University of Cyprus
Department of Biological Sciences

Common Myna (*Acridotheres tristis*) in Cyprus: Mapping Spread, control methods and impacts on birds globally.

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ABSTRACT

The Common Myna (*Acridotheres tristis*) stands as one of the most important avian invaders on a global scale, its presence extending across diverse ecosystems and continents. With its range continually expanding, the Common Myna poses significant challenges to both biodiversity conservation efforts and human populations. Among the regions susceptible to the invasion of such avian species are the Mediterranean islands, including Cyprus, which has recently invaded from Common Myna since the early months of 2022. The primary objective of this study was to assess the distribution of Common Mynas across Cyprus, implement effective control measures, and conduct a literature review on the global impacts of Common Myna on bird species. This served as an early warning signal for potential negative consequences for indigenous bird species in Cyprus. Since the initial sighting of the Common Myna in Limassol in 2022, fieldwork has resulted in the documentation of 54 Common Myna records from 20 locations across Cyprus. Through field observations and data validation processes, 39 of these records have been confirmed, leading to the creation of a distribution map for Common Mynas in Cyprus. For the reduction of Common Myna population, a combination of control methods has been employed, including shooting and trapping. Notably, shooting has emerged as a primary method for reducing Common Myna numbers, with 15 individuals culled from various locations in Limassol by 08/03/2023. Successive shooting periods have yielded discernible reductions in Common Myna sightings, suggesting the potential efficacy of this approach when implemented intensively and widely. The effectiveness of decoy traps remains inconclusive and requires further investigation. Along with fieldwork, a literature review has been conducted, revealing negative impacted avian species by the Common Myna worldwide. Among the 65 species identified, varying degrees of impact were observed, encompassing negative, positive, and neutral effects. Notably, small and medium-sized bird species were most negatively impacted, highlighting the need for management strategies in order to save vulnerable populations. Also, most cavity nesting birds are negatively impacted by the presence of the Common Myna, primarily through competition for nesting sites (61%), followed by predation or aggression (35%), and a small percentage due to competition for food (4%). Furthermore, the IUCN status of affected birds was considered, revealing that a significant portion

of negatively impacted species were classified as "Least Concern." However, several species classified as "Vulnerable," "Endangered," "Critically Endangered," and "Near Threatened" were also affected, highlighting the need for targeted management strategies to protect endangered species and mitigate the impact of Common Myna invasions. In conclusion, this study underscores the critical importance of continuous monitoring, public awareness, and proactive management strategies to mitigate the impacts of the Common Myna invasion in Cyprus. Through concerted efforts and interdisciplinary collaboration, it is hoped that Cyprus can effectively address the challenges posed by this avian invader, protecting its rich avifauna.

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COMPOSITION OF THE EXAMINATION COMMITTEE

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Committee Member: Associate Professor, Georgios Karris, Department of Environment, Faculty of Environment, Ionian University

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SEMINAR ANNOUNCEMENT

University of Cyprus
Department of Biological Sciences

Master Research Dissertation in Biodiversity and Ecology (BIO 831/601)

Student Presentation

Monday, 20 May 2024 at 15:00

The presentation will be online via Zoom – To join use the link:
https://ucy.zoom.us/j/68483680811?pwd=Nlhyd0Vnb3hjYUdla015SGNacDBIdz09

This seminar is open to the public

Nathanael Andreas

Thesis Supervisor: Assoc. Prof. Alexander Kirschel

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conservation efforts and human populations. Among the regions susceptible to the invasion of such avian species are the Mediterranean islands, including Cyprus, which has recently invaded from Common Myna since the early months of 2022. The primary objective of this study was to assess the distribution of Common Mynas across Cyprus, implement effective control measures, and conduct a literature review on the global impacts of Common Myna on bird species. This served as an early warning signal for potential negative consequences for indigenous bird species in Cyprus. Since the initial sighting of the common myna in Limassol in 2022, fieldwork has resulted in the documentation of 54 Common Myna records from 20 locations across Cyprus. Through field observations and data validation processes, 39 of these records have been confirmed, leading to the creation of a distribution map for Common Mynas in Cyprus. For the reduction of Common Myna population, a combination of control methods has been employed, including shooting and trapping. Notably, shooting has emerged as a primary method for reducing Common Myna numbers, with 15 individuals culled from various locations in Limassol by 08/03/2023. Successive shooting periods have yielded discernible reductions in Common Myna sightings, suggesting the potential efficacy of this approach when implemented intensively and widely. The effectiveness of decoy traps remains inconclusive and requires further investigation. Along with fieldwork, a literature review has been conducted, revealing negative impacted avian species by the common myna worldwide. Among the 65 species identified, varying degrees of impact were observed, encompassing negative, positive, and neutral effects. Notably, small and medium-sized bird species were most negatively impacted, highlighting the need for management strategies in order to save vulnerable populations. Also, most cavity nesting birds are negatively impacted by the presence of the Common Myna, primarily through competition for nesting sites (61%), followed by predation or aggression (35%), and a small percentage due to competition for food (4%). Furthermore, the IUCN status of affected birds was considered, revealing that a significant portion of negatively impacted species were classified as "Least Concern." However, several species classified as "Vulnerable," "Endangered," "Critically Endangered," and "Near Threatened" were also affected, highlighting the need for targeted management strategies to protect endangered species and mitigate the impact of Common Myna invasions. In conclusion, this study underscores the critical importance of continuous monitoring, public awareness, and proactive management strategies to mitigate the impacts of the Common Myna invasion in Cyprus. Through concerted efforts and interdisciplinary collaboration, it is hoped that Cyprus can effectively address the challenges posed by this avian invader, protecting its rich avifauna.

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1. INTRODUCTION

1.1. Invasive species

The term "invasive" is used to describe species which become established beyond their native range and which have negative impacts on native species populations and ecosystems (Grarock et al. 2013). A range of factors (environmental conditions, biotic environment and dispersal ability) can affect the distribution of species and it has been suggested that when these factors are favorable for invasive species, they establish viable local populations. Such factors include the lack of natural enemies, high propagule pressure, resource availability, reproduction intensity, wide habitat/dietary preferences, broad physiological tolerances, short generation time, ability to cope with human proximity, and high degree of genetic variability, overpowering other species that do not have these abilities (Magory et al. 2019). After habitat destruction, the negative impact of invasive species is the second most common threat associated with extinctions on a global scale (Bellard et al. 2016).

1.2. General information of Common Myna

Common Myna (*Acridotheres tristis*) belongs to the Sturnidae family and it is a sedentary bird measuring around 23-25 cm in length (Grarock et al. 2012), weighs between 82 and 143 g and has a wingspan from 120 to 142 mm. Typically, males and females have similar morphology with a brown body, black hooded head, and the beak, legs and bare skin behind their eyes are all bright yellow (Rasmussen et al. 2012). They may be identified in flight thanks to their white patches at the base of their primary wings and at the tips of their tail feathers (Rasmussen et al., 2012). Common Mynas are monogamous species and pairs use the same territory each year (Markula et al. 2009). In Australia, Common Myna's clutch size is between three or four eggs (Grarock et al. 2013; Markula et al. 2009). It is omnivorous and a generalist species which has a wide habitat and dietary range (Magory et al. 2019), and considered as an opportunistic species that frequently forages in human-dominated areas exploiting new feeding opportunities (Sol et al. 2012).

1.3. Distribution

Common Myna is native to central and southern Asia (Hart et al. 2020). The intentional and/or accidental introduction into new places, and the extensions of its range beyond the point of introduction have led to a significant increase to the global distribution of this bird (Per, 2022). It has been introduced to many parts of the world, including southern Africa, Australia, New Zealand, USA, Middle East, and many tropical oceanic islands (Feare et al. 2016). Common Myna, which is sometimes referred to as an urbanized bird, is anticipated to continue its worldwide growth since urban and rural development and fragmentation of natural habitats are in progress (Hart et al. 2020). Due to this global expansion, in 1999, the International Union for the Conservation of Nature (IUCN), through its Invasive Species Specialist Group (ISSG) of the Species Survival Commission, set up a list of 100 high-profile invasive species, in which Common Myna is one of only three bird species included on the list (Luque et al. 2013).

