Mating, courtship, and territorial behaviors of *Polychrus acutirostris* (Squamata: Polychrotidae) in a Caatinga area of Northeastern Brazil

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Parameters of an organism's life history, such as sexual maturity, survival, growth rates, and reproductive events are fundamental to the understanding of the ecology of a species (Stearns 1992). Among lizards, such parameters are often described in studies on courtship and mating behaviors, typically a set of occasional events, including cloacal rubbing in teiids, head nodding in tropidurids, dewlap extension in polychrotids, and skin darkening in leiosaurids (Carpenter, 1962; Carpenter 1977; Costa et al. 2010; Gogliath et al. 2010; Jenssen 1977; Lima & Sousa 2006; Vitt 1983).

Polychrus acutirostris (Spix, 1825) is a medium-sized, diurnal arboreal lizard with slow locomotion. This species is found in open vegetation formations in Argentina, Bolivia, Paraguay and Brazil, encompassing the phytogeographic domains of the Chaco, Cerrado and Caatinga (Cacciali et al. 2016; Garda et al. 2012; Kawashita-Ribeiro & Ávila 2008; Ribeiro et al. 2012) and is often observed near human dwellings (Vanzolini, 1974). Its diet consists predominantly of arthropods, mostly Coleoptera and Hymenoptera, and plant material such as leaves, seeds, and flowers (Vitt & Lacher 1981). Reproductive aspects indicate a short mating season, with the reproductive period occurring between September and November, producing only one clutch per season (Alvarez et al. 2005; Gainsbury

2019; Garda et al. 2012; Luedemann et al. 1977; Vitt & Lacher 1981) and female body size correlated with with mean clutch size (Winck & Rocha 2012). In this study, we report events related to the courting, copulation, and territorial behaviors of *P. acutirostris* in a Caatinga area in the state of Pernambuco, and we provide an ethogram for these events.

All events (n = 6) were recorded in rural areas, five on a private property named "Sítio Fechado" (07°17'57" S, 37°17'52" W; 791 m.a.s.l.) and one on a private property named "Sítio Degredo" (7°18'59" S, 37°16'46" W; 755 m.a.s.l.), both in areas of Caatinga in the municipality of Brejinho, state of Pernambuco, northeastern Brazil. The area presents a semi-arid climate (BSh), hot and dry with annual precipitation of 500 - 800 mm. Vegetation physiognomy is arboreal caatinga, with some disturbed areas due to cattle and agricultural activities (Velloso et al. 2002).

The first courtship and copulation event was recorded on 15 December 2019 by JDS who subsequently observed and recorded four more copulation events. From December 2019 to January 2020, three females (A, B, and C) and one male were observed and identified based on natural markings (Sazima 1988; Bernarde et al. 2000; Fonseca et al. 2021). Each lizard was captured, photographed, and measurements were made: snout-vent length (SVL), tail length (TL), and body mass (BM) in millimeters (mm) and grams (g), respectively. The largest female was female A (SVL 137.9 mm and BM 44.63 g). This female was distinguished by size and orange dorsal spots. Female B (SVL 136.7 mm, BM 42.67 g) was identified by white dorsal patches and black stripes near the eyes. Female C (SVL 73.6 mm, BM 6.41 g) like female B, presented white dorsal patches. The male measured SVL 98.3 mm and BM 13.38 g and was identified by yellow lateral spots and a brown stripe close to the eyes.

