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Macroparasites of introduced parakeets in Italy: a possible role for parasite-mediated competition

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Abstract Alien species are considered a cause of biodiversity loss throughout the world. An important but often overlooked form of competition with native species is the parasite-mediated one. Introduced species may bring their own parasites from their native ranges (spillover) or get native parasites from native species, thus increasing the parasites' spread and transmission risk (spillback). Thus, a complete knowledge of parasites hosted by introduced species is important to assess and to possibly prevent impacts. Ring-necked and monk parakeets have been introduced in many European countries, where they established a number of alien reproductive populations. We sampled 21 ring-necked parakeets and 7 monk parakeets from Italy and identified 35 arthropod ectoparasites belonging to five species. Amongst those, one species was native to India (*Neopsittaconirmus lybartota*), where alien populations of ring-necked parakeet may have been originated, and one species from South America (*Paragoniocotes fulvofasciatus*), which is typically found of the monk parakeet in its native range. The other three species of arthropod parasites were native to Italy and commonly found on native species, suggesting the possibility of spillback processes.

Keywords Alien species · Monk parakeet · Ring-necked parakeet · Ectoparasites · Spillover · Spillback

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Introduction

Animal species introduced outside their native range may variously affect local biodiversity in their introduced range: they may bring parasites, act as predators or at least act as competitors of indigenous species and they may introgress with native genomes as well (Mack et al. 2000). Despite being globally considered as the second main cause of the sixth biodiversity crisis (Simberloff et al. 2013; Galiana et al. 2014), impacts of biological invasions are still frequently overlooked or poorly considered, particularly in the case of indirect or less evident aspects of impact (Simberloff et al. 2013). For instance, when a species is released outside its natural range, it may also introduce its own parasites into its invasive range or, conversely, be subjected to infection by local species of parasites that it encounters there. Consequently, parasites can have a substantial impact in biological invasions.

Some species become invasive because they lose their original parasites in the new environment (Enemy Release Hypothesis: Prenter et al. 2004), either due to the unsuitability of the new environment, a founder effect amongst the

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introduced individuals, or due to the effects of medical treatment during captivity in the case of escaped individuals.

At the same time, the introduction of alien species may also increase incidence, pathogenicity, geographical or host range of their own (spillover) or native (spillback) parasites (cf. Kelly et al. 2009). For example, spillover is illustrated by the giant liver fluke *Fascioloides magna* (Platyhelminthes, Trematoda), a parasite introduced by North American deer (e.g. Wapiti) to Europe (Balbo et al. 1988; Novobilský et al. 2007), where they may attack native red deer *Cervus elaphus* and have lethal consequences for Roe deer *Capreolus capreolus*. Similarly, squirrelpox virus mediates the amount and type of competition between alien grey squirrels *Sciurus carolinensis* and native European red squirrels *Sciurus vulgaris* in the British Isles (Rushton et al. 2005; McInnes et al. 2013).

In contrast, spillback requires the invader to acquire local parasites from existing native hosts and to contribute to the levels of transmission back to the native host, therefore resulting in indirect competition mediated by the action of shared natural parasites (Price et al. 1986). For instance, grey squirrels introduced into Italy may acquire native squirrel fleas (*Ceratophyllus sciurorum sciurorum*), thereby increasing their transmission risk to native European red squirrels (Romeo et al. 2014).

Although there is a potential for parasite spillback from non-native species to impact native communities (Romeo et al. 2014), this phenomenon has been rarely documented in biological invasions because it is generally assumed that native parasites are unimportant when assessing the impacts of alien species (Kelly et al. 2009). Moreover, it is difficult to evaluate the native or non-native status of many parasite species because the inventories of parasites and their geographic range are incomplete for many countries (Kelly et al. 2009).

Hulme et al. (2009) concluded that only 11 % of the 11,000 alien species introduced in Europe have a proven ecological impact. Amongst birds, parrots (Aves, Psittaciformes) account for about 18 % of alien avifauna established in Europe; within this order, the ring-necked parakeet *Psittacula krameri* and the monk parakeet *Myiopsitta monachus*, both popular species as pets, are considered to be the most successful of invasive parrot species (Strubbe and Matthysen 2009; Di Febbraro and Mori 2014). Together these two species have established approximately introduced 100 populations throughout Europe (Strubbe and Matthysen 2009), with the number of breeding colonies increasing in many countries (e.g. Mori et al. 2013a). Despite this wide invasive range, information about their impact on native biodiversity is scarce and no data concerning macroparasites are available (Menchetti and Mori 2014).

