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SHORT COMMUNICATION

Kleptoparasitism in the endemic gecko *Phelsuma inexpectata*: pollen theft from foraging honeybees on Réunion

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Abstract: Interspecific kleptoparasitism (the stealing of already-procured items from other species) has received little attention in tropical reptiles. We report here the second case of kleptoparasitism in tropical lizards, and the first known case of pollen theft by a vertebrate species. *Phelsuma inexpectata*, a gekkonid lizard endemic to Réunion, was observed robbing pollen pellets from honeybees (*Apis mellifera*) foraging on *Latania lontaroides* flowers. Video-records were used to obtain reliable information on gecko-honeybee interactions occurring on *L. lontaroides* inflorescences. During the 19 observation periods (total duration 140 min) a total of 78 attempts were recorded, at least 40% were successful. Both males and females displayed kleptoparasitic behaviour. A high level of gecko kleptoparasitism occurred, with an average one-robbery attempt every 2 min. Behaviour of both the kleptoparasitic *P. inexpectata* and its host *A. mellifera* are described.

Key Words: *Apis mellifera*, Gekkonidae, Indian Ocean, kleptoparasite–host interaction, *Latania lontaroides*

Interspecific kleptoparasitism is defined as the stealing of already-acquired items from other species (Brockmann & Barnard 1979). This type of competitive exploitation between species is widespread among the animal kingdom. Despite being a major force driving the evolution of biotic interactions, few taxa (mostly birds and arthropods) have received significant attention (Iyengar 2008). So far, only two examples of interspecific kleptoparasitism have been described in tropical reptiles (*Varanus komodoensis* vs feral *Canis lupus*; Auffenberg 1981; *Boa constrictor* vs *Ameiva ameiva*; McConchie & Wilkinson 2004).

On Réunion, the Manapany day gecko *Phelsuma inexpectata* and the honeybee *Apis mellifera* both forage on the inflorescences of the palm tree *Latania lontaroides*. While investigating potential competitive interactions between these two species, we observed an unexpected interaction. On many occasions, the gekkonid lizard has been observed robbing and eating pollen pellets from foraging honeybee workers. In the present study, we describe the kleptoparasitic behaviour of *P. inexpectata*, estimate its frequency and briefly discuss its potential adaptive significance.

Phelsuma inexpectata (Mertens) (Gekkonidae) is a species endemic to Réunion, Indian Ocean. Its current distribution is restricted to an 11-km long littoral fringe in the south of the island (Sanchez & Probst 2011). This diurnal and arboreal species inhabits coastal vegetation. Its diet mainly consists of arthropods, fruit, nectar and pollen (Deso *et al.* 2008). In its remaining habitat, negative interactions with other species, such as interference or exploitative competition, could play a major role in the decline of this *Phelsuma* species (Sanchez *et al.* 2009).

Latania lontaroides (Gaertn.) H.E. Moore (Arecaceae) is endemic to Réunion. This palm tree species is almost extinct in its natural habitat, i.e. coastal ecosystems, but frequently used as an ornamental plant on Réunion (Lavergne *et al.* 2004). It grows up to 12 m high, and is a dioecious species. Once a year, male produce thousands of yellow cup-like staminate flowers (12 mm in diameter, 32 stamens) that grow in clusters on inflorescences (30–45 cm long) (Bosser *et al.* 1984). During the bloom period, inflorescences are daily visited by several hundreds of foraging honeybees (pers. obs.).

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Based on both morphological (Schneider 1989) and genetic criteria (Franck *et al.* 2001) the honeybee from Réunion has been described as *Apis mellifera unicolor* (Latreille) (Apidae), the subspecies endemic to Madagascar. This generalist pollinator is widespread throughout the island with more than 20 000 domestic hives documented in 2012 (O. Esnault, pers. comm.).

Observations were undertaken in Manapany-les-Bains (21°22′16″S, 55°35′10″E) where the largest known population of the Manapany day gecko occurs (Sanchez & Probst 2011). In this urbanized site, we focused our attention on geckos inhabiting young *L. lontaroides* that are planted every 5 m along a coastal road.

The study was conducted from 27 April to 6 May 2012, during *L. lontaroides* flowering period, and observations were carried out and from 7h30 to 15h00, during the main activity periods of *P. inexpectata* and *A. mellifera* species (pers. obs.). Gecko–honeybee interactions were recorded with a digital video camera (Sony DCR-SR90, Sony, Japan) so that rapid subtle movements could be observable later. The video camera and observers were at the greatest possible distance (2 m on average) to minimize observer effects (Kerr *et al.* 2004). Only one gecko was followed per observation and the same individual never monitored twice in a row. Once observed on inflorescences (1.5–1.8 m high) in presence of honeybees, each gecko was filmed during a 20-min period. Yet, geckos often escaped from view behind the inflorescences or on palms, where there was no honeybee to interact with. The length of 'informative' observation sequences, i.e. when both gecko and honeybees were present on the inflorescences and therefore potentially interacting, were therefore often much shorter. Based on 'informative' video records only, we noted the total number of attempted and successful thefts and estimated the frequency of this kleptoparasite behaviour. Failure is defined as an attempt without removal of pollen, and success as an attempt with at least a piece of the pollen pellet collected. Identification of each gecko was done *a posteriori*, based on video records by using both head and dorsal colour patterns and injury positions (Wanger *et al.* 2009). Males were recognized by their larger size and their green-blue highlighted colour on the dorsum; females by the presence of endolymphatic sacs on each side of the neck and their duller colour (Sanchez *et al.* 2009).