The first record of courtship and copulation was on 15 December 2019 at 09:57 h Two individuals were on a fence, the male on top of the tail of female A (Fig. 1A). After a few minutes, he moved off and then stood on the female's head, then at 10:02 h he positioned his body on the female's back, in the opposite direction to the female (Fig. 1B). At 10:05 h, the male positioned himself in the same direction as the female, making several movements with his head and pelvic region, until he was positioned to begin copulation. From the time of hemipenis insertion, copulation continued for 16 min (Fig. 1C). During copulation, the female remained still, but copulation ended when she moved, although the male remained on top of the female. The male moved his head again and removed himself from the fe-

male. The female continued to walk on the fence and the male followed her. At 10:43 h, we collected the couple to take measurements, releasing them at the same location, where they remained still for four hours. At 14:03 h they moved to a shaded location on a climbing plant (*Passiflora edulis*), where they stayed next to each other for the rest of the day. The next day, at 09:00 h, we observed the same *P. acutirostris* couple foraging on the *P. edulis*,. Between 16 and 19 December 2019, observations continued, although only foraging and thermoregulation events were seen. On 20 December 2019, another *P. acutirostris*, female C, was seen nearby, although she did not interact with the couple.

The second courtship and copulation record was observed on 22 December 2019 at 17:28 h. The male *P. acutirostris* mounted female A, exhibited head bobbing and slow movements of his trunk and pelvic region, a behavior called "cloacal friction" (Vitt & Lacher 1981). At 17:00 h, copulation (insertion of the hemipenis) began (Fig. 1D) and lasted 27 min, after which the male dismounted but remained beside the female overnight. The next day at 10:14 h the female left the branch to forage and the male accompanied her, with no physical contact.

The third record of courtship and copulation was on 25 December 2019 at 17:05 h. A male P. acutirostris approached female A, performing head bobbing, and mounted her (Fig. 1E). He shook his pelvic region and then began copulation that lasted 21 min. After copulation, the male remained on the back of the female. Observers returned the following day at 08:00 h, and the male was still on the female, remaining until 09:12 h when she began walking.

The fourth record of courtship and copulation was on 07 January 2020 at 12:22 h. We observed similar behavior, whereby the male positioned his head on the pelvic region of female C (Fig. 1F), remaining in this position until 14:12 h when the female moved with the male on top of her. The male dismounted and stood parallel to the female with his head on top of the female's head, remaining in this position until 17:27 h, when the male again mounted the back of the female. He moved his pelvic region a few times, then began copulation (Fig. 1G), which lasted 19 min. After copulation ended, the male walked a short distance along the fence, stopped, and stayed there until the next day, while the female remained in the same place.

The fifth record of courtship and copulation was on 07 November 2020 at 17:16 h. We observed two *P. acutirostris* individuals performing the same behavior, the male on the back of female C. The female began to walk with the

male on top of her (Fig. 1H). At 17:31 h the female stopped under a branch and the male remained on her back. The next day at 06:50 h the female began to walk with the male still on her back. When she stopped (Fig. 1I), the male moved his pelvic region until he began copulation, that lasted 15 min (Fig. 1J). At the end of the copulation event, the male remained on the female's back until 13:44 h, when the male dismounted and both climbed a tree.

There are few studies describing the reproductive behavior of *P. acutirostris* (Alvarez et al. 2005; Gainsbury 2019; Garda et al. 2012; Luedemann et al. 1977; Vitt & Lacher 1981). Vitt & Lacher (1981) recorded an attempted copulation event, similar to the third event described in this study, in which the male rode on top of the female, performed copulation that lasted only a few minutes, and then remained on top of the female's back. These same authors (Vitt & Lacher 1981) observed that the female twisted her body and tried repeatedly to bite the male, who then moved away from the female, and no additional courtship and/or copulation behavior was observed. The behavior observed by these authors, in which the female fights physically and violently in an attempt to escape from a mounting male is characterized as an event of a "forced" copulation (Gogliath et al. 2010, Stamps 1983). However, in our observations, the females remained passive during all events, and after copulation the male remained close to the female and in some cases copulated again. Another copulation event was observed in captivity for *P. marmoratus* (Carvalho-Jr. & Campello 2008). The copulation event was similar to those described in this study; no aggressive behaviors were observed, although *P. marmoratus* exhibited a longer copulation period than *P. acutirostris*.

