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On Biology of Houbara Bustard (*Chlamydotis undulata macqueenii*) in Balochistan, Pakistan: Influence of Vegetative Characters on Distribution

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Abstract: The analysis of 53 stands established in the Houbara wintering habitat in Balochistan suggests that vegetative diversity may increase the chances of finding Houbara, yet it has no effect on its density or constancy of appearance. The optimal Houbara density is recorded at 6-11% absolute vegetative cover (shrub cover) and both increasing and decreasing cover decreases Houbara density with very low densities at >24% cover. The increasing minimum shrub height had a direct effect on increase in Houbara density, while maximum height did not give a consistent pattern. The average minimum distance between plants/groups of plants in the stands having significant Houbara population, is 2.5±0.2 m (range 1-5 m). Houbara density shows a linear rise with increasing degree of foliage on the plants. Houbara density and constancy variation had different patterns of distribution in different vegetative communities.

Key words: Density, constancy, cover, vegetative state, sociability, plant height, vegetative community

Introduction

Houbara Bustard is largely herbivore and basically cursorial species, hence places a higher reliance on general vegetation for both food and shelter (Cramp and Simmons, 1980). Therefore, different phytoecological factors can be expected to play an important role in its distribution and conservation. Specific studies aiming at correlation of vegetative characters with Houbara distribution are only few. Goriup (1983) attempted a preliminary study in Morocco, but low population of Houbara did not allow detailed analysis of the data. Collins (1984) suggested that Houbara were more frequently seen in plains with high scrub cover, yet he never attempted a detailed association of Houbara population with vegetative characters. Launay ***et al.*** (1994) and Loughland and Launay (1994) attempted some studies in United Arab Emirates, while Rashid and Nadeem (1997), working in Pakistan, have given some indirect reference to association of some plant species with Houbara. The present paper attempts to present an analysis of possible influence of different phytoecological characters on Houbara with special reference to its population, wintering in Balochistan.

Materials and Methods

Fifty-three stands were created in Houbara tracts of Balochistan. Transect data on Houbara population was collected from different stands, surveyed during different parts of winters between 1983-84 and 1986-87 (Mian, 2002). The overall density figures were evolved after suitable mathematical conversions and pooling. The constancy of appearance in the stand was calculated by dividing the number of transects showing Houbara by the total number of stands studied and expressed in percentiles. Five constancy classes were created (1= >80%, II=61-80%, III=41-60%, IV=21-40%, V=<21%).

Data on different vegetative parameters was collected for different stands. The absolute cover was determined by optimal crown diameter using quadrat method and layer-by-layer analysis. Vegetative communities were identified on species contributing the dominant absolute stand cover. This data was also used to work out the number of plant species present in the stand and used as an index of vegetative diversity. Records were maintained on general height of dominant plants and the distance between plants/groups of plants. Each stand was placed into one of the five sociability classes (I= plants scattered as individual stalks, II= small groups of plants, III= small scattered patches or cushions, IV= large unbroken cushions, V= unbroken mat of vegetation) depending upon general physiognomic appearance of the stand. Vegetative state of the dominant plants was recorded in the field and each stand was attributed to one of the aspection classes (l = very dry, 2 = dry, an isolated species with green foliage, 3 = dry, with 2-5 species with green foliage, 4 = many species with a green foliage, 5 = profusely sprouting herbs and shrubs).

Different vegetative parameters were judged against Houbara density and constancy of its appearance (Mather, 1965).

Sokal and Rohlf (1969) were use for the statistical analysis.

Results

Diversity

Data on association of floral diversity (number of species per stand) with Houbara density or constancy of its appearance (Table 1) gave no persistent pattern. Correlation coefficient suggested statistically non-significant association of diversity with density ($r_{(10)}$= 0.0672) or constancy of appearance ($r_{(10)}$- 0.0533). There was, however, a good degree of similarity between pattern of distribution of density and constancy of appearance under changing floral diversity ($r_{(10)}$= 0.6417, significant at 0.05 level).

