SHORT COMMUNICATION

Notes on the mating behavior of *Kentropyx altamazonica* (Squamata: Teiidae): first evidence of courtship display for the genus

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A wide behavioral repertoire is known for the courtship and mating events of lizards, and studying such behaviors is a key step toward understanding their reproductive strategies (Tokarz 1995, Losos 2009). As part of this behavioral repertoire, many lizards exhibit visual displays to improve recognition by the opposite sex during courtship, allowing the male to access female reproductive readiness and receptivity, and the female to choose her mate (Tokarz 1995, Losos 2009). Nevertheless, mating strategies vary depending on lifestyles of the species (Bull 2000, Zaldívar-Rae and Drummond 2007). In the case of non-territorial lizards (e.g., the family Teiidae Gray, 1827), males often actively search for females and accompany them before and after mating (mate-guarding behavior) (Bull 2000). By doing this, they can reduce access of other males to the female, mate multiple times, or stimulate the female, thereby increasing the chance of fertilization (Beecher and Beecher 1979, Zaldívar-Rae and Drummond 2007, Sales and Freire 2021).

During courtship events, lizards often exhibit visual displays that are phylogenetically conserved (Losos 2009). Considering teiid lizards, such visual displays include the male performing circular movements around the female, push-ups, gular expansions, head movements, and/or cloacal rubbing (Carpenter 1962, Quesnel 1979, Ribeiro *et al.* 2011, Costa *et al.* 2013, Sales and Freire 2021). The behavioral repertoire of lizards can be stereotypic, and several visual displays used during courtship are emitted in different contexts of social interaction, such as territoriality and aggressiveness (Barlow and Stamps 1973, Ribeiro *et al.* 2011).

Although lizards employ a wide variety of behavioral strategies in social interactions, the challenges of observing individuals of many species in natural habitats make it particularly difficult to gather behavioral data, especially for occasional events such as courtship and mating (Costa *et al.* 2013). As a result, much of the knowledge associated with these events comes from laboratory experiments and observations of captive animals (e.g., Stamps 1975, Greenberg 1977, Grassman *et al.* 1991, Lima and Sousa 2006, Pandav *et al.* 2007, 2010), while observations in natural habitats are scarce and rarely scientifically reported (e.g., Mahrdt 1976, Censky 1995, Zaldívar-Rae and Drummond 2007, Sales and Freire 2021).

During recent fieldwork in Brazilian Amazonia, JAO observed a courtship and mating event for the teiid lizard *Kentropyx altamazonica* (Cope, 1875). This diurnal and heliothermic lizard has terrestrial and sub-arboreal habits, and is endemic to Amazonia, mostly occupying its western region (Ávila-Pires 1995, Vitt *et al.* 2001). To the best of our knowledge, courtship and mating behaviors of *K. altamazonica* remain unreported in the literature. In order to expand knowledge of social interactions of this species, we describe this field observation and compare it with behavioral events reported for closely related species.

The observation occurred on 9 June 2018 (i.e., at the beginning of the regional dry season) within the limits of the protected area Reserva de Desenvolvimento Sustentável Mamirauá, on the northern bank of the Solimões River (Uarini, Amazonas state, Brazil; 03°03'47" S, 64°50'56" W, datum WGS 84). The climate in this region has a fairly uniform seasonality and is mostly hot and humid, with mean annual temperatures of 26°C and annual rainfall of 2900 mm (Alvares *et al.* 2013). This protected area is mainly composed of periodically flooded forests (*várzea* forests), subjected to the annual flood pulse of the Solimões River. Such flooded forests correspond to preferred habitats occupied by *K. altamazonica* (Ávila-Pires 1995, Vitt *et al.*

2001). Individuals of *K. altamazonica* were observed exposed on stilts of a floating lodge dedicated to ecotourism (Uakari Lodge), located on a river channel connecting the Solimões River to the Japurá River. Despite low solar incidence during the observation of the reproductive event, the air temperature during the day was high.