1.4. Species habitat preferences

The native range of Common Myna is confined within tropical and subtropical regions. Although the species can tolerate a wide variety of climates, generally they prefer warm conditions (Hart et al. 2020). According to Pell and Tidemann (1997a), Common Myna has adaptations for living in urban areas where vertical structures can be found, as well as trees and buildings, which are suitable for nesting, roosting and sheltering. Also, as the same authors support, Common Myna evolved in open woodland habitats in India, but today it is characterized as a human commensal species because it can breed successfully in rural and urban areas especially in open, grassy woodland with remnant hollow-bearing trees.

1.5. Negative impacts on native bird communities

Negative impacts of Common Myna on native avifauna have been reported many times in previous years, especially on its competition for nesting cavities with native birds (Grarock et al. 2012; Charter et al. 2016). An example of this negative impact is described in a recent study by Colléony and Shwartz (2020), in which they analyzed trends of common native and non-native birds between 2003 and 2018 across Israel. The results of this study showed significant changes in abundance of common bird species between that period. Notably, the abundance of the Common Myna increased by 843 % from 2006 to 2018 across the country, in contrast with the house sparrow and the white-spectacled bulbul, whose numbers declined significantly (28 % and 44 %,

respectively). Also, according to Khoury et al. (2021), Common Myna has been found responsible for the predation of eggs and chicks on nests as well as disturbance resulting in other birds abandoning their nests. Common Myna is also regarded as a species that can spread dangerous pathogens, such as parasites, viruses and bacteria, which can lead to fatal infections in both humans and other animals (Rabou, 2022). Nesting on roofs of homes and by scavenging in urban areas, such as dustbins outside houses and rubbish dumps, shows the direct contact that these birds have with humans which provides a favorable environment for the transmission of diseases, including asthma and dermatitis through mites that they carry (Markula et al. 2016). Furthermore, there are studies that indicate the aggressive behavior of Common Myna against other bird species that share the same territory (Dhami and Nagle, 2009; Grarock et al. 2012). It is important to note that the impact of Common Mynas on native bird species can be context-dependent, influenced by factors such as the availability of resources and the specific ecological conditions of the region where they occur.

1.6. The theory of the taxon cycle

E. O. Wilson (Wilson 1961) formulated the theory of the taxon cycle, which has been associated with a variety of issues in biogeography including responses to global climate change, vulnerability to extinction, and the origin and control of invasive species (Ricklefs and Bermingham, 2002). Additionally, Ricklefs and Bermingham (2002) posited that new colonizers to an island may undergo an expansion phase because they have escaped substantial predation or disease that they might have encountered on the mainland. By consequence, according to the taxon cycle theory, native and/or endemic species are at risk because they can be driven towards extinction and replacement by the new colonists. It is thus important to take measures within an appropriate time, and this is especially the case for the Common Myna, which is an invasive species with a large range of habitat preferences, before the first stage of the taxon cycle is achieved.

1.7. Mediterranean region

The Mediterranean region is particularly at risk due to the Common Mynas establishment in parts of the region and potential for expansion (Magory et al. 2022). According to the same authors, in recent decades, there has been an acceleration in the trading, dispersal, and ensuing introduction of Common Myna across the Mediterranean. Its introduction in the late 1990s into the

Mediterranean region was documented in Israel (Holzapfel et al. 2006), Lebanon (Bara 2002)., Italy (Mori et al. 2020) and Turkey (Per 2022). Some of these introductions were the source for subsequent range expansions of Common Myna, e.g. from Israel to Egypt (Rabia et al. 2015), the West Bank (Handal and Qumsiyeh, 2021), Gaza (Abd Rabou, 2022) and Jordan (Khoury and Alshamlih, 2015). Common Mynas have also been spotted elsewhere in the Mediterranean region, including in France, Greece, Portugal and Spain (Magory et al. 2022). Some islands of the Canary Islands archipelago (Spain) were also colonized by Common Mynas, but vigorous attempts to eradicate them have so far been successful (Saavedra and Reynolds, 2019).

1.8. Effects on Mediterranean islands

Islands in the Mediterranean region may be particularly vulnerable to invasion by Common Myna. Islands are characterized by high endemism, a lower total species richness and frequently more vulnerable habitats than those on the mainland (Clavero et al. 2009). In comparison to continental regions, islands may be affected more by interactions with new colonizers (Bellard, 2016). A factor that may increase the pressure on insular species is that islands offer few alternative habitats for endemic species to adapt to in order to reduce competition with new colonists (Papanikolas et al. 2021). Also, specialist species are more likely to be harmed by habitat simplification and fragmentation, whereas generalist species are more likely to benefit (Colléony and Shwartz, 2020).

1.9. The island of Cyprus

The island of Cyprus is one of the largest islands in the Mediterranean Sea, covering an area of 9,000 km^2, with a Mediterranean climate characterized by hot, dry summers and cool, wet winters (Iezekiel et al. 2004a). Also, Cyprus has a rich and diverse avifauna due to its topography which consists of hills and mountains that are crisscrossed by steep-sided valleys covered by a mosaic of habitats, including Maquis and pine forests (Iezekiel et al. 2004b). Cyprus is recognized as an important area for birds, with over 400 species recorded, of which one third are residents of the island (Giosa et al. 2018). Cyprus hosts three endemic bird species that breed on the island and nowhere else in the world: Cyprus Wheatear (*Oenanthe cypriaca*), Cyprus Warbler (*Curruca melanothorax*) and Cyprus Scops Owl (*Otus cyprius*) (Hellicar et al. 2014). Moreover, four endemic subspecies have been described: the Cyprus Jay (*Garrulus glandarius glaszneri*), Cyprus Coal Tit (*Parus ater cypriotes*), Short-toed Treecreeper (*Certhia brachydactyla dorotheae*) and Red Crossbill (*Loxia curvirostra guillemardi*), though the latter is now thought to occur more

widely in the Eastern Mediterranean region (Hellicar et al. 2014). The remaining two thirds of all species recorded on the island are either regular or occasional migrants (Giosa et al. 2018). Millions of birds use its habitats as stopover sites or wintering grounds during their migrations between Europe and Africa in autumn and spring (Giosa et al. 2018).

1.10. Examples of bird invaders on the island of Cyprus

There are several examples of species that only recently colonized Cyprus and spread across the island rapidly. These include the Sardinian Warbler, *Sylvia melanocephala*, which spread across the island over the past three decades, and become an abundant breeder, in parallel with the decline of the endemic Cyprus Warbler, *Sylvia melanothorax* (Papanikolas et al. 2021). The Sardinian warbler's colonization was a natural occurrence, but others have been introduced, such as the Laughing Dove *Streptopelia senegalensis* (Magory et al. 2022) and expanded across the island over the last decade or so. Other examples of natural colonization of the island to become common breeding birds are European Greenfinch, *Chloris chloris* in 20th century (Flint, 2019), Cetti's Warbler, *Cettia cetti* with a recent and separate colonization event, probably of immigrants from Turkey (Flint, 2019) and the colonization of Famagusta freshwater lake originally by Cattle Egret, *Bubulcus ibis* (Charalambidou and Gucel, 2013, Flint, 2019), which again has spread island wide. These examples can used as indicators of the risk of spread following new invasions by birds on the island of Cyprus.

Recent studies by Peyton et al. (2019) and Magory et al. (2022) discuss how Common Myna was considered a significant invasion risk for Cyprus. In the case of the study by Peyton et al. (2019), they discuss the potential dangers that invasive alien species can pose to biodiversity and human health on the island of Cyprus. They ranked Common Myna in the highest risk category of invasion to Cyprus, citing threats of competition and predation with other birds. In the study by Magory et al. (2022), they mention the potential invasion of Cyprus by the Common Myna, noting that the bird trade promotes the introduction of alien species following the expansion patterns of Common Myna. They also make a particular reference to the little cooperation between the north and south sides of the island against the spread of invasive species, citing the example of Common Myna invasion from areas of Israel into the neighboring West Bank and Gaza.

1.11. Common Mynas in Cyprus: Chronology of spread

The first report of the presence of Common Myna in Cyprus was on January 29, 2022, on the Akrotiri peninsula in the south of the island. The report was of three individuals. Sovereign Base Areas Administration (SBAA) authorities were immediately alerted and mobilized to eradicate the invaders and shot them a matter of days after the report emerged. An alert was then issued and distributed widely across the island. Further reports of Common Myna ensued from all around the island. After field surveys, there were several confirmed records especially from the Limassol district. An initial estimate of the invading population involved 11 individuals (Magory et al. 2022). Since then estimates have increased as more and more sightings were reported. A collaboration was then formed to tackle the Common Myna situation in Cyprus, involving the University of Cyprus and other governmental entities and non-government organizations, including the Akrotiri Environmental Education Centre representing the Sovereign Base Areas Administration, the Game and Fauna service, Department of Environment and BirdLife Cyprus.

