Pakistan J. Zool., pp 1-8, 2023. **DOI**: https://dx.doi.org/10.17582/journal.pjz/20220923120947

Slope Direction, Elevation and Clutch Size Influences Breeding Success of White-Crested Kalij Pheasant (*Lophura leucomelanos*) in Margalla Hills National Park, Pakistan

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Article Information
Received 23 September 2022
Revised 20 May 2023
Accepted 07 June 2023
Available online 28 August 2023 (early access)

Authors' Contribution
AA and BAR conceived and designed the study. MSA and SA proofread the manuscript. SA helped in field work.

Key words
Breeding biology, Incubation, Kalij Pheasant, Margalla Hills National Park

ABSTRACT

White-crested kalij pheasant (*Lophura leucomelanos*) is endemic to Pakistan and recognized as flagship species of Margalla Hills National Park (MHNP), Pakistan. Data on breeding biology of kalij pheasant in MHNP are not available. Therefore, present study was conducted to document the breeding parameters and influence of slope, aspect, elevation and clutch size on breeding success. Kalij pheasant constructs nests with needles of chir pine *Pinus roxburghii* (65% by mass), oak leaves *Quercus incana* (20%), sticky hop bush (sanatha) *Dodonaea viscosa* (5%) and munj sweetcane (Sarkanda) *Saccharum bengalensis* (5%) on ground and can be found in natural vegetation viz., phulai *Acacia modesta,* sticky hop bush, Indian olive *Olea ferruginea,* shisham *Dalbergia sissoo* and boxwood *Buxus papillosa.* Breeding takes place in February to June and clutch size of 6.42±0.30 eggs was recorded. Hatching success were recorded the highest in nests with seven-egg clutches (52.57%). Multiple regression analysis shows that slope and elevation influence (P<0.05) nesting success. Kalij pheasant constructs a greater number of nests on north facing slopes at higher elevation as compared to south facing slopes. Only female incubated and brooded the eggs, eggs were hatched synchronously after 24.12 ± 0.07 days of incubation. Breeding success was recorded as 45%. Daily nest survival probability (0.992) and total survival probability were recorded 0.833 for kalij pheasant. Mongoose *Herpestes javanicus* and Jackal *Canis aureus* predated eggs. It is concluded that breeding activities of kalij pheasant are in good state. Slope, elevation and clutch size influence the breeding success. This is the first ever report on the breeding status of kalij pheasant in Pakistan.

INTRODUCTION

White-crested kalij pheasant *Lophura leucomelanos* is a member of genus *Lophura,* which includes twelve species of the pheasant called Gallopheasants. Nine sub-species of kalij pheasant have been documented worldwide (Fuller and Garson, 2000). In Pakistan, only white-crested kalij pheasant *Lophura leucomelanos hamiltonii* is present. White-crested kalij pheasant is a flagship species of the Margalla Hills National Park, Pakistan.

Kalij pheasant is distributed in Northern parts of India, Kashmir, some areas of Western Nepal, Bhutan, Bangladesh, Myanmar, Thailand, China and United States. In Pakistan, it extends from Siran and Kaghan valleys in Hazara region into Margalla Hills National Park (Roberts, 1991). Although current conservation status of this unique bird is Least Concern according to IUCN red list of threatened species (BirdLife, 2021), it has not been assessed at sub-species level. This species is facing many threats in its distribution range like climate change, recreational activities in parks, urbanization and deforestation (Amjad *et al*., 2011).

Kalij pheasant is either polygamous or monogamous. Only the female takes part in incubation and makes nests

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0030-9923/2023/0001-0001 $ 9.00/0

on ground (Ali and Ripley, 2007). Breeding season spans from March to June but it may change with altitude. Female kalij lays 7-10 eggs per clutch and incubates eggs for 24-25 days (Wayre, 1969; Johnsgard, 1986). Males have no role in protection of nests (Baker, 1930). Only the female incubates and provides defense from predation and weather (Sharma and Chandola-Saklani, 1992). Flight feathers of chicks grow very rapidly and within few hours, chicks are able to walk with their parents (Baker, 1930).