Individual behaviors were sampled using focal animal and all-occurrence sampling methods (Altmann 1974, Lehner 1996). The observer remained silent and at least ca. 3 m from the individuals to avoid interfering in the behavioral signals. The reproductive event was recorded using photos and video footage, with the aid of a digital camera (Canon t3i; Tokyo, Japan) and a telephoto lens (Canon EF 70-300 mm USM; Tokyo, Japan). We made a video compiling non-continuous footage freely available online (https://youtu.be/QQE634vIIps). During the observation, other people passed by at a distance of about 5 m from the individuals (apparently without interfering in the behavioral signals), but most of the time only the single observer was present. We could not confirm the sex of individuals by direct inspection, but we confirmed the sex by analyzing sexually dimorphic characteristics of the external morphology. Males of *K. altamazonica* have distinctly larger heads, hypertrophied jaw muscles, and thicker tail bases (hemipenial pouches), whereas females have comparatively smaller heads and considerably more robust abdomens (Vitt *et al.* 2001, Costa *et al.* 2013). In addition, teiid males usually have bright colors during reproductive periods (Baird *et al.* 2003), which was evident in the observed male by the presence of several bluish spots on the lateral sides of the body, and a brighter dorsum.

At 15:18 h, the two individuals of *K. altamazonica* were observed performing a series of repetitive behaviors composed of diverse body displays (interpreted as part of the courtship behavior given the later mating). During this series, the male moved in circles around the female, displaying an inflated gular region (Figure 1A–D). After short pulsed movements,

the male repeatedly raised and lowered the head (heading behavior), as well as the entire anterior body (push-up behavior) (Figure 1A–D). Periodically, the male performed inspection licks (tongue flicking) on the substrate and, sometimes, on the female's tail. The female, who remained in a central position relative to the male, rotated on its own axis and repeated body movements similar to those exhibited by the male, but with a slightly arched neck while slowly and periodically shaking the arms (wave behavior). In addition, the female also kept its mouth open, threatening to bite (Figure 1A–D) during most of the behavioral series, and occasionally slightly arched the base of its tail.

After about 90 s maintaining this behavioral series, a first attempt of mating occurred, starting with the advancement of the female toward the male, directing a bite to his neck. Quickly, the male displayed the same movement in reverse, briefly biting the female's neck, and positioning himself upon the female. This attempt did not result in effective mating due to a rapid movement by the female. A second attempt occurred a few seconds later, triggered by a new advance by the female toward the male, but again, this behavior did not result in effective mating. The individuals continued to exhibit this same repetitive behavioral series until mating finally occurred on the third attempt at 15:25 h, totaling 7 min of courtship. In this last attempt, the male rapidly jumped toward the female, and the female bit the male's neck in response (Figure 1E, F). The male quickly spun onto the female's right side and she loosened the bite. With a quick bite and a rotating movement of both individuals in body contact, the male positioned himself upon the female for mating, without further biting her (Figure 1G, H). Holding the female around the midbody with its arms, the male then attached the posterior region of his body to the right side of the female's tail base, possibly consummating the mating with an insertion of its left hemipenis. Unfortunately, behaviors emitted after this could not be monitored because of time constraints.

Our casual report of the courtship and mating behavior of *K. altamazonica* demonstrates that such events may include a set of visual displays as part of the behavioral repertoire of this species. Our observations differ considerably from that reported for the congeneric species *Kentropyx calcarata* (Spix, 1825) by the presence of a courtship behavioral repertoire (not recorded for *K. calcarata;* Costa *et al.* 2013). Although this difference potentially suggests real and relevant interspecific variation, visual displays prior to the mating of *K. calcarata* may simply not have been observed, as suggested by the authors (Costa *et al*. 2013). Our observations indicate that *K. calcarata* may exhibit a more complex courtship repertoire, but whose discovery depends on new observations.