1.12. Aim of the study

The aim of this study was to evaluate the distribution of Common Mynas across the island of Cyprus and try to find individuals of this species on the island from various sources. Another objective of the study was to identify and apply optimal control methods in Cyprus.

In addition, I conducted a literature review on the impact of Common Myna on bird species worldwide, exploring sources from around the globe. The aim of this literature review was to investigate the positive or negative effects Common Myna has on these birds. I anticipate that this literature review will serve as an “early warning signal'” for the potential negative consequences this species may have on the indigenous bird species of the island of Cyprus.

2. MATERIALS AND METHODS

2.1. Collection of records of Common Mynas in Cyprus

We gathered all records to track the spread of Common Myna in Cyprus. Our data mainly came from online sources and reports by various sources, mostly from birdwatchers around Cyprus. We placed all this information into a database and confirmed each site with field visits. It is worth noting that we include all the data in the database, even if some observers weren't considered very reliable. After gathering all the data, we proceeded to reconstruct the pattern of Common Myna distribution across Cyprus. ArcGIS Pro was used to prepare a map illustrating the distribution of the Common Myna in Cyprus.

2.2. Control methods

2.2.1. Shooting

To control invasion of the Common Myna, shooting was chiefly employed. This method was entirely implemented by the Cyprus Game and Fauna Service. This often involved coordination with our research group at the University of Cyprus regarding the data we had, such as the locations where the birds were present and the number of individuals. Subsequently, an assessment of cases was conducted by the Game and Fauna Service, with the aim of identifying suitable locations to shoot the birds.

2.2.2. Trapping

Decoy traps were employed as part of this study, with dimensions of 60 × 60 cm in width and a height of 40 cm. These traps were meticulously constructed using 25 × 25 mm galvanized wire mesh (*Figure 1*). Each trap featured a central compartment, which housed a taxidermic mount Common Myna decoy. There were two to four capture compartments around the decoy compartment, each equipped with a mechanism designed to hold the door open. In the event of a bird attempting to access the trap, any contact with this mechanism would trigger the door to swiftly descend, effectively ensnaring the bird. Both the decoy and capture compartments were fitted with roof doors to facilitate maintenance activities, such as attending to the decoy and the

removal of any captured birds. Decoys were prepared from deceased mynas shot and killed by the Game and Fauna Service. To monitor and manage the traps, daily visits were conducted to release any trapped birds, supply water and food to the capture compartments, and reset any triggered doors.

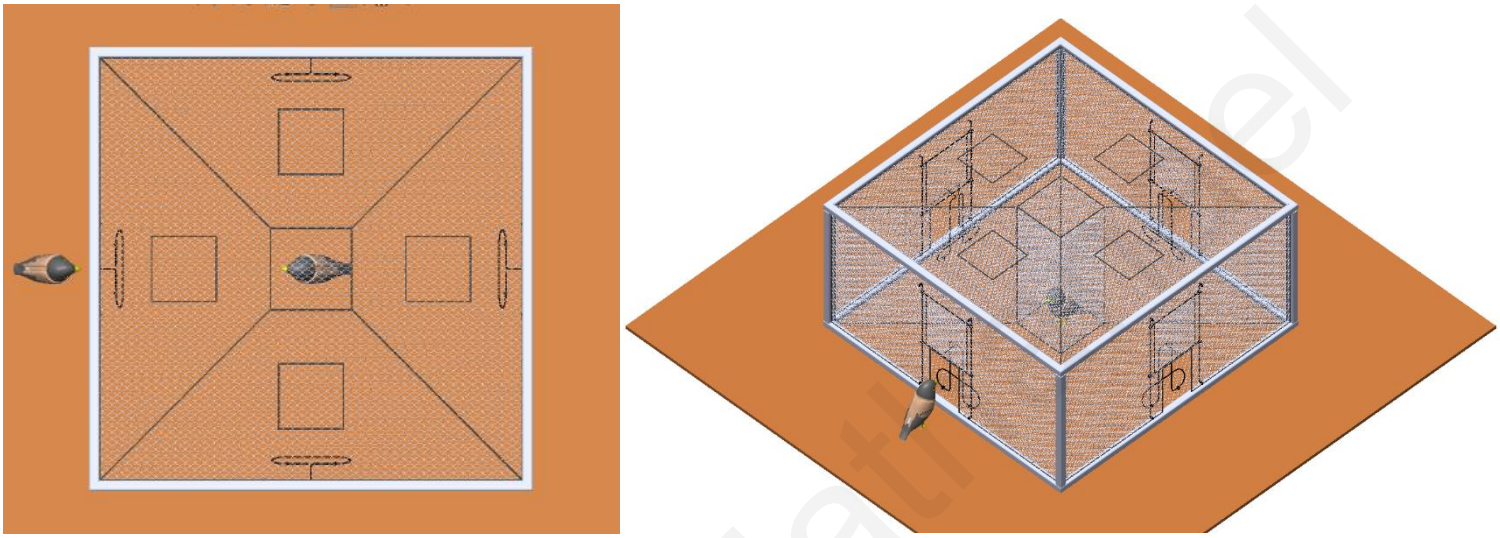

***Figure 1**: Illustrations of the decoy trap that we used. The above designs were created using SolidWorks software.*

2.3. Literature review

2.3.1. Data searching

For this literature review, articles were searched through the following electronic databases: PubMed, Springer, Google Scholar and ScienceDirect. The articles that used were identified using the following keywords: "Common Myna" OR "Common Myna" OR "Common Myna" OR "Indian Myna" OR "Indian myna" OR “Myna” OR “myna” OR "Acridotheres tristis" OR "introduced predators" OR "introduced birds" OR "invasive species" OR "invasive birds" OR "alien birds" OR "alien species" AND "competition" OR "compete" OR "impact" OR "negative impact" OR "threat" OR “predation” OR “ predator” OR "aggression" OR "aggressive" OR "interaction" OR "interacting" AND "native birds" OR “birds” OR “avifauna” OR "native species" OR "native avifauna" OR “native population” OR "birds population" OR "indigenous species" OR “cavity nesting birds” OR "indigenous birds". For these keywords we set a precondition that they exist only in the title or abstract.

2.3.2. Data collection

Our original search returned 863 studies after duplicates were removed. We then checked titles and abstracts to see how appropriate they were for our literature review. We retrieved and reviewed 127 full text articles against exclusion and critical appraisal criteria. Below you can find the inclusion criteria that we set for this literature review:

- Not discussing Common Myna's impacts on humans.
- Not addressing Common Myna's impacts on other species than birds.
- Explaining the effects of eradication control programs for Common Mynas.
- Discussing competition between Common Mynas and other bird species.
- Not discussing the effects of Common Mynas on the health of other birds.
- Not discussing disease transmission.
- Articles published in English language.
- Published after 1980.

3. RESULTS

3.1. Collection of records of Common Mynas in Cyprus - Distribution of Common Myna across Cyprus

A total 54 records were collected around Cyprus from 20 locations. From these 20 locations, 12 were in Limassol, 3 in Paphos, 3 in Larnaca, 1 in Nicosia and 1 in Kyrenia district. Out of the total 54 records, only 39 were confirmed, and many of these were from the same location (*Figure 2*). This emerged from the fact that we were monitoring the birds more than once for various reasons, such as determining the exact number of individuals, tracking their precise movements, or even assessing their age (juveniles or adults). The remaining unconfirmed information was also included in the database we made, considering them as data points for potential Common Myna sightings, with some of these reports from observers known to be reliable.

