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SHORT COMMUNICATION

Ectoparasites associated with two species of bee-eaters (Aves: Meropidae) in western Iran

Maryam Nazarbeigy[1] · **Pejman Mortazavi**[2] · **Ali Halajian**[3]

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Abstract
Three species of bee-eaters (Aves: Meropidae), i.e., *Merops apiaster*, *Merops orientalis*, and *Merops persicus* occur in Iran. As bee-eaters are migratory birds, during their migration, they face anthropogenic threats such as being killed as an apiary pest through hunting or poisoning by bee-keepers in different countries. The aim of this study was to investigate the ecto- and endoparasites of bee-eaters in Ilam, Iran. A total of 550 dead bee-eaters (*M. apiaster* and *M. persicus*), most probably poisoned, were collected in Ilam province, west of Iran, during April 2018 and April 2019. They were examined for ecto- and endoparasites. Gizzard and liver samples were fixed and processed for histopathology. A total of 3739 chewing lice (total prevalence = 66.0%) and 180 adult feather mites (total prevalence = 2.4%) were collected from 363 infested birds. Four species of chewing lice and one species of mite were identified. Lice included *Brueelia apiastri*, *Meromonopon meropis*, *Meropoecus meropis* and the mite *Piciformobia tetracanthura*, from *M. apiaster*, and *Brueelia erythropteri*, *Meromonopon meropis*, and *Meropoecus meropis* from *M. persicus*. Remarkable changes in histopathology of gizzard and liver samples were not detected. However, in the macroscopic examination, vascular hyperemia in the esophagus, petechial hemorrhages in the gizzard and diarrhea were observed. Although bee-eaters are known as effective ecosystem engineers, they are facing different threats like hunting and poisoning by bee-keepers in different parts of Iran. There is little information about ectoparasites of wild birds in Iran, and this study adds to our knowledge of the lice and mites fauna of Iran.

Keywords Bird parasites · Lice · *Merops apiaster* · *Merops persicus* · Mites

Introduction

Bee-eaters (Aves: Coraciiformes, Meropidae) are widely distributed around the world (Clements et al. 2018), and are represented by three species in Iran: *Merops apiaster* (Linnaeus, 1758) (European Bee-eater), *M. orientalis* (Latham, 1802) (Little Green Bee-eater), and *M. persicus* (Pallas, 1773) (Persian or Blue-cheeked Bee-eater). Although all three species of bee-eaters are reported in different parts of Iran (Rabii et al. 2006; Mansoori 2013), they mainly breed in southern Europe, north Africa, and west Asia (Snow 1978). All three species are of least concern category, IUCN (BirdLife International 2016), but there are threats over their population, such as decline of insect populations by the wide-scale application of pesticides on the breeding and wintering grounds, increase in large-scale crop monoculture, and canalization of rivers resulting in the loss of riverbank nesting sites (Fry and Boesman 2014). As bee-eaters are migratory birds, they face anthropogenic threats such as being killed as an apiary pest through hunting or poisoning (using insecticides) by bee-keepers in different countries (Tucker and Heath 1994). Although it has been shown that bee-eaters have a huge array of prey choice and the economic impact on agriculture is in general negligible (Galeotti and Inglisa 2001; Gyuracz et al. 2013), bee-keeper farmers believe that they only feed on honeybees and so they use different methods to get rid of the birds.

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✉ Maryam Nazarbeigy
Maryam.nazarbeigy@yahoo.com

1 Department of Pathobiology, Faculty of Veterinary Sciences, Ilam University, Ilam, Iran

2 Department of Pathology, Faculty of Specialized Veterinary Sciences, Science and Research Branch, Islamic Azad University, Tehran, Iran

3 Research Administration and Development, University of Limpopo, Sovenga 0727, South Africa

It has also been shown that according to available evidence, bee-eaters prefer domestic bees which may damage apiaries. For example, it had been demonstrated that a single bee-eater can predate about 9000 honeybees during summer in Ukraine (Petrov 1954). In South Africa, European bee-eaters were reported as a major threat to apiaries (Buys 1975), and considered pests of apiculture in Hungary, Russia, and Algeria (Szederkenyi et al. 1955; Yakubanis and Litvak 1962; Jenn 1973). In Italy, and particularly in Sardinia, it was estimated that large monetary costs have been incurred due to damage by bee-eaters (Woldhek 1979). The simple presence of bee-eaters near apiaries is usually troublesome to bee-keepers. Despite the strict rules for protection of bee-eaters in most Mediterranean countries, bee-keepers destroy birds every year. This is probably the most frequent way of controlling bee-eaters worldwide (Woldhek 1979). However, in Iran in particular, there is a lack of comprehensive studies on damage caused by bee-eaters on honeybee industry.

