Received: 3 March 2021 | Accepted: 6 January 2022

DOI: 10.1111/1365-2664.14150

POLICY DIRECTION

Journal of Applied Ecology BRITISH ECOLOGICAL SOCIETY

Accelerated avian invasion into the Mediterranean region endangers biodiversity and mandates international collaboration

Tali Magory Cohen[1,2] | Mark E. Hauber[3] | Triantaphyllos Akriotis[4] | Pierre-André Crochet[5] | Georgios Karris[6] | Alexander N. G. Kirschel[7] | Fares Khoury[8] | Mattia Menchetti[9] | Emiliano Mori[10] | Esra Per[11] | Luís Reino[12,13,14] | Susana Saavedra[15] | Joana Santana[12,13,14] | Roi Dor[16]

[1]School of Zoology, Faculty of Life Sciences, Tel Aviv University, Tel Aviv, Israel; [2]Steinhardt Museum of Natural History, Tel Aviv University, Tel Aviv, Israel; [3]Department of Evolution, Ecology, and Behavior, School of Integrative Biology, University of Illinois at Urbana-Champaign, Urbana, IL, USA; [4]Department of Environmental Studies, University of the Aegean, Mytilini, Greece; [5]CEFE, CNRS, Univ Montpellier, EPHE, IRD, Univ Paul Valéry Montpellier 3, Montpellier, France; [6]Lab of Environmental Physics, Energy and Environmental Biology, Department of Environment, Faculty of Environment, Ionian University, Greece; [7]Department of Biological Sciences, University of Cyprus, Nicosia, Cyprus; [8]Department of Biology and Biotechnology, American University of Madaba, Madaba, Jordan; [9]Institut de Biologia Evolutiva (CSIC-UPF), Passeig Maritim de la Barceloneta, Barcelona, Spain; [10]National Research Council—Research Institute on Terrestrial Ecosystems—Via Madonna del Piano, Sesto Fiorentino, Italy; [11]Department of Biology, Faculty of Science, Gazi University, Ankara, Turkey; [12]CIBIO, Centro de Investigação em Biodiversidade e Recursos Genéticos, InBIO Laboratório Associado, Campus de Vairão, Universidade do Porto, Vairão, Portugal; [13]CIBIO, Centro de Investigação em Biodiversidade e Recursos Genéticos, InBIO Laboratório Associado, Instituto Superior de Agronomia, Universidade de Lisboa, Tapada da Ajuda, Lisboa, Portugal; [14]BIOPOLIS Program in Genomics, Biodiversity and Land Planning, CIBIO, Campus de Vairão, Vairão, Portugal; [15]Invasive Bird Management (INBIMA), Tenerife, Spain and [16]Department of Natural and Life Sciences, The Open University of Israel, Ra'Anana, Israel

Correspondence
Tali Magory Cohen
Email: talimagory@gmail.com

Funding information
'La Caixa' Foundation, Grant/Award Number: LCF/BQ/DR20/11790020; Council for Higher Education (CHE) Postdoctoral Fellowship; Fundo Europeu de Desenvolvimento Regional through the Operational Competitiveness Factors Program "COMPETE"; National Funds through the Foundation for Science and Technology (FCT), Grant/Award Number: PTDC/BIA-ECO/30931/2017-POCI-0; Portuguese National Funds through FCT, IP, under the "Stimulus of Scientific Employment-Individual Support", Grant/Award Number: CEECIND/00445/2017; Tel Aviv University's Rector's Emergency Corona Fellowship; The Hanse-Wissenschaftskolleg (Institute for Advanced Study), Germany; Wissenschaftskolleg zu Berlin; United States-Israel Binational Science Foundation, Grant/Award Number: 2017285

Handling Editor: Gavin M Siriwardena

Abstract

1. Despite posing a serious threat to global biodiversity, national and international management efforts have not been able to limit the spread of most invasive species. In highly dispersive species, local invasions may be followed by regional range expansion that crosses international borders. In such cases, independent management efforts of the invading population may be futile unless international collaboration is practiced.
2. We focus on the ongoing human-mediated invasion of the common myna *Acridotheres tristis* into the Mediterranean basin, a region rich in overall numbers of species and endemic species, where common mynas have been introduced into a handful of countries. Some introductions were followed by subsequent range expansions into neighbouring countries. This species poses major threats to the biodiversity of the Mediterranean which is already susceptible to biodiversity loss as the result of ongoing land use and climate changes. Without action, this species and possibly others similar to it, could have severe consequences for native ecosystems.
3. *Policy implications*. Given the regional scope of its invasion in the Mediterranean basin, common myna management requires an international collaboration to successfully prevent additional introductions and range expansions and to avoid accelerating threats to Mediterranean biodiversity, already at risk as a result of

ongoing changes in land use and climate. We argue that international reciprocal transfer of information and the development of regional mitigation are essential for the successful management of the invasion of the common myna and other species into the Mediterranean.

