



## INTRODUCED SPECIES

# Greenhouses as Potential Reservoirs for the Brown Anole (*Anolis sagrei* Duméril & Bibron, 1837), an Exotic Invasive Lizard in Southwestern Taiwan

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Photographs by the senior author.

By excluding potential pest arthropods with the use of permanent and temporary greenhouses constructed out of fine netting (Fig. 1), the agricultural and nursery industries can meet the growing demands of consumers for pesticide-

free plants and produce (Hudson et al. 1996). An additional benefit of such practices is that the netting also can exclude frugivorous birds and thus mitigate conflicts between farmers and birds. However, in some instances greenhouse net-



**Fig. 1.** Papayas (*Carica papaya*) cultivated inside a greenhouse constructed out of fine netting in Santzepu, Sheishan District, Chiayi County, southwestern Taiwan.



**Fig. 2.** The banana (*Musa sapientum*) orchard described herein. Note the removed netting material along the border of the orchard, and the strips of plastic used for retaining soil moisture.

ting can lead to mortality among non-target species, such as the Gran Canaria Skink (*Chalcides sexlineatus*), Gran Canaria Giant Lizard (*Gallotia steblini*), and the Boettger's Wall Gecko (*Tarentola boettgeri*; Šmíd 2012). Herein we describe the potential of such greenhouses as reservoirs of Brown Anoles (*Anolis sagrei*) in Taiwan.

In an agricultural area in Santzepu, Sheishan District, Chiayi County, southwestern Taiwan (23°25'59"N, 120°29'18"E, 68 m elev., datum: WGS84), at ca. 1000 h on 27 June 2013, we inspected a temporary greenhouse around a banana (*Musa sapientum* L.) orchard (ca. 75 x 35 m). It had been erected about six months earlier and the netting was removed on 26 June 2013 when the plants had reached a desired stage of maturity (Fig. 2). The plants were planted in double rows on mounds (ca. 70 x 5 x 0.3 m) covered by strips of thin plastic (ca. 70 x 1.3 m) to prevent erosion and maintain soil moisture. Uncovered flat drainage furrows (ca. 1 m wide) separated the mounds. We observed large numbers (ca. 1 individual/4 m<sup>2</sup>) of *A. sagrei* of both sexes (Fig. 3) and all size classes in the orchard. During a brief search along the edge under the plastic sheeting we found an *A. sagrei* egg (Fig. 4), confirming our suspicion

that the females would use the moist soil under the sheets for nesting sites.

The occurrence of *A. sagrei* inside a greenhouse could be the result of individuals dispersing into the area where the greenhouse was being erected. The lizards and/or their eggs also might be introduced into a greenhouse with the cultivated plants. Because *A. sagrei* can be accidentally transported in bundles of bamboo stems to new localities (Norval and Mao 2007), another possible pathway for the introduction of these lizards into a greenhouse is the bamboo stems that are used as supports for both the netting material and/or the growing saplings.

Irrespective of the pathway for the introduction of *A. sagrei* into a greenhouse, once inside, the lizards are in a very favorable environment. The netting will not exclude small arthropods such as ants, which are an important component of the diet of *A. sagrei* in southwestern Taiwan (Norval et al. 2010). However, avian predators, such as Brown Shrikes (*Lanius cristatus*; Chiu et al. 2011) and Malay Night Herons (*Gorsakius melanolophus*; Norval et al. 2011), and very likely also reptilian predators, such as Long-tailed Skinks (*Eutropis longicaudata*; Norval et al. 2004) and the Mountain Wolf



**Fig. 3.** An adult male (left) and juvenile female (right) *Anolis sagrei* from the banana orchard described herein.



**Fig. 4.** An *Anolis sagrei* egg found under a strip of plastic used for retaining soil moisture in the banana orchard described herein.

Snake (*Lycodon ruhstrati ruhstrati*; Norval et al. 2007, Norval and Mao 2008), are excluded by the netting. In addition, the presumably higher air temperatures inside such greenhouses

and the relatively humid environment under the plastic sheeting also would promote the development of eggs.

When the netting is removed from such greenhouses, the lizards are able to disperse to neighboring areas, and potentially compete with native species. However, the greatest risk of this type of agricultural practice is that the lizards and/or their eggs could be transported to new localities along with plants, produce, and/or materials, and thereby extend the distribution of this exotic invasive species in Taiwan.

#### Acknowledgements

The authors thank Shao-Chang Huang for obtaining some of the references.

#### Literature Cited

Chiu, P.K., G. Norval, H.P. Chu, and J.J. Mao. 2011. Two records of Brown Shrikes (*Lanius cristatus* Linnaeus, 1758) preying on Brown Anoles (*Anolis sagrei* Duméril & Bibron, 1837) in Taiwan. *Herpetology Notes* 4:87–89.

- Hudson, W.G., M.P. Garber, R.D. Oetting, R.F. Mizell, and K. Bondari. 1996. Pest management in the United States greenhouses and nursery industry: V. Insect and mite control. *HortTechnology* 6:216–221.
- Norval, G., P.K. Chiu, H.P. Chu, and J.J. Mao. 2011. An instance of predation on the Brown Anole (*Anolis sagrei* Duméril & Bibron, 1837) by a Malay Night Heron (*Gorsakius melanolophus* Swinhoe, 1865). *Herpetology Notes* 4:5–7.
- Norval, G., W.F. Hsiao, S.C. Huang, and C.K. Chen. 2010. The diet of an introduced lizard species, the Brown Anole (*Anolis sagrei*), in Chiayi County, Taiwan. *Russian Journal of Herpetology* 17:131–138.
- Norval, G., S.C. Huang, and J.J. Mao. 2007. Mountain Wolf Snake (*Lycodon r. rubstrati*) predation on an exotic lizard, *Anolis sagrei*, in Chiayi County, Taiwan. *Herpetological Bulletin* 101:13–17.
- Norval, G. and J.J. Mao. 2007. Can *Anolis sagrei* be unintentionally transported to new localities in bamboo stem bundles? *Sauria* 29:51–54.
- Norval, G. and J.J. Mao. 2008. An instance of arbicolous predation by a Mountain Wolf Snake (*Lycodon rubstrati rubstrati* [Fisher, 1886]) on a Brown Anole (*Norops sagrei* Duméril & Bibron, 1837). *Sauria* 30:59–62.
- Norval, G., J.J. Mao, and H.P. Chu. 2004. *Mabuya longicaudata* (Long-tailed Skink). Predation. *Herpetological Review* 35:393–394.
- Šmíd, J. 2012. Greenhouse netting as an effective trap for lizards in Gran Canaria Island. *Herpetology Notes* 5:63.