Post-copulatory follow-up occurs when males maintain proximity to females after copulation (Andersson 1994; Birkhead & Møller 1992; Birkhead & Møller 1998; Olsson & Shine 1998). This is energetically beneficial to females, reducing a female's opportunity to copulate with other males and allowing males to protect the paternity of a female's offspring (Beecher & Beecher 1979; Censky 1997; Ribeiro et al. 2011). Generally, males accompany females for an extended period of time after successful mating and this period may vary among species (Anderson & Vitt 1990; Censky 1995; Cooper & Vitt 1997; Olsson 1993; Olsson & Shine 1998; Zaldívar-Rae & Drummond 2007).

Herein, in the third and fifth events, we describe that the male remained on the back of the female after copulation for 16 h and more than 19 h, respectively. Previous observations described events where a male individual remained on the female's back for more than 24 h

(Vitt & Lacher 1981). However, this behavior can be characterized as partner guarding, which ensures insemination and aids in the post-copulatory stimulation of the female, protecting paternity by repelling other males and decreasing the chances of extra-pair copulations (Ribeiro et al. 2011).

The first record of territoriality was on 29 October 2020 at 15:00 h. Two adult *P. acutirostris* of undetermined sex were on open ground. Lizard A bit the mouth of lizard B (Fig. 2A), then lizard A walked, pulling the immobilized lizard B. Lizard A stopped and bit the mouth and head of lizard B several times (Fig. 2B). After three min, lizard B began to move, but could not escape, as it was being held by the mouth of lizard A and had head injuries. The observer approached, at which time the lizards separated and moved to different trees; no further observations were possible. The event lasted 5 min and 37 sec.

The only study that addresses the territoriality of *P. acutirostris* (Vitt & Lacher 1981) reports bobbing, swaying, extension of the dewlap, lateral presentation, lateral expansion, color change, of open mouth, and biting as aggressive behaviors. The bites reported by these same authors were occasional bites, different from our observations where one lizard held the other by the mouth and bit it several times on the mouth and head. Open mouth threats and bites have been observed in *P. peruvianus* (Gorman et al. 1969).

Ethograms are tools that consist of a list of behaviors related to a category or several behavioral categories which may encompass reproduction, rest, defense, or locomotion and include behavioral acts and their descriptions (Grier 1984; Yamamoto & Volpato 2011). Such ethograms have provided important information about lizards' behavioral repertoire, as well as the context in which some behaviors are exhibited (Greenberg 1977; Pandav et al. 2007; Patankar et al. 2013; Sánchez-Hernández et al. 2012; Trivedi et al. 2013; Torr & Shine 1994). Considering the events presented here, we built an ethogram for the behaviors related to courting and copulation of *P. acutirostris* (Tab. 1).

Our observations of mating, courtship, and territorial behaviors of *Polychrus acutirostris* contribute to the knowledge of the natural history and behavior of this lizard. There is great difficulty in reporting and/or trying to quantify these events in nature, since not all behaviors are common and may be affected by the presence of the observer. Visual records of these behaviors, although infrequent, provide a detailed view of behavioral acts (Nogueira et al. 2003, Sousa et al. 2021, Teixeira & Giovanelli 1999, Turci et al. 2009). Only one note about the reproductive behavior of *P. acutirostris* exists (Vitt

& Lacher 1981). However, our information will contribute to the understanding of strategies and tactics related to reproduction addressing behavioral displays in courtship and reproductive success "post-copulatory follow-up".

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REFERENCES

Alvarez B.B., Lions M.L., Calamante C. 2005. Breeding biology and skeletal development of *Polychrus acutirostris* (Iguania, Polychrotidae). *Facena* 21:3–27.

Andersson M .1994. Sexual selection. Princeton University Press, Princeton, NJ.

Anderson R.A., Vitt L.J. 1990. Sexual selection versus alternative causes of sexual dimorphism in teiid lizards. *Oecologia* 84: 145–157. Doi: https://doi.org/10.1007/BF00318265.

