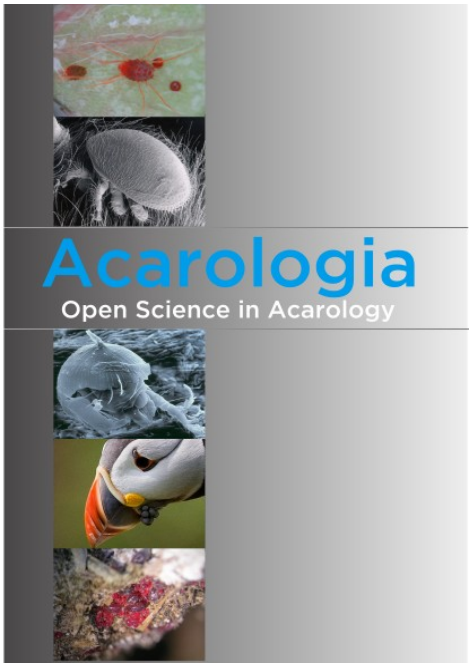

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ON THE BIOLOGY OF SCUTACARUS ACARORUM GOEZE (ACARINA : TROMBIDIFORMES)

BY Christian SCHOUSBOE *

PHORETIC, HYPERPHORETIC FEMALES OF SCUTACARIDAE ON HYMENOPTERA AND PARASITIDAE DEUTONYMPHS BIOLOGY ETHOLOGY

ABSTRACT : Phoretic females of *Scutacarus acarorum* Goeze occur in Denmark on bumblebees (*Bombus* Latr.) and cuckoo bumblebees (*Psithyrus* Lep.). Frequency and number of *S. acarorum* on castes of *Bombus terrestris* L. and *B. lucorum* L. is recorded ; the mites occur primarily on queens. Greatest number — 115 — was found on an overwintered queen of *B. terrestris*. Small numbers could be found on deutonymphs of *Parasitus* species (Mesostigmata) phoretic on the bumblebees. Physogastric females were found on bumblebee workers and drones and in late spring on queens. *S. acarorum* was reared in mass cultures feeding on mycelium of *Histoplasma capsulatum* Darling. Morphology of the *S. acarorum* male is illustrated.

PHORETISCHE, HYPERPHORETISCHE WEIBCHEN VON SCUTACARIDAE AUF HYMENOPTERA UND PARASITIDAE DEUTONYMPHEN BIOLOGIE ÉTHOLOGIE

ZUSAMMENFASSUNG : Phoretische Weibchen von *Scutacarus acarorum* Goeze wurden in Dänemark auf Hummeln (*Bombus* Latr.) und auf Schmarozerhummeln (*Psithyrus* Lep.) festgestellt. Häufigkeit und Anzahl auf Kasten von *Bombus terrestris* L. und *B. lucorum* L. ist angegeben ; die Milben sind primär auf Königinnen anzutreffen. Grösste Anzahl — 115 — ist auf einer Königin von *B. terrestris* im Frühjahr gefunden worden. Auf phoretische Deutonymphen von *Parasitus*-Arten (Mesostigmata) wurden kleine Anzähle von *S. acarorum* gefunden. Angeschwollene Weibchen wurden auf Hummelarbeiterinnen, Drohnen und im Spätfrühling auf Königinnen angetroffen. Aufziehung von *S. acarorum* gelang auf Myzel von *Histoplasma capsulatum* Darling. Morphologie von männliche *S. acarorum* geht von Abbildung hervor.

INTRODUCTION

Adult females of *Scutacarus acarorum* Goeze are found phoretic on European bumblebees, and have been recorded from USSR, Mongolia and North America.

A century ago, MICHAEL (1884) reared *S. acarorum* in the laboratory, and he depicted and described the larvae and adults. Until now, no other rearings of this species have been recorded, and the adult male is known only from MICHAEL's crude illustration and description, and from a line drawing made by BERLESE (reproduced in VITZTHUM 1943) on the basis of MICHAEL's material.

In the last decade, descriptions of males of other *Scutacarus* species have been published (BINNS 1980, ELBADRY *et al.* 1976, NORTON & IDE 1974, RACK 1975) and reproduction in *Imparipes histricinus* Berlese (Scutacaridae) has been studied (EBERMANN 1982). Although *S. acaro-*

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rum is found in all major parts of the northern hemisphere, very little is known of its biology.

