Rapid Communication

Range extension of the ocellated skink, *Chalcides ocellatus* (Forsskål, 1775), in southern Spain provides a warning on its invasion potential

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Abstract

Early detection of the introduction of alien species is essential for effective management and to avoid potential detrimental effects. The ocellated skink, *Chalcides ocellatus* (Forsskål, 1775), is a known invasive species. In April 2017, an introduced free-ranging population was found for the first time on the Iberian Peninsula, in Serra del Molar (Alicante). In the last two years, new records have appeared in areas distinct from the first locality. To assess the actual extent of this species' range, we conducted transects on foot in natural areas and held interviews with country house and plant nursery owners in the spring and summer of 2020. None of the transects in the natural areas found any *C. ocellatus*, but five confirmed and two probable records were obtained during interviews. These new localities were found between 6.3 and 12.5 km away from the initial locality. At the most distant locality, four country houses were surveyed and very high densities of *C. ocellatus* (25 skinks in a backyard of 0.2 ha) were found. The respondents agreed that the species started to be sighted around 2017 and 2018 and it is becoming more frequent with every passing year. Although we cannot rule out alternative scenarios, our data about the wide extension of the species and the high densities reached suggest a phase of rapid population expansion. According to guidelines of the allochthonous herpetofauna management in Spain, eradication and active management are strongly recommended before detrimental interactions with native wildlife, such as the endangered Bedriaga's skink *C. bedriagai* (Boscá, 1880) being detected. However, the fossorial behaviour of *C. ocellatus*, and it extending to private areas can make any management efforts extremely difficult. Altogether, this case illustrates the key role of regulating the horticultural trade to avoid biological introductions.

Key words: *Chalcides bedriagai*, horticultural trade, human-assisted dispersal, invasive species, invasion debt, nursery, palms

Introduction

A consensus has been reached by scientists that one of the main threats to global biodiversity, economy and human health is an increase in trafficking, introduction and establishment of alien species (Bellard et al. 2016; Levine and d'Antonio 2003; Millennium Ecosystem Assessment 2005). Early detection of introduction sources is essential for effective management and to avoid potential detrimental effects (Theoharides and Dukes 2007).

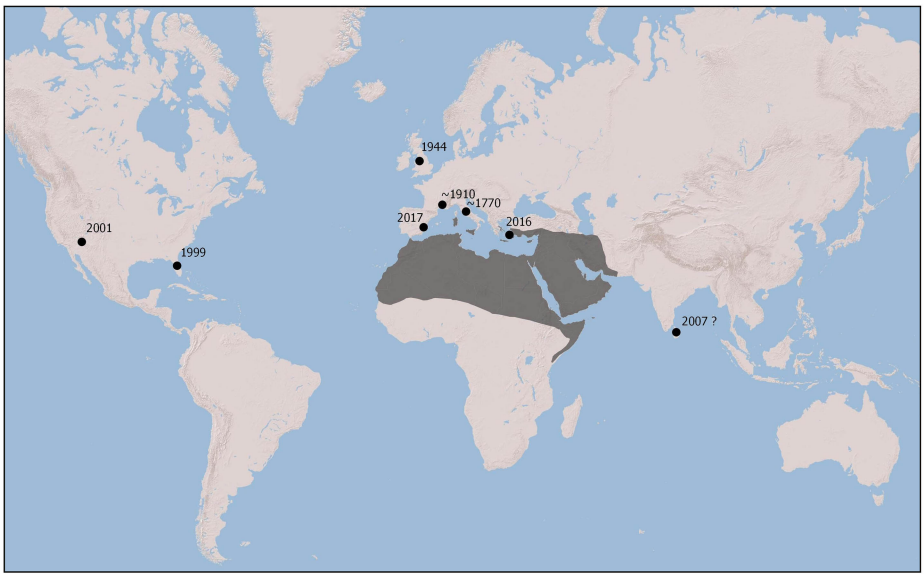

Figure 1. Native distributions of the ocellated skink *Chalcides ocellatus* in grey and reported introduced populations (black dots). The distribution map was drawn on the WGS84 projection.

The role of reptiles as invasive species has long been overlooked. In recent decades, increased research on the ecological role and damage they cause to native species has helped to raise awareness of the ecological threat posed by invasive reptiles (Kraus 2009). The main pathways for exotic reptiles are unintentional introductions results from species hitch-hiking rides in plant trade cargo or on the vehicles used in transport, and intentional introduction as for example pet trade (Kraus 2009; Gippet and Bertelsmeier 2021). Between 1999 and 2012, Robinson et al. (2015) estimated that more than 18 million reptiles were traded worldwide. The effects of these potential exotic invasive species are often not predictable and may have a myriad of significant emergent impacts (Pitt et al. 2005; Rouget et al. 2016). One of the groups that may suffer from these impacts are native reptiles (e.g. Montes et al. 2021) and, in fact, unsustainable trade and invasive species are some of the main reasons for their global decline (Pitt et al. 2005; Böhm et al. 2013).

