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Biological and ecological aspects of quill mites, parasites of domestic hen *Gallus gallus domesticus* (Aves, Phasianidae) from rustic breeding locations in the municipality of Juiz de Fora, Minas Gerais, Brazil[1]

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Abstract. This research was directed to record the species of quill mites of domestic hen, *Gallus gallus domesticus* (L.), raised in barnyards of small propriety in the municipality of Juiz de Fora, Minas Gerais, besides to go deep the knowledge about the biology and ecology of these mites. Were utilized 300 adults birds in three different localities. The fieldworks had been divided in two stages, searching to collect feathers in different period of the year, changing the gradients of the ambient as temperature and humidity. The birds were examined in the winter and reexamined in the summer of that year. The hosts were directly captured in the chicken houses, being individually marked. The wing feathers were examined and only those parasited were collected and opened in laboratory. All the mites found were collected, counted and kept in numbered glasses contend alcohol 70° GL, being later mounted and identified. Of 300 chickens examined during the winter, only 9 were infested with quill mites. During the summer we found 16 birds parasited. The specie of quill mites registered was *Syringophilus bipectinatus* Heller, 1880. All phases of the biological cycle (eggs, larvae, nymphs and adults) were found inside the quills, with the dominance of the females above males. We observe a tendency to a symmetrical occupation of the feathers of both sides of the wing, mainly in the most central feathers, the third, fourth and fifth feathers, in the case of primaries and third secondaries remiges, corresponding with the directions of the molt. The amount of quill mites and feathers occupied were greater during the summer, where we found recently formed feather infested with young forms and few or none adults. During the winter we found a greater amount of feathers with excreta, exuviae and only adult forms.

Key words: *Gallus gallus*, quill mites, *Syringophilus bipectinatus*.

Resumo: Aspectos biológicos e ecológicos de ácaros calamícolas, parasitos de galinha doméstica *Gallus gallus domesticus* (Aves, Phasianidae) de criações rústicas localizadas no município de Juiz de Fora, Minas Gerais, Brasil. O objetivo do presente trabalho foi verificar as espécies de ácaros calamícolas que ocorrem na microrregião de Juiz de Fora, Minas Gerais, além de aprofundar os conhecimentos a respeito da biologia e ecologia desse grupo de artrópodes. Para isso, utilizou-se 300 galinhas domésticas adultas criadas em regime de semi-liberdade, entre os anos de 2002-2004. Os hospedeiros foram capturados diretamente no interior dos galinheiros, sendo suas penas das asas cuidadosamente examinadas. Somente rêmiges primárias e secundárias encontradas parasitadas foram recolhidas e acondicionadas em sacos plásticos, posteriormente levadas ao Laboratório de Parasitologia da Pós-graduação em Comportamento e Biologia Animal, da Universidade Federal de Juiz de fora. Somente foram encontrados ácaros da espécie *Syringophilus bipectinatus* em 25 aves, sendo 9 delas coletadas durante o verão e 16 durante o inverno. Todos os estágios do ciclo biológico (ovo, larva, ninfa e adultos) foram observados no interior do canhão das penas, considerando válida a hipótese de todo o ciclo completar-se no interior do cálamo. Observou-se uma tendência de ocupação pelos ácaros das penas mais centrais, ou seja, a terceira, quarta e quinta rêmiges primárias e terceira secundária, provavelmente em virtude do sentido de troca das penas. Foram encontradas uma grande quantidade de penas ocupadas somente com restos de ácaros, fezes e exúvias durante as coletas de inverno. Já nas coletas realizadas no verão, observaram-se penas ocupadas por formas jovens, larvas e ninfas em sua maioria, verificadas em penas recém mudadas. Essas observações poderiam ajudar a esclarecer o fenômeno de infestação de novas penas, já que somente formas jovens, como larvas, teriam um tamanho adequado para transpassar a abertura do umbílico superior.

Palavras-chave: *Syringophilus bipectinatus*, ácaros calamícolas, galinha doméstica.

INTRODUCTION

Birds are hosts to various species of ectoparasites and endoparasites. Their plumage particularly is a propitious habitat for diverse arthropod ectoparasites, which can feed on their blood, body fluids, skin flakes and feather preening oil.

