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First breeding record of the Black-winged Stilt (*Himantopus himantopus*, Linnaeus, 1758) in man-made wetlands, northeast Iran: Implications of agricultural expansion and farm damming

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Abstract
The man-made farm dam surrounding the Kashaf-Rud Protected Area has created artificial wetlands, providing an ideal habitat for various bird species. One such species is the Black-winged Stilt (*Himantopus himantopus*), which has made the dam its breeding ground. A total of 42 nests of black-winged Stilts were investigated during the study period from early May onwards in the Kashaf-Rud Protected Area. Our study revealed that nests were built on small patches near the water's edge without aquatic plant incorporation. The mean distance between nests was 3.97±3.281 m, with a mean distance from nests to water of 2.76±1.866 m. We found differences in the mean of clutch size and nest depth compared to previous research in Guilan province of Iran and southern part of Spain highlighting the influence of environmental conditions on nesting attributes within the species. Our results underscore the significance of wetlands in northeastern Iran as favorable habitats for a variety of waterbird species.

Keywords: Charadriiformes, Farm dam, Kashaf-Rud Protected Area, Waders, Waterfowl.

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INTRODUCTION

Agricultural expansion has dramatically altered the land use and eliminated natural habitats worldwide (Lindenmayer, 1999; Vié et al., 2009). However, it has also created new habitats from which some species benefit greatly (Hazell et al., 2001). Globally, and particularly in Iran, wetlands and floodplains have been among the most impacted ecosystems by agricultural development and growing anthropogenic pressures over the past decades (Fox et al., 2005; Nourani et al., 2015; Tian et al., 2015). Consequently, wader and waterbird populations face increasing stress from a variety of threats (Kingsford & Thomas, 2004). In arid regions, farm dams can have contrasting effects. These small water bodies, primarily used for irrigation or livestock watering outside of wet seasons (Apinda Legnouo et al., 2014), can serve as potential breeding habitats for waterbirds, in particular colonially nesting species (Hamilton et al., 2017). Moreover, these flooded lands support a diverse range of aquatic and river-dwelling biota (Hazell et al., 2001; Céréghino et al., 2008; Jooste et al., 2020) along with their associated terrestrial communities (Hamilton et al., 2017).

In terms of topographical and climatic features, Iran is made up of a range of outstandingly diverse habitats (Sagheb Talebi et al., 2014), which annually host more than 500 breeding and migratory bird species (Kaboli et al., 2012). Waders and waterfowl are frequent visitors to Iran's wetlands, using them as staging grounds, wintering areas, or breeding sites (Nourani et al., 2015). Recent surveys in northeast Iran have revealed a noticeable increase in breeding bird numbers in the region, coinciding with a rise in private farm dam construction for agricultural purposes (Fig. 1A-D).

