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Daily behavioural patterns and time budgets of captive black-bellied sandgrouse (Aves: Pteroclidae)

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Abstract – Maintaining normal behavioural patterns is an important component of captive breeding with the aim of reintroduction. We examined the behaviours and daily time budgets in captivity of hand-raised black-bellied sandgrouse *Pterocles orientalis* provided with food and water *ad libitum*, and compared them with published observations of wild birds in order to assess the impact of captive rearing and captivity on behaviour in this species. We observed a bimodal pattern of active behaviours in the morning and afternoon, interrupted by a period of resting behaviours through the middle of the day when air temperatures typically exceeded 40°C. High temperature accentuated the bimodal activity pattern by increasing the midday resting period and by decreasing the general level of locomotors activity. Compared to birds in the wild, captive birds spent less time foraging (captive: 30%; wild: 53-58%) and more time preening and dust-bathing (captive: 25%; wild: 7-11%) and resting (captive: 28%; wild: 16-22%), probably related to differences in food availability between captive and wild situations. The broad similarity in daily activity patterns of wild and captive birds, and our observations on sexual behaviours and breeding in captive birds suggest that the behavioural routines of black-bellied sandgrouse are little affected by being hand-raised in captivity.

Key-words: black-bellied sandgrouse; captivity; behaviour; daily activity patterns; time budget; precopulatry behaviour.

INTRODUCTION

The black-bellied sandgrouse *Pterocles orientalis* is the largest species of the Old World family Pteroclidae with a body mass of c. 450-550 g (Cramp & Simmons 1985). In Morocco, this species of arid steppes is relatively abundant east and south of the Atlas Mountains (Thévenot *et al*. 2003, Liéron *et al*. 2007). Yet, population densities have drastically declined throughout the majority of steppe habitats in Haouz region of west-central Morocco. This decline is linked to ongoing habitat destruction as a result of agricultural intensification, poaching and illegal hunting (Aourir *et al*. 2007).

Conservation measures are therefore urgently required to reinforce declining black-bellied sandgrouse populations of the Haouz region. Within this framework, a captive breeding programme has been initiated. One aspect of this programme is the need for a thorough understanding of the species' daily behavioural activities and how the captive environment may influence them. This latter could then be designed in the way to let the animals live as "naturally" as possible. Comparisons between wild and captive animals of a certain species could be useful in this matter. Various behavioural observations have been made on different sandgrouse species in the wild (Maclean 1968, George 1969, Thomas & Robin 1977; Thomas & Maclean 1981, Thomas 1984a, 1984b, Hinsley 1994, Lloyd *et al*. 2000). Daily activity patterns have been investigated in black-bellied and pin-tailed sandgrouse *P. alchata* in Spain, in black-bellied and spotted sandgrouse *P. senegallus* in Israel (Hinsley 1994) and in Namaqua sandgrouse *P. namaqua* in South Africa (Lloyd *et al*. 2000).

The time-activity budget was also evaluated in the former three species (Hinsley 1994). Nevertheless, sociosexual behaviour of sandgrouse is still only rather poorly documented (Johnsgard 1991). In captivity, relatively detailed studies have been carried out on daily patterns of behaviour in the Namaqua and double-banded sandgrouse *P. bicinctus* (Thomas & Maclean 1981) as well as some aspects of the sexual behaviour in the latter species (Hinsley

& Hockey 1989). This study aims to: (1) investigate the whole behaviour repertoire displayed by flocks of captive, hand-reared black-bellied sandgrouse during the breeding season and the daily behaviour patterns and time-activity budget, and (2) compare the observed behavioural patterns to those reported for the black-bellied sandgrouse in the wild during the nesting period (Hinsley 1994).

MATERIALS AND METHODS

The behavioural study was carried out in the bird facilities of the Natural History Museum of Marrakech, Cadi Ayyad University, Morocco. Two flocks of 16 adult sandgrouse (2 males and 4 females) and (5 males and 5 females) respectively in 2004 and 2005 were obtained from artificially incubated eggs collected (under licence) in the Haouz region, west central Morocco. All the observations were clumped together because there was no evidence of any significant difference between the two years, regardless of the different sex-ratio of the two flocks (Chi-square test, $P > 0.05$). The sex has not been taken into account in our observations, due to the limited sample.

