

**MITES (*Acarina*) PHORETIC ON SOME COMMON
BUMBLEBEE SPECIES (*Bombus* spp.) FROM THE PUŁAWY
AREA (SOUTH-EASTERN POLAND)**

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Received 06 February 2008; accepted 31 March 2008

S u m m a r y

A total of 425 bumblebees from the 4 species: *Bombus lapidarius*, *B. lucorum*, *B. pascuorum* and *B. terrestris* were examined for external mites. The following phoretic mites were recorded - *Kuzinia laevis* (Dujardin) together with phoretic hypopi of several *Acaroidea* (*Caloglyphus*, *Calvolia*) and *Anoetoidea* (*Histiostoma* spp.), *Scutacarus acarorum* (Goeze) and *Parasitellus fucorum* (De Geer). Several other mites, belonging mainly to the mesostigmatid group, were recorded and identified to either family or genus only. Bees were collected from blossom of wild and cultivated plants in the Puławy district of Poland. Mites were recorded for prevalence and for intensity on queens, drones and worker bees and separately for each mite species. There was an overall prevalence of 50.4%, with 42% on workers, 65% on drones and 93% on queens. Prevalence for individual bee species was *B. lapidarius* 45.4%, *B. lucorum* 70.0%, *B. pascuorum* 33.7% and *B. terrestris* 69.4%. Numbers of mites varied enormously and ranged from one individual to over 100 per bumblebee. The adaptations of each species for life on the surface of bees includes sucker plates, tactile tarsal setae and sensilla, strongly curved and powerful claws, small size and dorso-ventrally flattened body shape. Phoresy and the feeding habits of these bee mites are discussed as well as the role of flowers in the transfer of mites from bee to bee.

Keywords: *Bombus*, bumblebees, mites, phoresy, Poland.

INTRODUCTION

There are about 300 species of bumblebee in the temperate world. Britain for example has 25 species (19 *Bombus* and 6 *Psithyrus*) (Alford 1975, Prys-Jones and Corbett 1987, Sladen 1989) and Poland 37 species (29 *Bombus* and 8 *Psithyrus*), (Banaszak 1993, Dylewska 1996, Dylewska and Flaga 2000, Pawlikowski 1999). They are important pollinators but species are under threat and there is an important need for conservation. One of the interesting aspects of bees is their relationship with mites.

In the case of honey bees (*Apis mellifera* L.) these associations are

well researched and documented. There are several parasitic mites known to damage or kill colonies of honey bees in Europe, the United States, India and the Far East (Baker et al. 2005). The most familiar are: *Varroa destructor* (Anderson et Trueman) and *Acarapis woodi* (Rennie). The species and their history has been reviewed (Baker 2000, Chmielewski 1998a). However, although some studies have been undertaken, the mite fauna on bumblebees and in their nests is not so well known.

As the phoretic acarofauna of bumblebees occurring in the Puławy region have not been examined, the

purpose of the present study was to add information to our knowledge on this topic. A number of mite species live on the surface of bumblebees or in their nests. Wide variations occur; sometimes the number is very high and oscillates from tens to hundreds per bee (e.g. queen) to over a thousand in their nests. Although the precise relationship is not always known, most if not all are phoretic. Some mites live internally as parasites (*Locustacarus* (= *Bombacarus*) *buchneri* (Stammer)) in the tracheae of bumblebees (Stammer 1951, Husband and Sinha 1970). These tracheal mites will not be considered here.

Bumblebees belong to the family *Apidae*. The species studied all belong to the genus *Bombus*. Their scientific names, and their common names are: *Bombus lapidarius* (L.) (red-tailed bumblebee), *Bombus lucorum* (L.) (white-tailed bumblebee), *Bombus pascuorum* (Scopoli) (common carder bumblebee) and *Bombus terrestris* (L.) (buff-tailed bumblebee).