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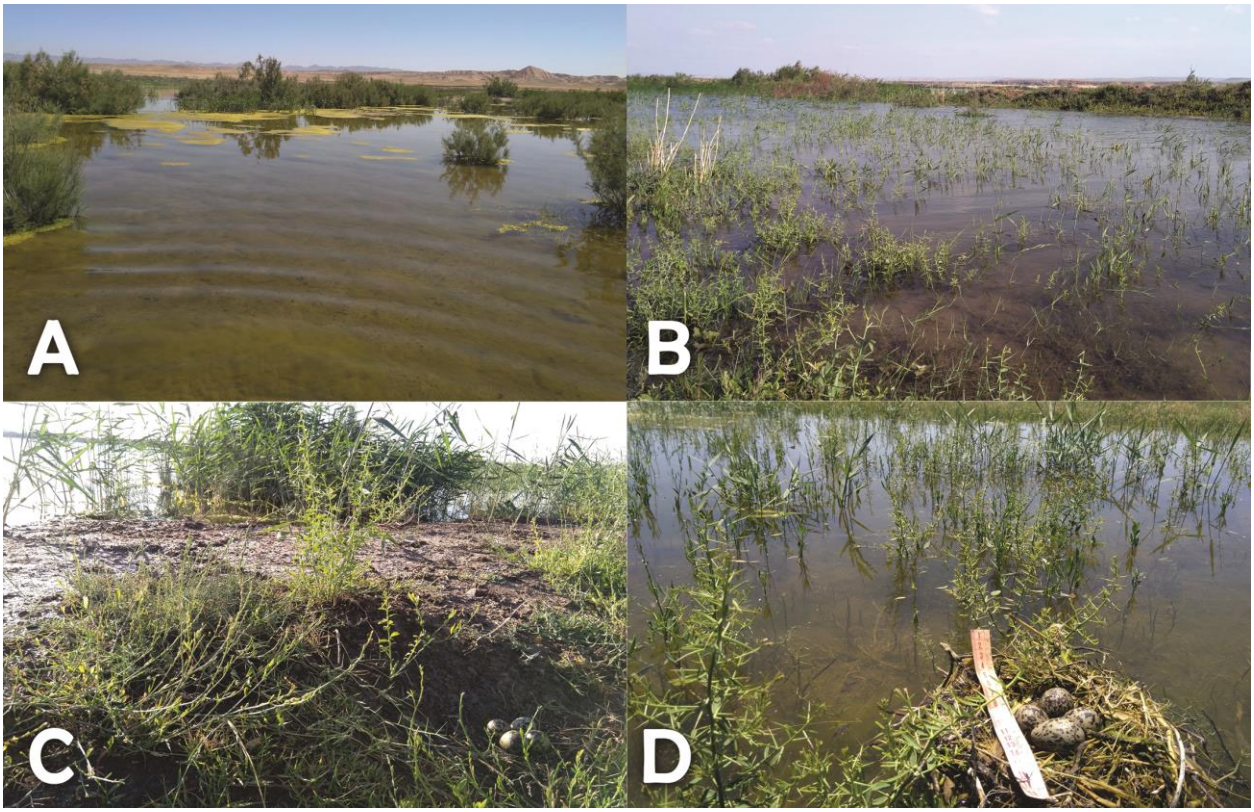

FIGURE 1. A-B) The Man-made farm dam leads artificial wetlands around Kashaf-Rud Protected Area. Nest was carefully constructed using plant materials, with the addition of Black-winged Stilt eggs laid in shallow water (captured by Morteza Monfared).

Remarkably, the Black-winged Stilt *Himantopus himantopus* (Linnaeus, 1758) has emerged as the most abundant colonial breeder among the Charadriiformes in the basin (Yousefi & Khani, 2017) (Fig. 2A-F) Although previously considered only a stopover site during migration, this species is a common breeding bird in shallow wetlands south of the Caspian Sea in northern Iran (Ashoori, 2011). While comprehensive information on the breeding biology of the black-winged Stilt was obtained from a study conducted in Boujagh National Park in northern Iran (Ashoori, 2011), no confirmed breeding records or observations have been reported from the wetlands in eastern Iran to date.

Therefore, this paper presents the first report on the breeding biology of *H. himantopus* in artificial wetlands of northeastern Iran. By comparing our data with previously published information, we aim to gain insights into the species' habitat quality, as well as the potential impacts of agricultural expansion and farm damming on its reproductive success and egg survival.

MATERIAL AND METHODS

The research was conducted in a study area covering 135 km^2 of artificial wetlands located adjacent to the Kashaf-Rud Protected Area in Khorasan Razavi province, northeast Iran (23°30′ S, 29°19′ E; 1090 m above sea level) (Fig. 3). The Kashaf-Rud River, spanning a total length of 290 km, originates from the Binaloud and Hezar Masjed Mountains and flows eastward until it reaches the Iran-Turkmenistan border, where it merges with the Hari-Rud River to form the Tejen River. The study area is situated 65 kilometers east of Mashhad and 35 kilometers west of Mazdavand (Mozduran) in Sarakhs country. Along the course of the Kashaf-Rud River, several man-made farm dams have been constructed.

The study area was monitored during the breeding season between 2014 and 2020 and field data were collected. Data on nests were recorded from mid-July to mid-August 2014 and juveniles were observed annually within the study area. Visits to the study area were conducted four times per week

during the first half of the study period, while visits were limited to once a week during the second half to minimize disturbance to nests. Each nest was inspected during daylight. A total of 42 nests were observed, photographed, and their clutch characteristics were recorded.