During October till December, these birds form a group of ten to twelve individuals but after January onward, birds are seen in pairs consisting of two to three females with one male (Gaston *et al*., 1981). Males are territorial and use loud drumming call for the advertisement (Baker, 1930). Kalij pheasant also produces some other types of vocalization besides territorial calling. Both sexes produce squealing whistle when alarmed.

Breeding biology of the species is affected by several factors such as predation risk, nesting material, landscape, food availability and selection of site for the nest (Newton, 1998). Any change in abiotic factors results in change in breeding biology of the species (Hughes, 2000). These changes can only be detected through long term observations (Sutherland, 1996; Newton, 1998; Thiollay, 2000). Several studies reported that breeding and nesting parameters differed due to habitat and landscape (Brooks, 2013). Moreover, clutch size influences the breeding success in various non-passerine species (Corbacho and Sánchez, 2000). To our knowledge, breeding biology of kalij has never been studied in Margalla Hills National Park, Pakistan. Therefore, present preliminary study was designed to record the breeding biology and influence of slope, elevation, aspect and clutch size on breeding success of kalij pheasant in Magralla Hills National Park, Pakistan from February 2020 to August 2021.

MATERIALS AND METHODS

Study area

Thirteen potential sampling sites were selected on the basis of presence of birds in the near vicinity or nests in MHNP (Fig. 1). MHNP, (33°43'N, 72°55'E). MHNP is located at the foothills of the Himalayas and comprises area of 17.38 km^2 and is about 456-1580 m above mean sea level (amsl). Vegetation on the southern slope includes shrub growth and deciduous trees while northern slopes support subtropical chir pine forest; chir pine *Pinus roxburghii* and ban oak *Quercus incana* being the dominant tree species (Shinwari and Khan, 2001). Annual temperature ranges between 16 to 40°C during summer and 3 to 24°C during winter. Average annual rainfall recorded at Islamabad is 1457mm of which 1200mm is received during July to August (Masud, 1977; Shinwari and Khan, 2001).

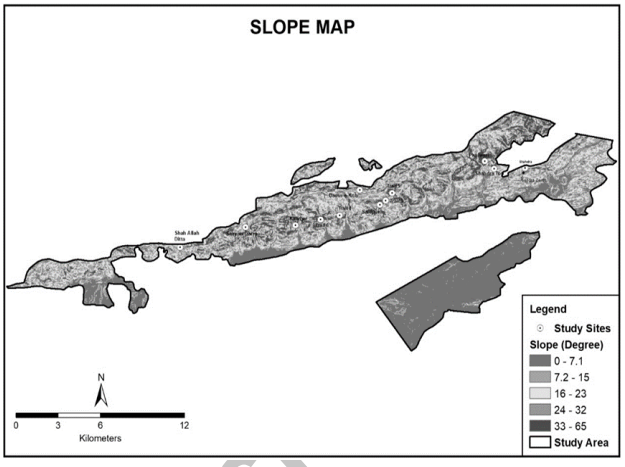

Fig. 1. Slope Map of Margalla Hills National Park, Pakistan showing location of study sites.

Study design

A reconnaissance survey was conducted to select potential sampling points for collection of data on breeding biology of kalij pheasant in MHNP, Pakistan. Based on reconnaissance survey, 13 potential study sites were selected on the basis of presence of the pheasant in near vicinity, accessibility of the area and location of nests. Five line transects 100m long and 50m wide were established in each study sites from February 2020 to August 2021 (until no newly built nests were found). Nests were located by following individual bird, observing their breeding behavior (mating, courtship) or with the help of wildlife watchers. Located nests were marked by GPS (Garmin eTrex 10) as active (nest with a female, eggs or fresh droppings). Once the nests were located, regular monitoring of the nests was done before the egg-laying period twice in a week (early morning) to record data on the onset of breeding season, nest size and structure, number of eggs, vegetation at nest site, clutch size, breeding success and egg losses without disturbing the bird (Martin and Geupel, 1993). Eggs were handled while wearing gloves (Soler *et al*., 1998). Electronic LCD digital vernier caliper was used to measure length and width of eggs. Nest material was noted while recording the breeding data.

