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Research **OPEN ACCESS**

Breeding behavior and chick development of king bird-of-paradise (*Cicinnurus regius*) at Bird Park Jagat Satwa Nusantara

Ade Basyuri*, Muhammad Piter Kombo, Wahyu Nalendra Akbar, Caesar Rizal Kurniawan Gusti, Ady Kristanto, Muhammad Fardhan Khan, Arisa Mukharliza

Jagat Satwa Nusantara Zoo, Taman Mini Indonesia Indah, East Jakarta, Jakarta, Indonesia

Abstract

Background The king bird-of-paradise (*Cicinnurus regius*) is endemic to Papua and Papua New Guinea's lowland rainforests. Its population declines due to habitat loss from deforestation, illegal hunting, and trafficking. As a protected species, urgent conservation efforts are needed. Ex-situ breeding programs can support its long-term survival.

Objective The present study analyzed breeding behavior patterns, including maternal care, feed palatability during breeding and non-breeding phases, environmental factors that influence breeding success, and chick development.

Methods The research employed purposive sampling and instantaneous sampling techniques. Observations were conducted on maternal behavior, feed preference, and environmental conditions (temperature and humidity) within the enclosure, and chick development to obtain comprehensive data on breeding activities.

Results Maternal care behavior: dominated by the flying (36.44%), perching (33.78%), and the parent feeding the chick (7.98%). Feed palatability: highest for crickets (92.4%) during the breeding phase and weaver ant eggs (100%) during the non-breeding phase. Environmental factors: cage temperature ranged from 27°C–29°C with humidity levels between 89%–91%. Observation of maternal behavior, feed palatability, and environmental factors resulted in healthy chick development, as evidenced by the chick's ability to leave the nest and begin reaching for its food at 17 days of age.

Conclusion The findings highlight the critical role of maternal care, high-quality feed, and stable environmental conditions in supporting the successful breeding and healthy chick development of the king bird-of-paradise (*C. regius*) in captivity. This study contributes valuable knowledge to strengthen ex-situ conservation strategies for this protected and ecologically significant species.

Keywords birds-of-paradise | breeding behavior | breeding control program | ex-situ conservation | feed palatability

Introduction

The king bird-of-paradise (Family Paradisaeidae) represents one of the most intriguing groups of avifauna on the planet, characterized by its distinctive morphology, vivid coloration, and intricate mating behaviors (Beehler, 1983). One species of particular interest is the king bird-of-paradise (*Cicinnurus regius*), which is endemic to the lowland rainforests of Papua New Guinea and other small islands in Indonesia, such as Waigeo, Batanta, and Misool Island (Beehler & Pratt, 2016). This species exhibits significant sexual dimorphism, with males characterized by bright red, metallic green feathers and a circular tail that is utilized in mating rituals. In contrast, females display more muted coloration, which serves to enhance their camouflage (Raunsay *et al.*, 2023). Males engage in "lekking", a behavior involving the display of movements and plumage in a designated arena to attract potential mates. Females will select mates based on the quality of these displays (Uy & Endler, 2004; Laman & Scholes, 2012). Despite being classified as "Least

***Corresponding author** Email: adebasyuri27@gmail.com

Concern" by the IUCN Red List (BirdLife International, 2023), the population of king bird-of-paradise continues to decline due to deforestation, increasing threats from illegal poaching for their feathers, involvement in traditional rituals, and illegal trade. In Indonesia, the bird-of-paradise species are subject to protection under the authority of the Ministry of Environment and Forestry Regulation No. P.106/MENLHK/SETJEN/KUM.1/12/2018, which prohibits all forms of hunting and trade in the absence of the requisite official permits (Ministry of Environment and Forestry, 2018).

Previous studies on king bird-of-paradise have predominantly focused on ecological aspects, distribution patterns, and mating behavior in natural habitats (Frith & Frith, 1993; Dalziell *et al.*, 2013). However, data concerning aspects of reproduction in captivity, such as parental care patterns, food preferences during the breeding and non-breeding phases, and the influence of environmental factors on reproductive success, remain very limited (Cita *et al.*, 2016). Therefore, this study provides preliminary data on reproductive success in captivity, including hatching success and chick survival, in the king bird-of-paradise (*C. regius*). This information serves as a critical guide in supporting ex-situ conservation, providing important strategies for maintaining species sustainability despite the threat of habitat degradation (Martin & Bateson, 2007). Furthermore, the diet of the king bird-of-paradise possesses an omnivorous diet, which includes consuming fruit, nectar, and small insects, has been shown to affect its health and reproduction (Mack & Wright, 1996). Research on the palatability of feed in captivity can facilitate the optimization of nutrition, thereby enhancing chick survival rates and breeding success.