Hand-reared, two-month old sandgrouse fitted with a metal numbered leg band and individually marked with a unique combination of color wing tags for remote identification, were transferred to an outdoor planted aviary (10 x 5 x 2.5 m) made of soft nylon mesh held under tension by a string framework with the bottoms of the walls buried in the ground, and located adjacent to a laboratory building (Fig. 1). The aviary was divided into three sections, each with a different substrate, namely sand and dusty ground; compact ground with gravel; and intermediate ground with small gravel (Fig. 1). A shelter (1.50 × 0.30 m, and 30 cm high) and several small shrubs were included in the aviary. The sandgrouse were provided with food and water *ad libitum;* a mixture of wheat, millet, wild mustard seeds, and lentils was scattered on the ground, and fresh water was provided in plastic drinkers sunk in the ground. In addition, poultry pellets (17.5% of proteins and 5000 kcal/100 g) were offered in feeders at different sites around the aviary (Fig. 1). The experiment was conducted during the 2004 and 2005 breeding seasons from early May to late June, with a 'daytime' defined from 07h00 to 19h00. During this period, sunrise occurred between 05h15 and 06h10 and sunset between 19h00 and 20h00.

The adult birds were observed directly by the same person throughout the whole study period. To minimize disturbance, a blind was set up on the roof of the adjacent laboratory building 5 m away from the aviary. This gave an uninterrupted view of all birds within the aviary. In early May, at the onset of the breeding season, preliminary observations were carried out to categorize the full variety of behaviours using *ad libitum* method for an ethogramme development (Altman 1974). Thereafter, behavioural activities of all individuals were recorded using instantaneous behavioural sampling method (Altman 1974, Martin & Bateson 1986), with regular scans conducted at five minute intervals over a period between 07h00 and 19h00 over 40 days each breeding season (to quantify the frequencies of the various behaviours). The social behaviour was described when sporadically observed.

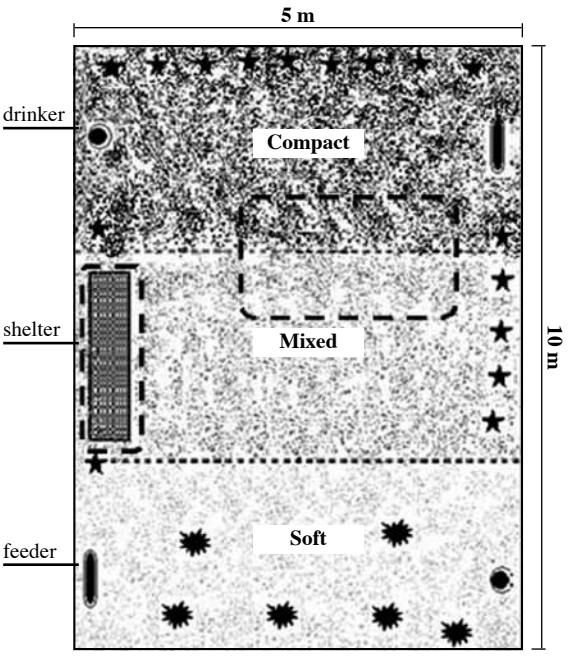

Figure 1. Schematic representation of the aviary to indicate the microhabitats available to the captive sandgrouse: soft, mixed and compact microhabitats. (★): nest position, (✸): dust-bathing sites and (----): resting area.

The series of observational sessions were regularly distributed at five day intervals starting on the first day of each month (20 days in May and 20 days in June during the breeding seasons 2004 and 2005). All the observations lasted for a total of 480 hours each breeding season. In order to examine the daily behavioural patterns, mean proportions (percentages) were calculated for each hour of the day using observations on all relevant days to build up a generalized picture of daytime (07h00 to 19h00h) activity patterns. The mean percentage of daytime spent in each behavioural activity was calculated for the observed individuals to quantify the time-activity budget. The following behavioural activities were considered: day inactivity (DI) (sitting; standing relaxed; standing relaxed look-

ing around; being in shady as opposed to sunny positions); foraging (F) (feeding behaviour includes collecting food in the feeders and scattered on the ground, besides grazing on some plants); drinking (D); preening and/or dust bathing (P); walking (W); standing alert (SA); flying (FI) and social behaviour (SB). Flying (typically brief) and natural incubation (suppressed because eggs were pulled within 40-50 min after laying for artificial incubation) behaviours were excluded. Time-activity budgets in our captive black-bellied sandgrouse were compared to those of wild birds of the same species studied in a semi-arid (Spain) and an arid (Israel) environments for a total of 3924 birds (3203 males and 721 females) observed (Hinsley 1994).