The circular movement behavior performed by the male *K. altamazonica* around the female during the courtship has been reported as part of the behavioral repertoire of other teiids, such as *Aspidocelis costatus* (Cope, 1878) (Zaldívar-Rae and Drummond 2007) and *Ameiva tobagana* Cope, 1879 (Quesnel 1979). During consensual reproductive events of these species, mating was consummated without the male chasing or biting the female, who exhibited a passive and permissive behavior (Quesnel 1979). Females are also generally described as passive during consensual courtships and mating of other teiids (Alfonso and Torres 2012, Costa *et al*. 2013, Quesnel 1979, Sales and Freire 2016). Interestingly, our observations of visual displays emitted by the female *K. altamazonica* (great agitation, mouth opening, repetitive push-ups, and biting attempts) are also exhibited in a stereotypic manner in aggressive contexts by other lizards (Ribeiro *et al.* 2011). Because more complex courtship behaviors are unknown for the genus *Kentropyx* Spix, 1825, it is difficult to affirm whether the signals emitted by this female represent standard courtship behaviors of this species or are indicative of a forced mating event, which usually occurs in other lizards (Lima and Sousa 2006, Gogliath *et al.* 2010, Sales and Freire 2021). A consensual mating is
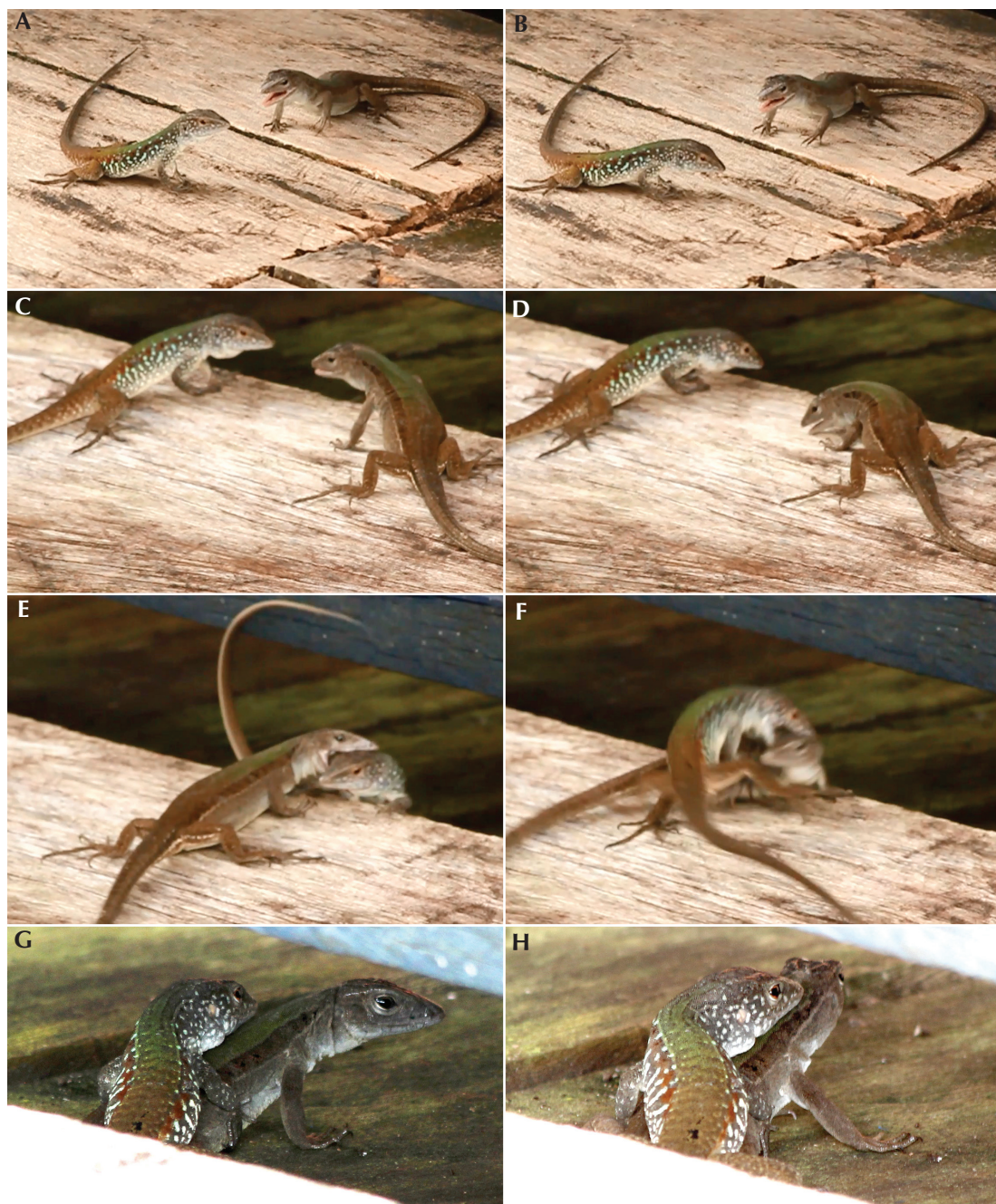
Figure 1. Courtship and mating behavior of *Kentropyx altamazonica* recorded in western Brazilian Amazonia. (**A–D**) Distinct behaviors emitted during the courtship series, with the male (on the left) circling the female, flexing the trunk and head, and keeping the gular region inflated, while the female rotated on its own axis replicating such movements, but also opening its mouth and waving its arms. (**E–F**) Pre-mating body contact, starting with a female's bite on the male neck (**E**) and then reversing positions (**F**). (**G–H**) Mating.

