Journal of King Saud University - Science 36 (2024) 103367

HOSTED BY

Contents lists available at ScienceDirect

Journal of King Saud University - Science

journal homepage: www.sciencedirect.com

Full Length Article

Range expansion and habitat preferences of an introduced bird in the northwestern Arabian Peninsula: The case of the common myna *Acridotheres tristis*

Abdulaziz S. Alatawi

Department of Biology, Faculty of Science, University of Tabuk, Tabuk City, Saudi Arabia

ARTICLE INFO

Keywords:
Distribution
Introduced species
Modified habitats
Saudi Arabia
Tabuk
Urban ecology

ABSTRACT

Introduced species can have harmful impacts on native species and ecosystems. Certain species can benefit from anthropogenic activities and habitat modification, even outside of their native ranges. Introduced species in Saudi Arabia have received little attention, which has resulted in limited knowledge on this topic, especially regarding the northwestern region of Saudi Arabia. One bird species introduced to Saudi Arabia is the common myna (*Acridotheres tristis*), which appears to be invading vast areas of the country. For the first time, the distribution and habitat preferences of the common myna have been investigated across different habitats in Tabuk Province, northwestern Saudi Arabia. Notably, common mynas were detected in habitats with different conditions, including urban, suburban, and agricultural habitats. Overall, the common myna appears to be a flexible species that has adapted to this arid environment and effectively uses available resources in foraging and nest site selection. Common mynas were observed in both urban and suburban environments of Tabuk City with their presence being noticeably higher in urban and suburban than in agricultural habitats. This suggests that the centers of human activity and urban/suburban development seem to be preferable sites for this species, as shown by analyzing the human influence index. Based on observations from fieldwork, the common myna population is expected to increase since breeding appears to be escalating with no major threats. The current ecological status of the common myna and its range expansion to different habitats in northwestern Saudi Arabia is worrying and thus warrants further monitoring and investigation.

1. Introduction

Threats from introduced species can have significant ramifications for biodiversity (Thomas et al., 2016; Pyšek et al., 2020). Great concern has been expressed about introduced species due to the possible ecological and economic consequences of their existence and expansion (Grarock et al., 2012; Pyšek et al., 2020; Fantle-Lepczyk et al., 2022). Various introduction pathways have facilitated the spread of non-native species outside of their native ranges (Pyšek et al., 2020). For instance, introduction pathways could include deliberate release, escape from captivity, and pest control strategies (Pyšek et al., 2020). Invasive species can impact ecosystem functions, alter ecological communities, and affect native species composition (Grarock et al., 2012; Pyšek et al., 2020; Siddiqui et al., 2021). Additionally, invasive species can affect human well-being, jeopardize food security, and potentially even carry disease (Pyšek et al., 2020; Siddiqui et al., 2021). Therefore, understanding the spatial distribution of introduced species and monitoring their expansion along potential invasion hotspot areas is critical (Magory Cohen et al., 2019; Khoury et al., 2021).

Species that can manage to survive and thrive in novel environments have a high likelihood of becoming invasive (Blackburn et al., 2011; Borden and Flory, 2021), particularly those that are commensal with humans (Holzapfel et al., 2006). Urban habitats can offer conditions such as an abundance and variety of food sources, refugia sites, and a lack of predators (Khoury et al., 2021). Therefore, urban areas can serve a significant role as suitable habitats for certain invasive species (Borden and Flory, 2021; Khoury et al., 2021). Success in urban environments likely requires species to be opportunistic and have the potential for behavioral adaptation and flexibility (Sol et al., 2012). Additionally, being a generalist species increases the likelihood of survival and reproduction in urban environments (Patankar et al., 2021). This implies that through their behavioral flexibility, introduced species may hold certain advantages and exploit resources in urban habitats that native species may rarely use (Sol et al., 2012; Grarock et al., 2014).

E-mail address: abalatawi@ut.edu.sa.

https://doi.org/10.1016/j.jksus.2024.103367
Received 31 July 2023; Received in revised form 13 July 2024; Accepted 19 July 2024
Available online 22 July 2024

The common myna (*Acridotheres tristis*) is a bird native to central and southern Asia (Feare and Craig, 1998). It is a generalist species with an omnivorous diet that feeds on a wide variety of food resources, including fruits, nectar, grains, invertebrates, and even small vertebrates (Feare and Craig, 1998; Dhami and Nagle, 2009; Hart et al., 2020). Common mynas also scavenge on refuse at dump sites (Feare and Craig, 1998; Hart et al., 2020). The common myna is also known to be commensal with humans (Feare and Craig, 1998; Saavedra, 2010; Hart et al., 2020). This species has been accidentally introduced through cage escapes and intentionally introduced for aesthetic purposes and as a biological pest control agent (Feare and Craig, 1998). Notably, this bird has exhibited successful invasion behavior throughout its introduced range (Jennings, 2010; Grarock et al., 2012; Magory Cohen et al., 2019, 2022; Hart et al., 2020; Boland and Alsuhaibany, 2020; Khoury et al., 2021), which has resulted in it being one of the most common and widespread invasive species in the world (Feare and Craig, 1998; BirdLife International, 2017; Magory Cohen et al., 2019; Hart et al., 2020). As a result, the common myna has been recognized as one of the world's top 100 worst invaders (Lowe et al., 2000). Common mynas can impact native species through competition, disruption, predation, and habitat alteration, which can negatively affect ecosystems and their native birds (Tindall et al., 2007; Dhami and Nagle, 2009; Grarock et al., 2012; Feare et al., 2017, 2021; Hart et al., 2020). Notably, common myna eradication campaigns have been held to eradicate this bird from invaded habitats, such as in Seychelles and Mallorca Island, Spain (Millett et al., 2004; Saavedra, 2010; Feare et al., 2017, 2021).