Monitoring the development of chicks is also a critical aspect of breeding programs. As altricial birds, king bird-of-paradise chicks are born helpless and require intensive care from their parents to survive (Kurniawan & Arifianto, 2017). It has been shown that environmental factors, including cage temperature and humidity, play a critical role in the development of both embryos and chicks (Rahn *et al.*, 1977). This study aims to address the existing knowledge gap by examining the factors that influence the successful breeding of the king bird-of-paradise at Bird Park Jagat Satwa Nusantara. These factors include Maternal care behavior, feed palatability, reproduction, and chick development. The results of this study are expected to serve as a basis for practical guidelines for breeding management, increase the success rate of ex-situ population breeding, and support in-situ conservation efforts, including the potential for reintroduction to their habitat. Thus, this study can contribute to the conservation of species that have high ecological, cultural, and aesthetic value, while strengthening Indonesia's commitment to global biodiversity conservation.

Methods

Location and Date

The research was conducted at the Bird Park Conservation Center, Jagat Satwa Nusantara, Taman Mini Indonesia Indah (TMII), East Jakarta, Indonesia, from December 2024 to March 2025. The tools used for data collection included data tabulation paper, a thermos-hygrometer to measure temperature and humidity, measuring tapes, a writing instrument, an action camera to record behavior, and a watch to record observation times. The subjects observed were king bird-of-paradise (*C. regius*), food scraps, and the cage environment.

Research Subjects

The subjects of the research are the female parent bird and the chick of the king bird-of-paradise (*C. regius*). The selection of the birds was based on the presence of certain health and reproductive criteria. The assessment was conducted by the education, conservation, research, and health divisions.

Data Collection Methods

The technique utilized for the observation of parental care behavior was purposive sampling and instantaneous sampling (Martin & Bateson, 2007). This approach involved the observation and recording of the types of parental care behavior demonstrated by the subject toward their offspring. The observation was conducted from 6:00 to 18:00 (UTC+7), with changes in behavior recorded every 5 minutes, starting from the onset of nest construction for 7 days, followed by behavioral observation during the incubation period (15 days) and chick-rearing behavior for 36 days. Feed palatability was measured by weighing the amount of feed given and the residual feed during the breeding phase (during brooding or nurturing for the chicks) and the non-breeding phase (outside breeding period). The feed used in this study included crickets, mealworms, weaver ant eggs, bananas, papayas, and a concentrate pellet. These items were selected based on their natural preferences as an omnivorous bird (Beehler, 1983). The cage temperature and humidity were measured three times a day (08:00, 12:00, and 16:00) using a thermo-hygrometer to ensure representation of environmental conditions. The development of the chicks was observed through a combination of camera recordings and direct observation, with the focus on three aspects: feather growth, motor skills, and independent behavior.

Data Analysis

The data collected were calculated according to the respective formula below, and used to assess the stability of the cage environment.

a. Parent care behavior towards offspring

$$\text{Behavior} = \frac{\text{frequency of behavior per day}}{\text{total frequency of behavior per day}} \times 100\%$$

b. Feed palatability (Widiarti, 2008)

$$\text{Palatability} = \frac{\text{amount of feed given} - \text{feed consumed}}{\text{amount of feed given}} \times 100\%$$

c. $$\text{Humidity (\%)} = \frac{\text{total humidity data}}{\text{all data}}$$

d. $$\text{Temperature (°C)} = \frac{\text{total temperature data}}{\text{all data}}$$

Results

Enclosure Environment

In this study, the cage measured 254 cm x 125 cm x 222 cm (**Figure 1A**) and was designed to resemble the natural habitat of the king bird-of-paradise with artificial vegetation such as branches and plants (**Figure 1B**). The cage temperature ranged from 27°C–29°C, with an average of 28°C, while the humidity ranged from 89%–91% (**Table 1**). The size and design of the enclosure were considered adequate to maintain the natural movement and mobility patterns of the female parent of the king bird-of-paradise, while still allowing it to remain focused on caring for its offspring.