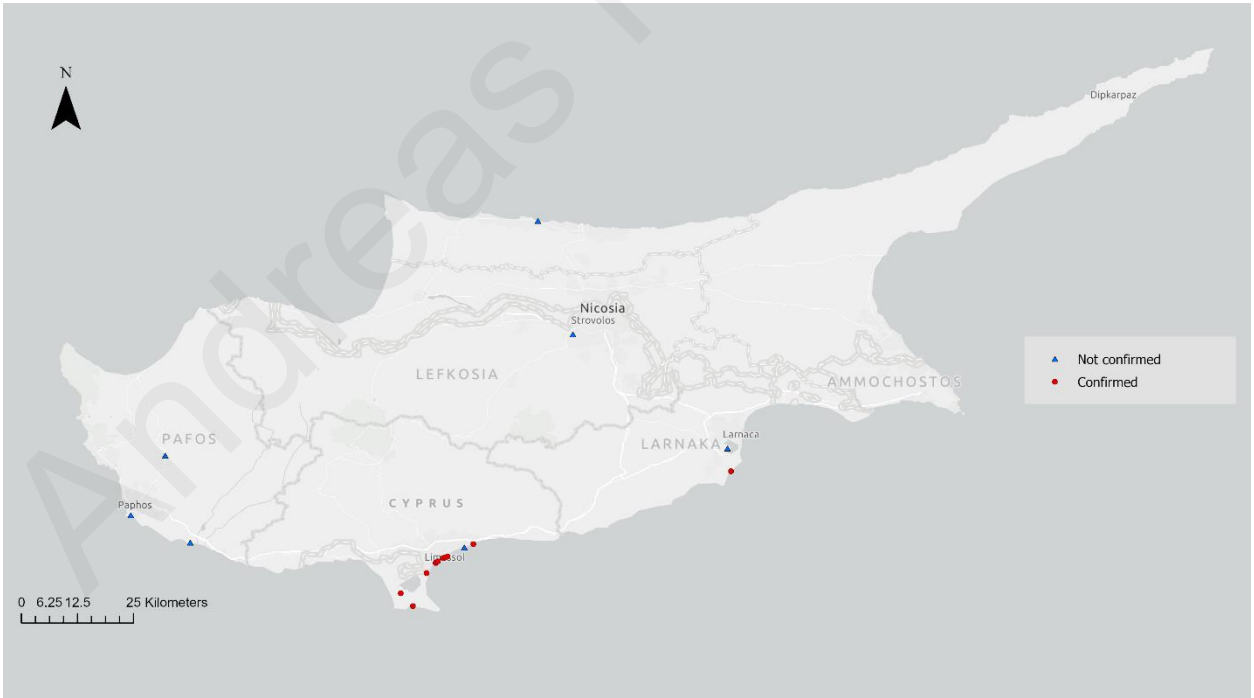

Figure 2: *Occurrence records of Ccommon Mmynas distributed in Cyprus. Red circles show the confirmed sightings and blue triangles represents the sightings that were not confirmed in follow-up searches*

3.2. Control methods

To combat Common Myna invasion in Cyprus we deployed the methods of shooting and trapping.

3.2.1. Shooting

Population reduction using the shooting method, the primary role was played by the Cyprus Game and Fauna Service, which, until 08/03/2023, had culled 15 individuals of the Common Myna from various locations in Limassol district, where most of the information and confirmed individuals were found. Specifically, as mentioned earlier, the service, in collaboration with other entities, identified the locations and, after a careful assessment of the area, proceeded with the shooting of the individuals. Subsequently, the deceased birds were collected and transported to the veterinary services of Cyprus, where they underwent analyses related to the potential transmission of pathogenic microorganisms.

3.2.2. Decoy trap

One trap was placed in the Meneou area in Larnaca district. The information for this specific location pertained to 2 individuals of the Common Myna observed on 29/08/2023 in a backyard with mango trees. As seen in *Figure 3*, these individuals found mangoes as their food source in that particular house, which is why they were present there. Immediately, we spoke with the homeowner to place a trap in the garden of the house, and he allowed us to do so on 06/10/2023 (*Figure 3*). The trap remained there for 19 days (until 24/10/2023) but no birds were captured. Additionally, during the trap's presence at this location, no bird activity was reported from the area.

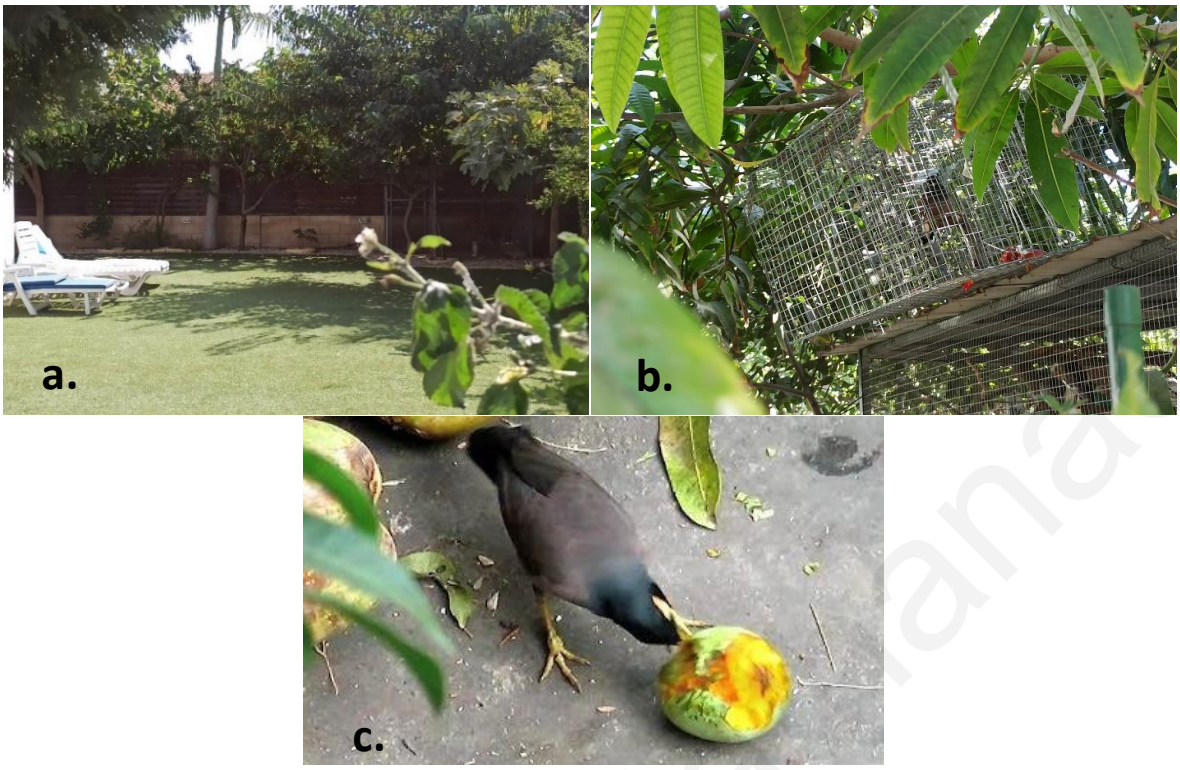

Figure 3: *The three photos depict the spot where 2 Common Mynas were sighted in the Meneou area in Larnaca, where the trap was placed on 06/10/2023.* ***(a)*** *The garden of the house where the trap was set up,* ***(b)*** *the decoy-trap placed above a birdcage in the corner of the garden, and* ***(c)*** *one of the two Common Myna individuals that were in the area, photographed while eating mango on 29/08/2023 (Photo: Nikos Kassinis).*

3.3. Literature review

The excluded studies may have had an observational or experimental nature, but some crucial criteria we set included the requirement for them to describe the positive or negative impact of the Common Myna on other bird species. Additionally, numerous articles were excluded as they assessed various control programs for invasive species. After full text screening, quantitative data were extracted from 28 studies.

From the literature review we conducted, a total of 65 bird species were identified, which were either negatively or positively impacted, or not impacted at all. Out of these 65 species, 49 were negatively impacted, 2 were positively impacted, on 12 there was no discernible impact and in a further 2 species there was a negative impact described in one article and no impact in another.

From the species that were affected negatively, 11 were affected by competition for nesting sites, 2 birds competed for food with Common Myna, and 36 were affected negatively by egg predation, chick predation or aggressive behavior from Common Myna. In the case of House Sparrow,

negative impacts are described in 3 articles with different impacts each time, including competition for food and nesting sites and aggressive behavior from Common Myna. Common Myna had negative impact on Seychelles Magpie Robin (*Copsychus sechellarum*) by destroy their nests and resulting in a negative effect on their breeding success. Moreover, in Samoan starling (*Aplonis atrifusca*), there was not only competition for nesting sites with Common Myna but also competitive exclusion between them.

