REPORT OF AGGREGATION BEHAVIOR IN *ERYTHROLAMPRUS POECILOGYRUS CAESIUS* (COPE, 1862) (SERPENTES: DIPSADIDADE) IN THE DRY CHACO

NOTA DE COMPORTAMIENTO DE AGREGACIÓN EN *ERYTHROLAMPRUS POECILOGYRUS CAESIUS* (COPE, 1862) (SERPENTES: DIPSADIDADE) EN EL CHACO SECO

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Resumen.– La agregación entre individuos de la misma especie es común en la naturaleza, y ha sido bien estudiada en insectos, mamíferos, aves y peces. Entre los vertebrados, mamíferos, aves y peces son considerados los más sociales. Entre los reptiles, las serpientes también forman agregaciones para reproducción, defensa y mudas, y este comportamiento está relacionado con el reconocimiento de individuos más cercanos. Este estudio documenta los primeros registros de agregación en *Erythrolamprus poecilogyrus caesisus*. Hicimos dos observaciones en el Chaco Seco Paraguayo. En la primera observación (2016) encontramos tres adultos de *E. p. caesius* debajo de un tronco caído. La segunda observación ocurrió en tres estanques temporales (2020), donde *E. p. caesius* se agregó en grupos de cinco (juveniles), diez (juveniles y subadultos) y dos (juveniles). La agregación podría reducir los riesgos de depredación, aumentar la supervivencia o el éxito reproductivo, y podría ocurrir en respuesta a señales externas. Futuras investigaciones deben enfocarse en el contexto de la agregación y definir experimentalmente los factores que la desencadenan, y si depende de los recursos ambientales o si es parte de una interacción social.

Palabras clave.– Dieta, historia natural, reproducción, serpientes, Sudamérica, Xenodontinae.

Abstract.– Aggregation among individuals of the same species is a common spatial pattern in nature, and has been well studied in insects, mammals, birds, and fishes. Among vertebrates, mammals, birds, and fishes are considered the most social. Among reptiles, snakes also form aggregations for mating, defense, or communal shedding, and this behavior can be associated to kin and conspecific recognition. Here, we report information on the aggregation behavior in *Erythrolamprus poecilogyrus caesius*. We made two observations in the Dry Chaco of Paraguay. In the first observation (2016) we found three adults of *E. p. caesius* under a fallen trunk. The second observation occurred in three temporary ponds (2020), where *E. p. caesius* aggregated in groups of five (juveniles), ten (juveniles and sub-adults), and two (juveniles). Aggregation can reduce predation risk, increase the survival or the reproductive success, and could occur in response to external cues. Future research must focus on aggregation context and define experimentally the factors that trigger it, and whether it depends on environmental resources, or if it is part of a social interaction.

Keywords.– Diet, natural history, reproduction, snakes, South America, Xenodontinae.

Aggregation can be considered when conspecifics occurs together consistently over the year, or within a specific season during the year (Gardner et al., 2016). Aggregation among individuals of the same species is a common pattern in nature and has been reported in several groups (Gardner et al., 2016). Organismal aggregations can be organized in two groups: those that self-organize, and those that aggregate as a response of external cues such as food and reproduction, described in many organisms, such as bacteria, birds, and reptiles (Perrish & Edelstein-Keshetz, 1999). Good examples of self-organize are bird flocks, fish schools and ungulate herds (Perrish & Edelstein-Keshetz, 1999). Aggregations may occur due to mutual attraction among individuals for reproduction, as a response to environmental cues, food requirements, or defense (Parrish & Edelstein-Keshetz, 1999). Although this social behavior has been well studied, most knowledge about it comes from a small percentage of model species (Bonnet et al., 2002). This behavior has been well studied in some groups of invertebrates and vertebrates (Doody et al., 2012). Among the latter group, mammals, birds, and fishes are considered the most social animals because of the widespread incidence of large, stable aggregations, the complexity of the interactions within these social groupings, the prevalence of prolonged parental care of neonates, and the high level of social deception in some groups (Doody et al., 2012).