Among reptiles, a known invasive species is the ocellated skink, *Chalcides ocellatus* (Forsskål, 1775) (Squamata: Scincidae). This species has a circum-Mediterranean distribution, occurring from Italy across the Mediterranean Region and the Middle East to Pakistan, as well as much of northern Africa from Western Sahara, Mauritania and Morocco east to Kenya, Ethiopia and Somalia (Kornilios et al. 2010; Anderson 1999; Lavin and Papenfuss 2012). Its native distribution has been augmented by a long history of human-facilitated introductions in North America and Europe, and the population detected in southeast Asia is very likely to also be human-related (Gunn et al. 2012) (Figure 1). Indeed, its entire distribution in the eastern Mediterranean is speculated to have been the result of many human-assisted dispersal events (Kornilios et al. 2010). This skink can be unintentionally transported as a stowaway during agricultural plant trade,

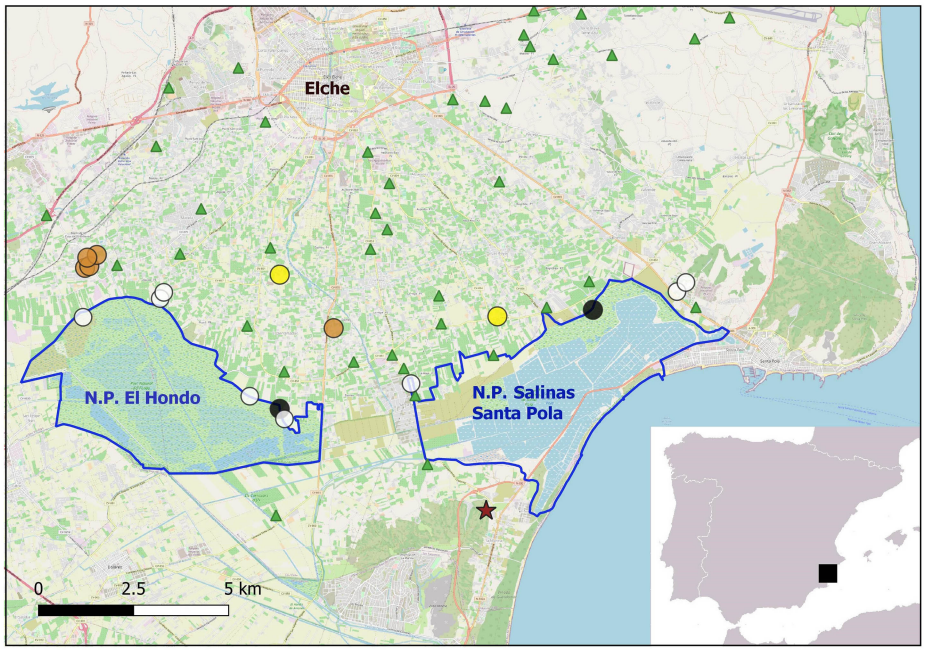

Figure 2. Map of confirmed (orange dots) and likely (yellow dots) records of the ocellated skink, *Chalcides ocellatus*, in Campo de Elche (southeastern Spain), as well as the previously known locality in Sierra del Molar (red star). Also shown are transects of presence of Bedriaga's skink *Chalcides bedriagai* (black dots), transects where no skink species were detected (white dots), plant nurseries (green triangles) and the boundaries of Natural Parks (blue).

and when moving ornamental plants and vegetative debris, it is also popular in the pet trade and is sold worldwide (e.g. Caputo et al. 1997; Kornilios et al. 2010; Gunn et al. 2012).

In April 2017, a wild population of *C. ocellatus* was found for the first time on the Iberian Peninsula, in Serra del Molar (Alicante province, SE Spain), as reported by Bisbal-Chinesta et al. (2019) (Figure 2). Their analysis of molecular data and archaeological records suggested that the species most likely reached the Iberian Peninsula through human-mediated dispersal via current or ancient trade routes. In August 2018, a *C. ocellatus* juvenile was found under an Aleppo pine *Pinus halepensis* trunk in the gardens of a country house in Crevillente (0.78W; 38.21N, WGS84), located 13.3 km from the unique previously known location of this species on the Iberian Peninsula (Figure 2). In September 2019, we returned to Crevillente and observed high densities of skinks: 12 individuals (including juveniles and adults) under a one square-metre plastic.

