BIOLOGICAL LETT. 2006, 43(2): 249–255
Available online at http://www.biollett.amu.edu.pl

Accidental acarophagy: mites found on fruits, vegetables and mushrooms

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(*Received on 19 December 2005, Accepted on 6 November 2006*)

Abstract: Considering the great abundance of mites in almost all habitats and their minute dimensions, acarophagy must be common and even humans eat lots of mites. The presence of mites was investigated in 90 food samples, representing 24 sorts of fruits, vegetables and mushrooms. Acarological analyses of the products detected the presence of 53 mite species of the orders Oribatida, Actinedida, Tarsonemida, Acaridida and Gamasida. Mainly the saprophagous soil-inhabiting oribatid mites, but also actinedid and tarsonemid mites, were frequently found in the analysed material. The highest number of mites was collected from fruits with uneven surface, covered with numerous hairs, e.g. raspberries, strawberries and red currants. About 50% of mites still remained on vegetables and fruits after cleaning them in running water.

Key words: Acari, food, vegetables, fruits, infestation

INTRODUCTION

Although the feeding relationships of mites (Acari) have rarely been studied, their high abundance in almost all microhabitats suggests that they should be an important source of food for many animals. Mites are eaten by certain groups of invertebrates, e.g. beetles, ants, centipedes, symphylans, diplurans, spiders, pseudoscorpions, opilionids and predatory mites. Some vertebrates also seem to feed on them. For example, mites were found in stomach contents of amphibians (WALTER & PROCTOR 1999). Some groups of mites, e.g. Oribatida, Uropodina and Gamasina, are extremely abundant on the forest floor, so small vertebrates foraging on the ground also eat at least the larger mites. There is an additional aspect of eating mites by animals, such as their high calcium and phosphorous content, which could be important to small vertebrates (WALTER & PROCTOR 1999). Many plant-feeding mites (e.g. Tetranychidae, Tarsonemidae, Eriophyoidea) and their predators (e.g. Cheyletidae, Phytoseiidae, Stigmaeidae) are abundant on plants, also on those eaten by humans. Furthermore, organic debris of all kinds normally supports large populations

of mites (EVANS et al. 1961). Mites are ubiquitous and usually invisible to the naked eye, so accidental acarophagy must be common and most probably each of us eats lots of mites.

The general aim of the project was to assess how many mites we usually eat with different sorts of fruits, vegetables and mushrooms. The focal questions of the study were as follows:

- How numerous are mites on selected food products and which species are most frequently eaten by us?
- Which of the selected food products are highly infested by mites?
- How effective is cleaning of fruits and vegetables in removing mites?

MATERIAL AND METHODS

For this study, 24 food types were selected, namely fresh fruits: 1 – red currants (sample size: 100 g); 2 – pear (1 whole); 3 – apple (1 whole); 4 – raspberries (10 berries); 5 – strawberries (10 berries); 6 – grapes (10 berries); dried fruits: 7 – figs (50 g); 8 – hazelnut shells (25 g); 9 – hazelnuts (25 g); vegetables: 10 – brussels sprout (1 head); 11 – leaves of 1 onion; 12 – cauliflower (1/2 head); 13 – kohlrabi (1 stem); 14 – cabbage (1/2 head); 15 – dill leaves (1/2 bunch); 16 – kohlrabi leaves (20 g); 17 – carrot (1 root); 18 – parsley leaves (1/2 bunch); 19 – red pepper (1 whole); 20 – leek (1 whole); 21 – lettuce (3 leaves); 22 – celery (1 whole); 23 – beans (5 pods); and fresh mushrooms: 24 – *Suillus luteus* (200 g).

Four samples of each product (apart from dried fruits and beans) were analysed. Two of these samples were washed in running water and the other two remained unwashed. In total 90 samples were tested. The products were bought in shops in the city centre of Katowice or collected from allotments in the suburbs of Katowice. Research was carried out in autumn 2004. Samples were put into modified Tullgren-style high-gradient funnels to extract the animals. Mites were next sorted into the Oribatida, Actinedida, Tarsonemida, Acaridida and Gamasida. Individuals were determined to the species, genus or family level and counted. In this work the classification system according to HAMMEN (1972) is applied.