KEYWORDS
anthropogenic impact, avian ecology, biodiversity, common myna, ecopolitics, international collaboration, invasive species, Mediterranean

The detrimental impacts of invasive alien species represent the second most common threat associated with species extinctions world-wide after habitat destruction (Bellard et al., 2016). Despite this call for alarm, current national and international policy strategies have failed to curtail the range expansion of most introduced species (Pyšek et al., 2020). In the Mediterranean, past avian introductions have already resulted in successful invasions, leading to established or breeding populations of alien species such as the ruddy duck *Oxyura jamaicensis* (Muñoz-Fuentes et al., 2006; Robertson et al., 2015), the rose-ringed parakeet *Psittacula krameri* (Pârâu et al., 2016; Souviron-Priego et al., 2018; Strubbe & Matthysen, 2009), the monk parakeet *Myiopsitta monachus* (Postigo et al., 2019; Strubbe & Matthysen, 2009), the red-vented bulbul *Pycnonotus cafer* (Nowakowski & Dulisz, 2019) or the crested myna *Acridotheres cristatellus* (Elias, 2021), among others. These alien species have already been shown to detrimentally affect local species in several ways, including hybridizing with endangered species (Hughes et al., 2006), competing over resources (Charter et al., 2016; Colléony & Shwartz, 2020; Hernández-Brito et al., 2014; Menchetti et al., 2014; Orchan et al., 2013) and altering the native plant communities (Menchetti & Mori, 2014). Their negative impact also extends to human economy by damaging crops (Haubrock et al., 2021; Senar et al., 2016) and health by acting as carriers of zoonotic diseases (Mori et al., 2018).

Here we focus on the ongoing human-mediated translocation, introduction and subsequent range expansion of the common myna *Acridotheres tristis* (Linnaeus, 1766), a starling native to south Asia, as a case study of the acceleration of avian invasions into the Mediterranean region. Having been introduced and subsequently becoming invasive on every continent except Antarctica (Magory Cohen et al., 2019), this bird has become a global concern in many parts of the world including Australia, New Zealand, Hawaii and South Africa (Fleischer et al., 1991; Long, 1981; Peacock et al., 2007; Pell & Tidemann, 1997; Tidemann, 2001). Documented introductions into the Mediterranean region started in the late 1990s in Israel (Holzapfel et al., 2006), Lebanon (Bara, 2002; Ramadan-Jaradi & Ramadan-Jaradi, 2012), Italy (Mori et al., 2020) and Turkey (Bilgin, 1996; Scalera et al., 2018). Some of those introductions were followed by subsequent range expansions from, for example, Israel to Egypt (where a separate introduction was also documented, Wael I. Hassan, Saudi Wildlife Authority, pers. comm., Rabia et al., 2015), Gaza (Abd Rabou, 2019), the West Bank (Handal & Qumsiyeh, 2021; Magory Cohen & Dor, 2019) and Jordan (Khoury et al., 2021; Khoury & Alshamlih, 2015), as well as into Lebanon's southernmost region (GBIF; https://www.gbif.org/). Additional sightings of common mynas in the Mediterranean include sites in Greece, France, Portugal and Spain (GBIF; https://www.gbif.org/; Saavedra et al., 2015) (Figure 1). Common mynas had also established in some isles of Canary Archipelago (Spain), but a strenuous effort to eradicate them has been successful so far (Figure 1; Saavedra et al., 2015). Importantly, in some cases, range expansion has occurred through climatically unfavourable areas by moving along corridors of human settlements and other green spots in desert habitats, for example, the Sinai desert (Egypt), the Negev highland (Israel) or Saudi Arabia (Jennings, 2010; Khoury et al., 2021; Magory Cohen & Dor, 2019).

The current distribution of common mynas and their potential spread present a particular risk to the Mediterranean. There appears to be an accelerated rate of common myna trade, dispersal, and subsequently, introductions across the Mediterranean in recent decades. Coupled with the high environmental suitability for the presence of this invader in large parts of this region according to species distribution models based on anthropogenic, climatic and topographic predictors (Figure 1; adapted from Magory Cohen et al., 2019), we suggest that the Mediterranean basin is at great risk of regional naturalization of the common myna. While the climatic similarities between the myna's native habitat and the Mediterranean contribute to the predicted suitability of this region for myna presence, it is in fact urbanization that is the most significant factor in determining habitat suitability for this species (Khoury et al., 2021; Magory Cohen et al., 2019). More generally, anthropogenic habitat modifications often increase the likelihood of invasion success of introduced species (Hufbauer et al., 2012). Since, to the best of our knowledge, most of the introductions of common mynas in the Mediterranean were made in urban environments through escapees from the pet trade (Holzapfel et al., 2006), their establishment success may have been mediated by the level of urbanization at release sites. Furthermore, the Mediterranean is highly susceptible to biodiversity loss as a result of ongoing land use and climate change (Newbold et al., 2020), emphasizing the expected strain on the region's biodiversity.