Cover

Statistically non-significant values of correlation coefficient between Houbara density and herb (r= -0.002) or total (r= -0.001) vegetative cover suggested no linear association between these parameters. However, graphic representation of the overall population density of Houbara under increasing stand or shrub cover (Fig. 1) exhibited an interesting pattern. Houbara density exhibited a sharp rise with the initial increase of cover so that maximum density appeared in stands having 6-11% cover. Further increase in the vegetative cover showed a gradual decrease in the Houbara density so that very low densities were recorded in stands having >24% cover. Such a broad pattern of distribution of Houbara density in increasing cover was consistently followed in the data on different years, parts of the winter and vegetative communities (Fig. 2),

Table 1: Distribution of Houbara population along increasing floral diversity (number of species in the stand) in its wintering ground in Balochistan

Diversity	No. of Stands	Density ± S.E. *	Constancy (%)
1	7	0.28±0.17a	37
2	1	0.04b	25
3	6	0.32±0.10a	54
4	4	0.32±0.17a	75
5	9	0.28±0.12a	75
6	9	0.18±0.10a	59
7	2	0.04±0.08a	20
8	3	0.18±0.06a	43
9	8	0.29±0.07a	61
10	2	0.44±0.16a	100
11	1	0.08c	67
14	1	0.00d	-

Mean sharing similar letters are non-significant (P<0.05)

with variation in cover optima and Houbara density levels. The increasing herbal cover, however, did not suggest a regular pattern for Houbara density variation.

Height

The general shrub height in Houbara habitat ranged between mean minimum of 0.28+0.03m and maximum 0.84 = 0.07m. The data on association of shrub height and Houbara density (Table 2) suggest that there was a general increase in the Houbara density with increasing minimum shrub height ($r_{(51)}$ = 0.3356, significant at 0.05 level). Increasing maximum shrub height, however, did not yield a consistent pattern ($r_{(51)}$= 0.0533, p> 0.10%, not significant). Scattered tall trees had no effect on Houbara density.

Sociability

Houbara population was mainly present in stands placed in sociability class II (83% of the stands) and III. Limited population appeared in one stand with a part placed in class I. None of the stands under present study was in class IV or V. The average Houbara density was not significantly different ($t_{(51)}$= 0.09) in class II (0.23±0.04 birds/km_2) and class III (0.24±0.10 birds/km_2). The average density was, however, significantly low (0.10 birds/km_2) in the stand with sociability class I.

The average distance between the plants/groups of plants in the stands bearing appreciable Houbara density fluctuated between 2.5±0.2 m (range 1-5 m) and 7.6±0.6m (range 2-20 m). A good population density was, however, recorded for the stands having widely scattered tall bushes of ***Haloxylon ammodendron*** (distance between shrub upto 15-20 m), ***Capparis decidua*** and groups of ***Salsola foetida*** and ***Anabasis*** sp.

Variation in distance between shrubs/groups of shrubs (Table 3) had no consistent effect on Houbara density. Both the minimum ($r_{(51)}$= 0.0502) and maximum ($r_{(51)}$ = 0.0131) distances

Table 2: Distribution of Houbara density (per km^2) in different minimum and maximum shrub height (m)

Distance	Density±S.E. *	No. of stands
Minimum		
0.1	0.32±0.17a	4
0.2	0.18±0.07a	32
0.3	0.15±0.07a	10
0.5	0.39a	1
0.7	0.31±0.03a	2
1.0	0.98±0.0.8b	3
Maximum		
0.3	0.22±0.13a	3
0.4	0.27±0.19a	2
0.5	0.24±0.12a	7
0.6	0.13±0.04a	18
0.7	0.14±0.04	7
0.8	0.37±0.10a	3
0.9	0.03d	1
1.0	0.28±0.17a	4
2.0	0.61±0.18c	6
3.5	0.28a	1

Mean sharing similar letters are non-significant (P<0.05)

Table 3: Distribution of Houbara density (per km^2) in different minimum and maximum distances (m) between shrubs/groups of shrubs

