

Habitat selection of the Central American boa *Boa imperator* (Serpentes, Boidae) in a pasture landscape of Costa Rica

Selección del hábitat de la boa centroamericana *Boa imperator* (Serpentes, Boidae) en un pastizal de Costa Rica

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ABSTRACT

The Central American boa has large populations, a wide distribution and inhabits natural, and anthropized environments alike. However, human activity can negatively affect some populations' viability, raising the need for conservation plans. Knowing the habitat requirements is essential in order to apply corrective measures, such as translocation programs, but also to establish control policies in the places where this species may be invasive. In this study, we monitored nine radio tagged Central American boas, five of them were translocated, in pasturelands of Costa Rica. The snakes behaved as a sit and wait predator, hiding in holes or shelters most of the time (76 % of locations) and passing up to 36 days in the same hole. Home ranges (MPCs: 4.85-54.39 ha) did not show differences between sexes or between translocated and resident individuals. Analyses on relation of available and used habitat pointed out that the Central American boa selected positively buildings, crops and riparian habitats while avoiding forests and pasturelands. Two snakes did not perform habitat selection while the remaining seven showed great variability, selecting each snake different habitat types. Hence, this study shows that the Central American boa behaves as a generalist species that benefits by inhabiting human transformed ecosystems. This, combined with the fact that it remains hidden most of the time, makes locating and removing strategies difficult, enhancing its invasive potential.

Keywords: Generalist, home range, radiotracking, sit-and-wait, translocated snakes.

RESUMEN

La boa centroamericana mantiene poblaciones abundantes, una amplia distribución y habita entornos naturales y antropizados. Sin embargo, la actividad humana puede afectar negativamente la viabilidad de algunas poblaciones que podrían necesitar la adopción de medidas de conservación. Conocer sus requerimientos de hábitat resulta imprescindible para implementar medidas correctivas, tales como

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programas de translocación. También lo es para la aplicación de políticas de control en aquellos lugares donde esta especie invasiva pudiera establecerse. En este estudio realizamos el radioseguimiento de nueve boas centroamericanas, cinco de ellas translocadas, en pastizales de Costa Rica. Las serpientes se comportaron como depredadores acechadores, permaneciendo escondidas en cavidades o refugios la mayor parte (76 %), llegando a ocupar una misma cavidad hasta 36 días. No se observaron diferencias entre sexos ni entre individuos residentes y translocados en la extensión del dominio vital (MPCs=4.85-54.39 ha). Los análisis sobre la relación entre el uso y la disponibilidad del hábitat indicaron que esta especie seleccionó positivamente edificaciones, cultivos y hábitats riparios, evitando bosques y pastizales. Dos serpientes no realizaron selección de hábitat, mientras que las siete restantes mostraron gran variabilidad, seleccionando diferentes tipos de hábitat. Este estudio muestra que la boa centroamericana es una especie generalista que se beneficia ocupando ecosistemas transformados por el hombre. Esto, unido a que la mayor parte del tiempo permanece oculta, puede dificultar la adopción de medidas para su localización y erradicación, aumentando el potencial invasivo de la especie.

Palabras clave: Acecho, dominio vital, generalista, radioseguimiento, serpientes translocadas.

INTRODUCTION

Large predators play important ecological roles in many ecosystems, however, they are sensitive to habitat changes and perturbation (Bouskila 1995, Pearson *et al.* 2005, Luiselli 2006). In fact, habitat loss is the primary driver of species imperilment and extinction (Mayor *et al.* 2009). Recently, the number of studies on large snakes has increased as a consequence of the invasion of some species, since many snakes escape while being held as pets (Hart *et al.* 2015, Walters *et al.* 2016, Bartoszek *et al.* 2021, Smith *et al.* 2021). This emphasized the study of those invasive species in their native distribution areas (Shine *et al.* 2019, Smith *et al.* 2021), for example, several large python species from Australia (Pearson *et al.* 2003, Pearson *et al.* 2005).

The knowledge of the home ranges and habitat selection of large snakes are imperative to the correct management of these species (Hart *et al.* 2015, Rivas 2015, Walters *et al.* 2016, De La Quintana *et al.* 2017, Smaniotto *et al.* 2020). The study of habitat selection and habitat use are crucial for understanding the biological requirements of animals and the strategies they use to fulfill their needs (Freitas *et al.* 2008), because habitat selection links individuals to the resources required for survival and reproduction (Leclerc *et al.* 2016). Some large snake species have invaded new areas in both continental and insular areas, showing good adaptive capabilities in the new areas (Romero-N *et al.* 2006, Hart *et al.* 2015, Walters *et al.* 2016, Khan 2018).

