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Nests of the black stork *Ciconia nigra* as a habitat for mesostigmatid mites (Acari: Mesostigmata)

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Abstract: We surveyed the Mesostigmatid mite fauna of nests of the black stork *Ciconia nigra*, to determine the role of these mites in the biology of their hosts. We present preliminary results obtained on the basis of material collected from 31 nests. A total of 1,615 mite specimens was recorded, belonging to 39 species. The most abundant species were *Dendrolaelaps strenzkei*, *Apionoseius infirmus*, *Macrocheles merdarius* and *Macrocheles ancyleus*, which constituted more than 65% of all the specimens recorded. The presence of large numbers of predatory mites could be beneficial to the birds, if they feed on the eggs and larvae of the bird's parasites. It is likely that many of the mite species found in these nests were carried there by phoresy on insects, mainly Coleoptera.

Key words: mites; Acari; Mesostigmata; *Ciconia nigra*; nest fauna; Poland

Introduction

Birds' nests constitute a specific, impermanent type of microhabitat that is inhabited by a unique assemblage of invertebrate fauna from a range of taxonomic groups. The most numerous among these are the arthropods, especially mites (Acari). The majority of studies on mites in this type of habitat have concentrated on the annual nests of small, mainly passerine birds (Błoszyk & Olszanowski 1985, 1986; Mašán & Krištofik 1995; Krištofik et al. 2001; Tryjanowski et al. 2001; Gwiazdowicz 2003a). The limited data available on the fauna of multi-annual nests of large species like birds of prey or wading birds, show that their mite assemblages are more uniform, characterized by specific species composition and structure (Philips 1981, 2000; Philips et al. 1983; Gwiazdowicz et al. 1999, 2000, 2005, 2006; Gwiazdowicz 2003b; Błoszyk et al. 2005, 2006; Bajerlein et al. 2006). The present paper adds to the available data by documenting the mites found in nests of the black stork *Ciconia nigra* (L., 1758) in Poland.

The black stork is a widely distributed species, breeding in at least 50 countries on three continents (Tamás et al. 2006). The breeding area covers central Europe and Asia, from the Atlantic to the Pacific, and a resident breeding population also exists in South Africa. The total world population is estimated at 10,000–25,000 breeding pairs (Janssen et al. 2004; Tamás et al. 2006). The Polish population was recently estimated at 1,100–1,200 breeding pairs (Profus & Wójciak 2007). These numbers represent a significant recovery from estimates of 500–530 breeding pairs in 1966 (Bednorz 1974, probably underestimated) and 800–900 pairs in 1981–1982 (Keller & Profus 1992), as a result of legal and active protection.

In Poland, the black stork occupies its nest from the end of March or April to July or August, sometimes September (Zawadzka et al. 1990; Pugacewicz 1994, 1995; Stój 1995). It nests mainly in old deciduous or mixed forest, close to wet areas such as rivers, old river beds, streams, moors, swamps and fishponds (Bednorz 1974; Keller & Profus 1992; Profus & Wójciak 2007), where it obtains its main food, consisting of fish and amphibians (Zawadzka et al. 1990; Keller & Profus 1992; Kurowski et al. 1995; Hampl et al. 2007). In lowland areas of Poland, *C. nigra* nests mainly in oak trees, *Quercus robur* L. and *Q. sessilis* Ehrh., and in Scots Pine, *Pinus sylvestris* L. (Bednorz 1974; Cieślak 1988; Zawadzka et al. 1990; Keller & Profus 1992; Pugacewicz 1994, 1995; Kurowski et al. 1995; Kuźniak et al. 1999; Kołudzki et al. 2003). In the Polish mountains the main nesting trees are fir *Abies alba* Mill. and beech *Fagus* *sylvatica* L. (Bednorz 1974; Stój 1995). It prefers old trees, older than 100 years (Pugacewicz 1994; Kołudzki et al. 2003), in which nests are built from 3 to 25 m above ground (Keller & Profus 1992; Pugacewicz 1994, 1995; Kurowski et al. 1995; Kołudzki et al. 2003, P. T. Dolata unpublished data).