the most plausible hypothesis in this case, given the prior occurrence of a courtship event and the absence of continuous immobilization of the female with bites (Zaldívar-Rae and Drummond 2007, Sales and Freire 2021). Most likely visual displays exhibited by the female *K. altamazonica* in our observation are part of the courtship behavioral repertoire of the species.

Regarding the mating behavior, our observation for *K. altamazonica* was similar to that reported for the congeneric *K. calcarata*, with the male moving onto the female without biting her neck during the intromission and ejaculation phase (Costa *et al.* 2013). This mating posture has been reported for other teiids, including *A. tobagana* and *Pholidoscelis plei* (Duméril and Bibron, 1839) (Quesnel 1979, Censky 1995). Another major type of mating posture known for teiids is that in which the male bites the female's trunk and acquires an arched (ring-shaped) posture during the ejaculation phase ("doughnut posture" *sensu* Crews 1987). Such a posture has been reported for *Ameivula ocellifera* (Spix, 1825) (Sales and Freire 2021), *Pholidoscelis auberi* (Coctaeu, 1838) (Alfonso and Torres 2012) and species of the genus *Aspidoscelis* Fitzinger, 1843 (Carpenter 1962, Mahrdt 1976, Crews 1987, Anderson and Vitt 1990). The drivers of such interspecific variation in teiid mating behaviors are poorly understood. A correlation of this variation with the species' body size is likely because the "doughnut posture" seems more commonly employed by smaller-bodied teiids (e.g., Crews 1987, Sales and Freire 2021). Our casual observation for a single breeding pair of *K. altamazonica* precludes broad comparisons but provides relevant evidence for further studies dealing with the generation and maintenance of this behavioral variation.

Because of time constraints, we could not determine the post-mating behavior emitted by the breeding pair of *K. altamazonica*. Mate-guarding behavior following the mating event is expected for this species, considering that it is recurrent in teiid reproductive events (Anderson and Vitt 1990, Zaldívar-Rae and Drummond 2007, Ribeiro *et al.* 2011, Sales and Freire 2016, 2021) and provides several benefits (see Beecher and Beecher 1979, Anderson and Vitt 1990, Bull 2000, Zaldívar-Rae and Drummond 2007). Accumulated observations of teiid reproductive behavior has increasingly revealed a wider range of repertoires, and different reproductive strategies have been observed even within a single species (Sales and Freire 2016, 2021). This is the case for *A. ocellifera*, in which consensual mating (i.e., after courtship) may or may not be followed by mate-guarding behavior, and forced mating is also frequent (Sales and Freire 2016, 2021). Further studies are needed to properly assess the range of reproductive strategies and post-mating behaviors of *K. altamazonica*.

References

Alfonso, Y. U. and J. Torres. 2012. Courtship behavior in the Cuban Ameiva (*Ameiva auberi ustulata*, Squamata: Teiidae) from the Siboney-Juticí Ecological Reserve in Eastern Cuba. *Reptiles & Amphibians 19:* 85–89.

Altmann, J. 1974. Observational study of behavior: sampling methods. *Behaviour 49:* 227–266.

Alvares, C. A., J. L. Stape, P. C. Sentelhas, J. D. M. Gonçalves, and G. Sparovek. 2013. Köppen's climate classification map for Brazil. *Meteorologische Zeitschrift 22:* 711–728.

Anderson, R. A. and L. J. Vitt. 1990. Sexual selection versus alternative causes of sexual dimorphism in teiid lizards. *Oecologia 84:* 145–157.

