

# New records and range expansion of *Norops sagrei* (Squamata: Dactyloidae) in Honduras highlight the importance of citizen science in documenting non-native species

Nuevos registros y expansión de ámbito de *Norops sagrei* (Squamata: Dactyloidae) en Honduras resaltan la importancia de la ciencia ciudadana en la documentación de especies no nativas

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## ABSTRACT

Populations of *Norops sagrei*, an anole lizard native to Cuba, the Bahamas, and the Cayman Islands, are established in northern Honduras. Here, we report seven new records in six departments for this species in northern, western, central, and southern Honduras, summarize the invasion progress of *N. sagrei* in the country, and comment on the importance of citizen science in the documentation of non-native species.

**Keywords:** *Anolis sagrei*, Central America, community science, exotic species, geographic distribution.

## RESUMEN

Las poblaciones de *Norops sagrei*, un lagarto anolis nativo de Cuba, las Bahamas y las Islas Caimán, están establecidas en el norte de Honduras. Aquí, reportamos siete nuevos registros en seis departamentos para esta especie en el norte, occidente, centro y sur de Honduras, resumimos el avance de la invasión de *N. sagrei* en el país y comentamos la importancia de la ciencia ciudadana en la documentación de especies no nativas.

**Palabras clave:** *Anolis sagrei*, Centroamérica, ciencia comunitaria, distribución geográfica, especie exótica.

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## INTRODUCTION

The Brown Anole, *Norops sagrei* (Cocteau in Duméril & Bibron, 1837), is native to Cuba, the Bahamas, and the Cayman Islands (Schwartz and Henderson 1991, McCranie and Köhler 2015, González-Sánchez *et al.* 2021), but has been introduced to numerous localities worldwide including Central, North, South America, and Southeast Asia (Tan and Lim 2012, Norval *et al.* 2016, Amador *et al.* 2017, Batista *et al.* 2019, Vásquez-Cruz *et al.* 2020). This species has a well-documented history as an invasive species in the southeastern USA dating back to the late 1800's (Garman 1887), and populations in Florida have been documented as the source for some secondary introductions and re-introductions (Kolbe *et al.* 2017). *Norops sagrei* is now considered the most widespread anole in Central America (González-Sánchez *et al.* 2021).

In Honduras, populations of this species have been reported from five departments to date, primarily in the north and the northwest: Atlántida, Cortés, Islas de la Bahía (Guanaja, Roatán, and Útila), Santa Bárbara, and Yoro (Fugler 1968, Espinal *et al.* 2014, McCranie and Nuñez 2014, McCranie and Köhler 2015, Solís *et al.* 2017, Herrera-B. and Mencia-Baide 2018). Recently, opportunistic surveys and photographs shared via social media and citizen science platforms suggest a significant expansion of the distribution of *N. sagrei* in western, central, and southern Honduras, far from the inferred area of initial introduction along the north-central coast. Here, we document the presence of the non-native *N. sagrei* in seven additional localities from five additional departments in Honduras, including several that appear to represent established, reproducing populations. We conclude by underscoring the value of citizen science observations for improving the detection of non-native species globally.

## MATERIALS AND METHODS

The generic classification of anole lizards remains controversial, with various authors assigning all anoles to either the single genus *Anolis* or to multiple genera (*e.g.* Etheridge 1959, Guyer and Savage 1987, Cannatella and de Queiroz 1989, Nicholson *et al.* 2012, 2014, 2018, Poe 2004, 2013, McCranie and Köhler 2015, Poe *et al.* 2017).

While recognizing criticisms of the multi-genera classification of anoles, we follow Nicholson *et al.* (2018) in their use of a multi-genera taxonomy, and we use *Norops* for the genus of our focal taxon.

We obtained seven new records for *N. sagrei* through casual encounters, dating back to 2014: two within a previously reported department and five in novel locations in western, central, and southern Honduras. All anoles were identified using the keys in McCranie and Köhler (2015) and possessed diagnostic features including a highly compressed tail with a dorsal ridge, four postmentals, a greatly enlarged outer postmental scale on each side (length greater than that of the mental scale), an orange dewlap in males, and pale transverse lines on the sides of the body of some individuals.