Nests are built from sticks and twigs (Gotzman & Jabłoński 1972; Makatsch 1974; Snow et al. 1998; Janssen et al. 2004), which may be up to 3 cm thick (Janssen et al. 2004), brought from the ground or broken from the nest tree, and reinforced by earth and grass (Snow et al. 1998). Nests of this species differ from those of other species of large birds in Poland, because black stork nests are composed of successive layers of sticks, soil and wheat-grass, sticks, and so on (Gotzman & Jabłoński 1972). The shallow nesting niche inside the nest is typically lined with moss, but also sometimes with grass, leaves, animal hair, dung, hay, bark, reeds, and also sometimes artificial materials, including cloth, paper, string and plastic bags (Gotzman & Jabłoński 1972; Makatsch 1974; Snow et al. 1998; Janssen et al. 2004). Nests are large. In Latvia Strazds (2003) reported average nest dimensions of 115 × 111 × 49 cm. The oldest nest was 170 × 155 × 115 cm, and was estimated to exceed one tonne in weight. Nests may be occupied for 40–50 seasons, sometimes with breaks (Bednorz 1974; Pugacewicz 1995). In Latvia Strazds (2003) reported nests lasting 11–40 years, and the longest uninterrupted period of successful breeding in one nest was 11 seasons.

The nests of the black stork form a favourable microhabitat for mites, but their mite fauna has never been studied. Microenvironmental conditions in these nests are subject to cyclic annual changes determined by the biology of the birds. We can identify two periods during the annual cycle of events in these nests during which the nest microclimate is determined by different factors. The first is the breeding season in which the birds are present, and the microclimate is strongly influenced by the birds' behaviour, and the second is the time when the nest is empty and the microclimate is influenced mainly by ambient atmospheric conditions. During the breeding season the presence of the birds makes the nutritional and microclimatic conditions in the nest more favourable for the mite fauna, so the species richness during this period should be the greatest. The results presented here refer to the mite fauna of black stork nests during the birds' breeding season.

The mites occurring in birds' nests may be either harmful, neutral, or beneficial to their host and its clutch. Some of the mite species may be parasites or vectors of pathogenic microorganisms. On the other hand, other species feed on the eggs and larvae of these parasites, and could be beneficial to the birds. The structure of the mite community might therefore provide new insights into the biology and breeding ecology of the bird. Furthermore, comparison of mite assemblages from multi-annual nests of different, closely related bird species can show the differences in environmental conditions occurring in those microhabitats.

The purpose of this study was to determine the species composition of the Mesostigmata fauna in black stork nests, and specifically, to find which species are dominant, most frequent and characteristic of this type of microhabitat. We then compared these results with those recorded from the nests of the white stork *Ciconia ciconia* (L., 1758), which is a member of the same genus as the black stork, but which shows important differences in biology and behaviour, including in nest building.

Material and methods

Thirty-one samples of nest material were collected from 27 nests of *Ciconia nigra* in June to July in 2004 and 2005, in the south Wielkopolska Region of Poland (51°25′–52°10′ N, 17°10′–18°05′ E), mainly in Antonin, Jarocin, Krotoszyn and Taczanów Forest Inspectorates (Jarocin, Ostrów Wielkopolski, Ostrzeszów and Środa Wielkopolska districts). Each sample consisted of 250–300 grams of nest padding material, collected from the middle of nests during the ringing of fledglings. Living mites were extracted from samples of nest material in Tullgren funnels for 48 hours, and collected into 75% ethanol. Temporary slide preparations were made in lactophenol for microscopic examination. Permanent mounts were made in PVA for selected specimens, or when identification of species was difficult. Mite specimens are deposited at the Invertebrate Databank Collection in the Department of Animal Taxonomy and Ecology of Adam Mickiewicz University, Poznań and the Department of Forest Protection in the University of Life Sciences in Poznań. The zoocenological analysis was conducted using two indices: occurrence (C%) and domination (D%) coefficients, as for previous papers in this series.

