Eight new microsporidian parasites of moss-mites (Oribatei, Acarina) in forest soils

By K. PURRINI and J. WEISER

Abstract

Four new species of the genus *Pleistophora* (*P. oribatei*, *P. cephei*, *P. platynothri*, and *P. dindali*), one of *Thelohania* (*Th. microtritiae*), and three of *Nosema* (*N. steganacari*, *N. acari*, and *N. führeri*) are discovered and described from mossmites (Oribatei, Acarina) in forest soil samples from Lower Saxony and Hessen (Federal Republic of Germany).

1 Introduction

Although Oribatids play an important role in the transformation of organic material into soil, little is known about their parasites and diseases (PURRINI and BÄUMLER 1976, 1977). Some moss-mites which are involved in the transmission of cestodes, *Moniezia benedeni*, and other parasites of grazing animals are also associated with Microsporidians, transmitting *Nosema bischoffi* Weiser together with its hosts, the tapeworms (WEISER 1951).

Investigations of the incidence of parasites in micro-arthropod populations in forest soils (PURRINI 1979) revealed that Oribatid-Microsporidia associations are more common than expected. Eight new species of Microsporidia were identified, and their descriptions are given in the present study.

2 Material and methods

During 1978 and 1979, about 3600 Oribatid specimens were collected from soil samples from 30 sites in mixed coniferous forests, beech forests and mixed deciduous forests in Lower Saxony and Hessen, Federal Republic of Germany. Their identification was carried out by Dr. V. Bukva, Prague.

For diagnosis of infection, smear preparations were examined either unstained under a phase contrast microscope or fixed with methanol and stained with Giemsa Romanowski. WEISER's (1976) method was used for identification of spore nuclei. Paraffin sections, prepared after fixation in Bouin and terpinol treatment (6 months), served for histological analysis. Our attempts to obtain satisfactory ultrathin sections from SPURR-medium embedded material remained unsuccessful because of the very hard integument of the Oribatids.

3 Results

3.1 The hosts

Sixty two Oribatid species, belonging to 38 genera and 25 families, were identified from our material. Twelve species, abundant in most samples, turned

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out to be infected by microsporidian parasites. A survey of the ascertained infection rates is given in the table. As to the microsporidian spectra of the individual hosts, only *Microtritia minima* and *Damaeus flavipes* were infected by more than one parasitic species.

3.2 The parasites

3.2.1 *Pleistophora oribatei* n. sp. (figs. 1 a–d, 3 a–c)

Hosts: *Phtiracarus piger* Scopoli, 1763 (Phtiracaridae); *Rhysotritia duplicata* Grandjean, 1953 (Euphtiracaridae); *Microtritia minima* Berlese, 1904

