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Research Article

Assembly of Optimum Habitats for Asian Houbara Bustard (*Chlamydotis macqueenii*) in the Arabian Peninsula: The Vegetation Aspects

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This research was conducted in four sites at Mahazat as-Sayd reserve in Saudi Arabia to determine the optimum habitats' constituents for Asian houbara bustard *Chlamydotis macqueenii* via assessing abiotic and biotic factors with special reference to vegetation aspects. Vegetative parameters were quantified using combinations of distance and line intercept methods. Acquired data were analyzed using cluster analysis and analysis of variance tests. Results indicated that three of the four plant communities of the study sites were dominated by *Acacia tortilis* with underground cover composed of lesser species. On the other hand, White Jabal was dominated by scrubs composed mainly of *Fagonia indica* with sparse Acacia trees. Rumrumiyya site recorded the highest species abundance and vegetative coverage (133%) among the sites. It is concluded that Black Jabal and White Jabal sites are used as nesting and foraging habitats for houbaras, whereas Jabal Khurse is specifically a males' display site. Nevertheless, Rumrumiyya site was used for foraging and shelter. The study confirmed that density and vegetation cover are of prime importance for houbara site selection. However, other factors affecting feeding and behavior of the species must be considered in further studies.

1. Introduction

Rainfall and temperature are considered as overriding factors in determining vegetation distribution at macroscale level [1–3]. However, variations of rainfall and temperature that influence vegetation are among the many factors affecting wildlife habitats [4, 5]. Yet, other site factors, including soil features, slope, and altitude, are of significant importance in determining vegetation attributes [6–11]. Meanwhile, vegetation composition and structure are key elements in the wildlife selection "preference" of habitat [12, 13].

The importance of vegetation composition and structure as key elements of houbara bustard (*Chlamydotis macqueenii*) habitat cannot be overemphasized [13–16]. Vegetation composition includes type, cover, associations, and species abundance. On the other hand, vegetation height, cover, closure, density, and structural and seral stages are vegetation composition attributes. Overall, vegetation is a source of food, water and forms a shelter for wildlife species [17]. It is reported that sparse vegetation that is composed of patches of scrub and tall shrubs forms the "most preferred habitat for houbaras" [18–20]. Moreover, [21] stated that vegetation with 10–17% coverage is preferable habitats for the species at Harrat al-Harrah reserve, in northern Saudi Arabia. Along with this argument, a number of researchers believe that topography and anthropy are superseding factors in habitat selection of houbaras [22, 23].

Habitat analysis in terms of vegetation parameters along with its edaphic and physiographic features aids in better overview of its hosting potentiality to wildlife [14]. Such understanding enables wildlife managers to device proper techniques to insure ecological habitat viability for wildlife.

