*Jurnal Biologi Tropis*

Original Research Paper

# Male and Female Pigeons (*Columba livia-domestica*) Behaviors in Matchmaking Period: Patterns and Interactions

**Anwari Adi Nugroho[1*], Muthia Mardyah[1], Dian Andhi Saputra[1], Sarima[1], Muhammad Nur Hidayad[1]**

[1]Biology Education Departement, Teacher Training and Education Faculty, Universitas Veteran Bangun Nusantara, Sukoharjo, Indonesia;

**Article History**
Received : June 20th, 2025
Revised : July 04th, 2025
Accepted : July 14th, 2025

*Corresponding Author:
**Anwari Adi Nugroho**,
Biology Education Departement, Teacher Training and Education Faculty, Universitas Veteran Bangun Nusantara, Sukoharjo, Indonesia;
Email: anwaribio@gmail.com

**Abstract:** This study explores the social interaction behaviors of domestic pigeons (*Columba livia domestica*) during the matchmaking period. The aim is to understand how multi-channel communication through body movements, vocalizations, and tactile contact affects the formation of pair bonds. This research employed an observational method at the Green House of Universitas Veteran Bangun Nusantara using the ad libitum sampling technique to record daily behaviors of pigeons kept in a confined space. The results revealed that male pigeons predominantly initiate interactions, while females exhibit selective responses that determine mating success. Characteristic behaviors such as bowing, cooing, billing, and allopreening were observed to follow a sequential pattern from orientation and approach to attraction and acceptance. These findings suggest that the intensity and consistency of social interactions significantly contribute to successful pair bonding in domestic pigeons. Future research may investigate hormonal or neurological aspects that underlie these social behaviors.

**Keywords:** Behavior, columba livia-domestica, mating.

## Introduction

Birds represent a diverse group of vertebrates characterized by their ability to fly using wings, although not all species are capable of flight. The diversity of avian species is remarkably high, ranging from large, flightless birds such as the ostrich (Struthio camelus), which can reach a height of up to 213 cm, to very small species like the hummingbird (Trochilidae). In Indonesia alone, approximately 1,500 bird species have been documented, contributing to the global estimate of 8,800 to 10,200 avian species. Among this extensive diversity, certain species are notable for their distinctive behaviors, physiological traits, or ecological adaptations (Dahrun *et al,* 2019; Unwin, 2011).

One of the bird species that is widely appreciated by hobbyists and birdwatchers is the pigeon (*Columba livia*). Pigeons are vertebrates characterized by the presence of wings and feathers, and they spend a significant portion of their lives in flight. A distinguishing feature of pigeons is their exceptional spatial orientation and navigational ability. They are capable of flying at speeds ranging from 65 to 80 km/h and can travel distances of up to 965 kilometers in a single day. Their elegant and aerodynamically efficient flight patterns provide a notable advantage. Beyond their flight capabilities, pigeons are also favored for their ease of maintenance, making them a popular choice among bird enthusiasts (Pranoto *et al*., 2015; Dial, 1992).

The various advantages possessed by pigeons make them attractive not only in terms of their physical appearance and navigational abilities, but also in their potential for domestication and breeding. Consequently, pigeons have become highly sought-after, both as pets and as livestock commodities. Their relatively simple maintenance requirements and the ease of obtaining breeding stock readily

available in bird markets further contribute to their popularity. However, before engaging in pigeon breeding, it is essential to have a comprehensive understanding of their behavioral characteristics. This knowledge is crucial for selecting high-quality breeders, particularly males, in order to produce superior offspring.

A thorough understanding of pigeon behavior requires a scientific approach grounded in the discipline of ethology. Ethology is a subfield of biology that focuses on the study of animal behavior and its underlying causes. Animal behaviors represent their adaptive responses to environmental stimuli and encompass a wide range of activities, including survival strategies, foraging, nesting, social interaction, vocalization, and reproductive behavior (Kadri *et al*., 2016; Syifa, 2022; Fernandez & Lattal, 2025).

In the context of mating behavior, birds exhibit diverse patterns across species. Typically, males perform specific displays or actions aimed at attracting females, who in turn select mates based on traits that signal genetic fitness and health (Kempenaers, 2007; Sardell *et al*., 2014; Cooney et al., 2019). Vocalizations also play a vital role, serving as a means of communication and as an attractant for potential mates. Other behaviors, such as preening, are common self-maintenance activities that help birds maintain feather condition. Social behaviors can be observed in flocking patterns during migration or foraging, providing advantages such as improved navigation and protection from predators. Among these complex social behaviors, matchmaking and breeding behaviors particularly in species like pigeons are of significant scientific interest due to their intricate and coordinated nature.

