Control of the ladder snake (*Rhinechis scalaris*) on Formentera using experimental live-traps

G. Picó[1], M.J. Fernández[1], J.E. Moreno[2] and V. Colomar[1]

[1]*COFIB (Consorci per a la Recuperació de la Fauna de les Illes Balears), Ctra. Sineu Km 14.400, 07142, Santa Eugènia, Spain. <gabrielap.pico@gmail.com>.* [2]*SPE (Servei de Protecció d'Espècies), DG Espais Naturals i Biodiversitat. Conselleria Med. Ambient, Agricultura i Pesca, Govern de les Illes Balears, Gremi de Corredors, 10, 07009, Palma, Spain.*

Abstract The ladder snake (*Rhinechis scalaris*) is a recent alien invasive species found on Formentera (83 km^2), in the Balearic Archipelago (4,492 km^2). It has been introduced in the last decade as cargo stowaway hidden within ornamental olive trees from the Iberian Peninsula, causing negative impacts on native fauna. This paper describes the methodology used to reduce the ladder snake population as a first attempt since it was detected in 2006. For this purpose, an experimental live-trap was designed by the wildlife management team of the Consorci per a la Recuperació de la Fauna de les Illes Balears (COFIB) during the 2016 campaign. As a result, 314 *R. scalaris* were trapped in an area of 472 ha, achieving an efficiency of up to 0.167 captures per trap and night, and 0.040 captures per unit effort on average. This outcome encourages the use of the live-trap as a cost-effective method for reducing the snake population in Formentera. Nonetheless, this method should be considered a starting point toward *R. scalaris* control.

Keywords: alien species, Balearic Islands, ophidian, population

INTRODUCTION

The accidental transportation of invasive alien species to new locations is a major cause of biodiversity loss worldwide. This is of special concern in island ecosystems, where native species are especially vulnerable to biological invasions (Quammen, 1996). In this regard, the presence of reptiles in the Balearic Islands is a paradigmatic case, with a greater number of alien species (19) than native ones (2), namely, the Lilford's wall lizard (*Podarcis lilfordi*) and the Ibiza wall lizard (*Podarcis pityusensis*) (Silva-Rocha, et al., 2015). The ladder snake (*Rhinechis scalaris*) is a Mediterranean species which is present in most of the Iberian Peninsula (just missing on the Cantabric ledge), in the south-east of France and the north-east of Italy (Pleguezuelos & Honrubia, 2002). This ophidian is also considered an introduced species on other Spanish islands, namely, Ons, Aurosa (in Pontevedra), Mallorca, Menorca, Ibiza and Formentera (in the Balearic Islands) (Pinya & Carretero, 2011), but fortunately not on any of the surrounding islets (Carretero & Silva-Rocha, 2015). However, in Menorca *R. scalaris* has a wide distribution and is catalogued as a protected species in the Catàleg Balear d'Espècies Amenaçades (Decret, 2005) due to its presence on the island dating from the pre-Roman period (Vigne & Alcover, 1985). Conversely, on Mallorca, Ibiza and Formentera *R. scalaris* is a recent introduction (Álvarez, et al., 2010; Mateo & Ayllón, 2012), so its presence is still isolated to particular locations and its range is expanding. In fact, in Ibiza and Formentera this ophidian is catalogued as an invasive alien species (Real Decreto, 2013).

Until 2006 Formentera was considered snake-free. The first *R. scalaris* was detected on 25 May 2008, followed by another sighting on 17 July 2008; both located near La Mola. Then, a third specimen, not identified, was recorded the 20 May 2009 (Álvarez, et al., 2010; Mateo & Ayllón, 2012). It is presumed that the first ophidian was introduced to the Pityusic islands through the trade of ornamental olive trees originating from the Iberian Peninsula (Álvarez, et al., 2010; Carretero & Silva-Rocha, 2015; Montes, et al., 2015), and genetic studies suggest that the whole *R. scalaris* population comes from one introduction event (Silva-Rocha, et al., 2015). Nonetheless, it would be expected that all the snakes spotted in Formentera during the first years could come from Ibiza, since direct connections between Formentera and the mainland are rather limited (Álvarez, et al., 2010; Mateo & Ayllón, 2012).

