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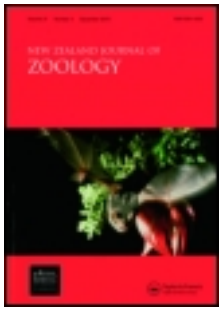

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Banded geckos, Gekko vittatus (Reptilia, Gekkonidae), as the main prey of barn owls (Tyto alba) on the Torres Islands (northern Vanuatu)

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Gekko vittatus
Tyto alba

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A large sample of bones representing prey remains of barn owls (*Tyto alba*) was collected from the surface of the floor of a cave on Toga Island, Torres Islands, a remote island of northern Vanuatu. These remains allowed us to obtain a first overview of the prey of barn owls on that island, knowing that elsewhere mammals constitute the major prey group. The dominant prey species were banded geckos (*Gekko vittatus*—47% of prey individuals found in our bone sample) followed by rats (*Rattus* spp.—35%). Also present were lesser numbers of other gecko species (*Gehyra oceanica*, *Nactus multicarinatus*), skinks (*Emoia* spp.), birds, and bats. Data show that nocturnal birds of prey remain important predators of large geckos on Toga Island. This finding contradicts interpretations of other late historical (following human colonisation), non-cultural bone assemblages from barn owls from other Pacific islands, where rats have replaced geckos as primary prey. The same situation as reported on Toga Island occurs in other places like the Canary Islands where barn owls also prey predominantly on an endemic gecko species. These observations suggest that the barn owl is an opportunistic predator taking whatever prey is available. The unanswered question is why geckos are the most frequent prey of barn owls on some islands and not on others.

Scincidae; Gekkonidae; *Gekko vittatus*; alimentation; predation; *Tyto alba*; Vanuatu

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Before the arrival of humans and their exotic commensals (dogs, pigs, rats, chickens) the primary vertebrate predators of reptiles on most oceanic Pacific islands were birds of prey, either diurnal (e.g. *Accipiter* spp., *Circus* spp., *Falco* spp.) or nocturnal (e.g. *Tyto* spp., *Ninox* spp., *Grallistrix* spp.) (Olson & James 1991; Michaux 1998) as terrestrial mammalian carnivores were totally absent (Steadmann 1995). Barn owls (*Tyto alba*) are especially adaptable nocturnal feeders, and their prey remains constitute the majority of the known non-cultural Holocene bone record (Pregill 1993, 1998; Holdaway & Worthy 1996; Pregill & Steadman 2009). That record is still expanding and continues to provide evidence of the faunal changes that have taken place since the Pacific islands were occupied by people (Worthy & Holdaway 1996). We report on recent prey remains from a barn owl roost on Toga Island, Torres Islands, Vanuatu, which curiously comprised mostly lizard prey with the prey dominated by a large gecko species. This finding is unusual, since

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elsewhere on Pacific Islands introduced mammals, particularly rats, have replaced lizards as the main prey of barn owls.

The herpetofauna of the main islands of Vanuatu was treated by Baker (1928), Angel (1935), Medway & Marshall (1975), Cranbrook (1985) and Ineich (2008, 2011) but the remote Torres Islands were not surveyed until 2007. The faunal list for the Torres Islands now includes 17 species of squamate reptiles (Ineich 2009, 2011). *Gekko vittatus* is the largest lizard on Toga (snout–vent length [SVL] 120 mm for adults, total length 250 mm).

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Barn owl prey remains were collected by one of the authors (BF) on Toga Island during a French herpetological and malacological survey of the Torres Islands in November 2007 (Ineich 2009; Haase et al. 2010). We attribute the bones to barn owl predation because easily recognizable barn owl feathers and disintegrating pellets were present. Moreover, owls are known by island inhabitants to use that cave for roosting (pers. comm.), and a barn owl was seen by one of the authors (BF) near the cave entrance. The barn owl, *Tyto alba*, is the only owl known in Vanuatu to use the particular cave we sampled for roosting (Bregulla 1992; Doughty et al. 1999).

