

Research Article

Habitat preference for nesting and foraging of Eurasian Spoonbill (*Platalea leucorodia*) in breeding season

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Abstract

Wetlands are valuable because they support considerable ecological functions and are important in maintaining and sustaining bird communities by supplying abundant resources. Wetlands are ecosystems with high biodiversity and a hotspot of research that allows their inhabiting species to carry out their basic vital activities, such as feeding, sheltering, and breeding. Due to the sensitivity and rapid reduction of wetlands, biodiversity, especially waterbirds, will also be affected by these changes. Binary logistic regression (BLR) is a widely used technique in habitat modeling, particularly for presence and absence data, which applies maximum likelihood estimation after transforming the dependent variable into a logit variable. The Eurasian Spoonbill (*Platalea leucorodia*) is a waterbird species found in the Gadaman Wetland, where its presence is limited to the breeding season. Wetland succession can impact various wetland-dependent birds, especially during the breeding season. Therefore, the habitat suitability modeling is limited only to this season. The overall classification accuracy and receiver operating characteristic (ROC) were assessed to determine the sensitivity and accuracy of the model. The model performance evaluated by the area under the receiver operating characteristic (ROC) curve was found to be 0.993 ± 0.008 , implying that the present model is effective. According to the results and data obtained based on the table of water depth and vegetation of *Carex-Juncus* spp. for foraging and *Cladium-Cyperus* spp. and *Blysmus-Phragmites* spp. for nesting.

Key words: Binary Logistic Regression, Eurasian Spoonbill, ROC, Waterbirds, Wetland



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Introduction

Waterbirds, as one of the top food chain predators (Wang et al. 2016), are avians that live in and around water (Gokulakrishnan et al. 2014), and also depend on wetlands (Li et al. 2022) for foraging behaviour, food selection, nidification, and habitat preference (Cherkaoui et al. 2022). Therefore, they are the most active component of wetlands (Li et al. 2022) and play key functional roles in many aquatic ecosystems, for example, as herbivores and vectors of seeds,

invertebrates, and nutrients, hence, the waterbird is regarded as one of the important indicators of the condition of the ecosystem (Wang et al. 2016).

Wetlands are valuable because they support considerable ecological functions (Maleki et al. 2019; Rosenblum and Schmeier 2022) and play a crucial role in maintaining and sustaining bird communities by supplying an abundance of resources (Zi-ling et al. 2021; Cherkaoui et al. 2022; Malekian et al. 2022). Thus, wetlands provide numerous beneficial services for humans and wildlife (Fournier et al. 2021; Malekian et al. 2022). In recent decades, these valuable ecosystems have been degraded by various forces, including wastewater, increases in water consumption, drought, and land use changes (Maleki et al. 2019). In wetlands, the distribution of surface water is one of the main determinants of species' spatial distribution and individual movements (Acácio et al. 2021) and the Geographic Information System (GIS) is an attractive alternative to traditional field methods because it provides detailed attributed information across multiple scales (Liu et al. 2010) to investigate and predict the distribution of species and habitats. Despite increased understanding of the benefits of wetlands, evidence is mounting that wetlands are one of the most seriously threatened ecosystems across the globe (Boros et al. 2023), such that they are being lost at a rate three times higher than that of natural forests (Rosenblum and Schmeier 2022). Climate change (Gaudreau et al. 2018; Malekian et al. 2022), an increase in the human population, urbanization (Ulusoy and Bulut 2020; Chen et al. 2022), and drainage (Wang et al. 2016) are among the factors that lead to the disruption of ecological functions and ecosystem services of wetlands (Wang and Yang 2020). These ecosystems, in the world, especially in Asia (Chen et al. 2022), are disappearing, and the remaining ones continue to degenerate (Wang et al. 2016; Malekian et al. 2022; Rosenblum and Schmeier 2022). Due to the sensitivity and rapid reduction of wetlands, biodiversity, especially waterbirds, will also be affected by these changes. Birds can be susceptible to changes in habitat structure (Liu et al. 2010); thus, with the reduction of the area and degradation of wetlands, birds, especially waterfowl and waterbirds that depend on these habitats, are affected by these changes and exposed to danger (Ma et al. 2010).