Air temperature (Ta) at 7 cm above the ground (shoulder level of the bird) was measured in three selected sites within the aviary by means of a telemetric thermometer (to the nearest 0.1°C). Average air temperature has been evaluated during the whole study period.

RESULTS

Air temperature in the aviary

The daily variation in the mean air temperature for the three sites within the aviary is shown in Figure 2. Average air temperature varied during the day with a mean minimum of 21.4 ± 1.2 °C early in the morning, and a mean maximum value of 43.3 ± 5.4 °C in the middle of the day. Air temperature was greatest between 13h00 and 14h00.

Time budgets and behavioural patterns

Foraging, preening and resting occupied the major part of daylight time hours with about 83% of the total daytime. Standing alert and walking represented respectively 7% and 8% of the daytime. The drinking and flying activities along with the social behaviour represented less than 1% of the daytime (Tab. 1).

All the activities displayed appeared to be influenced by the ambient temperature, then, the proportions of time devoted to the different activities varied during the daylight period. Captive birds spent 61% daylight time in foraging and preening during the morning and the afternoon periods. In the middle and warmer part of the day, the resting in shade represented 39% of daylight time whereas the foraging and preening activities were reaching 43% and only 18% of the daytime were allocated to the remaining activities.

Standing and moving activities

Day inactivity or resting occurred mostly during the midday period of higher air temperature (Fig. 3). The sitting posture often occurred after an intense bout of foraging or preening activity. It was also adopted for sunbathing during the morning or for resting in the shaded zones during hot periods of the day. Standing and walking activities peaked mid-morning and mid-afternoon.

Feeding and drinking

Feeding by captive birds occurred mainly in the morning and late afternoon, particularly between 08h00 and 09h00, and between 17h00 and 19h00, with minimal foraging activity through midday (Fig. 3). Feeding bouts for each individual occurred for relatively prolonged periods, interrupted by relatively long periods of preening and sunbathing. Generally, captive black-bellied sandgrouse foraged by walking and scanning the ground for seeds at different sites around in the aviary. When searching for food in a loose substrate, the birds shifted the substrate with sideway scratching movements of the feet and the bill. Sometimes birds foraged directly by grazing the leaves and/or flow-

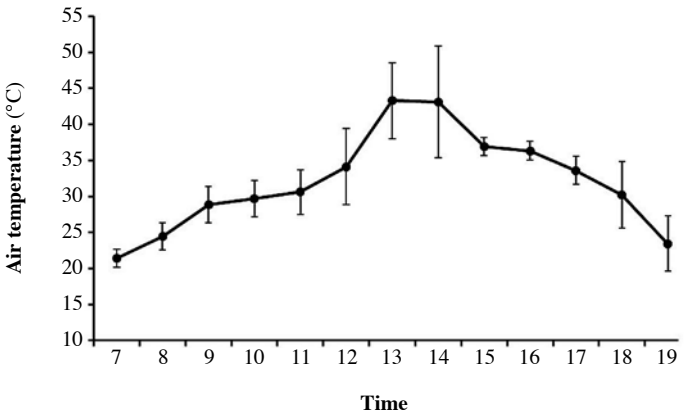

Figure 2. Variation in the mean air temperature 7 cm above the ground in the aviary in condition of sun.

Table 1. Time budgets, expressed as percentage of daylight time spent in each activity category of captive (the present study) and wild black-bellied sandgrouse (Hinsley 1994). (**DI**) Day inactivity, (**F**) Foraging, (**P**) Preening, (**SA**) Standing alert, (**W**) Walking, (**Fl**) Flying, (**SB**) Social behaviour, and (**D**) Drinking.

	Percentage of daylight time spent in each activity					
	Captivity				**Wild**	
Activity	Morning	Midday	Afternoon	Total	Spain	Israel
DI	19	39	27	28	22	16
F	30	21	39	30	53	58
P	31	22	22	25	11	7
SA	9	10	4	7	2	3
W	8	5	7	8	4	8
Fl	-	-	-	-	8	8
SB	1	2	<1	1	<1	<1
D	2	1	<1	1	-	<1

ers of some herbaceous plants (wheat *Triticum turgidum*, barley *Hordeum vulgare*, lentils *Lens culinaris*) within the aviary. Some stereotyped behaviours were observed with the bird picking up a potential unknown object (usually coloured), held it a moment in the bill tip, dropped it, picked it up again, and repeated the process several times before discarding it.

