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Reptile predators of swiftlets (genus *Aerodramus*) with a focus on their impact on the swiftlet farming industry

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Abstract. We conducted a comprehensive review of literature and online records to determine the extent of reptile predation on swiftlets (genus *Aerodramus*), especially on commercially farmed species. Reptiles appear to be a large component of reported swiftlet predators, including six species of lizards and 16 species of snakes representing eight families and 17 genera. Predation events have been reported from India, Peninsular Malaysia, Borneo, Indonesia, and Australia. The presence of reptile predators may negatively impact production at swiftlet farms and lead to human-wildlife conflicts. Additional research is needed to find mitigation measures so that industry stakeholders can coexist with reptiles. Further studies will likely identify additional species of reptile predators of swiftlets.

Keywords. Geckos, nest production, Reptilia, snakes, swiftlet farming, wildlife management

Introduction

Edible bird's nests are among the most expensive and sought-after animal products consumed by humans (Marcone, 2005). They are produced from the saliva of swiftlets (genus *Aerodramus*), and nests of two species, the White-nest Swiftlet (*A. fuciphagus*) and the Black-nest swiftlet (*A. maximus*), are the most harvested in Southeast Asia (Raharjo and Sinurat, 1998; Tompkins, 1999; Babji et al., 2015). Bird's nests are a booming industry and generate large revenue for countries like Thailand, Indonesia, and Malaysia, and this has led to increasing efforts to farm edible-nest swiftlets (ENS) on a commercial scale (Babji et al. 2015; Thorburn, 2015; Looi and Omar, 2016). Farming involves encouraging birds to nest in artificial structures and set up colonies close to human habitation for easier harvesting (Raharjo and Sinurat, 1998; Cranbrook et al. 2013; Babji et al. 2015; Nurshuhada et al. 2019). In Malaysia alone, the industry is valued at more than MYR 10 billion (ca. USD 2.2 billion) annually (Chong et al., 2021). Nevertheless, as with any form of agriculture challenges exist, and one of the problems faced by the ENS industry is the loss of birds to predators (Nurshuhada et al. 2019; Chong et al., 2021).

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Across the range of these birds, from the Indian Ocean eastwards through South and Southeast Asia to many of the offshore islands in the Pacific and southwards into northern Australia (Lee et al., 1996; Thomassen et al., 2003), they fall prey to many different types of predators, both in the wild and in artificial settings (Lim and Cranbrook, 2002; Sivakumaran, 2019; Nurshuhada et al. 2019; Dhamorikar et al., 2020; Chong et al., 2021), and among these are reptiles (Harrison, 1961; Manchi and Sankaran, 2009; Tarbuton, 2009). In this review, we compile to the best of our ability the published records of predation events on ENS by reptiles, with a focus on the commercial farming industry in Southeast Asia. This check list will serve as a useful reference for researchers and stakeholders in the ENS industry.

Methods

A comprehensive review of the published literature reporting predation events on swiftlets was conducted, similar to that adopted by Quah et al. (2022, 2023). Some of the literature was obtained via a keyword search in Google Scholar, using a combination of the phrases "Reptile / Snake / Lizard / Squamata / Serpentes predation / preying / feeding on swiftlets / swifts / edible-nest swiftlet / *Aerodramus* / Apodidae." Publications that were not detected and captured through this search were manually supplemented. In addition, a survey of records posted by ENS farmers on Facebook groups and blogs was conducted and the data were pooled with additional records from WhatsApp groups and personal communications with members. Predation events were considered and recorded when they involved reptiles preying and feeding on adult swiftlets, chicks, or eggs in either natural habitat or artificial structures (i.e., swiftlet houses). Reptile species recorded in the proximity of swiftlet nest but not observed during active consumption of birds or their young were recorded as potential

predators. Reptilian predators were identified to the lowest taxonomic category possible (Table 1), and the literature was assessed up to 15 November 2022.

Results

We recorded 22 species of reptiles, representing eight families and 17 genera, as predators or potential predators of swiftlets. Of these, six were lizards and the other 16 snakes. These records include predation events from India, Peninsular Malaysia, Borneo, Indonesia, and Australia (Table 1).