Bird populations are dynamic; each species chooses habitats and specific parts for nesting. Thus, nest patterns may change with seasons (Rushing et al. 2017; Wang and Yang 2020). Hence, providing high-quality habitats for waterbirds is a critical issue in waterbird conservation (Ma et al. 2010). Eurasian Spoonbill (*Platalea leucorodia*) is a specialist waterbird that is distributed over a wide range in the Palearctic (Champagnon et al. 2019; Pigniczki 2022a), and this species is of key conservation importance as a flagship, umbrella, and indicator (Pigniczki 2017; Hunt et al. 2022). Most studies have focused on migration (Botond et al. 2022), breeding (Kralj et al. 2013), molecular biology (Cherkaoui et al. 2022), ecology and distribution (Carapezza 2020; Pigniczki 2022b), and diet (Surdo 2020). Due to geographical and ecological conditions, Iran has a wide variety of waterbirds (Khaleghizadeh et al. 2020). This area has become an important habitat in flyways for migratory stopovers, wintering, and breeding. This study evaluates and determines suitable habitats of the Eurasian spoonbills' breeding status in the Gandoman wetland from the time of the species' presence, such as nesting and incubating on the wetland surface, until the time of migrating and leaving the wetland. A statistical technique for productive modeling used in this study was the application of Binary Logistic Regression (BLR).

Material and methods

Gandoma Wetland in Iran, with an area of 980 hectares and an average height of 2220 m above sea level, is located in the Aqbolaq watershed, on the eastern domain of the Kalar highlands, in the geographical range of 51°04'42"E to 51°07'45"E longitude and 31°48'43"N to 31°51'24"N latitudes (Fig. 1).

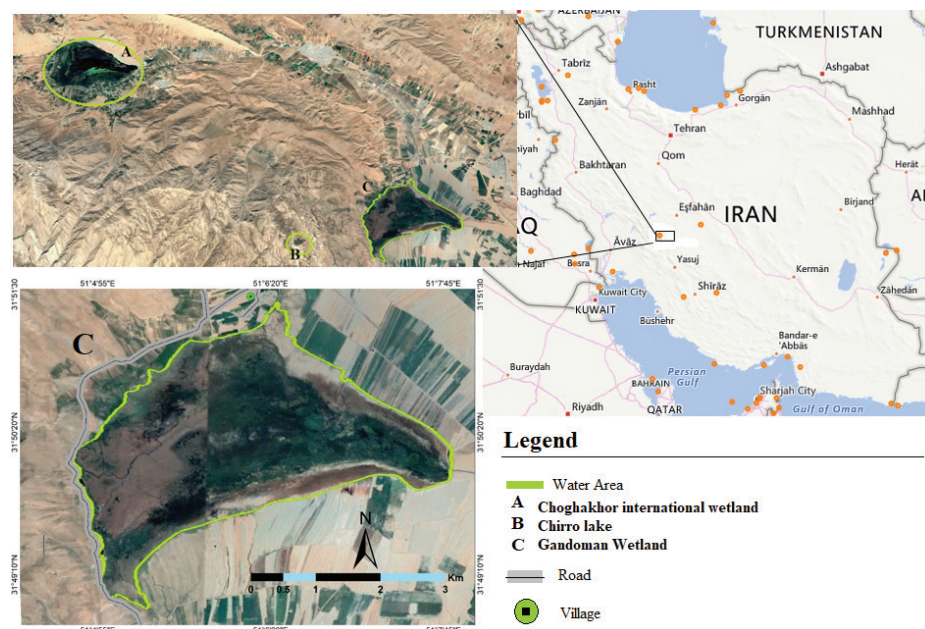


Figure 1. Map of the study area, Geographical location of Gandoman wetland downstream of Choghakhor International Wetland and Chirro Lake.

This wetland is located downstream of Choghakhor International Wetland (Ramsar Convention 2023); therefore, one of the water outlets of Choghakhor Wetland enters the Gandoman Wetland. Eurasian spoonbill – hereafter Spoonbill – (Fig. 2) (*Platalea leucorodia*) population is listed as “The Least Concern (LC)” globally according to the IUCN Red List and Birdlife International criteria (IUCN Red List 2019; Xi et al. 2021; Cherkaoui et al. 2022).