1.1 | Common myna traits: A swift and able adapter

As a pet bird commonly traded world-wide, the common myna possesses some traits, including singing and imitation ability,

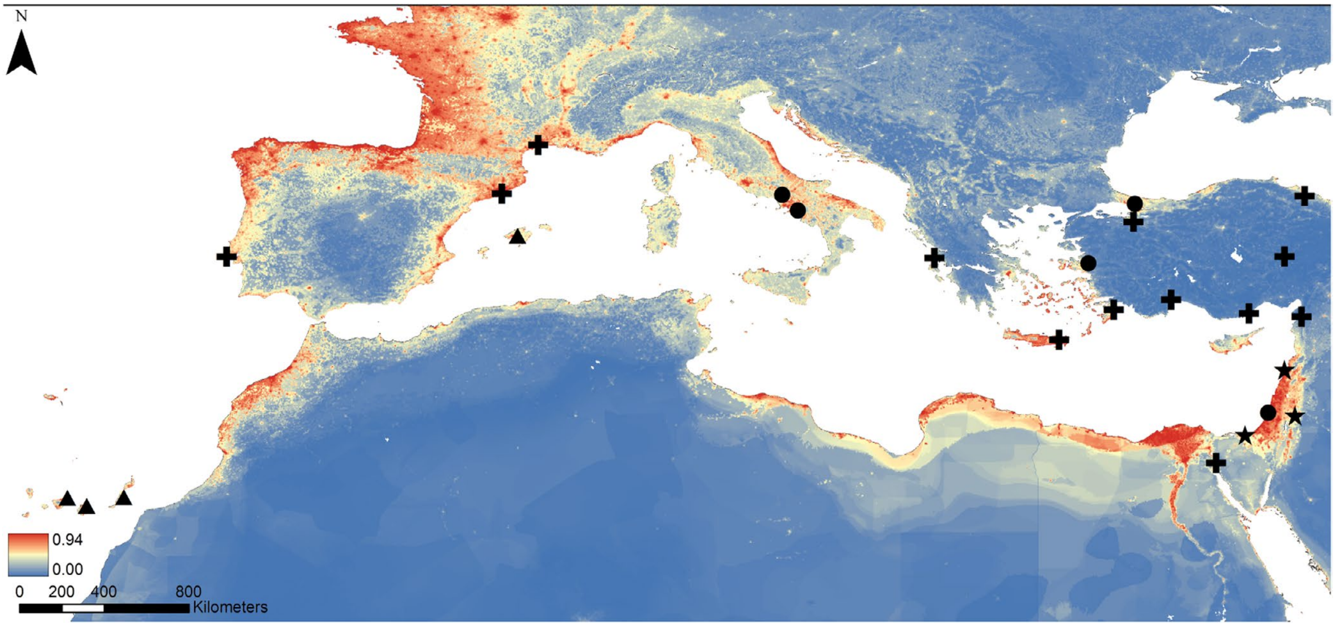

FIGURE 1 A map of average probabilities for suitable areas for common myna presence across the Mediterranean based on results from a species distribution model carried out with climatic, topographic and anthropogenic predictors adapted from (Magory Cohen et al., 2019). The legend contains colour code representation of the probability of common myna presence, where red colours represent areas of high suitability for common myna presence and blue colours represent areas of low suitability. Black circles represent introduction sites of established (breeding) populations, black stars represent regions into which an introduced population had expanded from a neighbouring country, black crosses represent sites where sightings had been reported after the year 2015, and black triangles represent sites from where common mynas have been eradicated

which increase its appeal to pet owners, whereas other traits have an enabling effect on its invasiveness. For instance, common mynas exhibit superior problem-solving performance, suggested to reflect advanced cognitive ability (Griffin et al., 2014; Griffin & Guez, 2016), both in their native and especially in their introduced ranges, which possibly plays a role in facilitating invasion success (Magory Cohen et al., 2020). Specifically, in urban environments, common mynas may be better at the acquisition of novel foods (e.g. outdoor provisioning of domestic/feral cats and dogs, human garbage and road carcasses) and foraging techniques (e.g. extracting food from public rubbish bins). Additionally, their commensal nature allows them to successfully exploit opportunities in close proximity to people and their settlements, and this is particularly intensified in urban environments (McGiffin et al., 2013). Additional life-history adaptations documented include changes to the timing and length of the breeding strategy, most likely depending on the availability of food resources (Counsilman, 1974). Breeding success in common mynas is also mediated by the broad diversity of nest cavity types that they use, including highly disturbed human-made structures like traffic lights and drainpipes (Counsilman, 1974) and thus, there are a multitude of available cavities for breeding within human settlements. Overall, these traits, especially when they reflect population-level phenotypic changes from native to introduced ranges, attest to the adaptable nature of common mynas and their increased potential as successful invaders.

1.2 | Current and expected threats to biodiversity in the Mediterranean due to common mynas invasion

Many invasive alien species have been described from the Mediterranean, including plants (Brunel et al., 2010; Lambdon et al., 2008; Manor et al., 2008), marine species such as fishes and molluscs (Galil, 2007; Katsanevakis et al., 2016), insects (El-Mergawy et al., 2011; Gasperi et al., 2012; Giorgini et al., 2019; Muñoz-Adalia & Colinas, 2020; Paine & Lieutier, 2016; Pellizzari & Porcelli, 2014), mammals (Capizzi, 2020; Traveset et al., 2009) and birds (Holzapfel et al., 2006; Kark et al., 2009; Kark & Sol, 2005; Postigo et al., 2019; Strubbe & Matthysen, 2009). Several of these species have been shown to have a detrimental effect on either natural or anthropogenic environments (Galil, 2007; Kumschick & Nentwig, 2010), but others remain understudied or difficult to assess. Specifically, avian invaders have been implicated in threatening local species through introgressive hybridization (Hughes et al., 2006), increasing the risk of local population declines (Charter et al., 2016; Colléony & Shwartz, 2020), leading to biotic homogenization (Colléony & Shwartz, 2020) and introducing diseases (Ancillotto et al., 2018; Kalodimos, 2013; Mori et al., 2019). The susceptibility of the Mediterranean region to common myna invasion and the species' set of traits that promote invasiveness suggest that in the event of inadvertent introduction or range expansion, common mynas are expected to establish, breed and spread if preventive measures are not applied. Should this occur, local biodiversity will be at risk.