Among these arthropod parasites of birds, one group of mites stands out due to the dearth of studies to date. These are the mites that live permanently on the feather surface, on the skin of birds or in the feather quills, all included in 'feather mites' for GAUD & ATYEO (1996) and DABERT & MIRONOV (1999). Here, however, we use the term 'quill mites' for species living within the feather quills and 'feather mites' for species living on the feather surface, following ecological aspects, as cited by Ventura (1999).

Although a few dozen species have already been described, little is known about the parasite-host relationship of this group of arthropods (FACCINI & BARROS, 1990), even though they represent the majority of bird-mite associations (PROCTOR & OWENS, 2000). Some studies have examined the distribution of mites on the wings of birds (CHOE & KIN, 1989), their transmission between birds (JOVANI & BLANCO, 2000), and factors shaping their prevalence and abundance (BLANCO *et al*., 1999). However, all these cited studies are related with feather mites, being necessary more information for quill mites. To our knowledge, only KETHLEY (1971), FACCINI & BARROS (1990) and VENTURA (1999) mentioned about biological and ecological aspects, including the prevalence, their feeding behavior, transmission and distribution of quill mites in the birds wings.

According to JOVANI & SERRANO (2001), study of the biology and behavior of quill mites has been largely overlooked, and there is a need to learn more about the distribution of these mites in the feathers, their transmission between hosts, their feeding behavior and the factors that influence their prevalence and abundance. The same authors considered an important topic, which also has received little attention, the effect of the moult of birds on the behavior and population dynamics of mites of birds.

According to Proctor & OWENS (2000), the most studied feather mites are those that harm their hosts, among them mites of the order Astigmata, which cause economic losses to poultry breeders.

Based on these factors, our main objectives were (1) to verify the species of quill mites found in the micro region of Juiz de Fora, Brazil; and (2) to gain more knowledge in relation the biology and ecology of the parasites of this group that use domesticated chickens as hosts.

MATERIAL AND METHODS

Study area and field procedures

We used a total of 300 adult hens, raised in a semi-free ranging regime, from three locations (100 hosts in each) ecologically similar in the municipality of Juiz de Fora, Brazil (Lat: -21 46' 02'' Long: -43° 21' 14''; Lat: -21° 47' 06'' Long: -43° 22' 48'' and Lat: -21° 48' 04'' Long -43° 19' 23''). The collects were realized in two seasons, one hot and humid (summer) and the other cool and dry (winter), during the years of 2002 – 2004 (100 birds in each year), seeking to obtain information on differences according to temperature and humidity conditions. The examination of the hosts was realized during the winter, being the same birds reexamined in the summer of that year. Don't occurred replacement of the hosts during the period of the experiment.

We captured the birds directly inside the coops, being each host individually marked following the methodology proposed by SANTOS-PREZOTO *et al*. (2001). The wings feathers were carefully examined under solar light, as described by VENTURA (1999). We only examined primary and secondary remiges, on both sides of the bird, seeking to confirm symmetry of parasitism. The parasited feathers were collected and placed in plastic pouchs and then transported to the Laboratory of the Postgraduate Program in Animal Biology and Behavior of Juiz de Fora Federal University, where the quills were opened and the contents spilled into Petri dishes.

All the mites found, including young and adult forms, were transferred to vials containing ethyl alcohol at 70° GL. Then the content of each vial

was poured into a Petri dish, under a stereoscopic microscope, and the specimens were separated into eggs, larvae, nymphs and adults (males and females). The mounting on slides followed the classic acarology routines described in FLECHTMANN (1973). The slides were envied to Rio de Janeiro Federal Rural University, where the mites have been identified by Professor Dr. João Luiz Horácio Faccini.

Statistical analysis

We tested whether the number of quill mites was statistically significance between both the sides of the wings of the same host with the "r" intraclass correlation coefficient, seeking to confirm the phenomenon of the symmetry of parasitism. The same approach was conducted for each bird separately to test the consistency of the quill mites distribution at feather level between the right and the left wing of each bird.