Results

A total of 1,614 specimens of Mesostigmata was found in the collected material, belonging to 29 species in the suborder Gamasina and 10 species in the suborder Uropodina (Table 1). Below we present a short account of the biology of the species that were most frequent and most abundant in the studied nests, with special consideration of their microhabitat preference and geographical distribution. The seven species listed below comprise 87% of all the mites collected.

Dendrolaelaps strenzkei Hirschmann, 1960 (Digamasellidae). This predatory species has been found in rotting wood, under bark, in the nests of *Formica rufa* L., 1761 ants, and also in soil, forest litter and compost (Hirschmann & Wiśniewski 1982; Karg 1993). It also inhabits nests of the white-tailed eagle *Haliaeetus albicilla* (L., 1758) (Gwiazdowicz et al. 2006). It occurs all over Europe, from Italy in the South, to Finland in the North, from Spain in the West, to Russia in the East.

Macrocheles merdarius (Berlese, 1889) (Macrochelidae) is a cosmopolitan predatory species found in manure and decomposing plant material, such as compost, silage and hay, and is phoretic on dung beetles of the family Scarabaeidae (Bregetova & Koroleva 1960; Krauss 1970; Bregetova 1977b; Mašán 2003; Błoszyk et al. 2005). It is often found in dung, either fresh and wet

Table 1. Mite species occurring in the nests of *Ciconia nigra*.

Species	Total	F	M	DN	PN	LV	D%	C%
Gamasina								
Dendrolaelaps strenzkei Hirschmann, 1960	507	177	28	263	37	2	31.41	45.16
Macrocheles merdarius (Berlese, 1889)	151	146	5	0	0	0	9.36	29.03
Macrocheles ancyleus Krauss, 1970	126	89	35	2	0	0	7.81	51.61
Dendrolaelaps longiusculus (Leitner, 1949)	97	61	21	15	0	0	6.01	22.58
Macrocheles glaber (Müller, 1860)	92	41	51	0	0	0	5.70	19.35
Proctolaelaps pygmaeus (Müller, 1860)	81	78	3	0	0	0	5.02	32.26
Androlaelaps casalis (Berlese, 1887)	57	49	8	0	0	0	3.53	19.35
Parasitus fimetorum (Berlese, 1904)	37	11	5	21	0	0	2.29	12.90
Macrocheles penicilliger (Berlese, 1904)	21	19	2	0	0	0	1.30	6.45
Hypoaspis brevipilis Hirschmann, 1969	18	17	1	0	0	0	1.12	19.35
Alliphis halleri (G. & R. Canestrini, 1881)	11	10	1	0	0	0	0.68	6.45
Hypoaspis praesternalis Willmann, 1949	10	8	2	0	0	0	0.62	6.45
Halolaelaps sp.	9	5	2	2	0	0	0.56	6.45
Dendrolaelaps fallax (Leitner, 1949)	7	5	2	0	0	0	0.43	12.90
Zercon triangularis C.L. Koch, 1836	7	3	2	1	0	1	0.38	6.45
Ameroseius macrochelae Westerboer, 1963	6	5	0	1	0	0	0.37	9.68
Parasitus coleoptratorum (L., 1758)	4	0	0	4	0	0	0.25	3.23
Hypoaspis aculeifer (Canestrini, 1883)	3	0	0	3	0	0	0.19	6.45
Asca aphidioides (L., 1758)	3	3	0	0	0	0	0.19	3.23
Dendrolaelaps arvicolus (Leitner, 1949)	3	3	0	0	0	0	0.19	3.23
Hypoaspis giffordi Evans & Till, 1966	3	3	0	0	0	0	0.19	3.23
Gamasodes spiniger (Trägårdh, 1910)	2	1	0	1	0	0	0.12	3.23
Veigaia nemorensis (C.L. Koch, 1839)	2	1	0	1	0	0	0.12	3.23
Amblyseius sp.	1	1	0	0	0	0	0.06	3.23
Gamasellodes bicolor (Berlese, 1918)	1	1	0	0	0	0	0.06	3.23
Pergamasus mediocris Berlese, 1904	1	1	0	0	0	0	0.06	3.23
Dendrolaelaps cornutus (Kramer, 1886)	1	1	0	0	0	0	0.06	3.23
Hypoaspis heselhausi Oudemans, 1912	1	1	0	0	0	0	0.06	3.23
Zercon peltatus peltatus C.L. Koch, 1836	1	0	1	0	0	0	0.06	3.23
Gamasina total	1263	740	169	314	37	3	78.25	
Uropodina								
Apionoseius infirmus (Berlese, 1887)	289	78	151	69	0	0	18.19	41.94
Leiodinychus orbicularis (C.L. Koch, 1839)	36	13	4	10	9	0	2.27	3.23
Oodinychus ovalis (C.L. Koch, 1839)	10	3	6	1	0	0	0.63	22.58
Trachytes aegrota (C.L. Koch, 1841)	7	2	2	3	0	0	0.44	6.45
Uroobovella pyriformis (Berlese, 1920)	3	1	1	1	0	0	0.19	6.45
Nenteria breviunguiculata (Willmann, 1949)	2	0	2	0	0	0	0.13	6.45
Janetiella pulchella (Berlese, 1904)	1	1	0	0	0	0	0.06	3.23
Uroobovella marginata (C.L. Koch, 1839)	1	0	0	1	0	0	0.06	3.23
Uroobovella fimicola (Berlese, 1903)	1	0	1	0	0	0	0.06	3.23
Uropoda orbicularis (Müller, 1776)	1	0	0	1	0	0	0.06	3.23
Uropodina total	351	98	167	86	9	0	21.75	
Mesostigmata total	1614	838	336	400	46	3	100.00	