Drinking occurred mostly during the morning, particularly between 09h00 and 10h00. A second much lower peak occurred during the heat of the early afternoon (Fig. 3). Individual birds took only one to four sips at a time, but might return to drink at several times during the day.

Thermoregulatory behaviour and self-maintenance activities

Captive birds commonly spent some time resting in the sun early in the morning. Birds sunbathe by orienting their body flanks towards the sun, thus maximizing the surface area exposed to direct radiation. Sunbathing is usually associated with feather erection at low temperature (< 25 °C). Almost all birds spent the hot midday hours sitting in shade, dozing from time to time. Gular fluttering was regularly observed in both sexes only during the heat of the day, mostly between 12h00 and 14h00 when birds did not have access to shade (Fig. 4).

Preening occurred irregularly throughout the day, but generally decreased during the afternoon (Fig. 4). The incidence of dust bathing was very low during the morning, but increased steadily during the afternoon to peak between 17h00 and 18h00 (Fig. 4). A dust-bathing bout began with pecking and scratching at a pre-selected potential dust-bathing site (Fig. 1). The bird then scratched out a scrape with its feet while rotating and continuing to peck at the ground. Thereafter, it lay down on its side and performed "side-rubs" and 'head-rubs'. Side-rubs involve motion of the legs as the bird pushes its body while in a lying position. During dust-bathing, the birds regularly turn on their sides, with both legs raised in the air, and they may even roll over on their backs while rubbing sand or dust into their feathers. The bird concludes a dust-bathing bout by standing up and giving a 'ruffle-shake' to shake off loose dirt particles. Other frequently performed self-maintenance activities include: (a) the still folded wings being stretched vertically above the back; and (2) a leg and the corresponding wing being stretched backwards while the tail is spread.

Precopulatry behaviour

An aggressive behaviour of pecking at the body feathers of other birds began to appear in late April and increased during the laying period. Both sexes can be subject to pecking, but females were more likely to peck other females which approach their mate. The aggressor with wings folded runs at the other female an lowers its head and neck in the direction of the intruder while emitting intimidation calls "Kot Kot Kot..." and then peck her. During the 2004 breeding season, one particular female, excluded by the flock that comprised more females than males, was continually attacked and her neck and rump feathers pecked until bleeding. During 2005, this behaviour was not exhibited within the five-pair group. Pair-bonding behaviours include the two mates moving and pecking on the ground together. The frequency with which individuals changed partners during the period of 05 to 14 May during the breeding season of 2005 suggests that monogamy is not the rule in captivity.

Eleven complete copulations were observed during the two breeding seasons. Each was preceded by a court-

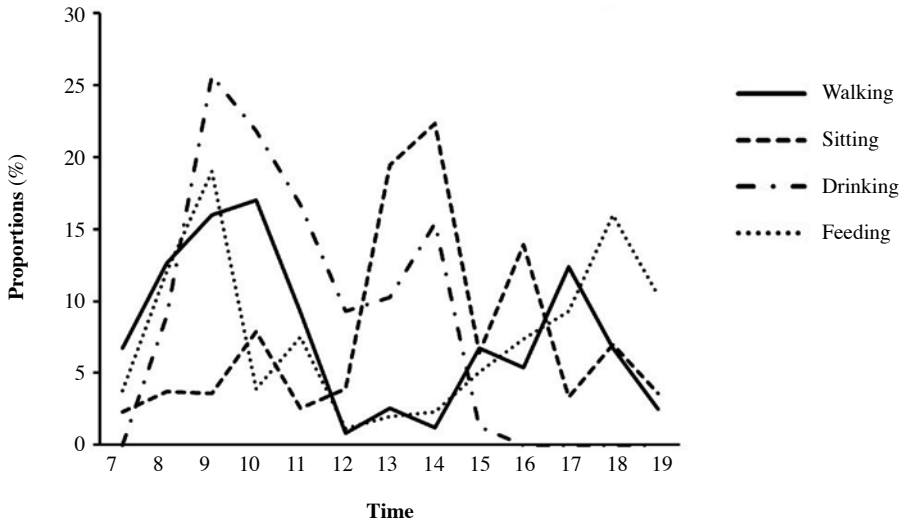

Figure 3. The mean proportions sitting, walking, feeding and drinking activities shown in relation to different times of day.