Pigeons (*Columba livia domestica*) have received notable scientific attention due to their cognitive abilities, navigation skills, and social behavior, making them a model species in ethological research. Prior studies have described general reproductive behavior in birds, but few have conducted detailed observations of pigeon matchmaking interactions in semi-natural settings (Johnston & Johnson, 1989; Zann, 1996; Goodwin, 1983). Recent studies have acknowledged the structured phases of courtship in birds—orientation, approach, attraction, and acceptance (Kroodsma, 1991; Catchpole & Slater, 2008) yet these are mostly descriptive or experimental in design. There remains a knowledge gap in field-based ethological studies focusing on the dynamic, reciprocal behaviors between male and female pigeons during the matchmaking period, especially those incorporating both quantitative (e.g., frequency) and qualitative (e.g., emotional nuance, synchronization) dimensions. This study seeks to enrich that gap.

The matchmaking period represents a critical period in the reproductive cycle of pigeons (*Columba livia domestica*), as it directly influences mating success. This stage encompasses mate selection, the establishment of social bonds, and both physiological and behavioral preparedness for reproduction. Ethological research highlights that behavioral factors, in addition to biological ones, play a pivotal role in determining reproductive outcomes. Pigeons engage in a repertoire of matchmaking behaviors such as bowing, cooing, and specific postural displays that function to attract potential mates and evaluate compatibility (Kroodsma, 1991). Social interactions, including direct face-to-face encounters, have been shown to significantly impact mating outcomes, even in cases of simulated or "sham" mating.

Furthermore, studies suggest that genetic similarity between mating pairs can negatively affect reproductive success due to inbreeding depression, thus underscoring the importance of genetic variability in the mate selection process. Both male and female pigeons exhibit distinct behavioral patterns during matchmaking. Typically, males perform actions such as bowing, herding the female, and presenting nesting sites, while females respond through physical gestures such as pecking the male's head or making body thrusts-signals indicating receptivity (Ware *et al*., 2017; Wang *et al.,* 2023).

These behaviors unfold in a structured sequence rather than occurring randomly. Matchmaking in birds can generally be divided into several phases: orientation, approach, attraction, and acceptance. During the orientation phase, both individuals become aware of each other's presence and begin to display interest. This is followed by the approach phase, where the male moves closer to the female using specific body movements. In the attraction phase,

visual and vocal signals such as cooing and body postures are exhibited. If the female responds positively, the interaction progresses to the acceptance phase, which is marked by intensified communication and the formation of a pair bond.

Communication during this phase includes a variety of signals, such as body movements, vocalizations (e.g., cooing), physical contact (e.g., preening, billing), and nest-building behaviors like carrying nest materials. These behaviors serve multiple functions: attracting a mate, strengthening pair bonds, and signaling readiness to engage in reproduction (Kroodsma & Byers, 1991; Gill, 2007; Catchpole & Slater, 2008).

During the matchmaking period, male pigeons exhibit typical behaviors to attract females. One of the most striking behaviors is "display courting", where the male will puff up his chest, highlight his neck feathers, and walk in a circle around the female while making a distinctive cooing sound. These actions serve to show strength, physical attractiveness, and readiness to mate. Interestingly, the female is not just passive to these behaviors. She will assess the sincerity and consistency of the male's efforts. If attracted, the female will remain near the male, stand still as a sign of acceptance, and then show interest through physical contact such as beak touching (billing). (Kerfoot, E.M., 1964).

Once the initial interaction is well underway, the pigeon pair will proceed to the courtship feeding and grooming stage together. The male will feed food directly from his cache to the female as a symbol of readiness to protect and care for his mate. They also clean each other's feathers, which reflects emotional comfort and the formation of a close social bond. These behaviors show that pigeon pair relationships are not only driven by biological instincts, but also by complex processes of communication and social cooperation. Touching and feeding activities during mating rituals strengthen pair bonding, making pigeons one of the leading examples of lifelong faithful monogamous birds. (Saxena, et al., 2008).