Ávila-Pires, T. C. S. 1995. Lizards of Brazilian Amazonia (Reptilia: Squamata). *Zoologische Verhandelingen 299:* 1–706.

Baird, T. A., L. J. Vitt, T. D. Baird, W. E. Cooper Jr, J. P. Caldwell, and V. Pérez-Mellado. 2003. Social behavior and sexual dimorphism in the Bonaire whiptail, *Cnemidophorus murinus* (Squamata: Teiidae): the role of sexual selection. *Canadian Journal of Zoology 81:* 1781–1790.

Barlow, G. W. and J. A. Stamps. 1973. Variation and stereotypy in the displays of *Anolis aeneus* (Sauria: Iguanidae). *Behavior 57:* 67–94.

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

Bull, C. M. 2000. Monogamy in lizards. *Behavioural Processes 51:* 7–20.

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

Censky, E. J. 1995. Mating strategy and reproductive success in the teiid lizard *Ameiva plei. Behaviour 132:* 529–557.

Costa H. C., L. O. Drummond, J. F. R. Tonini., and J. Zaldívar-Rae. 2013. *Kentropyx calcarata* (Squamata: Teiidae): Mating behavior in the wild. *North-Western Journal of Zoology 9:* 198–200.

Crews, D. 1987. Courtship in unisexual lizards: a model for brain evolution. *Scientific American 257:* 72–77.

Gogliath, M., L. B. Ribeiro, and E. M. X. Freire. 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.

Grassman, M., D. Burton, and D. Crews. 1991. Variation in the aggressive behavior of the parthenogenetic lizard (*Cnemidophorus uniparens*, Teiidae). *International Journal of Comparative Psychology 5:* 19–35.

Greenberg, N. 1977. An ethogram of the Blue Spiny lizard, *Sceloporus cyanogenys* (Reptilia, Lacertilia, Iguanidae). *Journal of Herpetology 11:* 177–195.

Lehner, P. N. 1996. *Handbook of Ethological Methods*. 2nd ed. New York. Cambridge University Press. 541 pp.

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

Losos, J. B. 2009. *Lizards in an Evolutionary Tree: Ecology and Adaptive Radiation of Anoles*. Vol. 10. Berkeley. University of California Press.

Mahrdt, C. 1976. Courtship and copulatory behavior of *Cnemidophorus tigris tigris* (Sauria: Teiidae). *Southwestern Naturalist 21:* 252–254.

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

Pandav, B. N., B. A. Shanbhag, and S. K. Saidapur. 2010. Growth patterns and reproductive strategies in the lizard, *Calotes versicolor* raised in captivity. *Acta Herpetologica 5:* 131–142.

Quesnel, V. C. 1979. The reproductive behaviour of the lizard *Ameiva ameiva tobagana. Living World, Journal of the Trinidad and Tobago Field Naturalist's Club 1978–1979:* 16–17.

Ribeiro, L. B., M. Gogliath, R. F. D. Sales, and E. M. X. Freire. 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.

Sales, R. F. D. and E. M. X. Freire. 2016. Reproductive biology of a whiptail lizard (Teiidae: *Ameivula*) in the Brazilian Caatinga. *Salamandra 52:* 189–196.

Sales, R. F. D. and E. M. X. Freire. 2021. Reproductive behavior of Spix's Whiptails in the wild: understanding the costs and benefits of mate-guarding. *Acta Ethologica 24:* 41–51.

Stamps, J. A. 1975. Courtship patterns, estrus periods and reproductive condition in a lizard, *Anolis aeneus. Physiology and Behavior 14:* 531–535.

Tokarz, R. 1995. Mate choice in lizards: a review. *Herpetological Monographs 9:* 17–40.

Vitt L. J., S. S. Sartorius, T. C. S. Ávila-Pires, and M. C. Espósito. 2001. Life at the river's edge: ecology of *Kentropyx altamazonica* in Brazilian Amazonia. *Canadian Journal of Zoology 79:* 1855–1865.

Zaldívar-Rae, J. and H. Drummond. 2007. Female accompaniment by male whiptail lizards: is it mate guarding? *Behaviour 144:* 1383–1402.

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