. pullus* to become adult earlier in those parts of Greenland which have a continental type of climate, even if found further northwards. For instance, only 5 % of my collection in the Umanak district between July 19 and 26, 1969, consisted of juveniles, in stages IV and V. In the innermost part of Arfersiorfik (south of Egedesminde) a fourth instar was found already on June 16, 1967. At Akugdlît, in southeastern Disko Bugt, about half of the population was adult by July 5, 1969. In this connection it is strange that a small collection of *C. pullus* from Umanak and Sãtut (Umanak district) taken between July

9 and 28, 1970 (leg. C. VIBE and P. VOLSØE) did not include a single imago. This presumably reflects the extraordinarily late advent of spring that year.

As mentioned previously, all adult specimens of *C. pullus* from Greenland which I have studied were females, implying that the species reproduce parthenogenetically in Greenland. In this respect it follows one of the typical trends of adaptation in insects in the Arctic (*cf.* DOWNES, 1962, 1965) and cytological studies would be highly desirable (*cf.* SUOMALAINEN, 1962). It must also be pointed out that this is one of the first reported instances of parthenogenesis among Heteroptera, and to my knowledge there is only one other, a rather doubtful case, involving another capsid bug (*Campyloneura virgula* (H.-S.); SOUTHWOOD & LESTON 1959).

Dissections of a small number of females of varying age (according to different degrees of pigmentation) showed that in all cases the body was nearly filled up with large eggs, extending even to the base of the head. A maximum of thirteen apparently ripe eggs was counted. No trace of longitudinal flight-muscles was detected, implying that flight is excluded (*cf.* p. 26). These points, however, need and deserve further study.

Egg-laying was never observed, nor were eggs found in the field. However, the females collected at Østerlien and used in the food-choice experiments between August 12 and 19, 1969 (p. 24) laid eggs in some of the plants employed, namely *Potentilla crantzii*, *Sibbaldia procumbens* and *Polygonum viviparum*. *Potentilla* was clearly favoured. The eggs were inserted singly or in small groups into stems, leaves and flowers (especially the floral receptacle). In *Polygonum* eggs were mainly found in the sheaths (Plate 6). Egg-laying was observed on August 16, but the first eggs were laid a few days earlier. Before using the ovipositor a hole was prepared with the stylets (*cf.* KULLENBERG, 1944, p. 403 ff.). The eggs were treated with low temperature, but — unlike *Nysius groenlandicus* — none of them hatched or showed any sign of embryonic growth. The egg has been described and drawn by KULLENBERG (1942) and PUCHKOV & PUCHKOVA (1956).

The adult population at Østerlien survived the first thrusts of winter and succumbed only when the autumn sun no longer melted the snow in the habitat, generally in the latter half of September.

Nutrition

According to KULLENBERG (1944) *C. pullus* is phytophagous and polyphagous, but he also observed it feeding occasionally on other insects. This general statement coincides with my observations in Greenland. He further established that *Achillea millefolium* is particularly favoured and that *Lotus corniculatus* and *Trifolium repens* are other important food-plants; in addition he observed sucking on *Taraxacum vulgare*, *Sedum acre* and *Festuca ovina*.

SOUTHWOOD & LESTON (1959) stated: "It is a pest of lucerne [*Medicago sativa*] in Russia, so although it is often found on sorrel [*Rumex acetosa*] and knotgrass [*Polygonum aviculare*], Papilionaceae such as black medick [*Medicago lupulina*] and white clover [*Trifolium repens*] are probably its food-plants".

Very few of the plant species mentioned are likely to be of any importance as food-plants for *C. pullus* in Greenland. According to T. W. BÖCHER, HOLMEN & JAKOBSEN (1968) *Lotus corniculatus* and *Festuca ovina* are absent, *Sedum acre* is extremely rare, and although the rest of the species are found in Greenland, they are all introduced and confined to the immediate surroundings of habitations, especially in the southwestern part of the country. However, many species of *Taraxacum* occur in Greenland, and some of them may be found in the dry places inhabited by *C. pullus*.

In order to investigate the food preferences of *C. pullus* in the Godhavn area some food-choice experiments were set up.