The present work deals with the relation between phoretic female *S. acarorum* and their hosts, and with observations in the laboratory, including experiences with rearing the species. Morphology of the adult male is illustrated.

Materials and Methods

Phoretic relationships between *S. acarorum* and bumblebees were studied by recording the mite fauna of the bumblebees. The bees were caught in the vicinity of Copenhagen, Denmark, and all were caught while visiting flowers. A total number of 382 bumblebees was studied : 138 overwintered queens, 119 workers, 111 drones and 14 young queens. The bees were killed either immediately after capture by submersion in alcohol or by decapitation or freezing after half a hour at 7° C.

Injection trials were carried out on overwintered queens. Each queen was injected with 0,1 ml concentrated watery solution of congo-red. Injection was done through the membrane between the 2nd and 3rd or between the 3rd and 4th tergum. Commercial needles 0,5 mm thick were used.

Scutacarus acarorum was reared in plastic petridishes provided with a layer of lampblack/plaster of Paris. The plaster surfaces were scraped with a stiff brush, whereby lumps of lampblack were removed, and hollows and furrows made. The dishes were placed at room temperature (ca 20° C), and kept in flat boxes of isolating material to minimize condensation. Dessication and condensation were not problems during rearing experiments. Mycelia were grown by placing pieces of baker's yeast on the soaked plaster, and placing a variety of objects on the yeast. These objects were small samples of different types of soil, parts of a year old bumblebee nest (*B. hypnorum* L., stored at room temperature) and objects taken from a honeybee hive. Phoretic female mites were scraped from bumblebees (*B. terrestris* queens) and placed in dishes with growing mycelia. Rearing was successful on mycelia growing in dishes, where dead honeybees, pollen loads from honeybees and pieces of honeybee comb with fecal droppings, had been placed on the yeast. Rearing of the mites was continued in new dishes after transferring mycelia to fresh pieces of yeast.

RESULTS

Phoresy

Adult females of *Scutacarus acarorum* were found on queens of bumblebees (*Bombus* Latr.) and cuckoo bumblebees (*Psithyrus* Lep.) (Table 1). On *Bombus terrestris* L. and *B. lucorum* L., the mites were found on about every second overwintered queen (Table 2). Of these queens 60,5 % had 5 or fewer, and 85,7 % had 10 or fewer *Scutacarus* mites on them. A total number of 115 *Scutacarus* females was found sitting on an overwintered queen of *B. terrestris*. Infection with the nematode *Sphaerularia bombi* Dufour, which infects the queens during their hibernation, sterilizes them and alters their behavior in the spring, has not been found to influence the fre-

Table 1 : Danish phoresy hosts of *Scutacarus acarorum* Coeze.

	overwintered queen	worker	drone	young queen
Bombus terrestris L.	+	+	+	+
Bombus lucorum L.	+	+		+
Bombus lapidarius L.	+	+	+	+
Bombus pratorum L.		+		
Bombus hortorum L.	+			
Bombus agrorum Fabr.	+			
Psithyrus bohemicus Seidl.	+			+
Psithyrus silvestris Lep.			+	

TABLE 2 : Phoretic *Scutacarus acarorum* Goeze found on bumblebees (*Bombus terrestris* L. and *B. lucorum* L.) and on phoretic *Parasitus* deutonymphs.

	number of bees	infected bees, %	range of mite numbers	mites pro infected bee	mites pro bee	% mites on *Parasitus*
overwintered queens	92	53,3	1-115	11,6	6,2	3,3
workers	95	8,4	1-6	2,8	0,2	45,5
drones	45	17,8	1-22	6,4	1,1	0

quency of *S. acarorum* (non-significant negative association : $\chi^2 = 3,74$; $P > 0,05$). On bumblebee queens, females of *S. acarorum* were found on the forewings and on the (3rd) notum of the thorax. On the forewings the mites were sitting on the lower surface near the base of vein III, where they were clinging to the short hairs with the big single claws of legs I. On each wing there were up to a dozen mites often sitting very close together. Single mites could be found on the upper surface of the forewings in the small grooves at the bases of vein I-II and of vein IV. On the notum — between the scutellum and propodeum — the mites were located at the base of the hairs, primarily the longer hairs in lateral positions, but when the mites were numerous on a queen, they sat attached close together forming a rim that more or less covered the notum. On overwintered queens the number of *Scutacarus* females attached to phoretic deutonymphs of *Parasitus sp.* (Mesostigmata) constituted only a minor part of the total number of *Scutacarus* (Table 2).

