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Mites associated with budgerigars *Melopsittacus undulatus* (Psittaciformes: Psittacidae) and the first report of *Ornithonyssus bursa* (Mesostigmata: Macronyssidae) in Mexico

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Abstract

Background: Hematophagous mites affect numerous bird species, causing severe injuries to the budgerigars. Some species can cause dermatitis in humans.

Aims: The purpose was to morphologically identify the mites related to budgerigars (*Melopsittacus undulatus)* and their nests in Yucatan, Mexico.

Methods: In May 2022, a private budgerigar hatchery was visited and mites were collected from the bodies of the birds and their nests. The morphological traits of the mites were confirmed by scanning electron microscopy.

Results: Four of 30 birds showed severe clinical signs of mite infestation. The Budgerigars revealed lesions in the cere, nostrils, eyelids, beak, and paws. The bird's skin showed signs of dryness and beige coloring. The birds with severe damage also presented anorexia and had deformed paws and beaks. The parasitosis was caused by the "burrowing mites," *Knemidocoptes pilae*. The burrowing mites and the *Grallacheles bakeri* were recovered and identified from paw scabs. To eliminate mites, a topical application of Ivermectin was administered to the necks of the birds. The dose was a single, which has a residuality of 21 days. Two drops (0.115 mg/ml) of ivermectin were applied to each bird. A gradual reduction in crusted lesions due to mite mortality was noted. The "tropical fowl mite" *Ornithonyssus bursa* was identified in the nests, which represents the first record in Mexico.

Conclusions: Three species of mites were discovered in a single budgerigar hatchery. This emphasizes the importance of deworming birds and keeping a clean environment in their cages to reduce the potential for parasitic mite infestation.

Keywords: Ornamental birds, *Knemidocoptes pilae, Grallacheles bakeri*, Tropical fowl mite, Predatory mites.

Introduction

Budgerigars are probably the most exploited animals traded around the world. Ornamental birds are kept as captive pets because of their beauty, bright colors, melodious songs, attachment to humans, and ability to imitate the sounds of some words (Roldan-Clara *et al.*, 2014). The sale and distribution of endemic psittacines (Psittacidae) such as parrots, parakeets, macaws, and parrots are illegal in Mexico since many of the species are threatened or endangered (PROFEPA, 2022). As an alternative, people can legally obtain Australian parrots from hatcheries. The Budgerigar, *Melopsittacus undulatus* (Shaw, 1805) (Psittaciformes, Psittacidae), is native to Australia (Wyndham, 1980). Today, it is a popular ornamental bird throughout the world, including Mexico (Roldan-Clara *et al.*, 2014). The Budgerigar has a high reproductive rate (Wyndham, 1980), and without proper care, it can cause overcrowding in the cages and deterioration in its health.

In overcrowded birds, mites can induce parasitosis. Burrowing mites of the genus *Knemidocoptes* infest the follicles of feathers and the skin of birds (Morishita and Schaul, 2008). *Knemidocoptes mutans*, *Knemidocoptes laevis gallinae*, *Knemidocoptes pilae*, *Knemidocoptes jamaicensis*, and *Knemidocoptes prolificus* are of interest in veterinary medicine due to their tendency to cause dermatologic lesions, encrustation, anorexia, and sometimes death in birds (Quintero and Acevedo, 1990; Morishita and Schaul, 2008; Rodríguez-Ortega *et al.*, 2018).

Knemidocoptes pilae (Lavoipierre and Griffiths, 1951) (Astigmata: Knemidocoptidae) commonly parasitizes *M. undulatus* (Elbal *et al.*, 2014; Abou-Alsoud and Karrouf, 2017; Palanivelrajan *et al.*, 2020; Akhtar *et*

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al., 2021), but *K. pilae* has also been found in scarlet-chested parrots (*Neophema splendida*), princess parrots (*Polytelis alexandrae*), yellow-fronted Kakariki (*Cyanoramphus auriceps*), cockatoos (*Nymphicus hollandicus, Probosciger aterrimus*), and green-winged macaws (*Ara chloroptera*) (Keymer, 1983; Shane *et al.*, 1985; Wade, 2006; Kim *et al.*, 2016). Mange mites feed on the keratin in the bird's skin, forming tiny tunnels that can cause obstruction of the nostrils; damage to the retina of the eyes; distorted growth of the upper jaw; locomotion-restricting epidermal lesions in the legs; and scabs in different parts of the body (Morishita and Schaul, 2008). On the other hand, the "tropical fowl mite" *Ornithonyssus bursa* (Berlese, 1888) (Mesostigmata: Macronyssidae) is a hematophagous mite of domestic, synanthropic, and wild birds, occasionally biting humans (Bassini-Silva *et al.*, 2019; Pavan *et al.*, 2022). This mite can cause lesions with intense pruritus and even result in the host's death. In addition, it usually causes economic losses in production animals due to decreased weight gain, egg laying, and growth retardation (Morishita and Schaul, 2008). Despite the damage parasitosis causes in captive birds, it is poorly documented. The purpose was to morphologically identify the mites related to budgerigars (*M. undulatus)* and their nests in Yucatan, Mexico.