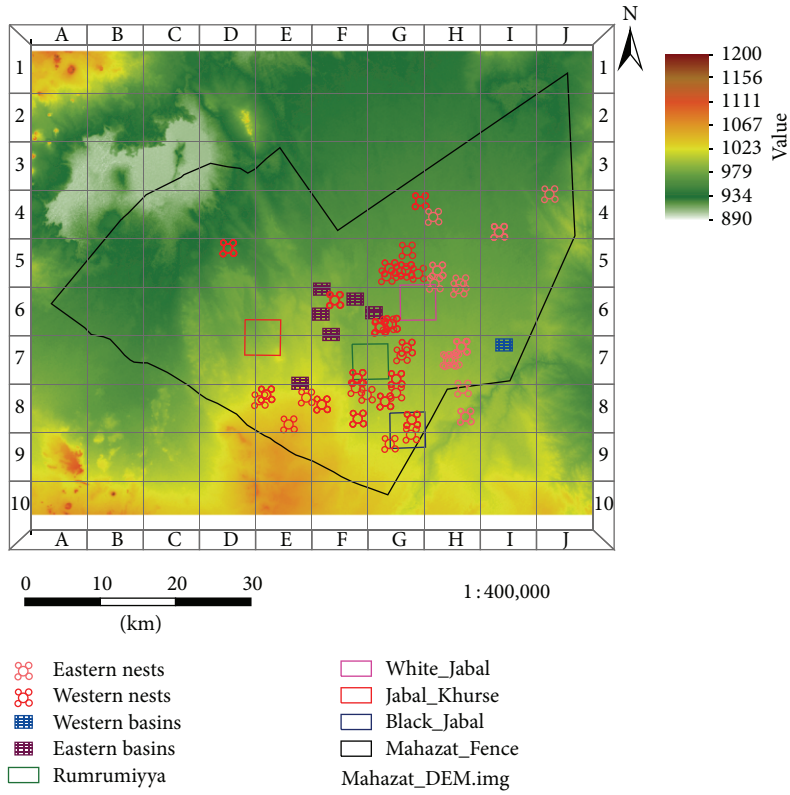


Figure 1: Plot locations in relation to pattern of distribution of Asiatic houbara in Mahazat as-Sayd reserve (after NWRC and KACST).

This study aimed at quantifying variables of selected houbara bustard habitats in Mahazat as-Sayd reserve in Saudi Arabia with special emphasize on vegetation attributes as well as climatic, edaphic, and physiographic features of selected areas that form habitat of Houbara in the reserve.

2. Material and Methods

2.1. Study Area. Mahazat as-Sayd is a 2200 Km^2 wildlife reserve in the Kingdom of Saudi Arabia [24]. It is a site of reintroduced houbara bustard, ostrich (*Struthio camelus camelus*), Arabian oryx (*Oryx leucoryx*), and rhim gazelle (*Gazella subgutturosa marica*) [25, 26]. The reserve is located 320 Km East of Jeddah and 180 Km North East of Taif City (E 782728-N 2480056) UTM Zone Q 37. It is a basalt relief intersected by sandy alluvial wadis with elevations varying between 900 and 1100 m [26]. The climate is hyperarid with xeromorphic vegetation dominating the reserve [27].

2.2. Methodology. Temperature and rainfall records for 1991–2011 were obtained from National Wildlife Research Center (NWRC) archive of the Saudi Wildlife Authority. Temperature and rainfall data were analyzed to reveal their trend and variations in the reserve. Temperature trend and 5-year rainfall moving average were computed. Study site topographic attributes such as location, slope, exposure, and elevation were measured using GPS and clinometers. Major soil groups were identified from soils map of Saudi Arabia.

Systematic method was used to select sampling areas based on the data on houbara distribution archived by NWRC. Vegetation attributes were assessed in summer of 2012 at four chosen 25 Km^2 sites in Black Jabal, White Jabal, Jabal Khurse, and Rumrumiyya (Figure 1). Measurements included plant density and coverage. Line intercept method was used to assess vegetation coverage in three 60 m transects paralleled 5 m apart on each of the sampling areas, whereas plant density was estimated using point centered quarter method [28–31]. Vegetation visual obscurity was estimated by detecting a half-meter height staff placed at 50-meter radius along transects [32, 33]. Species relative coverage, density, frequency, and importance value were calculated according to [31]. Diversity and similarity among plant communities in the four sites were computed using Shannon-Wiener diversity and Sorensen similarity indices, respectively [31, 34]. Analysis of variance and cluster analysis were used to differentiate between sites using CoStat (Ver. 6.4) [35] and Multivariate Statistical Package (MVSP 3.1) [36], respectively. Plant species were identified according to [37].

3. Results and Discussion

Analysis of temperature datafor the last two decades indicated that the maximum and minimum average temperatures for the hottest and coldest months in the year for the past two decades were 40.8°C and 10.8°C, respectively. On the other

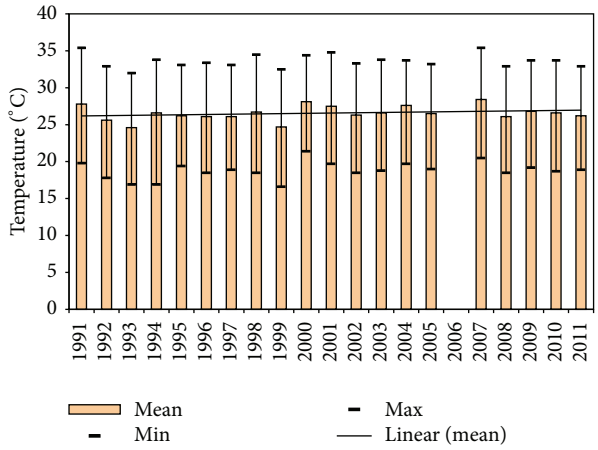


Figure 2: Trend of minimum, maximum, and mean annual temperatures at Mahazat as-Sayd reserve (1991–2011).