The subject of bumblebee mites occurring on the hosts and in their nests has been studied by Chmielewski (1971, 1977b). In a more recent review by the same author (Chmielewski 1998b), the most common species of mite recorded in Poland are: *Kuzinia laevis* (Dujardin), *Scutacarus acarorum* (Goeze) and *Parasitellus fucorum* (De Geer). Several acaroids (*Calvolia* sp., *Carpoglyphus lactis* (L.), *Lepidoglyphus destructor* (Schr.), *Tyrophagus putrescentiae* (Schr.), anoetids (*Histiostoma* spp.), all from the *Astigmata* group and other mites (*Ameroseius* spp., *Parasitus* spp., *Proctolaelaps* spp.) belonging to families in the *Mesostigmata* group have also been recorded. The majority of them were observed in the wild and also in artificial cultures of bumblebees. A tabulated list and the author's own observations have been included in the review.

The association of mites with bumblebees is especially interesting, forming a loose association known as phoresy. In the life cycle of acaroid and anoetoid mites, the phoretic stage is an optional, non-feeding nymphal stage with a reduced gnathosoma known as the hypopus (= heteromorphic deutonymph). It is found on several orders of insects. In phoresy, the mite uses the insect as a means of transport and thus acts as the distributive stage in the life cycle of the mite. Chmielewski (1969, 1991) has studied in detail the life cycle of *K. laevis*, fed bee-collected pollen and in particular has also studied the hypopus of this species. Allen et al.

(2007) have studied *K. laevis* populations on the invading *B. terrestris* in Tasmania. Koulianos and Schwarz (1999) have examined the diet, development and reproduction of *P. fucorum*. Schwarz and Huck (1997) have examined the role of flowers in the transfer of phoretic mites from one bumblebee to another. Some authors have conducted their studies on the bio-ecology and feeding behaviour of scutacarids, including the bumblebee philous species *S. acarorum* (Ebermann 1991, 1999, Schousboe 1986).

MATERIAL AND METHODS

Bees were collected from flowers of both wild and cultivated plants (mainly *Centaurea* spp., *Echium vulgare* L., *Helianthus annuus* L., *Melampyrum pratense* L., *Rosa* spp., *Trifolium pratense* L.) from June to August 2007, in an area around Puławy, Poland. The area included forest, meadow and cultivated ground. Bees were examined for external mites using a stereoscopic microscope. If necessary both bees and mites were kept in a refrigerator (temperature at below 0°C) prior to examination. Numbers were counted after removal. Lactic acid (50%) was used to fix large numbers for routine examination and sorting. Both air dried and

75% alcohol fixed material were used for Scanning Electron Microscopy. For the purposes of identification, mites were mounted in Oudemans' fluid (as recommended in Hughes 1976) on microscope slides. They were identified using the standard works of reference. Bumblebee species were determined with the use of field guides (Dylewska and Flaga 2000, Pawlikowski 1999). Mite identification was conducted with the help of keys and descriptions in the acarological literature (Baker and Wharton 1952, Baker et al. 1958, Boczek 1980, Biesiadka et al. 1997, Hughes 1976, Karg 1971, Rack 1964, Skøu et al. 1963, Smiley 1991, Vitzthum 1943, Zachvatkin 1941).

In order to prepare specimens for the scanning electron microscope, it was found that the best results were obtained by mounting air dried mites directly onto stubs using doubled sided sticky tape. This was done instead of using critical point drying. These specimens were either dry originally or air dried after being fixed in 70% alcohol.

RESULTS AND COMMENTS

Abundance of mites and infestation of bees.

A total of 425 bumblebee specimens were examined. Those included 288 workers, 123 drones and 14 queens. 214 were found to be infested with overall 121 workers, 80 drones and 13 queens. The following species and numbers of bee individuals were recorded with their incidence: *B. lapidarius* - 205 examined bees, 93 (45.4%) specimens were infested with mites; *B. lucorum* - 20 examined, 14 were infested (70.0%); *B. pascuorum* - 89 examined, 33 infested (37%) and *B. terrestris* - 111 collected bumblebees, 77 (69.4%) were infested with mites.

