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SHORT COMMUNICATION

NOCTURNAL FORAGING ACTIVITY BY THE LIZARD *AMEIVA AMEIVA* (SQUAMATA: TEIIDAE) UNDER ARTIFICIAL LIGHT

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INTRODUCTION

Urbanization is one of the main causes of biodiversity loss and biological homogenization in developed and less developed countries (Pauchard et al. 2006, Güneralp et al. 2013, Piano et al. 2019). Several studies have focused on a variety of cascading effects of urbanization that have impacts on biodiversity and ecosystem services, such as changes in biogeochemistry, climate, hydrological systems, and local temperature (see comments in Güneralp et al. 2013). A problem associated with urbanization, the occurrence of artificial light at night (also referred to as light pollution), has transformed nightscapes, with many studies reporting negative and, even, deadly effects for biodiversity (Hölker et al. 2010, Gaston & Bennie 2014, Gaston et al. 2015, Owens & Lewis 2018). The presence of artificial light increases nocturnal ambient illumination and creates a new habitat termed the "night-light niche" (Garber 1978). The use of the night-light niche by diurnal species has important biological consequences because it alters their daily activity patterns (Longcore & Rich 2004). The daily cycle of light and dark is necessary for the maintainance of life-sustaining behaviors such as foraging, rest, protection from predators and reproduction (Owens & Lewis 2018, Czarnecka et al. 2019, Touzot et al. 2019).

Ecological consequences of artificial light for different taxonomic groups have been reviewed (Rich & Longcore 2006). The effects that this light pollution has on amphibians and reptiles, however, remain poorly studied (Perry & Fisher 2006, Perry et al. 2008, Maurer et al. 2019). Among diurnal reptiles, anecdotal information about the effects of artificial light is available mainly for lizard species (Perry et al. 2008). However, there are no records for lizards of the family Teiidae. Here, we report, for the first time, a case of nocturnal foraging behavior under artificial light by the Giant Ameiva (*Ameiva ameiva*) – a known diurnal teiid lizard. We also update the list of diurnal lizard species known to respond to artificial light provided by Perry et al. (2008).

Ameiva ameiva is a medium-sized diurnal lizard that is widely distributed throughout Central and South America (Hoogmoed & de Avila-Pires 1989, Ibáñez et al. 2019). The species is commonly found in urban areas, where it takes advantage of disturbed environments due to its opportunistic behavior (Simmons et al. 2005). Behavioral observations of *A. ameiva* were made during a herpetological survey in the vicinity of human habitations in a low-density urban area in the municipality of Niquelândia (14º09'56"S, 48º20'12"W, WGS84), northern Goiás State, central Brazil (Figure 1, see study site description in Oda et al. 2017). A bibliographic search was conducted (using the Google Scholar literature search engine) to update the list of Perry et al. (2008) of diurnal lizard species known to respond to artificial light. The search terms used were: "nocturnal activity", "artificial light", and "reptiles". The journals Herpetological

Review (1967–2019), Herpetological Bulletin (2008–2018), Herpetology Notes (2008–2020), Herpetozoa (1988–2020), and Mesoamerican Herpetology (2014–2018) were also searched for articles and natural history notes. References cited by publications recovered by the primary bibliographic search were also located.

At 20:18 h, during a nocturnal survey on 3 April 2006, we observed an adult *Ameiva ameiva* foraging on the edge of a paved road near a forest remnant (Figure 1). For approximately 10 minutes, the lizard fed on insects that fell to the ground after being attracted to the artificial illumination of a streetlight. The lizard fled into the forest remnant after being disturbed by our presence. Records of diurnal lizards responding to artificial light include species of the families Agamidae, Corytophanidae, Dactyloidae, Gekkonidae, Lacertidae, Leiocephalidae, Liolaemidae, Phrynosomatidae, Scincidae, Sphaeradactylidae, and Tropiduridae (Table 1). This report, therefore, is the first of a lizard of the family Teiidae responding to artificial light and the first record of a lizard responding to artificial light in Brazil.

The bibliographic search identified twelve studies on the effects of artificial light on nine diurnal lizard species, seven of which were new records for the list of Perry et al. (2008). The new records provided by the present study increase the number of diurnal lizard species known to respond to artificial light to 41. Most of these records (75%) were in the Neotropics, especially in Central America (Table 1). The greatest number of reports in the Neotropics were related to native and invasive *Anolis* lizards (49% of the diurnal lizard species recorded in this review), which commonly forage or are otherwise active near artificial light in urban habitats (Perry et al. 2008, French et al. 2018). The data show that considerable knowledge gaps are yet to be filled with regard to field sampling in different biogeographic regions, but especially in highly-urbanized countries with diverse reptile faunas such as Australia, Mexico and Brazil (Uetz & Hošek 2019).