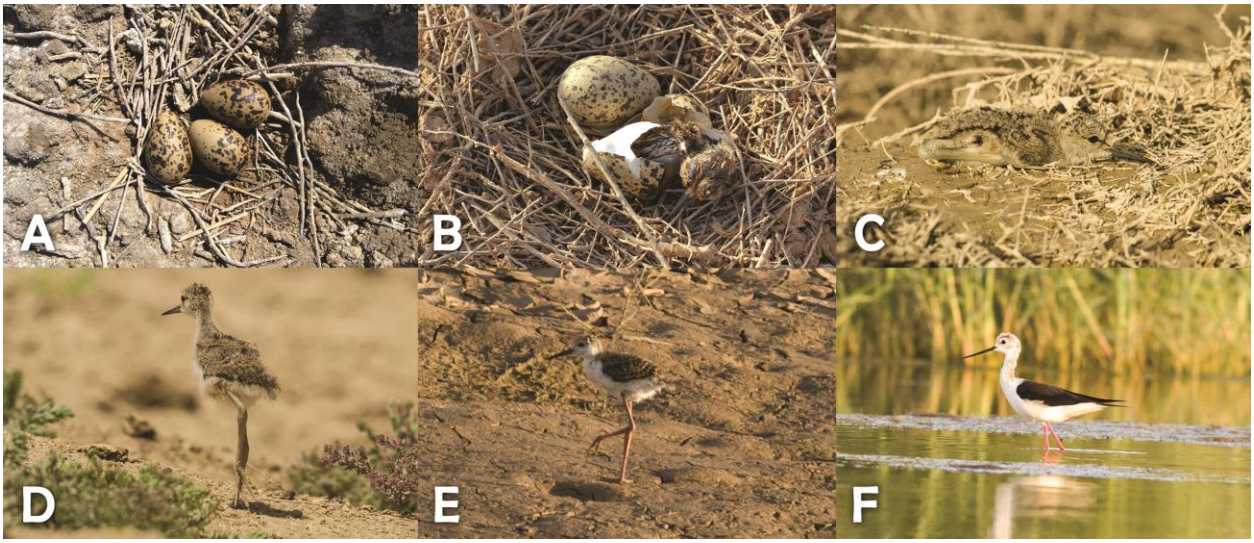

FIGURE 2. A-F) Evidence of the black the Black-winged Stilt breeding in eastern Iran (captured by Morteza Monfared).

The study focused on three different sets of variables: (a) measurements of clutch and egg sizes were taken to assess environmental conditions during the egg-laying period; (b) nest size, defined as the maximum horizontal area of the nest including the nest cup and dimensions; (c) calculations of the distance between nests and the distance between each nest and the water's edge were made to investigate the availability of suitable nesting sites. Therefore, measurements included the minimum, maximum, and average values of seven variables: clutch size (n), egg width (mm), egg length (mm), nest diameter (cm), nest depth (cm), distance between conspecific nests (m), and nest distance from water (m) (Table 1). The total volume or weight of the nest, as a measure of nest size, could not be obtained as most nests were built directly on the ground. The long and short axes of each egg were measured using a digital caliper with a precision of 0.01 mm. The distances between nests and between each nest and the water's edge were measured using a tape measure. Additionally, the depth of nests was measured using a digital caliper. All measurements were compared with those from previous studies (Cuervo, 2004; Ashoori, 2011). Throughout the study period, causes of nest mortality were evaluated to determine if any specific threats contributed to reduced nest survival. Physical conditions of the study area, anthropogenic activities, the presence of predators, and any signs or tracks were examined.

RESULTS

During the years of the study, a total of 115 pairs of black-winged Stilts were recorded. The first flocks of Stilts did not arrive in the wetlands of the Kashaf-Rud Protected Area until early March. These birds were observed in small groups in the shallow parts of the water bodies. Breeding behavior and nesting activities started in early May. A total of 42 nests were investigated during the study period in the breeding area. The nests were built on small patches very close to the water's edge, without any incorporation of aquatic plants. The mean distance between nests was 3.97 m (maximum= 13.5 m, minimum= 1 m), and the mean distance from the nests to the water was 2.76 m (maximum= 6.5 m, minimum= 0) ((Fig. 4A). The former exhibited a notable contrast with Cuervo (2004), while the latter was consistent with the same study. The mean nest diameter was 19.56 cm close to the findings of Cuervo (2004) (Fig. 4B).