Reptiles have often been overlooked regarding this behavior, being usually considered asocial (Doody et al., 2013), probably due to their secretive nature (Skinner & Miller, 2020). Nevertheless, social interactions have been reported for lizards and snakes, including parental vigilance (Ibargüengoytía & Cussac, 2002; Halloy et al., 2007), aggregation for reproduction, defense, communal shedding, and hunting (Reichenbach, 1983; Larsen et al., 1993; Alexander, 2018; Clark et al., 2012; Greene et al., 2002; Shine et al., 2003, 2005). In a recent revision of aggregation in squamates, Gardner et al. (2016) compiled data of 94 species of lizards and snakes with aggregations behavior (Gardner et al., 2016). Although, most observations are reported from lizards and North American snakes, a few observations of aggregation behavior in snakes have been reported in South America. These include communal nesting in *Dipsas mikanii* (Albuquerque & Ferrarezzi, 2004; Braz et al., 2008), mating aggregations in *Boa constrictor* (Bertona & Chiaraviglio, 2003), and aggregation behavior of *Imantodes cenchoa*, likely for reproduction (Thomas, 2019). Here, we reported the aggregation behavior of *Erythrolamprus poecilogyrus caesius* in the Dry Chaco ecoregion.

Erythrolamprus poecilogyrus (Wied-Neuwiedi, 1824) is a medium-sized snake widely distributed in South America (Cacciali, 2009; Cei, 1993; Nogueira et al., 2019). This species feeds mainly on amphibians (Andrade et al., 2020; Cabral, Bueno-Villafañe, et al., 2017; Carreira, 2002), and presents both diurnal and nocturnal habits (Cacciali, 2009; Cei, 1993). Currently, four subspecies are recognized (Uetz et al., 2021): *E. p. poecilogyrus* (Wied-Neuwied, 1825), *E. p. schotti* (Schlegel, 1825), *E. p. sublineatus* (Cope, 1860), and *E. p. caesius* (Cope, 1862). The latter is the only one that occurs in the Gran Chaco (Dinerstein et al., 2017), widely distributed in Northern Argentina, Southern Bolivia, west of Brazil and Paraguay (Cacciali et al., 2016).

The observations presented here are from two localities in the Dry Chaco of Paraguay. The first observation occurred on 5 August 2016 in the Parque Nacional Defensores del Chaco headquarters, known as Fortín Madrejón (20°37'47" S, 59°52'46" W). Approximately at 09:00 h, HC found an individual of *E. p. caesius* under a fallen trunk, and after a few minutes another two individuals were spotted in the same place. After a better inspection of the trunk, some shedding skins were found, which presumably belonged to these individuals (Fig. 1). All specimens were adults, and none were collected.

Figura 1. Vista general del tronco muerto en Fortín Madrejón, sede principal del Parque Nacional Defensores del Chaco. Obsérvese las mudas que fueron acomodadas en el tronco para tomar las fotografías; ellas estaban inicialmente debajo del tronco.

Figure 1. General view of the dead trunk at Fortín Madrejón, headquarters of Parque Nacional Defensores del Chaco. Notice the number of skins that were accommodated in the trunk to take photographs; they were initially under the trunks.

The second observation occurred at the Reserva Natural Cañada el Carmen (21°37'51" S,62°20'21" W) on 17 December 2020. At 20:30h we found three temporary ponds very close to each other. In the first one (Fig. 2A), with at least 70% of water on the pond, there were at least five juveniles of *E. p. caesius*, one of which was collected as a voucher specimen (IIBP 5701). In the second and larger pond, with approximately 50% of water on the pond (Fig. 2B), there were at least 10 specimens of E. p. caesius, mostly juveniles but at least three sub-adults (Fig. 2C), where juveniles of *E. p. caesius* were preying on tadpoles of *Leptodactylus bufonius*. We collected two specimens (one sub-adult and one juvenile) in this pond (IIBP 5699 and 5702, respectively). The third and smaller pond, with 30% of water on the pond (Fig. 2D), which was approximately one meter away from the previous one, we found two juveniles of *E. p. caesius* next to a *L. bufonius* nest. Also, we have evidence that when *L. bufonius* are reproducing, individuals of *L. p. caesius* predate on tadpoles, directly from the nest (Fig. 3). It is worth mentioning that the temporary ponds were drying up. In the next day, the snakes were still on those ponds.