However, in their native distributions many populations are affected by habitat degradation and environmental changes (Shine *et al.* 1999, Pearson *et al.* 2005). Especially in anthropic areas, like urban, suburban and agricultural environments, snakes are exposed to higher perturbation. The study of home range and habitat selection in these environments provide basic information for conservation measures (Romero-N *et al.* 2006, Reed and Rodda 2009, Bartoszek *et al.* 2021). For instance, agricultural intensification, one of the major threats to biodiversity (Donald *et al.* 2001, Foley *et al.* 2005, Wisler *et al.* 2008), and the conversion of pristine habitats to farmland and efforts at increasing yield of existing crops contribute to a decline in species richness (Donald and Evans 2006). This procedure often leads to a replacement of highly adapted specialists by habitat generalists of low conservation concern (Julliard *et al.* 2004).

The Central American boa (*Boa imperator* Daudin, 1803) is a species which does not reach body sizes of the largest constrictor snakes such as anacondas and pythons (Reed and Rodda 2009), but it is very common and, thus, has an important effect on species richness and diversity in tropical regions (Pough *et al.* 2001, Eichhorn 2016). Its distribution range covers the west and east coastal area from Mexico to the west of Andean mountains in Colombia. This species inhabits different environments from sea level to 1000 m, ranging from pristine rain forests to mangroves and dry shrub lands, but is also frequently encountered in

plantations and peri-urban areas (Duque-T *et al.* c2024). It utilizes both active foraging and ambush strategies to capture a broad variety of prey that includes reptiles, birds and mammals of small and medium size (Reeds and Rodda 2009, Duque-T *et al.* c2024). This information on its behavior and habitat use in the field mainly proceeds from transect sampling and occasional encounters (Romero-N *et al.* 2006). However, due to the cryptic nature of snakes, these data are most likely showing an incomplete image of their ecology and the use of radio emitters has become an essential tool in the study of spatial ecology in snakes (Reed *et al.* 2007). Moreover, previous telemetry studies on Central American boas were performed on island environments using small sample sizes or short-term studies (Montgomery and Rand 1978, Holtzman *et al.* 2007, Reed *et al.* 2007).

The Central American boa was listed as a Least Concern species in the Red List of Threatened Species because it has large populations and a wide and increasing distribution (Montgomery and da Cunha c2018). However, human presence negatively affects boa populations as locals capture them as pets or kill them for their skin, meat and fat, or when the snakes predate on domestic animals. Thus, persecution and intense traffic-related mortality seems to have decimated some populations of the Central American boa in Honduras and Ecuador (Reed *et al.* 2007, Duque-T *et al.* c2024). Hence, the general status of this abundant species is not incompatible with the fact that some populations' viability is compromised, raising the need for conservation plans. The translocation of individuals is a tool that allows reestablishing those threatened populations. However, it has to be proven beforehand that the translocated individuals are able to survive and adapt. For that, it is useful to compare the behavior and habitat use of both translocated and native cohorts (Newman *et al.* 2019).

Usually, it is easier for generalist species to adapt to different types of environments, allowing their survival, reproduction and the establishment of viable populations beyond their original distribution range. In fact, the Central American boa established a breeding population after the liberation of 10-30 individuals in 1971 in the Mexican island of Cozumel (Martínez-M and Cuarón 1999, Romero-N *et al.* 2006, Vázquez-D *et al.* 2012, Suárez-A *et al.* 2019). However, it is not currently known to have established any other breeding population (Krysko c2017),

the fact that it is widely transported as part of pet trade and frequently appears as stowaways in cargo shipments (Burger 2018) is concerning.

Hence, the aim of this study is to improve the knowledge of the spatial ecology of the Central American boa and to evaluate if the translocation of individuals affects movement patterns, habitat use or home range sizes. Considering the generalist character of Central American boa described in previous studies (Reed and Rodda 2009, Duque-T *et al.* c2024), we expect translocated individuals to behave similar to resident ones. The absence of significant differences between resident and translocated individuals could ease the viability of translocation programs. Furthermore, a generalist habitat use would imply a high capacity of the species to adapt, increasing the invasive potential of this species.