The apparatus used consisted of a large petri-dish (15 cm in diameter) radially divided in ten equal sections, with a small, circular room in the centre. The plant material (flowers, fruits, stems and leaves) was placed in the radial sections in such a way that two sections opposite each other contained the same plant species. The central room was equipped with wet filter-paper which kept the plant material fresh and allowed the insect to drink; a hole in the lid was placed above this room. In each experiment 25 to 35 adult bugs collected at Østerlien were employed. Position and eventual sucking of the bugs was examined at irregular intervals by means of a binocular microscope; following each observation the apparatus was turned to a new position in order to avoid one-sided influences.

The results are presented in Fig. 11. The plant species tested were some of the most common in the heath and on the slope of Østerlien (*cf.* Tables 1 & 2); experiment B exclusively deals with the dominant plants of the heath. In experiment D only fruits (and bulbils) were used.

In experiment A, *C. pullus* revealed a strong preference for *Potentilla crantzii* and *Sibbaldia procumbens*; in B, *Polygonum viviparum* was clearly preferred, but *Salix glauca* and *Vaccinium uliginosum* each accounted for about 20 $^0/_0$ of the observations (11 $^0/_0$ and 15 $^0/_0$, respectively, of the sucking observations). The five favoured species were then compared in experiment C. Now *Potentilla* and *Polygonum* were frequented equally, but there were five times as many observations of sucking on *Polygonum* (nearly exclusively on the bulbils). Sucking was observed on all parts of the plants, but in the case of *Salix* and *Vaccinium* the fruits were preferred; 86 $^0/_0$ of the sucking on *Polygonum* took place on the bulbils.

It seems justified to conclude that *Polygonum viviparum*, which is abundant both in the heath and on the slope, is a prominent food-plant in this area; on the slope *Potentilla crantzii*, too, undoubtedly plays a significant part. It is furthermore evident that a number of other plant species may contribute to the nutrition of *C. pullus*. In England Woodroffe (1955) suggested an association between *C. pullus* and another species of *Polygonum*, *P. aviculare*.

There is every indication that *Potentilla* spp. are of great importance as food-plants for *C. pullus* in Greenland. In addition to *P. crantzii*, there seems to be a marked affinity to *P. hookeriana* in the drier parts of NW Greenland (*cf.* p. 9); at Ikerasak, in the Umanak district, *C. pullus* was found in the flowers of this species (Plate 4, Fig. 1; Table 2: Stand 7). A relation to *P. tridentata* was strongly indicated in the Kap Farvel area (*cf.* p. 13). Compare also the quotation from Johansen (1910) p. 8.

It was very strange not to find *C. pullus* in two well-investigated localities in the northern part of the Ilua fjord system in the Kap Farvel

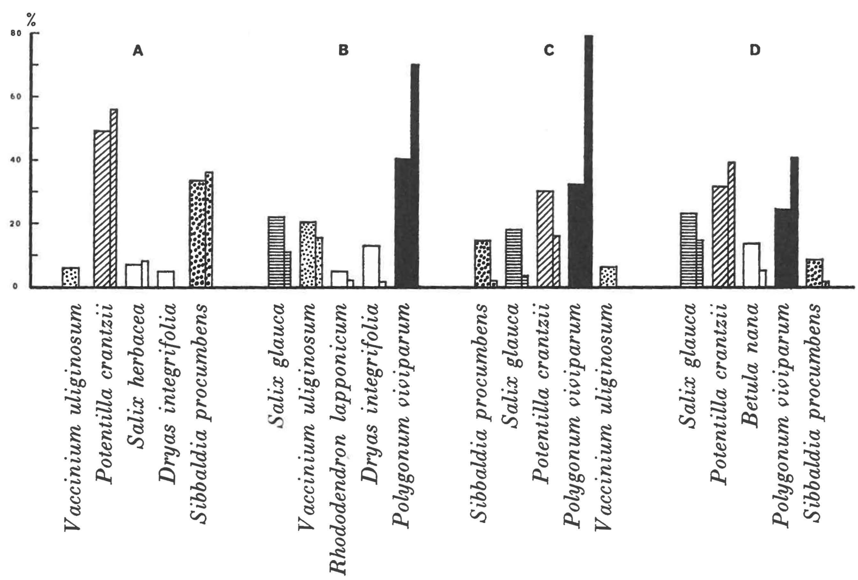

Fig. 11. Results of four-food choice experiments with *C. pullus*. The broad columns represent bugs sitting on the plant in question, the narrow columns indicate bugs sucking on the plant.