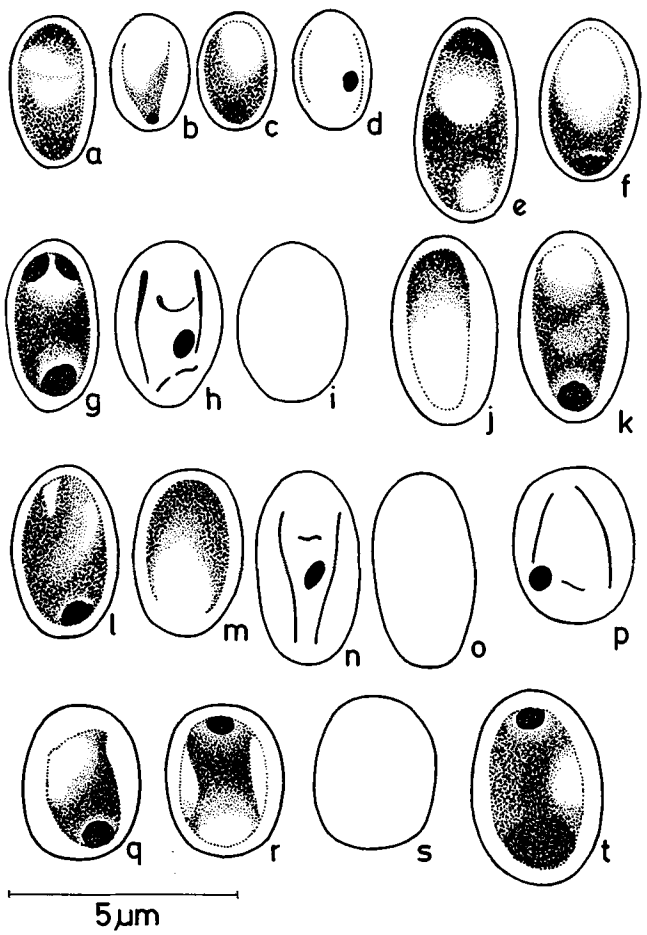


Fig. 1. a–d: Pleistophora oribatei n. sp., a, b, c = mature spores, Giemsa, d = spore after HCl treatment; *e–i: Pleistophora cephei* n. sp., e, f, g = mature spores, Giemsa, h = mature spore after HCl treatment, i = mature spore, fresh; *j–o: Pleistophora platynothri* n. sp., j, k, l, m = mature spores, Giemsa, n = mature spore after HCl treatment, o = mature spore, fresh; *p–t: Pleistophora dindali* n. sp., p = mature spore after HCl treatment, q, r = mature spores, Giemsa, s = mature spore, fresh, t = sporoblast, Giemsa

(Euphtiracaridae); *Damaeus clavipes* Hermann, 1804 (Damaeidae); *Carabodes femoralis* Nicolet, 1855 (Carabodidae), and *Phtiracarus* sp. (Phtiracaridae)

Tissue: lymphocytes, oenocytes, gonads, gut-wall

Localities: Mixed coniferous forests, beech forests, mixed deciduous forests, Bergen, Salzgitter Bad, Wildpark (Lüneburg), Marienmünster (Lower Saxony, F. R. of Germany), 1978, 1979.

A very common infection in several hosts. The pathogen was found in the gut-wall of *C. femoralis*, lymphocytes and oenocytes of *Rh. duplicata* and *M. minima*, in the gut-wall of *D. clavipes* and gonads of *Ph. piger* and *Phtiracarus* sp. There were no vegetative stages in smears. Spores were in clusters which divided into single spores. Fresh spores were of regular shape, oval, both ends equally rounded. Their dimensions varied in the range of 2.0–2.5 × 1.0–1.5 µm. A cone-like germ stained in the interior of the spores, and after hydrolysis a minute spherical nucleus in the posterior third of the spore. In *Rh. duplicata*, bag-like plasmodia were seen with finger-like protrusions bearing nuclei. They changed into oval uninuclear sporoblasts and developed into spores.

3.2.2 *Pleistophora cephei* n. sp. (figs. 1 e–i, 3 d–e)

Host: *Cepheus dentatus* Michael, 1888 (Cepheidae)

Tissue: Gut-wall

Locality: Mixed deciduous forests, Lonau (Lower Saxony, F. R. of Germany), 1978.

This microsporidian differs from the first in sporogony only by broader oval spores with a slightly elongated nucleus and minute remains of the posterosome in the top of the pole. In smears is the wall of the oval spores thick, showing a large exospore. Spore size 3.0 – 3.5 × 2.0 – 2.5 µm.

3.2.3 *Pleistophora platynothri* n. sp. (figs. 1 j–o, 3 f–g)

Host: *Platynothrus peltifer* C. L. Koch, 1839 (Camisiidae)

Tissue: Gut-wall

Locality: Mixed deciduous forests, Vogelsberg (Hessen, F. R. of Germany), 1979.

This rather rare microsporidian has broad oval, thin-walled spores, slightly deformed, with a narrow cone of the germ stained in Giemsa smears. Dimensions 4.5–5.0 by 2.5 µm. The nucleus is spherical, 0.1 µm in diameter, in the second third of the spore length.