Beecher M.D., Beecher I.M. 1979. Sociobiology of bank swallows: reproductive strategy of the male. *Science* 205: 1282–1285.

Bernarde P.S., Kokubum M.N.C., Marques O.A.V. 2000. Activity and habitat use in *Thamnodynastes strigatus* (Günther, 1858), in southern Brazil (Serpentes, Colubridae). *Bulletin of the National Museum of Rio de Janeiro* 428:1–8.

Birkhead T.R., Møller A.P. 1992. Sperm Competition in birds: Evolutionary Causes and Consequences. Academic Press, London.

Birkhead T.R., Møller A.P. 1998. Sperm competition and sexual selection. Academic Press, London.

Carvalho-JR E.A.R., Campello M.L.C.B. 2008. *Polychrus marmoratus* (NCN). Mating. *Herpetological Review* 39:1–93.

Cacciali P., Scott N.J., Ortíz A.L. A., Fitzgerald L.A., Smith P. 2016. The Reptiles of Paraguay: Literature, distribution, and an annotated taxonomic checklist. *Special Publication of the Museum of Southwestern Biology* 11:1–373.

Carpenter C.C. 1962. Patterns of behavior in two Oklahoma lizards. *American Midland Naturalist* 67:132–151.

Carpenter C.C. 1977. The aggressive displays of three species of South American iguanid lizards of the genus *Tropidurus*. *Herpetologica* 33:285–289.

Censky E.J. 1995. Mating strategy and reproductive success in the teiid lizard, *Ameiva plei*. *Behaviour* 132:529–557. Doi: https://psycnet.apa.org/doi/10.1163/156853995X00199.

Costa H.C., Silva E.T., Campos P.S., Oliveira M.P.C., Nunes A.V., Campos P.S. 2010. The corpse bride: a case of Davian behaviour in the Green Ameiva (*Ameiva ameiva*) in southeastern Brazil. *Herpetology Notes* 3:79–83.

Cooper W.E., Vitt L.J. 1997. Maximizing male reproductive success in the broad-headed skink (*Eumeces laticeps*): preliminary evidence for mate guarding, size-assortative pairing, and opportunistic extra-pair mating. *Amphibia Reptilia* 18:59–73.

Fonseca W.L., Correa R.R., Oliveira A.S., Oliveira I.S., Bernarde P.S. 2021. Habitat use and activity of *Bothrops bilineatus smaragdinus* Hoge, 1966 in the western Brazilian Amazon (Serpentes: Viperidae). *Herpetology Notes* 14:567–580.

Garda A.A., Costa G.C., França F.G.R., Giugliano L.G., Leite G.S., Mesquita D.O., ... Colli G.R. 2012. Reproduction, body size, and diet of *Polychrus acutirostris* (Squamata: Polychrotidae) in two contrasting environments in Brazil. *Journal of Herpetology* 46:2–8.

Gainsbury A.M. 2019. Observations on nest-site selection of *Polychrus acutirostris* Spix, 1825 (Squamata: Polychrotidae), in the Brazilian Cerrado. *Herpetology Notes* 12:813–814.

Greenberg N. 1977. An ethogram of the blue spiny lizard, *Sceloporus cyanogenys* (Reptilia, Lacertilia, Iguanidae). *Journal of Herpetology* 11:177–195. Doi: https://doi.org/10.2307/1563139.

Grier J.W. 1984. Biology of animal behaviour. St. Louis, Times Mirror, Mosby College Publishing.

Gogliath M., Ribeiro L.B., Freire E.M.X. 2010. Forced copulation attempt in the Blue-tailed Lizard, *Micrablepharus maximiliani* (Reinhardt & Luetken, 1862) (Squamata, Gymnophthalmidae) in the Caatinga of Northeastern Brazil. *Biota Neotropica* 10:347–350. Doi: https://doi.org/10.1590/S1676-06032010000400040.