A recent study by Alshamlih et al. (2022) listed 21 introduced bird species in Saudi Arabia, including the common myna. The common myna is a successful non-native breeding bird in the Arabian Peninsula, and its population has multiplied greatly throughout the region (Jennings, 2010). Felemban (1993) observed six pairs of common mynas at King Abdulaziz University in Jeddah City. The primary route of common myna introduction was originally its importation into Saudi Arabia for the pet trade (Alshamlih et al., 2022). Overall, it seems that the appearance of common mynas in different cities throughout Saudi Arabia occurred in different years (Jennings, 2010). Since then, the species has become established and its population has increased dramatically (Jennings, 2010; Boland and Alsuhaibany, 2020).

Knowledge of introduced species in Saudi Arabia remains incomplete, particularly in the northern region. As such, information on the distribution and ecological status of the common myna in northern Saudi Arabia remains significantly lacking. Thus, considering the potential negative impacts of this notorious bird on native species, it is scientifically important to have up-to-date information regarding its current distribution and habitat preferences, especially in under-studied habitats. In light of this, fieldwork was conducted to investigate common myna distribution in northeastern Saudi Arabia, particularly in Tabuk City and its surrounding area. The present study intends to provide an initial systematic baseline that can help the relevant authorities with future actions related to common myna management and control.

2. Materials and methods

2.1. Study area

The study area is located in Tabuk City and its surrounding habitats in Tabuk Province, northwestern Saudi Arabia (Fig. 1). The area of Tabuk Province is approximately 136,000 km^2 (Al Saud, 2020). The weather during the summer season is dry and hot, with the temperature having the potential to exceed 45 °C. Annual rainfall is generally low (Hasanean and Almazroui, 2015). Over the last three decades, Tabuk City has experienced substantial urban expansion (Albalawi, 2020). Additionally, the spatial extent of agricultural areas near Tabuk City has increased considerably (Al-Harbi, 2010; Albalawi et al., 2018). Notably, human-modified habitats in Tabuk Province have received little attention regarding the animals inhabiting these habitats, which has resulted

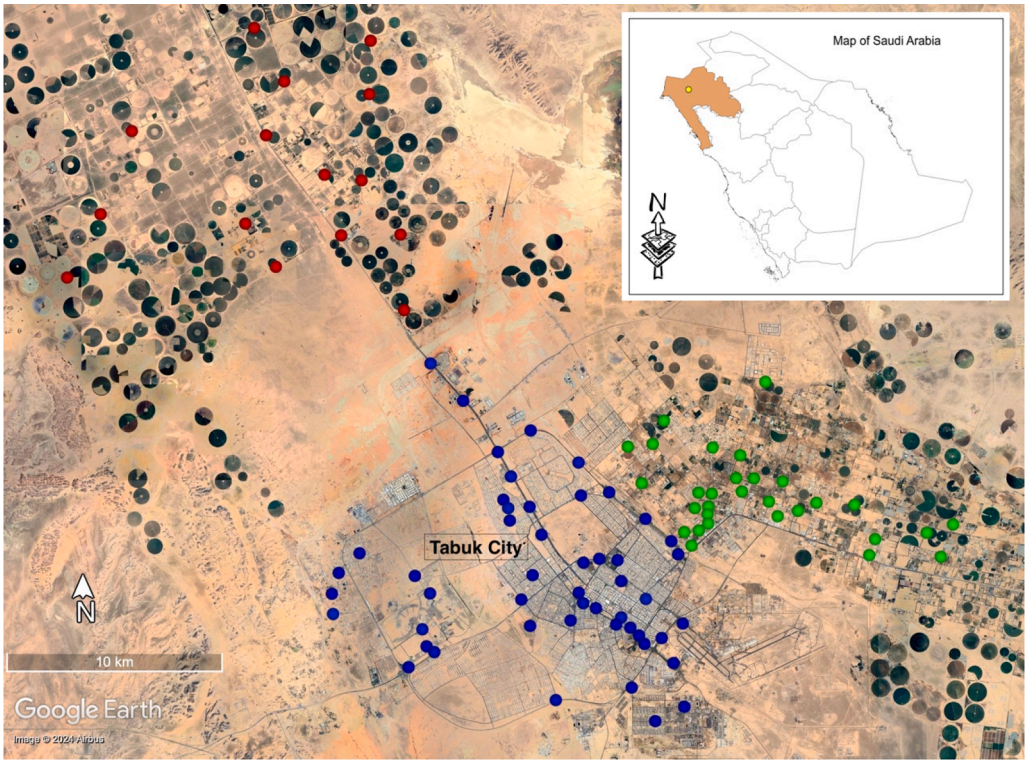

Fig. 1. The study area where the fieldwork was conducted to search for common myna in Tabuk City and its surrounding areas in the spring and summer of 2023 and 2024. Points on the map indicate a common myna occurrence record, with blue points indicating urban habitat, green points indicating suburban habitat, and red points indicating agricultural habitat. The image of the study area was obtained using the Google Earth Pro, accessed on June 29, 2024. The map of Saudi Arabia was generated using ArcGIS software.

in extremely limited data about these species (Alatawi, 2023).