Prevalence and intensity of infestation were greatest in queen bees, which also had

the largest number of mite species per insect. The different mite species were normally found on different parts of the bee's body.

Composition and prevalence of the phoretic acarofauna isolated from bees.

The following groups and species of mites were found:

Astigmata

The astigmatids collected were represented mostly by the phoretic forms (hypopi) of the *Acaroidea* (*Kuzinia*, *Caloglyphus*, *Calvolia*) and *Anoetoidea* (*Histiostoma*). Hundreds of hypopi belonging mainly to *K. laevis* were found. The hypopi of other acarids and anoetids were also occasionally recorded, usually as single specimens or in small numbers only. Hypopi were found on 214 *Bombus* specimens including queens, drones and workers. Queens were heavily infested; ten to one hundred or even more specimens per bee at times. Drones bearing middle numbers (1-30 range) and workers usually carried a lower number of mites or a single specimen only. Hypopi were attached to the

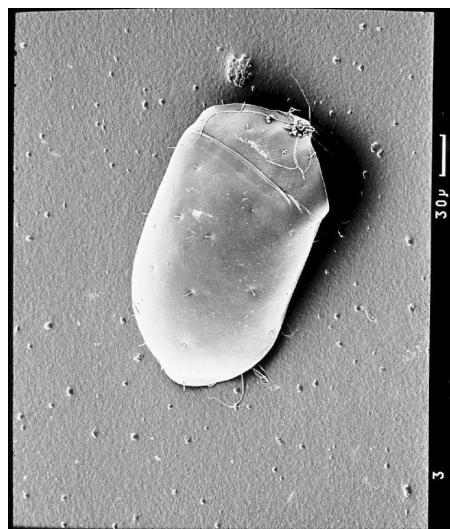


Fig. 1 - Dorsal view of the hypopus (= heteromorphic deutonymph) of *Kuzinia laevis* (Duj.) from *Bombus* drone.

lateral sides of the posterior part of the thorax and to the anterior segments (ventral and dorsal plates) of the abdomen. The first pair of sternites and the front tergites of the abdomen had the greatest numbers of *Kuzinia hypopi*, these being their characteristic sites. They were found lying one near another and attached very closely to the body surface with their sucker plates (Fig. 1-3).



Fig. 2 - Ventral view of *Kuzinia laevis* (Duj.) hypopus from a bumblebee body surface, showing reduced mouthparts, short legs and posterior sucker plate.



Fig. 3 - Sucker plate on the posterior ventral side of the hypopus of *Kuzinia laevis* (Duj.).

Imagines and juvenile specimens of this species live, feed and develop in the nest debris of bumblebees. They feed mainly on pollen, bee-bread and old combs. This was confirmed experimentally in earlier biological studies by the senior author (Chmielewski 1969, 1991, 1994).

Confirmation of the abundance of *K. laevis* hypopi on Polish bumblebees presented here and in earlier publications, agrees with the results of observations conducted on *B. terrestris* in Tasmania (Allen et al. 2007). However, the percentage of Tasmanian buff-tailed bumblebees infested with these mites and their average number per bee were significantly higher than the respective data reported for European bumblebees.

Heterostigmata

In the present observations, only phoretic scutacarids (*Scutacaridae*) were found and isolated from flying bees. The majority of them belong to *Scutacarus acarorum*. Sometimes they were also observed attached to the legs (intersegmental membranes) of large