Gorman G.C., Huey R.B., Williams E.E. 1969. Cytotaxonomic studies on some unusual iguanid lizards assigned to the genera *Chamaeleolis*, *Polychrus*, *Polychroides* and *Phenacosaurus*, with behavioral notes. *Breviora* 316:1–17.

Jenssen T.A. 1977. Evolution of Anoline lizard display behavior. *American Zoologist* 17:203–215.

Kawashita-Ribeiro R.A., Ávila R.W. 2008. Reptilia, Squamata, *Polychrus* spp.: new record, range extensions, and distribution map in the State of Mato Grosso, Brazil. *Check List* 4:362–365. Doi: https://doi.org/10.15560/4.3.362.

Lima A.F.B., Sousa B.M. 2006. Court and copulation behaviors of *Enyalius perditus* Jackson, 1978 (Squamata, Leiosauridae) in captivity conditions. *Revista Brasileira de Zoociências* 8:193–197.

Nogueira C., Sawaya R.J., Martins M. 2003. Ecology of the pitviper, *Bothrops moojeni*, in the Brazilian Cerrado. *Journal of Herpetology* 37:653–659.

Luedemann G., Colli G.R., Brandão R.A.1997. *Polychrus acutirostris* (sloth). Reproduction. *Herpetological Review* 28:43.

Olsson M .1993. Male preference for large females and assortative mating for body size in the sand lizard (*Lacerta agilis*). *Behavioral Ecology and Sociobiology* 32:337–341.

Olsson M., Shine R. 1998. Chemosensory mate recognition may facilitate prolonged mate guarding by male snow skinks, *Niveoscincus microlepidus*. *Behavioral Ecology and Sociobiology* 43:359–363.

Pandav B.N., Shanbhag B.A., Saidapur S.K. 2007. Ethogram of courtship and mating behaviour of garden lizard, *Calotes versicolor*. *Current Science* 93:1164–1167.

Ribeiro L.B., Gogliath M., Sales R.F.D., Freire E.M.X. 2011. Mating behavior and female accompaniment in the whiptail lizard *Cnemidophorus ocellifer* (Squamata, Teiidae) in the Caatinga region of northeastern Brazil. *Biota Neotropica* 11:363–368.

Ribeiro S.C., Roberto I.J., Sales D.L., Ávila R.W., Almeida W.O. 2012. Amphibians and reptiles from the Araripe bioregion, northeastern Brazil. *Salamandra (Frankfurt)* 48:133–146.

Sánchez-Hernández P., Ramírez-Pinilla M.P., Molina-Borja M. 2012. Agonistic and courtship behaviour patterns in the skink *Chalcides viridanus* (Fam. Scincidae) from Tenerife. *Acta Ethologica* 15:65 –71. Doi: http://dx.doi.org/10.1007/s10211-011-0109-6.

Sazima I .1988. A behavioral biology study of jararaca, *Bothrops jararaca*, using natural marks. *Memórias do Instituto Butantan* 50:83–99.

Sousa J.D., Lima J.H.A., Almeida M.E.A., Sousa I.T.F., Almeida J.F., Kokubum M.N.C. 2021. Novel behavioral observations of the lizard *Tropi-*

durus hispidus (Squamata: Tropiduridae) in Northeastern Brazil. *Cuadernos de Herpetología* 35: 305–317.

Stamps J.A. 1983. Reptilian herbivores, a review of iguanas of the world. *Science* 220:1145–1146.

Stearns S.C. 1992. *The Evolution of Life Histories*. Oxford University Press, Oxford, Reino Unido.

Teixeira R.L., Giovanelli M. 1999. Ecology of *Tropidurus torquatus* (Sauria: Tropiduridae) from the Guriri, São Mateus-ES. *Revista Brasileira de Biologia* 59:11–18.