2.2. Data collection

To delineate the ecological status of the common myna, fieldwork was designed to collect necessary data about this introduced species—including its distribution and habitat preferences—within the urban areas of Tabuk City and its surrounding habitats. The fieldwork was conducted during spring and summer, from May to July of 2023 and from May to June of 2024. The study area was divided into three categories: urban habitats (parks/gardens and urban areas within Tabuk City), suburban habitats (less populated habitats near Tabuk City that still host human activities), and agricultural habitats (areas dominated by large-scale agricultural activities) (Fig. 1). To standardize effort among sites and remain consistent, fieldwork was conducted during the morning (within 4–5 h from dawn) under normal weather conditions with no rain or high wind speeds (Bibby et al., 1992). Direct searching was applied as the field detection technique (Hill et al., 2005). The amount of time spent in each habitat type was determined based on the characteristics and sizes of visited habitats. Furthermore, opportunistic observations of common myna were also counted and marked on its distribution map. A hand-held GPS unit (Garmin eTrex 10) was used to record the coordinates of sites where common mynas were observed.

2.3. Extracting values of the human influence index (HII)

The global human influence index (HII) geographic dataset v2 (WCS and CIESIN, 2005) was downloaded at 30 arc-second grid cell sizes from the Socioeconomic Data and Applications Center (SEDAC). The HII layer was then uploaded into QGIS v.3.32 Desktop (QGIS Development Team, 2022), transformed into Raster format, and clipped to the spatial extent of the study area (Fig. 2). The HII values corresponding to coordinate points (*i.e.,* observations) were extracted using the "raster" package (Hijmans et al., 2023) in RStudio v.2024.04.0 (RStudio Team, 2020) equipped with R v.4.4 (R Core Team, 2021). Briefly, observation records were used to generate a spatial data frame stacked with a raster layer containing the HII values. The HII values were then extracted for all observation points and saved as an Excel worksheet.

2.4. Statistical analysis

To explore how common myna occurrences were affected by the HII among the three studied sites (*i.e.,* urban, suburban, and agricultural habitats), a one-way ANOVA test was implemented. Furthermore, significant differences among sites were assessed using Tukey's post-hoc test (at $p\text{-value} > 0.05$). Statistical analysis was conducted using PAST statistical software v.4.17 (Hammer et al., 2001), and graphical representations were plotted in QGIS v.3.32 (QGIS Development Team, 2022).

3. Results

For the first time, the distribution and habitat preferences of the introduced common myna have been systematically investigated in the northwestern region of Saudi Arabia. Common mynas were detected in different habitats within the studied areas (Fig. 3). Habitats with common myna detection represent a relatively large area including both the urban and suburban habitats of Tabuk City, as well as a relatively large agricultural habitat near Tabuk City (Fig. 1). All visited parks/gardens that had common mynas present. The distribution of the common myna appears to cover the entire perimeter of the urbanized areas of Tabuk City, where suitable conditions exist (Fig. 1). Additionally, common mynas were opportunistically observed within some neighborhoods of Tabuk City (Fig. 1).

The common myna population seems to be well-adapted, with their presence being noted across all visited sites. This implies that the species is successfully managing to use available resources. Common mynas were also observed scavenging on leftover food near waste containers, on the roadside, and from humans in parks, which appear to represent a major food source for this species (Fig. 3). Common mynas retreated into