In this note, we provide the first data about the macroparasite fauna of alien parrots in Italy, and we shed light on whether these alien species have introduced exotic parasites or acquired local ones, thus having the potential for spillover and/or spillback against native species. Arthropod parasites have been described from the native range of monk parakeet (*Psitticimex uritui*, *Ornithonyssus bursa*, *Paragoniocotes fulvofasciatus*, *Heteromenopon macrurum*: Keirans et al. 1973; Aramburù et al. 2003) and from the Indian range of rose-ringed parakeet (Saxena et al. 2009), while the only surveys to date from the African range of this species (Senegal; Najer et al. 2012) revealed no parasite.

Materials and methods

Parasites collection

A total of 21 ring-necked parakeets were analysed, 13 from Rome, six from Pavia and two from Follonica—Province of Grosseto (Fig. 1). Seven monk parakeets from Rome were also analysed. No data were available for the other colonies of these species in Italy (cf. Mori et al. 2013a, b).

Amongst individuals from Rome, all the monk parakeets and six rose-ringed parakeets were recovered at the Wildlife Rescue Centre operated by LIPU (Italian League for the Protection of Birds) and were treated with a commercial veterinary pesticide (Foractil®, by Formevet) soon after their admittance to kill and collect ectoparasites; two other rose-ringed parakeets were found in poor health conditions by private citizens, parasites collected and sent to the authors for examination. Parakeets from Follonica and Pavia in poor health conditions were sent by private citizens to local veterinarians. Collected parasites were stored in ethanol 95 % for identification. All parakeets were found in large urban parks, historic villas and private gardens.

Parasites identification

All parasites were sent to the Department of Life Sciences at The Natural History Museum in London, where they were identified by T.H. (*Tarsopsylla octodecimdentata octodecimdentata*: Ceratophyllidae: Siphonaptera Insecta) and V.S. (*Laemobothrion* sp., *Neopsittaconirmus lybartota* and *Paragoniocotes* sp.: Pthiraptera: Insecta). All identifications were completed morphologically using stereo microscopes. The squirrel fleas *T. octodecimdentata octodecimdentata* were determined using the descriptions and keys of Smit (1983) and Whitaker (2007) and by comparison with specimens in the Siphonaptera collections at the Natural History Museum. The lice were determined by comparison with specimens in the Natural History Museum's Phthiraptera collection and confirmed by cross-referencing with descriptions by Nelson and Price (1965) for *Laemobothrion* sp. and Palma (1973) for *Paragoniocotes* sp.

Fig. 1 Locations of the parakeets analysed in this work

The tick *Argas reflexus* was directly determined by a veterinarian from Pavia (S. Martone).

Results

We collected and identified a total of 35 arthropod ectoparasites belonging to five species (Table 1): one species of flea (Siphonaptera), one tick (Acarina) and three species of lice (Phthiraptera). A total of seven ring-necked parakeets (33.33 % of the total analysed individuals) and two monk parakeets (28.57 %) were infested by parasitic arthropod species (Table 1; Electronic Supplementary Material).

Discussion

All the arthropod ectoparasites identified were native to Italian species with two exceptions, *Paragoniocotes* sp., a louse genus common on neotropical parrots (Price et al. 2003) and *N. lybartota*, a louse typical of Asian (mainly Indian) parakeets (Saxena et al. 2009). The specimens collected on monk parakeets are almost certainly *P. fulvofasciatus* Picaglia, 1885, which is host specific to monk parakeet *M. monachus* (Price et al., 2003). This parasite species has previously been recorded in Italy as the type locality for *P. fulvofasciatus* is in the "vicinity of Modena" (Picaglia 1885). The detection of *N. lybartota* in rose-ringed parakeets in Italy provides an indirect support to the hypothesis that the introduced population in Rome belongs to the Indian subspecies (cf. Scalera 2001); in India, *N. lybartota* is a common parasite of the Alexandrine parakeet *Psittacula eupatria* (Saxena et al., 2009), which also breed sympatrically with *P. krameri* in Italy. Further studies are required to assess whether these alien parasites are transmitted to native hole-nester birds.

The red squirrel flea *T. octodecimdentata octodecimdentata* (Kolenati, 1863) was detected with the highest number of individuals on two ring-necked parakeets.