The naturalisation of this ophidian could result in important consequences for the Pityusic ecosystem and also for the demographic stability of the endemic Ibiza wall lizard (Rodríguez-Pérez, 2009; Álvarez, et al., 2010). Previous cases of introduction of snakes to island ecosystems have been terrible in terms of ecological balance as experienced by the ancient settlement of ophidians on the neighbouring islands of Mallorca and Menorca (SPE, 2007), the deliberate release of the Californian kingsnake (*Lampropeltis getula californiae*) on Gran Canaria (Cabrera-Pérez, et al., 2012) and the accidental introduction of the brown treesnake (*Boiga irregularis*) to the island of Guam (Savidge, 1987; Rodda, et al., 1997; Fritts & Rodda, 1998; Wiles, et al., 2003).

In the last decade, sightings from local people have increased and as Carretero & Silva-Rocha (2015) stated, "the area of Formentera where ladder snakes were spotted in the past, should be checked thoroughly and regularly". So, the need to monitor the presence of *R. scalaris* on Formentera is a real concern.

The present paper reports the first experience of trying to catch and reduce the presumed population of *R. scalaris* in the vicinity of La Mola in Formentera during the 2016 campaign. For this purpose, an experimental live-trap was designed by the wildlife management team of the Consorci per a la Recuperació de la Fauna de les Illes Balears (COFIB), along with the Government of the Balearic Islands. Budget constraints restricted the scope of this first campaign to confirming and mapping the presence of the ladder snake in the vicinity of La Mola. So, the aim was to determine the effectiveness of the trap, as defined by captures per unit effort (CPUE), in order to establish a starting point for future campaigns.

MATERIALS AND METHODS

Study area

This study was conducted on Formentera, the smallest (83 km^2) and southernmost island of the Balearic archipelago

In: C.R. Veitch, M.N. Clout, A.R. Martin, J.C. Russell and C.J. West (eds.) (2019). Island invasives: scaling up to meet the challenge, pp. 332–336. Occasional Paper SSC no. 62. Gland, Switzerland: IUCN.

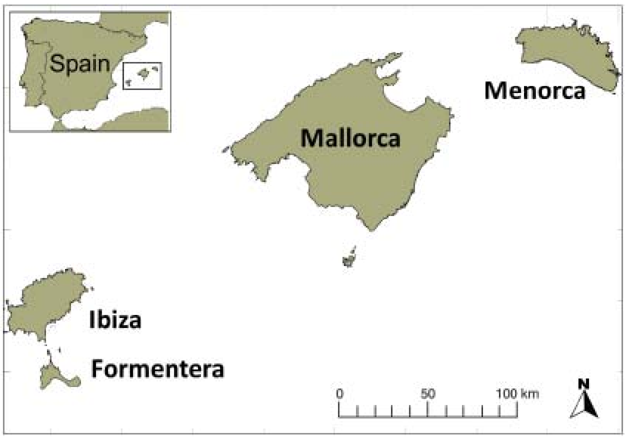

Fig. 1 Map of the Balearic Islands, showing the name of the main islands.

(Fig. 1). A channel of 3.6 km separates Formentera from the other Pityusic Island, Ibiza, and it is 100 km away from the Iberian Peninsula. Vegetation consists of sand dunes with pine forest, oak groves and brushwood. It is considered a flat island, with the highest point being La Mola, at 192 m above sea level, in the south-east of the island. This is where the *R. scalaris* population seems to be concentrated, thus, the study focuses on this area

The live-trap

To conduct this study, live-traps were designed by the COFIB for the purpose of capturing colubrid snakes. The trap used on Formentera was the same as those used in the project "Análisis de la efectividad de métodos de control de especies exóticas invasoras de la familia *colubridae* en islas" (COFIB, 2016) that took place simultaneously in a parallel campaign on Ibiza.

The trap measures 50.0 × 35.5 × 17.0 cm and is made of marine plank (1 cm thick) in order to endure inclement weather conditions (Fig. 2). The box consists of two compartments separated by a galvanised steel mesh of 5 × 5 mm, with two large doors on top to allow snake removal and bait maintenance. These doors are secured with a bolt in order to prevent escapes. The front side is also made of a galvanized steel mesh, allowing air flow through the mesh and the opportunity to glimpse the animals. Therefore, the trap is not completely opaque. There is just one entrance with a one-way flap door positioned on the mesh front of the trap, with a diameter of 3.5 cm. The flap only opens inwards, falling closed behind the snake to prevent escape and allowing multiple captures. This one-way flap entrance design has been used on a number of snake trap designs (reviewed by Rodda, et al., 1999a). Inside the snake compartment a hide is placed: a 300 mm length of 100 mm diameter plastic bottle, covered with 40 mm of water to prevent snake dehydration.