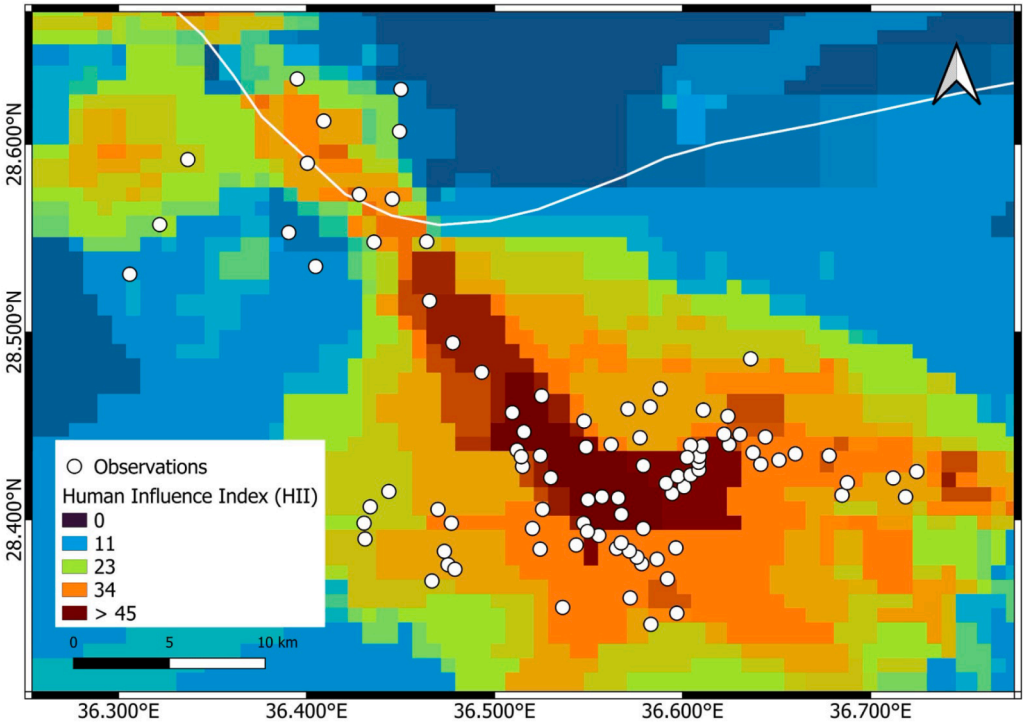

Fig. 2. Human influence index (HII) in the study area. Dark red pixels indicate a high HII value. The HII value is lower toward the peripheral urban areas of Tabuk City.

Fig. 3. Detection of the introduced common myna across the studied habitats in northwestern Saudi Arabia in 2023 and 2024. A and B: groups of common mynas observed in parks in Tabuk City. C: common mynas observed in a suburban habitat near Tabuk City. D: common mynas observed in an agricultural habitat. Photos by Abdulaziz Alatawi.

neighborhoods after foraging or when approached by the author from a distance, likely heading toward their nest sites. Common mynas were also observed carrying food and entering nesting sites, which included holes and crevices in buildings, lamp posts, road signs, and electrical boxes (Fig. 4).

There were significant differences among the three site categories (ANOVA, $F = 23$, $df = 2$, $p < 0.0001$). Tukey's pairwise test showed a significant difference between agricultural and suburban habitats (ANOVA, $p < 0.0001$), and between agricultural and urban habitats (ANOVA, $p < 0.0001$). However, Tukey's pairwise test indicated no significant difference between urban and suburban habitats (ANOVA, $p > 0.05$).

Six individual common mynas were also observed for sale at a pet shop in Tabuk City in May 2023 (Fig. 5A). A common myna was also observed on display at a local zoo in Tabuk City in June 2024 (Fig. 5B). These observations highlight the potential for the spread of this species through accidental escape or intentional release, which would increase its wild population.

4. Discussion

The common myna is an introduced bird in Saudi Arabia that seems to have dramatically expanded its distribution across human-modified habitats (Boland and Alsuhaibany, 2020; Alshamlih et al., 2022). However, its ecological status in the northwestern habitats of Saudi Arabia remains largely unknown. The results of this study indicate that the common myna has shown a dramatic range expansion across the modified habitats of Tabuk City and its surrounding areas. Notably, this species was more commonly found in urban areas than in the other investigated habitats. Overall, the common myna appears to have successfully adapted to inhabiting this arid ecosystem and effectively using its available resources. Further fieldwork to monitor this notorious species is recommended to investigate whether it is having harmful impacts on native birds and ecosystems.

Anthropogenic habitats can offer a variety of food resources for wild animals (Alatawi, 2023). The degree of habitat change dramatically enhanced the common myna population (Lowe et al., 2011; Magory Cohen et al., 2019). It has been shown that common mynas are capable of becoming an invasive species under the influence of anthropogenic factors, even in arid and semi-arid environments (Khoury et al., 2021). According to the distribution map presented by Jennings (2010), Tabuk City had no previous record of common myna occurrence. At present, the picture is completely different since this bird has significantly expanded its distribution range to include the northwestern region of Saudi Arabia. Here, the studied habitats near human centers and anthropogenic activities have common mynas present. This finding is congruent with what is already known about this species in different habitat conditions regarding the important role of anthropogenic factors in its distribution and survival. Khoury et al. (2021) reported that the expansion of common mynas and their current distribution in Jordan are driven more by anthropogenic factors than climatic variables. Magory Cohen et al. (2019) also found that at the global level, anthropogenic factors have a more influential role in common myna distribution than climatic variables. Overall, the Middle East region is currently experiencing the rapid proliferation of common myna populations (Holzapfel et al., 2006).

Common mynas are more frequently observed in areas with human-modified habitats (Peacock et al., 2007; Canning, 2011). In this study,