Explanations: F – female; M – male; DN – deutonymph; PN – protonymph; LV – larva; D% – dominance coefficient; C% – occurrence coefficient.

or old and dry, and is also found in bird nests, including those of the common blackbird *Turdus merula* L., 1758 (Mašán 2003), and the white stork (Błoszyk et al. 2005; Bajerlein et al. 2006).

Macrocheles ancyleus Krauss, 1970 (Macrochelidae) was described from a rotting log, but appears to have a strong affinity for bird nests. It has often been collected in the nests of birds of prey (Gwiazdowicz et al. 1999, 2000, 2005, 2006; Mašán 2003), and also in guano in a cave (Cicolani 1983; Mašán & Zubáčová 2001). It is a predatory species known only from Europe.

Dendrolaelaps longiusculus (Leitner, 1949) (Digamasellidae). This predatory European mite species has been recorded in manure, compost and decomposing litter (Hirschmann & Wiśniewski 1982) and is also found in bird nests, e.g., white stork (Błoszyk et al. 2005; Bajerlein et al. 2006) and the white-tailed eagle (Gwiazdowicz et al. 2005, 2006).

Macrocheles glaber (Müller, 1860) (Macrochelidae). This predatory species is found in decomposing organic matter, especially compost and dung (Krauss 1970). It has been found in the nests of birds, e.g., *Accipiter gentilis* (L., 1758), *Acrocephalus arundinaceus* (L., 1758), *Anser anser* (L., 1758), *Ciconia ciconia* (L., 1758), *Cygnus olor* (Gmelin, 1803), *Haliaeetus albicilla* (L., 1758), *Larus ridibundus* L., 1766, *Merops apiaster* L., 1758, *Nycticorax nycticorax* (L., 1758), *Parus major* L., 1758, *Parus montanus* Conrad von Baldenstein, 1827, *Passer montanus* (L., 1758), *Remiz pendulinus* (L., 1758), *Vanellus vanellus* (L., 1758) (Mašán 2003; Gwiazdowicz et al. 2005, 2006; Błoszyk et al. 2006; Bajerlein et al. 2006). It is distributed from lowlands up to the mountain zone (1,330 m a.s.l.), and occurs in Europe, Asia, North America and Australia. It is carried phoretically by insects including several genera of scarabaeid beetles, and by flies (Bregetova & Koroleva 1960; Bregetova 1977b; Mašán 2003).