Materials and Methods

Collection and identification of mites

In May of 2022, mites of budgerigar *M. undulatus* were recovered. The parasitized Australian parrots were found at a house in the urban population of Motul, Yucatan, Mexico. Three wire mesh cages contained captive Australian parrots. Four of the 30 birds in the house exhibited evidence of mite damage. To diagnose the causative agent, skin scrapings were taken from various body lesions. Scabs were removed using entomological forceps and were placed in individual vials and preserved with 75% ethanol. The clinical signs were also documented. Birds were treated with Ivermectin (single dose of topic solution at 0.115 mg/ml, Bioparacittopico®, Marvell, Mexico) by applying two drops of the commercial product to the dorsal zone of the neck to prevent the intoxication of birds by ingesting Ivermectin during grooming. Then, the areas affected by mites were lubricated by employing cotton swabs impregnated with olive oil. This is done in order to soften the scabs and reduce scaling. Birds were placed in a separate cage to avoid interaction with healthy parakeets. The nests were checked and were also positive for mites. Mites were cleared and stained in lactophenol solution for 2–4 days before being identified using taxonomic keys (Bassini-Silva *et al.*, 2019; De Leon, 1962; Kim *et al.*, 2016) under a microscope (Motic b3 professional®, Kowloon, Hong Kong). The specimens were mounted in Canada balm on microscope slides. Voucher specimens are stored in the Arbovirology Laboratory at the Universidad Autónoma de Yucatán, México.

Scanning electron microscopy (SEM) of mites

Mites were fixed in 2% glutaraldehyde and postfixed in 1% cacodylate buffer. Subsequently, the mites were dehydrated in a series of increasing ethanol concentrations and critical-point dried with CO_2 (Garcia-Rejon *et al.*, 2021). The specimens were then sputter-coated with gold. The SEM micrographs were obtained with a digital scanning microscope (Hitachi VP-SEM SU1510, Hitachi High Technologies America, Inc.) at the Laboratorio Nacional de Biodiversidad, Instituto de Biología, Universidad Nacional Autónoma de México (UNAM).

Ethical approval

Not required for this study.

Results

Knemidocoptes pilae adults were confirmed following the descriptions of Kim *et al.* (2016). Adult females were short and round, and had eight legs. The legs of females were segmented and lacked suckers. The dorsal striations of *K. pilae* females were broken and formed a scale-like pattern. The ventral striations of *K. pilae* females were simple and unbroken. On the dorsal surface, there was a pronotal shield with one transverse and two longitudinal chitinized bars. Other distinguishing features of adult female *K. pilae* included an anal slit on the dorsal aspect and two short setae at the idiosoma's terminus. The burrowing mite was found in four budgerigars' cere crusts, nostrils, eyelids, beaks, and paws. Paw crusts showed mixed infestation with *K. pilae* and *Grallacheles bakeri*. *Grallacheles bakeri* has an ovoid body with a length of 298.07 µm (gnathosoma: 103.85 µm; propodosoma and opisthosoma: 194.22 µm). For the first time, the electron microscopy photograph of *G. bakeri* is available (Fig. 1).

Ornithonyssus bursa was found in nests (Fig. 2). Blood was observed in the abdomen of the mites. The specimen measured 796.60 µm in length (gnathosoma: 191.80 µm, and dorsum: 604.80 µm). The tropical fowl mite was confirmed following the descriptions of Bassini-Silva et al. (2019) and Briceño *et al.* (2021). The differential diagnosis for this species is represented by the dorsal plate complete, posterior margin of the dorsal shield with four pairs of posterior setae (Z3, short Z4, S5, and Z5), the three pairs of setae inside the sternal shield, the epigynal plate with the epigynal seta (st5), and the anal plate longer than wide.

