

Full Length Research Paper

Breeding ecology of the Iranian ground jay (*Podoces pleskei*)

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Although *Podoces pleskei* is the only endemic bird of Iran, little information exists on its ecological features, population dynamics and threats that concern it. This species occurs in desert and semi desert areas, mostly on the Iranian plateau, though its range spreads southeast ward to the Iran-Pakistan border. In this research, a total of 52 nests were studied in three locations, the “Ghare Tappe”, “Marvast” and “Mehrano” region, from 2005 to 2008. Breeding habits, nest characteristics, hatching features, clutch size, length of incubation time, nesting period and features of the chicks were observed in the three locations and were analyzed using analysis of variance (ANOVA). To compare breeding success among the three study areas, Z test was applied. This bird builds its nest at the top of and within the denser parts of plants, particularly *Atraphaxis spinosa*, *Ephedra intermedia* and *Zygophyllum euryptherum*. At times of danger, they hide beneath shrubs. Z-tests showed that the breeding success of this bird varied between Marvast and Mehrano. The greatest cause of nest failure and chick mortality was the transcaspien desert monitor (*Varanus griseus caspius*), which feeds on the eggs and chicks.

Key words: Breeding ecology, Pleske's ground jay, nest characteristics, clutch size, nest success, threat.

INTRODUCTION

Podoces pleskei is placed by taxonomists in the family of Corvidae. This genus consists of 4 species: *Podoces biddulphi*, *Podoces hendersoni*, *Podoces panderi* and *P. pleskei*. These four species are all confined to arid and semiarid deserts in central Asia, ranging from Iran to China and Mongolia. Having long and strong legs is an adaptation for their terrestrial behavior in these areas. Their strong beak that is sharply pointed facilitates digging and rummaging of the ground, while hunting for salamanders and other small animals. This species is

virtually endemic to Iran, while recent report refers to its existence in desert and semi desert areas, as mostly on the Iranian plateau, although its range spreads southeastward to the Iran-Pakistan border. Little information exists on the breeding ecology and feeding habits of *P. pleskei* or the natural predator of this bird. Body length is approximately 25 cm long and it has a long pointed beak. The plumage is sand colored, mat-ching the environment with black tail, chest patch and with black and white wings. The bird has been reported from the following provinces in Iran: Sistan-Baloochestan, Khorasan, Gorgan, Kerman, Yazd, Khozestan and Fars (Balouch, 1977). Human activities and habitat destruction such as livestock grazing, threaten the population of this species.

Today, as the landscape continues to change, declining populations of such species are of conservation concern. Due to the lack of information on its ecology, comprehensive studies are essential to provide the basics for conservation actions with respect to extant populations and the habitats that are remaining. As such, we aimed to

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Abbreviations: TBR, Tooran biosphere reserve; GPA, Ghare Tappe protected area; BPA, Bahrame Gur protected area; GPS, global positioning system; L, long axis of the egg ellipsoid; B, short axis of the egg ellipsoid; K, the constant number.

assess breeding biology and behavior of this species which was totally unknown. Meanwhile, we tried to measure the breeding success of this bird in these study areas in order to find the most important threats.

MATERIALS AND METHODS

Study areas

During May and June (breeding season) of 2005, this research was carried out in Ghare Tappeh protected area (GPA), and in 2006, it was continued in Marvast region. In 2007 and 2008, the research was continued at Mehrano plain as a part of Tooran biosphere reserve (TBR).

GPA, located at $N 30^{\circ} 03' 04'' E 54^{\circ} 32' 29.2''$, is in the vicinity of Khatam city with an area of 46000 ha and is approximately 1500 to 1900 m above sea level. This protected area covers parts of southern Yazd and northern Fars provinces and is in close proximity to the Bahrame Gur protected area (BPA). The climate of these areas is arid. The average annual rainfall is 160 mm and the average temperature in a year is 18°C. The dry season is from February to April (Meteorology Office of Iran, 2006). The desert terrain contains small hills and seasonal rivers. The river banks support *Zygophyllum eurypterum* and *Ephedra strobilacea*, which often grow several kilometers away from the banks.