Bee-eaters can harbor different parasites (e.g., Williams 1981; Kristofik et al. 1996, 2007; Dik et al. 2011; El-Ahmed et al. 2012; Hoi et al. 2012; Karath et al. 2013; Mironov et al. 2014; Skoracki et al. 2017), but there is little information available on their biology and ecology in Iran. To the best of our knowledge, there are no reports of ectoparasites of bee-eaters in Iran.

There are different reports of chewing lice on bee-eaters around the world, including *Brueelia* (Keler, 1936) on *Merops superciliosus persicus* (Pallas, 1773) from Afghanistan and Kenya; on *Merops superciliosus superciliosus* (Linnaeus, 1766) from Israel; on *Merops superciliosus philippinus* (Linnaeus, 1767) from India and Thailand (Williams 1981); *Meropoecus meropis* (Denny, 1842) and *Meromenopon meropis* (Clay and Meinertzhagen, 1941) on *M. apiaster* in southern Slovakia (Kristofik 1996); *Brueelia apiastri* (Denny, 1842), *Meromenopon meropis*, and *Meropoecus meropis* on *M. apiaster* in Saudi Arabia (El-Ahmed et al. 2012); *B. apiastri*, *Meromenopon meropis*, and *Meropoecus meropis* on *M. apiaster* in Albertirsa, Hungary (Karath et al. 2013); and *Meromenopon meropis* on *M. apiaster* in Turkey (Dik et al. 2011). Mites of *M. apiaster* species are represented by a few records, i.e., *Androlaelaps casalis* (Berlese, 1887) and blood-sucking mites of *Dermanyssus hirundinis* (Hermann, 1804), *D. gallinae* (De Geer, 1778), and *Ornithonyssus sylviarum* (Canestrini and Fanzago, 1877) in southern Slovakia (Kristofik et al. 1996). The aim of this study was to investigate the ecto- and endoparasites of bee-eaters in Ilam, Iran.

Methods

This study was conducted on a total of 550 (350 female and 200 male) dead bee-eater birds (probably poisoned) from different areas of Ilam in April 2018 and April 2019.

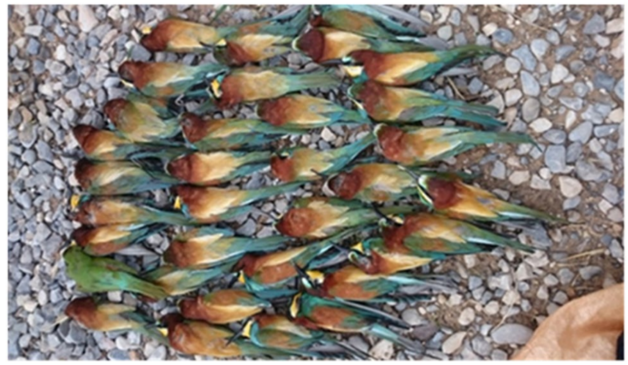

Fig. 1 Dead bee-eaters (*Merops apiaster* and *M. persicus*), probably poisoned, from Iran, collected in April 2018 and April 2019