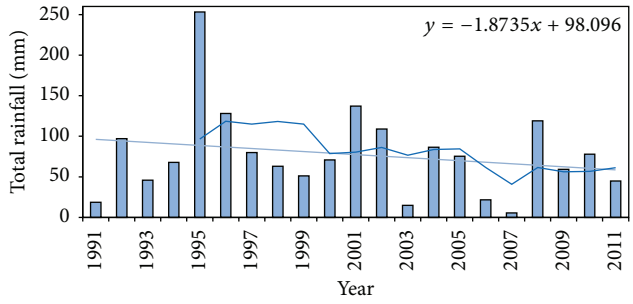


Figure 3: Total annual and 5-year moving average of rainfall (mm) at Mahazat as-Sayd reserve.

hand, mean annual temperature was 26.6°C showing an increasing trend over the same period (Figure 2).

Annual mean rainfall was 78.1 mm and varied temporally as it ranged from a minimum of 5.5 mm in 2007 to a maximum of 250 mm in 1995. Figure 3 represents a 5-year moving average of rainfall for the duration 1991–2011, which clearly shows a decreasing trend in rainfall. Annual variations in temperature and rainfall may have tremendous effects on vegetation composition, lowering availability of edible species, which in turns may affect presence as well as habitat selectivity of houbaras in the reserve. The gradual increase in temperature coupled with a decrease in rainfall may induce this indirect negative impact on houbara populations.

The results of the plant survey indicated that vegetation coverage in the four study areas ranged from 28% to 133%. *Acacia tortilis*, an arid environment tree, dominated plant communities in three sites with varying degrees of coverage, density, and frequency (Figure 4). Total vegetation coverage in White Jabal reached 28% of which *A. tortilis* formed 33%. Other site species include *Fagonia indica* and *Salsola imbricata*. Recorded plant density at the site was 1450 plants/ha. Likewise, Black Jabal calculated plant coverage was 65% of which *A. tortilis* constitutes 38%. Coverage of other common species is illustrated in Figure 3. Plant density at Black Jabal was 1573 plant/ha. of which *A. tortilis* formed 27%.

Table 1: Analysis of variance for vegetation cover among the 4 selected sampling areas at Mahazat as-Sayd reserve.

Source	df	Type III SS	MS	*F*	*P*
Blocks	3	76.38	25.46	5.24	.023*
Site	3	3172.35	1057.45	217.50	.00**
Error	9	43.76	4.86		
Total	15	3292.48			

*Significant at 5% level. **Highly significant at 5% level.

Table 2: Analysis of variance for vegetation density among the 4 selected sampling areas at Mahazat as-Sayd reserve.

Source	df	Type III SS	MS	*F*	*P*
Blocks	3	2574	858	2.32	.14 ns
Site	3	288284.50	96094.83	259.52	.00**
Error	9	3332.50	370.28		
Total	15	294191			

ns: Nonsignificant at 5% level. **Highly significant at 5% level.

In Jabal Khurse vegetation coverage reached 71% of which *Acacia tortilis* constitutes 69%, followed by *Salsola imbricata* (13%), *Indigofera spinosa* (10%), *Panicum turgidum* (7%), and *Tribulus arabicus* (2%). Plant density recorded 531 plant/ha. Vegetation coverage of Rumrumiyya site was 133% due to vegetation overlaps as the site is used as a feeding range of the houbaras. Relative coverage of *Acacia tortilis* in the feeding site was 36%, followed by *Indigofera spinosa*, *Salsola imbricata*, *Zygophyllum* sp., *Fagonia indica*, *Tribulus* sp., *Stipagrostis plumosa*, *Acacia ehrenbergiana*, and *Panicum turgidum*. Density of species was 1337 plant/ha. Analysis of variance indicated existence of significant differences at 5% level among sites in terms of vegetation coverage and density (Tables 1 and 2). The reported vegetation cover values of the sites in this study were far greater than those reported by [21] for preferable habitats for houbaras at Harrat al-Harrah reserve.