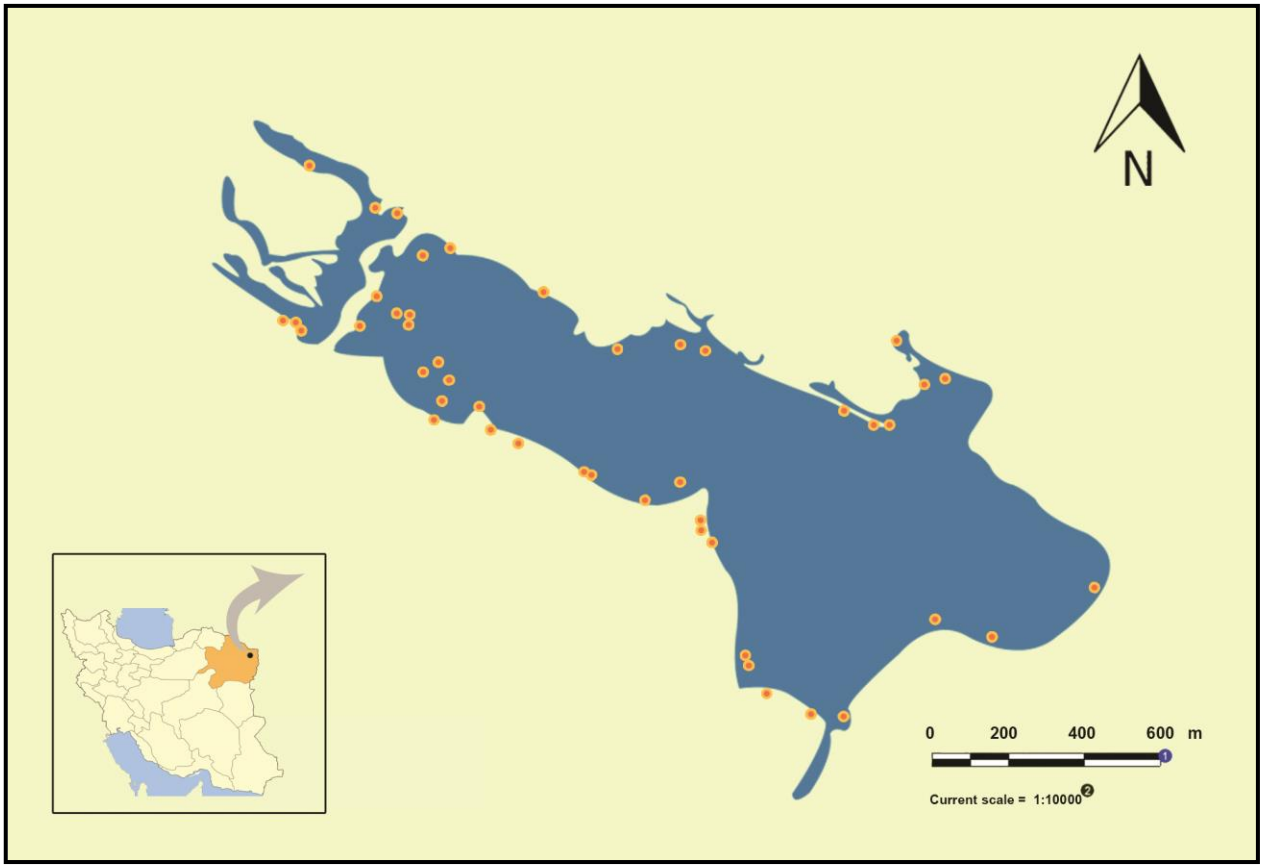

FIGURE 3. Location of the Kashaf-Rud Protected Area wetlands.

TABLE 1. Egg and nest measurements of the Back-winged Stilt.

	N	Mean	Minimum	Maximum	Std. Deviation
Clutch size	37	2.65	1	5	1.295
Egg width	38	29.71	27.28	32.38	1.265
Egg length	38	42.59	36.18	46.48	2.236
Nest diameter	32	19.56	16	30	2.950
Nest depth	31	2.74	1	3.50	0.518
Nests distance	34	3.97	1	13.50	3.281
Nest distance to water	35	2.76	0	6.50	1.866

The average depth of the nests measured 2.74 cm (Table 1). Our study showed a difference in nest depth compared to previous research conducted in Guilan province, north of Iran (Ashoori, 2011) (Fig. 5A), despite similarities in nest diameter. The nests were rarely deep inside, and the eggs were often laid on the ground. By late March, all nests contained at least one egg. Equal or close to equal parenting responsibility was observed between both sexes in all our observations. During the midday period from 12pm. to 3pm, both sexes were absent from the nest. Egg-laying lasted between 24 and 28 days. The results of clutch measurements were as follows: the mean clutch size was estimated as 2.65, a smaller average clutch size compared to previous study (Fig. 5B), the mean egg length was 42.6 mm, and the mean egg width was 29.7 mm. All the measurements of current study mentioned in Table 1.