Distance	Density± S.E.*	No.of stands
Minimum		
1	0.20±0.07a	14
2	0.20±0.05a	17
3	0.16±0.07a	14
5	0.59±0.14b	7
Maximum		
2	0.17a	1
3	0.12±0.03a	6
4	0.22±0.13a	3
5	0.12±0.07a	11
6	0.23±0.11a	4
9	0.01c	1
10	0.23±0.06a	16
15	0.49±0.11b	8
20	1.10d	1
50	0.16a	1

Mean sharing similar letters are non-significant (P<0.05)

Table 4: Distribution of Houabra density (per km^2) under different vegetative aspection classes (1= very dry, 2=isolated plants with fleshy foliage/fruits, 3=2-5 species with fleshy foliage/fruits, 4= green look on many shrubs/herbs, 5= profusely sprouting herbs/shrubs), during different parts of winter and in the overall population wintering, in Balochistan

Class	Density± S.E.			
	Early	Mid	Late	Overall
1	0.004±0.004a	0.092±0.057a	0.870±0.077a	0.067±0.033a
2	0.063±0.026b	0.173±0.054a	-	0.116±0.029a
3	0.151±0.050c	0.279±0.106a	-	0.208±0.054b
4	-	0.173±0.035a	0.431±0.098b	0.307±0.034c
5	-	-	0.123±0.034c	0.123±0.034a

Mean sharing similar letters are non-significant (P<0.05)

between the dominant shrubs/groups of shrubs gave non-significant values of correlation coefficient with Houbara density. None of the stands with Houbara population had a thick growth of tall grasses/ shrubs/trees. No population was recorded in patches with thick growth of ***Tamarix pallisii***, ***Nannorrhops ritchieana***, ***Typha*** sp., ***Phragmites*** sp. and/or in cultivated fields having standing crop of ***Andropogon sorghum***. Houbara, however, was recorded from patches having thick growth of herbs. It appeared attracted towards cultivated fields having sprouting wheat and/or flowering ***Eruca sativum***, especially when predominant general vegetation was dry.

Vegetative state

Distribution of Houbara density in different aspection classes (Table 4) suggested a gradual rise in its density from aspection class 1 through 4. The population density declined significantly in class 5. The trend was followed both in seasonal and pooled averages. The value of correlation coefficient between these parameters (r = 0.2566) was though not significant, yet it indicated a weak direct linear association.

Community

Distribution of Houbara density in different communities (Table 5) suggests that a high density (0.5-1.0 birds/km_2) appears in ***Salsola foetida***, ***Astragalus hyrcanus***, ***Panicum antidotale***, ***Rhazya stricta-Sophora griffithii***, and ***Haloxylon ammodendron*** communities. A moderate density (0.1-0.5 birds/km_2) was present in 7 communities (***Anabasis*** sp.-***Salsola arbuscula***, ***Zygophyllum*** sp., ***Anabasis*** sp., ***Atriplex crassifolia***, ***Saccharum ciliare***, ***Capparis decidua***, ***Haloxylon griffithii-Cocculus*** sp.). A low density was recorded for stands having ***Suaeda fruticosa***, ***Haloxylon salicornicum***, ***Suaeda monoica***, ***Cocculus*** sp., ***Anabasis*** sp.-***Convolvulus spinosus***, ***Cynodon dactylon***, ***Convolvulus spinosus*** and ***Gymnocarpos fruticosum*** communities. A very low density (recorded as 0.00, presence indicated by indirect evidences only) was observed in ***Stocksia brahuica***, ***Rhazya stricta***, ***Scorzonera tortuosissima***, ***Haloxylon griffithii*** and ***Andropogan halepensis*** communities.

Table 5: Mean density (per km^2 ±S.E.) and constancy of appearance (%, class: I= 80%, II= 61-80, III= 41-60, IV= 21-40, V= <21) of the Houbara population in different vegetative communities, identified from its wintering tracts in Balochistan