The Torres Islands are an isolated cluster of six raised limestone islands of northernmost Vanuatu in the southwest Pacific (see Fig. 1). Maximum elevation ranges from 150 m to nearly 350 m on Hiu Island (Mueller-Dombois & Fosberg 1998). Toga Island is the southernmost of the group. Caves and other solution features are common, and provide convenient roosting sites for barn owls. The bones, covering an area of about half a square metre, were found on the surface on the floor of Metekwerenpuge Cave, located at the base of a small, forested cliff east of Mt. Riparara (13.436°S, 166.694°E; 30 m elevation). The bones were packed in the field and returned to the Muséum d'Histoire Naturelle, Paris, from whence they were later send to the second author (GP) in San Diego, California, for identification. There was no need to extract bones since they were separated and easily available in the barn owl pellets. We used the minimum number of individuals based on the single most abundant bone element of that species, with paired elements counted separately, and the number of identified specimens.

None of the bones showed any signs of mineralisation. All appeared to have been deposited recently, probably in the latest historic period (c. past 100 years). Table 1 summarises the taxa represented. Our sample contained 378 lizard cranial bones (Table 2), 25 bird bones, 14 of bats, and 520 rat bones (*Rattus* spp.). We did not identify the 319 individual lizard postcranial elements (limb bones, girdles, vertebrae) separately, but assumed that they were distributed taxonomically in the same proportion as those of the skull.

Gekko vittatus and *Rattus* spp. accounted for c. 82% of all individuals (47% and 35%, respectively), and about 87% of the total number of bones, assuming that the lizard postcranial bones were distributed proportionately. Oceanic geckos, *Gehyra oceanica*, accounted for slightly more than 16% of lizards, and about 10% of all species. Although not as large as *G. vittatus* (c. 100 mm versus 120 mm SVL), it too was a likely prey item. The other lizards, *Nactus multicarinatus* and the unidentified skink(s), may have been included in the bone assemblage accidentally rather than as prey. Small and terrestrial species generally are not well represented in the pellets of Pacific barn owls (Pregill 1998). *Nactus multicarinatus*, for example, is represented by one individual in our sample (Table 1). Although nocturnal, this is a small gecko (adult 42.5–62.7 mm SVL; Zug & Moon 1995) that frequents ground litter and dead tree trunks. Two species may be represented in the skink material, one slightly larger, but both in the range of 60–80 mm SVL.

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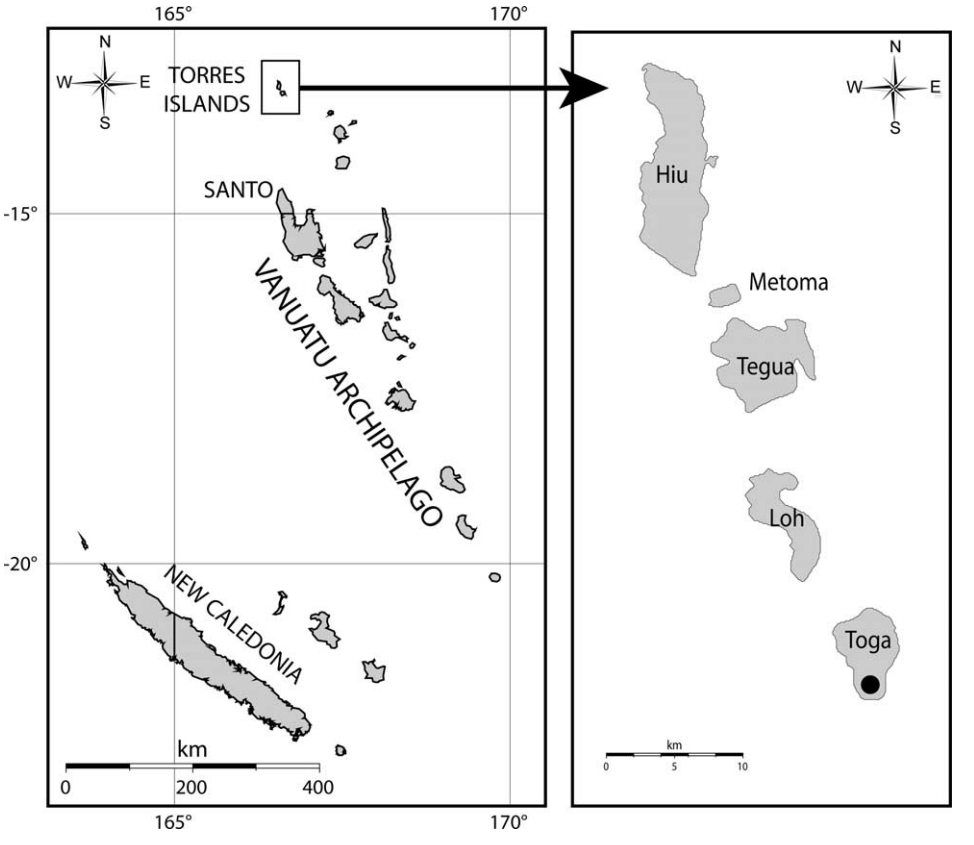

