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FIRST PREDATION RECORD ON THE INVASIVE LAGOMORPH *LEPUS EUROPAEUS* (LEPORIDAE) BY *BOA CONSTRICTOR* (BOIDAE) IN A SOUTHERN BRAZILIAN CERRADO PROTECTED AREA

PRIMER REGISTRO DE DEPREDACIÓN DEL LAGOMORFO INVASOR *LEPUS EUROPAEUS* (LEPORIDAE) POR *BOA CONSTRICTOR* (BOIDAE) EN UN ÁREA PROTEGIDA DEL SUR DEL CERRADO DE BRASIL

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Resumen.— Las observaciones de historia natural son resultados esenciales para descubrir aspectos desconocidos de las serpientes y sus dietas. Describimos por primera vez un evento de depredación ocasional sobre la especie invasora *Lepus europaeus* por la serpiente *Boa constrictor.* Comprender estas interacciones entre especies nativas y exóticas podría mejorar la visión sobre los impactos ecológicos que tienen las especies invasoras, especialmente en áreas naturales protegidas.

Palabras claves.— especie exotica, dieta, *Lepus europaeus*, relación de masa corporal, historia natural.

Abstract.— Natural history observations are essential to uncover unknown aspects of snake diets. Herein we describe a chance predation event upon the invasive *Lepus europaeus* by the snake *Boa constrictor*. Understanding interactions between native and alien species might shed light on the ecological impacts of invasive species, especially in protected areas.

Key words.— alien species, diet, *Lepus europaeus*, mass ratio, natural history.

Understanding trophic interactions at individual level is necessary for better insights into processes leading to intraspecific diet variation (Araújo et al., 2008; Tinker et al., 2012). Trade-offs associated with catch efficiency, nutritional yield or prey handling skills can affect predatory individual preferences, leading to hypotheses about how individuals may vary in their dietary preferences (Arnold, 1993; Svanbäck & Bolnick, 2005). Temporal or seasonal variations in abundance or quality of preferred prey and the increase in intraspecific competition can contribute to individual predators using uncommon resources, leading to niche expansion at population level (Araújo et al., 2008; Newsome et al., 2009). Thus, rare or atypical interactions, which are more difficult to detect, can play an important role in stabilizing food webs (McCann et al., 1998; Pringle & Hutchinson, 2020). Non-native species add one variable to the system, since they might as well interfere with trophic dynamics, creating new links or disrupting regular interactions (David et al., 2017). Resident alien species can compete for resources with natives, ultimately replacing their functional roles at the community level, and in the case of invasive prey, also acting as new food sources for native predators (Dick et al., 2013; Pintor & Byers, 2015).

Boa constrictor is a widespread boid snake recorded in forested and open areas from low to high elevations throughout South America (Nogueira et al., 2019). This species is active during daytime and at night and presents terrestrial and semi arboreal behaviour, occupying a variety of habitats (Martins & Oliveira, 1998; Sawaya et al., 2008; Marques et al., 2015). It is a large-bodied non-venomous snake with aglyphous dentition that