3.2.4 *Pleistophora dindali*[1] n. sp. (figs. 1 p–t, 3 h)

Host: *Carabodes coriaceus* C. L. Koch, 1863 (Carabodidae)

Tissue: Gut-wall

Locality: Mixed deciduous forests, Vogelsberg (Hessen, F. R. of Germany), 1979.

Spherical, sometimes oval, thickwalled (0.15–0.20 µm) spores with an irregular, large posterosome situated laterally near the pole of the spore. Fresh spores

[1] n. sp., is dedicated to Prof. Dr. Daniel D. Dindal, College of Environmental Science and Forestry, State University of New York, Syracuse, New York 13210, USA.

are spherical, the stained ones, however, were of a more rectangular shape. Spore size 2.0 – 2.5 × 1.8 – 2.0 µm. Some stages of sporoblasts were present in the smears stained with Giemsa. One spherical nucleus (0.8–0.9 µm in diameter) stained in the posterior third of the spore after HCl treatment.

3.2.5 *Thelohania microtritiae* n. sp. (figs. 2 a–e, 3 i–j)

Host: *Microtritia minima* Berlese, 1904 (Euphtiracaridae)
Tissue: Lymphocytes
Locality: Mixed deciduous forests, Bergen (Lower Saxony, F. R. of Germany), 1979.

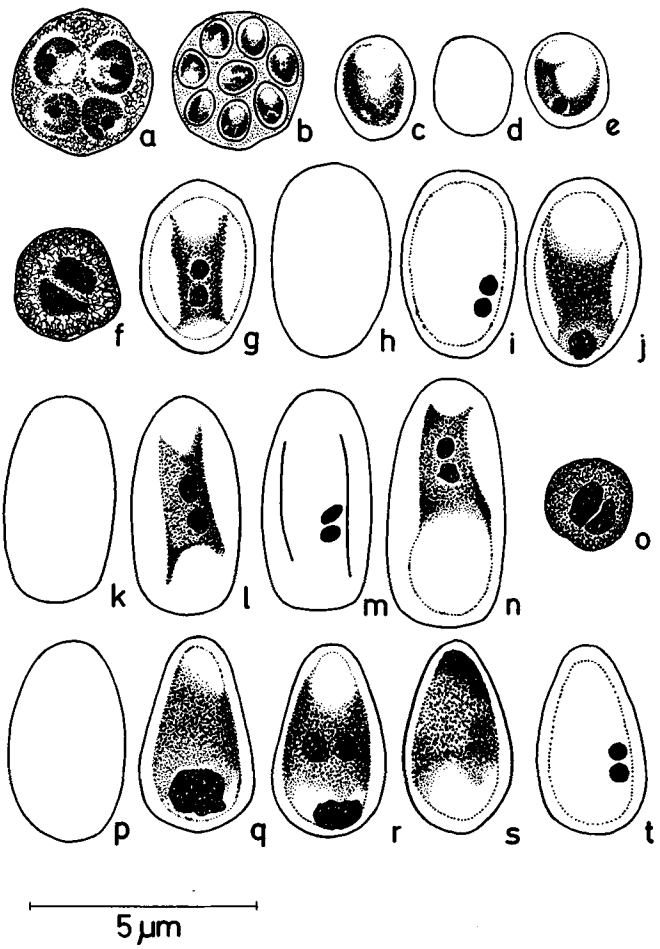


Fig. 2. a–e: Thelohania microtritiae n. sp. a = tetranucleate plasmodium, Giemsa, b = final pansporoblast with maturing spores, Giemsa, c, e = mature spores, Giemsa, d = mature spore, fresh; *f–j: Nosema steganacari* n. sp., f = sporont, Giemsa, g, j = mature spores, Giemsa, h mature spore, fresh, i = spore after HCl treatment; *k–n: Nosema acari* n. sp., k = mature spore, fresh, l, n = mature spores, Giemsa, m = mature spore after HCl treatment; *p–t: Nosema führeri* n. sp., p = mature spore, fresh, q, r, s = mature spores, Giemsa, t = mature spores after HCl treatment