TABLE 1 Documented impact of the common myna on local species of plants, reptiles, birds and mammals. Impact is categorized according to one or multiple forms of interaction. Location is described based on the respective study

Common name	Scientific name	Nest site competition	Competition for food	Predation	Alteration of flora community	Aggression	Interference	Location	Reference
Birds									
Black noddy	*Anous minutus*					Attacking		Midway Atoll	Grant, 1982 (quoted in Fitzsimons, 2006)
Brown noddy	*Anous stolidus*			Egg predator		Mobbing		Seychelles	Feare et al., 2015
Lesser noddy	*Anous tenuirostris*			Egg predator				Bird Island, Seychelles	Feare et al., 2015
Samoan starling	*Aplonis atrifusca*		Competition			Aggressor		American Samoa	Watling, 1982 (quoted in Freifeld, 1999)
Rarotonga starling	*Aplonis cinerascens*	Potential competitor—monopolizing resources						Rarotonga, Cook Islands	Turbott, 1977
Sulphur-crested cockatoo	*Cacatua galerita*	Potential competitor—nesting site competition						Australia	Grarock et al., 2012
St. Helena plover	*Charadrius sanctaehelenae*			Nest predation				St Helena	Burns et al., 2013
Red-billed gull	*Chroicocephalus novaehollandiae scopulinus*					Mobbing		New Zealand	Counsilman, 1974
Cave swiftlet	*Collocalia linchi*			Potential nest predator				French Polynesia	Seitre & Seitre, 1992; Holyoak & Thibault, 1978 (quoted in Feare & Craig, 1999)
Seychelles magpie-robin	*Copsychus sechellarum*	Nesting site competition		Egg and fledgling predator		Mobbing, killing		Seychelles	Burt et al., 2016; Watson et al., 1992
Jackdaw	*Corvus monedula*		Competition for road—kills and food from trash dumps					The West Bank	Handal & Qumsiyeh, 2021

TABLE 1 (Continued)

Common name	Scientific name	Nest site competition	Competition for food	Predation	Alteration of flora community	Aggression	Interference	Location	Reference
Red-crowned parakeet	*Cyanoramphus novaezelandiae*	Potential competitor—nesting site competition		Potential nest predator				New Zealand	Ortiz-Catedral & Brunton, 2008; Ortiz-Catedral & Brunton, 2009
Mauritius kestrel	*Falco punctatus*					Attacking		Mauritius	Jones, 1996 (quoted in Fitzsimons, 2006)
Seychelles fody	*Foudia sechellarum*			Egg predator		Attacking		Seychelles	Feare, 2010; quoted in Marshall & Cooper, 1969
Magpie lark	*Grallina cyanoleuca*					Potential aggressor		Australia	Grarock et al., 2012
White tern	*Gygis alba*					Mobbing		Midway Atoll	Grant, 1982 (quoted in Fitzsimons, 2006)
Mauritius black bulbul	*Hypsipetes olivaceus*		Competition	Predator				Mauritius	Safford, 1996; Cheke 1987 (quoted in Safford 1996)
Black backed gull	*Larus marinus*					Mobbing		New Zealand	Counsilman, 1974
Superb fairy-wren	*Malurus cyaneus*					Potential aggressor		Australia	Grarock et al., 2012
Sooty tern	*Onychoprion fuscatus*			Egg predator		Aggression leads to deserting eggs		Ascension Island	Hughes et al., 2008; Feare et al., 2015
Seychelles scops-owl	*Otus insularis*	Potential competitor—nesting site competition						Seychelles	Currie et al., 2004
Grand Comoro scops owl	*Otus pauliani*	Nesting site competition						Grand Comoro	Herremans et al., 1991
Striated pardalote	*Pardalotus striatus*					Potential aggressor		Australia	Grarock et al., 2012
Great tit	*Parus major*	Taking over active nests						Israel	Charter et al., 2016
House sparrow	*Passer domesticus*		Potential competitor—competitive exclusion					Israel, Jordan	Charter et al., 2016; F. Khoury, unpublished

(Continues)

TABLE 1 (Continued)