$ Location of Vanuatu, Torres Islands and Metekwerenpuge Cave (black circle) on Toga Island.

These body sizes correspond to that of *Emoia sanfordi* and *Emoia nigra*, both of which are known from Toga Island (Ineich 2009). These skinks are of modest size and diurnal. While they would be potential prey to some diurnal raptors (e.g., accipiters) they are unlikely to have been taken by nocturnal barn owls.

The mammal bones were dominated by *Rattus* spp. We have no information on the identity of large rats on Toga. The bones are larger than those of most populations of the Pacific rat, *Rattus exulans* (which is at least known from Hiu Island [Flannery 1995]), and are closer to the size of *Rattus rattus* or *Rattus tanezumi*. The small bat could be either *Miniopterus australis* or *Hipposideros cervinus*, the larger probably *Pteropus tonganus* (Flannery 1995). Large fruit bats (*Pteropus* spp.) do occur in raptor bone accumulations in the Pacific, although, as in our Toga sample, they are not abundant (Grant & Banack 1995; Koopman & Steadman 1995; Pregill & Steadman 2009).

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Non-cultural bone deposits produced by raptors reflect dietary preferences determined by the habits and availability of prey species (Holdaway & Worthy 1996). Prehistoric Pacific sites typically have more bones of lizards, small bats, and passerine birds, resulting from both diurnal and nocturnal predators. By contrast, cultural sites (those reflecting human predation) contain more bones of fish, seabirds, fruit bats, and ground-dwelling birds (megapodes, rails) (Steadman 2006; Pregill & Steadman

$ Number of specimens and minimum number of individuals identified from cranial elements found in Metekwerenpuge Cave, Toga Island.

Taxon	Number of specimens	Minimum number of individuals
Gehyra oceanica	43	8
Gekko vittatus	318	35
Nactus multicarinatus	3	1
%	14	4
Lizard postcranials	319	–
	25	–
!		
Bat (small)	11	–
Bat (large)	3	–
Rattus spp.	520	26
Total	1256	74

2009). Being nocturnal and large-bodied, species such as *Gekko vittatus* (and *Gehyra oceanica*) are potential prey for the barn owl. They are usually the largest nocturnal lizards on the Pacific islands where they occur. On Torres Islands, *G. vittatus* is abundant and can be easily observed during the night at about 2 m above ground on the lower branches on small trees and shrubs. Before the introduction of rats by indigenous people, and later by Europeans, large, arboreal geckos probably were eaten exclusively by barn owls. They rely on visual detection and, if necessary, use only sound for locating prey in complete darkness. Various species of *Gekko* emit squeaks, chirps, and clicks that might alert owls to their presence. Our results are surprising since mammals, particularly rats, do not constitute the main prey of barn owls on Toga Island as they do on most other Pacific Islands.

Barn owls living on continents overwhelmingly eat small mammals (mostly rodents and shrews) (Bruce 1999): reptiles are rare in their diet (Bunn et al. 1982; Burton 1984; Sommer et al. 2005; Mahmood-Ul-Hassan et al. 2007; Platt et al. 2009; de Marchi et al. 2009). In arid Australia, reptiles were present in only 5 of 16 barn owl study sites and represented no more than 13% of the prey (Higgins 1999). Lizards contributed less than 5% of the diet in eight of nine Caribbean islands, and 11% on the remaining island (Flikweert et al. 2007). Where mammals are scarce, however, barn owls will take other more abundant, prey species.