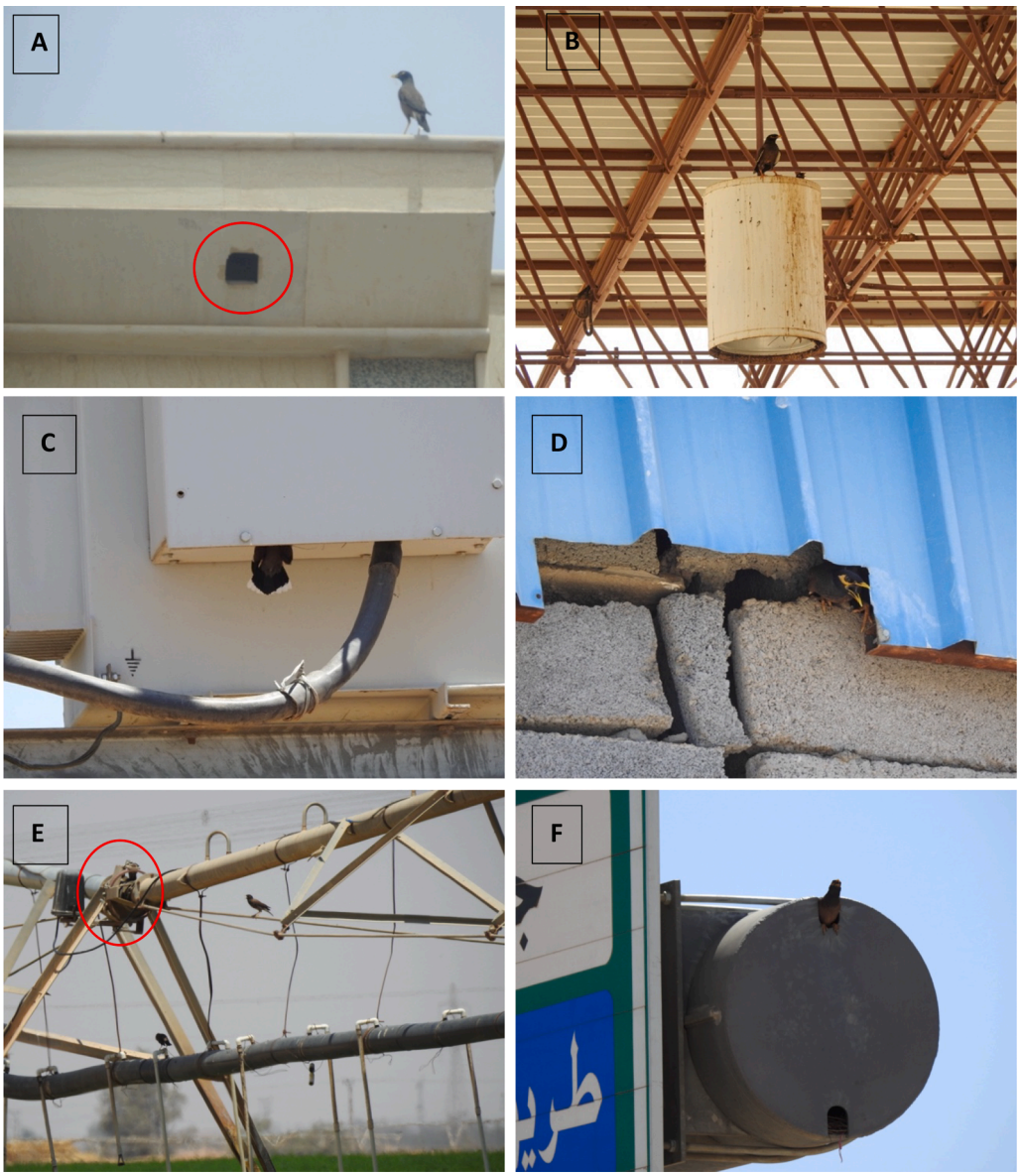

Fig. 4. Common myna nest site selection in some of the visited habitats in Tabuk Province, northwestern Saudi Arabia in 2023 and 2024. A: the red circle indicates a common myna nest located in a hole within a building. B: common mynas using lamp posts as nesting sites. C: a common myna entering an electrical box that was being used as a nesting site. D: a common myna nesting site located in a crevice within a wall covered by a metal sheet. E: common mynas observed entering a crack in the metal beam of an irrigation system in an agricultural habitat. F: a common myna using a road sign as a nesting site. Photos by Abdulaziz Alatawi.

common mynas were observed in both the urban and suburban environments of Tabuk City, with their presence being noticeably higher in urban and suburban than in agricultural habitats (Figs. 1 & 3), which suggests that the centers of human activity and urban/suburban development (Fig. 2) seem to be preferable sites for this species. Most common myna introductions in the Mediterranean region occurred in urban environments (Magory Cohen et al., 2022). In Israel, urban and suburban parks continued to be the main habitats of common myna populations (Holzapfel et al., 2006). Old et al. (2014) found that encounters of this species were more common in urban areas than in rural areas in Australia. Furthermore, Grarock et al. (2014) indicated that the abundance of common mynas was higher in urban areas than in nature reserves in Australia, with lower numbers observed in areas with higher tree densities within nature reserves. In the present study, the high abundance of common mynas in visited urban environments is likely due to these areas providing suitable conditions with a lack of natural predators, shelter against severe weather conditions, and—most importantly—easily accessible and rich food sources throughout the year, which support the expansion of this opportunistic bird. During the fieldwork, common mynas were observed eating invertebrates, scavenging close to refuse bins, and foraging on food left by humans in parks/gardens. Notably, such conditions might not be available in natural habitats. Overall, the expansion of this bird into local agricultural habitats is an important outcome that highlights the need for further monitoring.