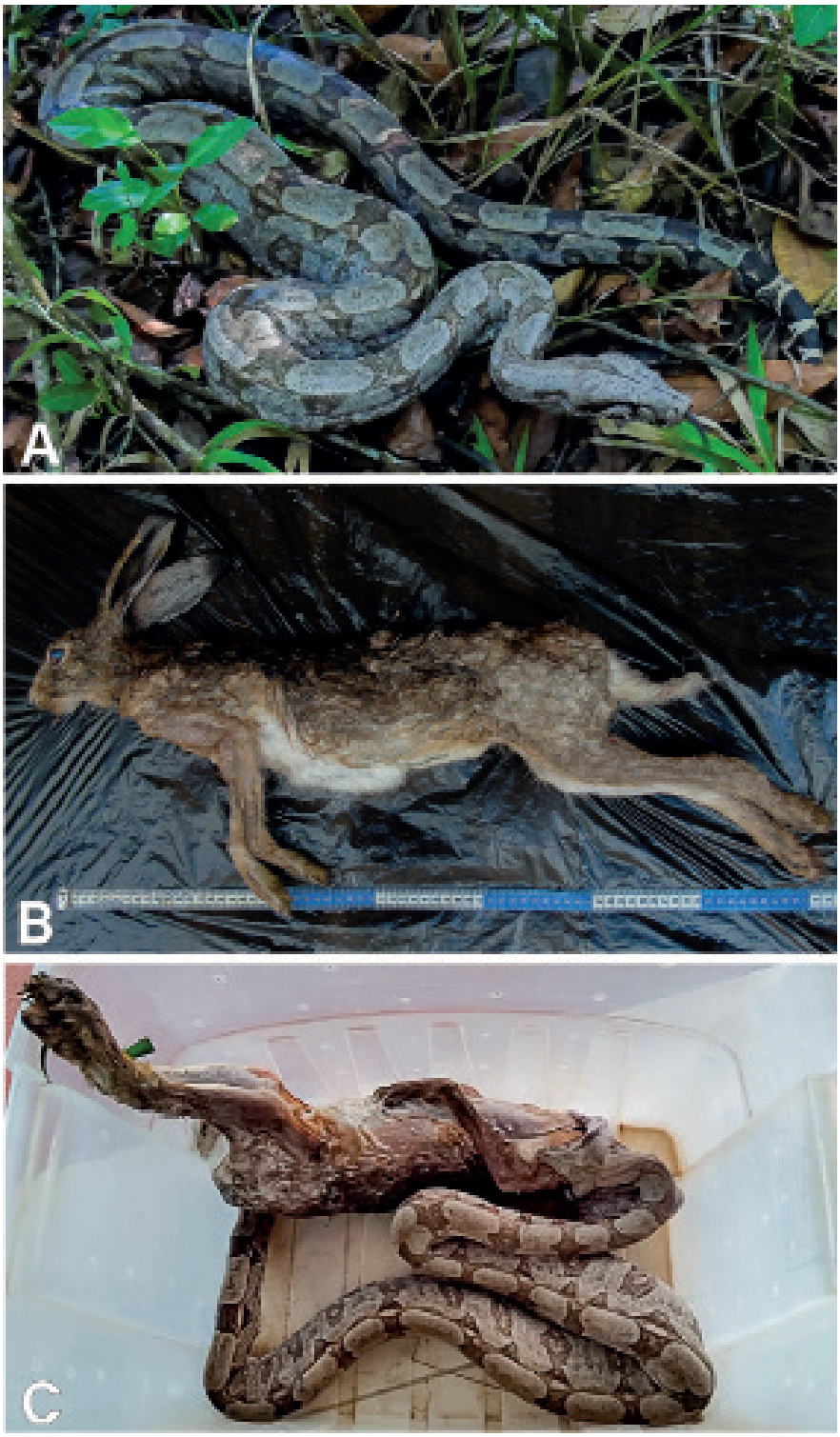

Figura 1. Individuo de *Boa constrictor* (A) que ingirió completamente un individuo de *Lepus europaeus* (B) y lo regurgitó posteriormente (C) en la Estación Ecológica Santa Bárbara, municipio de Águas de Santa Bárbara, estado de São Paulo, Brasil. Fotos (A y B) de Luciana de O. Furtado. Foto (C) de Marcos Antônio Soler ("Marcão").

Figure 1. Individual of *Boa constrictor* (A) that had fully ingested an individual of *Lepus europaeus* (B) and regurgitated it later (C) in the Santa Bárbara Ecological Station, municipality of Águas de Santa Bárbara, São Paulo state, Brazil. Photos (A and B) by Luciana de O. Furtado. Photo (C) by Marcos Antônio Soler ("Marcão").

subdues prey via body constriction, ingesting their prey often by the head (Greene, 1983; Scartozzoni & Molina, 2004; Cabral et al., 2019). Although *B. constrictor* is an abundant species, there are few specimens deposited in scientific collections, probably due to its large size and storage difficulties (Pinto-Coelho et al., 2020). Despite that, numerous published data on its diet (e.g., Martins & Oliveira, 1998; Sawaya et al., 2008; Pizzatto et al., 2009; Reed & Rodda, 2009; Bernarde & Abe, 2010; Gondim et al., 2012; Mesquita et al., 2013; Quintino & Bicca-Marques, 2013; Silva & Faggioni, 2015; Machado et al., 2018) reveal its generalist dietary habits, consuming from ectothermic vertebrates to birds and mammals (e.g., Pizzatto et al., 2009; Cabral et al., 2019). Mammal species found in the gut of *Boa constrictor* usually belong to the orders Rodentia, Didelphimorphia, and occasionally Chiroptera (Pizzatto et al., 2009; Sorrell et al., 2011; Cabral et al., 2019). In addition, there are predation records of primates (Cisneros-Heredia et al., 2005; Quintino & Bicca-Marques 2013), carnivores (Mole & Urich, 1894), and a controversial record (discussed below) of three unidentified young rabbits (Bogert & Oliver, 1945).