The breeding success was computed by the formula:

$$\text{Breeding success} \frac{\text{Number of fledglings}}{\text{Total number of eggs}}$$

Collection of habitat data

Several sources were used for collection of habitat data at each point. Digital elevation model (DEM) file of the study area was downloaded from (https://earthexplorer.

usgs.gov). DEM file was used for recording the aspect, mean elevation (m) and slope (degrees) with the help of ArcGIS version 10.2.

Daily cavity survival

Each nest was visited after every two days for recording data about daily nest survival probability. Data about broken eggs, hatchling loss and nest abandonment were recorded. Mayfield's (1975) method was used to calculate daily survival probability.

Daily survival probability = 1 – (total no. of failed nests ÷ total no. of exposure days)

The total survival probability= daily survival probability nesting period

Predation

The predation to eggs of kalij pheasant was recorded by utilizing following criteria. (a) unhatched: not having broken to release the fully developed young one (b) predated: when the eggs disappeared from the nest with no indication of chicks, (c) abandoned: when parents were absent from the nest all day, or there were no female kalij pheasant footprints on any side of the nest (d) hatched: when one or more eggs hatched.

Statistical analysis

The data were organized by calculating percentages, mean and standard errors using MegaStat® 10.1 (Orris, 2002). The data on nest diameter and inner depth of nests were presented as Mean±SEM. Materials used by kalij for nest construction were presented as percentages. Weight of eggs and weight of nest material was calculated using digital electronic weighing balance (Cubis® II Micro Balance). Multiple linear regression analysis was calculated using SPSS® versions 16.0 (SPSS Inc., Chicago, Ill., USA) to check the effect of aspect, slope and elevation on nesting success, keeping nesting success as the dependent variable and aspect, slope and elevation as independent variables. Mean length and width of eggs was calculated using electronic LCD digital Vernier caliper (MODEL: 100502-462) and presented as Mean±SEM. Correlations among egg weight, egg dimension, incubation period and hatching success were calculated utilizing Pearson's correlation test using SPSS® versions 16.0 (SPSS Inc., Chicago, Ill., USA). The data about breeding success and egg loss were presented as percentages.

RESULTS

Breeding biology of kalij pheasant was recorded from end of February to early July in Margalla Hills National Park, Pakistan. A total of 42 nests were located and observed for breeding success from 2020 to 2021. These nests were found at elevation range of 615-885m amsl. Only females incubated the eggs while males were never seen around nests within 10 m area for all nests. In all monitored nests, it was observed that during early morning, the female left the nest for foraging for one hour. After hatching, chicks stayed in the nest without feeding for one day. No multiple nesting attempts by the same female within a season were recorded.

Nidology

Nest construction activities by female kalij were not recorded because they collected materials while hiding themselves. Once the nest was constructed, all measurements and materials used for its construction were analyzed, when female kalij went out for searching food in early morning. All nests were concealed in bushes to avoid predators. The data on nest measurements included: nest diameter 181.8 ± 2.35 mm and inner depth 65.61±2.4 mm are given in Table I. Nests were constructed by chir pine needles (65%), oak leaves (20%), sticky hop bush (5%), munj sweetcane *Saccharum bengalense* (5%) and undifferentiated materials (5%) (Table I, Fig. 2). Nests were found in areas having vegetation of phulai, sticky hop bush, Indian olive, shisham and boxwood.

Table I. Dimensions of nests and nest materials (%) of kalij pheasant in area of Margalla Hills National Park, Pakistan (N=42).

	Mean ± SEM (mm)	Range
Diameter	181.8± 2.35	175.26-187.96
Inner depth	65.61±2.4	58.42-73.66
Nest materials (%)	Chir pine	65%
	Oak leaves	20%
	Sticky hop bush	5%
	Munj sweetcane	5%
	Undifferentiated materials	5%

Effect of slope, aspect and elevation on nest site selection

The data on the effect of slope, aspect and elevation on nest site selection and breeding density are given in Table II and Fig. 3. North-facing slopes were a significant predictor of kalij pheasant nesting density in our study. Twenty-six nests were found on north facing slopes and only 16 nests were on south facing slopes (N=42, Fig. 3). Elevation had significant effect on nest placement and a greater number of nests were recorded at higher elevation (twenty-six) as compared to low elevation (sixteen).