Binucleate, tetranucleate (6–7 μm in diameter), octonucleate and final, spherical pansporoblasts (5–7 μm in diameter) with maturing spores were found. Free spores occur outside the pansporoblast only after intensive smearing of the body content. Mature spores, when free from pansporoblats, are spherical, sometimes oval, thin-walled, 1.8 – 2.0 × 1.5 μm, with a round posterosome. The anterior vacuole (polaroplast) is very deep, taking more than a third of the spore contents. When treated with HCl and stained for nuclei, all mature spores show only one well-stained nucleus laterally in the posterior end of the spore. This species forms pseudocysts containing pansporoblasts.

3.2.6 *Nosema steganacari* n. sp. (figs. 2 f–j, 3 m)

Host: *Steganacarus striculus* C. L. Koch, 1836 (Phtiracaridae)
Tissue: Gut-wall
Locality: Mixed deciduous forests, Bergen (Lower Saxony, F. R. of Germany), 1979.
Besides spores, some stages of sporoblasts and sporonts with two distinct spherical nuclei were distinguished in the preparations. The oval spores are more constricted at both ends than in the other species of the genus *Nosema* described in this series, showing a rather thick exospore. The germ fills the spore with a rather thick mass; two spherical nuclei, staining after hydrolysis, are usually situated beside each other in the posterior third of the spore. Spore size: 3.5 – 4.0 × 2.0 – 2.5 μm.

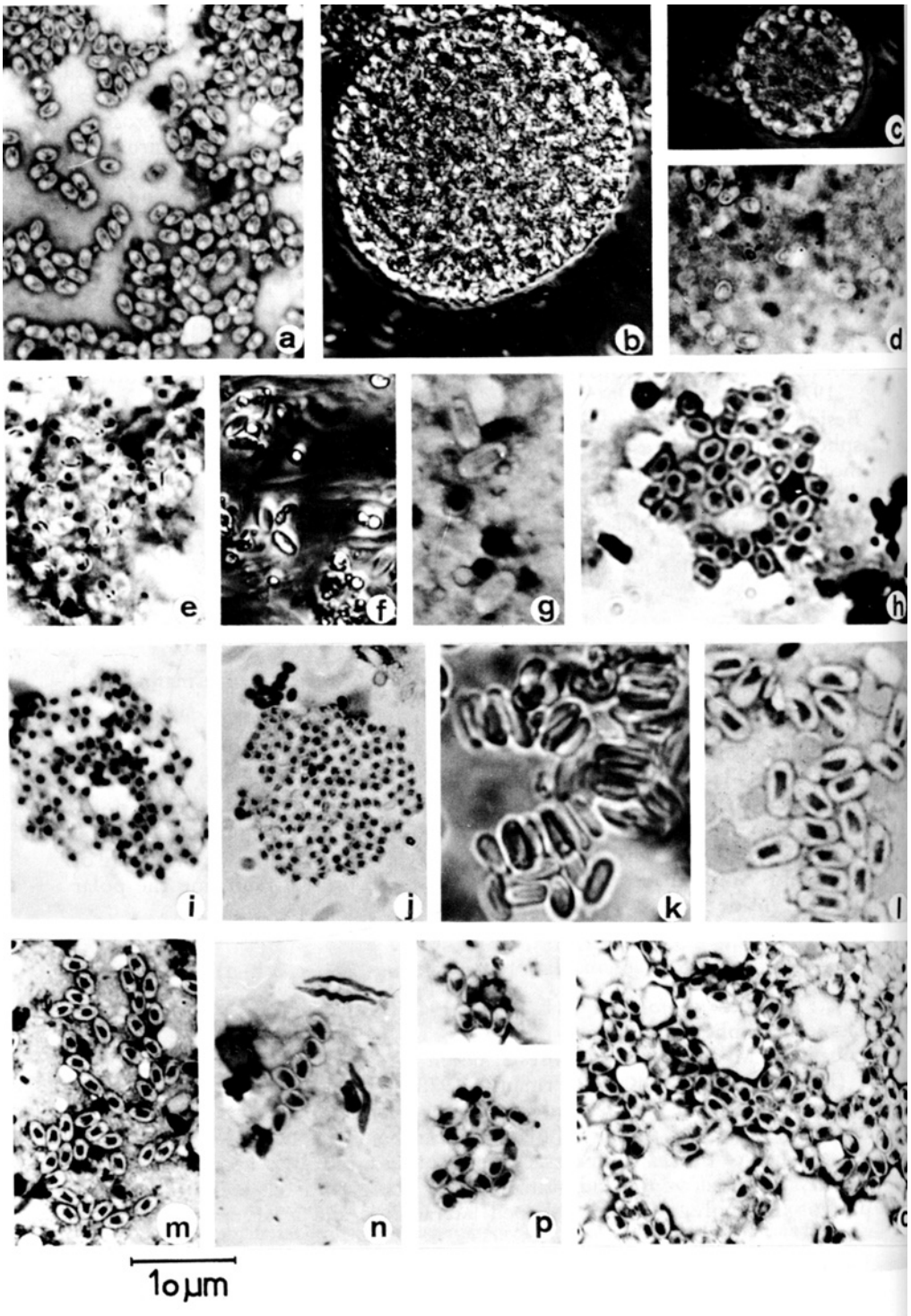
3.2.7 *Nosema acari* n. sp. (figs. 2 k–n, 3 k–l)