RESULTS

In total, 265 mites were collected from 90 samples of food products. All mite taxa collected from fruits, vegetables and mushrooms are listed below. For each taxon, numbers of individuals found in samples are given in square brackets. Each sample is denoted by food type number (see Methods) and sample type symbols (A = first sample; B = second sample; c = cleaned; n = not cleaned).

ORIBATIDA

Atropacarus (*Atropacarus*) *striculus* (C.L. Koch, 1836): 4Bn [1], 5Ac [1], 14An [1]
Adoristes poppei (Oudemans, 1906): 24An [2]
Ceratozetes gracilis (Michael, 1884): 8A [1]
Chamobates borealis (Trägardh, 1902): 1Bn [1], 4Bn [2]
Chamobates voigtsi (Oudemans, 1902): 4Ac [1], 10An [1]
Cultroribula bicultrata (Berlese, 1905): 8A [1], 8B [1]

Cultroribula juncta (Michael, 1885): 8B [2]
Hemileius initialis (Berlese, 1908): 4Ac [1], 4Bn [1]
Hypochthonius rufulus C.L. Koch, 1836: 10Bc [1juv.], 11Bc [1]
Lauroppia falcata (Paoli, 1908): 8A [1], 10An [1]
Medioppia obsoleta (Paoli, 1908): 4Bc [2]
Medioppia subpectinata (Oudemans, 1910): 4Ac [2], 4Bn [6],
Oppiella (*Oppiella*) *nova* (Oudemans, 1902): 3An [1], 4Bn [1], 4Bc [2], 8A [6], 8B [4], 10An [1], 10Bn [1], 14Ac [1], 14Bn [1], 20Ac [1], 24An [21], 24Ac [1]
Oribatula tibialis (Nicolet, 1855): 14An [1], 22An [1]
Protoribates variabilis Rajski, 1958: 1Bn [1]
Ramusella (*Ramusella*) *assimilis* (Mihelčič, 1956): 7B [1]
Scheloribates laevigatus (C.L. Koch, 1836): 24Ac [4], 24Bc [1]
Sellnickochthonius immaculatus (Forsslund, 1942): 4Bc [1]
Suctobelba trigona (Michael, 1888): 20An [1]
Suctobelbella alloenasuta Moritz, 1971: 10An [1]
Suctobelbella cornigera (Berlese, 1902): 8A [1]
Suctobelbella falcata (Forsslund, 1941): 8B [1]
Suctobelbella sarekensis (Forsslund, 1941): 7A [1], 20Ac [1]
Suctobelbella subcornigera (Forsslund, 1941): 8A [2]
Tectocepheus velatus (Michael, 1880): 4An [1], 4Bn [3], 5Bc [1], 8B [1], 14Ac [3], 17Ac [2], 24Ac [1]
Trichoribates novus (Sellnick, 1928): 1An [4], 1Bc [1]
Zygoribatula exilis (Nicolet, 1855): 8A [1], 8B [1]
Zygoribatula frisariae (Oudemans, 1910): 1An [1]
Juveniles: 1Ac [3], 1Bn [6], 1Bc [2], 2Bc [1], 4An [2], 4Ac [2], 4Bn [2], 4Bc [1], 5Ac [3], 8B [2], 10An [1], 11An [3], 18Bc [1], 20Ac [1], 22An [2], 22Bc [1], 23B [1], 24Ac [1], 24Bn [2]

ACTINEDIDA
Bdellidae (2 species): 1An [1], 1Bn [1], 1Bc [1], 15Bc [1]
Tenuipalpidae (4 species): 4An [1], 4Ac [1], 5An [2], 5Bn [1], 8B [1], 10Bc [1], 12An [2], 17Ac [1], 19An [1], 19An [1], 19Ac [1], 19Bn [1], 20An [2], 23A [1]
Tetranychidae (2 species): 1Bn [1], 5An [1], 5Bn [5], 20Ac [1], 21Bn [2]
Tydeidae (1 species): 20An [1], 21Bc [1]
Unidentified: 1An [1], 3An [1], 3Bn [2], 8B [1], 21An [2], 24Ac [1]