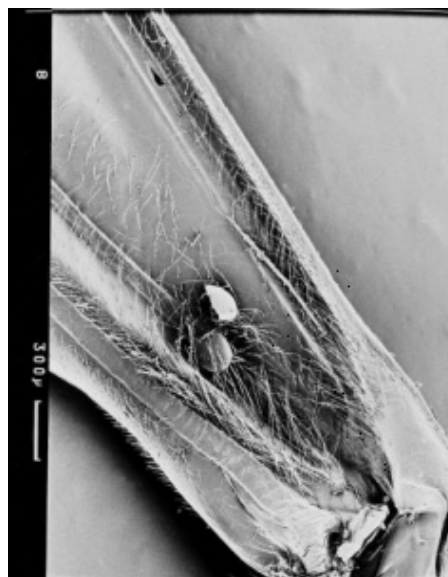


Fig. 4 - Two specimens of *Scutacarus acarorum* (Goeze) attached at the base of a wing I of bumblebee.

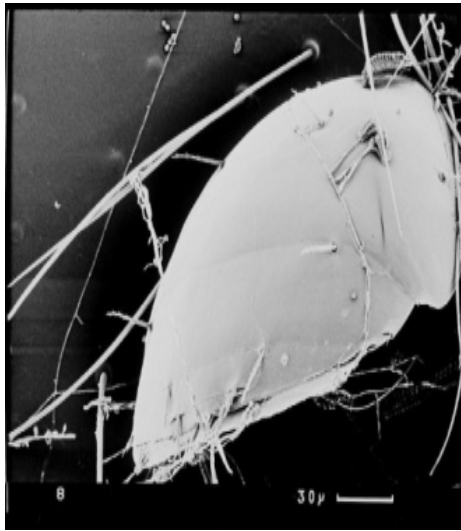


Fig. 5 - Lateral view of a specimen of *Scutacarus acarorum* (Goeze) collected from bumblebee queen.

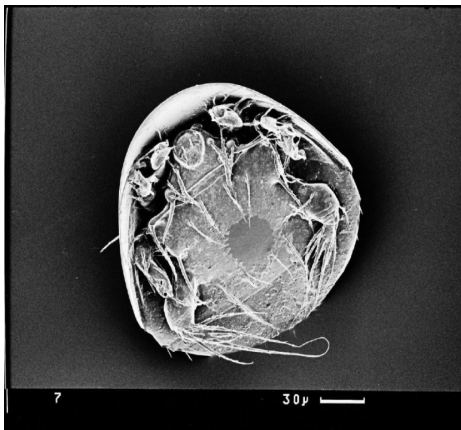


Fig. 6 - Ventral view of a phoretic specimen of *Scutacarus acarorum* (Goeze), isolated from the leg of a *Parasitellus* mite, which was attached to the body of a bee.

mesostigmatid mites (*Ascidae*, *Laelapidae*, *Parasitidae*, mainly *P. fucorum*), collected from *Bombus* adults. This is an example of hyperphoresy.

These mites live and develop in nest material. Scutacarids (*Scutacarus* spp.) are fungivorous mites, sucking fluid from fungal hyphae (Ebermann 1991, 1999). The

phoretic mite specimens (mainly adult females) were found on adult female bees. These adult female bees were queens and workers. Prevalence was 11.7%, and single or several (>10) specimens were found per bee. They were localized on the rear of the thorax and the base of the first pair of wings, mainly on queens, especially before their wintering period. They were rarely found on drones and workers (Fig. 4-6).

Mesostigmata

The occurrence of these mites are normally readily observed on bumblebees. These mites belong to the largest, brown coloured, very active group. They move rapidly on the body surface of their insect host. Most of the representatives of these mites were identified to family or genus only, i.e. *Ascidae* (*Melichares*), *Macrochelidae* (*Macrocheles*), *Laelapidae* (*Garmania*, *Hypoaspis*, *Proctolaelaps*), *Parasitidae* (*Parasitellus*, *Parasitus*). Representatives of the last two families were observed rather frequently, and especially *P. fucorum*, which is the most common species found.