After this discovery, we wondered whether the species could have settled in more intensively human-modified areas than those sampled by Bisbal-Chinesta et al. (2019), resulting in an underestimation of the occurrence of this species. *Chalcides ocellatus* has a demonstrated an excellent capacity to colonise anthropogenically modified areas, as documented in Kasos (Greece) and Florida (USA) (Gunn et al. 2012; Kornilios and Thanou 2016).

The Baix Vinalopó region in Alicante (SE Spain) is characterised by marked agricultural activity that dates back to historic times, with the significant transformation and a high density of dispersed human settlements.

It is also one of the areas with the largest nursery, cultivation and trade of ornamental plants on the Iberian Peninsula (Fernández-Zamudio et al. 2012), especially the palm trees *Phoenix* sp. and *Washingtonia* sp. The few existing natural areas are surrounded by a transformed matrix. Notwithstanding, populations of species of conservation concern remain, such as the western false smooth snake *Macroprotodon brevis* (Günther, 1862) or the Iberian endemism, Bedriaga's skink *C. bedriagai* (Boscá, 1880).

In order to evaluate the range of *Chalcides ocellatus*, we undertook two approaches; i) transects on foot to assess the species' presence in natural areas; and ii) interviews with owners of country houses and nurseries about records of the species to evaluate its presence in anthropogenically modified areas.

Materials and methods

Ten systematic transects were carried out on foot in areas with natural vegetation in the salt marshes surrounding the El Hondo Natural Park and the Salinas de Santa Pola Natural Park between June and August 2020 (Figure 2). These transects were carried out by groups of five people for 4 hours in the morning (starting from 7:00–8:00 h UTC), who actively searched an area of ~ 2 ha for basking specimens as well as lifting stones and plastic to search for specimens on the ground.

We used a combination of morphological criteria to separate *C. ocellatus* from *C. bedriagai* according to Salvador (1998) and Speybroeck et al. (2016). These criteria included total length, number of body scales, ratio of body length to tail and arrangement of scales on the head. Adult specimens of *C. ocellatus* reach 30 cm in total length, while the *C. bedriagai* only reach 17 cm of length. The intact tail in *C. ocellatus* can be as long as half the size from the tip of the snout to the cloaca, although it is usually shorter, in *C. bedriagai* the length of the intact tail is usually greater than half the size from tip of snout to cloaca. In *C. ocellatus* there are usually between 28 and 38 scales around the center of the body, in *C. bedriagai* between 24 and 28 scales. In *C. ocellatus* the loreal scale borders the second and third supralabials, in *C. bedriagai* said scale only borders the second supralabial.

Owners of country houses and plant nurseries in the area were interviewed about the species' presence. After showing a photo of a *C. ocellatus*, they were asked if they had seen such a reptile. If the answer was affirmative, we asked if they remembered the year that they had seen it for the first time. Then we requested them to take photos of future sightings to unequivocally identify the species. The observation was considered "confirmed" when the owner provided us with high-quality evidence (photos or videos) that allowed the species to be accurately identified. Observations were considered "probable" when evidence seemed to suggest *C. ocellatus*, but it was not possible to separate it for sure from *C. bedriagai* because of graphic quality

Figure 3. Adult ocellated skink *Chalcides ocellatus* recorded in a country house in Elche (SE Spain). Photograph by Adrian Orihuela-Torres.

or to the specimen's posture. In addition, other characteristics such as the habitat in which it was recorded (i.e. around houses, courtyards, gardens, etc.) or its relatively large length and size, lead to the presumption that it is the *C. ocellatus*.

Results

In the systematic walking transects conducted in the natural areas, no *C. ocellatus* were detected, but two records of *C. bedriagai* were obtained (Figure 2). The property owner interviews provided five confirmed and two probable records of *C. ocellatus* (Figure 2), which all occurred in anthropogenically disturbed habitats, such as country houses, gardens and plant nurseries. The geographical coordinates for each confirmed location are included in Supplementary material (Table S1). Four confirmed observations occurred 12.5 km away from the first record provided by Bisbal-Chinesta et al. (2019). They were located in independent properties less than 1 km from one another. A minimum of 25 different individuals were identified at one of the country houses (0.2 ha). The records collected in this area included the observation of specimens preyed on by a domestic chicken, *Gallus gallus*, a Montpellier snake, *Malpolon monspessulanus,* and a black-headed gull, *Chroicocephalus ridibundus*. A roadkill specimen was also found on the access road to one of these houses. Only four of the approximately 30 houses in the rural settlement could be checked, obtaining a minimum range of 5–16 individuals recorded per house. One more confirmed record was obtained in a country house located at 6.3 km from the first occurrence in Sierra El Molar and more than 6.7 km from the furthest site discovered here (Figure 3). At least 2 different adults were