The Marvast region ($N 31^{\circ} 03.240' E 54^{\circ} 20.767'$) was located between Marvast region and Yazd city in the vicinity of Mehriz protected area (MPA) with an area of 50,000 ha and 1,900 m asl. The average annual rainfall is 200 mm and the average temperature is 15°C (Meteorology Office of Iran, 2006).

The Tooran biosphere reserve (TBR) is located at the south of Shahrood city in the Semnan province. From the north, it extends to the Tehran-Mashhad road and Torood village, whereas to the east, it extends to the Zaman abad village and to the Southwest, it extends to the central plateau of Iran. This reserve covers an area of 1464992 ha and is the second largest protected area in Iran. It consists of three parts. The reserve has an arid climate and its average monthly temperature ranges from -15°C in January to 40°C. The average annual rainfall is 141 mm (Office of Meteorology Office of Iran, 2008). However, this research was restricted to the Mehrano plain within the protected area of the TBR ($N 54^{\circ} 22' E 49^{\circ} 44'$). This area is 12 km long and 5.5 km wide with an approximate area of 32,000 ha. It is 950 m asl and is mostly covered by *Z. eurypterum* and *Artemisia Siberia*.

Nest searching

Nests' searching usually starts in February each year. The location of each nest was found by observing and following a bird by using breeding bird protocol (Martin and Geupel, 1993). Some nests could be found by searching suspicious plants (Mezquida, 2001 and Marone, 2007). Searching in GPA was accomplished by motorcycle and in the Mehrano plain by walking, whereas nest searching continued until late April (about 2 months from the beginning of the search). Nests were divided into two groups: New (under construction) and old (nests from past years). The location of each nest was assessed with global positioning system (GPS), for future observations.

Nest structure

Plant species, in which the nest was placed, was recorded and nest

parameters such as length, height, diameter and depth were measured within 1 cm. The materials used in nest construction at each layer of the nest, were also recorded. These measurements were done after the chicks had left the nest, in order to avoid interfering with the nesting process.

Egg features

The number of eggs in each clutch, along with some characters as weight, length, breadth, volume and surface curvature of the eggs, was recorded. Surface patterns and their color were also noted. The volume of the eggs was calculated by multiplying the long axis of the egg ellipsoid (L) by the short axis of the egg ellipsoid (B) and the constant number (K) (Alborska and Kosicki, 2004). As such, the curvature was calculated by multiplying the ratio of the mean breadth of the egg by the mean length of the egg in 100 (Alborska and Kosicki, 2004). Length measurements were made using calipers, to the nearest of 0.1 mm and the weight measurements were made using a digital balance to the nearest of 0.1 g.

Egg laying, incubation and fledging

Eleven nests were observed twice a day to study egg laying, incubation and fledging. The number of days between successive eggs was recorded. In some cases when the exact time of the first egg laying was unknown, it was estimated by the number of eggs presented in the nest and it was assumed that one egg was laid per day (Gorenzel et al., 1982; Brisbin et al., 2002; McNair and Cramer, 2006). As such, the times between egg laying, hatching and fledging (leaving the nest) were noted and recorded.

Nest success

To calculate nest success, the whole nesting period was monitored. For those nests which were observed after egg laying or incubation had began, the Mayfield (1975) correction factor was applied. The incubation period and nestling period were determined by monitoring twice a week. In order to minimize the effect of human study on the nests, the protocol of Martin and Gupel (1993) was used for monitoring breeding birds. Nest survival rate, survival probability and standard error were calculated using the Mayfield (1961) method.

In some cases, when the required data were not available, nest success was calculated by using the egg laying period and hatching and fledging times (Werner et al., 2007). A nest in which at least one chick was fledged, was considered as a successful nest, otherwise, it was considered as an unsuccessful nest. The period of time between the completion of the clutch and the chicks' hatching time is referred to as the incubation period, while the period between hatching and the time the young ones leave the nest is called the nestling period.

Nest success and survival probability were measured during three periods: incubation time, hatching time and length of nestling time. For determination of nest success, nest survival probability, egg survival probability, nestling survival probability and standard error were calculated by using corresponding formulas (Small et al., 2005).

Parental care and behavior

Parental care and behavior were studied by direct field observations using 10 × 42 binocular and a 20 × 60 telescopes and by indirect field observation using a micro video camera, TV card, PC and electrical generator.