	Density		
Community	No. of stands	Mean±S.E.	Constancy, class
Salsola foetida	1	0.88±0.33a	100, I
Astragalus hyrcanus-Ziziphus sp.	1	0.77±0.39a	75, I
Panicum antidotale	1	0.64±0.53a	50,III
Sophora griffithii-Rhazya stricta	1	0.53±0.41a	67, II
Haloxylon ammodendron	5	0.52±0.21a	61, II
Salsola arbuscula-Anabasis sp.	1	0.38±0.21a	50, III
Zygophyllum sp.	4	0.27±0.16a	77, II
Anabasis sp.	12	0.24±0.03a	53, III
Atriplex crassifolia	1	0.20a	13, IV
Saccharum ciliare	1	0.20a	20, IV
Capparis decidua	1	0.20±0.20a	50, III
Haloxylon griffithii-Cocculus sp	1	0.13±0.13a	33, IV
Suaeda fruticosa	6	0.10±0.02a	86, I
Haloxylon salicornicum	2	0.08±0.05a	33, IV
Suaeda monoica	2	0.08±0.03a	33, IV
Cocculus sp.	2	0.07±0.01a	100, I
Convolvulus spinosus-Anabasis sp.	1	0.06±0.03a	67, II
Cynodon dactylon	1	0.04a	13, IV
Convolvulus spinosus	1	0.03a	13, IV
Gymnocarpos fruticosum	2	0.02±0.02a	50, III
Stocksia brahuica	1	0.00	0, V
Rhazya stricta	1	0.00	0,V
Scorzonera tortuosissimo	1	0.00	0,V
Haloxylon griffithii	1	0.00	0,V
Andropogon halepensis	1	0.00	0,V

Mean sharing similar letters are non-significant (P<0.05)

Constancy of appearance of Houbara suggests slightly different sequence of community importance. A very high constancy (class I, > 80% of transacts) was recorded for ***Salsola foetida***, ***Suaeda fruticosa*** and ***Cocculus*** sp. A high constancy (class II, 61-80 %) was suggested for ***Astragalus hyrcanus***, ***Rhazya stricta-Sophora griffithii***, ***Haloxylon accomendron***, ***Zygophyllum*** sp. and ***Anabasis*** sp. – ***Convolvulus spinosus*** communities. A moderate constancy (class III, 41-60%) appeared in ***Panicum antidotale***, ***Anabasis*** sp. -***Salsola arbuscula***, ***Anabasis*** sp., ***Capparis decidua*** and ***Gymnocarpos fruticosum*** communities. A low constancy (class IV, 21-40%) was suggested for ***Haloxylon griffithii-Cocculus*** sp., ***Haloxylon salicornicum*** and ***Suaeda monica*** communities, while

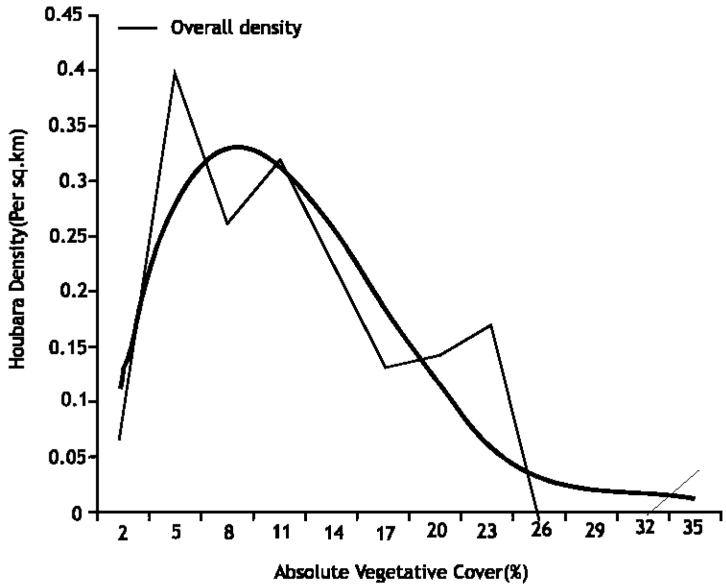

Fig. 1: Density of Houabra population under different covers of general vegetation. The bold line represents the computer developed smooth curve

a very low constancy (class V, < 21%) was recorded for ***Stocksia brahuica***, ***Rhazya stricta***, ***Scorzonera toruosissima***, ***Haloxylon griffithii*** and ***Andropogon halepensis*** communities.