Common name	Scientific name	Nest site competition	Competition for food	Predation	Alteration of flora community	Aggression	Interference	Location	Reference
Saddleback	*Philesturnus*			Potential egg and chick predator				New Zealand	Lovegrove, 1986 (quoted in Dhami & Nagle, 2009)
Crimson rosella	*Platycercus elegans*	Taking over active nests, competing for nest cavities				Mobbing		Australia	Pell and Tidemann (1997); Grarock et al., 2012; Grarock et al., 2013
Eastern rosella	*Platycercus eximius*	Taking over active nests, competing for nest cavities				Mobbing		Australia	Pell and Tidemann (1997); Grarock et al., 2012; Grarock et al., 2013
Black-throated finch	*Poephila cincta cincta*						Reducing calls	Australia	Hopkins et al., 2021
Tahiti flycatcher	*Pomarea nigra*					Aggression leads to higher nest failure or early fledgling death; attacking		Tahiti	Blanvillain et al., 2003; Blanvillain et al., 2020
Purple martin	*Progne subis*					Attacking		Florida,USA	Neville, 2003 (quoted in Fitzsimons, 2006)
Mauritius parakeet	*Psittacula eques*	Nesting site competition	Competition					Mauritius	Cheke 1987 (quoted in Bissessur & Florens, 2018); Jones, 1996 (quoted in Fitzsimons, 2006); Tatayah et al., 2007
Wedge-tailed shearwater	*Pufinus pacificus*			Egg and chick predator				Hawaii	Byrd, 1979; Byrd et al., 1983
Grey fantail	*Rhipidura fuliginosa*					Potential aggressor		Australia	Grarock et al., 2012
Willie wagtail	*Rhipidura leucophrys*					Potential aggressor		Australia	Grarock et al., 2012
Seychelles paradise flycatcher	*Terpsiphone corvina*			Egg and chick predator				Seychelles	Feare, 2010

TABLE 1 (Continued)

Common name	Scientific name	Nest site competition	Competition for food	Predation	Alteration of flora community	Aggression	Interference	Location	Reference
Mangaia kingfisher	*Todirhamphus ruficollaris*					Mobbing		Polynesia	Sherley & Hay 2001
Common blackbird	*Turdus merula*					Potential aggressor		Australia	Grarock et al., 2012
Silvereye	*Zosterops lateralis*					Potential aggressor		Australia	Grarock et al., 2012
Seychelles white-eye	*Zosterops modestus*			Potential nest predator				Seychelles	Henriette & Rocamora, 2012
Mammals									
Macchabé skink	*Gongylomorphus bojerii fontenayi*			Predator				Mauritius	Bissessur & Florens, 2018
Plants									
Lantana sp.	*Lantana sp.*				Distribution of seeds			Hawaii	W, 1925; Drake & Frick, 1939; Chaudhary, 2011; Smith, 1985 (quoted in Simberloff, 2000)
Reptiles									
Green lizard	*Phoenicolacerta laevi*			Egg predator				The West Bank	Handal & Qumsiyeh, 2021

TABLE 2 Current management schemes employed by Mediterranean countries to control common myna populations. Information given relates to countries for which information was available for this study; relevant information for the remaining countries was not available to the authors at the time of the study (this table was accurate as of late 2021. Current estimates in Turkey are of 262–344 birds, and at least 11 birds in Cyprus)

Country	Trade ban	Legal status	Purpose of management	Management practice	Years active	Source of funding
France	Since 2020	Invasive species	No management	None	NA	NA
Greece	Since 2019	Invasive Alien Species of European Union concern	NA	NA	NA	NA
Israel	Since 2002	Pest	Control	Sporadic, unfocused shooting, trapping (small-scale), egg-oiling (failed)	2017-present	Government
Italy	Since 2019	Invasive species of European concern	No management	None	NA	NA
Jordan	No	Invasive species	No management	NA	NA	NA
Portugal	Since 2019	Invasive species	No management	None	2001–2017	None
Republic of Cyprus	Since 2019	Invasive Alien Species of European Union concern	NA	NA	NA	NA
Spain—mainland	Sice 2013	Invasive species	No management	NA	NA	NA
Spain—Mallorca Island	Since 2013	Invasive species	Eradication	Trapping, shooting	May 2006 and July 2007	Local government
Turkey	No	Introduced species	No management	None	NA	NA
West Bank	No	NA	No management	NA	NA	NA

Detrimental impacts of common mynas on native species in their introduced range have already been documented (Table 1). For example, decreases in local avian species abundance have been shown to be related with increased common myna numbers and distribution, mainly through competition over food resources and avian nesting cavities (Grarock et al., 2012; Rogers et al., 2020). Additionally, predation of eggs and chicks of native species by common mynas on islands contributed to lower breeding success and reintroduction failure of native species (Feare et al., 2015). Modifications of the flora community have also been documented following differential seed dispersal by common mynas (Simberloff, 2000). Similar threats to biodiversity are expected in the Mediterranean region, and some evidence has already been gathered (Charter et al., 2016; Colléony & Shwartz, 2020; Orchan et al., 2013). Alternatively, anthropogenic land cover change has been suggested to be the driver of the homogenization of avian communities, and thus native species' declines may not only be caused by direct competition with common mynas (Grarock et al., 2014a). However, the intricate relationship between habitat modifications, native species abundance and alien success, requires that both