located at this site in a small orchard (80 m^2). Finally, two probable records were obtained. One was provided by a plant nursery owner (located at 5.1 km from Sierra El Molar), and the second was provided by a wildlife photographer, who took pictures of a skink predated by a European *Coracias garrulus* nesting in a palm plantation (located at 8.3 km from Sierra El Molar). In both cases the pictures suggested that the species was *C. ocellatus*, but this identification was not possible to confirm based only on the pictures provided.

All six owners of country houses and nurseries with confirmed or probable records reported that the first sightings were made in 2017 and 2018. They also note that they are encountering them more frequently each year.

Discussion

All the new localities where the species was present were highly anthropogenically modified habitats, such as palm nurseries, local gardens, farms or areas with rubble, and were especially abundant in compost piles (*pers. obs.*). This fact shows that the species is not exclusively linked with natural areas as suggested by Bisbal-Chinesta et al. (2019). Indeed, it seemed most abundant in areas with human disturbance. This is similar to other areas in which recent species introductions have occurred, as in Arizona and Florida (USA) or on the Aegean Islands of Greece (Gunn et al. 2012; Kornilios and Thanou 2016).

Lack of focus on samplings and searches for the species in more anthropogenically modified habitats might have been the cause of not previously detecting more populations of this species (Bisbal-Chinesta et al. 2019). The existence of at least four different locations and the occurrence of several dozen individuals of different ages indicate that the population has been present in this area for several years. This area holds one of the highest densities of plant nurseries in Spain (Fernández-Zamudio et al. 2012). Only in a 15 km buffer from the first Sierra del Molar location, we recorded a minimum of 47 active plant nurseries (see Figure 2).

The relationship between plant nurseries and palm crops, and the species' presence, are worthy of discussion. Some studies indicate that the horticultural trade is one of the main pathways of introductions of this species (Gunn et al. 2012). The importation of Egyptian palm trees may represent the pathway. In addition to its presence in plant nurseries, this would explain the lack of genetic differentiation between the specimens located in the Sierra del Molar and natural populations in Egypt (Bisbal-Chinesta et al. 2019) as many nurseries are located in this area. Moreover, the entry of Egyptian palms with no phytosanitary control in 1995 (Ferry and Gómez 2002) led to the introduction of red palm weevil *Rhynchophorus ferrugineus,* which has caused severe damage in the area (Ferry and Gómez 2007). Although the horticultural trade seems to be the most plausible route for this species' entry into the Iberian southeast, an alternative route could be the pet trade because this species is frequently kept in terraria.

In the work that reported this species' presence in the Iberian southeast for the first time, Bisbal-Chinesta et al. (2019) sequenced 303 bp of cytochrome *b* of five *C. ocellatus* specimens sampled at Sierra del Molar. These authors conducted phylogenetic analyses by considering 146 additional samples distributed across the Mediterranean Basin that well represented the species' distribution range. These molecular analyses revealed that the population located in Sierra del Molar was phylogenetically and closely related to specimens from NE Egypt and the southern Red Sea (the Iberian samples differed from the samples of the Eastern Mediterranean clade in only a single mutation). Consequently, these results ruled out the possibility of the species' natural dispersal from North Africa and identified *C. ocellatus* as an introduced species into the Iberian southeast. The resolving power of the molecular marker used by these authors did not allow historic and current events to be differentiated. Accordingly, the authors suggested current palm trade and historic stowaways as potential routes of entry, and argued that the isolation of Sierra del Molar by the deltas of the Vinalopó and Segura rivers (until 18th century AD) could explain the confined distribution of *C. ocellatus* in spite of its demonstrated high capacity to colonise new areas (i.e. Siépi 1913; Fitter 1959; Caputo et al. 1997; Karunarathna et al. 2009; Krysko et al. 2011; Gunn et al. 2012; Lo Cascio and Grita 2016; Kornilios and Thanou 2016).