Correlation coefficient between Houbara density and constancy of appearance in different communities (r = 0.0026, not significant at 0.05 level) suggests no direct association between these parameters.

Discussion

Though Houbara Bustard is very widely distributed in a variety of ecological conditions available to its wintering flock in Balochistan (Mian and Surahio, 1983; Mian and Shams, 1984; Mian, 1988), yet its population in an area is decided by interplay between different phytoecological and abiotic features of its habitat. Relative influence of different abiotic factors under the conditions of Balochistan has appeared in Mian (1997). The results of present study suggest that different vegetative parameters can affect the density of Houbara population in different ways and extents. Effect of each factor in deciding population density in a specific area, in principle, depends upon its role and mode of action on general biology of Houbara and hence its tolerance to these external stimuli.

Cover

Remarkable similar patterns exhibited during different periods, seasons and communities suggest a consistent and strong influence of vegetative cover in deciding Houbara density. Present results suggest that the maximum Houbara density appears at medium cover (6 -11%), which can be regarded as optimal cover for this species/race. Both increasing and decreasing

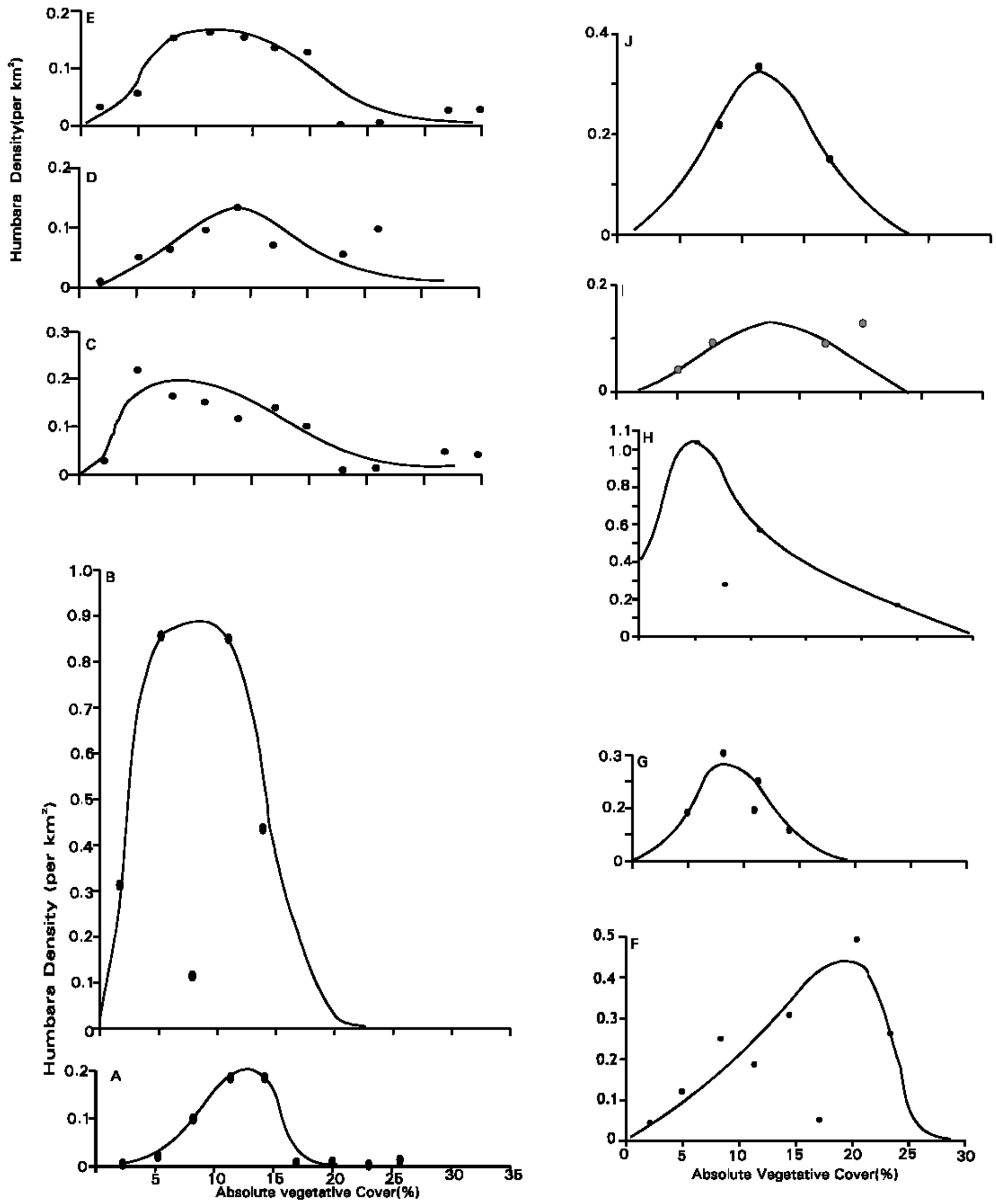

Fig. 2: Density of Houbara population under different vegetative covers, as exhibited during different years (A= 1984-85, B= 1985-86, C= 1986-87), seasons (D= early, E= mid, F= late) and vegetative communities (G= ***Anabasis*** sp., H= ***Haloxylon ammodendron***, I= ***Suaeda monica***, J= ***Zygophyllum*** sp.) by population wintering in Balochistan

cover beyond optimal level results in a gradual decrease in density. This pattern is explainable on the basis that Houbara is a basically cursorial bird placing a heavy reliance on camouflaging in vegetation for its protection from predators/raptors (Roberts and Savage, 1971). The bird finds an optimal protection without hindering its movements at medium covers. The increasing shrub cover increases camouflaging value of the vegetation for the cursorial Houbara. However, it is a large bird and requires a wider space between the plants for its movement. Hence increasing cover is liable of restricting it movements. Such behaviour has been indirectly pointed out for the Great Indian Bustard (***Ardeotis nigriceps***) by Ali and Rahmani (1982), Rahmani and Manakadan (1985) and Manakadan (1985) suggesting that increasing vegetative cover in a sanctuary decreased bustard density. Lowering the cover causes direct problem of protection exposing it to an easy detection and attack of predators. At places, however, physical obstacles, like edges of watercourses and depression between undulations, may add to the protection afforded by low vegetative cover and hence explains comparatively higher densities in certain stands with low vegetative cover.