The intraclass correlation coefficient (r) estimates the fraction of total variance of the number of mites attributable to bird identity. This coefficient was calculated as the division between the variance of the number of mites between both wings of the same bird, or between pairs of symmetric feathers (see JOVANI & SERRANO, 2004 for further details). Significance of r coefficients was calculated with a one-way ANOVA (5% of significance).

The differences between the periods of collects during the year, summer and winter, were analyzed with one-way ANOVA (5% of significance) to prove its statistical significance.

RESULTS AND DISCUSSION

The appearance of the infested feathers made them easy to distinguish from those free of parasites. The calamus of the parasitized feathers was opaque, with yellowish brown coloration, in contrast with parasite-free feathers, where the calamus was transparent. The transversal trabeculas were destroyed along with a large part of the rachis. Unlike expected, the infested feathers showed the same resistance when pulled out as those that were parasite-free, which suggests the follicle had not been injured. These observations also were verified by Faccini & Barros (1990) and Proctor (2003), which suggests that pathological alterations are related to the feeding habits of quill mites, which consume the internal part of the calamus and rachis wall. The keratinous medulla of the rachis is eaten by many quill mites, including those of the Syringobiidae (O'CONNOR, 1982) and Ascouracaridae families, which have robust chelicerae and denticles adapted to scrape the interior of the quill (PROCTOR, 1999).

The infested birds did not show any apparent sign of debility or behavioral change from those free of mites. According to PINTO *et al.* (2001), birds infested with ectoparasites become nervous due to the heavy parasite presence. They do not sleep normally and can injure themselves, pulling out their feathers in an attempt to alleviate the discomfort. This parasitism can reduce egg production and cause weight loss, resulting in lost profits, particularly to small and medium sized breeders. According to WILSON (1990), the use of products to combat mite infestation is very important in commercially valuable birds, mainly in laying hens, which can suffer effects in their reproduction caused by mites. However, GAUD & ATYEO (1976) considered that among bird parasite arthropods, quill mites generally do not harm their hosts, even in heavy infestations. These mites do not feed on live tissues, nor does the host ingest them, so they are not disease vectors. The hosts may become debilitated due to the presence of thousands of quill mites, but the cause of these heavy infestations is not known. Contributing factors may be other health problems of the birds or poor sanitary conditions in coops.

Of the 300 hosts examined during the summer (hot and humid) collects, 16 were infested with quill mites (5,33%), while in the winter (cool and dry) there were 9 out of 300 (3,0%) (Tab. 1). The abundance and parasite intensity observed during collects at summer and winter are presented in Table 2.

We found quill mites of the species *Syringophilus bipectinatus* Heller, 1880. Mites of this species are common in domestic chickens, living and reproducing inside the quills, feeding on the host tissue fluids by penetrating the calamus wall with their needle-like

Table 1. Amount of mites, feathers and hosts parasited found during the collects in the winter (cool and dry) and summer (hot and humid) of 2002 – 2004 in *Gallus gallus domesticus* of three "backyard" breeding locations in the municipality of Juiz de Fora, MG.

	Winter (cool and dry)			Summer (hot and humid)		
	2002	2003	2004	2002	2003	2004
	July	July	August	December	December	November
Host parasited	4	3	2	4	6	6
Feather parasited	15	18	10	24	32	43
Mites*	1323	913	635	2108	2370	1780
Temperature (oC)	22	22	20	28	25	26
Humidity (%)	58	50	55	68	63	67

* only were considered here larvae, nymphs and adults, showing the difference found in the collects of winter and summer. Mean of temperature and humidity registered during sampling.

Table 2. Parasite intensity and abundance of *Singophilus bipectinatus* in feathers of *Gallus gallus domesticus* of three "backyard" breeding locations collected during the winter (cool and dry) and summer (hot and humid) of 2002 - 2004 in the municipality of Juiz de Fora, MG.