Spoonbills come to spring wetlands (breeding season) in March to breed (Pigniczki 2017). April is important for breeding, but a few spoonbills still arrive at the breeding ground in late April. To survey and investigate the breeding and foraging habitats of spoonbills in the Gandoman wetland from the time of nesting and incubation of this species, monitoring and observation of the place of presence, feeding, foraging, and nesting point took place once a week from the end of April to the middle of July over three consecutive years (2020–2022). Based on the observation of adult birds during this period as an indicator of breeding (Pigniczki 2017), data on feeding and nesting were recorded using the Global Positioning System (GPS). Also, the depth of the nests and foraging places was measured. Since non-presence data cannot be considered as certain as presence (Imam et al. 2009; Alam et al. 2014), wherever evidence of a particular spoonbill was found, it was recorded as a “presence point” alongside habitats of other species. The presence of the spoonbill was not observed during three years of monitoring, and a “non-presence point” was marked. Google Earth Pro is used to estimate and determine the border area and to monitor and observe



Figure 2. Eurasian Spoonbills (*Platalea leucorodia*) in the Gandoman Wetlands (Photo by: R. Asgari).

the spoonbills using a Swarovski 20×60 monocular telescope, the Steiner 8×30 binocular, and a Canon 50× spotting scope. Data, including environmental variables and the presence/non-presence of spoonbills recorded during fieldwork on the Gandoman Wetland, were analysed in ArcGIS 10 and SPSS 26. Logistic regression is a technique widely used in habitat modeling based on the presence and absence data (Alam et al. 2014), which applies maximum likelihood estimation after transforming the dependent variable into the logit variable (Imam et al. 2009). According to the purpose of the study, the most important factor for the spoonbill as a waterbird was the water depth (which depths it prefers for nesting and feeding), Because water availability is an essential factor for the richness and abundance of species, such that, avian diversity in arid environments also depends on the proximity to water (Boros et al. 2023). Vegetation was transformed into raster themes and used for further analysis.

Results and discussion

Apprehending the habitat resource needs, and factors that affect the nest-site selection and foraging due to species' need for access to food resources (Sullender et al. 2016) and avoidance of predators, humans, and other species (Tayefeh et al. 2011), is a critical step toward understanding which wetland conditions support a diverse suite of species across the distinct annual cycles (Fournier et al. 2021). Disruptions are occurring constantly and severely in ecosystems worldwide, particularly in wetlands, and waterbirds are likely to be most affected (Sullender et al. 2020). Spoonbills have been used as an indicator of how bird populations are impacted by wetland drainage and other land-use changes (Sullender et al. 2016).

A Receiver Operating Characteristic (ROC) curve was generated to see the 'strength of conviction' of probability logistic regression scores that a subject falls into one category or another. The area under the ROC curve (AUC) varies from 0.5 (for a chance performance) to 1.0 for a perfect fit (Zarri et al. 2008). The ROC curve is a graphical representation of the trade-off between a test's false negatives and false positives (Imam et al. 2009). The overall classification accuracy and receiver operating characteristic (ROC) were assessed to determine the sensitivity and accuracy of the model. The level below the curve (ROC) is the probability of discernment power between the presence and absence data of a model. The model performance evaluated by the area under the receiver operating characteristic (ROC) curve was found to be 0.993 ± 0.008 (Table 1), implying that the present model is effective (Fig. 3).

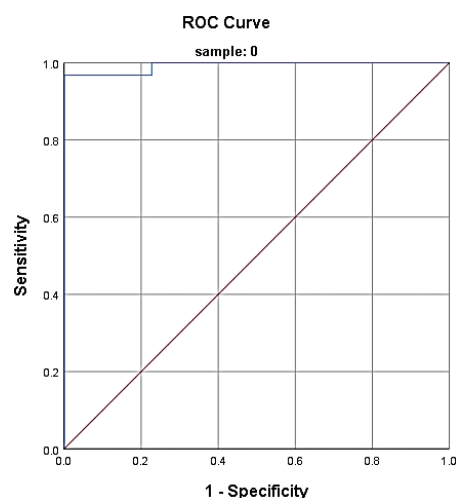


Figure 3. Graph depicting the area under the ROC curve

Table 1. Area under the curve.

Area	Std. Error	Asymptotic Sig. ^c	Asymptotic 95% Confidence Interval	
			Lower Bound	Upper Bound
.993	.008	.000	.976	1.000

The coefficients derived from BLR (Table 2) were used as the weight for variables to integrate all layers in the ArcGIS domain to arrive at the probability/suitability map for the spoonbill. According to the results and data obtained based on the table of water depth and vegetation of *Carex-Juncus* spp. for foraging and *Cladium-Cyperus* spp. and *Blysmus-Phragmites* spp. for nesting, also based on $\text{Exp}(B)$ value, it provides the chance of the presence of the species for feeding and nesting, which allows the prediction of the attention obtained by *Blysmus-Phragmites* spp., *Cladium-Cyperus* spp., and *Juncus* spp. for feeding and *Carex-Juncus* spp. and *Phragmites-Cyperus-Cladium* spp. for nesting.