Table 1. Nest parameters within the three study areas. Measurements are in centimeters.

| Nest parameter | Ghare Tappe (No. of nests 86) | | | Marvast (No. of nests 44) | | | Mehrano plain (No. of nests 44) | | |
|-------------------------------------|-------------------------------|------|------|---------------------------|-----|-----|---------------------------------|-----|-----|
| | Mean \pm SE | Min | Max | Mean \pm SE | Min | Max | Mean \pm SE | Min | Max |
| Height of the nest above the ground | 62.5 \pm 15.7 | 42 | 85 | 75.5 \pm 21.3 | 52 | 96 | 84.5 \pm 19.7 | 40 | 115 |
| Depth of the nest's interior | 9 \pm 1.2 | 7 | 10 | 11 \pm 1.2 | 9 | 13 | 8.5 \pm 0.6 | 7.5 | 9.5 |
| Height of the nest's interior | 15.5 \pm 2.4 | 12 | 18.5 | 2.2 \pm 2.4 | 20 | 25 | 21.7 \pm 2.6 | 17 | 25 |
| Diameter of the nest's interior | 15.2 \pm 2.5 | 12.5 | 18.5 | 17.4 \pm 1.6 | 15 | 20 | 8.8 \pm 0.9 | 7 | 10 |
| Diameter of the nest's exterior | 20.3 \pm 1.8 | 17 | 23 | 22.6 \pm 2.2 | 20 | 25 | 21.7 \pm 1.7 | 18 | 24 |

Two nests were monitored for a total of 292 h during the incubation period in 2006, and two nests were monitored for a total of 522 h during the nestling period in 2007. Monitoring was performed from sunrise to sunset on days in which the weather was suitable.

Statistical analysis

Nest characteristics which were analyzed statistically include: Height above the ground, inner diameter, outer diameter and depth. Egg features analyzed include: Length, breadth, volume and weight. Other data analyzed include: Average clutch size, length of incubation time and time in the nest of the chicks. The mating period was analyzed by using the breakdown of the unilateral variant and considering the effect of habitations as a grouped fixed effect. A least significant difference (LSD) test was used for mean comparison. As such, plant cover associated with nests was compared by using the chi-squared test at a significance level of 0.05, while nest success between the three study areas was compared using the Z test at a significance level of 0.05. However, all the statistical analyses were done by using SAS software.

RESULTS

Mate selection and mating

Since the Pleske's ground jay is a wary and furtive species, observing its behavior was very difficult during most seasons of the years. However, mate selection and mating activity probably begin shortly before the commencement of nest building.

Nest location

Among the 86 active and inactive nests studied in the GTA, 3 nests (3.04%) were placed in *Haloxylon*, 53 nests

(61%) in *E. strobilacea* and 30 nests (34%) in *Z. eurypterum*. In the "Marvast", from a total of 44 nests, 29 (65%) were built in *Atraphaxis spinosa* shrubs, 10 (22%) in *Z. europium* and 5 nests (11%) in *E. strobilacea*.

Nest structure

Nests were rounded cup shaped structures, and in color, they matched their surrounding environment. They were made of two layers including different animal and plant materials.

The inner layer was soft and consisted of plant fiber, livestock wool, and in some cases, feathers and cloth mud was also a common component. The outer layer was made from thin branches and twigs which were usually cylindrical in shape. In some shrubs, where the canopy was not very dense and did not provide much camouflage, the parents often built a shelter roof over the nest. These roofs provided protection from the sun and hide the nest from predators. The thickness of this protective roof was often, as much, as 10 cm.

Nest size

The volume of the nest provided enough space for the eggs and the incubating female. However, by the end of the nestling period, the nest space was so small that for nests with 4 to 5 chicks, the nearly fledged chicks took up all the space and the female bird had to stay out of the nest during the night time. Table 1 shows nest parameters within each of the three study areas. The highest and lowest nest height above the ground was pertained to Mehrano and Gharatappeh (GPA), respectively.