This complex communication system not only facilitates bonding but also illustrates the differentiated roles of males and females in the mating process. In many bird species, males are more proactive, initiating matchmaking through visual and auditory displays, while females take on a more selective role, choosing mates based on the quality of these signals. Female choice plays a central role in sexual selection and has shaped the evolution of reproductive strategies in birds. Hormonal influences, particularly elevated testosterone levels in males, further drive the expression of aggressive and persistent matchmaking behaviors (Andersson, 1994; Gill, 2007; Darwati et al, 2010).

Numerous studies have investigated avian reproductive behavior, particularly in species commonly used as models in ethological and neurobiological research, such as zebra finches and pigeons (*Columba livia domestica*). Johnston and Johnson (1989) found that male pigeons actively approach females using a combination of visual and vocal signals, and that mate selection in pigeons is not a random process. Similarly, Zann (1996) emphasized that mate formation in birds is a complex process involving repeated social interactions prior to copulation.

Despite these findings, there remains a lack of detailed studies specifically examining the form, intensity, and dynamics of male–female interactions during the matchmaking phase in pigeons, particularly those that address both quantitative aspects (e.g., frequency of behaviors) and qualitative aspects (e.g., variations in emotional expression or social responsiveness). This represents a notable gap in the literature, especially with regard to contextual and in-depth analyses of pigeon matchmaking behavior. Addressing this gap is crucial, as many prior investigations have been limited to general observations or experimental settings that may not reflect naturalistic conditions. Therefore, observational studies conducted in field-like or semi-natural environments are necessary to uncover the specific characteristics of matchmaking interactions in pigeons.

Addressing this gap is crucial, as many prior investigations have been limited to general observations or experimental settings that may not reflect naturalistic conditions. Therefore, observational studies conducted in field-like or semi-natural environments are necessary to

uncover the specific characteristics of matchmaking interactions in pigeons. Such research can serve as a scientific foundation for developing more effective strategies in pigeon care, pairing, and breeding, particularly within captive or managed breeding systems (Goodwin, 1983; Shimizu & Bowers, 1999; Adkins-Regan, 2005; Ball & Balthazart, 2010).

The present study aims to describe the various forms of interactive behavior exhibited by male and female pigeons during the matchmaking period and to identify the respective roles each sex plays in the pair-bond formation process. The focus is placed on the direct observation of communicative patterns and behavioral expressions, with the goal of understanding the mechanisms and mutual contributions that underlie successful mate bonding.

This research contributes significantly to the field of animal ethology, particularly in the context of domestic bird reproductive behavior, by offering detailed insights into the matchmaking and social rituals of pigeons. The findings enhance our understanding of pair formation and mating strategies in domesticated avian species, while also providing practical applications for breeders. Observable signs of mating readiness such as chest puffing, head bobbing, and responsive behaviors by females can serve as indicators for optimizing breeding programs, improving reproductive success, and supporting both productivity and animal welfare. Furthermore, the results of this study open new avenues for future research in behavioral biology and applied ethology.

This study also provides a foundation for more advanced research, particularly in examining how environmental, hormonal, or physiological stressors influence avian reproductive behavior. Understanding these factors is crucial for revealing the complex interplay between the nervous and endocrine systems in regulating sexual behavior and mate selection, both in natural ecological settings and controlled laboratory environments. Consequently, this research not only contributes scientifically to the field of ethology but also offers practical insights and a theoretical framework for the development of future interdisciplinary studies (Ball & Balthazart, 2010; Adkins-Regan, 2005).

Specifically, this study seeks to address two core research questions: (1) What are the behavioral characteristics exhibited by male and female pigeons during the matchmaking period? and (2) What are the dominant behaviors observed in this period, and how are roles distributed between the sexes during matcmaking interactions? By addressing a relatively underexplored topic in avian ethology, this research not only enhances theoretical understanding but also provides applied value for animal husbandry and wildlife conservation efforts.

## Research Methods

The research was conducted in the biology green house of Universitas Veteran Bangun Nusantara and was conducted in May until June 2025. This research is an exploratory descriptive research by observing the matchmaking behavior of male and female pigeons directly based on the behavior patterns that occur.