Hosts: *Damaeus onustus* C. L. Koch, 1841, *D. clavipes* Hermann, 1804 (Damaeidae)
Tissue: Caecum, lymphocytes
Localities: Mixed deciduous forests, beech forests, Wildpark (Lüneburg), Salzgitter Bad (Lower Saxony, F. R. of Germany), 1978, 1979.
In smears the thin-walled spores show many foldings and deformations. Fresh spores are large, oval, one pole slightly constricted; size: 4.0 – 5.5 × 2.2 – 2.5 μm. The two nuclei lie close to each other in the centre of the spore. Some macrospores (7 × 3 μm) were present, showing the polar filament inside.

3.2.8 *Nosema führeri*[2] n. sp. (figs. 2 o–t, 3 n–q)

Host: *Phtiracarus globosus* C. L. Koch, 1941 (Phtiracaridae)
Tissue: Lymphocytes, gonads
Localities: Mixed deciduous forests, beech forests, Lutter, Rodetal, Einbeck (Lower Saxony, F. R. of Germany), 1978, 1979.
The host tissues are diffusely infected by the microsporidian. Oval to spherical binucleate sporonts, 2.5 μm in diameter, can be occasionally distinguished in the remains of tissues in smears. Mature spores are oval to broadly piriform, slightly flattened on one side, thin-walled. The germ is visible in the central part of the spore, with cone-shaped lateral lines and a large, deep anterior

[2] n. sp. is dedicated to Prof. Dr. Erwin Führer, Institute of Forest Zoology, University of Göttingen, Göttingen, F. R. of Germany.


a
b
c
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e
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10 µm

Fig. 3. a, d, e, g–j, and l–q: Giemsa stain, ca. 2650; b, c, f: phase, ca. 1500x; k: fresh, watermount, ca. 2650x. *a–c: Pleistophora oribatei* n. sp., a = mature spore, gut, b = lymphocyte with maturing spores, c = oenocyte with maturing spores; *d–e: Pleistophora cephei* n. sp., d, e = young and mature spores with visible posterosomes (round posterior dot) and polaroplast (double anterior dot), gut; *f–g: Pleistophora platynothri* n. sp., f, g = mature spores, gut; h: *Pleistophora dindali* n. sp., mature spores, gut-wall; *i–j: Thelohania microtritiae* n. sp., i = group of binucleate, tetranucleate, and octonucleate plasmodia, lymphocyts, j = final pansporoblasts with maturing spores, lymphocyts; *k–l: Nosema acari* n. sp., k, l = mature spores, caecum; *m: Nosema steganacari* n. sp., mature spores, gut; *n–q: Nosema führeri* n. sp., n = mature spores in gonads, some spermatozoids visible, o, p = young and mature spores, in some of them the dark stained posterosomes visible

vacuole. A minute metachromatic granule is stained in the posterior apex of the germ. Two minute oval nuclei are situated sagittally in the middle third of the spore. Spore size: 2.5 – 3.0 × 2.0 μm.