Species identified in the literature review were divided into 3 groups based on their size (*Tables 1,2* and *3*): small birds (<25 cm head to tail), medium-sized birds (25 – 30 cm head to tail), and large birds (>30 cm head to tail). There were 28 small birds, 9 medium-sized birds, and 28 large birds. Of these, 23 were cavity nesters, of which 17 were negatively affected, 2 were positively affected by the abundance of Common Myna, 2 species showed neither positive nor negative effects and a further 2 birds were negatively affected in one study and there was no impact in another (Sulphur-crested Cockatoo and Laughing Kookaburra)

The species identified in this literature review derived from 14 different locations, as indicated below: Australia (n = 34), Israel (n = 7), Seychelles (n = 7), India (n = 1), Midway Atoll (n = 2), Mauritius (n = 3), Florida (n = 1), New Zealand (n = 2), American Samoa (n = 1), St. Helena (n = 1), French Polynesia (n = 1), Ascension Island (n = 1), Grand Comoro (n = 1), Tahiti (n = 1), Hawaii (n = 1), and Polynesia (n = 1). In some cases, impacts on the same species were reported from different locations.

Furthermore, the IUCN status of these birds was primarily characterized as "least concern" (n = 52), but there were bird species from the IUCN categories "near threatened" (n = 2), "vulnerable" (n = 6), "endangered" (n = 3) and even "critically endangered" (n = 2).

Table 1: *Documented impact of Common Myna on* ***small birds*** *(<25 cm head to tail) around the world. Type of impact, location and IUCN status are also documented. In the Effect column we categorized as (-) for negative impact, (+) for positive impact and (=) for neutral effect from Common Myna. Also, light green rows represent cavity nesting birds.*

No	Authors	Species	Scientific name	Country	IUCN status	Effect (+,=,-)	Competition for food	Competition for nesting site	Predation/ Aggression	Comments
1	Grarock et al., 2012	Superb Fairy-wren	*Malurus cyaneus*	Australia	LC	-			X	Significant negative relationship between Common Myna and Superb Fairy-wren abundance
2	Grarock et al., 2012	Striated Pardalote	*Pardalotus striatus*	Australia	LC	-			X	Significant negative relationship between Common Myna and Striated pardalote abundance
3	Grarock et al., 2012	Willie Wagtail	*Rhipidura leucophrys*	Australia	LC	-			X	Significant negative relationship between Common Myna and Willie Wagtail abundance
4	Grarock et al., 2012	Grey Fantail	*Rhipidura fuliginosa*	Australia	LC	-			X	Significant negative relationship between Common Myna and Grey Fantail abundance
5	Grarock et al., 2012	Silvereye	*Zosterops lateralis*	Australia	LC	-			X	Significant negative relationship between Common Myna and Silvereye abundance
6	Grarock et al., 2012	House Sparrow	*Passer domesticus*	Australia	LC	-			X	Significant negative relationship between Common Myna and House Sparrow abundance
	Colléony and Shwartz, 2020			Israel		-		X		Displace House Sparrows from nest sites and preyed on their chicks (Common Mynas), hereby reducing their breeding success
	Khera et al., 2009 Modak, 2015			India		-	X			Common Myna has an overlapping food niche with the House Sparrow
7	Grarock et al., 2012	Common Blackbird	*Turdus merula*	Australia	LC	-			X	Significant negative relationship between Common Myna and Common Blackbird abundance
8	Grarock et al., 2013b	White-throated Treecreeper	*Cormobates leucophaea*	Australia	LC	-			X	Significant negative relationship between Common Myna abundance and the abundance of this bird
9	Grarock et al., 2013b	Grey Butcher	*Cracticus torquatus*	Australia	LC	-			X	Significant negative relationship between Common Myna abundance and the abundance of this bird
10	Grarock et al., 2013b	Grey Fantail	*Rhipidura fuliginosa*	Australia	LC	-			X	Significant negative relationship between Common Myna abundance and the abundance of this bird
11	Grarock et al., 2013b	Eastern Spinebill	*Acanthorhynchus tenuirostris*	Australia	LC	-			X	Significant negative relationship between Common Myna abundance and the abundance of this bird
12	Grarock et al., 2013b	Buffrumped Thornbill	*Acanthiza reguloides*	Australia	LC	-			X	Significant negative relationship between Common Myna abundance and the abundance of this bird
13	Grarock et al., 2013b	Brown Thornbill	*Acanthiza pusilla*	Australia	LC	-			X	Significant negative relationship between Common Myna abundance and the abundance of this bird
14	Grarock et al., 2013b	Speckled Warbler	*Pyrrholaemus saggitatus*	Australia	LC	-			X	Significant negative relationship between Common Myna abundance and the abundance of this bird
15	Grarock et al., 2013b	Spotted Pardalote	*Pardalotus punctatus*	Australia	LC	-			X	Significant negative relationship between Common Myna abundance and the abundance of this bird
16	Grarock et al., 2013b	Common Starling	*Sturnus vulgaris*	Australia	LC	+				Significant positive relationship with Common Myna abundance

17	Charter et al., 2016	Eurasian Scops-owl	*Otus scops*	Israel	LC	-		X		Common Myna has been recorded occupied most of their nests (large-entrance nest boxes)
18	Charter et al., 2016	Great Tit	*Parus major*	Israel	LC	-		X		Breeding success was significantly lower for great tits breeding in the large entrance boxes compared with the small-entrance boxes
19	Currie et al, 2004	Seychelles Scops-owl	*Otus insularis*	Seychelles	CR	-		X		Potential competitor for nesting site
20	Feare, 2010	Seychelles Flycatcher	*Terpsiphone corvina*	Seychelles	VU	-			X	Observed predating eggs and chicks of the Seychelles Flycatcher
21	Feare, 2010	Seychelles Fody	*Foudia sechellarum*	Seychelles	NT	-			X	Serious head injuries to Seychelles Fodies are attributable to attack by mynas
22	Henriette and Rocamora, 2012	Seychelles White-eye	*Zosterops modestus*	Seychelles	VU	-			X	Potential nest predator
23	Fitzsimons, 2006	Purple Martins	*Progne subis*	Florida	LC	-			X	Mynas have been observed attacking this species.
24	Burns et al., 2013	St. Helena Plover	*Charadrius sanctaehelenae*	St Helena	VU	-			X	Nest predation events
25	Setire & Setire, 1992	Cave Swiftlet	*Collocalia linchi*	French Polynesia	LC	-			X	Predation on eggs of cave swiftlets
26	Herremans et al., 1991	Grand Comoro Scops owl	*Otus pauliani*	Grand Comoro	EN	-		X		Strong competitor for nest cavities
27	Blanvillain et al., 2003	Tahiti Flycatcher	*Pomarea nigra*	Tahiti	CR	-			X	Interactions between the two birds around nests that contains eggs and chicks strongly suggests the existence of nest predation
28	Thacker et al., 2022	Mangaia Kingfisher	*Todirhamphus ruficollaris*	Polynesia	LC	-			X	Aggressive interactions between Common Myna and Mangaia Kingfisher

Table 2: *Table 2: Documented impact of Common Myna on* ***medium-sized birds*** *(25 cm - 30 cm head to tail) around the world. Type of impact, location and IUCN status are also documented. In the Effect column we categorized as (-) for negative impact, (+) for positive impact and (=) for neutral effect from Common Myna. Also, light green rows represent cavity nesting birds.*