Fig. 2. Nest with eggs of kalij pheasant in area of Margalla Hills National Park, Pakistan.

Table II. Multiple linear regression analysis of nesting success, aspect, slope and elevation keeping nesting success as the dependent variable and aspect, slope and elevation as independent variables.

	Coefficient	S.E	T	P
Constant	-1.689	0.697	-2.425	0.042
Aspect	0.026	0.0234	1.139	0.288
Slope	.120	.076	1.580	.0.003
Elevation	.000	.003	.093	0.002

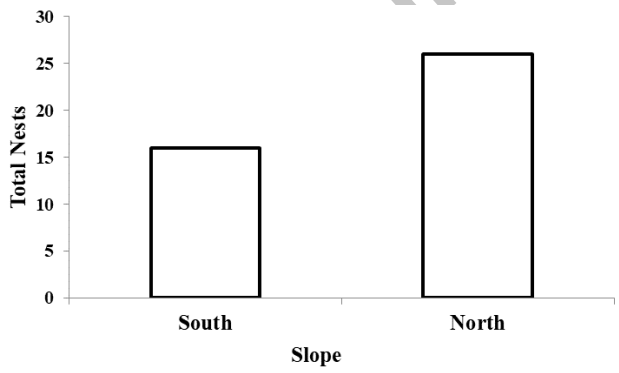

Fig. 3. Total number of kalij pheasant's nests located on South [16] and North [26] facing slopes during breeding seasons in MHNP.

Egg measurements

A total of 240 eggs were found in 42 nests in the study area. Eggs were of pale cream color and pointed from one end (Fig. 2). Surface texture of most eggs was smooth, while few eggs had rough texture. Mean dimension of eggs was recorded as 1769.8±15.75 mm^2 with mean length 50.18±0.42 mm, mean width 35.27 ± 0.31 mm and mean weight 28.79±0.16 g (Table III, Fig. 4).

Table III. Dimensions of eggs of kalij pheasant in area of Margalla Hills National Park, Pakistan.

	Mean ± SE	Range
Mean dimension (mm^2)	1769.8±15.75	1717.94-1811.07
Mean length of eggs (mm)	50.18±0.42	47.96-51.10
Mean width of eggs (mm)	35.27±0.31	34.12-36.42
Mean weight of eggs (g)	28.79±0.16	27.91-29.17

Fig. 4. Measurements of eggs of abandoned nests of kalij pheasant using digital Vernier caliper.

Breeding success

A total of 240 eggs were counted in 42 nests during survey of different study sites. Kalij pheasant has a clutch size of 6.42±0.30 (Range: 5-7 eggs) eggs. Most nests contained clutches of 7 eggs. Hatching success was recorded the highest in nests with seven-egg clutches (52.57%) while nests with five-egg clutches had the lowest hatching success (36.76%) (Fig. 5). Overall breeding success was recorded as 45%. Eggs were hatched synchronously after 24.12±0.07 days of incubation and after hatching successful nestlings left the nest. Egg weight, egg dimension and incubation period were negatively and non-significantly correlated with hatching success

(Pearson's correlation coefficient r = -0.103, P = .226, n = 240; Pearson's correlation coefficient r = -0.114, P = .181, n = 240; Pearson's correlation coefficient r = -0.001, P = .986, n = 240).

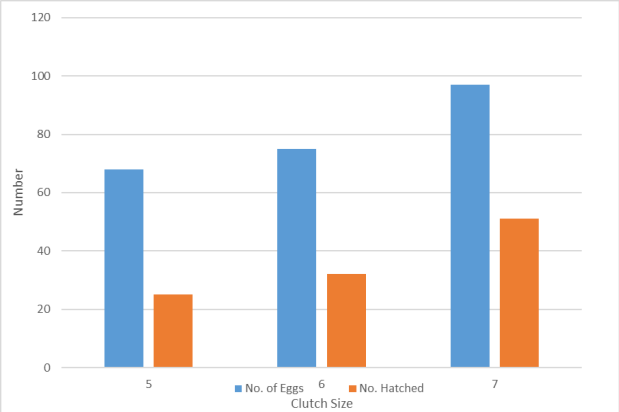

Fig. 5. Total no. of eggs and eggs hatched in different clutch sizes of Kalij in MHNP, Pakistan.