MATERIALS AND METHODS

Study Area

For this study, we used data collected between 19 March 1998 and 17 July 1999. We carried out fieldwork in a 16 km² plateau located in the surroundings of the Costa Rica Institute of Technology (hereafter TEC) at Santa Clara de San Carlos (Alajuela Province, 150 m above sea level) in the north of the Caribbean Slope of Costa Rica (10°21' North, 84°30' West). In this study site pastures occupy about 70 % of the area, since livestock farming is the major economic activity. Pasture landscape shows a typical grid appearance with fence posts or trees joined by barbed wires dividing the different plots. Main pasture species at the study time were the palisade grass *Urochloa brizantha* (A.Rich.) R.D.Webster and the African star grass *Cynodon nlemfluensis* Vanderyst, which can reach two and one meters, respectively. Another species was ratana grass *Polytrias indica* (Houtt.) Veldkamp which does not grow beyond 30 cm. Agriculture plots were also common (corn *Zea mays* L., banana *Musa x paradisiaca* L., citrus and timber species were the main crops in the study area) particularly in the surroundings of human settlements, which were usually next to roads and pathways. Finally, patches of secondary forest were also present; mostly near Peje, La Vieja, Santa Rita and San Lorenzo rivers (Mena-V 2002). Besides those four rivers, there is a large number of smaller water courses flowing through the study site. The region is non-seasonal in temperature (monthly mean tempera-

tures in the study time ranged from to 24.1° – 26.7° C) and, although the annual precipitation surpasses 3000 mm, it does experience a period of reduced rainfall from January to April. In some years, such as 1999, the dry season can be shorter and starts in February (Gómez *et al.* 2001).

Fieldwork and telemetry methods

Individuals of Central American boa were captured in the area by workers of the TEC or by farmers of the area. Captured animals were brought to the laboratory of the Clodomiro Picado Institute, where we measured Snout-Vent Length (SVL) to nearest 1 cm and weighed each individual to the nearest 1 gr. Afterwards, we implanted a radio emitter (TelonicsInc) in the snakes' body cavity using a mixture of 57 mg of ketamine and 11 mg of tiozine per kg for anesthesia and used a hollow needle to insert the antenna of the radio emitter under the snakes' dermis (Monrós 1997). All emitters weighed <5 % of the snakes' body mass. The animals were held in the laboratory for seven-fourteen days post-surgery to assure they were in good health conditions. Afterwards, each individual was released at the corresponding point of capture. When the origin was not exactly known, we released the snake in one of the different pasture plots belonging to the TEC and considered the individual as "Translocated". However, all "Translocated" individuals were from areas in a radius of 30 km from the TEC. We attempted to monitor each snake at least half of the study days but due to causes such as temporal losses after long movement of snakes or, especially in November 1998, when a flooding did not allow access to the study site, the mean value of tracking frequency is just above once every three days. At each snake location we recorded whether the individual was "sheltered" if it was completely within structural cover (e.g., hollow log, root system of a tree or building), or "not sheltered". We marked each different snake location with color plastic strips and used a compass and tape measure to relate its position to the previous location if the distance was lower than 50 m. We also draw a scheme of each location and possible reference points around it (e.g., distance and angle to a big tree, number of fence posts from the corner of the pasture plot, etc.) to facilitate future relocation. Coordinates of locations or reference points were obtained adjusting them to recent satellite images, although in case of changes in the area or that canopy prevented us to recognize the location on the satellite image, coordinates of a reference point to relate marked locations were obtained after differential correction of GPS coordinates (Moen *et al.* 1997, Rempel and Rodgers 1997).

Data analysis

We mostly followed the methodology described in similar studies (Heard *et al.* 2004, Drechsler *et al.* 2016, Bartoszek *et al.* 2021). We calculated the home range size by the Kernel method (at 90 % and at 50 % for the core area) and by the Minimal Convex Polygon (MCP) method with 100 % of the points, using the QGIS (c2018) v2.18.25 software. For the study of the home ranges, first, we discarded the existence of a correlation between home range size and the number of points or the SVL of the individuals, carrying out a Spearman correlation test. For the study of the habitat use we differentiated five habitat types: i) buildings, corresponding to man-made structures and human settlements; ii) crops, corresponding to agriculture lands; iii) livestock pastures; iv) forest areas with secondary tropical forest and v) riparian habitat, including the area with a distance of 20 m on lake, river or water courses sides.