Our results suggest that relatively low optimal vegetative cover (4-6%) is sufficient to afford protection to this large bird species. Hypothetically, protection is afforded collectively by physical obstacles and vegetative cover. Physical shelter is available in the habitat in the form of edges of watercourses and hilly/sandy undulates. This reduces the reliance on vegetative cover. Further, Houbara exploits watercourses and depressions as its microhabitat. The major part of the vegetation is distributed in such patches, which bear a higher vegetative cover. This bird is, therefore, actually present in a higher vegetative cover than suggested through the overall crude stand cover, being used in present and similar other analysis. The large bare patches are used by this bird species while becoming air borne, and hence are essentially required to save the bird from being entangled in shrubs. Variation in optimal cover or Houbara density levels occurring between the years, parts of winter or communities can also be safely attributed to physico-biotic variation.

Herbal cover is not directly important in deciding Houbara density. This can be explained on the fact that herbs are not directly important for providing shelter, though constitute a significant part of its food (Mian, 1986, 2000; Fox, 1988). The herbs, thus, can play an important role in attracting a better Houbara population only when the shrub vegetation and/or physical obstacles are sufficient to provide effective shelter from approaching predator.

Diversity

Presence of a very weak statistically non-significant, yet positive, correlation between vegetative diversity and Houbara density or constancy of appearance suggests that the increase in vegetative diversity have a little influence on Houbara population. Such a weak association can be conveniently explained on food-shelter logic of population distribution. The Houbara relies on shelter for its protection from predators. The shrub cover contributed by all the species in any phenological state has an equal shelter value. Houbara depends upon tender foliage of a large number of plant species (both herbs and shrubs) for food and water (Mian, 1986, 2000; Fox, 1988). Increasing floral diversity can increase the chances of finding tender foliage. Thus, though increasing vegetative diversity increases the chances of survival of the species, yet the low diversity tracts having suitable shrubs/herbs with preferred foliage available throughout the winter can also support equally good Houbara population. A significant correlation between Houbara density and constancy under different diversity suggest that vegetation diversity have a similar action in controlling both density and constancy.