The 'Habitat Suitability Index (H.S.I.) model' provides an efficient and low-cost method for determining habitat quality (Imam and Kushwaha 2013):

H.S.I for Spoonbill:

$$\frac{[\text{Exp}(B \times D) + (B \times BP) + (B \times CJ) + (B \times CC) + (B \times E) + (B \times J) + (B \times PCC) + \text{Constant}]}{[1 + [\text{Exp}(B \times D) + (B \times BP) + (B \times CJ) + (B \times CC) + (B \times E) + (B \times J) + (B \times PCC) + \text{Constant}]}$$

Table 2. Result of logistic regression analysis.

	B	S.E.	Wald	Df	Sig.	Exp(B)
Depth (D)	-.168	.070	5.817	1	.016	.846
Blysmus-Phragmites (BP)	.023	.013	2.874	1	.090	1.023
Carex-Juncus (CJ)	-.019	.010	3.350	1	.067	.981
Cladium-Cyperus (CC)	.024	.013	3.117	1	.077	1.024
Eleocharis (E)	-.011	.016	.480	1	.488	.989
Juncus (J)	.009	.010	.715	1	.398	1.009
Phragmites-Cyperus-Cladium (PCC)	-.029	.017	3.024	1	.082	.971
Constant	-43.046	29.949	2.066	1	.151	.000

Table 3. Classification accuracy for Spoonbill modelling.

	Non-presence	Presence	Percentage Correct
Non-presence	22	0	100.0
presence	1	30	96.8
Overall Percentage 98.1			

The model is presented in Fig. 4 for the Spoonbill; the overall classification accuracy of 98.1% was observed with the probability cut-off value at 0.64 (Table 3).

Gandaman Wetland, as the breeding and nesting habitat of the spoonbill, can be a corridor for migration in the geographical area because of the proximity of this wetland to the international Choghakhor Wetland. This research showed that the spoonbills in the Gandaman wetland choose different depths of the wetland for foraging, nesting, and breeding. According to the data analysis, it was found that the spoonbills choose shallow areas for feeding, while they build their nests in deep places. In addition to camouflage, the location of the objects among the reeds also protects the eggs and chicks from predators that threaten this species on land or at shallow depths. Water depth directly determines the accessibility of foraging habitats; thus, this relationship serves as the basis for the guidelines of wetland management. The vegetation is an important habitat element and greatly influences the habitat use by waterbirds. The waterbird population will increase with increasing vegetation cover in wetlands, especially during breeding periods when waterbirds are less mobile and more sensitive to disturbance. High, dense vegetation, however, can limit the accessibility of wetlands and adversely affect foraging and prey detection by waterbirds (Ma et al. 2010). Observations showed that spoonbills choose wetland areas with sparse vegetation for feeding, while building their nests among reeds because it is a safe place to stay away from predators and reduce stress.

Wetlands are ecosystems with high biodiversity and a hotspot of research that allow their inhabiting species to carry out their basic vital activities such as feeding, sheltering, and breeding (Liu et al. 2010; Ulusoy and Bulut 2020; Zi-ling et al. 2021). Wetlands cover less than 2% of the continental surface on Earth and continue to shrink (Ulusoy and Bulut 2020). Thus, those close to urban sites have a high chance of being converted to other land use types (Malekian et al. 2022), and the Gandaman wetland is no exception to this rule. Due to its proximity to the Chaghakhor wetland, the Gandaman wetland is a corridor