According to our data, we consider *C. ocellatus* to have been probably introduced in recent times and fast population expansion is happening. Interestingly, the first record of this species reported by the owners of the houses in which the skinks were found coincides with the field observation made by Bisbal-Chinesta et al. (2019). Therefore, it seems that the process coincides in time, pointing to a common event at the beginning of the expansion. Although it seems a less likely origin, we acknowledge that current data certainly do not rule out the species introduction in ancient times. For example, the observed pattern of expansion could be due to an invasion debt. Some species for a long time remain only at the point of translocation and after a while begin to expand (Rouget et al. 2016). The recent introduction of specimens from nurseries could have contributed to this process, which could also explain why some of the specimens sampled in El Molar have a different genetic pattern from the rest (Bisbal-Chinesta et al. 2019). Likewise, currently available information does not allow us to conclude whether this is active (expansion produced by the dispersion of specimens from a single/multiple release point(s) or passive (if colonisation has been facilitated by gardening equipment or pots themselves). What we can rule out is the deliberate movement by the house owners, since they denied to have translocated the animals. Further molecular studies with highly polymorphic markers by considering samples from the whole range in the Iberian southeast could help to elucidate this point.

Regardless of the way dispersal took place, and according to guidelines in a recent review about the status of allochthonous herpetofauna in Spain and management proposals (Santos et al. 2015), active management and eradication by regional governments are recommended before detrimental interactions with native wildlife are recorded. We recorded the presence of native *C. bedriagai* in the area, even though it is scarce and difficult to detect. The *C. bedriagai* population is believed to be declining, especially some island populations, and the IUCN has listed it as being "Near Threatened" (Pleguezuelos et al. 2009). In places like the Chafarinas Islands (south Spain), *C. bedriagai* can be found in sympatry with another closely related endemic species, the Chafarinas' skink *C. paralellus* (Doumergue, 1901), and apparently no detrimental interactions have been recorded (Civantos et al. 2020). But the precautionary principle must prevail due to the significant detrimental interactions that have been demonstrated by the introduction of alien species. In particular, detrimental effects described for native reptiles range from competition for food or shelters (Boland 2004; Cole et al. 2005) to genetic exogamy by hybridisation (Vuillaume et al. 2015) or collapse of native reptile populations (Montes et al. 2021). The *C. ocellatus* can even prey on *C. bedriagai* juveniles, as recorded for other lizard species in the areas into which it was introduced (Carretero et al. 2010; Adamopoulou and Pafilis 2019).

If we consider several cases in which the species has behaved as invasive in other parts of the globe, conservation actions to prevent the species' expansion in the Iberian southeast are urgent. Several studies show how the eradication of invasive species is very effective when carried out in the early colonisation stages (Theoharides and Dukes 2007). However, the semi-fossorial and discrete behaviour of this species, as well as its propensity to expand to private areas, such as country houses and plant nurseries, could make management efforts extremely difficult. Field experimental studies to assess *C. ocellatus* interactions with the native biota, as suggested by Bisbal-Chinesta et al. (2019), could help to assess the risk for other species (essential for making management decisions). However, other kind of studies (not focused to better guide the species management) could be counterproductive as they would delay the implementation of eradication actions.

Finally, this case also illustrates the key role of regulating the horticultural trade to avoid biological introductions. Specifically, in the southeast Iberia, the importation of palms from Egypt with insufficient sanitary control is probably the main responsible factor for the presence of this and other exotic species, which cause biological invasions. As the control of biological invasions is sometimes impossible in practical terms, more prevention efforts are necessary.

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Author contribution

JMPG, FB research conceptualization; JMPG, MF, AOT designed the study and methodology; JMPG, MF, AOT data collection; JMPG, AOT drafted the earlier version of the manuscript; MF, FB, EG revised the manuscript. All authors read and approved the final manuscript.

Ethics and permits

We have complied with the institutional and Spanish policies governing the humane and ethical treatment of the experimental subjects, and we are willing to share the original data and materials if so requested. As our research did not require the manipulation, handling, experimentation or tagging of the species, no special permit application was necessary.

References

Adamopoulou C, Pafilis P (2019) Eaten or beaten? Severe population decline of the invasive lizard *Podarcis siculus* (Rafinesque-Schmaltz, 1810) after an eradication project in Athens, Greece. *Herpetozoa* 32: 165, https://doi.org/10.3897/herpetozoa.32.e36609

Anderson SC (1999) The lizards of Iran. Society for the study of Amphibians and Reptiles. Ithaca, NY, 492 pp

Bellard C, Cassey P, Blackburn TM (2016) Alien species as a driver of recent extinctions. *Biology Letters* 12: 20150623, https://doi.org/10.1098/rsbl.2015.0623