In addition to opportunistic encounters, we used the citizen science platform iNaturalist to review observations of anoles in Honduras, looking for additional evidence of *N. sagrei* in the country. Two verifiable records (by FJD: <https://www.inaturalist.org/observations/9197098>; and HDR: <https://www.inaturalist.org/observations/45815777>) were found through these searches. Additional records that could not be identified with certainty due to the quality or angle of the photographs were also noted from the municipalities of Balfate (Colón) and Aramecina (Valle), which require further investigation. Additionally, two of the records we discuss below were previously submitted to iNaturalist by the authors prior to the completion of this manuscript (by JHT: <https://www.inaturalist.org/observations/34460668>; by AARB: <https://www.inaturalist.org/observations/46133231>).

We measured the snout-to-vent length (SVL) of captured individuals with digital calipers (Truper CALDI-6MP) to the nearest 0.01 mm, except for measurements taken by DIOM with analog calipers (Angelito-Germany 150x1/20mm) to the nearest 0.05 mm. We deposited photographic vouchers of individuals from each locality in the herpetology collection of the Universidad de San Carlos, Guatemala (USACF000005-11). Using a Garmin eTrex 10 Global Positioning System, we obtained geographical coordinates (WGS 84) and elevation for each new locality, and mapped them using QGIS version 2.18.

