SHORT COMMUNICATION

Notes on feeding and mating behavior of *Anolis* biporcatus (Squamata: Dactyloidae) in Costa Rica

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Anoles are small to midsize tree-dwelling lizards that inhabit a broad range of microhabitats along the vertical strata of Neotropical forests, ranging from those that are highly terrestrial or that occupy lower levels of the forest canopy to species that thrive in higher levels within the canopy (Losos 1994, Irschick et al. 1997). Natural history information, particularly for species that live at canopy levels like Anolis biporcatus (Wiegmann, 1834), remains scarce. This diurnal lizard can reach a total length of approximately 70-107 mm and ranges from southern Mexico to western Ecuador at elevations from near sea level to about 1220 m. a.s.l. (Savage 2002, Armstead et al. 2017). Individuals are typically green but can exhibit significant color changes (Savage 2002). Males have dewlaps with a blue center and a white base bordered by a red margin, while females possess white dewlaps without the distinctive coloration seen in males (Armstead et al. 2017).

Anolis biporcatus lays a few eggs in mosscovered branches and tends to be active during the rainy season (Fitch 1975, Leenders 2019). It also perches on trunks at heights between 20 cm to 18 m (Perez-Martinez et al. 2021) and consumes small to mid-size arthropods such as beetles, ants, and spiders (Savage 2002). Individuals are keratophagous (Rojas-Carranza and Anderson 2021) and consume small lizards as vertebrate prey (Taylor 1956). Due to its arboreal behavior, information about its diet and reproductive biology remain limited because individuals seldom descend from the canopy (but see Armstead et al. 2017, Esquivel and Vargas-Acuña 2017, Perez-Martinez et al. 2021, Rojas-Carranza and Anderson 2021). To better understand the natural history of this species, we present a series of field observations on adults of A. biporcatus at Veragua Rainforest in Las Brisas de Veragua, Limón Province, Costa Rica (9°55'21" N, 83°10'2" W, 420 m. a.s.l.).

On 19 February 2023 at approximately 13:00 h, we observed an adult female with a mid-size dragonfly in its mouth, clinging head down from the upper side of a leaf on a *Syzygium malaccense* (L.) Merr. and L. M. Perry tree at a height of

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about 2 m along an open trail (Figure 1). The lizard held its prey by the abdomen and using its jaw continually chewed its prey for about 2 minutes, holding on to the leaf using only its toes and claws. Though we did not witness the entire consumption process, given the small size of the prey relative to the lizard's body size, we expect that the lizard ingested it completely.

We classified the dragonfly as a member of the genus Gynacantha (Odonata: Anisoptera: Aeshnidae), based on the width of the base of the posterior wings and the absence of a triangular and elongated cell in this region (Esquivel 1995), thus adding adult odonates to the known diet of Anolis biporcatus. Color change has been reported several times during feeding events of A. biporcatus. Esquivel and Vargas-Acuña (2017) reported individuals transitioning from dull brown when perched to uniform green while capturing and ingesting stingless bees. Rojas-Carranza and Anderson (2021) witnessed changes from dull brown to light green on the head and upper body of an adult male while performing keratophagy of its shed skin. In contrast, Perez-Martinez et al. (2021) documented opposite color changes in A. biporcatus, shifting from a uniform green to prominent lateral stripes of contrasting dark green and yellow-green while feeding on a grasshopper. We noted that A. biporcatus was uniformly green while capturing and consuming the dragonfly; however, we did not witness any color change during consumption.

On 11 May 2023 at 13:42 h, we observed a breeding pair of *Anolis biporcatus* in a vertical, head-down position on a tree trunk at a height of 70 cm (Figure 2A). At the time of observation, both individuals were uniformly green, although the female's dorsum was darker than the male's. The male held its tail under the female's tail, with its arms and legs positioned across her back, facilitating cloacal contact while holding vertically to the tree trunk. These observations lasted about two minutes, during which no other courtship displays were witnessed. The lizards remained practically motionless, with their



Figure 1. An adult female *Anolis biporcatus* eating a dragonfly of the genus *Gynacantha* (Odonata: Anisoptera: Aeshnidae) in Veragua Rainforest, Costa Rica. Photo credit to Kenneth González Nájera.

brown-colored, curved tails positioned away from the tree trunk and their heads pointing upward in opposite directions. The male adhered to the trunk using only one of its arms and one of its legs, while the other arm held the female by the back, and the other leg surrounded the female's back.

On 15 October 2023 at 13:45 h, we observed a male *Anolis biporcatus* approaching a female that was vertically perched facing downward on a *Protium glabrum* (Rose) Engl. tree at a height of approximately 3 m (Figure 3). The male was light green, while the female looked darker than the male (Figure 3A). The male positioned itself



beside the female and held her at midbody with its arm, positioning its left leg around her inguinal region, and engaged in several dewlap displays (Figure 3B). After 10 seconds, the male proceeded to bite the female's neck for approximately minute (Figure one 3C). Subsequently, within seconds, the male changed from uniform green to green with distinct dark markings (Figure 3D) before reverting to its uniform green after approximately 30 s. The female then descended the trunk with the male on her back. After two minutes, the male began tail movements and initiated cloacal contact, maintaining this position for approximately five minutes. Both individuals repeatedly displayed

their dewlaps for about 40 min (Figure 3E–F). Next, the male and female began moving their legs, increasing cloacal contact for the next 15 minutes and continued displaying their dewlaps several times. At that moment, heavy rain began and we could not continue with the observations.