& Number and identification of cranial bones of lizards, by taxon, from Metekwerenpuge Cave, Toga Island.

Bones/species	*Gekko vittatus*	*Gehyra oceanica*	*Nactus multicarinatus*	Scincidae
Frontals	34	9	1	4
Prefrontals	8	–	–	–
Postorbitals	1	–	–	–
Parietals	37	–	–	1
Neurocrania	29	4	–	–
Vomers	4	–	–	–
Palatines	4	–	–	–
Pterygoids	27	–	–	–
Dentaries	68	11	–	4
Postdentaries	46	3	1	–
Quadrates	16	–	–	–
Maxillae	44	16	–	5
Total	318	43	2	14
MNI[1]	35	8	1	4

[1]MNI, minimal number of individuals.

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Lizards constitute up to half their diet in the Namib Desert whereas birds (e.g., doves, sparrows) constitute up to half of their diet in Egypt and Guinea Bissau (Bruce 1999). Barn owls are known to take sea birds on the landbridge islands in the Gulf of California (Velarde et al. 2007), arthropods (15%) in the Chilean Desert (Carmona & Rivadeneira 2006), and petrels, insects and geckos in the Cape Verde Islands (Hazevoet 1995; Rabaca & Mendes 1997; Bruce 1999). In the same way as on Ouvea in the Loyalty Islands, lizards contribute little to barn owl diets, which are dominated by mammals (Robinet & Salas 1996). *Gehyra* cf. *vorax* is the only large gecko present in the prey remains from the Loyalty Islands (Bauer & Sadlier 2000), but there is no prehistoric bone record so it is not known if it was ever eaten before.

Similar barn owl diets to those we observed are seen on Pacific islands, but in these instances the diet changed from large nocturnal geckos to rats (*Rattus* spp.) once rats become established on an island. Pacific island boas (*Candoia* spp.) also now eat mainly rats (Harlow & Shine 1992), although they initially ate lizards. On Guam in the Mariana Islands, for example, the Pacific rat, *R. exulans* appears in non-cultural prehistoric strata of c. AD 800–1000, and steadily increases in abundance in historical bone deposits, replacing the forest gecko *Perochirus ateles* (Pregill & Steadman 2009). The larger *R. diardii* (formerly a synonym of *R. tanezumi*) is known only in historic contexts, reflecting its more recent arrival on Guam. We can assume barn owl prey also followed the same temporal pattern in fossil bones on Guam. However, a high level of saurophagy has already been recognised in the Canary Islands, were native geckos *Tarentola angustimentalis* can represent about 70% of barn owl captures according to pellets—the remaining portion being introduced mice *Mus musculus* (Martin et al. 1985; Delgado 1993).

Similarly, on Toga Island, barn owls probably began to eat rats after the early introduction of the small Pacific rat, *R. exulans*, then added larger species of *Rattus* after Western contact. No specimens of *R. exulans* are known from Toga, but that is almost certainly a collection artefact. Bones of *R. exulans* are known in almost all Pacific settlement sites (Kirch 2000; Matisoo-Smith et al. 2009), and they became established on Pacific islands almost simultaneously with initial colonisation by the Lapita culture in Polynesia and parts of Melanesia c. 3000 years ago (Steadman 2006). The dominance of geckos in the diet of Toga Island barn owls is intriguing, because elsewhere in the Pacific rats replaced them historically as the predominant prey (Pregill 1993; Steadman 1999; Pregill & Steadman 2009).

Our results confirm that the barn owl is an opportunistic predator, taking whatever vertebrate prey is abundant and the easiest to catch. Additional field studies on Toga Island should focus on determining population densities of barn owls, geckos, and rats, and on uncovering a dateable, prehistoric bone record. Such field studies could lead to a better knowledge of rat–lizard interactions and thus offer new data for better conservation practices on islands where rats contribute to local extinctions. An important question is whether the rat density is lower on Toga Island than elsewhere, or whether there are particular habitat characteristics or gecko behaviours that make geckos easier to catch than rats.

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