A live mouse, with enough water and food for optimal welfare, is used as attractant. In this trap, the bait is contained in a separate compartment to prevent the snake from ingesting the mouse.

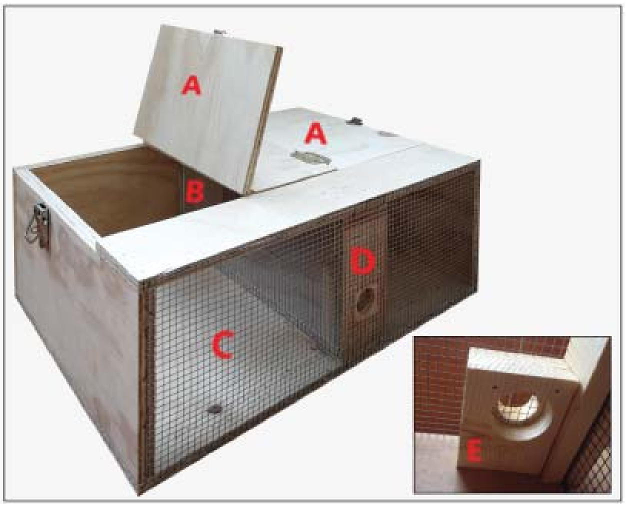

Fig. 2 Model of the live-trap designed by the COFIB. A: the two doors of the top, B: galvanized steel mesh that separates the two compartments, C: galvanized steel mesh of the front side, D: one-way flap door, E: detail of the trapping door viewed from the inside.

Trapping method

In the 2016 campaign, trap boxes were placed in the area near La Mola (Fig. 3), mostly at the limit of pine forests, near stone walls or at the base of vegetation (Montes, et al., 2015), all of them at ground-level. We covered a total area of 472 ha with 64 traps. Fourteen extra traps were placed in different locations on the island where no snakes had been spotted in the past, as snake indicators. All the traps located in the field were georeferenced.

Every effort was made to keep the mice alive during the whole project, as they are the basis for the operation of the trap (Mateo & Ayllón, 2012). During the coldest months of the year dry grass or similar materials were provided and the boxes were placed in the sunlight, avoiding hypothermia. Conversely, in summer the boxes were moved slightly towards the shade, helping the mice to endure the suffocating heat. Also, for the duration of the rainy season, traps were placed on stones and covered with plastic, preventing contact between the bottom of the box and a waterlogged ground. These measures were taken not just for humane and economic reasons but also because they allowed a longer period between inspections. All traps were checked and bait replaced every nine days, on average.

Capture and data gathering

When an ophidian was captured, it was identified to ensure it was a *R. scalaris* (as opposed to an unknown and possibly venomous snake), so handling did not require

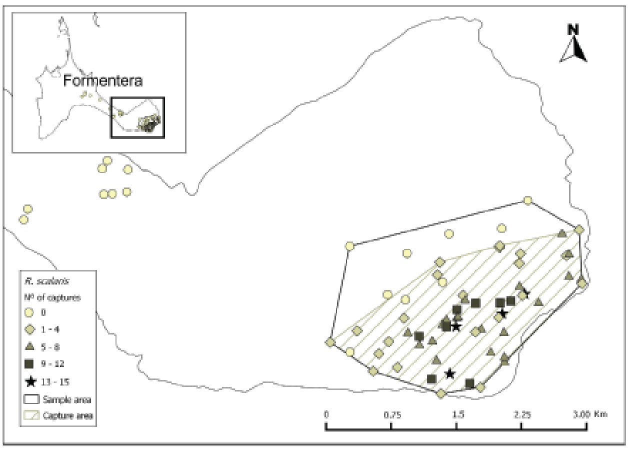

Fig. 3 Distribution of the ladder snake (*Rhinechis scalaris*) in Formentera in 2016. The number of captures per trap is represented with different shapes (see the key). The sample area and the capture area are determined by applying the minimum convex polygon method. All traps on the field are represented on the map but none of the indicator traps are included in the sample area.