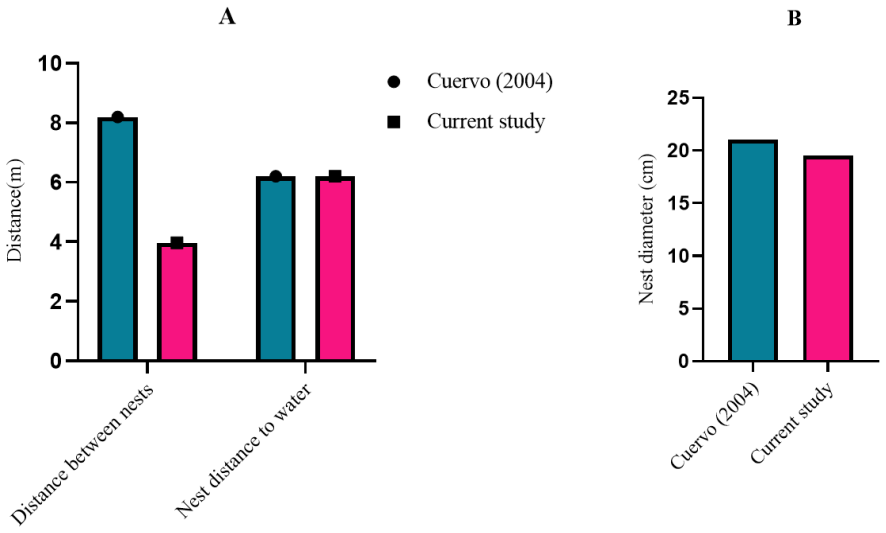

FIGURE 4. Comparison of the mean values of three variables: A) distance between nests, distance from nests to the water, B) nest diameter between Cuervo's (2003) study and the current study.

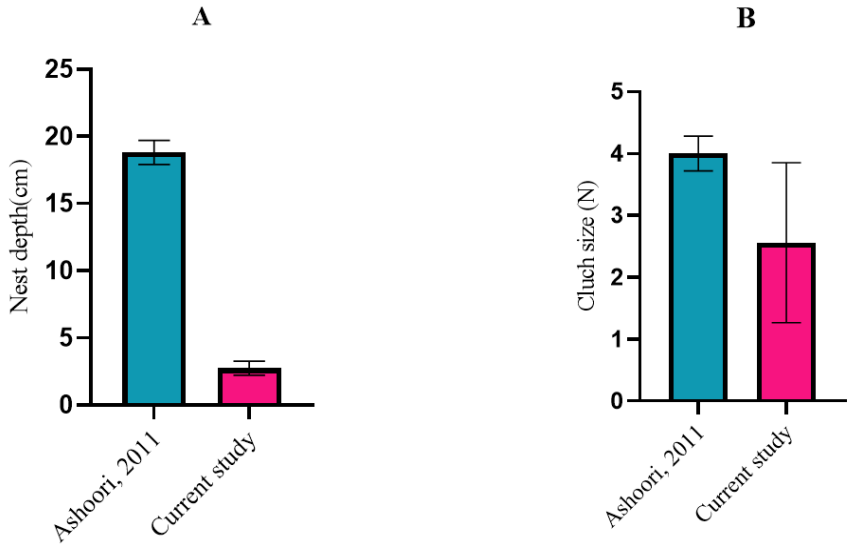

FIGURE 5. Comparison of the mean values of two variables: A) nest depth, B) clutch size between Ashoori's (2011) study and the current study.

Three to four days after hatching, the Black-winged Stilt chicks were able to walk alongside their parents. Despite their light weight, they could move on delicate aquatic algae, which surprisingly synchronized their growth with the hatching of the eggs. The Stilts exhibited diligent defense of their nests and chicks against predators, displaying different defensive behaviors in response to threats. When the parents were absent, the chicks primarily relied on camouflage to hide from predators. However, when intruders approached, the vigilant parents would quickly hide the chicks in reed vegetation. To deter intruders, the Stilts engaged in strong aggressive nest defense, emitting loud aerial alarms that were often mimicked by neighboring individuals. They would also perform a unique flight pattern directly at the threat, followed by a rapid retreat back into the air from a distance of approximately seven meters. The warning calls would often continue even when the intruder was a hundred meters away. Another defensive strategy observed was the broken wing deceptive display, which was used to divert the intruder's attention away from the nest or the chicks.