Table 1 Arthropod parasites detected in parakeets introduced to Italy

Species	Sex	Study site	Order	Parasite	No. of parasites	Origin of the parasite	Main hosts
P. krameri	F	Rome	Siphonaptera	*Tarsopsylla o. octodecimdentata*	8	N	*Sciurus vulgaris*
P. krameri	F	Rome	Siphonaptera	*Tarsopsylla o. octodecimdentata*	6	N	*Sciurus vulgaris*
P. krameri	M	Pavia	Acarina	*Argas reflexus*	2	N	*Columba livia*
P. krameri	F	Pavia	Acarina	*Argas reflexus*	2	N	*Columba livia*
P. krameri	M	Follonica	Phthiraptera	*Laemobothrion* cf. *maximum*	2	N	Falconiformes
P. krameri	F	Rome	Phthiraptera	*Neopsittaconirmus* cf. *lybartota*	4	I	Asian parrots
P. krameri	M	Rome	Phthiraptera	*Neopsittaconirmus* cf. *lybartota*	7	I	Asian parrots
M.monachus	??	Rome	Phthiraptera	*Paragoniocotes* cf. *fulvofasciatus*	2	I	Neotropical parrots
M.monachus	??	Rome	Phthiraptera	*Paragoniocotes* cf. *fulvofasciatus*	2	I	Neotropical parrots

N native to Italy, *I* introduced

This flea has a Holarctic distribution and is primarily found on tree squirrels or on their predators. Other accidental hosts (e.g. *Vulpes vulpes*, *Felis catus*, *Martes martes*, *Martes foina*, *Apodemus flavicollis*, *Microtus* sp., *Nucifraga caryocatactes*, *Ficedula hypoleuca* and *Parus major*: Smit 1966; Beaucournu and Launay 1990) are usually associated with trees as resting/breeding sites. Interactions between native Eurasian red squirrels and introduced parakeets have been recently described. Ring-necked parakeets may harass and repel squirrels, only rarely coming into physical contact with them (Menchetti and Mori 2014); Eurasian red squirrels *S. vulgaris* are listed amongst the predators of the chicks of ring-necked parakeets (Mori et al. 2013b); squirrels may be attacked or mobbed by parakeets defending their nests. Furthermore, squirrels may visit trunk cavities or occasionally inhabit a permanent tree den in a trunk cavity before they are later reused by parrots for breeding (Menchetti et al. 2014), thus increasing the probability of encounter between these two species. *S. vulgaris* is present in the area where flea-infested parakeets were found (Mori et al. 2013b).

The two louse specimens from the ring-necked parakeet from Follonica belonged to the genus *Laemobothrion* (an adult male and an adult female, possibly *Laemobothrion maximum* as suggested by their size: Perez et al. 1995), which is one of the largest louse genera, normally found on Falconiformes and, more rarely, on other birds (Nelson and Price 1965; Perez et al. 1995). *L. maximum* has been reported on 32 diurnal raptor species (Clay 1976). The most likely explanation for this infestation is that the parakeets were attacked by a hawk or other raptor, which resulted in a transmission from raptor to parakeet. This type of encounter has been previously documented: ring-necked parakeets have been often observed chasing or mobbing small hawk species and may be attacked by larger species (Menchetti and Mori 2014). Kestrels *Falco tinnunculus* and common buzzards *Buteo buteo* are present within the study area, and *Laemobothrion* species are known to locally occur on these species (E. Mori personal observation).

The pigeon tick *A. reflexus* (Acarina: Argasidae) recorded on ring-necked parakeets from Pavia may also affect human health. This tick species is typically found on pigeons *Columba livia* that live in urban and suburban areas and may be involved in the transmission of Lyme disease to humans, as well as of other conditions (systemic reactions with urticaria, angioedema and anaphylactic shock: Khouri and Maroli 2004). Given the high synanthropy of parakeets, which live mainly in urban environments in Italy (Mori et al. 2013a) and the pathologies brought by the presence of *A. reflexus* on parrots, this tick species and its associated vector species deserve further research.

Overall, these results represent a first assessment of the parasite community of alien parakeets in Italy, and the list of parasite species is likely to grow. Alien parakeets appear to be prone to spillback from native species which they come in contact with through competition (squirrels), predation (squirrels, raptors) or commensalism (pigeons); particularly intriguing is the likely case of parasite transmission between alien species occurring in the same environment, a phenomenon which may increase the complexity of impacts upon native ecosystems.

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Conflict of interest The authors declare that they have no conflict of interest.

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