Population status	Current population size estimate	Post-intervention monitoring	Source of spread to neighbouring countries	Are efforts coordinated with other countries	Reference
NA		NA	No spread to neighbouring countries	NA	http://especes-exotiques-envahissantes.fr/espece/acridotheres-tristis/#1458311727177-8bddca18-d3a1; PAC, per. obs.
Isolated records starting in 2017, single birds except one record of two birds in February 2021	0–5 individuals	NA	NA	No	Hellenic Rarities Committee: Annual Report—2017, 2018; www.gbif.org; www.inaturalist.org; www.observation.org; ΒΙΟΠΟΙΚΙΛΟΤΗΤΑ ΤΗΣ ΚΡΗΤΗΣ—CRETE'S BIODIVERSITY, 2021
Increasing		None	Jordan, Lebanon, Egypt, West Bank, Gaza	No	Holtzapfel et al. 2006; Magory Cohen et al., 2019; per. obs.; per. comm. [Yoav Motro, Ori Lineal, Ohad Hatzofe]
NA	15–20 individuals	NA	No, it occurs in southern regions	No	Mori et al., 2020
Increasing	Possibly 1,000+/ high density in a few areas, and otherwise still spreading in NW as predicted	NA	Possibly towards southern Syria (e.g. Dera'a area)	No	Khoury et al., 2021
Decreasing—not established	Occasional	NA	NA	No	https://dre.pt/application/conteudo/123025739; Elias, 2021
Absent	None	None	NA	No	Peyton et al., 2019
Absent	None	None	No	No	Saavedra et al., 2015
Eradicated	None	Yes	No	No	Saavedra & Reynolds, 2019
NA	125 individuals	NA	No	No	EP, per. comm.
Increasing	None	NA	Possibly Jordan	NA	Magory Cohen & Dor, 2019; Handal & Qumsiyeh, 2021

possible causes be considered when developing management schemes (Grarock et al., 2014a). Furthermore, the risk to local species communities is exacerbated by the potential of common mynas to expand from urban to non-urban habitats in their introduced ranges. Accordingly, in parallel to being primarily a semi-urban commensal in its native range, anecdotal reports of common myna observations in Israeli nature reserves and rural, agricultural areas (with some evidence for damage to agriculture) have already surfaced (Ohad Hatzofe, Israel Nature and Parks Authority Avian ecologist, per. comm.). In the Mediterranean basin, further loss of biodiversity could translate into impactful losses in absolute terms (Newbold et al., 2020). Mediterranean islands could be especially at risk of invasion by common myna. Islands tend to be characterized by high endemism but lower overall species richness and often more vulnerable incumbents than their mainland counterparts (Clavero et al., 2009). While common myna has not yet invaded Cyprus,[1] the

[1]During the preparation of the proofs, we learned of additional sightings of common mynas in the Mediterranean. More than 11 mynas were sighted and three were shot near the southern shores of Cyprus in early 2022. In Turkey, escaped birds were sighted in three more provinces (Samsun, Trabzon and Çanakkale), and possible breeding in Bursa. Figure 1 was accurate as of late 2021.

rapid spread within the last couple of decades across the island of a recent colonizer (Sardinian warbler *Sylvia melanocephala*) with parallel decline in the endemic Cyprus warbler *S. melanothorax* (Papanikolas et al., 2021), and expansion of the introduced laughing dove *Streptopelia senegalensis* within the last decade (ANGK, pers. obs.), are indicative of the risks, and common myna was ranked in the highest risk category of invasion to Cyprus in a horizon scan study (Peyton et al., 2019). Because many other birds traded as pets share some of the traits that promote invasiveness with the common myna (e.g. other Passeriformes and Psittaciformes), it is likely that more pet traded species will follow the same patterns of expansion, making the expected threat to Mediterranean biodiversity even greater.

2 | REGIONAL COOPERATION IS THE KEY

2.1 | Potential courses of action

Previous instances of international collaboration installed to manage invasive species can provide reference points as to what are some potential courses of action. For example, efforts to control invasive and established populations of the North American ruddy duck *Oxyura jamaicensis* in several European countries required a multi-regional coordination. The species, that was deemed a conservation threat to the endangered native white-headed duck *Oxyura leucocephala* (Hughes et al., 2006), was first introduced in the United Kingdom, and had later become established in Spain, France, Belgium and the Netherlands, and recorded in several other countries (Muñoz-Fuentes et al., 2006). Subsequently, an international action plan was developed for the eradication and control of the ruddy duck, requiring the engagement of legislators, public relations experts, researchers, managers and control teams and others (Hughes et al., 1999). Following active participation by most of the countries involved, this effort is now considered a success, and the European ruddy duck population has been reduced to less than 7% of that present in 2000 (Robertson et al., 2015). This positive result should encourage the instigation of a similar action plan for the common myna—whose numbers are far greater than those of the ruddy duck ever were in some of its Mediterranean range, like Israel—and other invasive species, such as the crested myna in Portugal (Elias, 2021), whose growing numbers merit immediate action while indicating a better prognosis. Specifically in the case of the common myna, some of the previous eradication attempts have been effective on islands (Canning, 2011; Feare, 2010; Feare et al., 2017; Millett et al., 2004; Prasad & Christi, 2014; Saavedra, 2010; Saavedra et al., 2015; Saavedra & Reynolds, 2019), while mainland control campaigns have had some success in reducing local numbers (Grarock et al., 2014b; Parkes, 2012). In most cases where a population has already established, especially when an additional, 'source' population is nearby, these efforts must remain continuous, and control and prevention of further spread, rather than eradication, may be the practical goal. Alternatively, when numbers are relatively small (such as in several Mediterranean countries—see Table 2), complete eradications may be considered, especially in relatively isolated islands (e.g. in Seychelles (Feare et al., 2017; Saavedra & Reynolds, 2019).

