Natural History Observations of the Ichthyological and Herpetological Fauna on the Island of Curaçao (Netherlands)

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Abstract
Despite increasing popularity of the island as an ecotourist destination, the ecology and natural history of many organisms native to the Lesser Antillean island of Curacao have remained enigmatic. We document multiple new observations of the behavioral ecology of several terrestrial and aquatic vertebrates that inhabit Curacao. We present the first report of avian predation on the endemic Curacao whiptail lizard, Cnemidophorus murinus, suggesting these lizards play a potentially important role in this island’s food web. We also document the first instance of predation by the introduced tropical house gecko, Hemidactylus mabouia, on the native Antilles gecko, Gonatodes antillensis. Tropical house geckos are thought to be displacing native geckos through a combination of niche displacement and competitive exclusion, and our finding suggests that predation on smaller native lizards may be another factor aiding the success of this introduced gecko on Curacao. We also present repeated observational evidence that juvenile bluehead wrasses (Thalassoma bifasciatum) seek refuge among the sessile and venomous giant Caribbean sea anemones (Condylactis gigantean).

Keywords
Hemidactylus mabouia, Gonatodes antillensis, Cnemidophorus murinus, Thalassoma bifasciatum, Condylactis gigantean, gecko, anemone, wrasse, predation

Introduction
Located approximately 40 miles north of Venezuela, the newly independent island of Curacao is the largest of the former Netherlands Antilles (which also included St. Maarten, St. Eustatius, Bonaire and Saba) (Figure 1). Curacao is home to several endemic animals, most of which are presumed to have their origins in South America (van Buurt 2005). Despite the island’s popularity as an ecotourist destination, many facets of its natural history remain poorly understood. Recent and ongoing collection efforts across various locations on Curacao (Figure 1) by a team of researchers from Yale University, the University of California, and the University of Texas have documented several novel and noteworthy behaviors and interactions, the first of which we present here.

Given the spread of recent introductions, such as the tropical house gecko (Hemidactylus mabouia), the lionfish (Pterois volitans) and the black rat (Rattus rattus), the last of which has already been implicated in the extinction of the Curacao rice rat (Oryzomys curasoeae) (Sanchez et al. 2001; Voss and Weksler 2009), understanding the common interactions of native organisms provides a critical baseline from which to assess how changes in the island’s community structure or trophic ecology may affect the life histories of other species. We report two new examples of predation and two examples of scavenging on the native
whiptail lizard, *Cnemidophorus murinus*. In addition, we report instances of shelter use in Caribbean sea anemones (*Condylactis gigantean*) by bluehead wrasses (*Thalassoma bifasciatum*), which inhabit Curaçao’s extensive network of near-shore coral reefs. Of equal importance is documenting cases of novel interactions between introduced and native species, as this provides insights into modeling the predictive outcomes of species introductions. To this end, we provide the first documented case of the introduced tropical house gecko (*H. mabouia*) preying on the native Antilles gecko (*Gonatodes antillensis*), suggesting that predation and not just competitive exclusion may be contributing to the decline of this native gecko.

**Observations**

**Instances of Avian Predation and Scavenging on Curaçao Whiptail Lizards**

The whiptail lizard, *Cnemidophorus murinus*, is one of the most conspicuous terrestrial organisms on the islands of the former Netherlands Antilles. The conspicuous nature of this lizard is in part due to its preference for open habitats (Pianka and Vitt 2003), long periods of diurnal activity (Vitt et al. 2005) and high population densities (van Buurt 2005). Moreover, the contribution of *C. murinus* to the terrestrial biomass of these islands is up to four times greater than the total biomass contributed by other lizards, such as *Anolis lineatus* or *Gonatodes antillensis* (Bennett and Gorman 1979). The high level of *C. murinus* biomass there is sustained by the species’ primarily herbivorous diet, which is supplemented by arthropods (Dearing and Schall 1992), carrion (van Buurt 2005), discarded human food items and other *C. murinus* (van Buurt 2005). Because *C. murinus* is becoming an increasingly common model organism for the study of squamate evolution (e.g., Schall 1990; Schall and Ressel 1991; Schall and Dearing 1994; Baird et al. 2003; Cooper et al. 2003, 2004; Vitt 2004; Vitt et al. 2005), it is surprising that the predators of this lizard are poorly known (van Buurt 2005). Herein we report the first documented cases of avian predation on *C. murinus* by two species of birds (Figure 2): the Groove-billed Ani (*Crotophaga sulcirostris*) and the Tropical Mockingbird (*Mimus gilvus*).