Proctolaelaps pygmaeus (Müller, 1860) (Ascidae) is a cosmopolitan species that occurs in soil, moss, decomposing organic matter and in the nests of small mammals, and most probably feeds on other microscopic invertebrates (Bregetova 1977a). It has been found in the nests of the white-tailed eagle and the white stork (Błoszyk et al. 2005; Gwiazdowicz et al. 2005, 2006; Bajerlein et al. 2006).

Androlaelaps casalis (Berlese, 1887) (Laelapidae) is found in forest litter, humus, and soil, but most commonly in the nests of small mammals and birds (Karg 1993). It occurs in the entire Palaearctic region and North America, and is probably cosmopolitan. In Poland it has been found in the nests of the white-tailed eagle and the white stork (Błoszyk et al. 2005; Gwiazdowicz et al. 2005, 2006; Bajerlein et al. 2006). It feeds on other mites and the eggs and larvae of insects (Hughes 1976).

Apionoseius infirmus (Berlese, 1887) (Trachytidae). This species is found in decomposing plant remains, tree trunks and tree holes in Europe and Asia. It is commonly found in birds' nests, and is phoretic on beetles (Wiśniewski & Hirschmann 1993; Mašán 2001; Błoszyk et al. 2005, 2006; Bajerlein et al. 2006; Gwiazdowicz et al. 2006).

Discussion

The most frequent species of Gamasina in the nests was *Macrocheles ancyleus* and the most abundant species was *Dendrolaelaps strenzkei*. Among the Uropodina the most frequent and abundant species was *Apionoseius infirmus*. In total, ten species of Gamasina and only two of Uropodina had occurrence coefficients of greater than 10%. The remaining species occur in the nests of the black stork only incidentally. The two most abundant species, *D. strenzkei* and *A. infirmus*, constituted almost 50% of the mites found, a phenomenon that is often observed in the mite communities of temporary microhabitats (Błoszyk et al. 2005). A further group included species with dominance coefficients between 5 and 10% and occurrence coefficients between 19 and 52%. These were *Macrocheles merdarius*, *Macrocheles ancyleus*, *Dendrolaelaps longiusculus*, *Macrocheles glaber* and *Proctolaelaps pygmaeus*. Those five species constituted 33.9% of the mites found. Among the Uropodina only one species had a high occurrence coefficient, *Oodinychus ovalis* (C.L. Koch, 1839), which was recorded in 23% of the nests sampled.

Most of the specimens recorded during the present study were adults, and females predominated in the majority of species. A few species, especially of Parasitidae, showed a high frequency of deutonymphs, as we also found in the nests of the white stork (Błoszyk et al. 2005). This observation is somewhat puzzling – one should expect the r-strategy to predominate in species inhabiting unstable habitats, and juvenile specimens should dominate the whole fauna. The explanation is quite straightforward – most of the species recorded in the nests sampled are typically found in rotting wood and decomposing plant material, and multiannual nests of the stork consist of rotting twigs and sticks. The K-type reproductive strategy is typical for most of those species when recorded outside the nests (Błoszyk 1999; Błoszyk et al. 2003). Since the nests constitute only a marginal habitat for their mite inhabitants, these mites have had no time or reason to evolve a new reproductive strategy.