## RESULTS

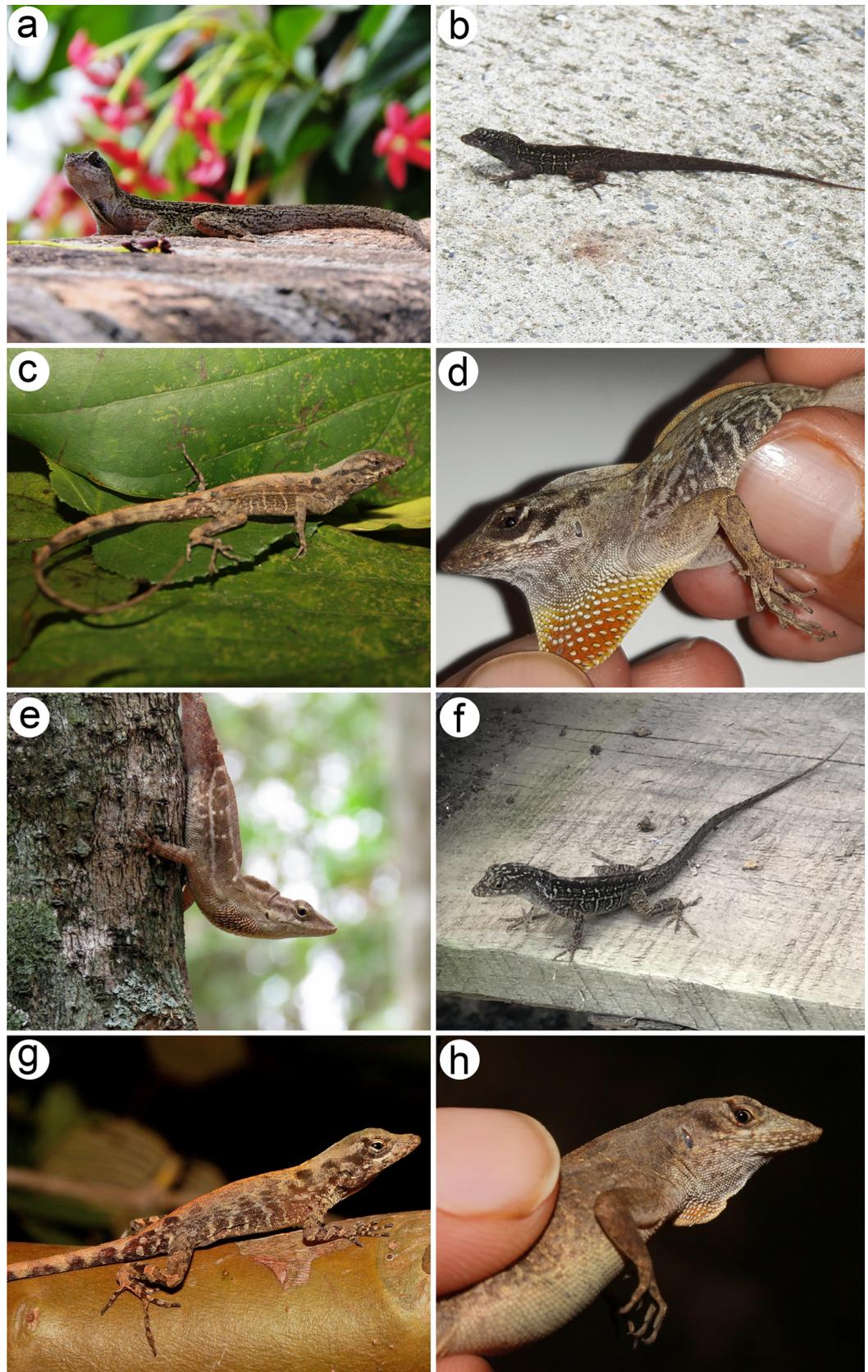
On 19 October 2014 at 1610 h FJD observed one adult *N. sagrei* (USACF000005; Fig. 1a) in the gardens of a local hotel in Barrio Buena Vista, Municipality of Copán Ruinas, Department of Copán (14°50' North, 89°09' West, 612 m a.s.l.; Fig. 2); this locality is approximately 100 km W of the locality documented in Santa Bárbara by Espinal *et al.* (2014). The individual was not sexed but presumed to be female based on its dorsal pattern. On 14–15 October 2019, JHT observed over two dozen adult and juvenile *N. sagrei* (USACF000006; Fig. 1b) on the grounds of a beachfront hotel in Veracruz, Municipality of Omoa, Department of Cortés (15°41' North, 88°06' West, 5–10 m a.s.l.; Fig. 2); this locality is approximately 25 km SW of the nearest locality in Puerto Cortés. On 29 February 2020 at 1314 h, CAAF observed one adult (SVL: 55.73 mm) and one subadult male (SVL: 42.95 mm) *N. sagrei* (USACF000008, USACF000007; Figs. 1c,d) active in the gardens of a banking agency in Barrio Abajo, City and Municipality of Danlí, Department of El Paraíso (14°01' North, 86°34' West, 764 m a.s.l.; Fig. 2). On 9 May 2020 at 1004 h, AARB observed an adult male *N. sagrei* (USACF000009; Fig. 1e) within a patch of lowland secondary humid tropical forest 1.58 km N of Tulín Community, Municipality of Juticalpa, Department of Olancho (14°43' North, 86°09' West, 487 m a.s.l.; Fig. 2); this lizard was perched ca. 0.5 m off the ground on a clear day. On 13 May 2020 at 1531 h, HDR observed an adult *N. sagrei* (USACF000010; Fig. 1f) active on a wooden board in an urban area within Cofradía, City and Municipality of San Pedro Sula, Department of Cortés (15°24' North, 88°09' West, 105 m a.s.l.; Fig. 2). This locality is approximately 125 km NE of our Copán record (see above). On 30 October 2020 at 1005 h, CAAF observed a subadult female *N. sagrei* (SVL: 31.20 mm; USACF000011; Fig. 1g) active ca. 1.5 m high in a garden and an area dividing a house and restaurant ca. 0.5 kilometers SE of the central park of the City and Municipality of Comayagua, Department of Comayagua (14°27' North, 87°38' West, 586 m a.s.l.; Fig. 2); at least twenty additional individuals—including adults and subadults—were also observed at this location. On 12 November 2020 at 1718 h, CAAF and DIOM observed about a dozen individuals, including two subadult *N. sagrei* (USACF000012; Fig. 1h) in the garden of a house in Residential Jardines de Miraflores, City of Tegucigalpa, Municipality of Distrito Central, Department of Francisco Morazán (14°04' North, 87°11' West, 984 m

a.s.l.; Fig. 2); the first individual was active in the branches of a shrubby plant about 0.5 m off the ground, and the second was active in a *Citrus* sp. about 3 m high. Previously, DIOM found and measured two adult males in the same location in 2018 (SVL: 68.10 mm, 62.35 mm); at least five other individuals were observed at this location.