The Dry Chaco is a semiarid ecoregion with stressful environments and marked climatic seasonality (Cabrera, 1994; Prado, 1993), characterized by xerophytic vegetation formed by a mosaic of grasslands, savannas, open woodlands, and thorny forest (Prado, 1993). The places where we made our observations are situated in one of the warmest areas of the Dry Chaco, with maximum temperatures reaching 48°C in the hottest months (Mereles et al., 2013) and an average annual precipitation between 600 and 800 mm (SEAM, 2016). The first observation shows that, at some extent, adults of *E. p. caesius* exhibit certain level of aggregation. This could be for protection

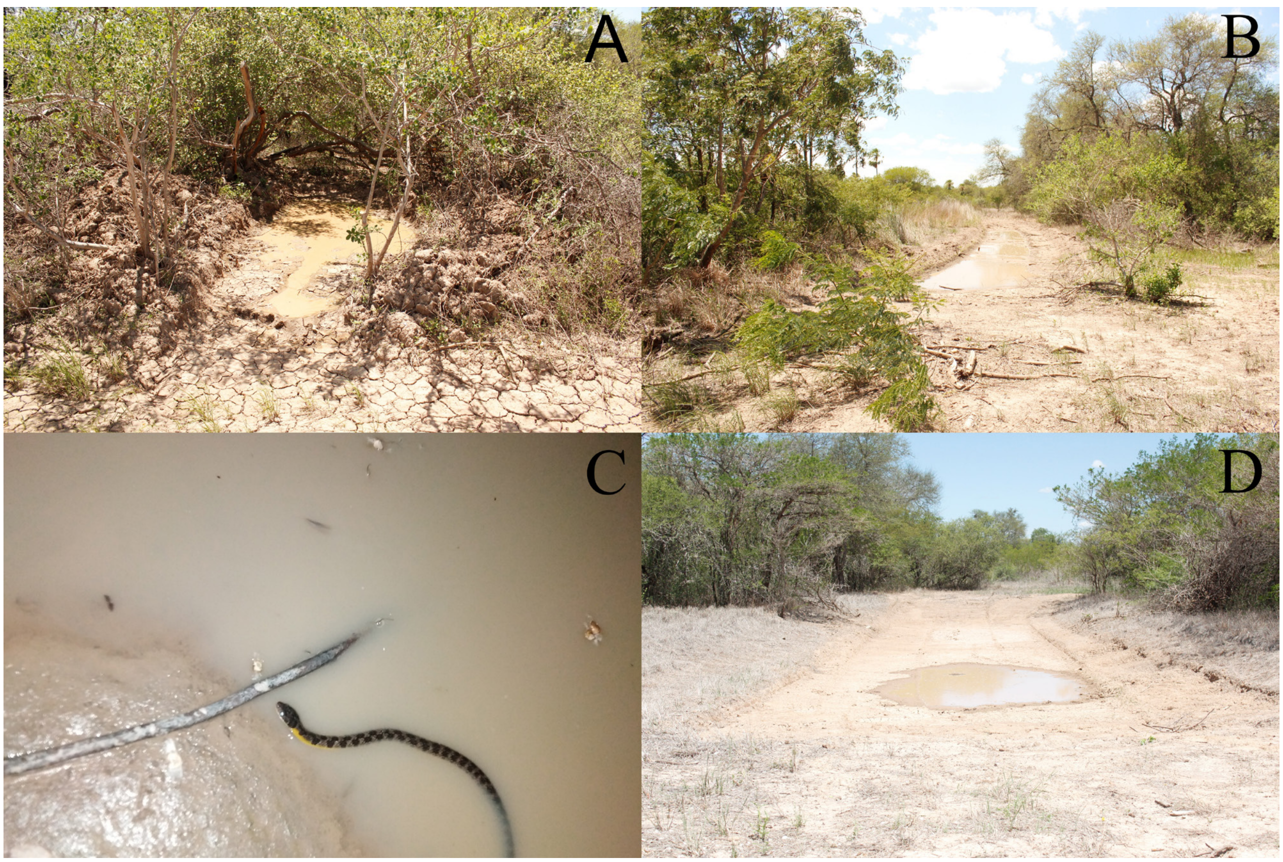

Figura 2. Vista general de la laguna temporal donde los individuos de *Erythrolamprus poecilogyrus caesius* fueron encontrados en la Reserva Cañada el Carmen. Obsérvese los diferentes tamaños de las lagunas. A) Primera laguna temporal con cinco individuos. B) Segunda laguna temporal con al menos 10 ejemplares. C) Ejemplar de un subadulto de *E. p. caesius* encontrado en la segunda laguna. D) Tercera laguna, que se encontraba cerca de la laguna más pequeña donde observamos dos ejemplares.

Figure 2. General view of the temporary pond where individuals of *Erythrolamprus poecilygurus caesius* were found at Reserva Cañada el Carmen. Notice the different size of ponds. A) The first pond with five individuals. B) The second pond with at least 10 individuals. C) Exemplar of a subadult of *E. p. caesius* found at the second pond. D) The third pond was near at 2 meters to the smallest pond where we spotted two individuals.

Figura 3. Depredación de renacuajos de *Leptodactylus bufonius* por *E. p. caesius*, los renacuajos se encontraban dentro del nido de *L. bufonius*. En ambas observaciones, solo una cuarta parte del cuerpo de la serpiente estaba dentro del nido, después de unos segundos las serpientes abandonan el nido. A) Registro hecho el 10 de Enero 2017 cerca de Pozo Hondo (22°19'47" S, 62°31'44" W), Departamento de Boquerón, Paraguay fotografía de Tatiana Galluppi. B) Registro hecho el 20 de Octubre 2019 en Porto Murtinho (21°41'11" S,57°42'40" W), Mato Grosso do Sul, Brasil.

Figure 3. Predation of tadpoles of *Leptodactylus bufonius* by *E. p. caesius*, tapdoles were inside the nest of *L. bufonius*. In both observations, only one-quarter of the snake body was inside the nest, after a few seconds the snakes leave the nest. A) Record on 10 January 2017 Near Pozo Hondo (22°19'47"S, 62°31'44"W), Boquerón Department, photo by Tatiana Galluppi. B) Record on 20 October 2019 in Porto Murtinho (21°41'11"S,57°42'40"W), Mato Grosso do Sul, Brazil.