The European hare (*Lepus europaeus*) is an invasive species that was brought to South America in 1888 by German travellers and introduced in Argentina and Chile for the practice of hunting (Grigera & Rapoport, 1983). Since then, populations quickly spread to several countries, reaching southern Brazil around 1946 (Faria et al., 2015; Instituto Hórus, 2021). The European hare is a large (around 3.8–4.0 kg) nocturnal lagomorph, which due to its high adaptability can occupy both disturbed areas and well-preserved landscapes, where it is mostly associated with open formations, such as shrubland and grasslands (Flux & Angermann, 1990; Faria et al., 2015; Hacklander & Schai-Braun, 2019). Natural predators within its native geographical range include canids such as the red fox (*Vulpes vulpes*), the Eurasian lynx (*Lynx lynx*), goshawks (*Accipiter* spp.), and the Eurasian eagle-owl (*Bubo bubo*) (see review in Faria et al., 2015). Additionally, Stanner & Mendelssohn (1986) found evidence of the consumption of *L. europaeus* in faecal pellets of the varanid lizard *Varanus griseus*. Outside its native range, in South America, *L. europaeus* is known to be preyed upon by native canids, felids, and owls, but no ectothermic predator has been recorded (Auricchio & Olmos, 1999; Bisceglia et al., 2008; Peters et al., 2009; Magioli et al., 2014; Faria et al., 2015). We report herein a case of a boid snake (*Boa constrictor*) preying upon the invasive European hare (*Lepus europaeus*) in southeastern Brazil. As far as we know, this is the first record of a boid preying upon the European hare in South America. Additionally, we provide an allometric equation to estimate *Boa constrictor* individuals body mass based on the recorded size of the snakes.

The event was recorded on 15 December 2020, at approximately 08:00 h, in a disturbed area characterized by a plantation of "Capim-Elefante" grass (*Pennisetum purpureum*), near the headquarters of the Santa Bárbara Ecological Station (SBES), located in the municipality of Águas de Santa Bárbara, São Paulo, Brazil (22.8168° S, 49.2380° W, datum WGS84; 619 m a.s.l.). The snake was captured and taken to the laboratory inside a plastic box by the ecological station management team. Standardized measurements (snout-vent length and body mass) were taken, and after data were collected, the snake was released near the site of capture. The *L. europaeus* individual was also measured (total body length), weighted, collected and preserved in alcohol, and is deposited under field number APC 2710 at the vertebrate collection of the Universidade Federal de São Carlos (Sorocaba, São Paulo, Brazil).

To estimate the body mass and the prey/predator mass ratio of previous studies where only the snake size and prey mass were provided (e.g., Chapman, 1986: "*B. constrictor* length ~ 200 cm; prey weight = 1.7 kg;"; Ferrari et al., 2004: "*B. constrictor* length ~ 300 cm; prey weight ~ 2.0–3.0 kg"; Quintino & Bicca-Marques, 2013: "*B. constrictor* length ~ 200 cm; prey weight ~ 4.0 kg") we fitted a linear model using a polynomial function on size and body mass measurements from 168 individuals of *Boa constrictor* from Manaus, Brazil (Silveira & Bentes, *unpublished data*).

We observed a male *Boa constrictor* (143 cm snout-vent length; 3.280 kg without prey item; Fig. 1A) which had recently ingested an individual of the European hare (body length 54 cm; weight 3.495 kg; prey/predator mass ratio = 1.07; Fig. 1B). At the time of the observation, the snake was still with an extended body. During transportation the snake started to regurgitate the prey, making the rear portion of *L. europaeus* visible in the first moment, confirming a head-first ingestion (Fig. 1C).

The fitted model ($F_{2,165}$= 327, p-value < 0.001, R^2 = 0.79), resulted in the following allometric equation, where TL is the total length in centimetres and where {TL:TL R | 53 cm ≤ TL ≥ 369 cm}:

$$Mass(kg) = 3.52882 - 0.06569 \times TL + TL^2 \times 0.00035$$

Therefore, the snakes' body mass of the studies of Chapman (1986) and Quintino & Bicca-Marques, (2013) (~200cm) were estimated in ~4.3kg, while for the individual reported in Ferrari et al. (2004) (~300cm) it was estimated in ~15.1 kg . In this sense, the estimated mass ratio of the events reported by Chapman (1986), Ferrari et al. (2004), and Quintino & Bicca-Marques (2013) would be 0.39, 0.13–0.20, and 0.93, respectively.