No	Authors	Species	Scientific name	Country	IUCN status	Effect (+,=,-)	Competition for food	Competition for nesting site	Predation/ Aggression	Comments
1	Grarock et al., 2012	Magpie Lark	*Grallina cyanoleuca*	Australia	LC	-			X	Significant negative relationship between Common Myna and Magpie Lark abundance
2	Grarock et al., 2013a Pell and Tidemann, 1997b	Eastern Rosella	*Platycercus eximius*	Australia	LC	-		X		Negative relationship between Common Myna nest box occupancy and Eastern Rosella abundance (Grarock et al., 2013a) Affect the breeding success of this species (Pell and Tidemann, 1997)
3	Grarock et al., 2013b	Red-rumped Parrot	*Psephotus haematonotus*	Australia	LC	+				Significant positive relationship with Common Myna abundance
4	Colléony and Shwartz, 2020	Spur-winged Lapwing	*Vanellus spinosus*	Israel	LC	-			X	Bird community changed from native based communities to alien communities (Common Myna was part of them)
5	Komdeur, 1996	Seychelles Magpie Robin	*Copsychus sechellarum*	Seychelles	EN	-		X	X	Nest disturbance by Common Mynas, had adverse effects on the breeding success of Robins (sometimes nest on the same trees with Robins)
6	Fitzsimons, 2006	Mauritius Kestrel	*Falco punctatus*	Mauritius	EN	-			X	Mynas have been observed attacking on Mauritius Kestrels.
7	Safford, 1996	Mauritius black bulbul	*Hypsipetes olivaceus*	Mauritius	VU	-	X			Its diet appears to overlap considerably with Common Myna.
8	Ortiz-Catedral & Brunton, 2009	Red-crowned Parakeet	*Cyanoramphus novaezelandiae*	New Zealand	LC	-		X		Nesting boxes that were installed to provide nest sites for cavity-nesting species are also used by Red-crowned Parakeets and Common Mynas (potential competitor for nesting sites)
9	Dhami & Nagle, 2009	Saddleback	*Philesturnus rufusater*	New Zealand	NT	-			X	Potential predator of chicks and eggs of Saddlebacks on Motukawanui Island

Table 3: *Documented impact of Common Myna on* ***large birds*** *(>30 cm head to tail) around the world. Type of impact, location and IUCN status are also documented. In the Effect column we categorized as (-) for negative impact, (+) for positive impact and (=) for neutral effect from Common Myna. Also, light green rows represent cavity nesting birds.*

No	Authors	Species	Scientific name	Country	IUCN status	Effect (+,=,-)	Competition for food	Competition for nesting site	Predation/ Aggression	Comments
1	Rogers et al., 2020	Rainbow Lorikeet	*Trichoglossus moluccanus*	Australia	LC	-			X	Use the same niche. Aggressive behavior
2	Grarock et al., 2012	Sulphur-crested Cockatoo	*Cacatua galerita*	Australia	LC	-		X		Reducing the breeding success of these species
	Grarock et al., 2013b					=				No significant relationship with Common Myna abundance
3	Grarock et al., 2012 Grarock et al., 2013a Grarock et al., 2013b Pell and Tidemann, 1997b	Crimson Rosella	*Platycercus elegans*	Australia	LC	-		X		-Reducing the breeding success of these species (Grarock et al., 2012 and Pell and Tidemann, 1997b) -Negative effect on the abundance of this cavity nesting species (Grarock, K. et al., 2013a)
4	Grarock et al., 2012	Laughing Kookaburra	*Dacelo novaeguineae*	Australia	LC	-		X		Reducing the breeding success of these species
	Grarock et al., 2013b					=				No significant relationship with Common Myna abundance
5	Grarock et al., 2012 Grarock et al., 2013b	Red Wattlebird	*Anthochaera carunculata*	Australia	LC	=				No affect through the study period
6	Grarock et al., 2012 Grarock et al., 2013b	Noisy Friarbird	*Philemon corniculatus*	Australia	LC	=				No affect through the study period
7	Grarock et al., 2012 Grarock et al., 2013b	Australian Magpie	*Gymnorhina tibicen*	Australia	LC	=				No affect through the study period
8	Grarock et al., 2012 Grarock et al., 2013b	Pied Currawong	*Strepera graculina*	Australia	LC	=				No affect through the study period
9	Grarock et al., 2012 Grarock et al., 2013b	Australian Raven	*Corvus coronoides*	Australia	LC	=				No affect through the study period
10	Grarock et al., 2013b	Gang-gang Cockatoo	*Callocephalon fimbriatum*	Australia	VU	-		X		Negative nesting success

11	Grarock et al., 2013b	Feral Pigeon	*Columba livia*	Australia	LC	=				No affect
12	Grarock et al. (2013b)	Satin Bowerbird	*Ptilonorhynchus violaceus*	Australia	LC	=				No affect
13	Grarock et al., 2013b	White-winged Chough	*Corcorax melanorhamphos*	Australia	LC	=				No affect
14	Grarock et al., 2013b	Black Faced Cuckoo Shrike	*Coracina novaehollandiae*	Australia	LC	=				No affect
15	Grarock et al., 2013b	Crested Pigeon	*Ocyphaps lophotes*	Australia	LC	=				No affect
16	Grarock et al., 2013b	Little Corolla	*Cacatua sanguinea*	Australia	LC	=				No significant relationship with Common Myna abundance
17	Grarock et al., 2013b	Australian King-parrot	*Alisterus scapularis*	Australia	LC	=				No significant relationship with Common Myna abundance
18	Colléony and Shwartz, 2020	Hooded Crow	*Corvus cornix*	Israel	LC	-			X	Bird community changed from native based communities to alien communities (Common Myna was part of them)
19	Colléony and Shwartz, 2020	Cattle Egret	*Bubulcus ibis*	Israel	LC	-			X	Bird community changed from native based communities to alien communities (Common Myna was part of them)
20	Feare et al., 2015	Brown Noddy	*Anous stolidus*	Seychelles	LC	-			X	Egg predation
21	Feare et al., 2015	Lesser Noddy	*Anous tenuirostris*	Seychelles	LC	-			X	Egg predation
22	Grant, 1982	Black Noddy	*Anous minutus*	Midway atoll	LC	-			X	Mobbing on Black Noddies individuals and also on chics. Negative impact on the nesting success of this species
23	Grant, 1982	White Tern	*Gygis alba*	Midway atoll	LC	-			X	Observed attacking White Terns and also a negative impact on the nesting success of this species
24	Fitzsimons, 2006	Mauritius Parakeet	*Psittacula eques*	Mauritius	VU	-		X		Common Mynas compete with Mauritius Parakeets for nesting cavities.
25	Freifeld, 1999	Samoan Starling	*Aplonis atrifusca*	American samoa	LC	-		X	X	Authors suggests competitive exclusion and also Common Myna may compete for nest sites with starlings
26	Hughes et al., 2008	Sooty Tern	*Onychoprion fuscatus*	Ascension Island	LC	-			X	major predator of Sooty Tern eggs
27	Byrd et al., 1983	Wedge-tailed Shearwater	*Pufinus pacificus*	Hawaii	LC	-			X	Major egg predator
28	Handal and Qumsiyeh, 2021	Jackdaws	*Corvus monedula*	Israel	LC	-	X			Compete for road-kills and food from trash dumps

4. DISCUSSION

The theory of invasion asserts that the process leading to expansion involves a repetitive sequence of events or phases: introduction, establishment, population increase and then further expansion into additional areas, with each phase being dependent on and influenced over time and scale by the previous one (Duncan et al., 2003). Following the introduction of Common Myna to Cyprus, there was an attempt to control it during the establishment phase by the authorities. This phase is particularly critical, as successful control would prevent progression to the subsequent stage of population increase, with all the implications this species could have on the island. Here, it should be noted that Common Myna was ranked in the highest risk category of invasion to Cyprus (Peyton et al., 2019), ringing the alarm for the implementation of measures and their management.

4.1. Distribution

The distribution of Common Myna in Cyprus was presented in this study. After data collection from the field and other information that came to us from various sources, we constructed a distribution pattern of Common Myna across Cyprus. The first sighting was on the 29th of January in 2022 at Akrotiri (Limassol district) and the last one that we include in this study was from 5th of November in 2023 at Germasogia (Limassol district).

As *Figure 4* shows, information was gathered from various parts of the island, but confirmed sightings were mainly located in the coastal area of Limassol, with only one confirmed observation in the coastal area of Larnaca. A hypothesis regarding the accumulation of Common Myna sightings in Limassol might be the fact that it hosts the main port of Cyprus, where there is significant traffic of commercial ships to and from the island. Many of these ships arriving at Cypriot ports (not only in Limassol) pass through the Suez Canal or from ports such as those in Israel, where, according to the literature, Common Mynas are known to exist (Holzapfel et al., 2006; Rabia et al., 2015). Thus, by passing through such ports, these ships may unintentionally transport these birds and bring them to Cyprus. Something similar is described in the study of Abellán et al. (2016) where they outline possible ways of introducing exotic birds in Spain and Portugal. They identify the importation of such birds via ship as a potential scenario in a limited

number of cases. The above scenario is merely a hypothesis that we formulated based on observing the bird sighting locations in Cyprus and requires further investigation to provide findings to the relevant authorities for the implementation of appropriate measures.