Examination and treatment of budgerigar

Physical examination of the budgerigars revealed areas of hyperkeratosis in the cere, nostrils, eyelids, beak, and paws. The skin was dry, covered with scabs, and beige in color. The most affected bird also presented with anorexia, pruritus, and had deformed paws and beaks. Treated birds showed a gradual reduction in crusted lesions, attributable to mite mortality.

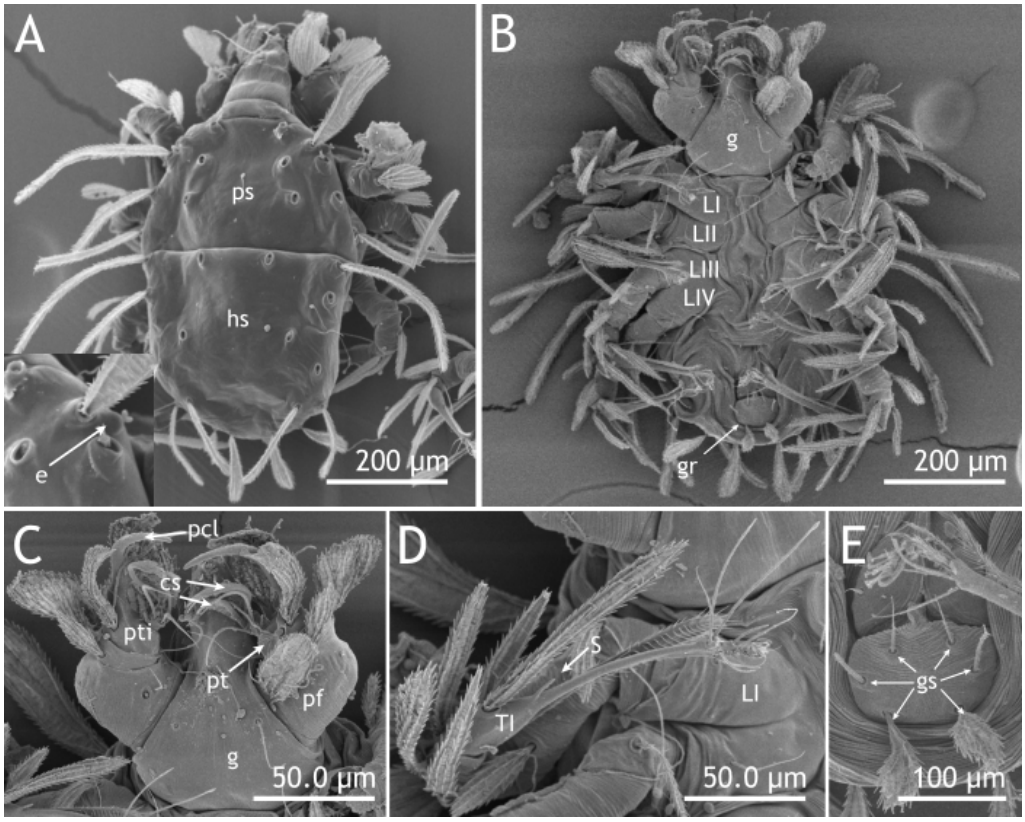

Fig. 1. SEM of female *G. bakeri*. (A): Dorsal view showing the propotonal (ps) and hysteronotal shields (hs), and the holes that are observed in the plates were due to the fall of setae, the eye can be seen in the lower left (e). (B): Ventral view showing the gnathosoma (g), legs (LI-LIV), and genito-anal region (gr). (C): Magnificent view of the gnathosoma (50 µm) showing the palpal claw (pcl), combo-like setae(cs), palpal tibia (pti), palpal tarsus (pt), and palpal femur (pf). (D): Magnificent view of the first leg (50 µm) showing the tibia I (TI) and solenidion (s). (E): Magnificent view of the genito-anal region (100 µm) showing genito-anal setae (gs).

Ivermectin was effective in eliminating the infestation, and a second application was not necessary due to the high persistence of its antiparasitic effect (Fig. 3).

Discussion

Knemidocoptes pilae is a common parasite of budgerigars; its occurrence is probably related to the distribution of exotic birds. Currently, the burrowing mite is documented in Australia, Belgium, Brazil, Egypt, India, Kenya, Mexico, the Netherlands, Pakistan, Spain, and the United States of America (Quintero and Acevedo, 1990; Ribeiro *et al.*, 1991; Elbal *et al.*, 2014; Abou-Alsoud and Karrouf, 2017; Palanivelrajan *et al.*, 2020; Akhtar *et al.*, 2021; GBIF, 2022a). In Mexico, this is the second time that *K. pilae* has been reported in *M. undulatus*. It was already documented in 1990, but the exact locality was not mentioned (Quintero and Acevedo, 1990). The finding represents the first report in the Yucatan State, in southeastern Mexico. Another burrowing mite documented in the country is *K. mutans* (Robin and Lanquetin, 1859). The latter was identified in miniature roosters in Hidalgo, in central Mexico (Rodríguez-Ortega *et al.*, 2018). Despite the fact that Knemidocoptiasis in birds is common, it is poorly documented in Mexico. We hope that, with our finding, more attention will be paid to parasite infestation in budgerigar farms.