Height

Available results lead to the conclusion that the mean shrub height in Houbara habitat falls between 0.3 and 0.8 m. This goes in conformity with the previous suggestion that the bird is present in almost treeless plains (Roberts and Savage, 1971). This range of the shrub height appears optimal for affording both protective camouflage and wider vision to this bird (standing height about 0.7 m).

The results in hand suggest that varying the maximum heights of the dominant shrubs within the protective range have no influence on Houbara density and/or constancy of its appearance. The average minimum shrub height in the stand, however, has a significant direct effect on Houbara density, while maximum height has no direct bearing on bird distribution. Thus, increasing minimum height has a direct shelter value, while scattered shrubs with maximum height do not occlude the vision of the bird.

Sociability

Present results on sociability pattern of the general shrub vegetation suggest that Houbara requires minimum distance of some 2 m in between the scattered individual shrubs (sociability class II) or groups of shrubs (class III). This distance appears to be the minimum required for the normal movements of this basically cursorial bird species. A smaller distance between the plants is liable of hindering the cursorial movements of this medium sized bird.

The sociability of shrub vegetation appears to work on all or none basis. If the sociability of the general shrub vegetation falls within the range of tolerance of the species, Houbara population is expected in an area. However, variation within the permissible sociability does not affect Houbara density/constancy. A lower density of bird population in sociability class I, and no population in class IV and V can be expected as the vegetative cover exceeds the range of tolerance of Houbara.

State

A gradual increases in Houbara density with increasing foliage, yet presence of a statistically not significant correlation suggests that the population level of Houbara is decided to a certain extent by the degree of green foliage. This can be expected, as Houbara is known to depend upon tender foliage/shoot for a significant part of its food (Mian, 1986; Fox, 1988). This also ensures water for this species, which is believed not to depend upon external drinking. The ensured availability of food and water from tender foliage is expected to have a direct bearing on the population levels of Houbara.

Vegetative community

Each community, having its own specific floral composition (depending upon location, physiognomy and abiotic habitat) provides a different degree of food, water and shelter (three basic needs of this cursorial bird species), therefore, variation in its potentials to attract different Houbara density can be expected. The inter-community variation in density/constancy of appearance of Houbara population, as suggested by the present results, has been referred previously by Mirza (1985), suggesting that Houbara in Cholistan remains restricted to areas having preferred plants (***Zygophyllum***, ***Haloxylon***, ***Neslia***, ***Capparis***). Similarly, Alekseev (1980) has also stressed that dominant vegetation in Houbara habitat of Kyzylkum (Central Asia) includes ***Salsola rigida*** and ***Arthrophytum aphyllum*** in the one locality and ***Salsola arbuscula*** in the other. As vegetative community is an association of plant species appearing under a complex of biotic and abiotic factors, therefore, it controls the Houbara population through an indirect action. Under a complex mode of action of community, density variation can be expected under its geographic location and/or other seasonal or annual variations.

The density is a direct attribute of population level, while constancy of appearance is the collective attribute of the level, dispersion and duration of stay of Houbara population in an area. The presence of a weak correlation between density and constancy in different communities suggests a relatively minor contribution of density in constancy of its appearance. This leaves us with dispersion and population movements as more potent factors in deciding constancy of appearance of Houbara in different communities. This is understandable as presence of Houbara in a stand is largely decided by its geographic location. The valleys in the central latitudes are known to hold Houbara population for a longer duration (Mian, 1997). The general physiognomy/aspection of stand/community influences Houbara dispersion. The communities with green foliage on widely scattered plants exhibit a clumped dispersion, while uniform/random dispersion appears in communities where green foliage is present on widely distributed plants of a species or different species. Thus, low density in tracts with evenly dispersed population maintained throughout the winter can yield a higher constancy of appearance. Conversely, a higher level of population appearing for short spells and in clumped states can result in a higher density but low constancy.

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