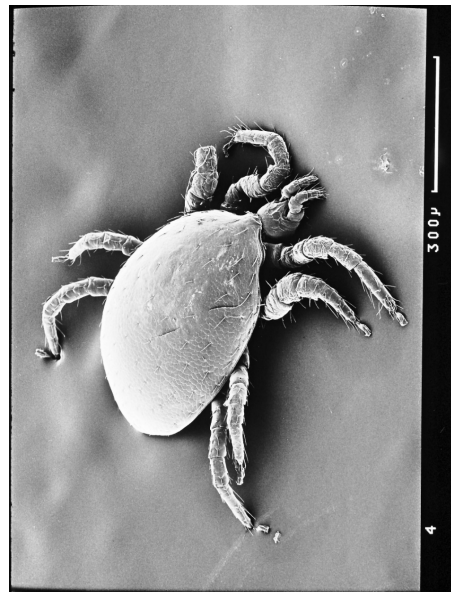


Fig. 7 - Dorsal view of a phoretic mite representing the *Mesostigmata* associated with *Bombus* spp.

This species lives and develops in the nests of bees. Their feeding habits are not always known. *P. fucorum* is probably a pollen eater (pollen grain, bee-bread remains). Depending on the developmental stage, they could also be: coprophagous (feeding on bee excrements), necrophagous (feeding on dead bees and brood) or a predator of small arthropods. Single or

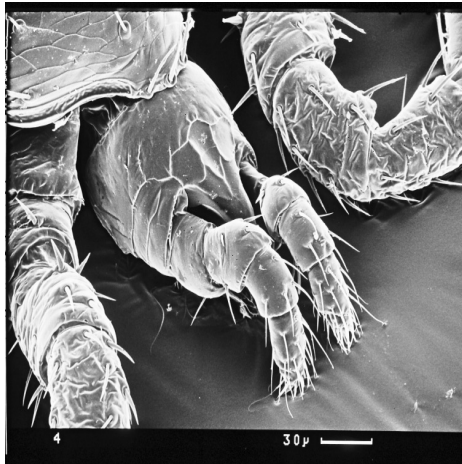


Fig. 8 - Dorsal view of the anterior end of phoretic mesostigmatid specimen from a *Bombus* queen, showing the gnathosoma, pedipalps and some segments of the first pair. of legs.

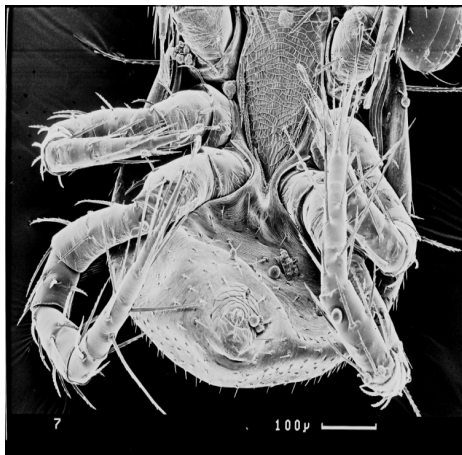


Fig. 9 - Posterior ventral view of *Parasitellus* specimen body, showing the anal and sternal plates, legs III and IV (visible also some pollen grains scattered on the mite body surface).

several (<10) specimens per bee were commonly found. Prevalence was about 17%. Phoretic specimens of this species were found on the thorax and abdomen of bumblebees. They were often found in the areas between these two parts of the body. Phoretic *Parasitellus* specimens, mostly nymphs were found mainly on queen bees. Worker bees were also often infested, but drones only rarely. (Fig. 7-9).

Specimens of the family *Laelapidae*, as single or < 5 per bee, were found and had a prevalence of 17.3%. Other mesostigmatids (undetermined specimens) were observed usually in small numbers. In only one case, there were 8 individuals attached to one *B. terrestris* worker (prevalence <1%).

Adaptations of phoretic mites on bumblebees and dispersion of the mite species.

The localization, strategy and mode of life of mites living on the body surface of bees are very characteristic. Depending on the species, each mite has its own specific adaptations.