TARSONEMIDA
Phytonemus pallidus (Banks, 1899): 1Bn [1], 5An [14], 5Ac [1], 5Bn [4], 5Bc [2], 10Bc [2]
Scutacaridae (1 species): 3An [1], 3Ac [1], 10Ac [1], 18Ac [1], 20An [1]
Unidentified: 24Ac [1]

ACARIDIDA
Histiostoma feroniarum (Dufour, 1839): 11Ac [1♂], 18Bn [1♀], 20An [7♂], 22An [3♀], 22Ac [2]
Rhizoglyphus robini Claparčde, 1869: 11An [1 hypopus], 11Ac [1]

Schwiebea sp.: 4An [1], 4Bc [4], 11An [2♀, 1 tritonymph]
Tyrophagus similis Volgin, 1949: 11Bn [1], 15An [1], 21Bn [1], 22Bc [1]
Tyrophagus sp.: 22Ac [1]

GAMASIDA
Ascidae (2 species): 11An [2]
Eviphididae (2 species): 11An [2], 18Bn [1], 20An [1, 1 juv.]
Parasitidae (1 species): 20An [1]
Phytoseidae (1 species): 6Ac [1]
Rhodacaridae (2 species): 13Ac [1], 20An [1], 22An [1]
Paraseiulus soleiger (Ribaga, 1902): 1Bn [1]
Typhlodromus sp.: 3Ac [1], 3Bc [1]
Uropodina (1 species): 22An [1]
Zerconidae (2 species): 11An [1], 22An [1]

DISCUSSION

Fifty-nine (65.5%) of the analysed samples were infested with mites. Oribatid mites were found most frequently and accounted for 55.5% of total catch. Mites of the orders Actinedida, Tarsonemida, Acaridida and Gamasida comprised 15.5%, 11.3%, 10.9% and 6.8% of total catch, respectively. Similarly, the species richness of oribatid mites was the highest (27 species). Thirteen species of gamasid mites and 9 species of actinedid mites were found in the material, whereas acaridids and tarsonemids were represented by 5 and 3 species, respectively. The highest number of mites was found on *Suillus luteus* (unwashed samples). This is not surprising because mushrooms are usually heavily polluted with leaf litter and soil, which are extremely rich in mites, especially the Oribatida. High numbers of mites were also collected from unwashed strawberries, raspberries, leeks, red currants and onion leaves. The characteristic uneven surface of berries and numerous hairs on currants create a suitable microhabitat for mites. Many specimens of mites were still found on these fruits after cleaning. The comparatively high numbers of mites collected from leeks and onion leaves can also be explained by the fact that these vegetables are in close contact with the soil.

It was interesting to observe how ineffective is cleaning of fruits and vegetables in running water and how many mites still remained on the cleaned samples. In general we can conclude that only 48.6% and 50% of the total number of mites were removed from fruits and vegetables, respectively. The process of cleaning mushrooms from dirt appeared to be more effective. Over 83% of mites were eliminated from *Suillus* in this way. It is noteworthy to remind that some fruits, e.g. berries or currants, are occasionally eaten without cleaning.

Saprophagous oribatid mites constitute the main component of acarine populations in the soil. However, they are not confined to the soil and may be abundant on aboveground parts of plants, in stored food or in house dust (WALTER & PROCTOR 1999). Oribatids were collected from 16 of the 24 types of food studied. The highest number of oribatid species was found on mushrooms (23), raspberries (16) and red currants (8). The species richness of collected oribatid mites was impres-

sive. Most of the 27 collected species are well known in the Polish fauna. *Oppiella nova* (38.3% of total catch) and *Tectocepheus velatus* (11.2%) were the most frequently collected oribatid species. Both species are well-known ubiquitous mites distributed all over the world (SCHATZ 1983). They are possibly the most numerous mites on the planet. *Medioppia subpectinata* (7.5%) and *Scheloribates laevigatus* (4.7%) were third and fourth most numerous species collected from food. Both species are typical eurytopic soil organisms. *S. laevigatus* is known as a coprophage and an intermediate host of the Anoplocephalidae (LUXTON 1972, SCHATZ 1983, DENEGRI 1993).