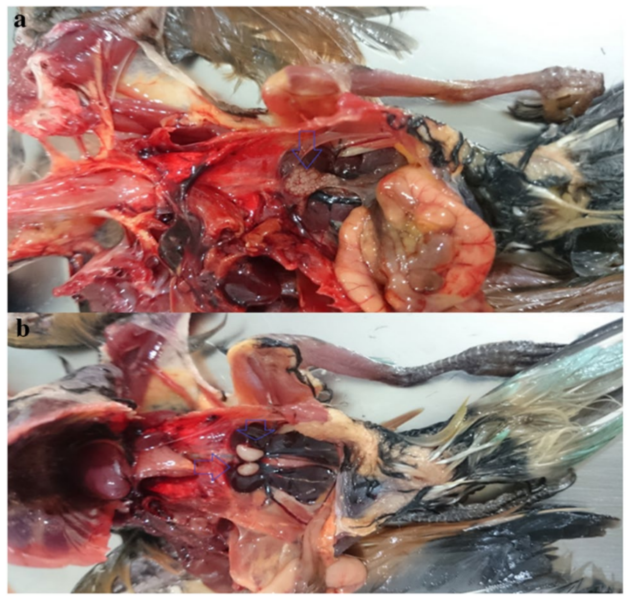

Fig. 2 The male and female reproductive systems of bee-eaters. **a** Ovary. **b** Testis, indicated by arrows

We collected the bodies of birds near a garden, under trees and roosting fences (Fig. 1). Birds were identified based on morphology using Mansoori's guide (2013). After necropsy procedures, the male and female reproductive systems were observed, and the sex of the birds was determined (Pollock and Orosz 2002) (Fig. 2a–b). Birds were individually placed in clean plastic bags and transported in cool conditions to laboratory of parasitology at Ilam University. The body of each bird was carefully and thoroughly examined for ectoparasites. The removed ectoparasites were counted and fixed in 70% ethanol. In later stage, they were cleared about 24 h in 10% KOH, and then left in distilled water for 1 day. Following dehydration in a graded alcohol series (70%, 80%, 90%, and 99%, in consecutive days), the specimens were mounted on slides using Canada balsam. After drying in an incubator, lice and mites specimens were identified under a compound microscope (Olympus®, CHT) and identified based on Williams's (1981), Kristofik et al.'s (1996), Price et al.'s (2003), Adam's (2004), Karath et al.'s (2013), and Mironov et al.'s (2014) works.

After checking for ectoparasites, birds were dissected for endoparasites. Organs were thoroughly checked. Additionally, stomach contents were checked. Tissue samples were taken from the gizzard and liver to check for any histopathological changes regarding potential poisoning. They were fixed in 10% buffered formalin. After processing, the tissue sections were stained with hematoxylin and eosin and studied by using a compound microscope (Olympus®, cx23).

Intensity is the number of individuals of a particular parasite species in a single infected host was calculated. Similarly, prevalence is the number of hosts infected with one or more individuals of a particular parasite species divided by number of hosts examined for that parasite species was evaluated following (Bush et al. 1997). Mean intensity was analyzed by using independent samples *t*-test, with a confidence interval of 95% (SPSS 16.0.0, SPSS Inc., and Chicago, IL, USA). Chi-square test was used to compare the prevalence of ectoparasite in two bee-eater birds. *P*-values ≤ 0.05 were regarded as significant.

Results

From a total of 550 examined birds, 363 were positive for lice infestation with 3739 chewing lice and nymph (total prevalence = 66.0%). In addition, 13 birds were positive for mite infestation, with 180 adult mites (total prevalence = 2.4%). Four species of chewing lice including *Brueelia apiastri*, *B. erythropteri* (Piaget, 1885), *Meromenopon meropis*, and *Meropoecus meropis* were identified (Table 1). The only mite found was *Piciformobia tetracanthura* (Gaud and Atyeo, 1975) in a single *M. apiaster* (Fig. 3a–f). The prevalence of *Meromenopon meropis* differed between *M. apiaster* and *M. persicus* ($\chi^2 = 1.105$, $df = 1$, $P < 0.05$), while prevalence of *B. apiastri*, *B. erythropteri*, and *Meropoecus meropis* between the two bee-eater species was similar ($\chi^2 = 0.321$, $df = 1$, $P = 0.563$). On the other hand, the intensity of infection of *B. apiastri* ($t = 11.801$, $df = 300$, $P < 0.001$), *B. erythropteri* ($t = 6.578$, $df = 361$, $P < 0.001$), *Meromenopon meropis* ($t = 15.395$, $df = 307$, $P < 0.001$), and *Meropoecus meropis* ($t = 2.132$, $df = 361$, $P = 0.034$) differed between *M. apiaster* and *M. persicus*.

To check for the possibility of poisoning, tissue samples of gizzard and liver of all birds were checked for histopathology. About 20 samples were selected with tissue lesions, but no clear histopathological signs were observed. However, in the macroscopic examination, vascular hyperemia in esophagus, petechial hemorrhage in gizzard, and diarrhea were observed in the examined birds. Histopathology was unable to provide evidences on toxicological issues. Reason of death and possibility of poisoning needs proper toxicological examination. In the current study, we did not find any internal parasites.