At 15:45 on 16 July 2009, we observed a Groove-billed Ani pluck a juvenile *Cnemidophorus murinus* off the driveway leading to the rear entrance of the Church of Sint Willibrordus, Curaçao (lat 12.2160, long –69.0636) after a period of light precipitation. The Groove-billed Ani landed in a nearby bush and was immediately mobbed by two conspecifics that attempted to steal the prey item. The attempted thefts were unsuccessful, and after approximately 30 seconds of avoiding the other Groove-billed Anis while violently thrashing the lizard, the bird swallowed the lizard. After the ingestion of the *C. murinus*, the trio of Groove-billed Anis flew out of sight. This is the first report of a Groove-billed Ani feeding on *C. murinus*, although members of the genus *Crotophaga* have been reported to feed on other lizard species, including various species of *Anolis* in Costa Rica (Henderson 2002) and juvenile *Iguana iguana* in Panama (Hilty and Meyer de Schauensee 2003; Logue 2007). Given the presence of *I. iguana* on Curaçao, it is reasonable to expect that they also experience predation from the Groove-billed Ani, although this has not yet been documented.

We observed an additional avian predation event on a juvenile *Cnemidophorus murinus* off the driveway leading to the rear entrance of the Church of Sint Willibrordus, Curaçao (lat 12.2160, long –69.0636) after a period of light precipitation. The Groove-billed Ani landed in a nearby bush and was immediately mobbed by two conspecifics that attempted to steal the prey item. The attempted thefts were unsuccessful, and after approximately 30 seconds of avoiding the other Groove-billed Anis while violently thrashing the lizard, the bird swallowed the lizard. After the ingestion of the *C. murinus*, the trio of Groove-billed Anis flew out of sight. This is the first report of a Groove-billed Ani feeding on *C. murinus*, although members of the genus *Crotophaga* have been reported to feed on other lizard species, including various species of *Anolis* in Costa Rica (Henderson 2002) and juvenile *Iguana iguana* in Panama (Hilty and Meyer de Schauensee 2003; Logue 2007). Given the presence of *I. iguana* on Curaçao, it is reasonable to expect that they also experience predation from the Groove-billed Ani, although this has not yet been documented.

We observed an additional avian predation event on a juvenile *Cnemidophorus murinus* by a Tropical Mockingbird at 12:15 on 17 July 2009 at the CARMABI research station in Piscadera Baai, Curaçao (lat 12.1239, long –68.9656). The Tropical Mockingbird grabbed a juvenile
C. murinus as the lizard moved across the parking lot between the research station and the adjacent house. The bird swiftly carried the lizard up to a perch on a nearby tree. Although the bird became obscured by foliage, it spent approximately 2 minutes in the tree before flying to another perch without the lizard. Although we did not witness the ingestion, this observation is highly suggestive that the Tropical Mockingbird consumed C. murinus while perched. This is the first record of a Tropical Mockingbird consuming C. murinus, although other lizard prey items have been documented in the diet of this bird (Wunderle 1981; Ffrench 1991).

These records constitute the first documentation of any avian predators consuming Cnemidophorus murinus. Although Schall (1974) believed the predation of whiptails in the former Netherlands Antilles to be rare, our observations, coupled with the high levels of biomass and the conspicuous nature of C. murinus, suggest otherwise. Additionally, we all observed repeated instances of scavenging on road-killed C. murinus carcasses by the Northern Crested Caracara (Caracara cheriway) and Tropical Mockingbird (Mimus gilvus). We speculate that these lizards may constitute an important component of food webs by transferring energy from primary producers to larger predators, particularly passerine birds, which can be significant predators of small vertebrates (e.g., Adolph and Roughgarden 1983; Poulin et al. 2001; Toledo et al. 2007; but see Lopes et al. 2005).

Predation on a Native Antilles Gecko by the Introduced Tropical House Gecko
The steady increase in international commerce and travel has facilitated the transport of plants and animals thousands of miles from their home ranges, although only a few these organisms establish viable populations (Williamson and Fitter 1996). Whereas some instances of this biotic mixing seem relatively benign (Mooney and Hobbs 2000), a sizable number of non-native species that establish viable colonies outside their native ranges have the potential to become pest species that can substantially affect native fauna (such as the zebra mussel [Dreissena polymorpha], the brown tree snake [Boiga irregularis] and crazy ants [Anoplolepis gracilipes]). Pest species can affect native species in a variety of ways, including changing the behavior of native species (e.g., Townsend 1996; Holway and Suarez 1999) and encouraging competitive exclusion (e.g., Petren and Case 1996; Byers 2000) and niche displacement (e.g., Kenwood and Holm 1993; Mooney and Cleland, 2001). In the worst case, introduced species can drive elevated rates of local, regional or even complete extinction for native species (reviewed in Mooney and Hobbs 2000; Mooney and Cleland 2001).

Members of the gecko genus Hemidactylus represent some of the most well-known and widespread reptilian pest species. Whereas most of the 100 species belonging to this genus have ranges restricted to Africa and southern Asia, seven species (H. brookii, H. frenatus, H. flaviviridis, H. garnotii, H. mabouia, H. persicus and H. turcicus) have become pervasive enough in their introduced ranges to be termed “weedy species” (Kluge 1969; Carranza and Arnold 2006). Several of these introductions have been directly linked to the collapse of native (or in some cases other exotic) gecko populations (Petren and Case 1996; Meshaka 2000; Dame and Petren 2006), with the most striking example occurring on the
Mascarene islands where \textit{H. frenatus} has been implicated in driving three of six species of \textit{Nactus} geckos to extinction (Arnold 2000; Cole et al. 2005). Given the repeatedly demonstrated potential of \textit{Hemidactylus} to displace insular fauna, monitoring the influence of these geckos on local species is of the utmost importance.