Parental Care Behavior of King Bird-of-Paradise

The majority of maternal care behaviors were exhibited by the female parent, either flying (36.44%) or perching (33.78%) (**Table 2**).

Table 1 Humidity and temperature measured in this study

Parameters	Average		
	Morning	Afternoon	Evening
Humidity (%)	89	91	90
Temperature (°C)	27	29	28

Table 2 Maternal care behaviors observed in the study

Maternal care behavior	Percentage (%)
Parent flying	36.44
Parent perching	33.78
Parent feeding chick	7.98
Parent brooding chick	6.12
Parent feeding	5.32
Parent grooming chick with beak	5.32
Vocalization	2.93
Parent monitoring surrounding & check on the chick's condition	2.13
Total	100

Feed Palatability of King Bird-of-Paradise

According to **Table 3**, the feed palatability of king birds of paradise during the breeding phase revealed variation in consumption preferences. The feed with the highest palatability level is crickets (92.4%), followed by mealworms (75.8%) and weaver ant eggs (72.4%). Meanwhile, papaya had moderate palatability (52.4%), while concentrate pellet (32.3%) and bananas (27%) showed lower consumption rates, even though bananas were the feed given in the largest quantities. In the non-breeding phase, the king bird-of-paradise showed an altered consumption pattern in comparison with the breeding phase. Weaver ant eggs maintained their status as the primary food source, with a palatability level of 100%.

The second most palatable food was banana (55.2%), while papaya experienced a significant decline (13.8%). The consumption rate of mealworms remains at a relatively high level (42.2%), but this figure was lower than during the breeding phase. The consumption of concentrate pellets was reduced, and crickets were excluded from the diet. This finding suggested that during the non-breeding phase, the nutritional needs of birds were primarily met by energy sources derived from specific fruits and insects. In contrast, there was an increased demand for protein, which could be sourced from mealworms and crickets, during the breeding phase.

Based on **Table 3**, crickets have been shown to have the highest palatability percentage (92.4%) during the breeding phase due to their high protein levels, which range from 56–72 per 100 g (**Table 4**). Meanwhile, mealworm and weaver ant eggs were 75.8% and 72.4%, respectively. Weaver ant eggs contain a high protein content (24.1 g) and a relatively high fat content (42.2 g), making them a potential source of energy for birds. Meanwhile, papaya is lower in energy and protein but contains natural sugar (5.9 g) and fiber (1.8 g).

Reproduction

The breeding period for the king bird-of-paradise in this study spanned from November 2024 to March 2025, during which 16 observations were recorded (see **Table 5**). The sequence of events began with the female building the nest and continued until the chicks were independent and actively flying.

Figure 1 Assessment of the enclosure environment for the king bird-of-paradise (*Cicinnurus regius*) at Bird Park Jagat Satwa Nusantara. (A) Measurement of enclosure dimensions to evaluate available spatial volume; (B) General condition and structural integrity of the enclosure; (C) Characteristics of the enclosure substrate relevant to hygiene, drainage, and animal welfare.

Table 3 Palatability in breeding and non-breeding phases of the king bird-of-paradise

Food types	Binomial name	Breeding phase			Non-breeding phase		
		Given feed (g)	Uneaten feed (g)	Palatability (%)	Given feed (g)	Uneaten feed (g)	Palatability (%)
Banana	*Musa paradisiaca*	64	46.7	27	64	28.7	55.2
Papaya	*Carica papaya*	24.4	11.6	52.4	13	112	13.8
Weaver ant eggs	*Oecophylla smaragdina*	10	2.8	72.4	4.9	0	100
Mealworms	*Tenebrio molitor*	29	7.2	75.8	14.47	8.5	42.2
Crickets	*Acheta domesticus*	5	0.4	92.4	-	-	-
Concentrate pellet	-	10	6.8	32.3	10	7.5	25