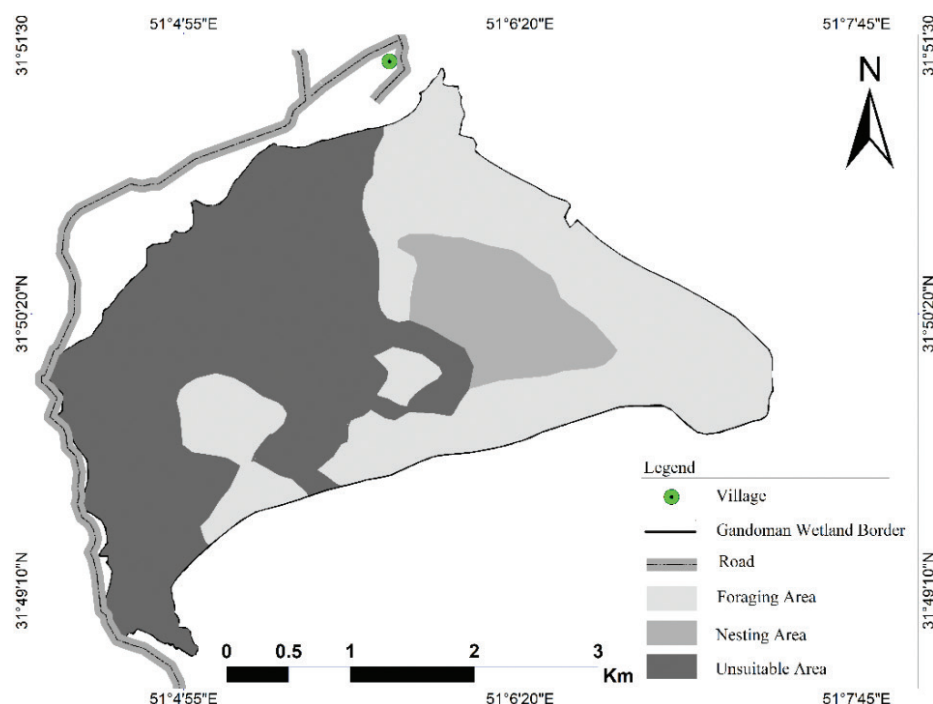


Figure 4. Habitat Suitability Predicted for Foraging and Nesting of Spoonbill in Gandoman Wetland.

habitat and even a corridor for many birds, including spoonbills, which spend the breeding season in this wetland and leave it in winter. Larger species with longer necks, bills, and legs can feed in deeper habitats than smaller species. According to the results obtained in this research, Spoonbills were feeding at depths less than 40 cm. The areas with this depth provided the preferred habitats, and foraging was more successful for Spoonbills in this area (Sullender et al. 2016). The Spoonbill is a specialist water bird of wetlands with shallow water because it can forage only in water that is not deeper than 40 cm (Pigniczki 2022a). Therefore, water depth is an important variable affecting waterbirds' use of wetland habitats (Ma et al. 2010; El-Hacen et al. 2013; Xu et al. 2024). Selecting nest sites by waterbird species may depend on balancing factors that affect predation risks (Fournier et al. 2021). Some bird species select for vegetation structure rather than choosing habitat based on a particular land cover category (Liu et al. 2010). According to Table 2, the Wald value is obtained and used to determine the significance level of independent variables. Its importance is also based on the Sig. From these results, one can understand the importance of depth in the wetland for foraging and nesting of the Spoonbills.

Conclusions

The reeds of Gandaman Wetland are a suitable habitat for nesting, breeding, and foraging of waterbirds and waterfowl species. They are very effective in creating a shelter for the chicks and ensuring the safety of the eggs. The binomial multiple logistic regression for habitat suitability of the Eurasian Spoonbills successfully predicted the suitability of the habitat in the Gandoman Wetland, with most of the variables found to be significant predictors. Considering

the wetland restoration measures that have been carried out in recent years and the construction of an earthen dam at the exit of the eastern part of the wetland, which has increased the water depth in the northern and central parts of the wetland and increased the area and range of reed plant growth, it seems that in the coming years, the number of this species will increase in the breeding season. Generally, an individual wetland rarely meets all the requirements (foraging, nesting sites, etc.) of diverse waterbirds. Therefore, developing and maintaining multiple and complementary wetlands in an ecosystem can provide the resources that diverse waterbirds need. From a landscape perspective, other surrounding wetlands can influence the number of waterfowl species and their reproductive performance in one wetland. Although the development of agriculture and the proximity of the city may create threats to the wetland, due to the ecological conditions of the wetland and the presence of birds and even other species of wildlife, this wetland has become one of the prohibited hunting areas of the Environmental Protection Organization. Therefore, by monitoring and management, this wetland can be designated as one of the Important Bird Areas (IBAs) in Iran.

Additional information

Conflict of interest

The authors have declared that no competing interests exist.

Ethical statement

No ethical statement was reported.

Use of AI

No use of AI was reported.

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Author contributions

Conceptualisation, A.N. and C.M.; methodology, A.N., A.S. and A.N.; software, A.N.; validation, A.S., C.M. and A.N.; formal analysis, A.N. and C.M.; investigation, A.S. and A.N.; resources, A.N. and A.S.; data curation, C.M. and A.N.; writing—original draft preparation, A.N.; writing—review and editing, C.M., and A.N.; visualisation, A.N. and A.S.; supervision, C.M. and A.N.; project administration, A.N. and A.S. All authors have read and agreed to the published version of the manuscript.

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Data availability

Data are available on request due to restrictions, e.g., privacy or ethics. The data presented in this study are available on request from the corresponding author.

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Supplementary material 1

Spoonbills data

Authors: Abbas Naqibzadeh

Data type: xls

Explanation note: occurrences.

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