This explanation also holds true for a second interesting observation. The community of Uropodina found in these nests comprises mainly bisexual species, in contrast with soil communities, where female-only populations are common, but similarly to those found in decomposing plant material (Błoszyk et al. 2003). Of the species observed in this study, only *Uropoda orbicularis* (O.F. Müller, 1776) and *Uroobovella pulchella* (Berlese, 1904) might be described as thelytokous. However, even in these cases occasional males have been found, and these species are facultatively parthenogenetic (Faasch 1967; Błoszyk et al. 2006).

The mite fauna of the nests of the black stork is strikingly different from that of the nests of white stork, which we have described previously (Bloszyk et al. 2005; Bajerlein et al. 2006). The sampling methods used for the two bird species were not always identical, so a rigorous comparison of the results is not possible. However, some general trends can be seen. From a total of 61 species of Mesostigmata, only 17 species were common to both stork species, and the species similarity index (S) amounted to slightly less than 31%. Also the mean abundances of mites in the nests of the two species differed significantly (Mann-Whitney U test: $Z = 3.2$; $P < 0.01$; Fig. 1). The most abundant species in the nests of *C. nigra*, *Dendrolaelaps strenzkei*, was not found at all in the nests of *C. ciconia*, and the second most abundant species in the nest of *C. ciconia*, *Macrocheles robustulus* (Berlese, 1904), was absent from the nests of *C. nigra*. At a generic level, *Macrocheles* made up 71% of the mites from *C. ciconia* but only 24% from *C. nigra*, and *Dendrolaelaps* made up 38% of the mites from *C. nigra* but less than 1% from *C. ciconia*. Possible reasons for these differences may be found in the different construction materials used by the two species of birds, differences in the birds' behaviour, and the different habitats in which their nests are built. The interior lining of the nest of *C. nigra* is made of tightly compressed moss, which remains humid and can even support a pool of water, while that of *C. ciconia* is more open in structure, and less likely to retain water. Also, *C. ciconia* nests in exposed synanthropic situations such as buildings and power transmission pylons, while in Poland, the nests of *C. nigra* are built in heavily shaded sites in forest trees (Pugacewicz 1995), where the microclimate is likely to be much more cool and

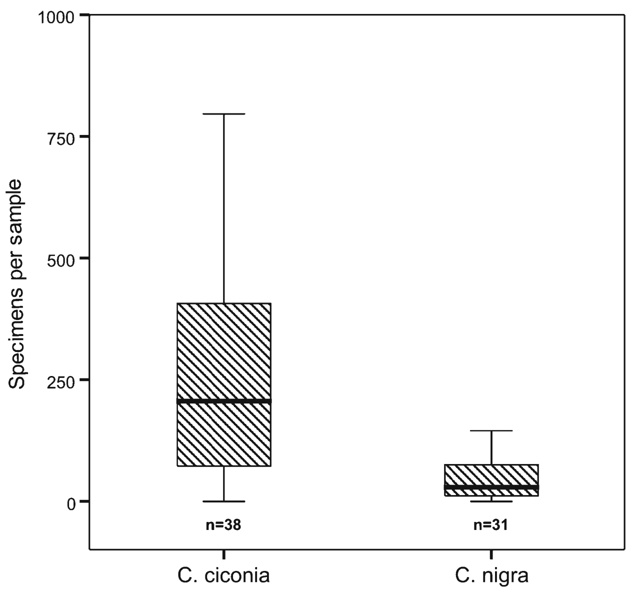

Fig. 1. Box-plot comparing the number of mite specimens recorded in samples from the nests of both stork species.

humid. We have previously reported that *C. ciconia* brings cow dung and compost into its nests (Bajerlein et al. 2006), and this is likely to introduce coprophilous mite species into the nests, such as *Macrocheles*. These species are likely to be further favoured by the presence of pellets of undigested food in the nests of *C. ciconia* (skin and bones of small mammals and amphibians). *Ciconia nigra* rarely brings dung or compost into its nests, since it feeds mainly in water, unlike *C. ciconia*, which feeds in meadows. Dung or compost was never observed in the nests studied here. Also, *C. nigra* does not leave undigested food in its nests.