Daily nest survival

Daily nest survival probability was recorded as 0.992. The total survival probability during surveys was 0.833. Nest survival is the probability that a nest fledges at least one young.

Egg losses

The data on egg losses are presented in Table IV. Out of 240 eggs, 17% eggs were un-hatched, 18% eggs were predated and 20% eggs were abandoned because incubating females went out during incubation and did not return at nests. Mongoose and jackal predated on eggs.

Table IV. Egg losses of kalij pheasant in Margalla Hills National Park, Pakistan.

	Number	%
Number of eggs found	240	100
Un-hatched	41	17
Predated	44	18
Abandoned nests	47	20
Hatched	108	45

DISCUSSION

White-crested kalij pheasant breeds between February and June. Our results are in agreement to previous studies that suggested that kalij pheasant bred between March and June (Gaston *et al*., 1981). However, Johnsgard (1986) reported that breeding season of white-crested kalij was from February to October but mainly in April and May. Zeng *et al*. (2016) reported that nesting period of kalij in Hawaii could extend into July. The variation in breeding months may be due to different climatic conditions. In the present study, it was recorded that only female incubated the eggs. Ali and Ripley (2007) also supported this finding that only female kalij incubated eggs. Zeng *et al*. (2016) studied 17 nests of kalij in Hawaii and revealed that male kalij were not present near 5m from nests and only females took part in incubation. However, Baker (1930) observed male kalij with small chicks after hatching with no female, which indicating that after hatching, the male rejoins family group. Bump and Bohl (1961) stated that kalij inhabited elevation from 400m to 3,300 m that supported the present study.

Kalij pheasants build nests with needles of chir pine and leaves of oak. Different types of plants were present around nests. These included phulai, sticky hop bush, Indian olive, shisham and boxwood. In a study conducted by Sambandam and Viswanath (1992) reported *Quercus leucotrichophor, Litseae umbrosa*, *Lyonia ovalifolia*, *Rhododendron arboreum* and *Q. glauca* as major tree species present around nests of kalij pheasant in Kedarnath Wildlife Sanctuary, India. The different tree species around nests were due to different habitats.

In current study, elevation and slope had significant effect on nest placement. More nests were found on north facing slopes at higher elevations. This might be possible due to variation in habitat, associated leaf-litter characteristics and composition of tree species (Crosby and Loomis, 1974; Schwilk and Caprio, 2011; Kreye *et al*., 2013; Vitz *et al*., 2013) potentially providing better nesting material for kalij pheasant on North-facing slopes. Leaves from tree species present in North-facing slopes (e.g., oaks) provide a drier, more loosely compacted litter layer as compared to South-facing slopes e.g., phulai, sticky hop bush, Indian olive etc. (Crosby and Loomis, 1974). There may be thermoregulatory benefits for ground nesting species to orient nest towards north. Higher ambient temperature during the whole day provides advantage about time spent on brooding on nest or foraging away from eggs (Conway and Martin, 2000).

Sambandam and Viswanath (1992) investigated eight pale cream-colored eggs of kalij pheasant in Kedarnath Wildlife Sanctuary, India that supports current study. However, in contrast to present study; Zeng *et al*. (2016) measured length of kalij eggs 46.9 ±1.52 mm, width 35.3 ± 0.90 mm and weight 32.9 ± 1.21g. You *et al*. (2009) reported variation in egg size, length and weight due to age, experience of reproductive female and physiological or nutritional constraints.