Several procedures can aid regional efforts in the Mediterranean (Table 3). Predominantly, information sharing by countries experienced with common myna legislation, control and eradication, can shorten response time, increase success and focus efforts on efficient strategies. For instance, knowledge on which management procedures have achieved success in certain parts of the Mediterranean or elsewhere (Canning, 2011; Feare, 2010; Feare et al., 2017; Millett et al., 2004; Ralph et al., 2020; Saavedra, 2010; Saavedra & Reynolds, 2019) can be applicable for management regimes in similar environments. Although complete eradication of established continental populations is unlikely, knowledge achieved during management of the species in one country can aid in prioritizing management actions and legislation to be implemented. Similarly, should strategies to increase the survival and breeding success of native species by ways of habitat manipulation (e.g. distributing artificial nest boxes with an entry size unfit for common myna) be included in the management scheme, they can be applied in areas where common mynas have yet to breed, thus reducing their invasion success. Sharing knowledge among countries may also lead to surprising shifts in our understanding of the invasion process of the common mynas. For example, despite having previously bred in France, Portugal and continental Spain, common mynas have not successfully established in these countries as of 2020, and their

TABLE 3 Potential courses of action for managing invasive alien species

Strategy	Potential implementation
Knowledge sharing	Joint workshops, designated working groups
Collective data collection	Global/continental database, literature curation
Regional strategy planning	International team strategizing management schemes, joint culling or control efforts across country borders
Engaging public support	Using social media for public engagement and education, establishing citizen science projects to document the presence of these invaders and potential competition with native species for nest cavities, engaging in open dialogue
Coordinated legal steps	Ban on sale and trade, ban on keeping as pets, declaring an invasive alien species
Development of large-scale management methodologies	Models to assess regional/continental impacts of invasive alien species, predictive large-scale distribution models

remnant populations are decreasing, even without active management. Furthermore, data collection for developing analytical and applicative tools will also be more informative if it is collated from multinational origins. In the absence of national databases, or in supplement of these, global databases (e.g. GAVIA (Global Avian Invasions Atlas) project (Dyer et al., 2017)) and citizen science platforms (e.g. eBird, www.ebird.org, (Sullivan et al., 2009); iNaturalist, www.inaturalist.org), can help optimize these processes. Effectively, traditional and social media can be used to increase public awareness to the ecological, financial and health-related costs of common myna invasion, as well as to harvest additional information that is otherwise difficult to achieve by employing citizen science projects (e.g. recording new sightings, documenting impact on local fauna). Finally, coordinated mitigation efforts must be put in place in order to carefully control recently invaded areas, prevent further spread and design management practices, aiming to successfully prevent recurring invasions from adjacent countries. This is especially relevant in neighbouring countries, where common myna range expansion has already taken place, such as Israel, Gaza, The West Bank, Egypt, Jordan and Lebanon.

Public perception may also constrain effective control of invasive species. Courchamp et al. (2017) effectively reviewed the difficulties arising from sympathy for alien species, which may lead in many cases to objection to their removal. At times, such protest has led to the failure of management efforts of invasive species, for example, the grey squirrel in northern Italy (Perry, 2004) or the mute swan in the United States (Perry & Perry, 2008). However, public opinion is a collection of diverse groups of stakeholders, and the previous knowledge, social values and ethical perceptions can result in different views of alien species and their management (García-Llorente et al., 2008; Luna et al., 2019). Several practices have already been shown to aid in this respect, primarily citizen science-based projects that allow for direct involvement of the public in collecting data and accessing it (Mannino & Balistreri, 2018). A modified version in which local communities are directly involved in control efforts has also been shown to be effective in certain cases (Grarock et al., 2014b; Santo et al., 2015). In addition, involving stakeholders in designing management practices and implementing new technologies can also aid in increasing social support for control campaigns (Kirk et al., 2020; Schüttler et al., 2011). Importantly, an open dialogue with the public, including an increased transfer of information from experts to the public known as the 'dialogue model', would likely greatly benefit the continuous efforts often involved in long-term management of alien species (Courchamp et al., 2017).

2.2 | Major barriers to effective regional cooperation

Currently, national-level efforts to control common myna populations are scarce (Table 2). Only two countries in the Mediterranean have formally recognized the threat that common mynas may pose to the region and implemented regulations prohibiting the trade of this species: Israel (banned in 2002) and Spain (banned in 2013). In Turkey, decision-makers have been making efforts to introduce such a ban to curtail the country's multiple common myna and other invasive alien bird introductions at the project 'Addressing of Invasive Alien Species Threats in Terrestrial Areas and Inland Waters in Turkey' (TERIAS) (EP, unpublished). Similarly, in Jordan, a list of potentially invasive and harmful species has been prepared to consider in the banning of trade and import, leading to eventual control measures (FK, unpublished). The European Union (EU) has only recently added the common myna to the list of invasive alien species of concern through EU regulation 1143/2014 (Scalera et al., 2018), recognizing this species' risk to its member nations and territories. Although the EU regulation does apply in Cyprus (Peyton et al., 2019), where there is a history of imports for the pet trade, there is little cooperation between the north and south of the island against the spread of invasive species, which would be necessary in the event of common myna introduction. Indeed, the threat of common myna spread may increase among neighbours. For example, the common myna population in Israel (an associated state of the EU) has already expanded into the neighbouring West Bank and Gaza (with which Israel has a conflict), Egypt and Jordan (with which Israel has peace treaties) and Lebanon (with which Israel has no official diplomatic relations). It is likely that a similar range expansion has also occurred into Syria (with which Israel has no official relations), although only anecdotal evidence is available to support this (FK, unpublished). Similarly, North African countries at high risk of common myna invasion (Figure 1) could greatly benefit from employing preventive strategies prior to actual introductions (Table 3). It is also worth noting that the results of species distribution models suggest that areas in central Europe are highly suitable for common mynas, indicating that without preventive measures the species is likely to spread into major parts of Europe (Figure 1; Magory Cohen et al., 2019). This implies that effective management of common myna spread in the Mediterranean requires international collaboration, which is currently non-existent. The mosaic geopolitical nature of the Mediterranean region presents challenges for such regional efforts. Nonetheless, we argue that multidirectional transfer of information and expertise and the development of regional mitigation strategies that include all the countries in the region are essential for the successful management of the invasion of the common myna and other species into the Mediterranean.