Table 4 Nutritional content of king bird-of-paradise feed per 100 g

Nutrient	Banana	Papaya	Weaver ant eggs	Mealworm	Cricket	Concentrate pellets
Energy (Kcal)	109	39	493	475	121	300
Carbohydrate (g)	26.3	9.81	4.3	13	5	48
Protein (g)	0.8	0.61	24.1	47	56 - 72	21
Fat (g)	0.5	0.14	42.2	28	5	5
Fiber (g)	5.7	1.8	4.6	6	13.4	5
Sugar (g)	12.2	5.9	-	0.5	0.5	-
Calcium (g)	0.01	0.023	0.008	2.86	0.155	0.9
Phosphorus (g)	0.03	0.012	0.113	0.98	0.125	0.6
Total digestible nutrients (TDN) (g)	30.16	11.263	61.45	74	25.3	70

In the early stages of this process, the female constructed her nest using materials found in the surrounding area. The nest was built in a plant pot that measured 26 cm in height and 33 cm in diameter. The plant material identified in the pot is andong, also known as green hanjuang (*Cordyline fruticosa*), with an estimated height ranging from 60 to 80 cm. The specimen examined consists of four stems, each measuring between 3 and 5 cm in diameter. The second material used was a suitable quantity of dried pine leaves, arranged in a plastic tray. The base material of the cage consisted of soil mixed with river stones. Additional decorations included wild plants and wooden perches positioned at heights of 170 cm and 120 cm, along with numerous branches of varying diameters.

Chick Development

The development of king bird-of-paradise chicks was observed six different times at various ages (**Figure 2**). Each observation required the documentation of the chick's condition and its characteristics on that specific day. The observations were conducted in accordance with the developmental phases of king bird-of-paradise chicks, starting from hatching and continuing through feather growth and color changes that are similar to their parents.

Table 5 Reproduction period of the king bird-of-paradise observed in this study

Date	Condition	Notes
December 19– 23, 2024	The parents (male and female) start to build a new nest	Beginning of breeding phase
December 24–25, 2024	The nest had begun to form	Breeding phase
December 26, 2024	The nest was fully formed and ready for use	Breeding phase
December 27, 2024	The female laid one egg in the nest and was ready to begin incubation	Breeding phase
December 28, 2024 – January 11, 2025	The female was undergoing egg incubation	Breeding phase
January 12, 2025	The egg successfully hatched, the male was separated to prevent conflict between the female and the male, and the female initiated feeding preparation	Breeding phase
January 13–February 4, 2025	The female provide care and fed the chick	Breeding phase
January 27, 2025	The chick began to leave the nest	Breeding phase
February 5– 17, 2025	The chick began to learn to consume the provided feed types while continuing to be fed by the female	Breeding phase
February 18–March 6, 2025	The chick successfully achieved independent feeding on the provided diet and became actively flight-capable	Non-breeding phase

Figure 2 Post-hatch developmental progression of the king bird-of-paradise (*Cicinnurus regius*) chick during early development, from day 0 to day 17, at Bird Park Jagat Satwa Nusantara. (A) Day 0 (hatching), the chick exhibits a reddish, sparsely feathered body with no developed plumage; the eyes are closed and body size is minimal; (B) By day 3, fine natal down feathers begins to emerge, and the eyes partially open; (C) At day 6, feather growth becomes more pronounced, the eyes open further, and the beak becomes clearly visible; (D) By day 12, primary feathers show substantial growth, the eyes are fully open, the legs increase in strength, and wing development is evident; (E and F) On day 14, the chick begins to leave the nest; plumage is fully developed with coloration resembling that of the parents, and the legs and wings are sufficiently developed to support standing and short movements; (G and H) By day 17, the juvenile leaves the nest in the morning, perches during the day, and remains under parental care.

Discussion

It has been determined that these abiotic factors play a significant role in maintaining optimal physical conditions for the parent birds during the egg incubation period. Temperature and humidity have been identified as environmental factors that play a pivotal role in the successful incubation of king bird-of-paradise (*C. regius*) eggs. The role of humidity in this process is well-documented; it plays a crucial role in preventing excessive evaporation from the pores of the eggs. According to Rahn *et al.* (1977), humidity greater than 80% is required to ensure the maintenance of water balance in eggs during the incubation period, with an optimal range for water loss of 12%–15%. Low humidity (<80%) has been observed to result in the drying out of the egg membrane. In contrast, extremely high humidity (>95%) has been shown to potentially increase the risk of fungal growth, which can negatively impact embryo development. In this study, humidity in the range of 89%–91% provided an optimal environment for maintaining gas and water permeability in eggs, thereby supporting healthy embryo development (Rahn *et al.*, 1977).