Frequency and number of *S. acarorum* mites on bumblebee workers was much lower than on overwintered queens (Table 2). Nearly half of the *Scutacarus* found on workers were sitting on phoretic *Parasitus* nymphs (Table 2). On workers, *Scutacarus* mites were found on the lower surfaces of the forewings as on queens, and on hairs of various parts of the thorax-propodeum.

Scutacarus acarorum females were found on drones of *Bombus* and *Psithyrus* (Table 1). Frequency and number on drones was about twice that of workers (Table 2). None was found on *Parasitus* nymphs phoretic on drones. On the drones, *Scutacarus* mites were located on the lower surface of the forewings as on queens, on the upper surface of forewings (base of vein IV), and on the long hairs that form the lateral margins of the central shorthaired face of the propodeum.

Scutacarus females were found on phoretic deutonymphs of *Parasitus fucorum* De Geer, *sensu* VITZTHUM 1930, of *Parasitus anglicus* Vitzthum 1930, and of *Parasitus crinitus* Oudemans, *sensu* VITZTHUM 1930. Of 241 *P. fucorum* found on the bumblebees, 18 (7,5 %) carried *Scutacarus* (total 24 individuals). Of 64 *P. anglicus, Scutacarus* mites were found on 2 (3,1 %), and on 114 *P. crinitus* only one *Scutacarus* was found. On the *Parasitus* nymphs, *Scutacarus* mites were found clinging to setae on the frontal tip of the anterior dorsal shield (setae J1), to setae on legs II, III and IV, and in one case to sternal setae.

Very pale, almost uncoloured individuals of *S. acarorum* were occasionally found among normal red-brown mites on the bumblebees. On overwintered queens, the mites were seen discharging dark fecal pellets, and removing the pellets by horizontal movements of legs IV and their long distal setae. On forewings of some overwintered queens, a zone of fecal pellets could be seen distolaterally to the cluster of mites.

At the time of year when the first bumblebee workers (*B. terrestris*) were seen, queens that had not founded colonies (being infected with *Sphaerularia bombi*) were caught ; on these queens about half of the *Scutacarus* mites were dead, and the majority of the living ones were in a physogastric state (Fig. 1). Physogastric females were also found on workers and drones.

LABORATORY OBSERVATIONS

Injection trials

If staining the haemolymph of the bumblebee is followed by presence of the stain in the mites, parasitism would be proven. Twelve overwintered queens (*B. terrestris*) had their haemolymph stained by injection of congo-red. Immediately after injection a pronounced colouring could be seen through the membrane of the neck. The bees were killed — or they died 1-3 days after injection. *Scutacarus* mites from the queens did not show any trace of red colouring : parasitism was not demonstrated.

Rearing

Rearing of *Scutacarus acarorum* on mycelia from various sources was tried in early spring, but without success. Successful rearing was started with mites taken from queens at the time of year when the first queens (*B. terrestris*) had just founded their new nests and were seen with pollen loads.

In all petri-dishes where *S. acarorum* bred quickly and in some numbers, mycelia of *Histoplasma capsulatum* Darling were growing.

Histoplasma spread from the yeast as a fine network of hyphae bearing macroconidia. Ovipositing females, eggs, and quiescent female larvae accompained by one to several males were usually found in hollows underneath the *Histoplasma* mycelium. Grazing zones in the mycelium were often seen surrounding adult females and big larvae. Adult males were seen moving around carrying quiescent female larvae on their backs. From phoretic females development of the first offspring of males and quiescent larvae took about 9 days.

On mycelia of other fungi, females would graze, could become physogastric, and in some cases could produce eggs ; if such eggs did hatch, the larvae grew slowly and did not pass the larval stage. Nothing indicated that the larvae or females fed on the yeast or on bacterial colonies.