Discussion

In Iran, only a few studies have been conducted on lice infestation in wild birds. There was no previous targeted research on ectoparasite infestation of bee-eaters. We report for the first time in this study ectoparasite on two bee-eater bird species examined. Overall, 3739 chewing lice and 180 mite specimens were collected from infested birds, including 350 female and 200 male.

There have been a few studies on lice fauna of wild birds in Iran (Rafyi et al. 1968; Rak et al. 1975; Dik and Halajian 2013; Moodi et al. 2013), although none looked at bee-eaters. In the current study, four chewing lice species, i.e., *B. apiastri*, *B. erythropteri*, *Meromonopon meropis*, *Meropoecus meropis*, and the mite *P. tetracanthura* were identified for the first time on *M. persicus* and *M. apiaster* in Iran. Lice fauna of *M. apiaster* have been studied in other countries (Williams 1981; Kristofik et al. 1996; Adam 2004; Karath et al. 2013).

Table 1 Prevalence and intensity of ectoparasites collected from 450 *Merops apiaster* and 100 *Merops persicus* from Ilam province, western Iran

Birds (n = sample size)	Parasites (lice and mite)	No. of infested birds	Prevalence (%)	Intensity range	Mean intensity ± SE
Merops apiaster ($n = 450$)	*Brueelia apiastri*	300	66.6	2–8	3.5 ± 0.10
	Meromonopon meropis	300	66.6	1–7	1.7 ± 0.04
	Meropoecus meropis	300	66.6	3–93	5.8 ± 0.50
	Piciformobia tetracanthura	13	28.8	1–20	13.8 ± 1.57
Merops persicus ($n = 100$)	*Brueelia erythropteri*	63	63.0	1–4	2.0 ± 0.07
	Meromonopon meropis	9	9.0	1–28	11.0 ± 3.44
	Meropoecus meropis	63	63.0	3–6	3.5 ± 0.11