Fig. 4 Two specimens of ladder snake (*Rhinechis scalaris*), a juvenile on the left and an adult on the right, caught with the same live-trap in the field on Formentera.

anything special other than a pair of gardening gloves (Fig. 4). We euthanised the snakes using pentobarbital (the approximate dose was 0.1 ml per 100 g) and all injections were performed by an experienced veterinarian, who was the main field technician. Once the specimen was lifeless, it was placed in a 'zip' bag with an identification label including trap number, species, and date. Each captured specimen was stored in a freezer for further investigation; no morphological data was collected on the field. Afterward, all captures were mapped in order to estimate the abundance of *R. scalaris* in La Mola, using the minimum convex polygons tool of Quantum GIS (1.8.0).

RESULTS

A total of 64 traps where placed on La Mola, remaining in the same location for the entire sampling period (Fig. 3). The trapping was conducted between May and late November. The team was based on Ibiza and, for this reason, both sea conditions and vehicle availability restricted the number of possible surveys to 19. The number of traps increased in nearly every survey till the end of July and August, when we had the total number of traps placed in the field. The capture area comprised 321 ha from a sampling area of 472 ha. No indicator trap had any capture.

By the end of the campaign, 314 ladder snakes had been caught, with a total of 7,906 trap-nights (Table 1). It is evident that this was a grass-roots effort, using the best available knowledge to catch as many snakes as possible while keeping costs as low as possible. Therefore, we did not have the time to estimate the density of snakes prior to the trapping. Instead of this, we evaluated the trap effectiveness as defined by captures per unit effort (CPUE). By the end of the project we had an average of 0.040 CPUE.

In May, the first month of trapping, we obtained a trap efficiency of 0.108 captures per trap and night. Next month, June, we got 0.075 captures per unit effort (CPUE), even though the number of traps in the field was more than double. A similar pattern occurred in the following months: the captures per unit effort continued dropping, until we got 0.006 CPUE in November. Therefore, preliminary data seems to indicate an encouraging trap capture decay rate, with a high CPUE at the beginning and a declining recovery from traps as the local supply of snakes depleted. However, seasonal changes in capture success need to be evaluated.

DISCUSSION

The 2016 trapping campaign is the first attempt to remove large numbers of snakes as a step towards controlling the invasion of *R. scalaris* on the island of Formentera. Previous attempts on the neighbouring islands of Ibiza (Montes, et al., 2015) and Mallorca (Mateo, 2015) have tested different methods to capture *R. scalaris* and *Hemorrhois hippocrepis*. After a thorough review of these documents, we decided to use a passive method to trap as many snakes as possible, continuing the work of Montes, et al. (2015) by adapting the wooden box they used. In this regard, we followed the advice and recommendations of previous snake trapping studies. As Rodda, et al. (1999a) showed, it is possible to have higher capture rates using live mice as lures, opaque chambers and flap entrances. Firstly, flap traps have a lower entry rate than open funnel traps, but the former have a higher capture rate. For this reason, we replaced the two open-funnels used by Montes, et al. (2015), with a single frontal flap door, as these are considered to have a negligible escape rate (Rodda, et al., 1999a).

Secondly, in contrast with the lack of a mouse's chamber in the wooden box by Montes, et al. (2015) and the small one that housed the mouse inside the funnel trap described by Mateo & Ayllón (2012), our trap had a proper shelter for the mouse, which was the second big compartment of the cage. With this modification we avoided snake ingestion of the lure and contributed to reducing mouse mortality.

Finally, in order to enhance capture success, refugium bottles were placed inside the snake's compartment as it has been observed that there is a significantly higher number of entries into traps having hiding places, even if the possibility of escape is unlikely (Rodda, et al., 1999a).

Our trap optimises previous designs and the positive capture rates seem to be the result of using both a flap door and a bottle refuge, as these contribute to reducing the number of snakes escaping, along with the separate compartments, which keeps the trap active after a first successful capture. Indeed, our results (0.040 CPUE) confirm a higher efficiency when compared with the study by Montes, et al. (2015) (0.007 CPUE).

All data could have been more accurate had we had a technician exclusively dedicated to checking the traps every other day. Then, not only the number of traps per hectare would have been greater, but the capture rate probably higher. In this case, re-check intervals were determined in relation to care and maintenance of live lures (as the snakes had enough water to avoid death by dehydration during these intervals) instead of capture rate increase. This allowed optimising labour and maximising cost-effectiveness. Even so, trap captures are hypothesised to be higher if the area of trapping is not disturbed (Rodda, et al., 1999a), suggesting normal entrance rates if checks are done within longer intervals. In this study, traps were checked weekly during the summer season but checks were done every 12 days in autumn.