We used the R software with the "adehabitat" package (Calenge 2006, R Studio Team c2025), to study the snake habitat selection. To do so, we considered each individual separately (Bartoszek *et al.* 2021) and, after drawing a square on the satellite images that contains all home ranges, we measured the area of each habitat type within the large square and each home range and transformed them into proportions. We analyzed the proportion of the area occupied of each habitat type within each home range, and the proportion of locations in each habitat type (Table 1). The "adehabitat" package (Calenge 2006, Manly *et al.* 2002) allowed us to evaluate which habitat is selected or avoided using the W_i value ($W_i > 1$ indicates a positive selection and $W_i < 1$ indicates an avoidance).

RESULTS

The SVL of Central American boas ranged from 103 to 194 cm (mean = 147.7; sd = 34.4; n = 9) and presented a normal distribution (Shapiro-Wilk W test = 0.9194; p = 0.38; n = 9). The SVL was distributed normally even when considering both sexes separately: males (mean = 149; s.d. = 26.8; Shapiro-Wilk W test = 0.898; p = 0.42; n = 4) and females (mean = 146.5; s.. = 42.7; Shapiro-Wilk W test = 0.867; p = 0.25; n = 5). Differences between sexes were not significant (t-test = 0.579; p = 0.58; df = 7) and differences between resident and translocated boas were also not significant (t-test = 0.627; p = 0.55; df = 7). MCP ranged from 4.85 to 54.39 ha (Table 2).

Table 1. Availability and use of each habitat type in each monitored individual. For each habitat type, we show the proportion (%) of the area it occupies of each MCP (left), and the proportion (%) of the locations found within the corresponding habitat, in relation to the total locations of the individual (right); n: total number of locations of the individual. Individuals are identified considering their origin (R=Resident; T=Translocated) and their sex (M=Male; F=Female).

Snake	Pastures	Crops	Riparian	Forest	Buildings	n
Id1TF	3.8 60.0	51.9 20.0	-	44.3 20.0	-	20
Id2RF	63.5 19.8	1.7 8.0	31.3 11.7	-	3.5 60.5	162
Id3TM	6.5 21.0	9.4 32.8	5.0 3.4	79.1 42.8	-	119
Id4TF	95.5 63.6	4.0 35.6	-	-	0.5 0.8	129
Id5TM	71.5 64.6	27.0 32.7	-	-	1.5 2.7	110
Id6RF	70.3 33.7	-	29.7 66.3	-	-	83
Id7RF	79.2 72.7	9.4 13.6	3.8 4.6	7.6 9.1	-	22
Id8TM	36.4 23.1	63.6 76.9	-	-	-	26
Id9RM	75.9 38.9	3.5 30.6	7.8 26.4	9.9 4.1	2.9 0.0	72

We recorded 743 locations after snake releases, with a mean and standard deviation of 82.6 ± 51.8 locations per snake, where 408 of them (54.9 %) did not show movement in relation to the previous contacts. We could detect significant differences in movement versus resting behaviors between the boas ($\chi^2 = 25.11; p = 0.0015; df = 8$). However, this difference was not significant when removing from the analyses the two snakes with the lowest number of locations ($\chi^2 = 11.08; p = 0.08; df = 6$), as those showed more locations with movements than resting. When movement occurred, Central American boas traveled distances up to 344.5 m daily (mean = 37,6 m; sd = 48.8; n = 293). Travel distance of each snake did not show a normal distribution (Shapiro-Wilk W test $p < 0.001$), except the two translocated snakes with the lowest location numbers (Id1TF: Shapiro Wilk W test = 0.89; $p = 0.19; n = 10$. Id8TM: Shapiro Wilk W test 0.85; $p = 0.056; n = 11$). Travel distances showed significant differences between snakes (K-W test = 22.41; $p = 0.004$).