Exposure to artificial light has threatened a variety of invertebrate and vertebrate organisms (Rich & Longcore 2006). For nocturnal invertebrate taxa, such as insects, artificial light negatively affects movement, foraging, reproduction, and predation (Lewis et al. 2020, Owens et al. 2020). For nocturnal vertebrate taxa, such as bats, artificial light negatively affects a range of behaviors including foraging, commuting, emergence, roosting, breeding, and hibernation (Stone et al. 2015, Rowse et al. 2016).

In the case of *Ameiva ameiva*, artificial light can expose individuals to predation due to increased detectability by nocturnal predators such as birds and mammals (Tozetti et al. 2005, Filadelfo et al. 2011). Artificial light, however, can also have positive impacts for diurnal lizard species that are capable of exploiting the night-light niche. Since powerful light emitters also serve as external heat sources that allow animals to maintain their body temperature within thermal safety margins (Afsar et al. 2018), diurnal lizards can take advantage of them to extend their period of foraging activity. Another advantage, observed in brown anole lizards exposed to artificial light in the laboratory, is increased growth and reproductive output, thus improving fitness (Thawley & Kolbe 2020). In the present study, *Ameiva ameiva* likely took advantage of the night-light niche for opportunistic feeding (Garber 1978), since light emitters attract insects (Perry et al. 2008). They also used this niche to avoiding our presence, since unlit parts of roads provide escape routes (Afsar et al. 2018).

Negative and positive impacts of artificial light likely play important roles in determining which diurnal lizard species can exploit urbanized areas (Thawley & Kolbe 2020). Further research, including experimental and field studies, are needed to better understand how the activity patterns and thermal behaviors of diurnal lizard species respond to light pollution.

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Table 1. Diurnal lizard species reported responding to artificial light. Asterisk (*) indicates unpublished data provided by Perry et al. (2008).

Family/species	Location	Biogeographic realm	Source
Agamidae			
Agama agama (Linnaeus, 1758)	Douala, Littoral Region, Wouri Dept (CMR) Tchibanga, Mougoutsi Dept., Nyanga Prov. (GAB)	Afrotropics Afrotropics	Böhme (2005) Pauwels et al. (2004)
Corytophanidae			
Basiliscus basiliscus (Linnaeus, 1758)	(CRI)	Neotropics	Perry et al. (2008) *
Dactyloidae			
Anolis aeneus Gray, 1840	(GRD)	Neotropics	Perry et al. (2008) *
Anolis bimaculatus (Sparrman, 1784)	Saint Eustatius (NLD)	Neotropics	Perry et al. (2008) *
Anolis brevirostris Bocourt, 1870	Santo Domingo (DOM)	Neotropics	Bowersox et al. (1994)
Anolis carolinensis Voigt, 1832	Hawaii (USA) Mississippi (USA) Edinburg, Texas (USA)	Oceania Nearctic Nearctic	Perry & Fisher (2006) Perry et al. (2008) * McCoid & Hensley (1993)
Anolis cristatellus Duméril & Bibron, 1837	(DOM) Guana Island (VGB) San Juan (PRI)	Neotropics Neotropics Neotropics	Schwartz & Henderson (1991) Perry and Lazell (2000) Garber (1978)
Anolis cybotes Cope, 1862	Hispaniola Island (DOM and HTI)	Neotropics	Henderson & Powell (2001)
Anolis distichus Cope, 1861	Hispaniola Island (DOM and HTI)	Neotropics	Perry et al. (2008) *
Anolis equestris Merrem, 1820	Miami, Florida (USA)	Neotropics	Stroud & Giery (2013)
Anolis gingivinus Cope, 1864	(AIA) Simpson Baai (SXM)	Neotropics Neotropics	Hodge et al. (2003) Powell & Henderson (1992)
Anolis leachii Duméril & Bibron, 1837	Long Island (ATG)	Neotropics	Meurer et al. (2019)