Regarding trap location, Rodda, et al. (1999a), argue that traps should be widely spaced in order to maximise the capture rate when traps are infrequently checked. However, there is still a lack of a mathematic equation describing the relationship between capture rate and trap spacing, as well as a poorly understood interaction between trap design and the environment in which it is used. Taking into account that *R. scalaris* is an active forager (Pleguezuelos, et al., 2007), traps were placed as far apart as it was practical for revisits considering the topography, the trapping area and the number of traps available, resulting in a wide range from 50 m to 600 m apart.

Table 1. Data on ladder snakes (*Rhinechis scalaris*) caught during the 2016 campaign on Formentera.

Survey	Month	No. Traps	No. Captures	Trap/night	CPUE
1	May	9	3	36	0.083
2	May	18	15	90	0.167
3	May	18	12	157	0.076
4	May	43	37	336	0.110
	Average for May	**22**	**67**	**619**	**0.108**
5	June	56	41	306	0.134
6	June	57	40	392	0.102
7	June	57	36	497	0.072
8	June	63	13	532	0.024
	Average for June	**58.25**	**130**	**1,727**	**0.075**
9	July	63	29	635	0.046
10	July	63	11	420	0.026
11	July	64	2	506	0.004
	Average for July	**63.33**	**42**	**1,561**	**0.027**
12	August	64	14	408	0.034
13	August	64	9	408	0.022
	Average for August	**64**	**23**	**816**	**0.028**
14	September	43	6	352	0.017
	Average for September	**43**	**6**	**352**	**0.017**
15	October	43	14	645	0.022
16	October	44	18	602	0.030
17	October	44	7	396	0.018
	Average for October	**43.67**	**39**	**1,643**	**0.024**
18	November	44	5	616	0.008
19	November	44	2	572	0.003
	Average for November	**44**	**7**	**1,188**	**0.006**
		TOTAL	**314**	**7,906**	**0.040**

The first traps distributed on the ground were placed within view of neighbours (on the south of the road to the lighthouse of La Mola), and then a consecutive radial expansion was drawn. As can be seen in Fig. 3, there is a clear 'hot spot' to the south of La Mola, with the highest number of captures close to the southern coast. The number of captures decreases the further we move from this high-density area and the traps on the north and west boundaries are characterised by no captures (except for two traps on the west). Considering that the sea is a natural barrier, potential expansion is only possible to the north or to the west of the sample area. As mentioned above, no indicator traps in other parts of the island had any captures. Therefore, our trap array gives an initial indication about the range of *R. scalaris* on Formentera, having a higher density of snakes in the core of the invasion zone than at the edges. Still, a larger array of traps around La Mola, especially on the west boundary, would depict the range of *R. scalaris* more accurately.

It is clear that a population of *R. scalaris* is naturalised in Formentera. Previous extinctions of endemic birds and lizards have been documented as a result of the introduction of an alien snake, such as the well-known case of the *B. irregularis* in the Island of Guam (Savidge, 1987; Rodda, et al., 1997; Fritts & Rodda, 1998). Therefore, the Guam experience should made us wary of the invasive potential that *R. scalaris* could have on the native fauna of the Pityusic islands. It has the potential to affect a wide range of animals, such as the emblematic Ibiza wall lizard, the Balearic shearwater (*Puffinus maruritanicus*), the Scopoli's shearwater (*Calonectris diomedea*), the storm petrel (*Hydrobates pelagicus*) or the garden dormouse of Formentera (*Eliomys quercinus ophiusae*) (Hinckley, et al., 2016), as few predators are present on Formentera and the abundant endemic fauna is an easy and vulnerable target because prey species lack co-evolutionary experience with snakes (Rodda, et al. 1999b).

Successful control of *R. scalaris* is Formentera's highest conservancy priority (Pleguezuelos, et al., 2015). This is an early invasion, in chronological terms, and the area of invasion seems to be relatively small. The use of this wooden box trap seems to be a useful starting point towards *R. scalaris* control. However, more comprehensive research is required to determine whether the ladder snake's expansion on Formentera can be stopped by using this capture method. In order to assess this question, the study will continue in future years with a greater trap array.