Discussion

Geckos (five of the six lizard species) and various species of snakes were recorded as the main reptile predators of swiftlets (Table 1). Four of the five gecko species (*Gekko gecko*, *G. monarchus*, *Hemidactylus frenatus*, *H. platyurus*) are well-known human commensals that thrive in anthropogenically modified environments and frequently colonize homes and buildings (Grismer, 2011; Badli-Sham et al., 2019). As such, it comes as little surprise that these species would also be found to occupy swiftlet houses and exploit a readily available food source. One of the most commonly reported species infesting ENS houses and preying on them was the *Gekko gecko* (Linnaeus, 1758). The voraciousness of this species is well-known, and these geckos have an appetite for a variety of vertebrate prey, including small birds (Flower, 1899; Krysko and Love, 2016; Sy and Tanalgo, 2018). The three other species, *G. monarchus* (Schlegel, 1836), *Hemidactylus frenatus* Duméril & Bibron, 1836, and *H. platyurus* (Schneider, 1797), are opportunistic predators and also known to prey on other vertebrates (Quah et al., 2022).

The only non-gekkonid lizard, *Varanus salvator* (Laurenti, 1768), is also common in anthropogenic habitats (Grismer, 2011; Kulabtong and Mahaprom, 2015; Badli-Sham et al., 2019) and exploits all kinds of prey, including birds, both as a predator and scavenger (Yu et al., 2021). Some of the avian prey reported to be ingested by *V. salvator* include *Acridotheres grandis*, *Aix galericulata*, *Amaurornis phoenicurus*, *Anas* sp., *Ardea purpurea*, *Bubulcus ibis*, *Corvus splendens*, *Gallus gallus domesticus*, *Gallus lafayetii*, *Mesophoyx intermedia*, *Pavo cristatus*, *Phalacrocorax niger*, and *Vanellus indicus* (Karunarathna et al., 2015; Kulabtong and Mahaprom, 2015). Thus, it is not surprising that these lizards will learn to raid swiftlet houses if the opportunity arises, and this could even be an extension of their natural behaviour as *V. salvator* and other species of varanids are known to hunt for prey in cave environments (Clarkson and Massyn, 2020; Tanalgo et al., 2020).

Similar to the largely human-commensal gecko species, some of the snakes that have been commonly recorded in artificial swiftlet houses, such as *Chrysopelea ornata* (Shaw, 1802) (Fig. 1A), *C. paradisi* Boie, 1827 (Fig. 1B), *Coelognathus radiatus* (Boie, 1827), and *Malayopython reticulatus* (Schneider, 1801) are also species that are known to be adaptable and can occupy anthropogenic habitats (Purkayastha et al., 2011; Baker and Lim, 2012; Tan, 2014; Purkayastha, 2018; Badli-Sham et al., 2019; Goh, 2019). Birds are also known to feature in the diets of these species and some, like *Boiga cynodon* (Boie, 1827) and *Gonyosoma oxycephalum* (Boie, 1827), may even have a preference for avian prey (Murphy, 1977; Malkmus et al., 2002; Stuebing et al. 2014; Fernando and Sy, 2019; Charlton, 2020), which makes their attacks on swiftlets unsurprising.

In addition to the species recorded in this study, a number of other reptile species have been recorded from cave ecosystems around the region (e.g., Ziegler et al., 2006, 2007; Davis et al. 2018; Quah et al., 2021), which are the natural nest sites of these swiftlets (Phach and Voisin, 1998; Tompkins, 1999; Sankaran, 2001; Tarbuton, 2009; Cranbrook et al., 2013), and some of these could also potentially be predators of ENS, albeit in their native settings. In contrast, some listed reptilian predators are probably questionable. For example, Manchi and Sankaran (2009) reported *Ophiophagus hannah* (Cantor, 1836), and seasnakes as potential predators of swiftlets and their nestlings in the Andaman and Nicobar Islands. However, as its scientific name suggests, king cobras prey chiefly on other snakes and would more likely be attracted to caves when hunting for other snakes (Taylor, 1965; Charlton, 2020). Similarly, seasnakes and sea kraits of the families Hydrophiidae and Laticaudidae feed on marine invertebrates and fish, especially eels and gobies (Stuebing et al., 2014; Charlton 2020). *Homalopsis buccata* (Linnaeus, 1758) has been reported at swiftlet houses (Table 1) but this species is another unlikely predator of swiftlets as it does not feed on avian prey but survives on a diet of fish and frogs (Voris and Murphy, 2002; Stuebing et al., 2014; Charlton, 2020). As a semi-aquatic snake, *H. buccata* may have been attracted to the ponds built in or around some of the swiftlet houses to cool their temperatures, attract insect prey for the birds, and as a means of maintaining humidity (Rharjo and Sinurat, 1998; Looi and Omar, 2016; Nurshuhada et al., 2019).