against predators and maybe for reproduction, since the species exhibit a continuous reproductive cycle through the entire year (Vitt, 1983; Pinto & Fernandes, 2004; Quintella et al., 2017) although we cannot be sure since we could not determine sex of the observed specimens. The other observations are probably an aggrupation of newborns for protection and feeding, or maybe, they were born in the pond and stayed nearby to take advantage of the remaining water, the shelter it provides in such extreme environments and its amphibians (food) occupants. Apparently, juveniles of the species have an opportunistic behavior for feeding (Cabral et al., 2017). Although it was not yet reported for the species, this behavior could be associated with site fidelity, taking advantage of available resources to survive in extreme conditions, and the absence of any other water resources near for the species to subsist.

Aggregation may occur in response to external cues, such as food finding strategies, which is enhanced in aggregations (Calvert et al., 1979). Also, it has been demonstrated that aggregation could reduce predation rates through predation saturation or dilution (Calvert et al., 1979), thus increasing the survival or reproductive success of organisms (Parrish & Edelstein-Keshetz, 1999). Many features of Squamata, such as limited parental care, cooperation, reproduction, and diet strategies, make of this taxon an ideal group for the study of sociality, which has increased considerably since the early 2000s (Gardner et al., 2016). Nevertheless, data on aggregation are still scarce in Squamata and we consider that observations reporting new aggregation in species such as those of this study could help to improve our understanding of the evolution of sociability. Information reported here, provide us a better understanding of how many species exhibit stable aggregations, filling the gaps in the knowledge of this behavior, and how aggregation is reflected in the phylogeny, making possible the comparisons between different groups. Future research must focus on aggregation context and define experimentally what trigger aggrupation, and whether it depends on environmental resources, like shelter or food, or if it is part of a social interaction between conspecifics with communication, chemical signals, and kin recognition.

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