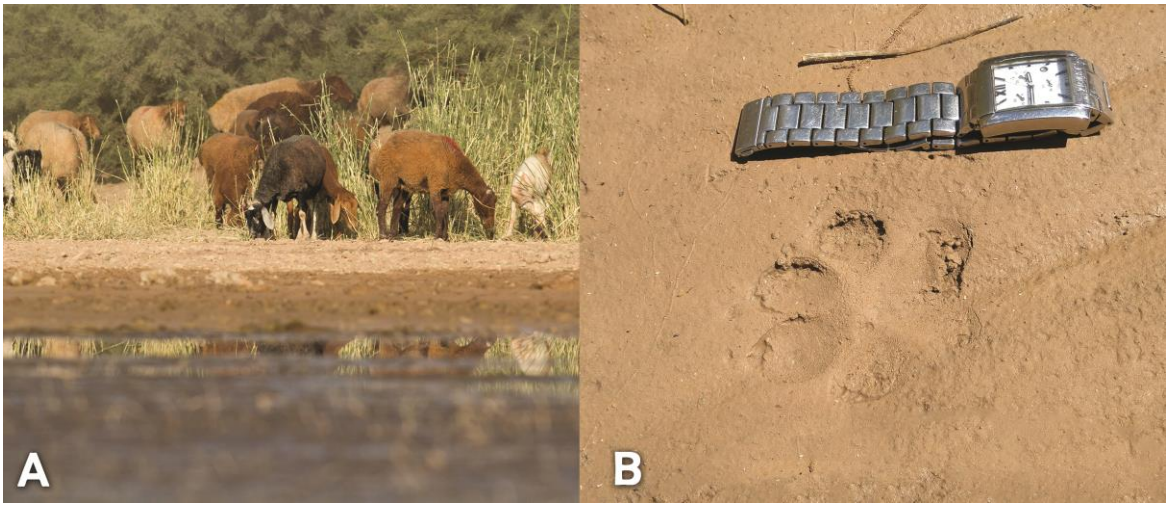

FIGURE 6. A) Overgrazing was frequently observed in the area B) the persistence of Carnivora documented in the area (captured by Morteza Monfared).

The Black-winged Stilt mainly feeds on insects and their larva, tadpoles, and occasionally small fish and other small aquatic animals that are abundant in the wetlands. The dominant vegetation types in the region are Saltcedar (*Tamarix ramosissima*), Common reed (*Phragmites australis*), and Saltwort (*Salsola rigida*). Both human-related and natural disturbances were frequently observed in the study area, including livestock overgrazing, intentional use of fire, operation of heavy machinery and bulldozers, and the presence of canids such as herd dogs, Red fox (*Vulpes vulpes*), and Golden jackal (*Canis aureus*). The spotted whip snake (*Hemorrhois ravergieri*) was found in both the terrestrial and aquatic environments of the basin, while birds of prey like the Western marsh harrier (*Circus aeruginosus*) and Eurasian magpie (*Pica pica*) were particularly common in the area. Tracks of wild boar (*Sus scrofa*) were also recorded near drinking sites close to the nests.

DISCUSSION

Previous research has explored the significance of farm dams as artificial breeding sites for various bird species (Winterbottom, 1937; Tian et al., 2015; Hamilton et al., 2017). However, there has been no scientific investigation into their contribution to biodiversity in Iran. Our survey revealed that man-made farm dams used for agricultural purposes in the Kashaf-Rud Protected Area provide new habitats for feeding and breeding for the Black-winged Stilt.

The presence of essential resources such as food, suitable nest sites, and protection from predators plays a crucial role in the nesting and egg-laying behavior of birds (Cuervo, 2004). Previous studies have highlighted the significance of the *P. australis* as a nesting material for the Black-winged Stilt in a breeding site in northern Iran (Ashoori, 2011). However, despite the observed increase in the population of common reed in the Kashaf-Rud basin over the past decade, we did not observe its utilization in nest construction, except for its function in concealing the nests. The expansion of modified agricultural landscapes has led to an increase in the population of frogs, toads, and their tadpoles in farm dams (Céréghino et al., 2008). These habitats also support abundant populations of insects and their larvae, which make up the primary diet of the Black-winged Stilt (Ueng et al., 2009). With an abundance of high-nutrient resources available, there is no necessity for this bird to undertake long-distance travel in search of food.