Finally, swiftlet farming is one of the solutions to relieve collection pressures off wild populations which have seen significant declines in recent decades (Phach and Voisin, 1998; Tompkins, 1999; Gausset, 2004; Hobbs, 2004; Manchi and Sankaran, 2014) and ensure more sustainable harvesting into the future (Sankaran, 2001). However, the predation of swiftlets by reptilian predators creates human-wildlife conflict issues and in most instances the predators are killed (Chong et al., 2021). The economic returns derived from this industry also support the livelihoods of a great number of people across Southeast Asia (Babji et al. 2015; Thorburn, 2015; Looi and Omar, 2016) and any setbacks, such as the reptile-human conflict, will affect the local communities in addition to the animals (both predators and prey) themselves (Dhamorikar et al., 2020).

Based on the very limited preliminary data we have at this point, we refrain from making any recommendations to resolve the predation issues faced by ENS farmers. However, the results of our study serve as a baseline for future studies

Table 1. Reptilian predators of swiftlets (*Aerodramus* sp.). Potential predators that remain unconfirmed are indicated by an asterisk (*). Among the sources are cited references, public Facebook groups, WhatsApp groups, and the Blogspot *Swiftlet Farming: Million Dollars a Year Income Potential*.

Taxon	Localities		Location	Source
	Wild	Artificial		
LIZARDS				
Gekkonidae				
Cyrtodactylus cavernicolus Inger & King, 1961	X		Borneo	Harrison, 1961
Gekko gecko (Linnaeus, 1758)		X	Peninsular Malaysia; Borneo	Facebook, WhatsApp
Gekko monarchus (Schlegel, 1836)		X	Peninsular Malaysia; Borneo	Facebook, WhatsApp
Hemidactylus frenatus Duméril & Bibron, 1836		X	Peninsular Malaysia	WhatsApp
Hemidactylus platyurus (Schneider, 1797)		X	Peninsular Malaysia	WhatsApp
Varanidae				
Varanus salvator (Laurenti, 1768)		X	Peninsular Malaysia; Borneo	Facebook, WhatsApp
SNAKES				
Pythonidae				
Antaresia maculosa (Peters, 1873)	X		Australia	Tarbuton 2009
**Malayopython reticulatus* (Schneider, 1801)	X		Andaman and Nicobar Islands	Manchi and Sankaran, 2009
**Malayopython reticulatus*	X		Borneo	Koon and Cranbrook, 2002
**Malayopython reticulatus*		X	Peninsular Malaysia	WhatsApp
Colubridae				
Boiga cynodon (Boie, 1827)		X	Borneo	Facebook
Boiga irregularis (Bechstein, 1802)	X		Australia	Tarbuton, 2009
Chrysopelea ornata (Shaw, 1802)		X	Peninsular Malaysia	Blogspot, Facebook
Chrysopelea paradisi Boie, 1827		X	Peninsular Malaysia; Borneo	Blogspot, Facebook
Coelognathus radiatus (Boie, 1827)		X	Peninsular Malaysia	Blogspot
Elaphe taeniura[a] Cope, 1861	X		Borneo	Koon and Cranbrook, 2002; Das, 2007; Stuebing et al., 2014
Elaphe taeniura[a]	X		Indonesia	Marlon, 2014
Elaphe taeniura[a]	X		General	Das, 2012
Gonyosoma oxycephalum (Boie, 1827)	X		Andaman and Nicobar Islands	Manchi and Sankaran, 2009
Gonyosoma oxycephalum		X	Peninsular Malaysia	Blogspot
Xenopeltidae				
**Xenopeltis unicolor* Reinwardt, 1827		X	Borneo	Facebook
Homalopsidae				
**Homalopsis buccata* (Linnaeus, 1758)		X	Peninsular Malaysia	WhatsApp
Elapidae				
**Naja kaouthia* Lesson, 1831		X	Peninsular Malaysia	Blogspot
**Naja sumatrana* Müller, 1887		X	Peninsular Malaysia	Facebook
**Ophiophagus hannah* (Cantor, 1836)	X		Andaman and Nicobar Islands	Manchi and Sankaran, 2009
**Ophiophagus hannah*		X	Borneo: West Kalimantan	Facebook
**Ophiophagus hannah*		X	Peninsular Malaysia	WhatsApp
**Hydrophis* sp./*Laticauda* sp.	X		Andaman and Nicobar Islands	Manchi and Sankaran, 2009
Viperidae				
**Trimeresurus* sp.	X		Andaman and Nicobar Islands	Manchi and Sankaran, 2009

[a] sometimes previously reported as *Orthriophis taeniurus*

to assess the impacts of reptile predators on the production of edible bird nest at farms. We acknowledge that our list of species is far from complete and have little doubt that some species may have been overlooked during the course of our review, especially those records buried in the grey literature or in non-English or non-Malay language publications. Despite this, we believe that we have sufficiently demonstrated that reptiles have the potential to be of significant concern to