Hypopi do not feed and have reduced mouthparts. They are adapted for clinging on between the bee hairs and fit close to the body surface of adult insects. In this case this means on the front sternites and tergites of the bee's abdomen. They have a well developed posterior-ventral sucker plate which is used for attachment/climbing. The hypopi are dorso-ventrally flattened, shield shaped and heavily sclerotized. These features protect them from damage, removal from the host and desiccation.

Scutacarid phoretic forms (mainly females) are of small size, their strongly sclerotized and brown coloured idiosoma is dorsal-ventrally flattened. Their legs are very short and the gnathosoma is well adapted for firm attachment to their hosts. They settle on the rear part of the bee thorax. They occupy the furrow between

the meso- and meta-thorax or are found at the basal part of the first pair of wings. They attach with the help of their gnathosoma. Sometimes they were observed on other phoretic mites (large specimens of mesostigmatids, e.g.

P. fucorum) associated with bees. In such a case they were attached mainly to the intersegmental membrane of *Parasitellus* legs II, III (Chmielewski 1971, 1983).

Parasitid, laelapid and other phoretic mesostigmatid mites observed on bumblebees are usually bigger than the other mite species. The main representatives are *Parasitellus* specimens which occur mainly as phoretic deutonymphs. They have long, powerful legs equipped with powerful bent claws, tactile tarsal setae and sensilla (chemoreceptors). In comparison with other species, they are highly mobile and have a strong gnathosoma with functional palpi and chelicerae. These features give them the possibility for holding on and attaching to bees. Their behaviour, quick reaction and good orientation in very dense body-hairs make them well adapted phoretants associated with bumblebees (*Bombus* spp.).

Not only *Parasitellus*, but *Kuzinia* and *Scutacarus* species also, were observed as phoretics on cuckobees (*Psithyrus rupestris* F., *P. vestalis* Fourcr. and *Psithyrus* spp.), which are associated with particular bumblebee species as their specific nest parasites. These data were published earlier (Chmielewski 1977a), but were not considered in details here.

Exchange and distribution of phoretic mites between flying bees, takes place: through their sexual contacts during bee copulation, by visiting flowers and looking for places for nests (spring) and overwintering (autumn). When they change their hosts, the larger mites (e.g. *Parasitellus*) contribute to the dispersion of smaller mites, such as acaroids, anoetoids or scutacarids, which are sometimes found

attached to them (hyperphoresy).

The adaptations of the various mites found on bumblebees include: sucker plates, tactile tarsal setae and sensilla, strong curved claws, reduced mouth parts, small size, gnathosoma developed for attachment, short legs with tactile setae, dorso-ventrally flattened body shape and powerful claws. These, combined with their behaviour, mean that these species are well adapted for a phoretic association with their hosts. They are specialized for particular regions of the body of the bee. Observations show that the mobile and protruding peripheral body parts of the host, such as legs, wings (distal parts), head, antennae, mouthparts, the tip of the abdomen (sting region), and the bare surfaces of some parts of a bee's body are usually free of mites.

DISCUSSION AND CONCLUSIONS

The association of mites with social insects, and the evolution and life history patterns of mites associated with bees were the subject of interesting and important studies by Eickwort (1991, 1994).

Phoresy is defined as a form of association involving transportation of one organism by another. In this case the mites are passengers on the body of the bumblebees and the bumblebee plays a role in their distribution. This is a loose form of association. However, the precise relationship of some of the mites found is unclear. This is because their feeding habits have not been studied in detail, with the exception of *K. laevis*, where the food preferences were studied under laboratory conditions (Chmielewski 1969, 1991, 1994). Large numbers of hypopi of *K. laevis* were found on *Bombus* bees. These are typical mobile phoretic (heteromorphic) deutonymphs, which do not feed.