Summer (hot and humid)			Winter (cool and dry)		
Host	Intensity	Abundance	Host	Intensity	Abundance
1	475	20,86	1	347	9,57
2	694		2	214	
3	587		3	412	
4	352		4	350	
5	311		5	155	
6	276		6	183	
7	442		7	575	
8	621		8	249	
9	248		9	386	
10	472				
11	351				
12	147				
13	346				
14	219				
15	504				
16	213				

*Mites only were considered here larvae, nymphs and adults.
Abundance = total number of mites/ total number of host.
Intensity = total number of mites found in each hen.
Host 1-4 collected in 2002; 5-10 collected in 2003 and 11-16 collected in 2004 (summer). Host 1-4 collected in 2002; 5-7 collected in 2003 and 8-9 collected in 2004 (winter).

chelicerae. They belong to the Prostigmata order and are believed to be the only quill mite of the Syringophilidae family to parasitize *Gallus gallus*. Recently, SKORACKI *et al*. (2001) described a new mite species of this family, *Picobia polonica*, infesting the body feathers of a specimen of *Gallus gallus domesticus* in Poland.

In fact, the presence of only this quill mite species can be explained by the altitude where the city of Juiz de Fora is located, about 800 meters above sea level. In works seeking to analyze the occurrence of possible changes due to alterations in the ecological gradients on the populations of quill mites, VENTURA (1999) found that this species predominates at higher elevations, and is not found in areas at sea level.

Regarding the symmetry phenomenon, which consists of the occupation of both sides of the host, in the primary remiges we found feathers presented 100% of symmetry, feathers with rate between 50 and 75%, and only three feathers, had symmetry levels below 50%. The same occurred in secondary remiges, where we found feathers with 100% of symmetry, between 50 and 75% and only four secondary remiges had symmetry levels below 50%. Moreover, the amount of quill mites found in each feather of both the sides of the wing was statistically significant, in other words, the number of quill mites was highly repeatable between both wings of each host ($r = 0.75$, $F_{1,48} = 40.45$, $P < 0.005$, in the primaries and $r = 0.68$, $F_{1,40} = 32,30$, $P < 0,005$ in the secondary feathers of the wings) (Fig. 1A and B).

Hence, the hypothesis of symmetry, both in primary and secondary remiges, can be considered valid. The explanation for this may be related to the molting of the hosts' feathers, since this has been

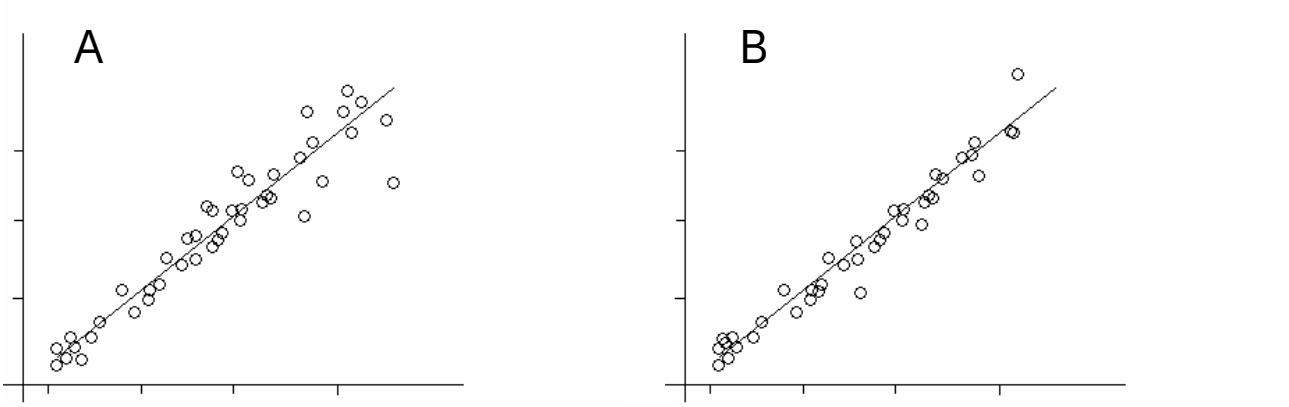

Figure 1. Number of quill mites on the right vs. the left wing of *Gallus gallus*. A) Number of mites on the right vs. left primary remige of the wing. B) Number of mites on the right vs. left secondary remige of the wing.

shown to be symmetrical (SICK, 1997). At the time of feather renewal, the mites have two opportunities for occupation; one on the right and one on the left side, so the symmetrical parasitism can occur as the feathers become available during molting.