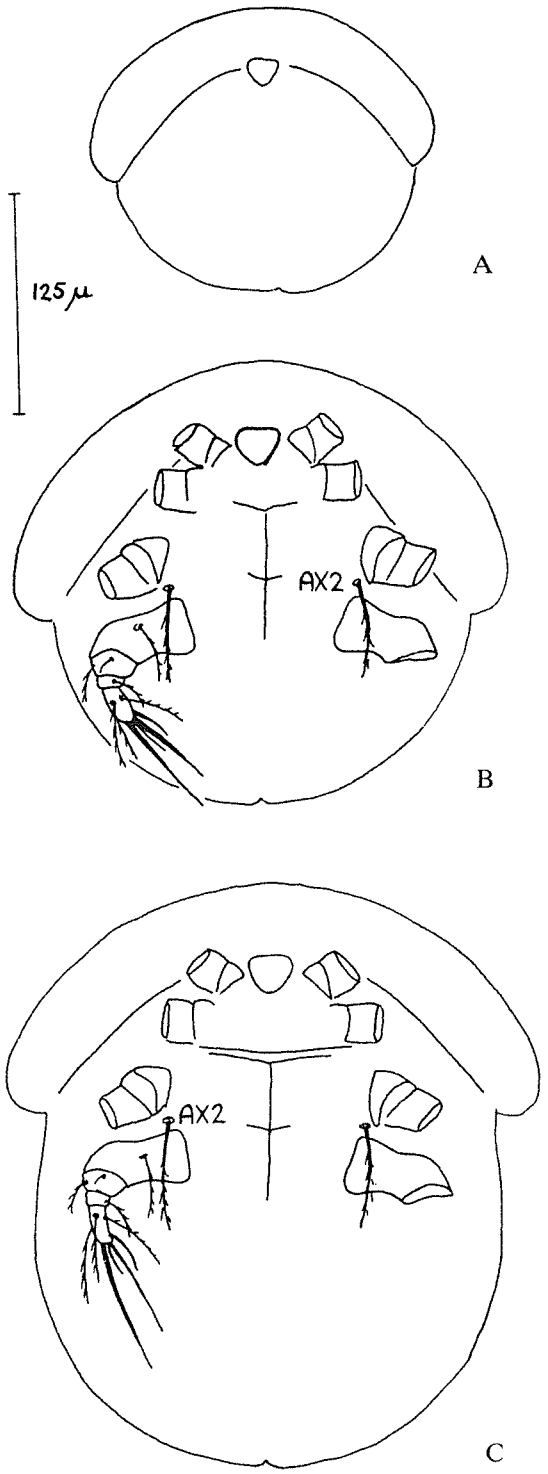

FIG. 1 : Phoretic females of *Scutacarus acarorum* Goeze. A : Outline of small dead mite from *Bombus* worker ; AX2 spacing 80 µm. B : Outline of large mite from same bee as A ; AX2 spacing 110 µm. C : Outline of large physogastric mite from overwintered *Bombus* queen ; AX2 spacing 110 µm.