Mean cutch size of kalij pheasant recorded during present study was 5-7. Eggs were hatched synchronously after 24.12 ± 0.07 days of incubation. Hatching success of kalij pheasant recorded was 45% with higher hatching success having clutch size 7. Findings of present study are in agreement to previous studies that reported clutch size of kalij pheasant range from 6-9 (Fitter, 1971). Baker (1930) reported 4-10 eggs per clutch of kalij pheasant. Ali and Ripley (1978) reported 14 eggs in one nest of kalij pheasant that was thought to be eggs of more than one female. In captivity (Dhodial Pheasantry Mansehra, 2005), 25 clutch size was reported which might be due to balance diet and large size of aviary. Zeng *et al*. (2016) in Hawaii reported large clutch size of kalij 7.47 ± 2.24 eggs in 17 nests while there were 13 chicks in a single brood. According to Howman (1993), clutch size of kalij generally ranged from 9-15 in aviaries. Corbacho and Sánchez (2000) reported higher hatching and breeding success from larger clutches in Montagu's harrier *Circus pygargus*, regardless of any conservation measures. It was suggested that clutch size gave a direct measure of parental investment in reproduction, which in turn affects the breeding success (Arroyo *et al*., 1998). Previous studies noted linear relationship between clutch size and the energy available per offspring and as a result a direct relationship between clutch size and probability of survival (Goodnight and Rosenthal, 2019). It was also believed that clutch size depended on the availability of food resources; large clutch size occurs when excessive amount of food is available and easy to obtain (Vijayan, 1980). Wayre (1969) and Johnsgard (1986) reported 27 days' incubation period in kalij that could vary with elevation and temperature. Zeng *et al*. (2016) in Hawaii reported that chicks of kalij hatched after ~25 days. Baker (1930) concluded that at high temperature, incubation period of kalij might shrink to 20 days whereas at higher altitude and in cooler areas, it may extend to as long as 24 days.

During the present study, abandoned nests were the major cause of low hatching success (20%). In current study, common predators of kalij pheasant recorded during surveys were Mongoose and Jackal. According to Shahabuddin *et al*. (2016), cats and common crow *Corvus splendens* were major nest predators of common pheasants in Europe while Zeng *et al*. (2016) in Hawaii described mongoose, feral cat (*Felis catus*), Hawaiian hawk (*Buteo solitarius*), Hawaiian short-eared owl (*Asio flammeus sandwichensis*), barn owl (*Tyto alba*) and domestic dog (*Canis familiaris*) as major predators of kalij adult, eggs and chicks in Hawaii. Furqan and Ali (2022) reported forest fires as the major factor for population decline of kalij pheasant followed by hunting, habitat destruction and natural predators. The mayfield estimator showed that daily survival probability and total survival probability of kalij pheasant was 0.992 and 0.833 respectively. Thompson *et al*. (2001) and Armstrong *et al*. (2002) observed that daily survival estimation was necessary component of avian demographic modeling and revealed maximum likelihood of nest survival in different areas of distribution. Rakha *et al*. (2021) recorded low nest survival of rose-ringed parakeet *Psittacula krameri* in Margalla Hills National Park 0.70 ± 0.1 due to high rate of predation.

It is concluded that Margalla Hills National Park provides favorable sites for nesting of kalij pheasant. Breeding season of kalij started from March and continued till June. Only females took part in incubation. Larger clutches have higher breeding success. Kalij pheasant prefers nesting on northern slopes at higher elevation as compared to southern slopes and lower elevation. This is the first ever report on the breeding status of kalij pheasant in Pakistan.

ACKNOWLEDGEMENTS

Authors are thankful to Higher Education Commission, Pakistan for providing financial support for conducting this research study under Indigenous 5000 PhD Fellowship Scheme Phase II - Batch V.

Funding

Current study was supported by Higher Education Commission, Pakistan through financial support under Indigenous 5000 Fellowship Scheme Phase II - Batch V.

IRB approval

The current research had been provisionally approved in 49th meeting of Advanced Studies and Research Award held on 11-11-2019 vide Notification No. PMAS-AAUR/DAS/79.

Ethics statement

During present study, birds were not shot. Only field data has been collected as per specified guidelines. Non-invasive technique was used for data collection which does not require any special permits and hence meets the standards of science ethics.

Statement of conflict of interest

The authors have declared no conflict of interest.

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