Table 2. Date of egg laying and reproduction periods (in days) of the three regions.

| Mehrano plain (19 nests) | | Ghare Tappe (16 nests) | | Marvast (14 nests) | |
|----------------------------------|--------------------------------------|---------------------------------|--------------------------------------|---------------------------------|--------------------------------------|
| Dates of first egg laying (2007) | No. of days until last young fledged | Date of first egg laying (2006) | No. of days until last young fledged | Date of first egg laying (2006) | No. of days until last young fledged |
| 12 February | 34 | 16 March | 33 | 1 April | 34 |
| 14 February | 33 | 18 March | 34 | 2 April | 33 |
| 18 February | 33 | 21 March | 35 | 4 April | 32 |
| 21 February | 35 | 25 March | 34 | 14 April | 34 |
| 22 February | 35 | 26 March | 36 | 14 April | 35 |
| 26 February | 32 | 1 April | 37 | 21 April | 36 |
| 3 March | 36 | 2 April | 32 | 24 April | 35 |
| 5 March | 37 | 6 April | 33 | 26 April | 34 |

Dates of egg laying and duration of time until fledging

This bird started nest building and egg laying at the end of winter. The dates that egg laying commenced and the duration of the nest use period are shown in Table 2. The duration of nest use, commencing with egg laying and continuing through the nestling stage until the young fledged and left the nest varied from 32 to 37 days in both the Mehrano plain and Ghare Tappe study areas (GPA). In the Marvast, the duration was from 32 to 36 days.

The nest use averages period was 34.8, 34.25 and 34.12 days in the Mehrano, Ghare Tappe (GPA) and Marvast, respectively. A T-test showed that there is no significant difference between these averages ($P > 0.05$). The nest use period averages are 33.3, 35, 34.1 and 35 days for the months of February, March, April and May, respectively which are significantly different ($P < 0.05$). Nesting took place in February and March on the Mehrano plain, March and April in Ghare Tappe (GPA) and April in the Marvast study area.

Eggs features

Eggs are elliptical in shape and the color lines on the surface are twisted in pattern. The surface of eggs was smooth and shiny, and the eggs were white to cream in color with bright green blotches which were denser at the extremity of the egg. The physical features of the eggs are shown in Table 3.

Eggs were the smallest in all measurements in the Mehrano, but the differences were not significant. A larger roundness index indicates that the egg is more rounded in shape.

Clutch size and incubation period

Table 4 shows the date for clutch size and durations of the incubation period. Mean clutch size was significantly different between the three study areas ($P < 0.05$), but

there were no significant differences for the durations of the incubation period ($P > 0.05$). Therefore, the different habitats do not appear to have significant effect on the latter parameter. The number of eggs laid decreased at higher environmental temperatures.

Monitoring by remote camera shows that only female birds did the incubation, while males watched and guarded the nest from nearby. Nest monitoring also showed that the pairs laid only a single clutch of eggs annually. The total time spent for incubation each day ("attentive" periods) averaged 18 h a day with a maximum of 23 h per day towards the end of the incubation. Females were observed to move the eggs from one side of the nest to the other during the incubation period. During incubation time, they regularly brought food to the females.

Hatching and the nestling stage

Since incubation began with the laying of the first egg, hatching was asynchronous and all young ones did not hatch at exactly the same time. However, all hatching in each nest took place within two days. The female carried the egg shells out carefully to a proper distance away from the nest. The newly hatched chicks were altricial and were unable to take care of themselves, thus, requiring parental care. They were naked and pink in color with olive colored streaks, lacking any feathers or down on their body. The chicks were extremely weak and feeble and could not hold their heads up except for a very short time. Young birds were fed almost entirely by the females. They were fed once every 15 to 45 min. Chicks solicited food by producing vocal begging sounds, by holding their head up high and opening their mouth widely. Usually, all chicks were fed every time by nourishing a female that brought food to the nest, but sometimes the stronger birds obtain most of the food.