Lepus europaeus is known to prevent fox attacks by signalling the predator that it has been detected (Holley, 1993). Signalling (bipedal position, ears erect, and with the body directly facing the predator) discourages the predator attack because adult hares are fast enough to avoid it, with foxes being successful only when catching them unaware (Holley, 1993). Thus, hares may have evolved secondary defence strategies associated with high escape speed, effective against pursuit predators (Ruxton et al., 2004). Many snakes, such as heavy-bodied viperids, pythonids and boids, are sit-and-wait ambush predators (Greene, 1997). The cryptic nature of this behaviour could be associated with the capture, subduction, and ingestion reported here, as the escape techniques of *L. europaeus* might not avoid this unfamiliar Neotropical predator, due to its short historical co-occurrence in the Neotropics.

Our record also reveals a prey/predator mass ratio never reported for *Boa constrictor* (1.07). The largest mass ratios found in the literature for this species, when both the snake and prey were weighted, corresponds to an adult male *Iguana iguana* (Linnaeus, 1758) (prey weight = 2.2 kg, B. constrictor weight = 6.85 kg, mass ratio = 0.32; Boback, 2004), and for the marsupial *Didelphis albiventris* Lund, 1840 (prey weight = 1.23 kg, *B. constrictor* weight = 4.25 kg, mass ratio = 0.29; Cabral et al., 2019). In fact, most studies on predation events by *B. constrictor* upon large prey did not report the snake mass, relying on visual estimates about the snake's size (e.g., Chapman, 1986; Ferrari et al., 2004; Quintino & Bicca-Marques, 2013, mentioned above). Considering that these studies are the ones with the largest prey items found, our record represents the highest prey/predator mass ratio reported for *B. constrictor,* with a prey item weighing around 107% of the snake body mass.

Since the snake had already fully ingested the European hare, the prey/predator mass ratio described here is not beyond the ingestion capacity of *B. constrictor*. The movement limitations imposed by such a proportionally large prey remain unknown, although we know that some snake species can consume more than 150% of their body mass in prey (Greene, 1997). The high prey/predator mass ratio found here could be explained by a trade-off between the energy costs associated with the subjugation of a large prey, and the benefits of its consumption (see Greene, 1997). As the organs involved in snake digestion have a great capacity to increase volume during prey ingestion, especially in individuals who have faced long fasting (Secor & Diamond, 2000), the risk associated with ingesting a large prey can offset the energy gain (Arnold, 1993). Moreover, although the ingestion of large prey is less frequent, its importance should not be underestimated, as the selection to increase the size of ingestible prey may be strong, even if these items are only rarely found (Shine, 1991; see Baca, 2006, for a study case of the invasive *Boa imperator* in the island of Cozumel, Mexico).

The record of the lagomorph *Lepus europaeus* as a prey item is novel for the family Boidae in South America (see Pizzato et al., 2009; Henderson & Pauers, 2012; Henderson et al., 2013). For North America, there is a record of three young rabbits for *Boa sigma* (following the taxonomy proposed by Card et al., 2016) in the Mexican state of Sonora (Bogert & Oliver, 1945). Although Reed & Rodda (2009) cite a record of *Sylvilagus* Gray, 1867 as a prey item of *B. constrictor,* this information was based on the above-mentioned record of Bogert & Oliver (1945) (see Greene, 1983). As the genera *Sylvilagus* and *Lepus* occur in the state of Sonora (Velázquez, 2012), it is not possible to determine the genus of the three young rabbits recorded as prey. Finally, the record of *B. constrictor* preying upon *Sylvilagus floridanus* in Aruba refers to an introduced population of *B. constrictor* (Quick et al., 2005).

The ecological impacts of *L. europaeus* invasion in Brazilian ecosystems are still poorly known. The niche preferences of *L. europaeus* in São Paulo state include disturbed areas, such as sugarcane plantations, abandoned pastures, and managed forests (e.g., *Eucalyptus* spp. and *Pinus* ssp. plantations), with native forests (e.g., Atlantic forest and woodland savannas formations) probably acting as a barrier for its dispersal (Pasqualotto et al., 2021). For open formations of the Cerrado, Pasqualotto et al. (2021) demonstrate that there is no clear evidence that native areas can negatively affect the occupancy by the hare. Our study area presents a management history of the presence of *Eucalyptus* spp. and *Pinus* ssp. plantations, and is inserted in a matrix of pastures, annual crops, and reforestation patches (Melo & Durigan, 2011), probably favouring the European hare occurrence. On the other hand, recent management actions within our study area have been directed to understand the impacts of the removal of *Eucalyptus* spp. and *Pinus* ssp. plantations on animal and plant species diversity. Future monitoring of the *L. europaeus* population within the SBES might inform the efficiency of these management actions on the restoration of Cerrado native vegetation and, consequently, on the maintenance of native species and on the control of invasive species. In this sense predation events such as the one reported here should be considered as an additive, and perhaps positive, effect to evaluate such management outcomes.