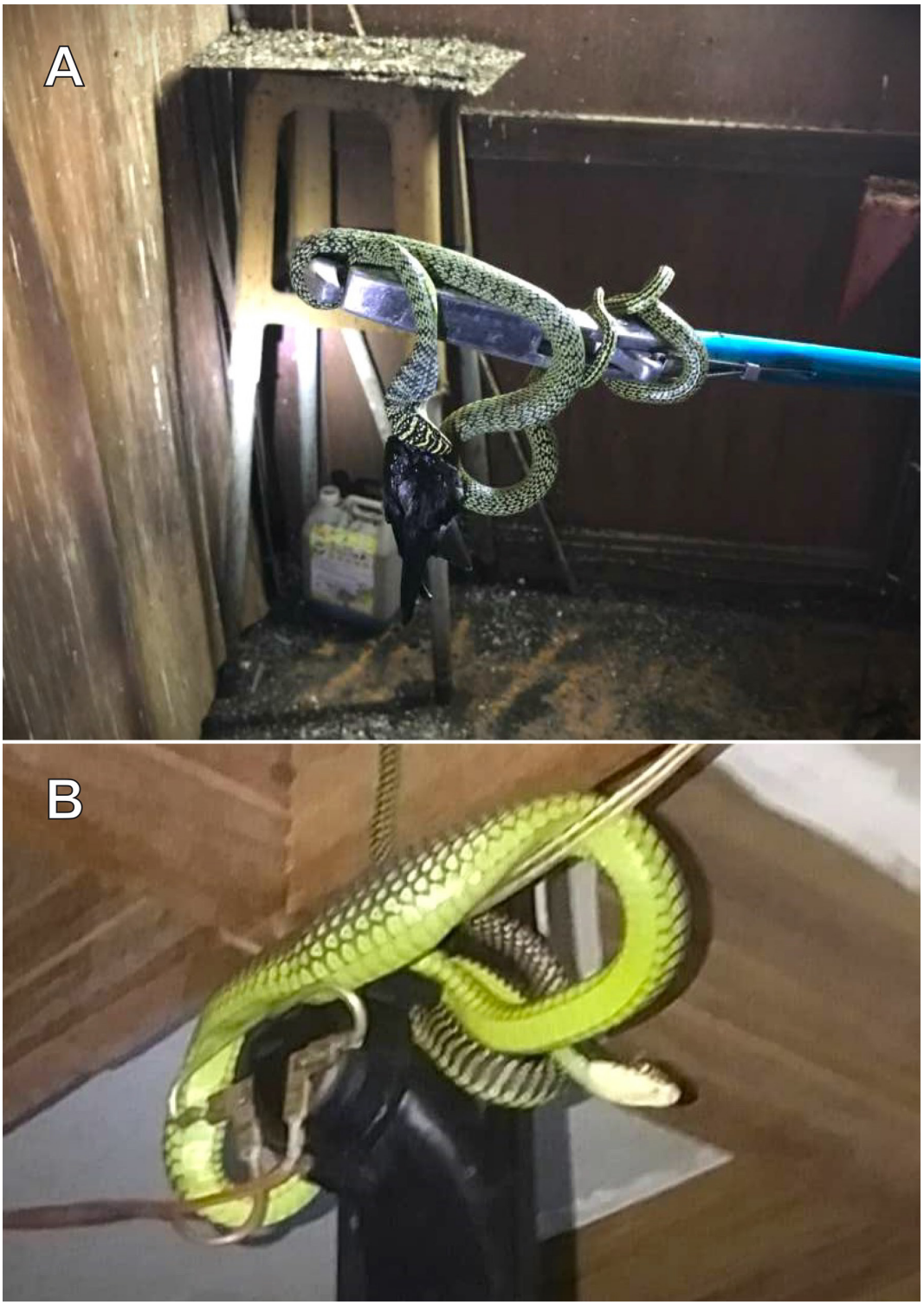

Figure 1. Snake predators of swiftlets (genus *Aerodramus*) in commercial swiftlet houses. (A) A Golden Treesnake (*Chrysopelea ornata*) was caught in the midst of swallowing a swiftlet. (B) A Paradise Treesnake (*C. paradisi*) that just recently ate a swiftlet (not the distended section of the body) coiled near the ceiling in a swiftlet house. Photos by Wan Mohammad Zulkifli.

commercial ENS farm operations. Only with more thorough research can effective mitigation measures be implemented to reduce human-wildlife conflicts between the farmers and the reptiles that raid their bird houses in the future.

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