The male rarely fed the chicks, but they provided parental care by protecting the nest from predators. Fecal sacs produced by the chicks were carried out of the nest by both parents. These sacs consisted of phyllophagous

Table 3. Physical features of the eggs.

| Study area | Mean \pm SD | | | | |
|----------------------|------------------|-----------------|-----------------|--------------------------------|---------------------|
| | Mean height (mm) | Mean width (mm) | Mean weight (g) | Mean volume (mm ³) | Egg roundness index |
| Mehrano (N = 88) | 28.03 \pm 1.5 | 20.65 \pm 0.6 | 6.01 \pm 0.6 | 5802.7 | 0.72 |
| Ghare Tappe (N = 46) | 30.61 \pm 0.9 | 21.50 \pm 0.5 | 6.28 \pm 0.6 | 6791.7 | 0.72 |
| Marvast (N = 78) | 30.24 \pm 1.2 | 21.65 \pm 0.5 | 6.08 \pm 0.5 | 6803.6 | 0.71 |

Table 4. Clutch sizes, mean lengths of incubation and nestling period.

| Study area | Clutch size | Clutch size SD \pm mean | Incubation period (days) SD \pm mean | Nestling period (days) mean \pm SD |
|----------------------|-------------|---------------------------|--|--------------------------------------|
| Mehrano (n = 21) | 3 to 6 | 4.1 \pm 0.6 | 17 \pm 4 | 17 \pm 4 |
| Ghare Tappe (n = 26) | 1 to 5 | 3.7 \pm 0.8 | 18 \pm 4 | 4 \pm 16 |
| Marvast (n = 14) | 1 to 6 | 4.6 \pm 0.4 | 18 \pm 4 | 16 \pm 4 |

worms, *Z. eurypterum*, ants, small insects and rarely small lizards, all of which had been fed to the chicks. The fecal sacs were capsule shaped, soft but with a thin strong shell that prevented them from collapsing, and thus, on the nest and body of the chicks. They were collected at every second feeding of the chicks and were carried away (15 to 20 m), to where they were buried. Chicks' growth in the nest was quite rapid, and the body feathers were quickly acquired. At the time of fledging, the legs were unusually long and strong, enabling a young bird to run very well, and to climb into bushes and shrubs. Mean lengths of the nestling stage are shown in Table 4.

Fledging and early juvenile stage

At the end of nestling period, the young birds in the nest were so large that there was no longer any space for the female, who remained nearby at night. Young birds fledged and left the nest in succession, moving into nearby bushes, where they hid in the stems and branches. The parents remained nearby, providing protection and nourishment. This behavior lasted for 2 to 3 weeks until the young birds could fly. After they could fly, the parents continued to feed them for another 2 to 3 months, and as such, the newly fledged young birds had a good ability to run and escape from potential predators.

Nest success and causes of mortality

Nest success was measured using Mayfield (1961; 1995) method. The data used in this research and the results are shown in Tables 5 and 6. Results were compared using the Z test. The frequency of destroyed nests in Ghare Tappe (GPA), Marvast and Mehrano were 31.3,

50 and 5.9%, respectively, which showed a significant difference between Mehrano and Marvast ($p < 0.05$). However, there were no other significant differences between the three study areas.

The most important causes of mortality were demolition of the nests and eggs by sheep, predation on the eggs and young birds by 'transcaspien desert monitor', snakes, hawks, foxes and sheepdogs. Seasonal rain led to occasional flood which destroyed some of the nests.

Parental care

Both male and female protected the nest and nestlings, though with different roles. During egg laying and incubation, the female rarely ventured far from the nest. When the female was absent from the nest, the male watched the nest from the top of neighboring vegetation or sometimes from the ground. During most of the incubation period, the female stayed in the nest at night, protecting the young ones. The male bird tried to distract predators by aggressive swoops and loud vocalizations. The female would sometimes join to mob the predator. Both parents would attempt to drive predators away from the nest or from the young ones. They also attempted to attract a predator's attention by pretending not to notice it while they pretended to forage on the ground and search for food in close proximity of the predator, thus directing its attention away from their nest or young ones.