ACKNOWLEDGEMENTS

This work was supported by the Consell Insular de Formentera and Eivissa, Agents de Medi Ambient and IBANAT. The wooden trap would not have been possible without the help of the Escola d'Arts i Oficis d'Eivissa in making the first prototype. This project has been funded by the FEADER (Fondo Europeo Agrario de Desarrollo Rural) through the Desenvolupament Rural de les Illes Balears Programme.

REFERENCES

Álvarez, C, Mateo, J.A., Oliver, J. and Mayol, J. (2010). 'Los ofidios ibéricos de introducción reciente en las Islas Baleares'. *Boletín de la Asociación Herpetológica Española* 21: 126–131.

Cabrera-Pérez, M.A., Gallo-Barneto, R., Esteve, I., Patiño-Martínez, C., and López-Jurado, L.F. (2012) 'The management and control of the California kingsnake in Gran Canaria (Canary Islands): Project LIFE+ *Lampropeltis*'. *Aliens: The Invasive Species Bulletin* 32: 20–28.

Carretero, A. and Silva-Rocha, I. (2015). 'La culebra de escalera (*Rhinechis scalaris*) en las Islas Baleares'. *Boletín de la Asociación Herpetológica Española* 26(2): 84–87.

COFIB (Consorci per a la Recuperació de la Fauna de les Illes Balears) (2016). *Análisis de la Efectividad de Métodos de Control de Species Exóticas Invasoras de la Familia Colubridae en Islas.* Unpublished report. Palma: COFIB.

Decret (2005). 'D.75/2005, de 8 de juliol, pel qual es crea el Catàleg Balear d'Espècies Amenaçades i d'Especial Protecció, les Arees Biològiques Crítiques i el Consell Assessor de Fauna i Flora de les Illes Balears'. Boletín Oficial de las Islas Baleares (BOIB) 106. <http://www.caib.es/sites/institutestudisautonomics/ca/n/decret_752005_de_8_de_juliol_pel_qual_es_crea_el_cataleg_balear_despecies_amenacades_i_despecial_proteccio_les_arees_biologiques_critiques_i_el_consell_assessor_de_fauna_i_flora_de_les_illes_balears_-58273/>.

Fritts, T.H. and Rodda, G.H. (1998). 'The role of introduced species in the degradation of island ecosystems: A case history of Guam'. *Annual Review of Ecology, Evolution, and Systematcs* 29: 113–140.

Hinckley, A., Montes, E., Ayllón, E. and Pleguezuelos, J.M. (2016). 'The fall of a symbol? A high predation rate by the introduced horseshoe whip snake *Hemorrhois hippocrepis* paints a bleak future for the endemic Ibiza wall lizard *Podarcis pityusensis*'. *European Journal of Wildlife Research* 63(1): 13.

Mateo, J.A. (2015). 'Los Anfibios y los Reptiles Introducidos en Baleares: un repaso a lo que sabemos y un ejemplo de puerta de entrada'. In: Servei de Protecció d'Espècies (ed.) *Llibre Verd de Protecció d'Espècies a les Balears,* pp. 447–454. Palma: Govern de les Illes Balears. Conselleria d'Agricultura, Medi Ambient i Territori.

Mateo, J. A. and Ayllón, E. (2012). *Viabilidad del Control de Ofidios en Ibiza y Formentera*. Palma: Asociación Herpetológica Española.

Montes, E., Estarellas, J., Ayllón, E., Carretero, M.A., Feriche, M., Hernández, P.L. and Pleguezuelos, J.M. (2015). 'Dades Preliminars del Projecte Pilot de Control de Serps a l'Illa d'Eivissa'. In: Servei de Protecció d'Espècies (ed.) *Llibre Verd de Protecció d'Espècies a les Balears,* pp. 455–464. Palma: Govern de les Illes Balears. Conselleria d'Agricultura, Medi Ambient i Territori.

Pinya, S. and Carretero, M.A. (2011). 'The Balearic herpetofauna: A species update and a review on the evidence'. *Acta Herpetologica* 6: 59–80.

Pleguezuelos, J.M. and Honrubia, S. (2002). '*Elaphe scalaris'*. In: J.M. Pleguezuelos, R. Márquez and M. Lizana (ed.) *Atlas y Libro Rojo de los Anfibios y Reptiles de España,* pp. 281–283. Madrid: Organismo Autónomo de Parques Nacionales.