On 17 October 2023 at 14:13 h, a third party observed another breeding pair of *Anolis biporcatus* perched over a wood railing at a height of approximately 1 m, located 5 m horizontally from the previous observation site (Figure 2B). The male's dorsum was green with white markings, while the female's dorsum was lighter with faint dark green markings. The tails



Figure 3. Courtship repertoire of a pair of *Anolis biporcatus* breeding in Veragua Rainforest, Costa Rica. (A) Breeding pair's position on the tree trunk, with the light green male on top and the darker green female on bottom.
(B) Male using its left arm to hold onto the female, with its left leg positioned around her inguinal region.
(C) Male biting the back of the female. (D) Color change by the male, shifting to green with distinct dark markings. (E) Male displaying an expanded dewlap. (F) Female with an expanded dewlap.

of both individuals were brown. The pair engaged in mating behavior, with the male positioned on top of the female, holding her midbody with its arm and left leg around her inguinal region for approximately 5 minutes. The lizards oriented their heads in the same direction, and, although the male's tail was aligned with that of the female, it was curved due to cloacal contact. The pair remained motionless and no additional courtship behavior was observed on this occasion.

On 14 January 2024 at 14:38 h, we observed another breeding pair of *Anolis biporcatus* on a branch of a plant in the family Melastomataceae at about 2.5 m height (Figure 2C), close to an area of frequent human activity. The male was dark brown with clear white markings, while the female was uniformly green with faint white markings. The male positioned himself on top of the female, holding her midbody with its arm and left leg around her inguinal region for approximately 10 minutes. The male's head was positioned in the same direction as the female's but was tilted upward. The female's tail remained straight and green, while the male's tail curved downward after cloacal contact, extending toward the female's tail before curving upward again to pass under the medial section of the female's tail.

Considering limited information the available on the reproductive biology of Anolis biporcatus, our observations of its behavior provide new insights into its ecology and reproductive biology, revealing details of the courtship and copulatory behavior. After analyzing the four breeding events, we noted that both sexes of A. biporcatus use dewlap displays and have color variants (color intensity, patterns, and distribution of markings) during mating. The breeding pairs showed differences in perching angles, mating in vertical (Figure 2A), horizontal (Figure 2C), and diagonal (Figure 2C) profiles. The most common breeding position seems to be with both individuals facing downward from a vertical substrate (Figure 2A, Figure 3). These variations suggest potential individual or contextual differences in mating behavior among individuals of A. *biporcatus*, further underscoring the complexity of mating behaviors and sexual selection processes in this species.

Most anoles exhibit territoriality, wherein males defend an exclusive area containing female territories, suggesting that males may mate with multiple females, while females mate exclusively with the male residing in their territory (Kamath and Losos 2018). Whether territoriality occurs in *Anolis biporcatus* is unknown due to the limited exploration of its arboreal habits and reproductive biology. Based on parental investment, Trivers (1976) proposed that differences in male and female reproductive strategies could influence courtship behaviors and territoriality patterns in *A. garmani* Stejneger, 1899, a green Jamaican anole related to *A. biporcatus*. Further exploration is warranted on *A. biporcatus*, particularly considering its shared characteristics with *A. garmani*, Stejneger, 1899, including their canopy habitat, arboreal behavior, medium size, and distinctive color change and dewlap displays (Trivers 1976). A deeper understanding of these aspects will not only enhance our understanding of the reproductive biology of this species but also shed light on the evolution of mating behaviors in arboreal anoles.

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References

- Armstead, J. V., F. Ayala-Varela, O. Torres-Carvajal, M. J. Ryan, and S. Poe. 2017. Systematics and ecology of *Anolis biporcatus* (Squamata: Iguanidae). *Salamandra* 53: 285–293.
- Esquivel, C. 1995. *Las libélulas de Costa Rica: aportes al desarrollo sostenible*. Heredia. Universidad Nacional. 34 pp.

- Esquivel, C. and F. Vargas-Acuña. 2017. Norops biporcatus (Wiegmann, 1834). Color change during foraging. Mesoamerican Herpetology 4: 177–178.
- Fitch, H. S. 1975. Sympatry and interrelationships in Costa Rican anoles. Occasional Papers of the Museum of Natural History, University of Kansas 40: 1–60.
- Irschick, D. J., L. J. Vitt, P. A. Zani, and J. B. Losos. 1997. A comparison of the evolutionary radiations in mainland and Caribbean *Anolis* lizards. *Ecology* 78: 2191–2203.
- Kamath, A. and J. B. Losos. 2018. Estimating encounter rates as the first step of sexual selection in the lizard *Anolis sagrei. Proceedings of the Royal Society B: Biological Sciences 285:* 20172244.
- Leenders, T. 2019. *Reptiles of Costa Rica: a field guide*. New York. Cornell University Press. 531 pp.
- Losos, J. B. 1994. Integrative approaches to evolutionary ecology: Anolis lizards as model systems. Annual Review of Ecology and Systematics 25: 467–493.

- Perez-Martinez, C. A., A. Kamath, A. Herrel, and J. B. Losos. 2021. The anoles of La Selva: Niche partitioning and ecological morphology in a mainland community of *Anolis* lizards. *Breviora* 570: 1–27.
- Rojas-Carranza, A. and N. Anderson. 2021. A case of keratophagy in the neotropical Green Anole Anolis biporcatus (Wiegmann, 1834) in Costa Rica (Reptilia: Dactyloidae). Herpetology Notes 14: 411– 413.
- Savage, J. M. 2002. The Amphibians and Reptiles of Costa Rica: A Herpetofauna Between Two Continents, Between Two Seas. Chicago. Chicago. University of Chicago Press. 934 pp.
- Taylor, E. H. 1956. A review of the lizards of Costa Rica. University of Kansas Science Bulletin 38: 3–322.
- Trivers, R. 1976. Sexual selection and resource-accruing abilities in Anolis garmani. Evolution 30: 253–269.

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