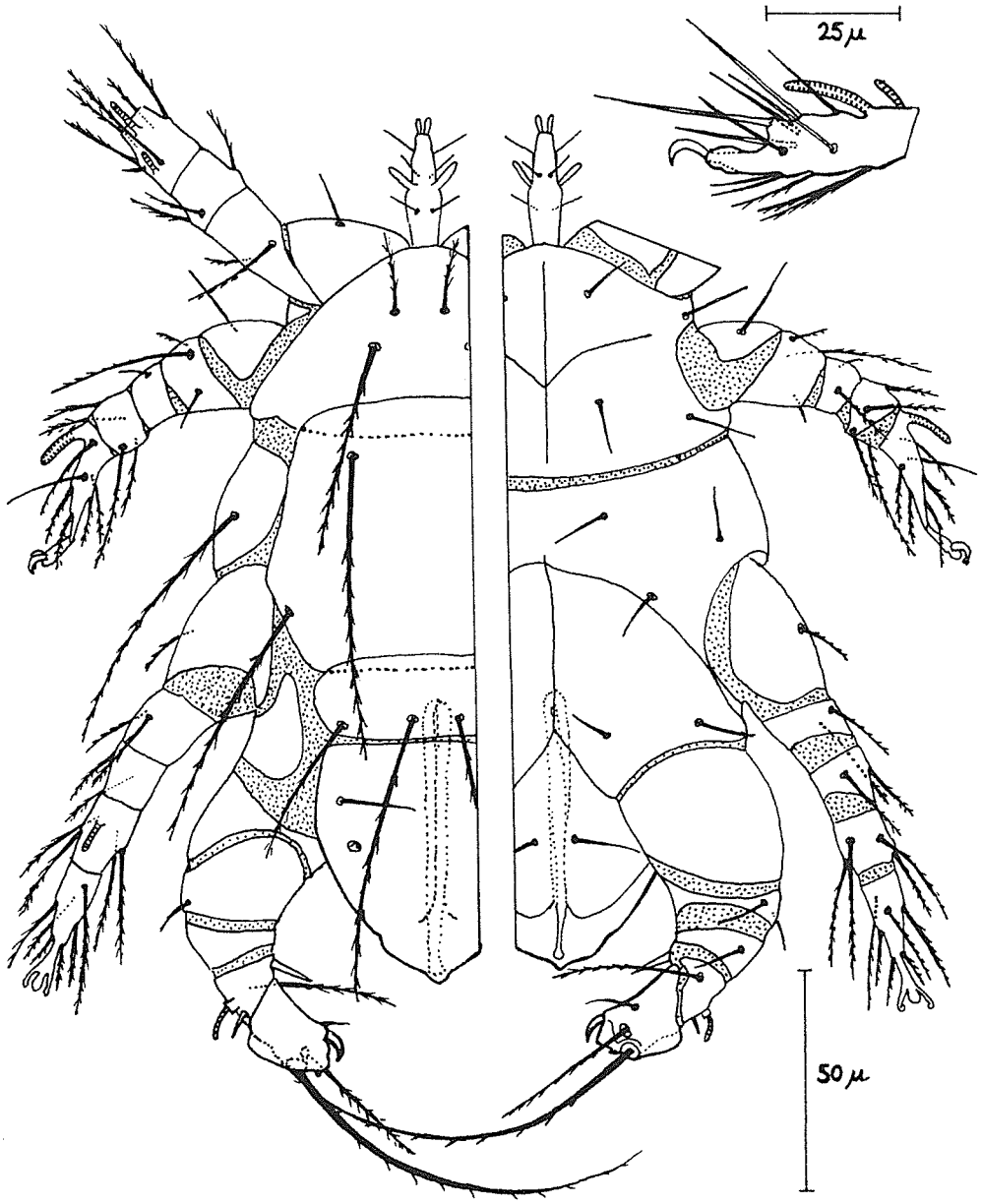

FIG. 2 : Male of *Scutacarus acarorum* Goeze. Left : Dorsal aspect, tarsus I omitted. Right : Ventral aspect, leg I omitted. Upper right : Tarsus I, adaxial aspect.

Scutacarus continued to breed as long as the conditions were favorable. In case of dessication, or if *Histoplasma* was grazed by too many mites, the larvae and the adult males died, but the females assembled at various sites, often in high positions, e.g., in remains of aerial mycelia of *Mucor sp.* If dessication continued the females gathered together in deep hollows in the plaster, where they if further dessication was avoided stayed alive for at least 5 months.

Colourless adult females were not observed among the progeny. Compared to phoretic females, the progeny was of rather uniform size. Size ranged between 72,5 μm and 97,5 μm with a

mean of 86,8 μm (50 females from one dish), when the spacing of ventral setae AX2 (terminology after KARAFIAT 1959, see Fig. 1) was used as a measure of body size.

Host finding

The perching stance described by BINNS (1980) in *S. baculitarsus* was not observed in *S. acarorum*.

Young adult females could not be induced to mount flies (*Fannia canicularis* L., *Lucilia sp.*), but on honeybee workers and bumblebee workers (*B. terrestris*) few to numerous mites could be found after confinement of the bees in rearing dishes for 1,5 — 4 hours. On bumblebee workers the mites gathered together on hairs surrounding the wing bases. Forewings torn from honeybee workers being dead for one month did not activate the mites, but after both the wings and a living honeybee had been confined in the rearing dish for two hours, mites were found on the bee as well as on the loose wings.

Leaving the host

Phoretic *S. acarorum* did not leave overwintered queens killed by decapitation and did not leave wings torn from the queens ; the mites stayed in the phoretic position until they died, probably from dehydration. Exposure to various temperatures (30, 12, 7° C) and to moisture-saturated air for 3 days did not induce the mites to leave loose wings. Neither did phoretic females leave loose wings put in rearing dishes containing *Histoplasma* mycelium and breeding mites. Mites leaving their phoretic position were only observed in one case : a wing with two mites was placed in moisture-saturated air at room temperature ; on the 7th day hyphae were growing on the wing base, both mites had left their position and one was dead, but the other was sitting in the hyphae, where it remained alive until at least the 14th day.