Pleguezuelos, J.M, Fernández-Cardenete, J.R., Honrubia, S., Feriche, M., Villafranca, C. (2007). 'Correlates between morphology, diet and foraging mode in the ladder snake *Rhinechis scalaris* (Schinz, 1822)'. *Contributions to Zoology* 76(3): 179–186.

Pleguezuelos, J.M., Ayllón, E., Arribas, O., Bertoloero, A., Bosch, J., Cabido, C., Carranza, S., Carretero, M.A., Díaz-Paniagua, C., Egea-Serrato, A., Garin-Barrio, I., Giménez, A., Gosá, A., Garciá, E., Guicking, D., Llorente, G.A., Martínez-Solano, I., Mateo, J.A., Montori, A., Palomar, G., Perera, A., Pinya, S., Pretus, J.L., Pujol-Buxó, E., Rato, C., Recuero, E., Sanz-Azkue, I., Silva-Rocha, I., Vasconcelos, R., Velo-Antón, G., Vörös, J., Santos, X. (2015). 'Conclusiones y propuestas de gestión de las poblaciones y especies de anfibios y reptiles alóctonos en España'. *Boletín de la Asociación Herpetológica. Española* 26 (2): 113–115.

Quammen, D. (1996). *The Song of the Dodo: Island Biogeography in an Age of Extinction*. New York: Simon and Schuster.

Real Decreto (2013). 'RD.630/2013, de 2 de agosto, por el que se Regula el Catálogo Español de Especies Exóticas Invasoras'. Boletín Oficial del Estado (BOE) 185. <https://www.boe.es/buscar/pdf/2013/BOE-A-2013-8565-consolidado.pdf >.

Rodda, G.H., Fritts, T.H., Clark, C.S., Gotte, S.W. and Chiszar, D., (1999a) 'A State-of-the-Art Trap for the Brown Treesnake'. In: G.H. Rodda, Y. Sawai, D. Chiszar, and H. Tanaka (ed.) *Problem Snake Management: The Habu and the Brown Treesnake*, pp. 268–305. Ithaca and London: Cornell University Press.

Rodda, G.H.; Fritts, T.H.; McCoid, M.J. and Campbell, E.W. III. (1999b). 'An Overview of the Biology of the Brown Treesnake, *Boiga irregularis*, a Costly Introduced Pest on Pacific Islands'. In: G.H. Rodda, Y. Sawai, D. Chiszar, and H. Tanaka (ed.) *Problem Snake Management: The Habu and the Brown Treesnake*, pp. 44–80. Ithaca and London: Cornell University Press.

Rodda, G.H., Fritts, T.H. and Chiszar, D. (1997). 'The disappearance of Guam's wildlife; new insights for herpetology, evolutionary ecology, and conservation'. BioSience 47: 565–574.

Rodríguez-Pérez, J. (2009). 'Pérdidas de interacciones planta-animal en islas: dispersión de semillas por la lagartija balear y sus consecuencias para la regeneración de un arbusto endémico'. *El Indiferente* 20: 36–43.

Savidge, J.A. (1987). 'Extinction of an island forest avifauna by an introduced snake'. *Ecology* 68: 660–668.

SPE (Servei de Protecció d'Espècies) (2007). *Pla de Recuperació del Ferreret (Alytes muletensis)*. Palma: Conselleria de Medi Ambient. Govern de les Illes Balears.

Silva-Rocha, I., Salvi, D., Sillero, N., Mateo, J.A. and Carretero, M.A. (2015). 'Snakes on the Balearic Islands: An invasion tale with implications for native biodiversity conservation'. *PLOS ONE* 10(4): e0121026. doi:10.1371/journal.pone.0121026

Vigne, D. and Alcover, A. (1985). 'Incidence des relations historiques entre l'homme et l'animal dans la composition actuelle du peuplement amphibien, reptilien et mammalien des îles de méditerranée occidentale'. *Actes 110e Congrès national des Sociétés savantes, Section* Sciences: 79–91.

Wiles, G.J., Bart, J., Beck, Jr., R.E., and Aguon, C.F. (2003). 'Impacts of the brown tree snake: patterns of decline and species persistence in Guam's avifauna' *Conservation Biology* 17: 1350–1360.