Trivedi J., Bayani A., Pratyush P., Suresh B. 2013. Study of egg laying behaviour of Fan-Throated Lizard, *Sitana ponticeriana* (Cuvier, 1829) from shrubland of Vadodara City, Gujarat, India. *International Research Journal of Biological Sciences* 2:74–77.

Torr G.A., Shine R. 1994. An ethogram for the small scincid lizard *Lampropholis guichenoti*. *Amphibia-Reptilia* 15:21–34.

Turci L.C.B., Albuquerque S., Bernarde P.S., Miranda D.B. 2009. Activity, habitat use, and behavior of the Bothriopsis bilineatus and of the *Bothrops atrox* (Serpentes: Viperidae) in Moa river forest, Acre – Brazil. *Biota Neotropica* 9:197–206.

Vanzolini P.E. 1974. Ecological and geographical distribution of lizards in Pernambuco, northeastern Brazil. *Papéis Avulsos de Zoologia* 25:61–90.

Velloso A.L., Sampaio E.V.S.B., Pareyn F.G.C. 2002. Ecorregions: Proposals for the Caatinga biome. Results of the Seminar of Ecorregional Planning of Caatinga / Aldeia- PE. Northeast Plants Association, Environmental Conservation Institute. The Nature *Conservancy do Brasil*, Recife.

Vitt L.J., Lacher T.E. 1981. Behavior, habitat, diet and reproduction of the iguanid lizard *Polychrus acutirostris* in the Caatinga of Northeastern Brazil. *Herpetologica* 37:53–63.

Vitt L.J. 1983. Reproduction and sexual dimorphism in the tropical teiid lizard, *Cnemidophorus ocellifera* *Copeia* 2: 359–366. Doi: https://doi.org/10.2307/1444378.

Winck G.R., Rocha C.F.D. 2012. Reproductive trends of Brazilian lizards (Reptilia, Squamata): the relationship between clutch size and body size in females. *North-Western Journal of Zoology* 8:57–62.

Yamamoto M.E., Volpato G.L. 2011. *Comportamento animal*. 2a (ed), Natal: EDUFRN. pp. 191–207.

Zaldívar-Rae J., Drummond H. 2007. Femaleaccompanimentbymalewhiptail lizards: is it mate guarding? *Behaviour* 144:1383–1402. Doi: *https://doi.org/10.1163/156853907782418187.*

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Table 1. Ethogram for the behaviors related to the territoriality, courting and copulation exhibited by the lizard *Polychrus acutirostris* in Sítio Fechado and Degredo, municipality of Brejinho, state of Pernambuco, Brazil.

Behavior	**Description**
Head bobbing	Vertical rapid movements of the head; performed by males and females before and/or after copulation.
Assemble	The male positions itself on top of the female, placing the forelimbs and posterior limbs on it and performs vibratory movements with the posterior region of the trunk, pelvis, hind limbs and tail base.
Copulation	When the cloacas come into contact, hemipenis intrusion occurs, the male then immediately holds the female with its hind limbs and positions its head on the female.
End of copulation	When the male removes the hemipenis from the female's cloaca, it can remain on the female's back, even if she moves.
Post-copulatory follow-up	After copulation the male remains close to the female and may copulate again.
Territoriality	Confrontation - When two males meet and one male bites the mouth and head of the other. Escape - when one of the lizards manages to detach and quickly flees.