The predation record reported here provides evidence that interactions between an invasive species and a native predator are plausible, occurring also within preserved habitats at the range of the native species in southern Brazilian Cerrado. The

complexity of food webs makes it difficult to predict how the impacts of an invasion might propagate in the ecosystem (David et al., 2017). Specifically, the impacts of non-native species as prey for native species is poorly discussed, with the focus being often on the short-term outcomes of invasive predators in the system (Pintor & Byers, 2015). Invasive species may represent a new resource for local predators, which may imply direct positive effects on resident species at higher trophic levels (David et al., 2017). For example, Lake Eires aquatic snake population benefited from the introduction of non-native gobies fishes which now represent more than 90% of their diet (King et al., 2006). However, if the new resource is less profitable than a native resource, the long-term net effect for the native predator may be negative (see Pintor & Byers, 2015). We have no reason to believe that *L. europaeus* would represent a less profitable resource to *B. constrictor*. In fact, by representing a larger prey item than is usually reported for the species, we might consider that this interaction is rather more beneficial. On the other hand, given the tendency in snakes for the capture and consumption of larger prey (Shine, 1991; Baca, 2006), the spread of *L. europaeus* and consequent increase in the opportunity for interactions with native predators could eventually impact the structure of the local prey-predator networks, since changes in natural interactions can alter the evolutionary trajectories of species (Fricke & Svenning, 2020). Furthermore, detailed information on how the European hare interacts (directly or not) with native leporids such as *Sylvilagus* are mandatory to assess potential risks associated with this species spread and to guide future management actions (Pasqualotto et al., 2021).

Our record expands our knowledge on *B. constrictor* diet, highlighting its role as predators of an invasive species (Faria et al., 2015). It also provides evidence of the large dietary plasticity of the family Boidae. Regarding *L. europaeus* presence, this record also represents a confirmation to the species occurrence in a new locality in São Paulo state, raising to 16 records in protected areas in Brazil, and the third considering conservation units within the Cerrado domain (see Melo & Durigan, 2011; Faria et al., 2015). Understanding how native and invasive species may interact in a local community may shed light on the options available for management and conservation. That is especially relevant for the southern portion of the Brazilian Cerrado, as most of its natural areas have already been lost to pastures and monocultures (see Durigan et al., 2003), and the current system of protected areas may not be able to adequately protect its biodiversity.

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CITED LITERATURE

Araújo, M.S., P.R. Guimarães Jr., R. Svanbäck, A. Pinheiro, P. Guimarães, S.F. Reis & D.I. Bolnick. 2008. Network analysis reveals contrasting effects of intraspecific competition on individual vs. population diets. Ecology 89:1981-1993.

Arnold, S.J. 1993. Foraging theory and prey size-predator size relations in snakes. Pp. 87-112. In R. A. Seigel & J. I. Collins (Eds.), Snakes: Ecology and Behavior. McGraw-Hill, New York, NY, USA.

Auricchio, P. & F. Olmos. 1999. Northward Range Extension for the European Hare, *Lepus europaeus* Pallas, 1778 (Lagomorpha-Leporidae) in Brazil. Publicações Avulsas do Instituto Pau Brasil, 2.

Baca, C.A.G. 2006. Ecología de Forrajeo de *Boa constrictor.* Un depredador introducido a la Isla Cozumel. Tesis de Maestría. Centro de Investigaciones en Ecosistemas, Universidade Nacional Autónoma de México, México.

Bernarde, P.S. & A.S. Abe. 2010. Hábitos alimentares de serpentes em Espigão do Oeste, Rondônia, Brasil. Biota Neotropica 10:167-173.

Bisceglia, S.B., J.A. Pereira, P. Teta & R.D. Quintana. 2008. Food habits of Geoffroy's cat (*Leopardus geoffroyi*) in the central Monte desert of Argentina. Journal of Arid Environments 72:1120-1126.

Boback, S.M. 2004. *Boa constrictor* (*Boa constrictor*). Diet. Herpetological Review 35:175.