DISCUSSION

In 1845 GROS wrote on *S. acarorum* sitting on a *Parasitus* mite : " On voit le petit animal plonger son rostre dans le fémur ", and until lately the opinion of *Scutacarus acarorum* being parasitic has been advocated (CHMIELEWSKI 1971). Morphology of the scutacarid gnathosoma (ATHIAS 1973, KARAFIAT 1959) indicates that these mites hardly could be parasites, and rearing of *Scutacarus* species on brewer's yeast (BINNS 1980), mushroom bedding compost (NORTON & IDE 1974), and on decaying bodies of ants (ELBADRY *et al.* 1976), makes it unlikely that parasitism occurs among *Scutacarus* species. The negative result of the injection trials and the successful rearing on hyphae, described in the present work, makes it very unlikely that *S. acarorum* should be anything but purely phoretic on the bumblebee hosts. MICHAEL (1884) reared *S. acarorum* on cheese.

Histoplasma capsulatum is probably not the only species of fungi on which *S. acarorum* can breed, but *Histoplasma* has special interest in connection with bumblebees. This fungus grows parasitically in animals, including small rodents, and saprophytically in soil enriched with animal feces (EMMONS *et al.* 1977), and many species of bumblebees build their nests in tunnels and nests of small rodents. *Histoplasma* causes histoplasmosis in humans as well as in animals (vertebrates).

In the scarce literature on *Scutacarus acarorum*, the mite is reported either on bumblebees or on *Parasitus* mites. Finds of the mite in bumblebee nests are very few : RACK (1964) and RICHARDS & RICHARDS (1976) found *S. acarorum* on *Parasitus* mites in nests. CHMIELEWSKI (1971) found *S. acarorum* in nests, but only rarely and in small numbers, and TRÄGÅRDH (1910) reported the mite from a single nest. In view of the great number of bumblebee nests that for various purposes have been observed and analysed over the years, it is

noteworthy that *S. acarorum*, with its wide geographical distribution and high frequency on bumblebees, has not been reported from the bees nests more often. This might be explained by the small size and the slow movements of these mites. Processing bumblebee nests and nest surroundings in a Berlese-Tullgren apparatus or by an appropriate flotation method might prove that *S. acarorum* is rather common in the nests.

As *Scutacarus acarorum* feeds on hyphae, the frequencies and numbers of these mites can be expected to be highest in bumblebee nests with a high and stable humidity, i.e. in subterraneous nests. In the present study *S. acarorum* was only found on bumblebee species that normally or frequently nest in the ground and on species of cuckoo bumblebees parasiting underground nesting bumblebees. *Scutacarus* is expected to be unable to propagate in man-made above-ground bumblebee domiciles as well as in natural above-ground nests (e.g. *Bombus hypnorum*). Species of predatory mites (*Parasitus, Hypoaspis, Garmaniella*) that live in bumblebee nests and overwinter in phoretic stages on the queens are expected to prey on breeding populations of *S. acarorum*, and may together with the presence of appropriate mycelia be the two major factors limiting the number of *S. acarorum* mites in the nests.

KARAFIAT (1959) found that *S. acarorum* was among the most abundant of scutacarids in samples of meadow soils (Wiesenboden), and it is possible that the mite lives in soil habitats other than bumblebee nests and their immediate surroundings. As both workers, drones and young as well as overwintered queens can pass the night away from nests and can seek sites shelter under soil litter during showers, they might pick up the mites in places other than their nests. Finds of physogastric female mites on *Sphaerularia*-infected queens indicate that this might happen regularly. Bumblebee queens tend to seek sites with special oecological properties for their underground hibernation, and these sites may offer *S. acarorum* a second breeding locality. As *Sphaerularia*-infected queens revisit the hibernation sites, physogastric *S. acarorum* females can possibly be picked up here.

Scutacarus acarorum females have been found on wasps (VITZTHUM 1927), in honeybee hives (GROBOV 1975, HOMANN 1934), in debris under a wild honeybee nest (KARAFIAT 1959), on *Parasitus* nymphs from honeybee hives (SCHOUSBOE 1984), and on the honeybees themselves (HOMANN 1934). *S. acarorum* is likely to be brought into honeybee hives with bumblebee queens which in the spring often invade the hives (MORSE & GARY 1961), presumably attempting to steal honey.

The vast majority of phoretic *S. acarorum* females was found in Denmark on bumblebees and only a few on phoretic *Parasitus* deutonymphs. According to information given by RICHARDS & RICHARDS (1976), the reverse relation occurs in North America.

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