Cheyletidae mites are one of the most important families of predatory mites. They are voracious and are considered valuable natural control agents for other mite species and other small arthropods (Krantz, 2009). In Mexico, there are 42 species grouped into 23 genera. *Cheyletus eruditus* (Schrank, 1781), *Hemicheyletia bakeri* (Ehara, 1962), *Metacheyletia longisetosa* (Atyeo *et al.*, 1984), *Ornithocheyletia hallae* (Smiley, 1976), and *Acaropsis* sp. are predatory mites associated with birds in Mexico (Hoffmann, 1998). These mites are abundant in the nests, where other arthropods are their prey. They also often climb on the bodies of birds to feed on their parasites and mites, providing a symbiotic relationship with the host (Hoffmann, 1998; Krantz, 2009). *Grallacheles bakeri* was originally identified in a house in Florida, USA, in soil litter in association with psocids (De Leon, 1962). In Mexico, it was identified

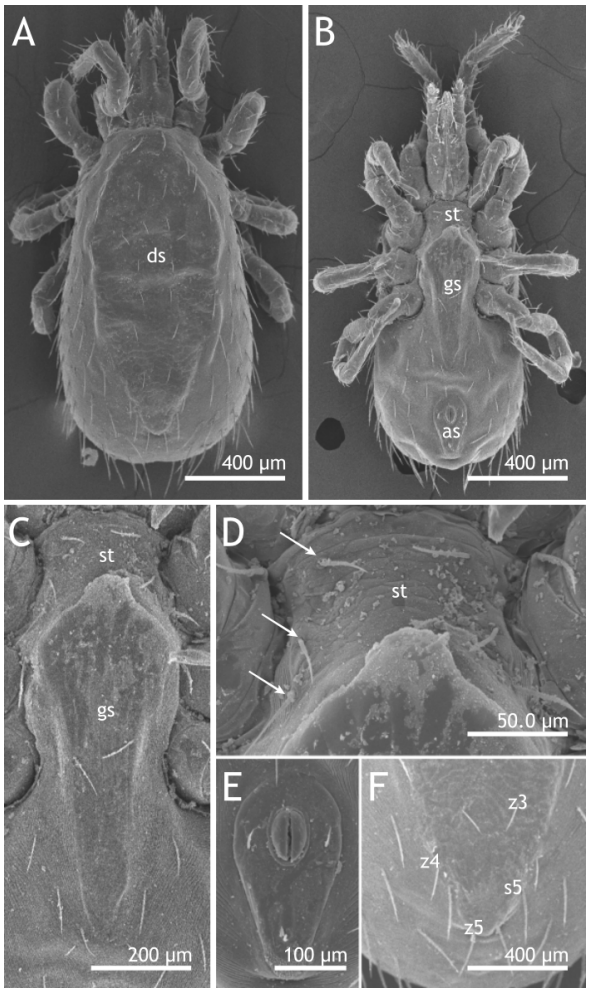

Fig. 2. SEM of female *O. bursa.* (A): Dorsal shield (ds). (B): Ventral view showing the sternal shield (st), genital shield (gs), and anal shield (as). (C): Magnificent view of the sternal shield (st), and genital shield (gs). (D): Magnificent view of the sternal shield (st) (50 µm) showing three pairs of setae (white arrows). (E): Magnificent view of anal shield (100 µm) showing three simple setae. (F): Posterior margin of the dorsal plate with z3, z4, s5, and z5 setae.

in the green sapote plant and in chicken manure (De Leon, 1962; Hoffmann, 1998). We identified it in the paw scabs of budgerigars, along with *K. pilae*. With this background, there is no evidence that *G. bakeri* is a predator of other mites. In addition, the parrot exhibited severe injuries caused by *K. pilae*, which suggests that *G. bakeri* is not a biological controller. Further observations should confirm or rule out predatory behavior.