## DISCUSSION

These records of *N. sagrei* represent the first for the departments of Comayagua, Copán, El Paraíso, Francisco Morazán, and Olancho, and the species is now known from ten of the eighteen Honduran departments. Of these new records, the closest to previously vouchered populations are those from Comayagua, ca. 82.5 km SE of the nearest vouchered localities in Santa Bárbara (Fig. 2, Espinal *et al.* 2014). Additionally, all new department records were from elevations (487–984 m a.s.l.) higher than any previous record reported in Honduras (262 m a.s.l., Espinal *et al.* 2014). The new localities that we report here for the department of Cortés might represent dispersion towards the Caribbean coast of Guatemala from Veracruz and further west (*e.g.* Santa Bárbara, Copán, etc.) from Cofradía.

The presence of several adult and sub-adult individuals—including males and females—suggests that *N. sagrei* has established reproductively-viable populations at three of the seven new localities we report herein: the towns of Comayagua (Comayagua), Tegucigalpa (Francisco Morazán), and Omoa (Cortés). In the remaining four new localities (Danlí [El Paraíso], Copán Ruinas [Copán], Cofradía [Cortés], and Juticalpa [Olancho]), we only observed one or two individual *N. sagrei*, nearly all of which were males; whether viable, reproducing populations are established at these locations remains unclear and requires further investigation. Given that these new records are from urban areas that follow major roads and highways, it is likely the anoles were accidentally transported via the anthropogenic movement of plants (or similar means) from the Atlantic coast of Honduras, and/or utilized the corridors of associated edge habitat as a means of dispersal. If range expansion continues in this manner, the species can be expected to appear in departments such as Choluteca, Colón, Intibucá, La Paz, Lempira, Ocotepeque and Valle in the near future. Following Blackburn *et al.* (2011), the invasion progress of *N. sagrei* in Honduras can now be considered a category D2: a “self-sustaining population in the wild,



**Figure 1.** Novel records of Brown Anoles (*Norops sagrei*) from Honduras. **a.** Adult female in Copán Ruinas, Copán (USACF000005), **b.** Adult male in Veracruz, Cortés (USACF000006), **c.** Subadult male in Danlí, El Paraíso (USACF000007), **d.** Adult male in Danlí, El Paraíso (USACF000008), **e.** Adult male in Tulín, Olancho (USACF000009), **f.** Subadult male in Cofradía, Cortés (USACF000010), **g.** Subadult male in Comayagua, Comayagua (USACF000011), **h.** Adult female in Tegucigalpa, Francisco Morazán (USACF000012).

with individuals surviving and reproducing a significant distance from the original point of introduction”.

As this species is able to rapidly colonize areas and is capable of displacing native lizards, this spread is concerning for the native fauna in Honduras (Williams 1969). These reports are of special concern given the proximity of these locations to departments (*e.g.* Choluteca, Colón, Intibucá, La Paz, Lempira, Ocotepeque and Valle) and countries (El Salvador and Nicaragua) where *N. sagrei* have not yet been recorded. It is increasingly likely that the spread of non-native *N. sagrei* will put native anoles at risk in these locations. We found *Norops mccraniei* and *Gonatodes albugularis* at the same or nearby localities as *N. sagrei* in Olancho, El Paraíso, and Francisco Morazán (CAAF and ARB, *pers. obs.*), though no direct interactions between the species were witnessed. Some interactions involving non-native lizards in urban sites in Honduras have been documented recently (Antúñez-Fonseca *et al.* 2021), and potential interactions involving non-native populations of *N. sagrei* and native lizards is also well documented (*e.g.*

Stroud *et al.* 2017, Fisher *et al.* 2020, Vásquez-Cruz *et al.* 2020).