A. August 7 to 10, 1969. 26 recorded positions. 410 observations of sitting, 25 observations of sucking.

B. August 12 to 16, 1969. 30 recorded positions. 517 observations of sitting, 136 observations of sucking.

C. August 16 to 19, 1969. 21 recorded positions. 571 observations of sitting, 57 observations of sucking.

D. September 1 to 4, 1969. 15 recorded positions. 216 observations of sitting, 62 observations of sucking.

area. In one of these places (Igdlorssuit, Kangersuneq qíngordleq) there was a large, rather dry, south-facing slope covered with an extremely rich and luxuriant vegetation, including abundant *Potentilla crantzii*, *P. tridentata* and *Polygonum viviparum*. Conditions for *C. pullus* seemed ideal, and its absence from this place, surrounded as it is by about 2000 m high mountains carrying numerous glaciers, must be due to historical reasons and the limited dispersal powers of the species.

In two cases I have seen *C. pullus* feeding on other insects. In the laboratory it was observed sucking out a nymph of a *Psylla* sp. on *Salix glauca* on one occasion, and an adult *Psylla* on another. This adult *Psylla* was in an aspirator containing a sweep-net sample from *Betula nana*-dominated scrub in the Umanak district (Tasiussaq; August 25, 1968). Presumably *C. pullus* is a facultative predator, at least in the adult stage. This would explain the occurrence of the species in the dry scrubs of the Umanak district (*cf.* p. 10) where it may be hunting for such small insects as psyllids and aphids. In one locality (Qarássap nunatâ; July 18, 1969) 61 specimens were caught by twenty sweeps in *Betula-Salix* scrub.

Behavioural notes

C. pullus is a very active insect whenever temperature permits, at least the antennae are in constant motion. Generally it keeps close to the ground and to the lowest part of the vegetation; in one case it was, however, observed in the flowers of *Potentilla hookeriana* and it was taken by sweeping in *Betula nana*-scrub (*cf.* above). When frightened it jumps for a distance of 10–15 cm using its long hind-legs. It is always fully winged, but I have never clearly seen the wings in use during leaping. Neither have I seen it flying. When *C. pullus* is disturbed on a plant stem, for example, it instantly shifts its position to the side of the stem opposite the stimulus. This makes it very difficult to detect the species in the vegetation.

While capturing an apparently healthy individual in the laboratory it suddenly lost one of its hind-legs (autotomi, *cf.* LARSÉN, 1941) and entered a cataleptic state which lasted for several minutes; its behaviour did not return to normal until one hour later. This was my only observation of autotomi and catalepsis, so that this extreme type of behaviour occurs only in certain ultimate cases of emergency.

Summary and conclusions

1. Four species of Heteroptera have been recorded in Greenland, among them *Chlamydatus pullus* (Reuter). Hitherto most of the Greenlandic material of *Chlamydatus* Curtis has been erroneously identified as *C. pulicarius* (Fallén), but only *C. pullus* occurs in Greenland.

2. The finds of *C. pullus* in Greenland are mapped (Fig. 1). Presumably it is distributed fairly continuously from NE to NW, being only absent in the north; but on a smaller scale, the distribution is very disjointed. The drier the climate of an area, the more frequently and ubiquitously *C. pullus* is found.

3. The habitat of the species in Greenland corresponds well with the biotopes preferred in Europe. Typically it is found on dry, south-facing slopes with a rather sparse vegetation. In addition, in dry areas it occurs in heaths and scrubs dominated by *Betula nana.*

4. Microclimatic measurements indicate that the species is found in places with a hot and dry microclimate.

5. Experiments were carried out on the reactions of the species to gradients of humidity and temperature and to slowly rising temperatures. An initial xerophily was gradually converted to a hygrophily after six to eight hours without access to water and food. *C. pullus* showed a preference for temperatures in the interval 35° to 40° C. Normal activity was replaced by excessive activity in the interval 40° to 45° C, heat stupor set in about 46° C and the death occurred at 49° C. A distinct low temperature threshold of activity was not established.