A. tortilis had the highest importance value among plant species at all sites with the exception of White Jabal where *Fagonia indica* dominates (123%). Accordingly, two plant communities emerged in Mahaza as-Sayd, namely, *A. tortilis*, a tree type class community and *Fagonia indica* a scrub type class community. This is in contrary to [27] finding where four plant communities, *Calligonum comosum*, *Acacia tortilis*, *Zygophyllum simplex*, and *Pulicaria incisa*, were reported in the same reserve. Plant similarity between White Jabal with both Black Jabal and Jabal Khurse was 77% and 67%, respectively. On the other hand, Jabal Khurse and Black Jabal were the least similar (55%). Rumrumiyya site had the highest species abundance (9) followed by Black Jabal (7), White Jabal (6), and Jabal Khurse (5). Likewise, Rumrumiyya was the most diverse plant species as a diversity index reached 1.79 contrary to Black Jabal, Jabal Khurse, and White Jabal as values of 1.68, 1.38, and 1.01, respectively. The low species diversity is typically a character of Saudi flora due to low rainfall, whereas differences in diversity between sites could be attributed to edaphic, grazing, and disturbances [38, 39]. Plant similarity index between Rumrumiyya, White Jabal,

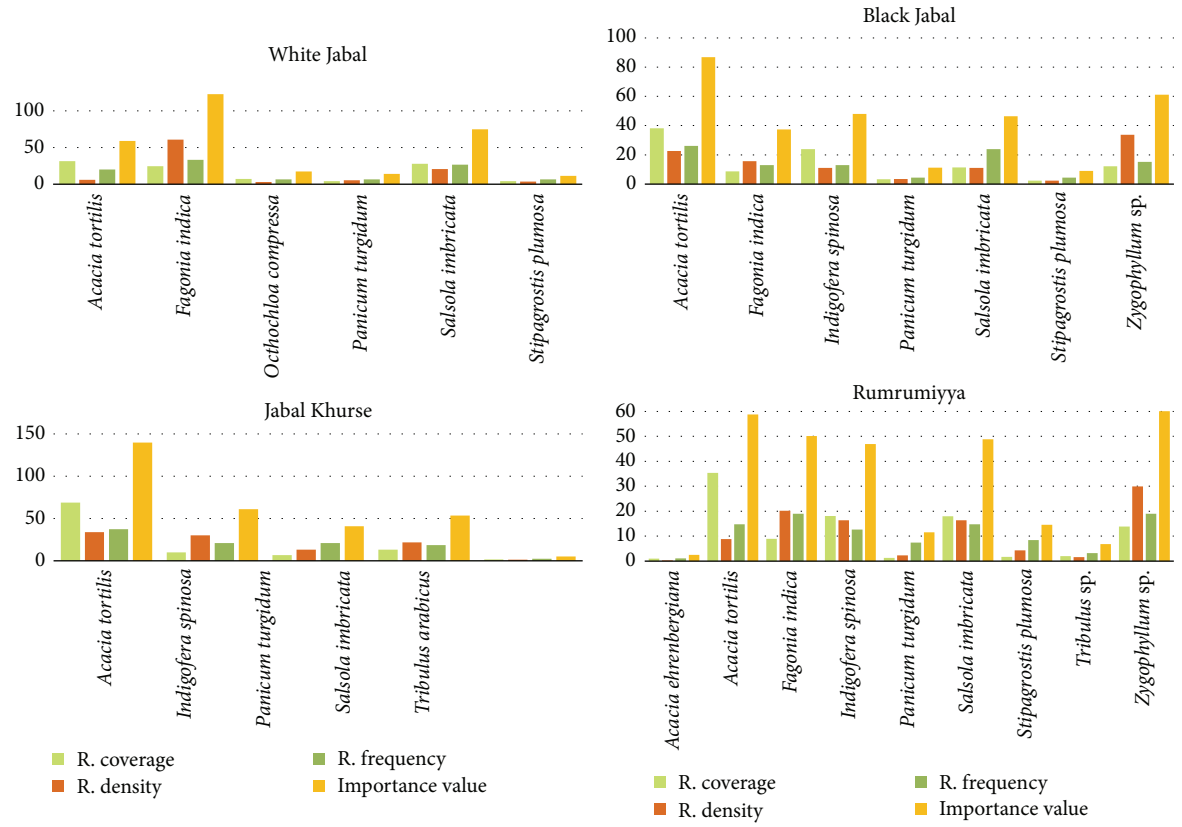


Figure 4: Relative coverage, density, frequency, and importance value of species in the study sites.

Black Jabal, and Jabal Khurse reached 88%, 87%, and 71%, respectively. The reported number of plant species in this study differs than that reported by [16, 27] due to location and season of sampling.

Vegetation structure in the study sites was composed of trees and scrub formations which is typical for the area [18, 27, 38]. Trees were represented by *A. tortilis* and *A. ehrenbergiana* with an average height of 1.5 m whereas the measured average heights of scrub class were 0.5 m. Obscurity values were more than 50 m at 50 cm height in White Jabal, Black Jabal, and Jabal Khurse compared to less than 35 m in Rumrumiyya where existing dense vegetation coupled with high percentage coverage due to vegetation overlapping. Cluster