Bisbal-Chinesta JF, Tamar K, Gálvez Á, Albero L, Vicent-Castelló P, Martín-Burgos L, Alonso M, Sánchez R, Ortega C, Gómez A, Candel D, Cervera M, Carranza S, Blain H-A (2019) Trade and stowaways: molecular evidence for human-mediated translocation of eastern skinks into the western Mediterranean. *Amphibia-Reptilia* 41: 49–62, https://doi.org/10.1163/15685381-20191249

Böhm M Collen B, Baillie JEM, Bowles P, Chanson J, Cox N, Hammerson G, Hoffmann M, Livingstone SR, Ram M, Rhodin AGJ, Stuart SN, van Dijk PP, Young BE, Afuang LE, AghasyanA, García A, Aguilar C, Ajtic R, Akarsu F, Alencar LRV, Allison A, Ananjeva N, Anderson S, Andrén C, Ariano-Sánchez D, Arredondo JC, Auliya M, Austin CC, Avci A, Baker PJ, Barreto-Lima AF, Barrio-Amorós CL, Basu D, Bates MF, Batistella A, Bauer A, Bennett D, Böhme W, Broadley D, Brown R, Burgess J, Captain A, Carreira S, Castañeda MDR, Castro F, Catenazzi A, Cedeño-Vázquez JR, Chapple DG, Cheylan M, Cisneros-Heredia DF, Cogalniceanu D, Cogger H, Corti C, Costa GC, Couper PJ, Courtney T, Crnobrnja-Isailovic J, Crochet P-A, Crother B, Cruz F, Daltry JC, Daniels RJR, Das I, de Silva A, Diesmos AC, Dirksen L, Doan TM, Dodd CK, Doody JS, Dorcas ME, Duarte de Barros Filho J, Egan VT, El Mouden EH, Embert D, Espinoza RE, Fallabrino A, Feng X, Feng Z-J, Fitzgerald L, Flores-Villela O, França FGR, Frost D, Gadsden H, Gamble T, Ganesh SR, Garcia MA, García-Pérez JE, Gatus J, Gaulke M, Geniez P, Georges A, Gerlach J, Goldberg S, Gonzalez J-CT, Gower DJ, Grant T, Greenbaum E, Grieco C, Guo P, Hamilton AM, Hare K, Hedges SB, Heideman N, Hilton-Taylor C, Hitchmough R, Hollingsworth B, Hutchinson M, Ineich I, Iverson J, Jaksic FM, Jenkins R, Joger U, Jose R, Kaska Y, Kaya U, Keogh JS, Köhler G, Kuchling G, Kumluta¸s Y, Kwet A, La Marca E, Lamar W, Lane A, Lardner B, Latta C, Latta G, Lau M, Lavin P, Lawson D, LeBreton M,

Lehr E, Limpus D, Lipczynski N, Lobo AS, López-Luna MA, Luiselli L, Lukoschek V, Lundberg M, Lymberakis P, Macey R, Magnusson WE, Mahler DL, Malhotra A, Mariaux J, Maritz B, Marques OAV, Márquez R, Martins M, Masterson G, Mateo JA, Mathew R, Mathews N, Mayer G, McCranie JR, Measey GJ, Mendoza-Quijano F, Menegon M, Métrailler S, Milton DA, Montgomery C, Morato SAA, Mott T, Muñoz-Alonso A, Murphy J, Nguyen TQ, Nilson G, Nogueira C, Núñez H, Orlov N, Ota H, Ottenwalder J, Papenfuss T, Pasachnik S, Passos P, Pauwels OSG, Pérez-Buitrago N, Pérez-Mellado V, Pianka ER, Pleguezuelos J, Pollock C, Ponce-Campos P, Powell R, Pupin F, Quintero Díaz GE, Radder R, Ramer J, Rasmussen AR, Raxworthy C, Reynolds R, Richman N, Rico EL, Riservato E, Rivas G, da Rocha PLB, Rödel M-O, Rodríguez Schettino L, Roosenburg WM, Ross JP, Sadek R, Sanders K, Santos-Barrera G, Schleich HH, Schmidt BR, Schmitz A, Sharifi M, Shea G, Shi H-T, Shine R, Sindaco R, Slimani T, Somaweera R, Spawls S, Stafford P, Stuebing R, Sweet S, Sy E, Temple HJ, Tognelli MF, Tolley K, Tolson PJ, Tuniyev B, Tuniyev S, Üzüm N, van Buurt G, Van Sluys M, Velasco A, Vences M, Veselý M, Vinke S, Vinke T, Vogel G, Vogrin M, Vogt RC, Wearn OR, Werner YL, Whiting MJ, Wiewandt T, Wilkinson J, Wilson B, Wren S, Zamin T, Zhou K; Zug G (2013) The conservation status of the world's reptiles. *Biological Conservation* 157: 372–385, https://doi.org/10.1016/j.biocon.2012.07.015