Snakes were mainly found resting in covered environments like holes or shelters (76%, n = 732; Table 2, Fig. 1). No significant differences between males and females were observed when we pooled the locations ($\chi^2 = 0.23$;

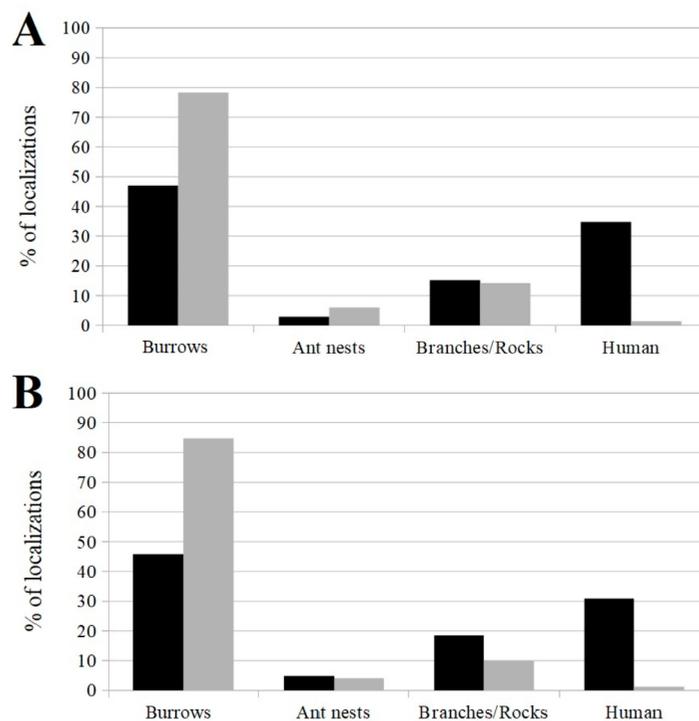


Figure 1. Representation of the percentage of locations the individuals were found in different types of holes (burrows, leaf cutter ant nests, below branches or rocks and human structures). We show the differences between resident (A, black) and translocated (A, grey) individuals and between females (B, black) and males (B, grey).

$p = 0.67$; $df = 1$). However, distribution comparisons considering each sex separately showed highly significant differences: males ($\chi^2 = 17.67$; $p = 0.0008$; $df = 1$) and females ($\chi^2 = 80.43$; $p = 0.0001$; $df = 1$). Comparisons between resident and translocated snakes also showed significant differences ($\chi^2 = 8.73$; $p = 0.002$; $df = 1$).

Home ranges calculated by the MCP method and the Kernel 90% did not have a normal distribution (MCP: Shapiro-Wilk-W test = 0.78; $p = 0.011$; Kernel 90%: Shapiro Wilk-W test = 0.76; $p = 0.007$). However, the core area, represented by the Kernel 50% was distributed normally (Shapiro-Wilk-W test = 0.88; $p = 0.14$). Home ranges did not show significant differences between sexes in any case: MCP (Mann-Whitney test $Z = 1.10$; $p = 0.28$); Kernel 90% (Mann Whitney test $Z = 0.1225$; $p = 0.9025$) and Kernel 50 % (t-test = 0.72; $p = 0.49$; $df = 7$). Furthermore, there were no significant differences in home ranges between translocated and resident individuals (MCP: Mann Whitney test $Z = 0.12$; $p = 0.9025$;

Kernel 90% Mann Whitney test $Z = 0.12$; $p = 0.9048$; Kernel 50% t-test = 0.748; $p = 0.47$).

Analyses on relation of available and used habitat pointed out that the Central American boa selected positively buildings, crops and riparian habitats while avoiding forests and pasturelands (Table 3). Considering each snake, analyses showed that seven out of nine snakes belonging to both groups (resident and translocated) performed a strong selection (Table 4). Regarding habitat selection, Id2RH represented the extreme case (Table 2). This individual showed preferences for holes in man-made structures. Indeed, for most of the study time (40 % of locations), it remained inside the metal hollow beams that supported the roof of a pigsty (26 x 13 m) where it was captured and where it returned three times over the 396 days it was monitored. It also remained for long periods in other buildings such as the floor of a poultry house that was visited on three separate occasions and the subsoil of a dairy.

Table 2. Main information of each individual. Snakes are identified considering their origin (R=Resident; T=Translocated) and their sex (M=Male; F=Female). SVL (cm), starting date of the monitoring, the days each individual was monitored and the number of locations (n). Hole use for each monitored individual: the times each individual was found hiding in holes or on the surface, maximum time in consecutive days spent in one hole (T_{max}) and mean and standard deviation of the time spent in each hole (T_{mean}), the different obtained home ranges (ha) and the cause why the monitoring ended.