The turbulent political status of most of the Mediterranean provides considerable challenges for a collaborative regional front in addressing the spread of the common myna. Therefore, attaining regional cooperation will likely require the development and implementation of focused diplomacy, policies and adjustments and harmonization of current national regulations, aiming to converge into a transnational strategy against invasive bird species in the area. Some examples are already in place, like the Convention on Biological Diversity (CBD) that identified guidelines for invasive alien species management, and recent work by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), which are forthcoming with detailed recommendations. These and other treaties and regulations provide scaffolding for international joint actions and guidelines on how—and when—to apply the necessary steps. Other, more focused examples, such as the European Risk Analysis for *Acridotheres tristis* (Scalera et al., 2018) or the Italian National Plan for common mynas (SS, per. comm.), could provide guidelines for the development of both national and regional programs. We reason that without the immediate implementation of such guidelines by Mediterranean countries, the naturalization of common mynas in the Mediterranean region is inevitable and likely to eventually affect extensive parts of the area. Whereas national action plans at the single-country level are essential for localized control, regional cooperation is key to the success of mitigation of this species on both national and international schemes. Embracing international strategies will help address the problem of one of the most notorious invasive alien species, the common myna, in the fight to protect biodiversity in the Mediterranean, one of the most densely populated vulnerable ecoregions on Earth.

ACKNOWLEDGEMENTS

This research was supported by Grant No. 2017285 from the United States-Israel Binational Science Foundation (BSF) (to R.D. and M.E.H.). M.E.H. was also supported by the Wissenschaftskolleg zu Berlin, Germany, during the preparation of the manuscript drafts. T.M.C. was supported by the Tel Aviv University's rector's emergency Corona fellowship and the Council for Higher Education (CHE) postdoctoral fellowship. L.R. was supported by Portuguese National Funds through FCT, IP, under the 'Stimulus of Scientific Employment—Individual Support' contract 'CEECIND/00445/2017' and L.R. and J.S. were also funded by Fundo Europeu de Desenvolvimento Regional through the Operational Competitiveness Factors Program 'COMPETE' and by National Funds through the Foundation for Science and Technology (FCT) through the project ALIENTRADE (PTDC/BIA-ECO/30931/2017-POCI-01-0145-FEDER-030931). M.M. (grant LCF/BQ/DR20/11790020) was supported by 'La Caixa' Foundation (ID 100010434).

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

AUTHORS' CONTRIBUTIONS

T.M.C. conceptualized the study and drafted an early version of the manuscript; R.D. and M.E.H. obtained funding for this study. All authors made a significant contribution to the interpretation of data, contributed to the consensus approach as experts, participated in drafting and revising the article and approved the final version of the manuscript.

DATA AVAILABILITY STATEMENT

No primary data were generated through this study.

ORCID

Tali Magory Cohen https://orcid.org/0000-0001-7341-2901
Mark E. Hauber https://orcid.org/0000-0003-2014-4928
Triantaphyllos Akriotis https://orcid.org/0000-0003-2907-4065
Pierre-André Crochet https://orcid.org/0000-0002-0422-3960
Georgios Karris https://orcid.org/0000-0001-5264-8026
Alexander N. G. Kirschel https://orcid.org/0000-0003-4379-7956
Fares Khoury https://orcid.org/0000-0001-6283-4818
Mattia Menchetti https://orcid.org/0000-0002-0707-7495
Emiliano Mori https://orcid.org/0000-0001-8108-7950
Esra Per https://orcid.org/0000-0002-7764-1215
Luís Reino https://orcid.org/0000-0002-9768-1097
Joana Santana https://orcid.org/0000-0002-4100-8012
Roi Dor https://orcid.org/0000-0002-8743-9387

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How to cite this article: Magory Cohen, T., Hauber, M. E., Akriotis, T., Crochet, P-A, Karris, G., Kirschel, A. N., Khoury, F., Menchetti, M., Mori, E., Per, E., Reino, L., Saavedra, S., Santana, J. & Dor, R. (2022). Accelerated avian invasion into the Mediterranean region endangers biodiversity and mandates international collaboration. *Journal of Applied Ecology*, *00*, 1–16. https://doi.org/10.1111/1365-2664.14150