Boland CRJ (2004) Introduced cane toads *Bufo marinus* are active nest predators and competitors of rainbow bee-eaters *Merops ornatus*: observational and experimental evidence. *Biological Conservation* 120: 53–62, https://doi.org/10.1016/j.biocon.2004.01.025

Caputo V, Guarino FM, Baldanza F (1997) A new finding of the skink, *Chalcides ocellatus*, in the ex-royal garden of Portici (Naples, Italy). *Boletín de la Asociación Herpetológica Española* 8: 3–4

Carretero MA, Lo Cascio P, Corti C, Pasta S (2010) Sharing resources in a tiny Mediterranean island? Comparative diets of *Chalcides ocellatus* and *Podarcis filfolensis* in Lampione. *Bonn Zoological Bulletin* 57: 111–118

Civantos E, Arribas R, Martín J (2020) Niche occupancy of two (congeneric) skinks in an islands environment. *Amphibia-Reptilia* 41: 337–347, https://doi.org/10.1163/15685381-bja10002

Cole NC, Jones CG, Harris S (2005) The need for enemy-free space: the impact of an invasive gecko on island endemics. *Biological Conservation* 125: 467–474, https://doi.org/10.1016/j.biocon.2005.04.017

Fernández-Zamudio MA, Bartual J, Roca D, Verdeguer A, Martínez PF (2012) Ornamental horticulture at the mediterranean seaside of Spain: present situation and future challenges. *Acta Horticulturae* 937: 51–57, https://doi.org/10.17660/ActaHortic.2012.937.4

Ferry M, Gómez S (2002) The Red Palm Weevil in the Mediterranean Area. *Palms* 46(4): 172–178

Ferry M, Gómez S (2007) El picudo rojo de la palmera datilera: gravedad de la plaga en España y necesidad de un cambio radical y urgente de estrategia en la lucha, [The red palm weevil of the date palm: seriousness of the pest in Spain and the need for a radical and urgent change in control strategy]. *Phytoma España: La revista profesional de sanidad vegetal* 185: 42–46

Fitter RSR (1959) The ark in our midst: the story of the introduced animals of Britain; Birds, Beasts, Reptiles, Amphibians, Fishes. Collins, London, 320 pp

Gippet JM, Bertelsmeier C (2021) Invasiveness is linked to greater commercial success in the global pet trade. *Proceedings of the National Academy of Sciences* 118: e2016337118, https://doi.org/10.1073/pnas.2016337118

Gunn J, Bowker RW, Sullivan KO, Sullivan BK (2012) An Old World skink, *Chalcides ocellatus*, with a long history of anthropogenically assisted dispersal, now established in Mesa, Arizona, USA. *Herpetological Review* 43(4): 551–553

Karunarathna DMSS, Wickramasinghe LJM, Samarawickrama VAP, Munindradasa DAI (2009) The range extension of genus *Chalcides laurenti*, 1768 (Reptilia: Scincidae) to Sri Lanka. *Russian Journal of Herpetology* 15(3): 225–228

Kornilios P, Thanou E (2016) Two additions to the herpetofauna of Kasos (Aegean Sea, Greece) and the role of human-mediated dispersals. *Herpetological Review* 47(4): 633–635

Kornilios P, Kyriazi P, Poulakakis N, Kumlutaş Y, Ilgaz Ç, Mylonas M, Lymberakis P (2010) Phylogeography of the ocellated skink *Chalcides ocellatus* (Squamata, Scincidae), with the use of mtDNA sequences: A hitch-hiker's guide to the Mediterranean. *Molecular Phylogenetics and Evolution* 54: 445–456, https://doi.org/10.1016/j.ympev.2009.09.015

Kraus F (2009) Alien reptiles and amphibians: a scientific compendium and analysis (Vol. 4). Springer Science & Business Media, 563 pp, https://doi.org/10.1007/978-1-4020-8946-6

Krysko KL, Burgess JP, Rochford MR, Gillette CR, Cueva D, Enge KM, Somma LA, Stabile JL, Smith DC, Wasilewski JA, Kieckhefer III GN, Granatosky MC, Nielsen SV (2011) Verified non-indigenous amphibians and reptiles in Florida from 1863 through 2010: Outlining the invasion process and identifying invasion pathways and status. *Zootaxa* 3028: 1–64, https://doi.org/10.11646/zootaxa.3028.1.1