The optimal temperature during incubation has been demonstrated to have a significant impact on the development of the embryo. According to the study by Deeming (2002), the standard incubation temperature for birds of paradise typically falls within the range of 28°C–32°C. Temperatures lower than 27°C can slow embryo metabolism, while temperatures above 32°C risk dehydration and embryo death. In this study, temperature fluctuations were maintained within a range of ±1°C during the morning and evening periods, a range that has been shown to minimize thermal stress experienced by parents and eggs. This temperature stability is crucial for sustaining the embryo's metabolic rhythm and enhancing the probability of successful hatching (DuRant *et al.*, 2013).

Compared with a study of the lesser bird-of-paradise (*Paradisaea minor*) at the Bird Park, TMII (Cita *et al.*, 2016), the cage temperature in this study was more stable (±1°C) compared to the 26°C–31°C fluctuations reported for *P. minor*. This stability likely contributed to the successful hatching of king bird-of-paradise eggs, as temperature fluctuations above 2°C can increase thermal stress in embryos (DuRant *et al.*, 2013). Higher humidity (89%–91% in *C. regius* and 85%–90% in *P. minor*) also supported gas and water permeability in the eggs, reducing the risk of membrane drying or fungal growth. The average temperature in Jayapura is 25.3°C. These findings underscore the importance of cage design that mimics the conditions of Papuan lowland rainforests to support ex-situ reproduction.

The behavior of flying and perching by the parent suggests that parents prioritize maintaining a safe position and mobility to ensure the safety of their offspring. Meanwhile, the chick showed perching behavior, implying that the chick commences the process of adapting to their environment while continuing to receive parental supervision. Perching behavior in bird-of-paradise is defined as a passive behavior characterized by remaining still without performing any other activities (Dewi, 2015). During the display of perching behavior, these birds typically sit on a branch with their bodies in a fixed posture and both eyes open. This behavior indicates

one form of natural behavior exhibited by the bird-of-paradise in their natural habitat (Takandjandji *et al.*, 2010). The observed incidence of offspring being fed by parents reached 8.09%, suggesting that feeding was executed competently and that the young had started to acquire the ability to forage for food independently.

A range of behaviors has been identified as contributing to the maintenance of a healthy ecological balance. These include feeding (4.85%) and caring for offspring using the beak (4.85%), which demonstrate a balance between fulfilling the parent's needs and their responsibility to care for their offspring. Vocalization (2.96%) is also a significant form of communication between parent and offspring, while monitoring the surroundings and checking on the offspring (2.15%) reflects the parent's awareness of potential threats in the environment. Despite the minimal prevalence of brooding behavior, which is observed in only 2.16% of cases, it remains a significant component of the early stages of offspring development, preceding their attainment of independence.

The behavior shown by king bird-of-paradise (*C. regius*) parents in caring for their offspring is indicative of the characteristic parenting traits observed in altricial birds. After hatching, king bird-of-paradise chicks are born without feathers, have their eyes closed, and are completely dependent on their parents for sustenance and protection. According to the research conducted by Chen *et al.* (2019), male and female birds of paradise engage in a cooperative parenting strategy, wherein both parents contribute to the care of their offspring. The female bird is typically responsible for the incubation of the eggs and the nurturing of the chicks post-hatching. In the initial phases of development, the chicks remain in the nest for extended periods, receiving substantial care from their parents until they reach a sufficient level of development to depart from the nest. In this study, however, the egg incubation period was divided between male and female birds-of-paradise. Therefore, the chicks were solely cared for by the female during the hatching and rearing period. The separation was determined by an evaluation of the previous breeding period of birds of paradise, which revealed that the male exhibited aggressive behavior by removing the chicks from the nest during the initial week of life.

The characteristic behavior of altricial birds is also evident in the longer development phase of the chicks, in which the parents gradually train the chicks to recognize suitable food and improve their response to environmental threats (Düttmann *et al.*, 1998). Furthermore, the protective behaviors exhibited by parents regarding their offspring's nests are indicative of an adaptive strategy commonly observed in altricial birds. This strategy involves the augmentation of vigilance and the utilization of vocal alarms to mitigate external disturbances (Muralidhar, 2017).