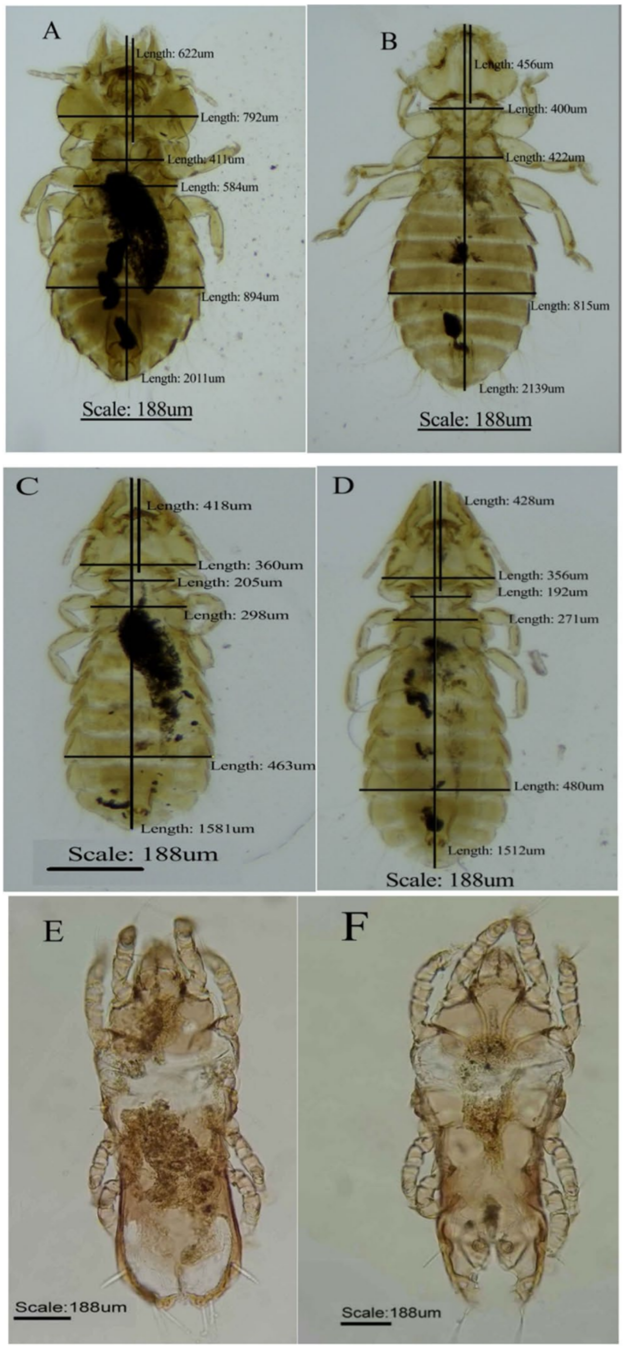

Fig. 3 Ecotoparasites of bee-eaters, *Merops apiaster* and *M. persicus* from Iran. **a** *Meropoecus meropis*, adult male. **b** *Meromonopon meropis*, adult male. **c** *Brueelia apiastri*, adult male. **d** *B. erythropteri*, adult male. **e** *Piciformobia tetracanthura*, adult female. **f** *Piciformobia tetracanthura*, adult male

Meropsiella apiastri (=*Brueelia apiastri*), *Meromenopon meropis*, and *Meropoecus meropis* were reported on *M. apiaster* by Dik et al. (2017). Also, *Meromenopon meropis* and *Meropoecus meropis* have been reported from *Merops apiaster* and *M. persicus* in southeast of Algeria (Torki et al. 2020). Our results are consistent with these studies.

Regarding endoparasites, two nematodes *Hadjelia truncata* (Creplin, 1825) and *Syphaciella capensis* (Mönnig, 1924) were recovered from the alimentary tract of *M. s. persicus* in central and southern Iraq (Al-Moussawi 2008) and *Haemoproteus meropis* (Zargar, 1945 emend Bennett, 1978), and *H. hudaidensis* described from *M. apiaster* and *M. s. persicus* again in Iraq (Mohammad and Al-Neaimi 2000). However, in the current study, we did not find any internal parasites.

Feather mites of the genus *Piciformobia* (Gaud and Atyeo, 1975) (*P. cinnycerthiae* and *P. henicorhinae*) have been described from *Cinnycerthia unirufa* (Lafresnaye, 1840) and *Henicorhina leucosticte* (Cabanis, 1847) (Passeriformes) in Ecuador and *P. henicorhinae* from *H. leucosticte* in Costa Rica (Mironov et al. 2014). Although different species of feather mites have been reported from passerine birds in various parts of Iran (Moodi et al. 2014), there is no previous report of mites on bee-eaters in Iran. In this study, *P. tetracanthura* was found in *M. apiaster*.

Histopathology of liver and gizzard was unable to provide evidence on toxicological issues. Causes of death and possibility of poisoning need proper toxicological examination, which was not possible in our case. Our observations imply that bee-eaters are commonly affected by human-wildlife conflicts in west of Iran, although this subject needs to be further investigated for a better estimate of their damages and loss of their population as outcome of the conflicts with farmers. Educational programs are also needed to raise awareness among farmers and meanwhile help them with some mitigation measures to decrease the effects of bee-eaters on honeybee industry.

Regarding the impacts of parasites on bee-eaters, the ectoparasites that were found do not seem to have any harmful effects on the infested birds, although this matter also will need a long-term study. Similar to other birds, bee-eaters play important roles in the environment. It was shown that the European Bee-eater can be a major bioturbating organism (erosive agent) in arid areas, removing a noticeable amount of soil, increasing biodiversity in nesting and roosting habitats to a broad array of organisms, such as other bird species, snakes, frogs, and rodents, and providing food resources to many other species, reinforcing the structure of the community, and enhancing more complex food networks (Casas-Crivillé and Valera 2005). It was also shown that although economic impact of bee-eaters on apiculture is, in general, negligible, at the same time, loss of drones was locally important and potentially detrimental to small or specialized apiculture (Galeotti and Inglisa 2001). In Iran, such studies are not available, and similar to several other countries, national monitoring, conservation, and protection projects are needed (Gyuracz et al. 2013).

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Declarations

Ethics approval and consent to participate All applicable international, national, and/or institutional guidelines for the care and use of animals were followed.

Conflict of interest The authors declare no competing interests.

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