Quill mites were found on all the flight feathers, except on the first primary, first and second secondary remiges. However, the mites tended to concentrate on central wing feathers, mainly on the 3°, 4° and 5° primaries and 3° secondary. Although they have been found in the others feathers, the number of mites was very low, mainly in the collects of winter, with less than 10 mites in each feather. JOVANI & SERRANO (2004) found similar results, mites with distribution in all the flight feathers, except on the first primary and first secondary, but for feather mites. The authors suggested as possible explanations the moult and the aerodynamic particularities of these feathers. VENTURA (1999) considered the moult and the thickness of the feathers as limiting factors to the development of population of ectoparasites. Moreover, the author observed a tendency of *S. bipectinatus* to occupy the central wing feathers due the lesser thickness, facilitating their feeding on the calamus wall, what could to explain our results.

All life stages of the mites were found within the quills, so the hypothesis that this is completed within the quill can be considered valid. Faccini & Barros (1990) and VENTURA (1999) also reported all stages of the biological cycle of *Gallilichus hiregoudari* D'Souza & Jagannath, 1982, a species of quill mite belonging to the Astigmata order, within the calamus. It should be pointed out that this species belongs to a different order than *S. bipectinatus*, so there can be differences in its behavior and biology.

We did not find any quill mites outside the calamus, which according to GAUD & ATYEO (1996) can happen due to an intense infestation of the host or when the mites leave one feather to find a new one to invade.

There were more females than males, a finding also reported by FACCINI & BARROS (1990) and VENTURA (1999) for *G. hiregoudari*. Those authors suggest that males have shorter life spans to explain this, a fact that can be discarded for *S. bipectinatus* due to the absence of male exuviae inside the quills.

An important aspect to mention is the occurrence inside the quills of a large number of exuviae and few live mites, only adult form, in feathers likely ready to fall out soon, in contrast to young or recently formed feathers, where there were many immature forms, such as larvae and nymphs, and few or none adult form. Parasitic ectosymbionts have been shown to synchronize their reproduction and activity with that of their hosts (MARSHALL, 1981). According to JOVANI & SERRANO (2001), feather mites may be "synchronized" in their biological cycles according to the time when the feathers fall out. In other words, as the old feathers get ready to fall out, the mites abandon them and seek newer feathers to occupy.

They could have developed an adaptive escape behaviour from feathers close to falling out (escape hypothesis). DUBININ (1951) found that he could induce the feather mites of a single bird to move out of a single feather made to vibrate by making a cut on the quill, considering that feather mites could use the vibration of the feather next to fall out as a cue to escape from moulting feathers (vibration hypothesis). Fact also considered by JOVANI & SERRANO (2001), that verified that feather mites were better at escaping from those feathers that were predicted to vibrate at a high rate before they fell out. This behavior change could be true also for quill mites, and the vibration of the feather could to active the escape movement. The adult mites found in old feathers probably are cases in which they were too large to escape through the superior umbilicus. These mites would only abandon these feathers after they fall, through the inferior umbilicus. Probably only young forms, such as larvae and nymphs, are small enough to escape by the superior umbilicus and penetrate newer feathers through the same passage, which leads us to the discussion of how quill mites spread in the feathers, a phenomenon about which little is known.

Seasonal variation in mite abundance on particular feathers are in part due to movements of mites caused by external factors such as temperature and humidity, and also by host activity, sociality and moult (BLANCO et al., 1997). We observe that the occurrence of feathers found only with adult forms, excreta and exuviae was during the cool and dry season (Tab.3), probably the period where the mites escape of feathers ready to fall out soon, what contrasts with the observations of KETHLEY (1971), who studying sparrows infested by *Syringophiloidus minor* in Ohio, U.S.A. found that during the winter and summer there was no dispersion of quill mites, only development of these populations. This disparity in results is probably due to the differences in the species of mites and birds or differences in temperature and humidity in countries with tropical climates like Brazil, in contrast to regions with temperate climates like Ohio.