4 Discussion

Investigation of the diseases of moss-mites (Oribatei) in forest soils of Lower Saxony and Hessen (F. R. of Germany) revealed an interesting feature, as did examination of the spring-tails (Collembola) populations (WEISER and PURRINI 1980). Obviously, the soil fauna has its own array of infections, presumably involved in the regulation of its density. They seem to be adapted to transmission even under the very specific conditions of the soil litter (mulch). Infections of the gut are more common than those of other tissues, which may promote the dissemination of spores. The low infection rates obtained in this study (table) do not reflect the actual proportions of sick specimens in the populations, since weakened and dead animals certainly escaped examination owing to the collecting and selecting techniques applied. The 15 % infection rate of *Rhysotritia duplicata*, and 10 % of *Microtritia minima* may represent local outbreaks of the diseases. Only *Pleistophora oribatei* n. sp. is associated with diverse host species, whereas the other microsporidians seem to be more host specific. The preponderant distribution of microsporidian infections in

Frequency of microsporidian infections of some Oribatid mites collected from forest soils

Oribatid species	Specimens examined indiv.	infected %
Carabodes coriaceus	91	4
Carabodes femoralis	63	2
Cepheus dentatus	82	5
Damaeus clavipes	412	3
Damaeus onustus	299	2
Microtritia minima	98	10
Phtiracarus sp.	46	2
Phtiracarus globosus	58	2
Phtiracarus piger	162	4
Platynothrus peltifer	89	2
Rhysotritia duplicata	311	15
Steganacarus striculus	161	2

deciduous forests may depend either on the habitat specific host species diversity or on direct effects of the environment on the parasites. Other data on diseases of mites, with the exception of *Hirsutella*, are scarce; they include *Entomophtora* (Fungi), some Amoebae (Amoebida), and Gregarina (Eugregarinida) (THOR 1930; FISCHER 1950; WEISER 1968; PURRINI 1979). Two microsporidian infections of moss-mites in Bavaria have already been described (PURRINI and BÄUMLER 1976, 1977).

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Zusammenfassung

Acht neue Mikrosporidien-Arten aus Hornmilben (Oribatei, Acarina) aus Waldböden

Im Rahmen einer vergleichenden Bodentieruntersuchung wurden in verschiedenen Waldstandorten Niedersachsens und Hessens 62 Hornmilbenarten festgestellt, von denen 12 Arten mit Mikrosporidien infiziert waren. Diese gehören acht verschiedenen Species an, die hier als neue Arten beschrieben werden: *Pleistophora oribatei* n. sp. in verschiedenen Hornmilbenarten; *P. cephei* n. sp. in *Cepheus dentatus* Michael (Cepheidae); *P. platynothri* n. sp. in *Platynothrus peltifer* C. L. Koch (Camisiidae); *P. dindali* n. sp. in *Carabodes coriaceus* C. L. Koch (Carabodidae); *Thelohania microtritiae* n. sp. in *Microtritia minima* Berlese (Euphtiracaridae); *Nosema steganacari* n. sp. in *Steganacarus striculus* C. L. Koch (Phtiracaridae); *N. acari* n. sp. in *Damaeus onustus* C. L. Koch and *D. clavipes* Hermann (Damaeidae), und *N. führeri* n. sp. in *Phtiracarus globosus* C. L. Koch (Phtiracaridae).

Der nachgewiesene Mikrosporidienbefall betrug bei den meisten Wirtsarten 2–5 %, nur bei *Rhysotritia duplicata* Grandjean (Euphtiracaridae) lag er bei 15 % und *M. minima* 10 %.

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