DISCUSSION

Although, breeding period follows a similar pattern in all years of study (Table 2), reproduction date was different probably because of the climate change. Other studies (Bardin, 1989) showed that egg laying of *P. panderi* in

Table 5. Nest data used to calculate nest success.

| Study area | Nest exposure days | Total nest | No. of nest failed | Mean incubation period | Total No. eggs | No. eggs failed | Eggs exposure days | No. all chicks | No. of nestling failed on hatching day | Average of nestling stage | No of chicks fatality along the period of nesting | No. of days of observation |
|--------------|--------------------|------------|--------------------|------------------------|----------------|-----------------|--------------------|----------------|--|---------------------------|---|----------------------------|
| Ghare Tappeh | 272 | 16 | 5 | 18 | 63 | 25 | 365 | 38 | 2 | 16 | 1 | 336 |
| Marvast | 224 | 14 | 7 | 18 | 62 | 19 | 325 | 43 | 8 | 16 | 2 | 343 |
| Mehrano | 207 | 17 | 1 | 17.5 | 69 | 31 | 745 | 38 | 5 | 17 | 1 | 394 |

Table 6. Nest success by using Mayfield method.

| Study area | Survival rate | | | | | | | |
|--------------|----------------|---------------|--------------------------|-------------------------|-------------------------|-------------------|-------------------------|-------------------------|
| | Nests survival | Eggs survival | Incubation time survival | One day chicks survival | One day chicks survival | Nestling survival | Nestling stage survival | Total survival \pm SD |
| Ghare Tappeh | 0.71 | 0.37 | 0.262 | 0.94 | 1 | 0.95 | 0.95 | 0.23(0.008) |
| Marvast | 0.56 | 0.33 | 0.184 | 0.81 | 1 | 0.91 | 0.91 | 0.13(0.011) |
| Mehrano | 0.916 | 0.475 | 0.435 | 0.86 | 1 | 0.96 | 0.96 | 0.36 (0.004) |

Mangolia started in the late winter season. Monitoring of the start date of the breeding activity of *P. pleskei* in the three study areas were differently estimated from 30 to 40 days (Table 2). Generally, Iranian ground jay reproduction season starts by building nests and mating in late January, while at Ghare Tappe (GPA), it starts in early February and continues in early April. Due to the differences in the date of breeding season, in one region, flying chicks can be seen by initial beams, while in other regions, there are adult birds at the stage of incubation. For instance, at Mehrano, chicks start flying between April 4th and 9th, but in protected area of GT, chicks left the nest between May 10th and 15th. These patterns of the date of breeding activity were also observed for *P. panderi* (Rustamov, 1954).

Based on our observations, this bird does not usually use the abandoned nest built in previous

years and selects a new proper shrub within 50 m away from the old nests. Gubin et al. (1986) reported 500 to 1000 m distances between the active nests of the *P. panderi* from each other.

The study showed that the average heights of the nests in three regions were one meter (Table 1), but the other studies reported that it is as high as three meters on *Tamarix sp.* (Francois and Etchecopar, 1970). In GTA, the nests are usually set on the plants such as *E. strobilacea* and *Zygophyllum atriplicoids*, but in Mehrano, nests were built on *Atraphix spinosa*. As such, the results were in concordance with Hamedanian (1998) observation.

This bird selects the open plain and small round hills in semi-arid desert which is similar to the other species of Corvidae that choose open and semi-arid plains (Rustamov, 1954). Hamedanian (2000) also pointed out that the breeding site of

this species were on *E. strobilacea*, *Haloxylon Sp.* and *Z. eurypterum* in open and semi-arid plains of Iran.

In the three regions of the study, the shape and color of eggs were similar to other family members of the Corvidae as well as Hue and Etchecopar (1970) observation. The result of this study showed that the size and weight of egg of this species (Table 2) were exactly similar to *P. panderi* which was reported by Gubin et al., (1986).

Egg-laying starts late in February and lasts till early March. The number of eggs takes 2 days to be completed and the average number of the eggs which is similar to *P. panderi* was studied by Gubin et al., (1986). Based on this study, incubation period is 17 to 19 days. This period was reported for *P. panderi*, 16 to 19 days in Turkmenistan (Rustamov, 1954). By continuous

monitoring of the birds within the period of study for the three study areas, it was seen that the chicks are fed mostly with insects and pieces of lizards. Both parents help in taking care of chicks. Young chicks remain with their parents until the full growth time.

Nest threat such as nest touching by human cause the birds to easily leave the nest at the stage of egg laying, but after hatching, even when the nest is being threatened, the bird resists to leave the nest. Fledging period of *P. pleskei* in all three regions is 15 to 18 days which is similar to *P. panderi* with 17 days (Gubin et al., 1986).

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