6. In Greenland *C. pullus* has only one annual generation, whereas there are two in Europe; it winters in the egg-stage. At Godhavn the nymphs appear from the last half of June to the beginning of July, according to the disappearance of snow from the habitat. Adults are present from mid-July and predominate about August 1. Further southward and in more inland parts of Greenland the species may become adult one month earlier. In the Godhavn area egg-laying probably takes place from mid-August onwards.

   Only females have been collected in Greenland, implying that the species here occurs in a parthenogenetic, arctic form. This is one of the first reported instances of parthenogenesis among Heteroptera.

7. Just as in Europe, *C. pullus* is phytophagous and polyphagous in Greenland. However, it is also an occasional predator on small insects. Preferred food-plants appear to be *Polygonum viviparum* and different species of *Potentilla.*

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Færdig fra trykkeriet den 28. oktober 1971.

PLATES

Plate 1

Chlamydatus pullus (REUT.). Taken in the "*Potentilla tridentata*-steppe" at Anordliuit-soq, Pamiagdluk, in the Kap Farvel area. Reproduced from color slides. The length of the bug is about 2.5 mm. J. B. phot. August 1970

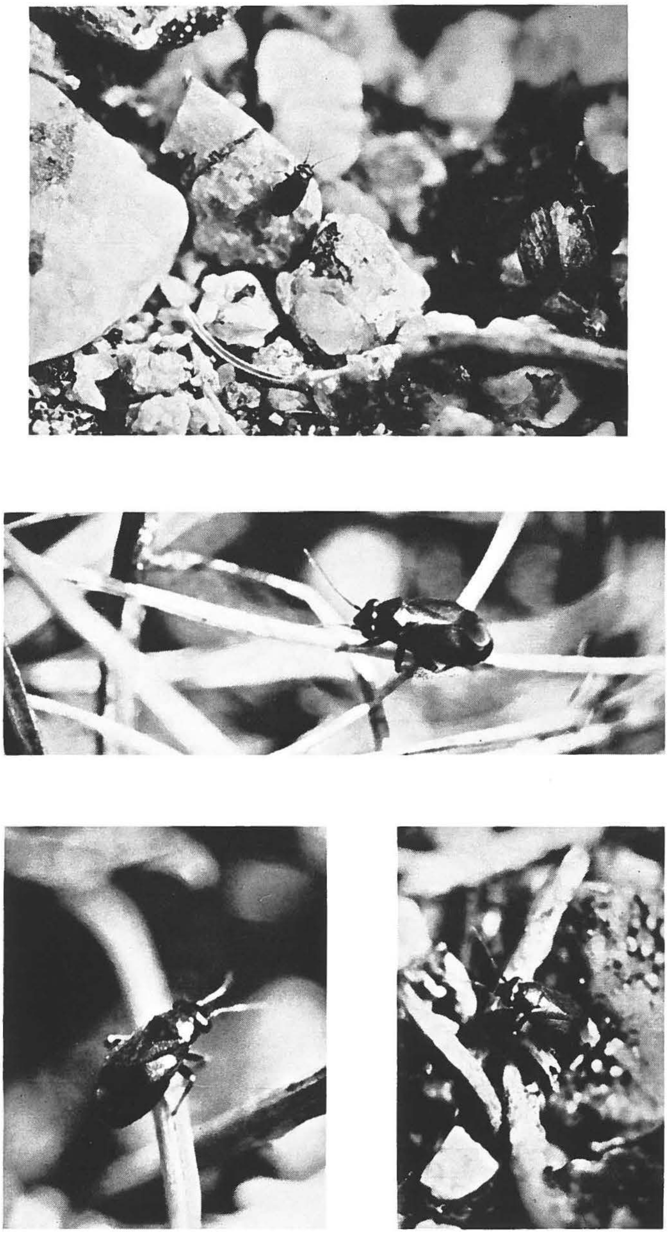

Plate 2

Fig. 1. View of a part of Østerlien at Godhavn, facing NE. The habitat of *C. pullus* is limited to small areas below the snow patch at the foot of the slope and to the upper left portion of the plain. *Cf.* Fig. 2 in the text. J. B. phot. 23/6 1969.