Bogert, C.M. & J.A. Oliver. 1945. A preliminary analysis of the herpetofauna of Sonora. Bulletin of the American Museum of Natural History 83:297-426.

Bonvicino, C.R., A.N. Menezes, A. Lazar, V. Pena-Firme, C. Bueno, M.C. Viana, P.S. D'Andrea & A. Langguth. 2015. Chromosomes and phylogeography of *Sylvilagus* (Mammalia, Leporidae) from eastern Brazil. Oecologia Australis 19:158-172.

Cabral, S.O., I.S. Freitas, V. Morlanez, M. Katzenberger & C. Calabuig. 2019. Potential seed dispersers: a new facet of the ecological role of *Boa constrictor constrictor* Linnaeus 1758. Biota Neotropica 19:e20180626.

Card, D.C., D.R. Schield, R.H. Adams, A.B. Corbin, B.W. Perry, A.L. Andrew, B.W. Perry, A.L. Andrew, G.I. Pasquesi, E.N. Smith, et al. 2016. Phylogeographic and population genetic analyses reveal multiple species of *Boa* and independent origins of insular dwarfism. Molecular Phylogenetics and Evolution 102:104-116.

Chapman, C.A. 1986. *Boa constrictor* predation and group response in White-faced Cebus Monkeys. Biotropica 18:171-172.

Cisneros-Heredia, D.F., A. León-Reyes & S. Seger. 2005. *Boa constrictor* predation on a Titi monkey, *Callicebus discolor*. Neotropical Primates 13:11-12.

David, P., E. Thébault, O. Anneville, P.F. Duyck, E. Chapuis & N. Loeuille. 2017. Impacts of invasive species on food webs: A review of empirical data. Pp 1-60. In D.A. Bohan, A. J. Dumbrel & F. Massol (Eds.), Networks of invasion: A synthesis of concepts. Academic Press, Oxford, United Kingdom.

Dick, J.T., K. Gallagher, S. Avlijas, H.C. Clarke, S. E. Lewis, S. Leung, D. Minchin, J. Caffrey, M.E. Alexander, C. Maguire, et al. 2013. Ecological impacts of an invasive predator explained and predicted by comparative functional responses. Biological Invasions 15:837-846.

Durigan, G., M.F. Siqueira, G.A. Franco, S. Bridgewater & J. A. Ratter. 2003. The vegetation of priority areas for Cerrado conservation in São Paulo state, Brazil. Edinburgh Journal of Botany 60:217-241.

Faria, G.M., C.A. Rosa, G.L. Corrêa, F. Puertas, K.M. Jiménez, L.N. Perillo, L. Hufnagel, B. Leles, R.C. Paula, F.H. Rodrigues, et al. 2015. Geographic distribution of the European hare (*Lepus europaeus*) in Brazil and new records of occurrence for the Cerrado and Atlantic Forest biomes. Mammalia 80.

Ferrari, S.F., W.L. Pereira, R.R. Santos & L.M. Veiga. 2004. Fatal attack of a *Boa constrictor* on a Bearded Saki (*Chiropotes satanas utahicki*). Folia Primatologica 75:111-113.

Flux, J.E. & R. Angermann. 1990. The Hares and Jackrabbits. Pp. 61-94. In J.A. Chapman & J.E. Flux (Eds.), Rabbits, hares and pikas: Status survey and conservation action plan. IUCN.

Fricke, E.C. & J-C. Svenning. 2020. Accelerating homogenization of the global plant-frugivore meta-network. Nature, 585:74-78.

Gondim, P.M., D.M. Borges-Nojosa, M.J. Borges-Leite & C.G. Albano. 2012. *Boa constrictor* (*Boa constrictor*). Diet. Herpetological Review 43:654-655.

Greene, H.W. 1983. *Boa constrictor* (Boa, Béquer, Boa Constrictor). Pp. 380-382 In D.H. Janzen (Ed.), Costa Rican natural history. University of Chicago Press, Chicago, USA.

Greene, H.W. 1997. Snakes: the evolution of mystery in nature. University of California Press, California, USA.

Grigera, D.E. & E.H. Rapoport. 1983. Status and distribution of the European hare in South America. Journal of Mammalogy 64:163-166.

Hacklander, K. & S. Schai-Braun. 2019. *Lepus europaeus*. The IUCN Red List of Threatened Species. https://dx.doi.org/10.2305/IUCN.UK.2019-1.RLTS.T41280A45187424. en [Accessed in November 2021]

Henderson, R.W. & M.J. Pauers. 2012. On the diets of neotropical treeboas (Squamata: Boidae: *Corallus*). South American Journal of Herpetology 7:172-180.