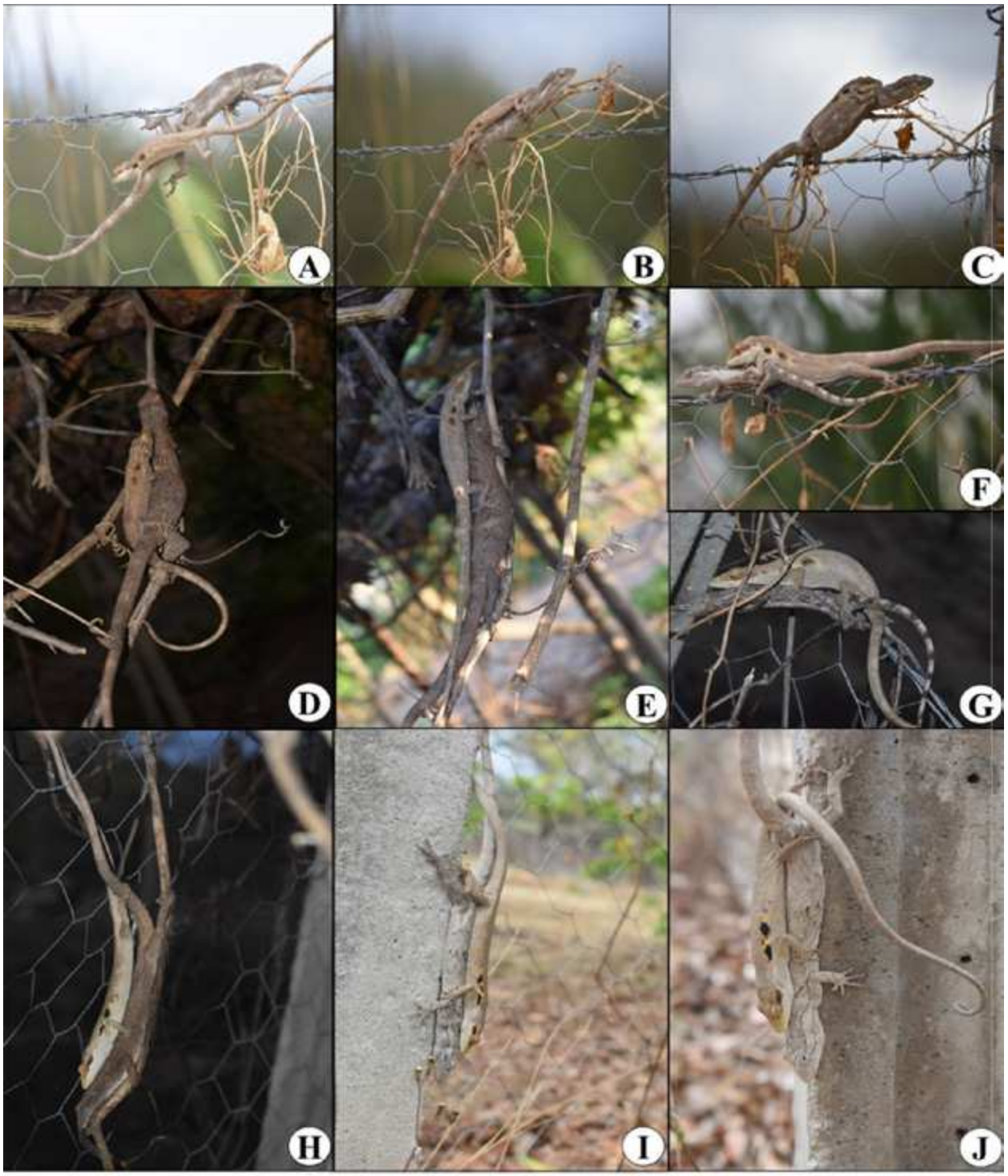

Figure 1. (A) Two *Polychrus acutirostris* individuals on a wire fence, with the smaller male on top of the female's tail; (B) The male mounted the female and faced the opposite direction; (C) The male mounted the female and performed the first copulation; (D) The male mounted the female and performed the second copulation; (E) The male mounted the female and performed the third copulation; (F) The male placed its head on the pelvic region of the female while holding it with his forefeet; (G) The male mounted the female and performed the fourth copulation. (H) Male on top of female's back under a twig; (I) Female walking on the side of a stake with male on her back; (J) The male mounted the female and performed the fifth copulation.



Figure 2. (A) Two adult lizards encountered each other on open ground, and one individual (top) bit the mouth of the other; (B) The attacking lizard (right) stood on the other (left) and continued to bite its mouth and head several times.