Fig. 2. Østerlien in early autumn. In the foreground is the heath inhabited by *C. pullus*. In the background is the slope, where the species is found in small, dry patches towards the base. *Cf.* Table 1 b and Table 2: Stand 1. J. B. phot. 1/9 1969

Fig. 1.

Fig. 2.

Plate 3

Fig. 1. Part of the slope at Østerlien, Godhavn, at the end of June. The habitat of *C. pullus* is found in front of the woodden pole used for the temperature measurements. *Cf.* Table 1 a. J. B. phot. 25/6 1969

Fig. 2. The type of *Betula nana*-scrub in which *C. pullus* commonly occurs in the Umanak district. Taken at Pangnertôq, Uvkusigssat Fjord, northern Umanak district. J. B. phot. 18/8 1968

Fig. 1.

Fig. 2.

Plate 4

Fig. 1. Vegetation in dry rock crevices near Ikerasak in the Umanak district. The flowering plants are *Cerastium alpinum* and *Potentilla hookeriana*. In the distance is Nûgssuaq. *Cf.* Table 2: Stand 7. J. B. phot. 20/7 1969

Fig. 2. Steppe-like vegetation on a south facing slope at Qarássap nunatâ in the southeastern Umanak district. The flowering plants are *Cerastium alpinum* and *Saxifraga tricuspidata*. *Cf.* Table 2: Stand 6. J. B. phot. 19/7 1969

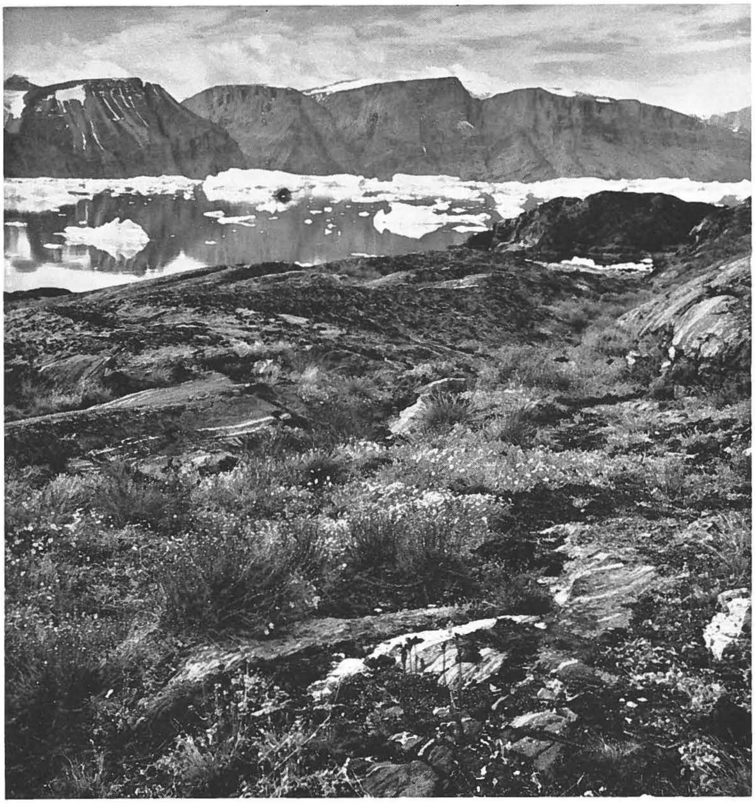

Fig. 1.

Fig. 2.

Plate 5

Fig. 1. "*Potentilla tridentata*-steppe" at Anordliuitsoq, Pamiagdluk, in the Kap Farvel area. The main camp of the Kap Farvel Expedition is seen. In the background (to the south) is Tôrnârssuk.