Interestingly, our study recorded a smaller average clutch size compared to previous studies (2.84 vs. 4) (Tinarelli, 1992; Ashoori, 2011). The size of clutch size has been suggested to be directly associated with environmental conditions during the egg-laying period (Oro, 2002). Based on our findings, it can be argued that the environmental conditions in the Kashaf-Rud River are still lacking high-quality habitats compared to Boujagh National Park in northern Iran. The relatively high number of destroyed nests in the area may explain the reduced egg survival. Overgrazing, predation, and rising water

levels were identified as major threats to the nests. Livestock grazing was frequent and intense in the area, having both direct impacts on breeding success through increased trampling risk (Vickery et al., 2001) (Fig. 6A) and indirect impacts by altering vegetation cover (Adler et al., 2001; Hobbs 1996; Kruess & Tscharntke, 2002), which in turn exposes the nests to higher predation risk due to vegetation removal. The correlation between nest failure due to trampling and nest densities has been documented (Jensen et al., 1990). The presence of wild boars, herd dogs, feral dogs, and foxes (Fig. 6B) also posed a significant threat to the nests, eggs, and chicks. Considering that *H. himantopus* is a colonial and ground-nesting species with nests located near drinking sites (Cuervo, 2004), it can be inferred that the species is relatively high levels of trampling, resulting in nest and chick losses and ultimately reducing its reproductive success.

We here confirmed that the presence of wild boars, herd dogs, feral dogs, and foxes remains a major threat to *H. himantopus* nests, eggs and chicks (Suárez et al., 1993; Saniga, 2002). We observed their presence and frequently found their tracks near the nests. In one instance, a small island with 16 nests, located approximately 80 meters from the mainland, was attacked by a herd of wild boars, leaving only two nests undamaged. In addition to the direct impact of dogs through predation, they also disrupt the habitat, leading to lower reproductive success not only for *H. himantopus* but also for other waterbird species (Doherty et al., 2017).

To protect their nests, parents had to engage in defensive behavior by continuously making loud alarm calls or performing the broken wing display. Previous research provides ample evidence that the red fox is a predator of avian nests (Saniga, 2002; Liebezeit & Zack, 2008). Therefore, we restricted our visits to certain areas after observing red fox tracks, suggesting that the animal may have been following our scent or footprint trails.

Due to the temporary nature of farm dams and their water storage function for agricultural irrigation, water levels drop rapidly, leaving the nests exposed on dry land and vulnerable to predation much earlier than the hatching time of the chicks. Moreover, Fluctuating cycles of drought and rainfall further contribute to nest failure. Although the Black-winged Stilt can repair and rebuild nests during water level fluctuations, the effectiveness of nest repair depends on the speed of water-level rise (Tinarelli, 1992).

In line with previous studies, our findings highlight the importance of wetlands in northeastern Iran as suitable habitats for various waterbird species (Yousefi & Khani, 2017). The availability of resources (e.g., food, nest sites, nesting materials, etc.) and the construction of artificial wetlands have led to an abundance of wintering and breeding species with specific habitat requirements. Despite the favorable environmental conditions for *H. himantopus* breeding, there are still inconsistencies in achieving optimal breeding success rates compared to data from natural wetlands. It is crucial to address the risks of nest failure mentioned above in order to develop well-planned conservation strategies for all ground-nesting birds in this basin. However, this study was unable to determine the dominant factors affecting nesting success, highlighting the need for further comprehensive research in the future. Currently, there is limited precise information on the composition of waterbirds in the studied region. The number and abundance of species are important indicators of ecological conditions and provide insights into the overall health of an ecosystem. Therefore, additional studies focusing on richness, abundance and community composition of waterbirds of this region and their potential association with farm dams for breeding are clearly needed. It is well acknowledged that natural wetlands remain imperative to waterbirds' survival and merit conservation priority, yet man-made farm dams provide secondary support in times of drought or resource scarcity. The knowledge gained from studies of this nature is essential to guiding efforts toward effective conservation of waterbirds and secure their long-term persistence in Iran.

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