The nests that we examined contained large numbers of predatory mites, dominated by the genera *Dendrolaelaps* and *Macrocheles*, which raises the question of what these mites were feeding on. The black stork and other species of *Ciconia* are attacked by a variety of ectoparasites, including lice (Ezealor 1985; Martin Mateo 1988; Złotorzycka 1990; Lanzarot et al. 2005; Dik & Uslu 2006), parasitic Astigmata (Fain & Laurence 1986; Chen & Fan 2003), quill mites (Bochkov & Mironov 1999), ticks (Ezealor 1985; Dik & Uslu 2006) and feather mites (Perez & Atyeo 1992; Janssen et al. 2004). It is possible that predatory mites play a role in nest hygiene by feeding on these parasites. However, parasitic Mesostigmata were not found in the nests we examined. This is consistent with the observations of Lanzarot et al. (2005), who found lice on 11 of the 50 nestlings of *C. nigra* that they examined in Spain, but no other parasites. A near or complete absence of blood-feeding parasitic Mesostigmata has also been reported for nests of the white-tailed eagle (Gwiazdowicz et al. 2005, 2006; Fenďa & Lengyel 2007), and the white stork (Bloszyk et al. 2005; Bajerlein et al. 2006). In contrast, large populations of parasitic mites, such as *Dermanyssus hirudinis* (Hermann, 1804), *D. gallinae* (De Geer, 1778), *Ornithonyssus bursa* (Berlese, 1888), *O. sylviarum* (Canestrini et Fanzago, 1877) have commonly been found in the nests of passerine birds (Krištofík et al. 1993, 2001, 2002; Mašán & Krištofík 1993; Gwiazdowicz 2003a). Even more surprising is the fact that the parasite *Dermanyssus gallinae* was the most abundant mite species found in the nests of boreal owl *Aegolius funereus* (L., 1758) in Bohemia by Krištofík et al. (2003), but was absent from nests of the same owl species examined by Philips (1981) in Norway. Several families of saprophytic mites in the suborder Astigmata have been reported from birds' nests (Philips 1981; OConnor 1979), and these are a further possible type of prey for predatory mites. However, in the present study and others, Astigmata were not found. Inconsistencies in the occurence of Astigmata and parasitic Mesostigmata in the nests of different bird species are difficult to explain, but highlight the fact that the ecology of mites in birds' nests is not yet fully understood.

Apart from being carried with nest material, phoresy on coprophilous insects could be an important mode of migration of mites to and from nests (Faasch 1967). Some of the Mesostigmata species recorded in this study, including *Macrocheles merdarius*, *M. glaber*, *Alliphis halleri* (G. et R. Canestrini, 1881) and *Proctolaelaps pygmaeus*, are phoretic on many species of dung beetles. Some informal observations (J. Błoszyk, unpubl. data) indicate that at least 20 other species reported in the present paper can adopt the same means of dispersal. That would be consistent with previous observations conducted on mite fauna of multi-annual nests of other bird species (Błoszyk et al. 2005, 2006; Gwiazdowicz et al. 2005, 2006; Bajerlein et al. 2006).

We can identify a further possible route by which mites may enter the nests of *C. nigra*, through the activities of other species of birds. Nests of *C. nigra* from the previous breeding season are sometimes occupied by birds of prey in the next breeding season, for example the common buzzard *Buteo buteo* (L., 1758), the Northern goshawk *Accipiter gentilis*, and the lesser spotted eagle *Aquila pomarina* C.L. Brehm, 1831 (Bednorz 1974; Pugacewicz 1995; Snow et al. 1998; P.T. Dolata unpublished data). The effects of these birds on the mite fauna are likely to be variable and unpredictable, and introduce a further unknown level of heterogeneity into the data presented here.

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