The common myna is capable of learning to avoid dangers (Griffin and Boyce, 2009). Despite being known to be commensal with humans, common mynas showed a high level of vigilance when foraging in the study area since they immediately retreated when approached from a distance. Common mynas were mostly observed flying toward buildings in nearby neighborhoods when flushed. This species was observed to use holes/crevices in buildings, road signs, and lamp posts as nesting sites (Fig. 4). Nesting in a hole or crevice is a known technique for the common myna (Feare and Craig, 1998; Jennings, 2010). They were also observed flying toward Tabuk City's airport building. Common mynas were also previously observed at an airport in Jordan (Khoury and

Fig. 5. A: Common mynas photographed in captivity at a pet shop, where they were displayed for sale in May 2023. B: a common myna displayed in captivity at a local zoo in June 2024. Photos by Abdulaziz Alatawi in Tabuk City, Tabuk Province, Saudi Arabia.

Alshamlih, 2015).

From a conservation perspective, the information provided in this study regarding the introduced common myna is alarming. Competition for food, nesting sites, and territory are domains in which the common myna can compete with native birds (Dhami and Nagle, 2009; Hart et al., 2020). Grarock et al. (2012) found that the long-term abundance of some small bird species and cavity-nesting species was negatively affected by the establishment of common myna populations. The common myna has also been shown to harm endangered bird species by competing for food and nesting sites in island habitats (Canning, 2011). As a result, common myna eradication campaigns have been held in some invaded habitats (Millett et al., 2004; Saavedra, 2010; Canning, 2011; Feare et al., 2017, 2021). The continued range and population expansions of this species in Tabuk City and its surrounding areas might adversely influence native birds, as has occurred in other localities. Overall, its ecological status and stage of invasiveness in Saudi Arabia require further investigation.

Several common mynas were observed in a cage at a pet shop in Tabuk City, ready for sale (Fig. 5A), and one was also observed at a zoo in Tabuk City in June 2024 (Fig. 5B). As such, regulations must be applied to control its trade and possession, which might reduce its accidental and intentional release. Increasing public awareness is an important tool and a key aspect of conservation that should be incorporated to control such issues (Alatawi, 2022). For an introduced bird that invades an extremely large area of the world, international cooperation—particularly between neighboring countries—may be required to control it (Khoury et al., 2021; Magory Cohen et al., 2022).

5. Conclusion

Conservation measures in urban areas are as important as those implemented in natural habitats (Alatawi et al., 2020; Alatawi, 2024). In the sensitive arid environment, urban ecology clearly requires more research attention and conservation efforts. Common mynas showed behavioral flexibility by inhabiting various human-modified habitats and effectively using available resources to survive and thrive. Even if the introduced species appears to have no visible impact on native birds, its status should be regularly monitored and assessed. This must be emphasized when working with a globally well-known invader such as the common myna, which has been shown to have harmful effects on native birds in other areas. To this end, the current ecological status of common mynas and their rapid spread to different habitats in northwestern Saudi Arabia is worrying and warrants further monitoring.

Funding

This research received no external funding.

CRediT authorship contribution statement

Abdulaziz S. Alatawi: Conceptualization, Data curation, Formal analysis, Methodology, Resources, Supervision, Writing – original draft, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

The author thanks the anonymous reviewers for their valuable suggestions and comments to improve the manuscript. The author thanks Dr. Mohanad Abdelgadir for the help with statistical analysis.

References

Al Saud, M.M., 2020. Sustainable Land Management for NEOM Region. Springer Publisher, p. 220.
Alatawi, A.S., 2022. Conservation action in Saudi Arabia: challenges and opportunities. Saudi J. Biol. Sci. 29, 3466–3472. https://doi.org/10.1016/j.sjbs.2022.02.031.
Alatawi, A.S., 2023. Role of Agricultural Areas as Shelters for Carnivores in a Desert Ecosystem in Saudi Arabia. Pak. J. Zool. 56, 1–8. https://doi.org/10.17582/journal.pjz/20230422050418.
Alatawi, A.S., 2024. Amphibian distribution and habitats in northwestern Saudi Arabia. Russ. J. Herpetol. 31, 39–46. https://doi.org/10.30906/1026-2296-2024-31-1-39-46.
Alatawi, A.S., Gilbert, F., Reader, T., 2020. Modelling terrestrial reptile species richness, distributions and habitat suitability in Saudi Arabia. J. Arid Environ. 178, 104153 https://doi.org/10.1016/j.jaridenv.2020.104153.
Albalawi, E., Dewan, A., Corner, R., 2018. Spatio-temporal analysis of land use and land cover changes in arid region of Saudi Arabia. Int. J. GEOMATE 14, 73–81. https://doi.org/10.21660/2018.44.3708.
Albalawi, E., 2020. Assessing and predicting the impact of land use and land cover change on groundwater using geospatial techniques: a case study of Tabuk, Saudi Arabia (Doctoral dissertation, Curtin University). 164 pp.
Al-Harbi, K.M., 2010. Monitoring of agricultural area trend in Tabuk region–Saudi Arabia using Landsat TM and SPOT data. Egyptian J. Remote Sensing Space Sci. 13, 37–42. https://doi.org/10.1016/j.ejrs.2010.07.005.