\textit{Hemidactylus mabouia} is a relatively recent addition to the biota of Curaçao, most likely having become established on the island during the 1980s (van Buurt 2005). Over the past three decades, \textit{H. mabouia} has already displaced two native geckos, \textit{Gonatodes antillensis} and \textit{Phylloodactylus martini}, from most areas with extensive human habitation and is now hypothesized to be the most common gecko on the island (van Buurt 2005, 2006). Although competition is often invoked as an explanation for \textit{H. mabouia} displacing \textit{Phylloodactylus} and \textit{Gonatodes}, we offer an observation that suggests that the role of \textit{H. mabouia} as a predator of smaller geckos may be an additional component of this gecko’s ability to successfully colonize new habitats.

From 11 to 17 July 2009, we collected 17 \textit{Hemidactylus mabouia} from the vicinity of Westpunt and Playa Kalki (see Figure 1) in Northern Curaçao (Yale Peabody Museum [YPM] specimens: YPM HERR 017557, YPM HERR 017563–017578). Although we took no formal census, visual observations suggest this gecko to be locally abundant in the area, although \textit{Phylloodactylus martini} (YPM HERR 017585–017607) and \textit{Gonatodes antillensis} (YPM HERR 017579–017584) are also present in lower numbers. Investigations of the stomach contents of the collected \textit{H. mabouia} revealed the identifiable remains of \textit{G. antillensis} in YPM HERR 017575. While this finding could represent an isolated incident, we routinely observed both juvenile \textit{P. martini} and \textit{G. antillensis} foraging in the vicinity of adult \textit{H. mabouia}.

The ramifications of the \textit{Hemidactylus mabouia} introduction for the native geckos on Curaçao remain unclear, as \textit{H. mabouia} seems unable to penetrate the arid mondi (bush) and is restricted to areas of human habitation (van Buurt 2005). However, the decline of \textit{Phylloodactylus martini} and \textit{Gonatodes antillensis} in urban areas, coupled with the high human population density and forecasted growth rate of the island (CIA 2010), paints a gloomy picture for the future of these native lizards. This is particularly unfortunate because \textit{G. antillensis} is the only member of the genus \textit{Gonatodes} to have re-evolved a nocturnal lifestyle (Schargel 2008), making this an ideal species from which to gain significant insights into the evolution of dim-light vision in vertebrates. If \textit{H. mabouia} is driving the isolation of \textit{Phylloodactylus} and \textit{Gonatodes} within fragmented patches of the mondi, determining whether \textit{H. mabouia} is also a major predator of these animals will be critical in modeling how this introduced gecko will alter patterns of gene flow between native gecko populations (Rivas et al. 2005).

\textbf{Use of the Giant Caribbean Sea Anemone as Shelter by Juvenile Bluehead Wrasses}

In the period from 1 October to 15 November 2006, and again from 11 July to 18 July 2009, we observed juvenile bluehead wrasses (\textit{Thalassoma bifasciatum}) associating with the sea anemone \textit{Condylactis gigantea} in several locations in

\begin{figure}[h]
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\caption{Distant (A, B) and close-up (C) views of juvenile bluehead wrasses (\textit{Thalassoma bifasciatum}) using a Caribbean sea anemone (\textit{Condylactis gigantea}) as shelter. Photographs A, B by A. Dornburg; C by D.L. Warren.}
\end{figure}
Curaçao, including Piscadera Baai, Director’s Bay and Playa Kalki (see Figure 1). This association has been noted before (Gendron and Mayzel 1976; Hanlon and Kaufman 1976; Blanquet et al. 2006), but several features of the observations discussed here are noteworthy: first, we observed that the occupation of anemones by bluehead wrasse juveniles was very common, in contrast to the observations of Gendron and Mayzel (1976) in the Bahamas and Blanquet and co-workers (1980) in Honduras, in which these associations were seen only rarely. Although no formal count was maintained, each of us independently estimated that about 70% of _C. gigantea_ anemones were occupied by juvenile blueheads in surveyed locations. Second, many juvenile _T. bifasciatum_ were observed occupying the same anemone (Figure 3).

This confirms previous observations in this system (Gendron and Mayzel 1976; Hanlon and Kaufman 1976) and is interesting in contrast to observations that juvenile _T. amblycephalum_ in the Pacific are usually found on anemones in groups of three individuals (Arvedlund et al. 2006). In many cases juveniles were found close to, and apparently touching, the tentacles of _C. gigantea_ (as in Blanquet et al. 1980, but contra Gendron and Mayzel 1976; see Figure 3). When approached, the juveniles tended to hide near the bases of tentacles, close to and perhaps touching the tentacles and oral discs. At no point were juveniles observed to leave the anemone and hide in rubble nearby.

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**Literature Cited**