Ornithonyssus bursa is reported for the first time in Mexico. To distinguish the northern fowl mite, *Ornithonyssus sylviarum* (Canestrini and Fanzago, 1877) from *O. bursa*, the following morphological characteristics were observed: the northern fowl mite has a single pair of setae at the posterior dorsal plate, versus *O. bursa*, which bears two pairs of setae in this location. Moreover, *O. bursa* has three pairs of setae on the sternal plate, while *O. sylviarum* only has two pairs (Morishita and Schaul, 2008). *Ornithonyssus bursa* had previously been recorded in the American countries of Argentina, Brazil, Chile, Cuba, the United States of America, Haiti, Puerto Rico, and Trinidad and Tobago (Post, 1981; Aramburú *et al.*, 2002; Pérez-García *et al.*, 2015; Rodríguez-García *et al.*, 2017; Bassini-Silva *et al.*, 2019; Briceño *et al.*, 2021; GBIF, 2022b). The tropical fowl mite was discovered in the *M. undulatus* nests in this study. This is a mite related to birds collected from the nets of *Agelaius xanthomus*, *Agapornis fischeri*, *Myiopsitta monachus*, *Vanellus chilensis*, *Gallinago paraguaiae*, *Columbina picui*, *Columbina talpacoti*, *Columba livia*, *Leptotila verreauxi*, *Zenaida auriculata*, *Anumbius annumbi*, *Certhiaxis cinnamomeus*, *Progne tapera*, *Cacicus chrysopterus*, *Mimus saturninus*, *Zonotrichia capensis*, *Basileuterus culicivorus*, *Turdus albicollis*, *Turdus leucomelas*, *Paroaria coronata*, *Sicalis flaveola*, *Pitangus sulphuratus*, *Xolmis irupero*, and *Nothura maculosa* (Post, 1981; Aramburú *et al.*, 2002; Mascarenhas *et al.*, 2009; Goulart *et al.*, 2011; Moraes *et al.*, 2011; Pérez-García *et al.*, 2015; Rodríguez-García *et al.*, 2017; Silva *et al.*, 2018).

Pets require a clean, spacious, and comfortable space to ensure their health. Deworming is an important part of pet care because it helps to reduce the number of mites that infest pets and their owners. Moxidectin, sulfur solution, sodium fluoride, ivermectin, mineral oil, fipronil, and mushroom calvatia craniiformis powder are a few of the drugs recommended against *K. pilae* (Elbal *et al.*, 2014; Jameel, 2016; Kim *et al.*, 2016; Abou-Alsoud and Karrouf, 2017; Palanivelrajan *et al.*, 2020; Akhtar *et al.*, 2021). Ivermectin has been used to kill *K. pilae* in several studies (Elbal *et al.*, 2014; Kim *et al.*, 2016; Abou-Alsoud and Karrouf, 2017; Palanivelrajan *et al.*, 2020; Akhtar *et al.*, 2021). Ivermectin is an endecticide that acts by potentiating glutamate-gated chloride channels. This causes the parasite to become paralyzed and die by increasing the permeability to chloride ions and hyperpolarization of nerve cells (Laing *et al.*, 2017). We used ivermectin and it was effective in eliminating *K. pilae*. The burrowing mites show no evidence of genetic resistance against ivermectin. In most studies, mite-infested budgerigars recovered from severe injuries (Elbal *et al.*, 2014; Kim *et al.*, 2016; Abou-Alsoud and Karrouf, 2017; Palanivelrajan *et al.*, 2020; Akhtar *et al.*, 2021). In contrast to our study, ivermectin, chlorhexidine, and silver sulfadiazine were used to kill burrowing mites in *C. novaezelandiae*. Unfortunately, the red-crowned parakeet died suddenly shortly after receiving treatment (Kim *et al.*, 2016), likely as a result of an advanced decline in the bird's health. Knemidocoptes scabies is transmitted by direct contact between birds.

Fig. 3. Face (A) and legs (B) of *M. undulatus* before and after treatment with ivermectin.

Therefore, periodic inspection of the birds is suggested to guarantee their health.

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Authors' contributions

C.M.B.B.: conception, design, and organization of the study; W.A.C.C.: conducted the study; I.Y.C.C. and J.C.T.D.: acquisition of data; J.I.C.P., I.Y.C.C., and J.C.T.D.: analysis and interpretation of data; J.G.R., N.C.T., and K.Y.A.V.: drafting of the manuscript and critiquing the output for important intellectual content. All authors discussed the results and commented on the manuscript.

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This does not apply.

Conflict of interest

The authors have no conflict of interest to declare.

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