According to Allen et al. (2007), *K. laevis* is a bee parasite. This is disputed by the present authors, who believe that the adult mite and their juvenile stages - larvae, protonymphs and homeomorphic deutonymphs, live in the nests of bees and their heteromorphic deutonymphs are phoretic on bees. These authors (Allen et al. 2007) found that on summer - autumn - collected drones and queens, mites were present on over 80% of the bees. The mites averaged 350-400 per bee and were more abundant on younger bees. Prevalence and intensity (incidence and numbers) were significantly lower in workers, compared to drones and queen bees, at least under Polish conditions.

P. fucorum deutonymphs are found in the wild on queen bees in the spring and early summer and also stay with the bee when she overwinters. Some drop off and transfer to other bees or transfer horizontally when bees forage on a flower (Schwarz and Huck 1997). The deutonymphs attach to young queens in the late summer and early autumn and overwinter in this way, until the following spring. At this time the deutonymphs detach and moult into adults before colonising the nest (Koulinanos and Schwarz 1999). Some details of the life history and mite bio-ecology of this species have similarities to those observed in the case of *K. laevis* (Chmielewski 1969).

The exchange and spreading of phoretic mites from one bee specimen to another takes place inside the nests of bees and between members of the same colony. Dispersion outside the nests takes place between bee individuals belonging to various *Bombus* species and from different populations of bumblebees.

In addition to the species recorded in the present account, Schwarz and Huck (1997) in their studies of bumblebee mites on flowers, listed *Parasitus ignotus* Vitzthum and *Hypoaspis hyatti* Evans et Till (*Mesostigmata*). Kouliananos and

Schwarz (1999) carried out breeding and feeding experiments using the deutonymphs and adults of *P. fucorum*. They stated that this mite lives and reproduces in the nests of bumblebees. They observed adult mites feeding on the nectar coating at the surface of pollen grains before discarding them and that adult males preyed upon the larval and protonymphal instars.

Some mites appear to use flowers as a means of transfer between bees. However according to Schwarz and Huck (1977), *K. laevis* did not occur on flowers. It was thought its small size and ventral sucker plate made transfers between flowers and bees impossible, except in possible incidental cases. On the other hand *S. acarorum* compensates for its small size and limited mobility by attaching to larger mites. This includes members of the genus *Parasitellus* (Schwarz and Huck 1997).

The presence of phoretic mites on the bodies of their host is harmless. In cases where the number of mites is very high (hundreds, occasionally even over a thousand specimens), they affect the movement and flying of the bee. Phoresy then becomes a kind of "transport parasitism", which might be harmful to the insect.

It is known that acaroid hypopi do not feed and there is a reduction of their mouthparts. There are some authors who believe that gamasids are predators of small arthropods or feed on bee-nest debris. Scutacarids likewise, are unlikely to be parasitic and are thought to feed and develop on fungi living in *Bombus* provisions and other organic nest material. No observations, however, have been made on the feeding behaviour of phoretic mites during their period on their "hosts". Further work is required to confirm the feeding habits of bumblebee associated mites. Questions as to whether *Parasitellus* feeds on pollen grains or whether *Scutacarus*

sucks haemolymph from its host, at present remain unanswered.

A comparison of the present results with data from earlier studies, show that the composition and abundance of the phoretic acarofauna of *Bombus* populations in Puławy, is typical of their association with bumblebees and close to that observed previously (Chmielewski 1971).

The present results contribute to an understanding of the economic significance and the effect of bumblebee mites on the rearing and production of these plant pollinating bees cultivated in greenhouses.

ACKNOWLEDGEMENTS

The authors wish to acknowledge and thank Adrian Hick, from the University of Leeds, for his help in the preparation of the Scanning Electron Micrographs used in this paper.

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**FORETYCZNE ROZTOCZE (*Acarina*) KILKU POSPOLITYCH
GATUNKÓW TRZMIELI (*Bombus* spp.) Z TERENU PUŁAW
(POLSKA POŁUDNIOWO-WSCHODNIA)**

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S t r e s z c z e n i e

Forezja jest formą powiązania dwóch organizmów polegającą na przenoszeniu jednego przez drugiego z nich. Tego typu powiązania roztoczy z owadami pszczołowatymi (*Apoidea*), a zwłaszcza trzmielami (*Bombinae*), spotyka się w przyrodzie dosyć często.