In the collects of 2002 we found only the same hosts infested, in other words, only the same four birds parasited in the winter were parasited in the summer. Moreover, the amount of occupied feathers and the amount of mites was very lesser in the winter. During the others years, all the hosts that we found parasited in the winter were with mites in the summer and new birds with quill mites were found. Again, the amount of mites and occupied feathers was greater in summer. These differences in the results were demonstrated statically significant ($p < 0,05$).

Probably the fact of hens remains more time in contact during the cool allowed to mites to occupy new hosts. Symbionts may also have evolved the ability to detect changes in host sociability to increase reproduction and changes of dispersal through horizontal transmission during periods when hosts

Table 3. Structure of the populations of *Syringophilus bipectinatus* in feathers of *Gallus gallus domesticus* of three "backyard" breeding locations collected during the winter (cool and dry) and summer (hot and humid) of 2002 - 2004 in the municipality of Juiz de Fora, MG.

Life cycle stages	Winter (cool and dry)			Summer (hot and humid)			
	2002	2003	2004	2002	2003	2004	
	n			n			Total
Eggs	742	152	226	1599	541	610	3870
Larvae	652	482	159	872	1145	698	4008
Nymphs	348	254	142	492	542	532	2310
Exuviae	328	214	482	125	45	98	1292
Males	49	28	37	103	208	135	560
Females	274	149	297	641	475	415	2251
Total	2393	1279	1343	3832	2956	2488	14291

n= amount of collected mites

are gregarious, or through vertical transmission from parents to offspring during host reproduction (CLAYTON & TOMPKINS, 1994).

Future studies should be conducted to shed more light on questions such as the influence of temperature and humidity in the movement of quill mites in the feathers, the moult and the escape of quill mites, and the way and time of the year the mites disperse among their hosts' feathers.

CONCLUSIONS

The quill mites synchronize their reproduction and activity with that of their hosts. The dispersion of quill mites of the species *Syringophilus bipectinatus* in the feathers and the infestation of new hosts occur in winter, when the moult of feathers occurs and the birds remain more time gregarious. In the summer, there is higher infestation, when young feathers were found infested mainly by larvae and nymphs – the dispersion forms. During cooler periods, more feathers were found with a large amount of excreta and exuviae and infested only by adult forms, in the feathers abandoned by young forms because they were getting ready to fall out.

The phenomenon of symmetry of parasitism suggests this occurs both in primary and secondary remiges due to the simultaneous process of feather molting on each side of the bird, so that there are normally two chances to occupy newly forming feathers. The quill mites occupy all the flight feathers, except the first primary, first and second secondary remiges, tending to concentrate on central wing feathers, mainly on the 3°, 4° and 5° primaries and 3° secondary, due the moult and the thickness of these feathers. The entire biological cycle of quill mites occurs inside the quills, since all stages were found there.

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REFERENCES

BLANCO, G.; SEOANE, J. & de LA PUENTE, J. 1999. Showiness, non-parasitic symbionts, and nutritional condition in a passerine bird. Annales Zoologiques 36 (1): 83-91.

BLANCO, G.; TELLA, J.L. & POTTI, J. 1997. Feather mites on group-living red-billed choughs: a non-parasitic interaction? Journal of Avian Biology 28 (1): 197-206.

CHOE, J.C. & KIN, K.C. 1989. Microhabitat selection and coexistence in feather mites (Acari: Analgoidea) on Alaskan seabirds. Oecologia 79 (1): 10-14.

CLAYTON, D.H. & TOMPKINS, D.M. 1994. Ectoparasite virulence is linked to mode of transmission. Biological Sciences 256 (1347): 211-217.

DABERT, J. & MIRONOV, S.V. 1999. Origin and evolution of feather mites (Astigmata). Experimental and Applied Acarology 23 (1): 437-454.

DUBININ, V.B. 1951. Feather mites (Analgesoidea). Introduction to their study. *In*: JOVANI, R. & SERRANO, D. 2001. Feather mites (Astigmata) avoid moulting wing feathers of passerine birds. Animal Behaviour 62 (4): 723-727.