Alshamlih, M., Alzayer, M., Hajwal, F., Khalili, M., Khoury, F., 2022. Introduced birds of Saudi Arabia: Status and potential impacts. J. King Saud University-Science 34, 101651. https://doi.org/10.1016/j.jksus.2021.101651.

Bibby, C.J., Burgess, N.D., Hill, D.A., 1992. Bird Census Techniques. Academic Press, p. 257.

BirdLife International, 2017. *Acridotheres tristis*. The IUCN Red List of Threatened Species 2017: e.T22710921A111063735. https://doi.org/10.2305/IUCN.UK.2017-1.RLTS.T22710921A111063735.en.

Blackburn, T.M., Pyšek, P., Bacher, S., Carlton, J.T., Duncan, R.P., Jarošík, V., Wilson, J. R., Richardson, D.M., 2011. A proposed unified framework for biological invasions. Trends Ecol. Evol. 26, 333–339. https://doi.org/10.1016/j.tree.2011.03.023.

Boland, C., Alsuhaibany, A., 2020. The Birds of Saudi Arabia. Volume 2: Species Accounts. Motivate Media Group. 452 pp.

Borden, J.B., Flory, S.L., 2021. Urban evolution of invasive species. Front. Ecol. Environ. 19, 184–191. https://doi.org/10.1002/fee.2295.

Canning, G., 2011. Eradication of the invasive common myna, *Acridotheres tristis*, from Fregate Island. Seychelles. Phelsuma 19, 43–53.

Dhami, M.K., Nagle, B., 2009. Review of the biology and ecology of the Common Myna (*Acridotheres tristis*) and some implications for management of this invasive species. Pacific Invasives Initiative. The University of Auckland, Auckland, p. 28.

Fantle-Lepczyk, J.E., Haubrock, P.J., Kramer, A.M., Cuthbert, R.N., Turbelin, A.J., Crystal-Ornelas, R., Diagne, C., Courchamp, F., 2022. Economic costs of biological invasions in the United States. Sci. Total Environ. 806, 151318 https://doi.org/10.1016/j.scitotenv.2021.151318.

Feare, C., Craig, A., 1998. Starlings and Mynas. Christopher Helm, London, p. 285.

Feare, C.J., van der Woude, J., Greenwell, P., Edwards, H.A., Taylor, J.A., Larose, C.S., Ahlen, P.-A., West, J., Chadwick, W., Pandey, S., Raines, K., Garcia, F., Komdeur, J., de Groene, A., 2017. Eradication of common mynas *Acridotheres tristis* from Denis Island. Seychelles. Pest Manage. Sci. 73, 295–304. https://doi.org/10.1002/ps.4263.

Feare, C.J., Waters, J., Fenn, S.R., Larose, C.S., Retief, T., Havemann, C., Ahlen, P.-A., Waters, C., Little, M.K., Atkinson, S., Searle, B., Mokhobo, E., de Groene, A., Accouche, W., 2021. Eradication of invasive common mynas *Acridotheres tristis* from North Island, Seychelles, with recommendations for planning eradication attempts elsewhere. Manage. Biol. Invasions 12, 700–715. https://doi.org/10.3391/mbi.2021.12.3.12.

Felemban, H.M., 1993. On exotic birds imported into Jeddah, Saudi Arabia. Zoology in the Middle East. 8, 15–16. https://doi.org/10.1080/09397140.1993.10637632.

Grarock, K., Tidemann, C.R., Wood, J., Lindenmayer, D., 2012. Is it Benign or is it a Pariah? Empirical evidence for the impact of the Common Myna (*Acridotheres tristis*) on Australian Birds. PLoS ONE 7, e40622.

Grarock, K., Tidemann, C.R., Wood, J., Lindenmayer, D., 2014. Are invasive species drivers of native species decline or passengers of habitat modification? A case study of the impact of the common myna (*Acridotheres tristis*) on Australian bird species. Austral Ecol. 39, 106–114. https://doi.org/10.1111/aec.12049.

Griffin, A.S., Boyce, H.M., 2009. Indian mynahs, *Acridotheres tristis*, learn about dangerous places by observing the fate of others. Animal Behaviour 78, 79–84. https://doi.org/10.1016/j.anbehav.2009.03.012.

Hammer, O., Harper, D., Ryan, P., 2001. Past: Paleontological statistics software package for education and data analysis. Palaeontol. Electron. 4, 1–9.

Hart, L.A., Rogers, A., van Rensburg, B.J., 2020. Common Myna (*Acridotheres tristis* Linnaeus, 1766). In: Downs, C.T., Hart, L.A. (Eds.), Invasive Birds: Global Trends and Impacts. CAB International, Wallingford, pp. 25–32.

Hasanean, H., Almazroui, M., 2015. Rainfall: features and variations over Saudi Arabia, a review. Climate 3, 578–626. https://doi.org/10.3390/cli3030578.

Hijmans, R.J., et al., 2023. Raster: Geographic Data Analysis and Modeling. 249 pp.

Hill, D., Fasham, M., Tucker, G., Shewry, M., Shaw, P., 2005. Handbook of Biodiversity Methods. Survey, Evaluation and Monitoring. Cambridge University Press. 573 pp.