Actinedid mites were also found on many analysed products (14 types). The highest number of specimens was recorded on strawberries, apples and leeks. Most individuals belonged to the families Tenuipalpidae (41.5%) and Tetranychidae (24.4%). Both families are represented by plant-feeding parasites and they are infamous for the damage they cause to various cultivated plants (BOCZEK & BŁASZAK 2005). Predatory mites, e.g. of the families Bdellidae and Tydeidae, were infrequent on food products.

Tarsonemid mites were recorded on 7 types of products. *Phytonemus pallidus* was the most numerous species (80%) of this order and was mainly collected from strawberries. It is an economically important parasite of strawberries (BOCZEK 1980).

Five species of the Acaridida were recorded from 8 types of fruits and vegetables. They were most frequently found on leeks, raspberries and onion leaves. *Histiostoma feroniarum* (the most numerous representative of this group – 48.3% of total catch) is a cosmopolitan species found in seeds, onion, bulbs of ornamental plants, and soil (BOCZEK & BŁASZAK 2005). The genus *Schwiebea* (27.6%) is known from many different habitats, e.g. bushes, flowers, dead wood, corridors of bark beetles, and decaying material of plant origin (HUGHES 1976). Other collected acaridid species of the genera *Tyrophagus* and *Rhizoglyphus* occupy a wide range of niches and are known as the commonest pests of various food products (BOCZEK & BŁASZAK 2005).

The least numerous group of mites recorded in the analysed products were gamasid mites. However, they were represented by a high number of species (13). Species of the genus *Typhlodromus* were the most frequently found (16.7%). They are members of the family Phytoseiidae, the dominant predatory gamasid mites on plants (BOCZEK & BŁASZAK 2005). Members of the other 5 families are predators in soil and litter (KRANTZ 1978).

Mites associated with our diet – those found on fruits, vegetables, teas or herbs – have rarely been studied (CHMIELEWSKI 1971a, b, 1990, 1998, GOŁĘBIOWSKA & CHMIELEWSKI 1972, HUGHES 1976, KORYCIAK-KOMARSKA 2000). Thorough studies on mites associated with stored apples are worth mentioning (CHMIELEWSKI 1990, 1998). All samples of stored apples were infested with numerous and diverse mites. A single apple in his study contained a much higher number of individuals (more than 100) than detected in our study. However, that author examined fruits visually and next dissected them. In this way, eriophyid mites, most juvenile stages, wintering eggs and heteromorphic deutonymphs of acaridid mites were also collected. In contrast, these forms were not generally extracted in our study.

Should we be thus afraid of eating a dessert prepared from strawberries, or a salad prepared from lettuce, carrot and red pepper? Many mite species, e.g. numerous acaridids, house dust mites or tarsonemids produce strong allergens (SOLARZ 2002). Furthermore, some species of the Acaridida and the Oribatida are intermediate hosts of tapeworms, e.g. *Moniezia expansa* or *Catenotaenia pusilla* (DENEGRI 1993). Faeces of acaridid mites can pollute food. Fortunately, the number of mites on a single fruit or vegetable is generally low. It seems worthwhile to mention that their small size and cryptic appearance make mites difficult to detect and thus, they are practically impossible to remove completely from food products. Therefore, the reflection on impressive diversity of life; its ubiquity should rather appear in our thoughts while eating this kind of healthy food. Mites are a part of amazing biodiversity on our planet, which is still only partly described.