FACCINI, J.L.H. & BARROS, R.V. 1990. Observações sobre o parasitismo de *Gallilichus hiregoudari* D´Souza & Jagannath (Acari: Syringobiidae) em *Gallus gallus* (L.) em infestações naturais. Revista Brasileira de Zoologia 7 (3): 277-279.

FLECHTMANN, C.H.W. 1973. Ácaros de importância médico-veterinária. Ed. Nobel, São Paulo, SP. 192p.

GAUD, J. & ATYEO, W. T. 1996. Feather mites of the world (Acarina: Astigmata): the supraspecific taxa. Annales Sciences Zoologiques 277 (1): 3-193.

GAUD, J. & ATYEO, W.T. 1976. Ascouracarinae, n. subfamille des Syringobiidae Sarcoptiformes plumicoles. Acarologia 18 (1): 143-162.

JOVANI, R. & BLANCO, G. 2000. Resemblance within flocks and individual differences in feather mite abundance on long-tailed tits *Aegithalos caudatus*. Ecoscience7 (1): 428-432.

JOVANI, R. & SERRANO, D. 2004. Fine-tuned distribution of feather mites (Astigmata) on the wing of birds:the case of blackcaps *Sylvia atricapilla*. Journal of avian biology 35 (1): 16-20.

JOVANI, R. & SERRANO, D. 2001. Feather mites (Astigmata) avoid moulting wing feathers of passerine birds. Animal Behaviour 62 (4): 723-727.

KETHLEY, J. 1971. Population regulation in quill mites (Acarina: Syringophilidae). Ecology 52 (6): 1113-1118.

MARSHALL, A.G. 1981. The ecology of ectoparasitic insects. *In*: BLANCO, G. & FRIAS, O. 2001. Symbiotic feather mites synchronize dispersal and population growth with host sociality and migratory disposition. Ecography 24 (1): 113-120.

O'CONNOR, B.N. 1982. Evolutionary ecology of astigmatid mites. Annual Reviews Entomology 27 (1): 385-409.

PINTO, C.; POSSATI, M.; VILLAÇA, A.; GUERIM, L.; SÁ-FREIRE, L. & SERRA-FREIRE, N. M. 2001. Ocorrência de malófagos em galinhas caipiras e sua relação com o padrão de coloração da plumagem. Entomologia y Vectores 8 (3): 299-301.

PROCTOR, H.C. 1999. *Gallilichus jonesi* sp n. (Acari: Ascouracaridae): a new species of feather mites from the quills of the Australian brush-turkey (Aves: Megapodiidae). Australian Journal of Entomology 38 (1): 77-84.

PROCTOR, H.C. 2003. Feather mites (Acari: Astigmata): ecology, behavior and evolution. Annual Reviews Entomology 48 (1): 185 – 209.

PROCTOR, H.C. & OWENS, I. 2000. Mites and birds: diversity, parasitism and coevolution. Trends in Ecology Evolution 15 (1): 358-364.

SANTOS-PREZOTO, H.H.; D'AGOSTO, M.; DAEMON, E. & PREZOTO, F. 2001. Técnica alternativa de marcação individual para estudos de campo com *Gallus gallus* Linaeus, 1758. Revista de Etologia 4 (2): 43-46.

SICK, H. 1997. Ornitologia Brasileira. Editora Nova Fronteira, Rio de Janeiro. 912p.

SKORACKI, M.; MAGOWSKI, W. & DABERT, J. 2001. *Picobia polonica* sp. n. (Acari: Prostigmata: Syringophilidae), a new species of quill mite from the domestic hen, *Gallus gallus domesticus* (Aves: Phasianidae). Folia Parasitologica 48 (1): 154-158.

VENTURA, P.E.C. 1999. Aspectos bioecológicos de ácaros calamícolas parasitos de *Gallus gallus domesticus* (Linnaeus, 1758) no Estado do Rio de Janeiro. Tese de Doutorado, Universidade Federal Rural do Rio de Janeiro, Seropédica, Rio de Janeiro. 113p.

WILSON, J.L. 1990. Efectos de los ácaros en las reproductoras pesadas. Aviculture Professional 8 (1): 24-25.

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