

RECENT INTRODUCTION OF THE BROWN ANOLE *NOROPS SAGREI* (REPTILIA: SQUAMATA: DACTYLOIDAE) TO SINGAPORE

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ABSTRACT. — The brown anole, *Norops sagrei* (Duméril & Bibron), is recorded in Singapore for the first time from the gardens at Marina Bay. It is believed to have been introduced there with imported plants.

KEY WORDS. — brown anole, *Anolis sagrei*, *Norops sagrei*, nursery trade, introduced species, Singapore

INTRODUCTION

The brown anole, *Norops sagrei* (Duméril & Bibron), is a lizard from the neotropical family Dactyloidae. Until recently, it was better known under the genus *Anolis*, but was reassigned to the genus *Norops* by Nicholson et al. (2012). This is a small, slender species that attains a maximum known total length of 21 cm. The tail is very long, taking up about two-thirds of the total length. The head is long and tapering. The limbs are relatively long with slender digits, the undersides of which are lined with expanded toe-pads, each composed of a number of laterally expanded scales called lamellae. Females and juveniles are brown to grey on the dorsum, with dark and pale markings on the sides, and most notably a dark-edged whitish mid-dorsal stripe. The edges of this stripe are generally dark and scalloped. The undersides are pale brown to grey without markings.

This species is sexually dimorphic (Bartlett & Bartlett, 1997, as *Anolis sagrei*; pers. obs.), with the males being larger, bulkier, and generally darker with indistinct pale markings. Males also have a large dewlap or throat fan that varies from orange to red, and has a whitish or yellowish border. When the appendage is not erected, it appears as a reddish streak on the throat. Females and juveniles have either no dewlap or a poorly developed one. Some males have well-developed tail crests, erectile nuchal crests, and less distinct vertebral crests.

The diurnal brown anole is arboreal but prefers the lower trunks of trees and shrubs, and on the ground in relatively exposed environments (Bartlett & Bartlett, 1997; Losos, 2009; Meshaka, 2011; as *Anolis sagrei*). It is largely insectivorous, feeding on flies, crickets, grasshoppers, caterpillars and moths. It is also known to feed on the hatchlings of other small lizards. The males are territorial and advertise their dominance by bobbing their heads and flashing their reddish throat fans (Fig. 1). A similar display is also used for courting females. After mating, the female lays single eggs or clutches of two eggs among plant debris in a shallow scrape on the ground under boards or other moisture-retaining material. The eggs are produced at intervals of about 14 days, and take about 30 days to hatch.

The brown anole is native to Cuba, the Bahamas, and some adjacent islands in the Caribbean (Schwartz & Thomas, 1975; Losos, 2009; as *Anolis sagrei*). It has been introduced to many parts of the southern United States, particularly in Florida where it is firmly established (Bartlett & Bartlett, 1997, as *Anolis sagrei*). This lizard has also been introduced to the Hawaiian Islands, some other Caribbean islands, Mexico, and the Canary Islands. On the eastern hemisphere, the species has been recorded from Taiwan (Huang et al., 2008; Kraus, 2009; as *Anolis sagrei*).

Recently, the brown anole has been observed in Singapore where a population appears to be established. The sightings are recorded in this article, and the anoles' possible origin and implications of their presence are briefly discussed. The snout-vent length (SVL) is measured from the tip of the snout to the cloacal opening at the base of the tail. Total length (TL) is measured from the snout tip to the tail tip.

OBSERVATIONS

On the morning (around 0800 hours) of 18 Oct.2012, HHT and some of his colleagues noted a number of small lizards identifiable as *Norops sagrei* among the ornamental plants at Gardens by the Bay, the gardens of Marina Bay South. About four different individuals were photographed (Figs. 1–3).



Fig. 1. Male *Norops sagrei* of about 6 cm TL displaying its bright orange dewlap at the Gardens by the Bay on the morning of 18 Oct.2012. Note generally the darker colours and indistinct pale markings. (Photograph by: Heok Hui Tan).



Fig. 2. Female or juvenile male *Norops sagrei* of about 4 cm TL with the distinct whitish dorsal stripe at Gardens by the Bay South Gardens on 18 Oct.2012. (Photograph by: Heok Hui Tan).

KKPL visited the gardens on the morning of 21 Oct.2012. Between 0830–1000 hours and in sunny weather, no less than 20 individual anoles were observed on low growing plants such as bromeliads, miniature pandanus, ornamental orchids, and lantana. They were perched mainly on the foliage, either in the shade or under full sun. Two were observed on the trunk of small palms. None were observed more than 1 m off the ground. They ranged from adults of about 6 cm SVL to hatchlings of about 2 cm SVL. Many of the lizards were seen in plant beds near high human traffic. The grey-brown colouration and chalky white mid-dorsal stripe serve as effective camouflage for the lizards as they were difficult to detect among the plants if they kept still. However, many of the lizards were actively chasing each other, lunging at small flying insects or trying to evade the observer who approached too closely by darting into the undergrowth. An adult male performed a territorial-courtship display on an artificial rock. Five changeable lizards (*Calotes versicolor*) and a spiny-tailed house gecko (*Hemidactylus frenatus*) were observed together with the anoles in the garden during the visit. Interaction between these lizards was not observed, but the considerably larger changeable lizard appears capable of preying on the anoles. Being of similar size, the anole is not expected to pose a threat to the adult gecko, although it may prey on the latter's hatchlings.