Fig. 2. The microclimatic station in the "*Potentilla tridentata*-steppe" (*cf.* Fig. 1), facing NE. Flowering *Potentilla tridentata* dominates the foreground. *Cf.* Table 2: Stand 9. J. B. phot. 1/8 1970

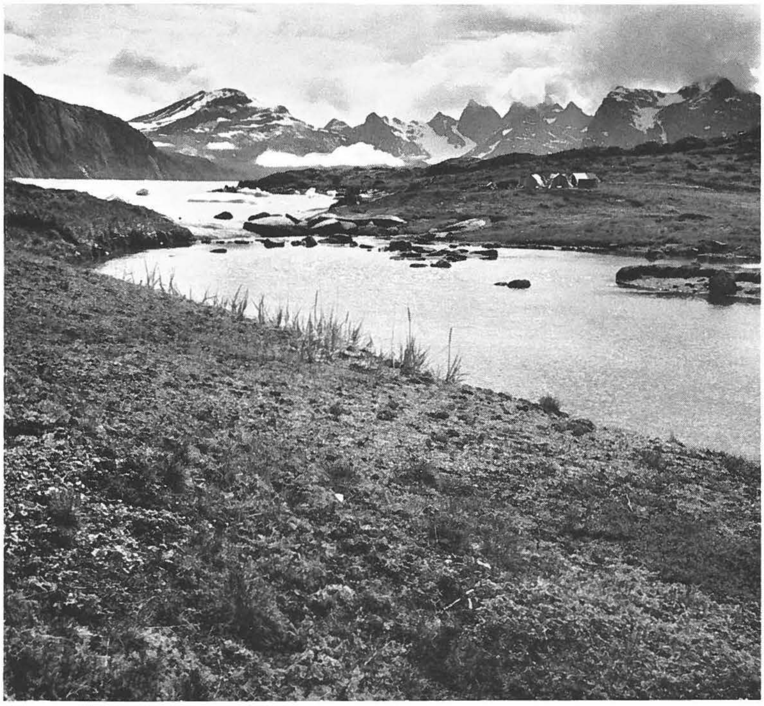

Fig. 1.

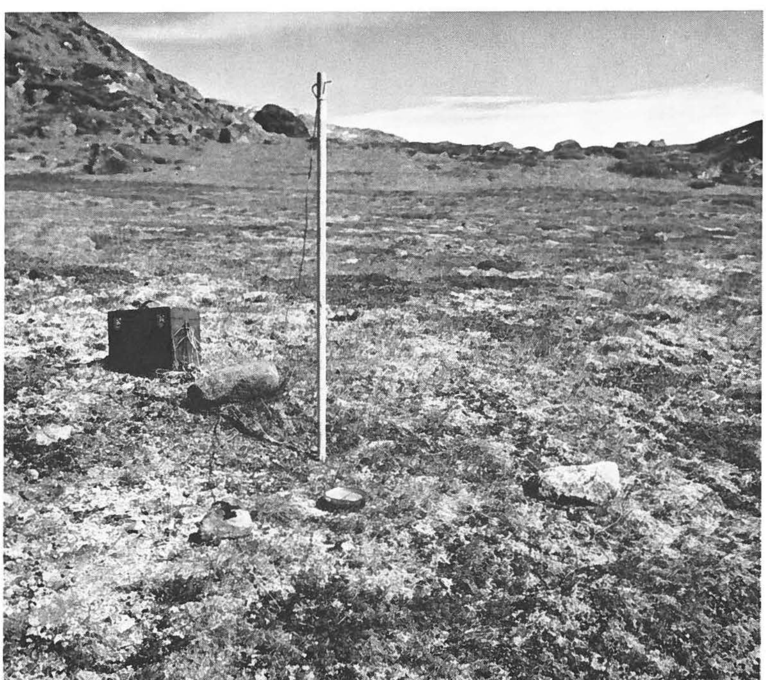

Fig. 2.

Plate 6

Figs. 1 & 2. Eggs of *C. pullus* in the sheaths of *Polygonum viviparum.*

Fig. 3. Eggs of *C. pullus* inserted into the mid-rib of a withered basal leaf of *Polygonum viviparum.* Only the micropyles are visible. The length of the egg is about 0.7 mm. J. B. phot. 14/11 1969

Fig. 1.

Fig. 2.

Fig. 3.