As king bird-of-paradise chicks mature, there is an increased display of motor activity, which is indicative of a transition from complete dependence to the initial stages of independence. As with other altricial birds, this maturation period is marked by improved movement coordination, particularly in wing flapping exercises and balance within the nest before finally attempting to leave the nest (Düttmann et al., 1998). Parents persist in their role as stimulators of behavior, encouraging chicks to interact with their environment. One method employed is to relocate food sources to a greater distance from the nest, thus motivating the chicks to engage in active movement (Pittet *et al.*, 2012).

In comparison to the greater bird-of-paradise (*P. apoda*), which has been observed to exhibit a higher frequency of feeding its offspring (10–12% of total daily behavior) in captivity (Raunsay *et al.*, 2023), the king bird-of-paradise appears to demonstrate a more efficient utilization of energy resources in caring for its young. This difference may be due to the smaller body size of the king bird-of-paradise, which reduces its nutritional requirements compared to larger bird-of-paradise species. Additionally, vocalization (2.49%) and environmental monitoring (1.81%) behaviors indicate adaptive strategies for detecting threats, similar to patterns observed in other altricial birds such as the South Island robin (*Petroica australis*), which increases vocal alarm calls to protect the nest (Muralidhar, 2017).

There are differences in feeding patterns between the two phases (**Table 3**), due to changes in the birds' energy requirements and metabolism. During the breeding phase, birds require a higher protein intake to support egg formation, chick growth, and increased mating and nesting activity (Van Emous *et al.*, 2015). In contrast, during the non-breeding phase, energy requirements tend to be lower due to reduced reproductive activity, leading to higher consumption of energy sources (fruit) than high-protein feeds (insects and mealworms) (Hardin *et al.*, 2021). Furthermore, hormonal shifts have been demonstrated to influence avian appetite and metabolism, potentially contributing to alterations in food preferences (Honda *et al.,* 2017).

Cricket has the highest palatability percentage during the breeding phase, followed by mealworm and weaver ant eggs (**Table 3**). This finding indicates that avian species favour feed with high protein and energy content. Furthermore, the palatability of feed is influenced by its texture and shape, which can affect the ease of consumption and the birds' preference for certain foods (Linz *et al.*, 1995). Papaya is lower in energy and protein, but it has high sugar content and fiber, which gives a sweet taste. The preference for sweet-tasting foods can also be linked to the natural tendency of birds to choose quickly digestible energy sources (Sardesai, 2011).

These results (**Table 3**) are consistent with the findings of research conducted by Cita *et al.* (2016), which indicates that small birds of paradise observed in the Bird Park at TMII and Mega Bird and Orchid Farm (MBOF) during the period of March-April 2015 showed the highest consumption of mealworm and weaver ant eggs, as well as crickets and weaver ant eggs. Buntu (2002) reported that the protein and fat content in live feed is higher, providing energy for the body and a source of fat for the body, feathers, and claws. The live feed possesses a high nutritional content due to its minimally processed composition, which preserves the original nutritional content.

On the other hand, bananas exhibited the lowest palatability score (26.8%), despite their high carbohydrate (26.3 g) and sugar (12.2 g) content. This finding indicates that avian species prefer diets with low carbohydrate content and high protein and fat ratios. Another contributing factor is the soft

texture of bananas, which may be less appealing than foods with a denser texture or higher fat content. The king bird-of-paradise (*C. regius*) exhibits a distinctive feeding behavior that differentiates it from other avian species. As a fruit and insect eater, this bird has been observed to pick up small fruits with its beak, then shake or press the fruit to ease its intake (Beehler, 1983). The fruits consumed typically possess a soft texture, such as papaya or figs, which easily break down into pieces with their small beaks. Furthermore, these birds have been observed actively catching insects in the air or picking them from branches and leaves (Mack & Wright, 1996).

As illustrated in **Table 5**, the following is a detailed discussion of the observation of the reproductive period of the King Bird-of-Paradise. On 25 November 2024, the nest constructed by the female was destroyed. This phenomenon is likely the result of external disturbances or inherent instability in the nest's structural integrity. Recovery efforts were initiated on 19 December 2024 by introducing supplementary materials to the nest to prompt the female to reconstruct the site for egg-laying. Two days later (21 December 2024), the female initiated the reconstruction of the nest, and within three days (24 December 2024), the structural elements of the nest began to manifest. On 27 December 2024, the female commenced oviposition, initially depositing a single egg. However, the next day (28 December 2024), no additional eggs had been added. Following this, the female initiated the process of egg incubation inside the nest. After oviposition, the incubation period is pivotal in ensuring the development of the embryo until hatching. The female parent plays a pivotal role in the care of the chicks, which includes brooding, feeding, and protecting them from predators (Ritchison, 2023).