Common Mynas were observed in urbanized environments, primarily on buildings and businesses, in outdoor restaurant spaces searching for scraps of human food, near trash bins, in parking lots and along roadside verges. It should also be noted that the areas frequently visited by Common Mynas were characterized by rich vegetation with tall trees or irrigated grass lawns. The birds were also observed invading home yards and feeding on food attracting native birds, as in the case of a house with olive trees at Germasogeia area in Limassol district and a house with mango trees at Meneou area, in Larnaca. The preferences of mynas for similar habitats were also observed in the Gaza Strip, with even more presence points (Abd Rabou, 2022). Common Myna is generally considered to coexist with humans, and their distribution is known to be influenced by anthropogenic factors in environments where they are not considered as native birds (Grarock et al., 2014; Hart et al., 2020).

4.2. Trapping and shooting

The shooting method was employed 10 times, resulting in the removal of 15 individuals from the field, while the trapping method was used once with no success. It is noteworthy that trapping as a method for combating Common Mynas in Cyprus may not be representative, as it was applied only once when only 2 birds were observed in the area. Specifically, the failure of trapping Common Myna in the area where we installed the decoy trap may have been due to the fact that while the information we had about their sightings in the area was on 29/08/2023, the homeowner gave us permission to place the trap several weeks later on 06/10/2023. This delay may have played a crucial role in the ineffectiveness of this method, as after visits to the area in mid-September, sightings of the 2 Common Myna began to decrease in the area. A more accurate assessment of the effectiveness of this method could have been achieved if it had been applied more frequently.

As for the shooting, attempting to interpret *Figure 4*, we can observe a decrease in information and sightings of Common Mynas after each shooting period. Perhaps this is an indication that shooting may be an effective method for combating Common Myna in Cyprus if implemented in a more intensive and widespread manner. Here it should be noted that high human density raises

safety and disturbance concerns regarding shooting, as was the case in many of the urban areas where Common Mynas have appeared in Cyprus.

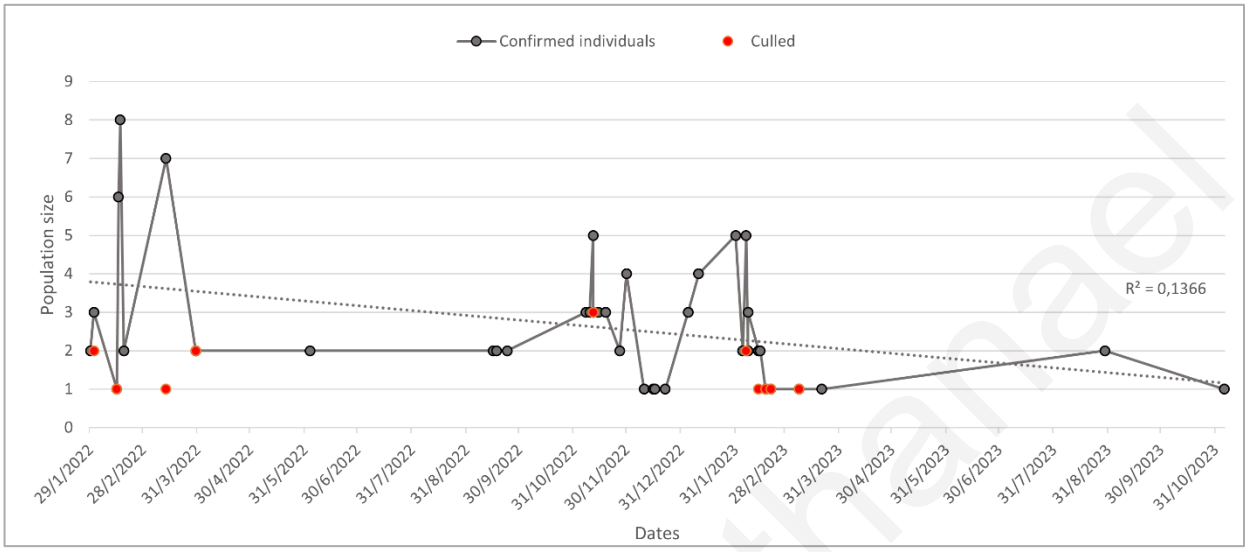

Figure 4: *No. of confirmed individuals (grey circles) and culled individuals (red circles).*

According to the literature, in the case of eradication of Common Myna on North Island in the Seychelles, trapping proved to be an effective method when a large number of individuals were present, while shooting was employed when their numbers decreased (Feare et al., 2021). The same methodology was implemented on Denis Island in Seychelles, where trapping was mainly used in large numbers to eradicate Common Myna and shooting was employed in the later stages of the project (Feare et al., 2016). According to Feare et al. (2016), shooting was postponed until the end of the eradication process when the remaining Common Mynas were scarce, difficult to trap and no longer congregated in flocks, making shooting more effective as a method for low numbers of individuals. This approach of using shooting as the most effective method for low numbers of Common Mynas may be logical, as it represents a more targeted approach, whereas trapping may attract non-target animals, rendering the trap ineffective (Feare et al., 2016). Nevertheless, a study by Saavedra and Reynolds (2019) demonstrated that on Fuerteventura Island in the Canary Islands, the species was successfully combated using only the trapping method. In the case of Mallorca in Balearic Islands, both trapping and shooting methods were used effectively to eradicate Common Myna, with low numbers of Common Mynas (21 and 22, respectively) in both instances.

4.3. Literature review

Our literature review indicates that Common Myna had a negative impact on native bird species at various levels (e.g., nesting site competition, competition for food, predation, aggressive behavior). The birds identified affected through this literature review were categorized based on their size since it appeared to play a significant role in the negative impact the Common Myna has on various species. A similar categorization was used in the study by Grarock et al. (2012), where they divided the birds according to their size to draw their own conclusions. The presence of the Common Myna has a negative impact on the majority of the birds found in this study (*Figure 5*). The negative impact was found to exist in 96.4% of small birds, 88.8% in medium-sized birds, and 53.3% in large birds. Similar results were found in the study by Grarock et al. (2012), where the presence of the Common Myna was shown to negatively affect the abundance of small bird species, but the negative impact on the large birds they studied was not found. In our study, about half of the large birds were negatively impacted, and this was due to the fact that 9 out of 16 birds found to be negatively affected were cavity nesters, as is the Common Myna.

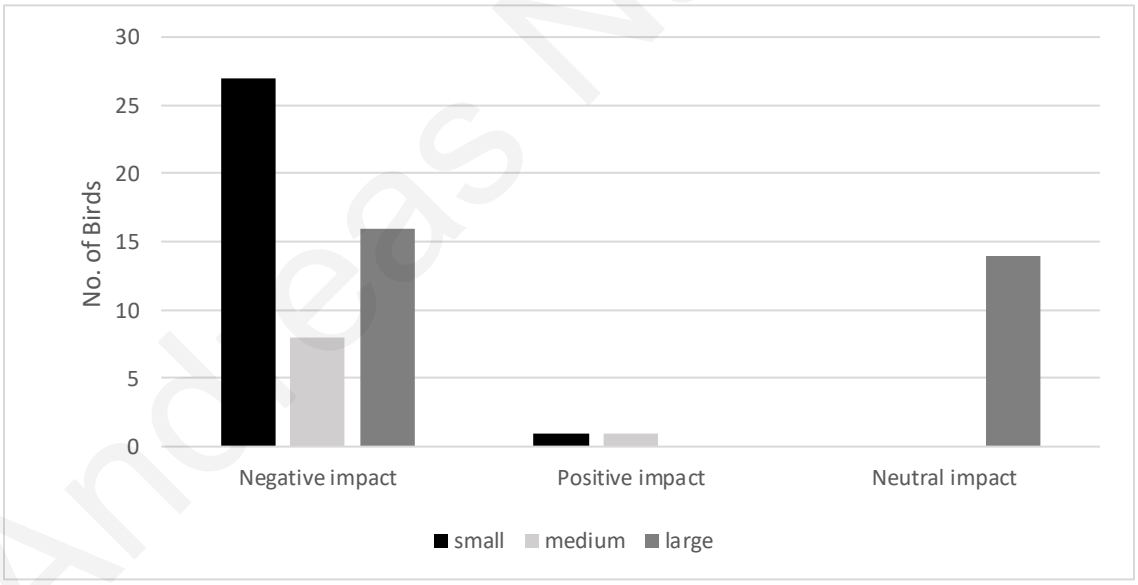

Figure 5: *The impact that Common Myna has on other birds based on their size.*

Common Myna also appears to negatively affect indigenous cavity-nesting species. Most cavity nesting birds are negatively impacted by the presence of the Common Myna, primarily through competition for nesting sites (61%), followed by predation or aggression (35%), and a small