ship display initiated by the male, during which the male droops the wings close to the body and holds the tail down obliquely to touch the ground while the head is retracted and also held down with the beak pointing at the ground. Holding this posture, the male moves with a stiff, slow gait and exaggerated stepping, usually 1-2 m behind the female. The female then performs precopulatry behaviour, adopting a crouching position with wings slightly held and the head held down, whereafter the male approaches with a slow gait and mounts her. Copulation lasts about 20-30 seconds during which the female remains passive, while the male keeps his wings slightly open. After dismounting, the male runs a short distance in front of the still-crouching female and gives one to two soft calls, whereafter the female stands up and follows the male.

Nesting and egg laying

The nest consists of a superficial scrape; about 150 mm in diameter that is excavated by the female only resting on her breast and sinks into the soil. However, in many cases, the eggs were just laid on the ground with no clear scrape. Immediately before oviposition, the female displayed a stereotyped behaviour of walking with quick comings and goings very close to the aviary wall. Egg laying occurred

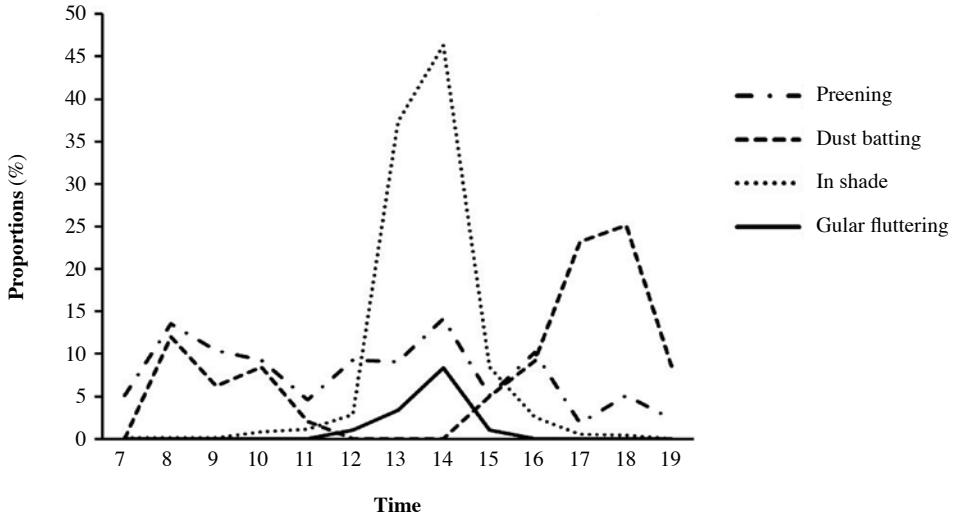

Figure 4. The mean proportions shading, gular fluttering, preening and dust-bathing activities, shown in relation to different times of day.

only in the afternoon, between approximately 13h30 and 18h00. After laying an egg, the female became noticeably more aggressive and defended the nest by adopting agonistic postures towards any other birds, except their mate. The male remained close to the female on the nest, usually standing behind her. The female does not lay all her eggs in the same site; it changed nest position after egg pulling (Fig. 1). Only the female performed an aggressive display to a human approaching to remove the egg when she was still on the nest during the first 30-40 min after egg-laying.

DISCUSSION

The behavioural patterns and daily time activity in the captive, hand-reared black-bellied sandgrouse were comparable to those reported for other captive sandgrouse, where a bimodal pattern of morning and late-afternoon feeding and watering activities is separated by a period of lower activity through the middle of the day (Thomas & Maclean 1981). This pattern also accords with observations of black-bellied sandgrouse in the wild in Spain, where birds became inactive around midday, but not in Israel, where they continued to forage throughout the hottest part of the day (Hinsley 1994). These differences may be related to differences in food availability; when food is abundant, as it is when provided *ad libitum* in captivity, birds can afford to rest for longer periods. Indeed, our captive birds spent substantially less time foraging and more time resting or preening than wild birds (Tab. 1).