analysis (Figure 5) illustrates differences among sites in relation to vegetation density, coverage, obscurity, species diversity, physiographic, and edaphic factors. Although analysis showed that White Jabal and Black Jabal were the most similar, NWC records and field observations indicated the use of White Jabal and Black Jabal for nesting purposes by houbaras, where scrub formations prevail. In contrary, Jabal Khurse and Rumrumiyya were used for male display and foraging sites, respectively. Such sites were called "preferred habitats" [18, 20, 21].

While differences exist among sites in terms of vegetation parameters, slope, and soil type, these parameters do not explain species preferences for a specific habitat [18]. Apparently, other site physiographic features like lush vegetation,

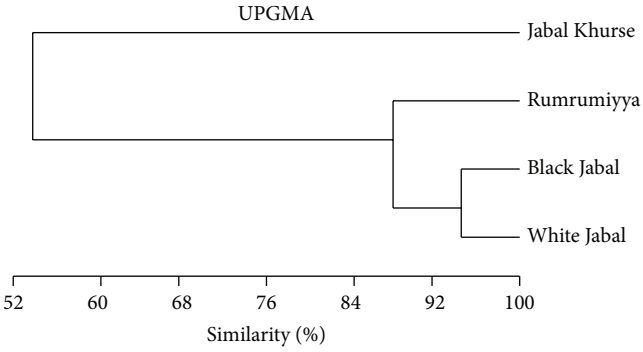


Figure 5: Cluster analysis of sites variables (unweighted pair-groups method using arithmetic averages).

phenology, and closeness to wadis play an important role in habitat selection [18] which is contrary to [14, 40] findings where they negated the influence of vegetation phenology. Black Jabal and White Jabal slopes form gentle banks for wadis where large areas exist for nesting. On the other hand, Jabal Khurse is a rounded hill and low in vegetation density that is more suitable for bird display. This result is in line with [18–20] as they reported that vegetation heights of less than a meter were found to be the "preferred daytime habitats" for the species in the reserve.

4. Conclusions

Optimum habitats for Asian houbara bustard cannot be assembled by vegetation parameters alone. Other factors that affect feeding, species' behavior, and its rhythm cycle must be considered in further studies. However, this study confirmed that density and vegetation cover are of prime importance for houbara site selection. Habitats with hills and depressions could serve in assembling a permanent habitat where houbaras may forage, display, and nest at a single area as is the case in Mahazat as-Sayd.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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