We recorded gecko–honeybee interactions during 19 observation periods (lasting from 20 s to 20 min). Geckos were clearly observed robbing and eating pollen from foraging honeybees. Geckos sought for the honeybee corbicula load, approaching honeybees from the side or the back of the insect. Then, if the honeybee did not fly off, the gecko easily removed a piece or the entire pollen pellet (Supplementary Material). Honeybees were never observed being aggressive towards geckos. Their responses, when they occurred, were limited to flying off from inflorescences. During the 140 min of 'informative' video records (gecko and honeybees potentially interacting on inflorescences), a total of 78 attempts were recorded, at least 40% were successful (Table 1). Based on 'informative' video records, a total of eight different adult geckos were identified. Seven of them attempted pollen theft. Note that the only female that was not observed attempting pollen theft was observed only once during our study. Both males and females displayed kleptoparasitic behaviour, whatever the observation period. With an average of one attempted theft every 2 min during the 140-min observation period, this kleptoparasitic behaviour is therefore far from being anecdotal.

Table 1. Video observations of kleptoparasitism by *Phelsuma inexpectata* on honeybees on Réunion. The geckos were robbing the honeybees (*Apis mellifera*) of *Latania lontaroides* pollen. For each gecko identified are given: the number of observation periods recorded, the total 'informative' observation time, the total number of attempts and the number of successful thefts.

Individual	Number of observation periods	Total informative observation time (s)	Number of attempts	Number of successful attempts
Male 1	1	202	1	0
Female 1	4	2329	17	7
Female 2	5	2175	26	11
Female 3	4	1776	20	4
Female 4	1	973	0	0
Female 5	1	178	2	2
Undetermined sex 1	1	156	3	1
Undetermined sex 2	2	657	9	6
Total	19	8446	78	31

Pollen thefts from foraging honeybees have previously been observed in arthropods (Jean 2005, Maeta *et al.* 1996); this is the first report of pollen-pellet thefts by a vertebrate species. This observation confirms that pollen, containing up to 25% protein, diverse vitamins, minerals, amino acid, carotenoid (Campos *et al.* 2008), could be an important component of the gecko diet. It also reveals that *P. inexpectata* would gain from *A. mellifera* presence, rather than undergo strong negative effects of a potential competition, at least on *L. lontaroides* inflorescences.

For kleptoparasitim to be profitable and evolve, the benefit (energy gained) must exceed the cost (energy expenditure and risk of injury from the host) (Iyengar 2008). Based on our observations, the risk of injury from the host seems very low and the cost for the gecko is therefore limited to energy expenditure. Geckos face the energy expenditure trade-offs between independent foraging (collecting directly pollen grains from flowers) versus kleptoparasitism (robbing pollen pellets from honeybees). During our behavioural survey, geckos were never observed collecting pollen directly from *L. lontaroides* flowers, even when honeybees were not

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present on inflorescences. Geckos only forage for *L. lontaroides* pollen already acquired by honeybees. Two non-exclusive adaptive hypotheses could be proposed: (1) 'Bee' pollen presents antibacterial and anti-fungicidal proprieties (Carpes *et al.* 2007) that could significantly increase gecko's fitness. Indeed, honeybees combine collected pollen grains (fine powder-like material) with nectar and regurgitated honey to accumulate it as pellets in pollen baskets (Hodges 1974). Geckos would gain essential nutritional elements and enzymes from pollen already acquired by honeybees. (2) If honeybees forage successively on different floral resources and produce mixed pellets (Craig & Stewart 1988, Hodges 1974), geckos inhabiting *L. lontaroides* could benefit from a polyfloral pollen diet without the cost of foraging. A study conducted by Alaux *et al.* (2010) demonstrated that in honeybees, polyfloral pollen diet induced higher immunocompetence levels compared with monofloral diets. Comparative studies of both *L. lontaroides* pollen and 'bee' pollen composition would help in understanding why *P. inexpectata* does not directly collect pollen grains on *L. lontaroides* flowers.

Lastly, even though the gecko was in close proximity to the honeybee when stealing pollen, the honeybee was never aggressive towards the gecko. As suggested by Barnard (1984) to explain the apparent 'tolerance' of some hosts involved in kleptoparasitic interactions, here honeybees might not attack kleptoparasites because the cost of defence is greater than the cost of 'evasion' or the cost of collecting more pollen. Given the high density of hosts, the relatively low density of kleptoparasites and the abundance of resources at this period, costs associated with gecko kleptoparasitic behaviour at the honeybee-colony level might be almost insignificant and difficult to estimate. Further quantitative studies on behavioural interactions between *Phelsuma* geckos and honeybees on *L. lontaroides* and other plant species, at different seasons, are required to have a better understanding of ecological conditions promoting kleptoparasitism in *P. inexpectata*. Attention should be paid to other *Phelsuma* species, especially those from the monophyletic Mascarenes group (Rocha *et al.* 2009, 2010), to examine the origin of such a specialized behaviour and investigate the evolution of this singular kleptoparasite–host interaction.

SUPPLEMENTARY MATERIAL

For supplementary material for this article, please visit http://dx.doi.org/10.1017/S0266467413000229

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