Fig. 3. Two separate individuals of female or juvenile male *Norops sagrei* of about 4 cm SVL at the Gardens by the Bay on 18 Oct.2012. Note the whitish mid-dorsal stripe and the intricate markings on the sides of the body. The individual in on the right has lost part of its tail. (Photographs by: Heok Hui Tan).

Outside the gardens, many anoles were observed on planted plots along the sidewalk leading to Marina Barrage, on 10 Nov.2012 (Darren C. J. Yeo, pers. comm.).

The 101-hectare Gardens by the Bay at Marina South were planted and completed in Oct.2011 on land reclaimed from the sea (see Gardens by the Bay, 2012). It is surrounded by the Marina Reservoir to the north, a busy highway (East Coast Parkway) and commercial buildings to the west, and coastal land under construction to the south and east. Marina Bay is located at the south-central edge of Singapore Island, in a heavily populated commercial and recreational area.

DISCUSSION

This is the first record of *Norops sagrei* in Singapore. The many individuals, hatchlings, and courtship activities observed at the Gardens by the Bay strongly suggest that the brown anole has already established a population in Singapore, at least within Marina Bay. It is the first reptile from the Americas that has done so there. Another neotropical lizard, the green iguana (*Iguana iguana*), has been recorded in Singapore, but is not known to be established (Yeo & Chia, 2010). The brown anole is possibly the second introduced species of lizard that has established a feral population in Singapore. The first species to have done so is the changeable lizard (*Calotes versicolor*, family Agamidae; Baker & Lim, 2008; Yeo & Chia, 2010).

The brown anole is easily distinguished from other lizards in Singapore by its long, tapering head and pointed snout, relatively long limbs with slender clawed digits that are not greatly expanded. Small changeable lizards and flying dragons (*Draco* species) may, at a glance, appear similar, but are distinguishable by their shorter heads. Changeable lizards have two pale stripes, instead of one, down their backs. Flying dragons have a pair of wing-like skin flaps (patagia) supported by extensions of their ribs, a morphological feature that is absent on the changeable lizard and the anole. Male flying dragons also have an erectile dewlap on their throats, but these are triangular, while those of the anole are oval-shaped (Baker & Lim, 2008).

As *Norops sagrei* is a neotropical species, and not known from the surrounding areas, it must have been imported. Although we are unable to establish the mode of introduction, the appearance of brown anoles in various other places has been attributed to the nursery trade (Kraus, 2009, as *Anolis sagrei*). We believe the Singapore population is no exception. It appears likely that the lizards were introduced with plants for the Gardens by the Bay. The planting for the gardens began in 2010 with plants sourced from various parts of the world (see Gardens by the Bay, 2012), so it is possible that the first anoles were introduced around that period of time. The brown anoles in Singapore may also be from populations established outside the lizard's native range. Kolbe et al. (2004, as *Anolis sagrei*) believe that recently introduced brown anole populations around the world have originated from Florida (USA). Their genetic analyses of the brown anole populations in Florida have indicated that there were at least eight separate introductions from across the lizard's native range, blending genetic variation from different geographic source populations, thus producing feral brown anoles with substantially more genetic variation than native ones.

The brown anole is reputed to be an invasive species that has apparently caused the decline of the native and syntopic green anole (*Anolis carolinensis*) in Florida where it is firmly established by feeding on the latter's hatchlings (Kraus, 2009; Meshaka, 2011; as *Anolis sagrei*). In southern Taiwan, Huang et al. (2008) found that brown anoles, introduced to the island since 2000, can significantly alter the community structure of ants on betelnut palm plantations either by direct predation by the lizards or indirectly causing the ants to shift foraging sites.

The possible ecological impact from feral brown anoles in Singapore is unknown. At the time of writing, the species seems to be confined to the Marina Bay area, which is an artificial habitat planted with mostly ornamental vegetation. The anole's preference of exposed scrubland and gardens should enable it to spread beyond the Marina Bay area. However, this should also prevent the anoles from penetrating dense forest at the Bukit Timah Nature Reserve and Central Catchment Nature Reserve where most of Singapore's small native lizards with similar habits, such as *Aphaniotis fusca* and *Eutropis rugifera*, are locally confined. Its effect on native fauna in Singapore remains to be seen, and is worthy of study. Its interaction with the changeable lizard (*Calotes versicolor*), another introduced species with similar habitat requirements, would be of particular interest. The anoles provide interesting diurnal activity to the gardens, and can probably be tolerated. Eradication of these lizards may be an option before they spread further, but it would be difficult considering their small size and great agility. The population can probably be restricted to the Marina Bay area by creating barriers on the landward sides, and ensuring that individuals are not inadvertently transported out among plant debris.

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