Henderson, R.W., M.J. Pauers & T.J. Colston. 2013. On the congruence of morphology, trophic ecology, and phylogeny in Neotropical treeboas (Squamata: Boidae: *Corallus*). Biological Journal of the Linnean Society 109:466-475.

Holley, A.J. 1993. Do Brown Hares signal to Foxes? Ethology 94:21-30.

Instituto Hórus. 2021. Base de dados de espécies exóticas invasoras do Brasil. *Lepus europaeus*. Instituto Hórus de Desenvolvimento e Conservação Ambiental, Florianópolis, Santa Catarina, Brazil. http://bd.institutohorus.org.br/www [Accessed in November 2021].

King, R.B., J.M. Ray & K.M. Stanford, 2006. Gorging on gobies: beneficial effects of alien prey on a threatened vertebrate. Canadian Journal of Zoology. 84:108-115.

Machado, H.T., C.S. Matias, E.P. Alcantara & C. Ferreira-Silva. 2018. *Boa constrictor* (*Boa constrictor*). Diet. Herpetological Review 49:123-124.

Magioli, M., M.Z. Moreira, K.M. Ferraz, R. . Miotto, P.B. Camargo, M.G. Rodrigues, M.C. Canhoto & E.F. Setz. 2014. Stable Isotope Evidence of *Puma concolor* (Felidae) Feeding Patterns in Agricultural Landscapes in Southeastern Brazil. Biotropica 46:451-460.

Marques, O.A., A. Eterovic, C.C. Nogueira & I. Sazima. 2015. Serpentes do Cerrado. Holos Editora Ltda, Ribeirão Preto, SP, Brazil.

Martins, M. & M.E. Oliveira. 1998. Natural history of snakes in forests of the Manaus region, central Amazonia, Brazil. Herpetological Natural History 6:78-150.

McCann K., A. Hastings & G.R. Huxel. 1998. Weak trophic interactions and the balance of nature. Nature, 395:794-98.

Melo, A.C. & G. Durigan. 2011. Plano de Manejo da Estação Ecológica de Santa Bárbara. São Paulo: Instituto Florestal - Secretaria do Meio Ambiente.

Mesquita, P.C., D.C. Passos, D.M. Borges-Nojosa & S.Z. Cechin. 2013. Ecologia e história natural das serpentes de uma área de Caatinga no nordeste brasileiro. Papéis Avulsos de Zoologia 53:99-113.

Mole, R.R. & F.W. Urich. 1894. Biological notes upon some of the Ophidia of Trinidad, BWI, with a preliminary list of the species recorded from the island. Proceedings of the Zoological Society of London 499-518.

Newsome, S.D., M.T. Tinker, D.H. Monson, O.T. Oftedal, K. Ralls, M.M. Staedler, M.L. Fogel & J.A. Estes. 2009. Using stable isotopes to investigate individual diet specialization in California sea otters (*Enhydra lutris nereis*). Ecology 90:961-974.

Nogueira, C.C., A.J. Argôlo, V. Arzamendia, J.A. Azevedo, F.E. Barbo, R.S. Bérnils, B.E. Bolochio, M. Borges-Martins, M. Brasil-Godinho, H. Braz, et al. 2019. Atlas of Brazilian snakes: verified point-locality maps to mitigate the Wallacean shortfall in a megadiverse snake fauna. South American Journal of Herpetology 14(sp1):1-274.

Pasqualotto, N., D. Boscolo, N.F. Versiani, R.M. Paolino, T.F. Rodrigues, V.G. Krepschi & A.G. Chiarello. 2021. Niche opportunity created by land cover change is driving the European hare invasion in the Neotropics. Biological Invasions 23:1-18.

Peters, F.B., P.R. Roth, A.A. Jeronimo, M.S. Pereira, F. Poerschke, L.F. Machado & A.U. Christoff. 2009. Predação de *Lepus europaeus* (Lagomorpha: Leporidae) por *Bubo virginianus* (Strigiformes: Strigidae) no Sul do Brasil. Biodiversidade Pampeana 7:31-34.

Pinto-Coelho, D., B. Hamdan & R. Lira-da-Silva. 2020. Geographic an altitudinal distribution of snakes of the family Boidae in the state of Bahia, northeastern Brazil. Revista Nordestina de Zoologia 12:26-50.