Lavin BR, Papenfuss TJ (2012) The phylogenetic position of *Chalcides ocellatus* (Squamata: Scincidae) from Yemen and Somalia. *Zootaxa* 3221: 26–36, https://doi.org/10.11646/zootaxa.3221.1.2

Levine JM, D'Antonio CM (2003) Forecasting biological invasions with increasing international trade. *Conservation Biology* 17: 322–326, https://doi.org/10.1046/j.1523-1739.2003.02038.x

Lo Cascio P, Grita F (2016) Introduzione accidentale di gongilo *Chalcides ocellatus* (Forskal, 1775) (Squamata Scincidae) nell'isola di Stromboli (Arcipelago Eoliano), [Accidental introduction of ocellated skink *Chalcides ocellatus* (Forskal, 1775) (Squamata Scincidae) in the island of Stromboli (Aeolian Archipelago)]. *Naturalista Siciliano* 40(2): 325–328

Millennium Ecosystem Assessment (2005) Ecosystems and Human Well-being: synthesis. World Resources Institute, 155 pp

Montes E, Kraus F, Chergui B, Pleguezuelos JM (2021) Collapse of the endemic lizard *Podarcis pityusensis* on the island of Ibiza mediated by an invasive snake. *Current Zoology* zoab022, https://doi.org/10.1093/cz/zoab022

Pitt W, Vice D, Pitzler M (2005) Challenges of invasive reptiles and amphibians, In: Nolte DL, Fagerstone KA (eds), Wildlife Damage Management Conferences Proceedings, Wildlife Damage Management Working Group, pp 112–119

Pleguezuelos JM, Sá-Sousa P, Pérez-Mellado V, Márquez R, Martínez-Solano I (2009) *Chalcides bedriagai*. The IUCN Red List of Threatened Species 2009, e, T61472A12472701

Robinson JE, Griffiths RA, John FAS, Roberts DL (2015) Dynamics of the global trade in live reptiles: Shifting trends in production and consequences for sustainability. *Biological Conservation* 184: 42–50, https://doi.org/10.1016/j.biocon.2014.12.019

Rouget M, Robertson MP, Wilson JR, Hui C, Essl F, Renteria JL, Richardson DM (2016) Invasion debt-quantifying future biological invasions. *Diversity and Distributions* 22: 445–456, https://doi.org/10.1111/ddi.12408

Salvador A (1998) Fauna Ibérica, Vol 10, Reptiles, Museo Nacional de Ciencias Naturales, Editorial CSIC, Madrid, 1368 pp

Santos XS, López EA, Arribas OJ, Badenes AB, Bosch J, Cabido C, Carranza S, Carretero M,Á, Díaz-Paniagua C, Egea-Serrano A, Garin-Barrio I, Giménez A, Gosá A, Graciá E, Guicking D, Llorente GA, Martínez-Solano Í, Mateo JA, Montori A, Palomar G, Perera A, Pinya S, Pretus JL, Pujol-Buxó E, Rato C, Recuero E, Sanz-Azkue I, Silva-Rocha I, Vasconcelos R, Velo-Antón G, Vörös J, Pleguezuelos JM (2015) Síntesis de las introducciones de anfibios y reptiles en España, [Synthesis of amphibian and reptile introductions in Spain]. *Boletín de la Asociación Herpetológica Española* 26(2): 98–108

Siépi G (1913) Adaptation du Gongyle ocellé, au territoire de Marseille, [Adaptation of the Ocellated Skink to the territory of Marseille]. *La Feuille des Jeunes Naturalistes* 511: 114

Speybroeck J, Beukema W, Bok B, Van Der Voort J (2016) Field guide to the amphibians and reptiles of Britain and Europe. Bloomsbury publishing, 432 pp

Theoharides KA, Dukes JS (2007) Plant invasion across space and time: factors affecting nonindigenous species success during four stages of invasion. *New Phytologist* 176: 256–273, https://doi.org/10.1111/j.1469-8137.2007.02207.x

Vuillaume B, Valette V, Lepais O, Grandjean F, Breuil M (2015) Genetic evidence of hybridization between the endangered native species *Iguana delicatissima* and the invasive *Iguana iguana* (Reptilia, Iguanidae) in the Lesser Antilles: management implications. *PLoS ONE* 10: e0127575, https://doi.org/10.1371/journal.pone.0127575

Supplementary material

The following supplementary material is available for this article:

Table S1. Locations of *Chalcides ocellatus* recorded in southeastern Spain.

This material is available as part of online article from:
http://www.reabic.net/journals/bir/2022/Supplements/BIR_2022_Perez-Garcia_etal_SupplementaryMaterial.xlsx