The first egg finally hatched on 12 January 2025 at 10:50 WIB, thus marking the beginning of the chick care phase. On the same afternoon, the female initiated the process of brooding her chicks. This behavior was observed as a means of maintaining their body temperature and providing protection from potential threats. On the day following the hatching (13 January 2025), the male was separated from the female and chicks to ensure optimal conditions for the offspring, with monitoring performed weekly. On 15 January 2025, the chicks were three days old and still in the intensive care phase with their mother. The female bird's behavior of building and repairing the nest is an adaptive response to environmental disturbances and is important for reproductive success (Kolbe & Janzen, 2002).

The initial observations of physiological development in chicks were recorded on 25 January 2025 and characterized by the emergence of primary feathers, which is an early indicator of morphological maturity (Leeson & Walsh, 2004). On 27 January 2025, the chicks initiated their first departure from the nest, signifying an enhancement in their locomotor capacity and the initial stage of investigating the surrounding environment (Dial, 2003). The first documented instance of flight occurred on 15 February 2025 and continued to increase until 25 February 2025, when the chicks exhibited active and responsive flying behavior. This stage plays a critical role in the post-fledging phase of bird development, as outlined by Starck and Ricklefs (1998). They contend that the development of feathers and the enhancement of motor abilities are significant indicators of successful postnatal development in avian species.

The ecological learning phase was initiated on 2 March 2025 when the offspring engaged in foraging activities, particularly for worms, like their parents. This process suggests that significant social learning has occurred in the development of independent survival skills (Bengtsson & Rydén, 1981). On 6 March 2025, the chicks were separated from their parents as part of an environmental adaptation management strategy (Smiseth *et al.*, 2008). The chicks demonstrated an adaptive response by adapting to the new cage conditions immediately, including the ability to perch independently. On 7 March 2025, the chicks demonstrated sustained levels of activity, thus indicating that they did not experience significant stress due to separation. This finding serves to validate the hypothesis that the initial care phase was successful and that the chicks were adequately prepared to transition to a controlled environment independently. As indicated by Mota-Rojas *et al.* (2023), early experiences and the quality of parental care can directly influence the adaptive capacity and behavioral stability of the chicks.

King bird-of-paradise (*C. regius*) chicks show a significant developmental pattern based on **Figure 2**. On the first day, they have red bodies and no feathers. Their eyes are closed, and their bodies are very small. These characteristics are typical of altricial birds, which require intensive care from their parents (Mock, 2022). By the third day, fine feathers have begun to grow, and the chicks' eyes have opened slightly, signaling the beginning of sensory development important for survival. By the sixth day, the feathers have grown thicker, and the beak is clearly visible, indicating progress in morphological development that supports adaptation to the environment. The chick's development accelerates on the 12th day, marked by significant growth of primary feathers, fully open eyes, and stronger legs. This phase indicates the chick's readiness to adapt to the outside environment. By the 14th day, the chicks have fully grown feathers and a color similar to their parents', and they begin to leave the nest. Their legs and wings are well-developed, enabling them to fly. By the 17th day, the chicks exhibit independent behavior, leaving the nest in the morning and perching on top during the day, though they remain under their parents' care.

Conclusion

The results of the study determined that the abiotic factors for the temperature range were 27°C–29°C and the humidity range was 89%–91%. The behaviors displaying the highest parental care were parents flying at 36.44% and parents perching at 33.78%. In the breeding phase, the highest feed palatability was 92.4% for crickets and 100% for weaver ant eggs in the non-breeding phase. During the breeding phase, there was an increase in the consumption of insect protein. Reproduction and chick development are related to feed palatability and parental care. Incubation and chick-rearing were performed exclusively by the female. At 17 days of age, the chick had left the nest but remained under maternal care, particularly in terms of feeding.

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Availability of data and materials All data are available in the manuscript.

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