Acknowledgements: We are grateful to Dr. hab. GRAŻYNA MADEJ (University of Silesia) and Dr. hab. KRZYSZTOF SOLARZ (Silesian Medical Academy) for identification of gamasid, acaridid and actinedid mites.

REFERENCES

BOCZEK J. 1980. Zarys akarologii rolniczej [Synopsis of agricultural acarology]. 387 pp., PWN, Warszawa.

BOCZEK J., BŁASZAK C. 2005. Roztocze (Acari). Znaczenie w życiu i gospodarce człowieka [Mites (Acari). Significance in life and economy of humans]. 267 pp., SGGW, Warszawa.

CHMIELEWSKI W. 1971a. Akarofauna występująca w artykułach spożywczych [Acarofauna occurring on food products]. Pr. Nauk. Inst. Ochr. Roślin 13: 167–186.

CHMIELEWSKI W. 1971b. Wyniki badań akarofauny w artykułach importowanych ze szczególnych uwzględnieniem gatunków nowych dla Polski [The results of the studies of acarofauna in the imported wares with a particular reference to the species, new for Poland]. Pr. Nauk. Inst. Ochr. Roślin 13: 187–200.

CHMIELEWSKI W. 1990. Roztocze (Acarina) zasiedlające jabłka w przechowalni owoców [Mites (Acarina) settling apples in fruit store]. Zesz. Prob. Post. Nauk Rol. 373: 77–85.

CHMIELEWSKI W. 1998. Mites (Acarina) collected from stored apples. J. Fruit Ornam. Plant Res. 6: 33–40.

DENEGRI G. M. 1993. Review of oribatid mites as intermediate hosts of tapeworms of the Anoplocephalidae. Exp. Appl. Acarol. 17: 567–580.

EVANS G. O., SHEALS J. G., MACFARLANE D. 1961. Terrestrial Acari of the British Isles. 219 pp., Brit. Mus. Nat. Hist., London.

GOŁĘBIOWSKA Z., CHMIELEWSKI W. 1972. Akarofauna ziół importowanych, składowanych w kilku magazynach w kraju [Acarofauna of imported herbs stored in some storehouses in the country]. Pol. Pismo Entomol. 42: 187–198.

HAMMEN L. V. D. 1972. A revised classification of the mites (Arachnidea, Acarida) with diagnoses, a key, and notes on phylogeny. Zool. Meded. 47: 273–292.

HUGHES A. M. 1976. The mites of stored food and houses. Tech. Bull. Minist. Agric., Fish. Food 9, 400 pp.

KORYCIAK-KOMARSKA H. 2000. Ocena częstości występowania roztoczy (Acari) o znaczeniu medycznym w próbkach ziół rozprowadzanych w handlu hurtowym na terenie Górnego Śląska [Estimation of the frequency of occurrence of mites (Acari) of medical significance in samples of herbs distributed in the wholesale trade in Upper Silesia]. In: Akarologia polska u progu nowego tysiąclecia [Polish acarology at the eve of new millenium] (IGNATOWICZ S., Ed.), pp. 301–310, SGGW, Warszawa.

KRANTZ G. W. 1978. A manual of acarology. 2nd ed., 509 pp., Oregon State University Book Stores Inc. Corvallis.
LUXTON M. 1972. Studies on the oribatid mites of a Danish beech wood soil. I. Nutritional biology. Pedobiologia 12: 434–463.
SCHATZ H. 1983. Catalogus Fauna Austriae, Teil IXi U. Ordn.: Oribatei, Hornmilben. 118 pp., Österreichischen Akademie der Wissenschaften, Vienna.
SOLARZ K. 2002. Roztocze alergogenne [Allergenic mites]. In: Parazytologia i akaroentomologia medyczna [Parasitology and Medical Acaroentomology] (DERYŁO A., Ed.), pp. 332–377, PWN, Warszawa.
WALTER D. E., PROCTOR H. C. 1999. Mites. Ecology, Evolution and Behaviour. 332 pp., CABI Publishing, New York, USA.

Associate editor: MACIEJ SKORUPSKI