Trzmiele są ważnymi zapylaczami roślin uprawianych i żyjących w stanie dzikim. Niektóre gatunki tych pożytecznych owadów są zagrożone wyginięciem i dlatego są one objęte ochroną. Prowadzi się też masowe hodowle trzmieli w warunkach kontrolowanych, w celu ich wykorzystania do zapylania upraw szklarniowych (pomidory, ogórki). Z tego też względu ważna jest wiedza na temat stanu zdrowotnego i kondycji tych owadów, w tym także w aspekcie ich powiązań z towarzyszącymi im roztoczami.

Celem badań jest poznanie składu gatunkowego i nasilenia występowania foretycznych roztoczy występujących na kilku pospolitych gatunkach trzmieli spotykanych w rejonie Puław, gdzie badań takich dotychczas nie prowadzono.

Trzmiele odławiano w sezonie wegetacyjnym (VI-VIII) 2007r. Wykonano analizy akarologiczne 425 osobników trzmieli z 4 gatunków, *Bombus lapidarius*, *B. lucorum*, *B. pascuorum* i *B. terrestris*. Stwierdzono na nich obecność foretycznych form roztoczy głównie z następujących gatunków: *Kuzinia laevis*, *Scutacarus acarorum*, *Parasitellus fucorum* i mniej licznie także innych przedstawicieli *Astigmata* i *Mesostigmata*.

Zbadano częstość i intensywność występowania roztoczy na matkach, trutniach i robotnicach trzmieli. Generalnie, z ogólnej liczby 214 (50,4%) owadów, na których stwierdzono roztocze, najczęściej i najsilniej zasiedlone były matki (93%); w przypadku trutni i robotnic zasiedlenie było niższe (odpowiednio: 65 i 42%). Zasiedlenie poszczególnych gatunków trzmieli przez roztocze przedstawiało się następująco: *B. lapidarius* - 45,4%, *B. lucorum* - 70,0%, *B. pascuorum* - 33,7% i *B. terrestris* - 69,4%. Liczebność roztoczy spotykanych na poszczególnych osobnikach trzmieli była znacznie zróżnicowana i wahały się od jednego do ponad 100 osobników na jednym trzmielu.

Spośród przystosowań roztoczy do utrzymywania się na powierzchni ciała trzmieli można wymienić odpowiednio przystosowany aparat gębowy (chelicery, palpy), tarczki przyssawkowe, tarsalne szczeciny dotykowe i pałeczki zmysłowe (sensilla), silnie zbudowane odnóża, wyposażone w zakrzywione i mocne pazurki, stosunkowo małe wymiary i grzbietowo-brzusznie spłaszczony kształt ciała.

Forezja i sposób odżywiania się tych roztoczy, jak również rola kwiatów w przenoszeniu roztoczy między poszczególnymi osobnikami trzmieli, są przedmiotem dyskusji w prezentowanym opracowaniu.

Z porównania rezultatów obecnych badań z wynikami podobnych obserwacji uzyskanymi i opublikowanymi wcześniej wynika, że skład gatunkowy i nasilenie występowania foretycznych form roztoczy trzmielolubnych w okolicy Puław są bardzo zbliżone do składu akarofauny i charakterystycznych powiązań tego typu obserwowanych między roztoczami i trzmielami krajowymi (Chmielewski 1967, 1971).

Obecne wyniki mogą stanowić przyczynek do zrozumienia gospodarczego znaczenia roztoczy trzmieli, ich wpływu na wyniki hodowli tych zapylaczy i ich produkcję na potrzeby zapylania roślin w uprawach szklarniowych i w warunkach polowych.

Słowa kluczowe: *Bombus*, trzmiele, roztocze, forezja, Polska.