Finally, our work serves as an opportunity to highlight the importance of citizen and community science platforms in recording the spread of nonnative taxa. Citizen science is increasingly being recognized as a critical component of documenting biological invasions (Encarnaçao *et al.* 2021), and volunteers contribute identifications and data that are valuable to the scientific community (Crall *et al.* 2011). The iNaturalist platform, for example, allows for interactions between amateurs and experts that act as data-quality filters in documenting native and non-native taxa (*e.g.* Spear *et al.* 2017, Hiller and Haelewaters 2019, Callaghan *et al.* 2020). This platform has proven useful for documenting the spread of non-native lizard species (*e.g.* Erickson and Burt 2019, Auguste and Fifi 2020) and other non-native taxa (*e.g.* Hiller and Haelewaters 2019, Encarnaçao *et al.* 2021 and references therein). Several records we report here were obtained through collaboration with users of iNaturalist, and we encourage the continued use

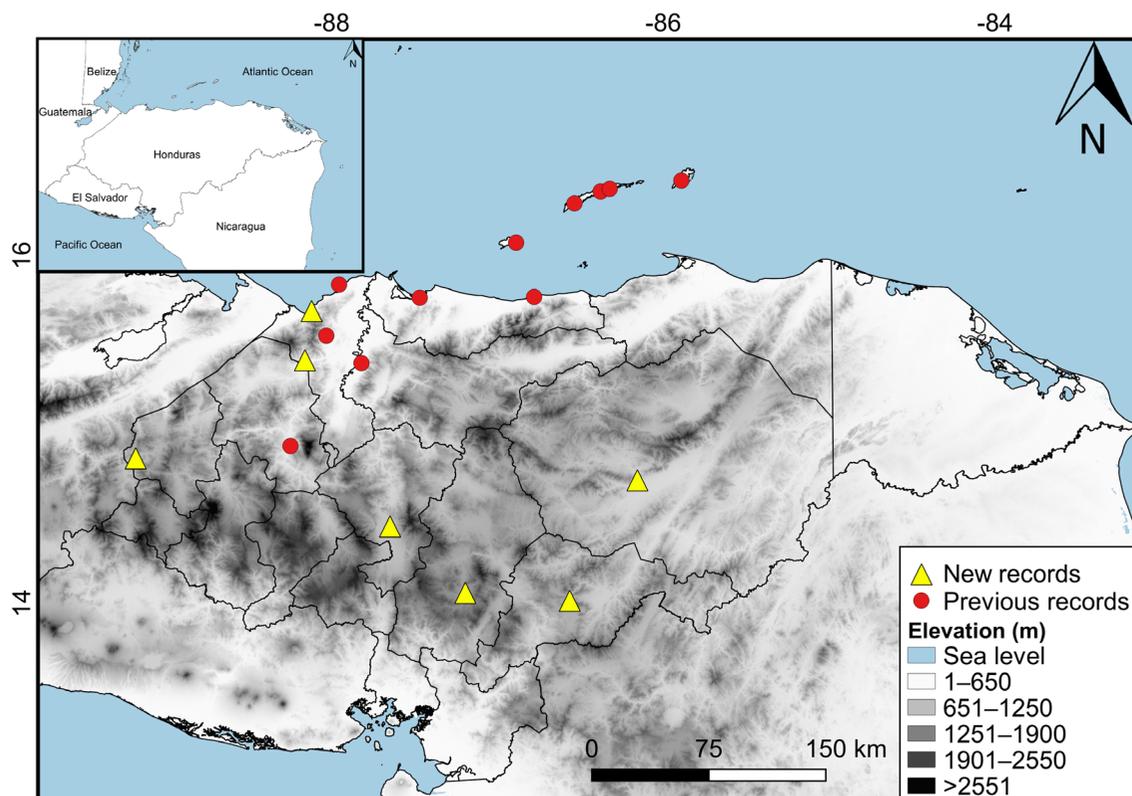


Figure 2. Geographic distribution of *Norops sagrei* in Honduras.

of this and other citizen science platforms for documenting species introductions.

## AUTHOR'S CONTRIBUTIONS

CAAF, EPH and JHT planned the study, reviewed the literature, and collected citizen science records; CAAF, AARB, DIOM, JHT, FJD, and HDR collected data; CAAF, AARB, JHT, FJD, and HDR photographed individuals; CAAF, EPH, and JHT led the writing of the manuscript with contributions from all authors. All authors reviewed and approved this paper.

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## CONFLICT OF INTEREST

The authors declare that they do not have conflict of interest.

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