Family/species	Location	Biogeographic realm	Source
Anolis lineatopus Gray, 1840	Kingston (JAM)	Neotropics	Rand (1967)
Anolis luteogularis Noble & Hassler, 1935	(CUB)	Neotropics	Perry et al. (2008) *
Anolis marmoratus Duméril & Bibron, 1837	(GLP)	Neotropics	Powell & Henderson (1992)
Anolis richardii Duméril & Bibron, 1837	Saint George's (GRD)	Neotropics	Perry & Fisher (2006)
Anolis sabanus Garman, 1887	Saba (NLD)	Neotropics	Powell & Henderson (1992)
Anolis sagrei Duméril & Bibron, 1837	Miami, Florida (USA) Bahamas (BHS) Southern Florida (USA) Southern Florida (USA) O'ahu, Hawaii (USA) Calderitas, Chetumal, Quintana Roo (MEX) Isla Flores, Departamento de Petén (GTM)	Neotropics Neotropics Neotropics Neotropics Oceania Neotropics Neotropics	Wilson & Porras (1983) Schwartz & Henderson (1991) Carmichael & Williams (1991) Meshaka et al. (2004) Powell (2015) Badillo-Saldaña et al. (2016) Brown & Arrivillaga (2017)
Anolis schwartzi Lazell, 1972	Sint Eustatius (NLD)	Neotropics	Powell et al. (2005)
Anolis sericeus Hallowell, 1856	Estación de Biología Los Tuxtlas, near San Andrés Tuxtla, Veracruz (MEX)	Neotropics	Badillo-Saldaña et al. (2016)
Anolis trinitatis Reinhardt & Lütken, 1862	Saint Vincent (VCT) Young Island (VCT)	Neotropics Neotropics	Perry et al. (2008) * Perry et al. (2008) *
Anolis wattsii Boulenger, 1894	Long Island (ATG)	Neotropics	Meurer et al. (2019)
Gekkonidae			
Lygodactylus capensis (Smith, 1849)	(ZAF)	Afrotropics	Perry et al. (2008) *
Phelsuma laticauda (Boettger, 1880)	Hawaii (USA) Hawaii (USA)	Oceania Oceania	Perry & Fisher (2006) Seifan et al. (2010)
Phelsuma madagascariensis Gray, 1831	Ankarafantsika Reserve (MDG)	Afrotropics	García & Vences (2002)
Lacertidae			
Darevskia rudis (Bedriaga, 1886)	Anatolia (TUR)	Paleartcic	Afsar et al. (2018)
Podarcis muralis (Laurenti, 1768)	Belgrade (SRB)	Palearctic	Carretero et al. (2012)
Leiocephalidae			
Leiocephalus carinatus Gray, 1827	Southern Florida (USA)	Neotropics	Perry et al. (2008) *
Liolaemidae			
Liolaemus tenuis tenuis (Duméril & Bibron, 1837)	Pulmari Lk., Alumine Dept., Neuquén Prov. (ARG)	Neotropics	Avila & Morando (2015)
Phrynosomatidae			
Phrynosoma asio Cope, 1864	Michoacán (MEX)	Neotropics	Raya-García (2014)
Scincidae			
Cryptoblepharus poecilopleurus (Wiegmann, 1836)	Cocos Island, Guam (USA)	Oceania	McCoid & Hensley (1993)
Lamprolepis smaragdina (Lesson, 1829)	Pohnpei (FSM)	Oceania	Perry & Buden (1999)
Sphaerodactylidae			
Gonatodes humeralis (Guichenot, 1855)	Iquitos region (PER)	Neotropics	Dixon & Soini (1975)

Family/species	Location	Biogeographic realm	Source
Gonatodes vittatus (Lichtenstein & Martens, 1856)	Talparo and Tunapuna (TTO)	Neotropics	Quesnel et al. (2002)
Sphaerodactylus cinereus Wagler, 1830	Southern Florida (USA) (HTI)	Neotropics Neotropics	Perry et al. (2008) * Perry et al. (2008) *
Sphaerodactylus difficilis Barbour, 1914	Hispaniola Island (DOM and HTI)	Neotropics	Perry et al. (2008) *
Sphaerodactylus elegans (Macleay, 1834)	Southern Florida (USA)	Neotropics	Meshaka et al. (2004)
Sphaerodactylus macrolepis Günther, 1859	Guana Island (VGB)	Neotropics	Perry & Lazell (2000)
Sphaerodactylus sputator (Sparrman, 1784)	(AIA)	Neotropics	Howard et al. (2001)
Teiidae			
Ameiva ameiva (Linnaeus, 1758)	Niquelândia, Goiás (BRA)	Neotropics	**This study**
Tropiduridae			
Plica plica (Linnaeus, 1758)	(TTO)	Neotropics	Werner & Werner (2001)

AIA, Anguilla; ARG, Argentina; ATG, Antigua and Barbuda; BHS, Bahamas; BRA, Brazil, CMR, Cameroon; CRI, Costa Rica; CUB, Cuba; DOM, Dominican Republic; FSM, Micronesia; GAB, Gabon; GLP, Guadeloupe; GRD, Grenada; GTM, Guatemala; HTI, Haiti; MDG, Madagascar; MEX, Mexico; NLD, Netherlands; PER, Peru; PRI, Puerto Rico, SRB, Serbia; SXM, Sint Maarten; TTO, Trinidad and Tobago; TUR, Turkey; USA, United States of America; VCT, Saint Vincent and the Grenadines; VGB, British Virgin Islands; ZAF, South Africa.