	SVL	Start	Days	Holes	Surface	T_{max}	T_{mean}	n	MCP	K 90	K 50	Finished due to
Id1TF	187	19/03/98	24	12	7	6	2.20 ± 2.68	20	4.85	14.27	1.74	Killed by local
Id2RF	141	04/04/98	396	159	2	32	6.70 ± 7.20	162	5.27	3.39	0.46	End of study
Id3TM	111	23/05/98	353	97	20	36	6.50 ± 7.35	119	9.47	2.62	0.61	Signal loss
Id4TF	103	23/05/98	378	72	56	26	6.40 ± 6.40	129	15.77	23.79	4.09	Dead in burrow
Id5TM	160	23/05/98	279	87	21	19	4.92 ± 4.61	110	54.39	86.16	9.90	End of study
Id6RF	108	15/06/98	235	57	23	24	5.68 ± 7.44	83	9.71	13.31	1.98	Signal loss
Id7RF	194	07/09/98	98	10	11	18	7.40 ± 6.69	22	19.48	31.61	5.62	Signal loss
Id8TM	173	05/09/98	100	15	11	26	9.25 ± 11.44	26	9.89	9.40	2.36	Signal loss
Id9RM	152	03/01/99	195	44	28	17	6.42 ± 5.62	72	28.30	28.64	4.19	End of study

Id9RM was another individual with pronounced values of habitat selection (Table 4). In spite of inhabiting an environment with pasture predominance, it preferred crops and riparian environments. The riparian habitat also was selected positively by Id6RM where it rested at 66.3% of the locations (Table 1). Further, the individuals Id4TF and Id8TM used preferably crops although pastures were available, being Id1TF the sole individual that showed strong preferences for pastures (Table 1).

Table 3. Habitat selection of all individuals combined. W_i values >1 means positive selection. W_i values <1 means negative selection.

Habitat	W_i	SE	C lower	Cupper
Pastures	0.7907	0.1592	0.3806	1.2007
Crops	1.4661	0.4561	0.2912	2.6408
Riparian	1.4485	0.5985	-0.0931	2.9900
Forest	0.5401	0.0486	0.4149	0.6653
Buildings	7.7108	5.2658	-5.8529	21.2746

Table 4. Test of habitat selection for each snake according to Manly's selection ratio for design III. Individuals are identified considering their origin (R=Resident; T=Translocated) and their sex (M=Male; F=Female).

Snake	Khi2Lj	df	p
Id1TF	130.58	2	$p < 0.0001$
Id2RF	150.22	3	$p < 0.0001$
Id3TM	38.02	3	$p < 0.0001$
Id4TF	52.35	2	$p < 0.0001$
Id5TM	1.36	2	ns
Id6RF	28.46	1	$p < 0.0001$
Id7RF	1.32	3	ns
Id8TM	4.10	1	$p = 0.043$
Id9RM	68.62	3	$p < 0.0001$

DISCUSSION

This study analyses the spatial ecology of nine radio tagged Central American boas in pasture lands of Costa Rica, with 743 locations recorded during 16 months. Despite the number of monitored snakes is low, the sample size and the tracking duration are similar to those of other studies on large constrictor snakes (Heard *et al.* 2004, Smaniotto *et al.* 2020, Smith *et al.* 2021). In contrast, other papers such as the study about invasive Burmese pythons (*Python bivittatus* Kuhl, 1820) in southwestern Florida (Bartoszek

et al. 2021) or yellow anacondas (*Eunectes notaeus* Cope, 1862) (Smaniotto *et al.* 2020) showed a higher number of monitored snakes, but the number of locations per individual was lower. Thus, our study on the Central American boa presents a sample size comparable to other studies dealing with large constrictor snakes.

The available information about the Central American boa's habitat use shows a generalist use of the environment, as it occupies both open and closed, humid and dry, environments and even cultivated areas (Reed and Rodda 2009). This generalist character was also shown in areas the species invaded recently, like the Cozumel Island, where the abundance of Central American boas was similar in different environments (Romero-N *et al.* 2006). Our results partially confirm this, as several individuals presented no significant habitat selection independently if they were translocated or resident. However, six individuals presented a remarkable habitat selection. Some individuals selected highly anthropized environments like buildings and others resided in spaces dedicated to agriculture. The analysis of the selected habitat showed that there is a preference for anthropized environments and an avoidance of forests, which is independent of the sex or the translocation of the individuals. This contrasts with the results in Cozumel, where the species was more abundant in uninhabited areas (Romero-N *et al.* 2006).