The behaviours of captive black-bellied sandgrouse through the middle of the day, when temperatures generally exceeded 40 °C, are consistent with previously described behavioural adaptations to reduce or disperse the total heat load during the hottest period of the day, namely reduced activity levels, sheltering in the shade, and gular fluttering (Thomas & Robin 1977, Thomas & Maclean 1981, Thomas 1984a). Several behavioural studies confirmed that the sandgrouse activity patterns in the wild are closely dependent on air temperature and time of the day (Thomas & Robin 1977, Thomas & Maclean 1981, Thomas 1984a).

Our captive black-bellied sandgrouse spent more time preening and dustbathing (25% of the day) than those observed in the wild in either Spain (11%) or Israel (7%) (Hinsley 1994). This may be due to captive birds having either more time available for self-maintenance activities, or higher ectoparasite infections. In the wild, dust-bathing has also been observed following wading and drinking, apparently for the purpose of drying the body feathers (Johnsgard 1991). In our study, most dust-bathing was not related to plumage drying, suggesting that it is an important component of feather care even in the absence of feather wetting.

Observations on the social behaviours of sandgrouse are still surprisingly limited, despite several species having been successfully bred in captivity in recent years. In the wild, all sandgrouse species are reported to be apparently monogamous (Urban *et al*. 1986, Johnsgard 1991). Yet, our captive black-bellied sandgrouse switched mates relatively frequently and stable pair-bonds were not identified. This suggests that monogamy is not the rule in captivity. In this regard, Grueber (*in* Johnsgard 1991) reports that in captivity, a male sandgrouse will apparently copulate with any female that allows it, even when pair-bonded. Apart from one account of a male displaying to a female with tail raised and wings drooping (Gavrin *et al*. *in* Johnsgard 1991), ours are the first observations of the courtship and copulation behaviours of black-bellied sandgrouse.

In contrast to captive double-banded sandgrouse, where both male and female select the nest-site (Hinsley & Hockey 1989), only the female selected the nest site in our captive black-bellied sandgrouse. By contrast to the observations in the wild in West central Morocco in the same species (Znari *et al*. 2008), nests were never well delimited with objects (i.e., feathers, bits of dry plants, small stones and shells) scattered around it. Change in the nest position could be due to the simulated predation (i.e.; egg pulling). These could be considered as artifacts related to the captive environment conditions.

Daily behavioural routines of the black-bellied sandgrouse in a captive environment are in conformity with the behaviour of their wild conspecifics. Time budget study carried out in Spain and Israel, revealed that foraging and day inactivity occupied the major part of daylight hours, a total of 75% in black-bellied, pin-tailed and spotted sandgrouse (Hinsley 1994). On the other hand, captive black-bellied sandgrouse spent less time in day inactivity and foraging, respectively 28% and 30% (a total of 58%). This decrease in time spent in foraging by captive bird, which is concomitant with the increased day inactivity and preening, could be related to the high food availability in captivity.

In the present study, the alert behaviour in captive black-bellied sandgrouse was not sex-dimorphic as in flocking Galliforms such the grey partridge *Perdix perdix* (Dahlgren 1990, Fusani *et al*. 1997). Captive birds spent more time standing alert (7%) than wild birds, 2% and 3% respectively in Spain and Israel (Hinsley 1994). This could be related to the higher level of disturbance from human activities in the captive environment; although people were out of the sight, noises were sometimes intrusive.

In this work, the frequency of occurrence of social behaviour in captivity was similar to that reported in the wild (1.3% *vs*.1%) (Hinsley 1994) despite of the interactions (especially aggressions) between birds kept in group within a restricted space in the aviary compared to the pairs spreaded out throughout an unlimited open stepparian area during the breeding season.

We conclude that, in spite of the permanent availability of food and water, and some disturbance due to the human activities, which are the artificial aspects of the captive environment, the behaviours of captive black-bellied sandgrouse, but not activity-time budget, are roughly similar to those reported for wild birds. Finally, we advise that designs of sandgrouse captive breeding facilities, one should provide suitable microhabitats with loose substrates for dust-bathing, multiple refuges for the birds to shelter from the midday sun under, and appropriate undisturbed nesting sites in the edges of the aviary. The black-bellied sandgrouse seems to be a good candidate for captive breeding due to its high adaptability to the captive conditions.

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Circus pygargus (Dresser 1871-1881)