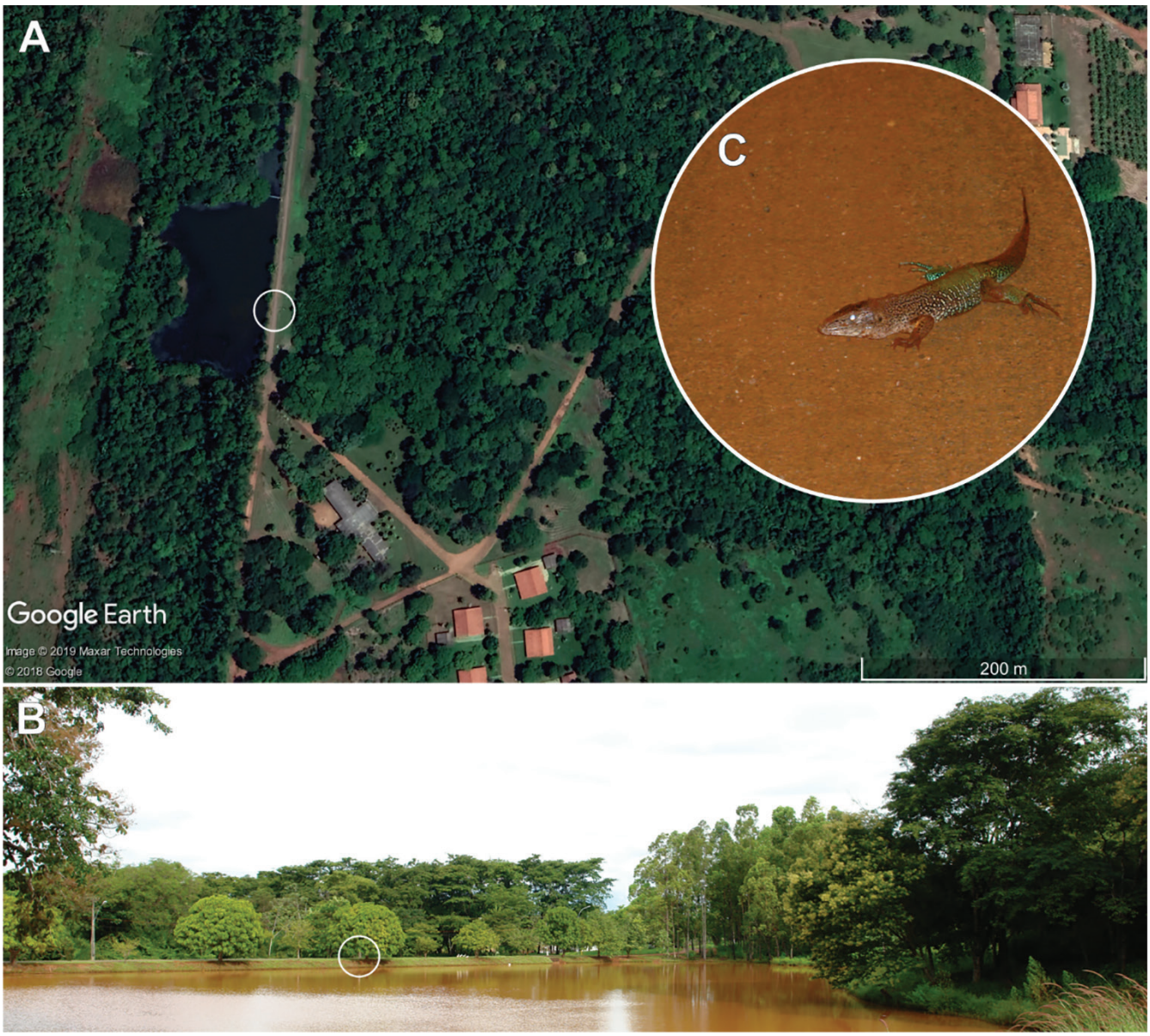

Figure 1. (A) Aerial view and (B) general landscape during the day of the study site where nocturnal foraging activity by *Ameiva ameiva* was observed (white circle represents the foraging area). (C) Adult *A. ameiva* displaying nocturnal foraging on a paved road.