Food abundance was suggested in the past to explain the habitat preferences in the case of carpet python *Morelia spilotta melcafeii* (Wells and Wellington 1984). This species presents an increased movement activity and a remarked concentration in disturbed areas during summer months, apparently in search of prey (Slip and Shine 1988, Heard *et al.* 2004, Baxley and Qualls 2009). In diamond pythons *Morelia spilotta spilotta* (Lacépède 1804), the preference of the species to inhabit places close to buildings was explained by higher densities of potential preys as they feed on rats, which can be found in higher densities near human settlements (Slip and Shine 1988). Buildings and cattle shelters are environments where rodents thrive and both environments must constitute a valuable source of food for the Central American boa. This hypothesis could be supported by the fact that the individual Id2FR regurgitated a rat when it was captured for the first time and, despite data about rodent abundance are not available, rats were frequently observed inside the beams that supported the roof of the pigsty.

The Central American boa spends most of the time in holes and covered shelters, a clear hunting strategy of snakes characterized by sit and wait behavior (Slip and Shine 1988, Quintino and Bicca-M 2013, Simkova *et al.* 2017). The time in holes and resting in shelter places varied individually with an extreme case of more than 60% of its time. This long time in a covered site can be due to easy prey availability (Secor 1995, Downes 2002, Zoroa *et al.* 2011, Ross and Winterhalder 2015). The frequent use of burrows or leaf cutter ant nests could also be a behavior related to facilitating the capture of preys (Reed and Rodda 2009).

In our study area, the Central American boa also presents a home range size individually variable and similar or higher than the home range sizes found in other constrictor species (Pearson *et al.* 2005, Newman *et al.* 2019, Smaniotto *et al.* 2020). We have not found differences between home ranges of males and females, agreeing with results obtained in other snake studies (Wasko and Sasa 2009, Buchnan *et al.* 2017). However, there are papers pointing out differences between sexes. For instance, in the Everglades of southwestern of Florida (USA) the males of Burmese python showed a larger home range size than females (Bartoszek *et al.* 2021). Nevertheless, studies on the same species may present variable results in different locations. For example, studying carpet pythons in two different regions, Pearson *et al.* (2005) pointed out that the comparison between male and female home range size showed larger home range size in males than females in one of the localities but not in the other.

The results of our study indicate that the Central American boa is a generalist species capable of benefitting from resources derived from human activity, just like some rodent or bird species, which show abundant populations in anthropized areas (Bernat-P *et al.* 2022). However, there are also cases where populations of the Central American boa have been decimated due to negative effects of human activity (Reed *et al.* 2007, Duque-T *et al.* 2024). Thus, in conjunction with other corrective measures like carrying out educational programs for the local population (Dodd 1993), the translocation of individuals can be a valuable tool when trying to revert this situation. As in the Newman *et al.* (2019) study on Jamaican boas, we did not find significant differences in the home range size between translocated and resident snakes but we found translocated individuals less frequently in holes, which suggests that

they tend to be more exposed due to the lack of familiarity with the environment. (Madsen and Shine 1993, Reinert and Rupert 1999, Holzman *et al.* 2007) and this could lead to an increased exposure to predation and risks associated with human activity. Indeed, the only two snakes we found dead during the study belonged to the group of translocated snakes. Id1TF was killed by locals a few weeks after we released it but this is not the case of Id4TF, since this individual was found dead in a burrow located in a revisited pasture one year after it was released. The fact that three out of the four snakes with the longest study time belonged to the group of translocated snakes, suggests that a significant proportion of individuals could survive translocation.

Furthermore, the results of this study suggest that the generalist behavior of the Central American boa, combined with the fact that individuals remain hidden most of the time, reducing their detectability by humans, caters to an important invasive potential, making a possible eradication in non-native areas difficult (Hart *et al.*, 2015). This is especially concerning when considering the popularity of the species in pet trade. The fact that the species was not yet able to establish in a wide range of environments around the globe may be due to thermal restrictions. There are no studies on Central American boas, but on Burmese pythons (Dorcas *et al.* 2011). However, in the context of climate change and global warming, more and more areas may become habitable by large constrictor snakes such as the Central American boa, representing a possibly significant threat to biodiversity.

AUTHOR CONTRIBUTIONS

JAGD, JG and JSM study design and field work; JAGD and RMD data analyses; JAGD, JG, RMD manuscript writing; All the authors discussed the manuscript.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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