Holzapfel, C., Levin, N., Hatzofe, O., Kark, S., 2006. Colonisation of the Middle East by the invasive Common Myna *Acridotheres tristis* L., with special reference to Israel. Sandgrouse 28, 44–51.

Jennings, M.C., 2010. Atlas of the Breeding Birds of Arabia. Fauna of Arabia, Vol. 25. 751 pp.

Khoury, F., Alshamlih, M., 2015. First evidence of colonization by common myna *Acridotheres tristis* in Jordan, 2013–2014. Sandgrouse 37, 22–24.

Khoury, F., Saba, M., Alshamlih, M., 2021. Anthropogenic not climatic correlates are the main drivers of expansion of non-native common myna *Acridotheres tristis* in Jordan. Manage. Biol. Invasions 12, 640–653. https://doi.org/10.3391/mbi.2021.12.3.08.

Lowe, S., Browne, M., Boudjelas, S., De Poorter, M., 2000. 100 of the World's Worst Invasive Alien Species A selection from the Global Invasive Species Database. Published by The Invasive Species Specialist Group (ISSG) a specialist group of the Species Survival Commission (SSC) of the World Conservation Union (IUCN), 12pp. First published as special lift-out in Aliens 12, December 2000. Updated and reprinted version: November 2004.

Lowe, K.A., Taylor, C.E., Major, R.E., 2011. Do Common Mynas significantly compete with native birds in urban environments? J. Ornithol. 152, 909–921. https://doi.org/10.1007/s10336-011-0674-5.

Magory Cohen, T., McKinney, M., Kark, S., Dor, R., 2019. Global invasion in progress: modeling the past, current and potential global distribution of the common myna. Biol. Invasions 21, 1295–1309. https://doi.org/10.1007/s10530-018-1900-3.

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. J. Appl. Ecol. 59, 1440–1455. https://doi.org/10.1111/1365-2664.14150.

Millett, J., Climo, G., Shah, N.J., 2004. Eradication of common mynah *Acridotheres tristis* populations in the granitic Seychelles: successes, failures and lessons learned. Adv. Vertebrate Pest Manage. 3, 169–183.

Old, J.M., Spencer, R.J., Wolfenden, J., 2014. The Common myna (*Sturnus tristis*) in urban, rural and semi-rural areas in Greater Sydney and its surrounds. Emu-Austral Ornithol. 114, 241–248. https://doi.org/10.1071/MU13029.

Patankar, S., Jambhekar, R., Suryawanshi, K.R., Nagendra, H., 2021. Which traits influence bird survival in the city? A review. Land 10, 92. https://doi.org/10.3390/land10020092.

Peacock, D.S., van Rensburg, B.J., Robertson, M.P., 2007. The distribution and spread of the invasive alien common myna, *Acridotheres tristis* L. (Aves: Sturnidae), in southern Africa. S. Afr. J. Sci. 103, 465–473.

Pyšek, P., Hulme, P.E., Simberloff, D., Bacher, S., Blackburn, T.M., Carlton, J.T., Dawson, W., Essl, F., Foxcroft, L., Genovesi, P., et al., 2020. Scientists' warning on invasive alien species. Biol. Rev. 95, 1511–1534. https://doi.org/10.1111/brv.12627.

QGIS Development Team., 2022. QGIS Geographic Information System. Open Source Geospatial Foundation. https://www.qgis.org.

R Core Team, 2021. R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing. https://www.R-project.org/.

RStudio Team, 2020. RStudio: Integrated Development Environment for R. RStudio, PBC. http://www.rstudio.com/.

Saavedra, S., 2010. Eradication of invasive Mynas from islands. Is it possible. Aliens: the Invasive Species Bulletin 29, 40–47.

Siddiqui, J.A., Bamisile, B.S., Khan, M.M., Islam, W., Hafeez, M., Bodlah, I., Xu, Y., 2021. Impact of invasive ant species on native fauna across similar habitats under global environmental changes. Environ. Sci. Pollut. Res. 28, 54362–54382. https://doi.org/10.1007/s11356-021-15961-5.

Sol, D., Bartomeus, I., Griffin, A.S., 2012. The paradox of invasion in birds: competitive superiority or ecological opportunism? Oecologia 169, 553–564. https://doi.org/10.1007/s00442-011-2203-x.

Thomas, J., El-Sheikh, M.A., Alfarhan, A.H., Alatar, A.A., Sivadasan, M., Basahi, M., Al-Obaid, S., Rajakrishnan, R., 2016. Impact of alien invasive species on habitats and species richness in Saudi Arabia. J. Arid Environ. 127, 53–65. https://doi.org/10.1016/j.jaridenv.2015.10.009.

Tindall, S.D., Ralph, C.J., Clout, M.N., 2007. Changes in bird abundance following Common Myna control on a New Zealand island. Pac. Conserv. Biol. 13, 202–212. https://doi.org/10.1071/PC070202.

Wildlife Conservation Society - WCS, and Center for International Earth Science Information Network - CIESIN - Columbia University. 2005. Last of the Wild Project, Version 2, 2005 (LWP-2): Global Human Influence Index (HII) Dataset (Geographic). Palisades, New York: NASA Socioeconomic Data and Applications Center (SEDAC). DOI: 10.7927/H4BP00QC. Accessed 29-06-2024.