Pintor, L.M. & J.E. Byers. 2015. Do native predators benefit from non-native prey? Ecology Letters 18:1174-1180.

Pizzatto, L., O.A. Marques & K. Facure. 2009. Food habits of Brazilian boid snakes: overview and new data, with special reference to *Corallus hortulanus*. Amphibia-Reptilia, 30:533-544. https://brill.com/view/journals/amre/30/4/article-p533_10.xml [Accessed in November 2021]

Pringle, R.M. & M.C. Hutchinson. 2020. Resolving Food-Web Structure. Annual Review of Ecology, Evolution, and Systematics 51:55-80.

Quick, J.S., H.K. Reinert, E.R. Cuba & R.A. Odum. 2005. Recent occurrence and dietary habits of *Boa constrictor* on Aruba, Dutch West Indies. Journal of Herpetology 39:304-307.

Quintino, E.P. & J.C. Bicca-Marques. 2013. Predation of *Alouatta puruensis* by *Boa constrictor*. Primates, 54:325-330.

Reed, R.N. & G.H. Rodda. 2009. Giant constrictors: biological and management profiles and an establishment risk assessment for nine large species of Pythons, Anacondas, and the Boa constrictor. U.S. Geological Survey Open-File Report 2009-1202. USA

Ruedas, L.A., S.M. Silva, J.H. French, R.N. Platt II, J. Salazar-Bravo, J.M. Mora & C.W. Thompson. 2017. A prolegomenon to the systematics of South American cottontail rabbits (Mammalia, Lagomorpha, Leporidae: *Sylvilagus*): designation of a neotype for *S. brasiliensis* (Linnaeus, 1758), and restoration of *S. andinus*

(Thomas, 1897) and *S. tapitillus* Thomas, 1913. Miscellaneous Publications of The Museum of Zoology, University of Michigan, 205. http://hdl.handle.net/2027.42/136089 [Accessed in November 2021]

Ruedas, L.A. & A.T. Smith. 2019. *Sylvilagus tapetillus* (errata version published in 2020). The IUCN Red List of Threatened Species. https://www.iucnredlist.org/species/142542759/165117046 [Accessed in November 2021]

Ruxton, G.D., T.N. Sherratt & M.P. Speed. 2004. Avoiding attack: The evolutionary ecology of crypsis, warning signals, and mimicry. Oxford University Press, Oxford, United Kingdom.

Sawaya, R.J., O.A. Marques & M. Martins. 2008. Composition and natural history of a Cerrado snake assemblage at Itirapina, São Paulo state, southeastern Brazil. Biota Neotropica 8:127-149.

Scartozzoni, R.R. & F.B. Molina. 2004. Comportamento alimentar de *Boa constrictor, Epicrates cenchria* e *Corallus hortulanus* (Serpentes: Boidae) em cativeiro. Revista de Etologia 6:25-31. http://pepsic.bvsalud.org/scielo.php?script=sci_arttext&pid=S1517-28052004000100003 [Accessed in November 2021]

Secor, S.M. & J.M. Diamond. 2000. Evolution of regulatory responses to feeding in snakes. Physiological and Biochemical Zoology 73:123-141.

Shine, R. 1991. Why do larger snakes eat larger prey items? Functional Ecology 5: 493-502.

Silva, L.V. & G.P. Faggioni. 2015. *Boa constrictor* (Boa Constrictor). Diet. Herpetological Review 46:99-100.

Sorrell, G.G., S.M. Boback, R.N. Reed, S. Green, C.E. Montgomery, L.S. Souza & M. Chiaraviglio. 2011. *Boa constrictor* (Boa Constrictor). Foraging behaviour. Herpetological Review 42:281.

Stanner, M. & H. Mendelssohn. 1986. The diet of *Varanus griseus* in the southern coastal plain of Israel (Reptilia: Sauria). Israel Journal of Zoology 34:67-75.

Svanbäck, R. & D.I. Bolnick. 2005. Intraspecific competition affects the strength of individual specialization: an optimal diet theory method. Evolutionary Ecology Research 7:993-1012.

Tinker, M.T., P.R. Guimarães Jr., M. Novak, F.M. Marquitti, J.L. Bodkin, M. Staedler, G. Bentail & J.A. Estes. 2012. Structure and mechanism of diet specialisation: testing models of individual variation in resource use with sea otters. Ecology Letters 15:475-83.

Velázques, A. 2012. El contexto geográfico de los lagomorfos de México. Therya 3:223-238.