percentage due to competition for food (4%) (*Figure 6*). The negative impacts of the Common Myna on indigenous cavity nesting species has also been documented in parts of Australia (Grarock et al., 2012, Grarock et al., 2013a, Rogers et al., 2020). In the study by Grarock et al. (2012), it was described how the establishment of the Common Myna negatively affected the abundance of the Crimson Rosella, Sulphur-crested Cockatoo and Laughing Kookaburra, which is noteworthy considering the latter two birds are larger than the Common Myna. Also, according to Charter et al. (2016), in Israel, it was observed that nest boxes with large entrances were mostly occupied by invasive species, such as the Common Myna and Rose-ringed Parakeet (accounting for 77.5%) and only three native birds (about 9%), while the small-entrance boxes were exclusively used by two smaller native species, the Great Tit and House Sparrow. Over time, this might lead to a reduction in the population of these indigenous birds as the case of the native Cyprus Scops Owl (*Otus cyprius*) where Eurasian Scops-owl in Israel was found to be negatively affected by the presence of Common Myna (Charter et al., 2016). Charter et al. (2016) also concluded that placing nest boxes with small entrances might serve as an effective supplementary method, offering some small native cavity breeders a place to nest in areas where natural cavities are dominated by alien species. From these studies we can determine the potential negative impact Common Myna may have on native birds on the island of Cyprus

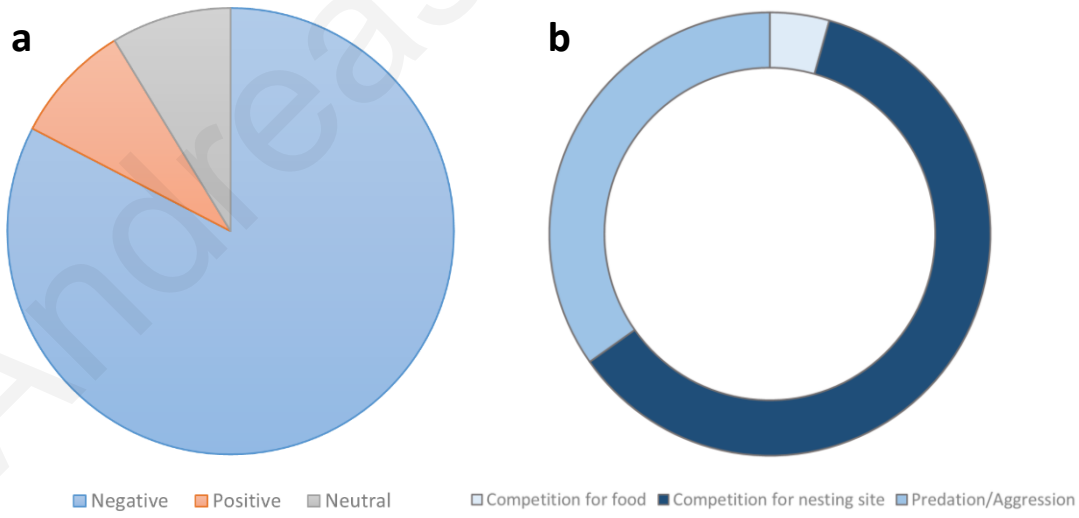

Figure 6: ***(a)*** *Impact on cavity nesting birds.* ***(b)*** *Type of impact that Common Myna has on negative affected cavity nesting birds*

Another characteristic taken into account in this study was the IUCN status of all the birds found. The birds negatively affected by all three size categories belonged to the LC category (38 birds), followed by the categories VU (6 birds), EN (3 birds), CR (2 birds), and NT (2 birds) (*Figure 7)*. In the category of large birds, only the Gang-gang Cockatoo and Mauritius Parakeet were in the VU category, while the rest were in the LC category. The categories of small and medium-sized birds had a higher percentage of threatened species, with approximately one-third for small birds and around one-half for medium-sized birds. Among the small birds, the Seychelles Scops-Owl and Tahiti Flycatcher belong to the Critically Endangered category, something that should be taken into consideration for the proper management and protection of endangered species, as well as for the management of the Common Myna population in each invaded area. It is noteworthy that from the birds found to be negatively affected and belonging to some of the threatened categories of the IUCN, 90% of them came from an island (Seychelles, St Helena, French Polynesia, Grand Comoro, Tahiti, Mauritius, New Zealand). In the study by Duena et al. (2021), it was shown that birds were the category of organisms most affected by invasive species, from which 98% of the birds found to be negatively affected came from islands. Just like Cyprus, in the case of possible colonization of the island by the Common Myna, the data indicate a negative impact on species that may be considered threatened, ringing the alarm once again for an immediate management action plan against the Common Myna.

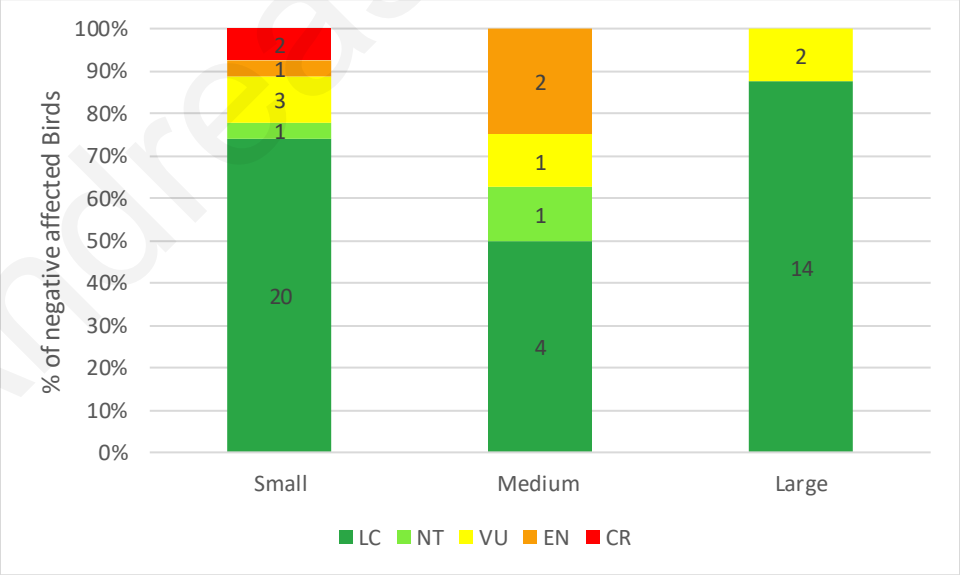

Figure 7: *The IUCN status of the negative affected bird species according to their size. Additionally, for each IUCN category, besides the percentage on the y-axis, the number of species is shown on each bar segment.*

5. CONLUSION

The 65 bird species in this review come from different regions worldwide, not only from continental regions but also from continental and oceanic islands, and these negative impacts of Common Myna on native birds provide a warning for Cyprus. However, how the Common Myna would specifically affect indigenous species in Cyprus is something that could only be studied in the scenario of the possible establishment of Common Myna on the island. According to Simberloff (2002), the management of invasive species can be approached in three stages: firstly, preventing their entry, secondly, if they get in, find and try to eradicate them and finally, if they cannot be eradicated, controlling their population size at low levels. In the case of Cyprus, we are in the second stage where we need to find and try to eradicate them quickly, which began with the cooperation of various authorities. However, their continuous vigilance should be maintained, as well as informing the public for faster detection of the species on the island. The timing of sightings also suggest that multiple invasion events may have occurred, thus prevention of further invasion events must remain a priority.

ABBREVIATIONS

ABBREVIATION	MEANING
IUCN	International Union for Conservation of Nature
LC	Least Consern
VU	Vulnerable
EN	Endangered
CR	Critically endangered
NT	Near Threatened

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