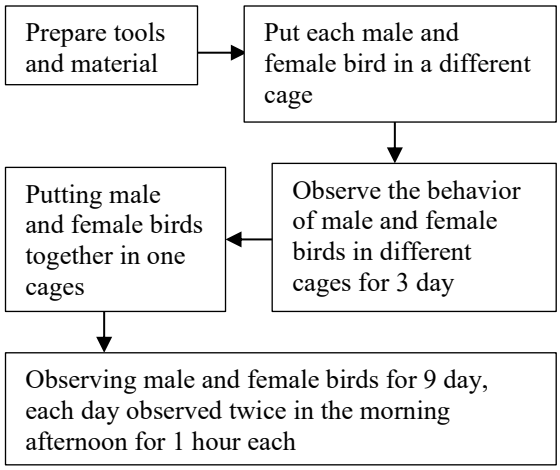


**Figure 1.** Research procedure

Tools used in the study included 2 bird cages, 1 camera, 1 book. Materials used were 1 male and 1 female pigeon. Pigeons used in this study were male and female teritory pigeons. Males and females were about 8 months old with an average size of 32 cm and 35 cm. The method used was the ad libitum sampling method, which is a recording technique that includes all behaviors observed and displayed during the observation process (Sentosa et al, 2012). The activities observed were specifically pigeon activities during the matchmaking period. The

research procedure of male and female pigeon matchmaking behavior pattern can be seen in Figure 1.

The explanation of Figure 1 is as follows: 1) prepare the tools and materials for the study, 2) put the male and female birds in different cages, 3) observe the behavior of the male and female birds in different cages for 3 days, 4) put the male and female pigeons together in one cage, 5) observe the behavior for 7 days. Each day was observed twice, in the morning and afternoon, for 1 hour each. The research design can be seen in Figure 2. Data were collected through observation using observation sheets, field notes, and documentation tools. The data obtained was then analyzed using descriptive method, by describing the various behaviors of male and female pigeons observed during the observation process.

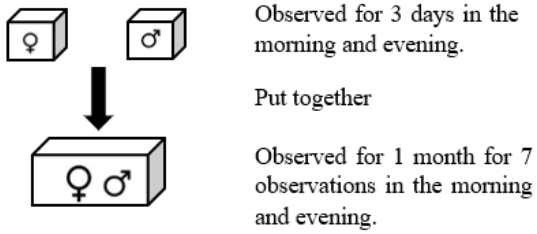


**Figure 2.** Research Design

## Results and discussion

Understand the communication patterns and social bonding between male and female pigeons, direct observations were made of the behaviors that emerged during the matchmaking period. The results of these observations are presented in the Table 1, which describes the types of behaviors, their frequency of occurrence, and the differences in behavioral contributions between the two sexes.

**Table 1.** Behavior of male and female pigeons in Matchmaking Period

| Day | Time | Behavior | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | | 7 | | 8 | | 9 | | 10 | | 11 | |
| | | ♀ | ♂ | ♀ | ♂ | ♀ | ♂ | ♀ | ♂ | ♀ | ♂ | ♀ | ♂ | ♀ | ♂ | ♀ | ♂ | ♀ | ♂ | ♀ | ♂ | ♀ | ♂ |
| 1 | Morning | | √ | | | | √ | | | | √ | √ | | | | | | | | | | | |
| | Afternoon | | | √ | √ | | | | √ | √ | | √ | √ | √ | √ | | | | | | | | |
| 2 | Morning | | | √ | √ | | √ | √ | √ | | √ | √ | | √ | √ | | | | | | | | |
| | Afternoon | | | | | | | √ | √ | | | √ | √ | | | | | | | | | | |
| 3 | Morning | | | √ | √ | | √ | √ | √ | | | | | | | √ | √ | | | | | | |
| | Afternoon | | | | | | | √ | √ | | | | √ | | | | | | | | | | |
| 4 | Morning | | √ | √ | | | | | √ | | | | | | | | | | √ | | | | |
| | Afternoon | | | √ | √ | | | | | | | √ | √ | | | | | | √ | | | | |
| 5 | Morning | | | √ | | | | √ | | | | √ | | | | √ | √ | | √ | | | | |
| | Afternoon | | | | √ | | | √ | √ | | | √ | | | | | | | | | | | |
| 6 | Morning | | √ | | √ | | | √ | √ | | | | | | | √ | √ | | √ | | | | |
| | Afternoon | | | | | | | √ | | | | | | | | √ | √ | √ | | | | | |
| 7 | Morning | | | √ | √ | | | √ | √ | | | | | | | √ | √ | | √ | | | | |
| | Afternoon | | √ | | | | | √ | √ | | | √ | √ | | | √ | √ | | √ | | √ | | |
| 8 | Morning | | | | | | | | | | | | | | | | √ | | | | √ | | |
| | Afternoon | | | √ | √ | | | √ | √ | √ | | √ | | | | | | | √ | | | | |
| 9 | Morning | | | | | | | √ | √ | | | √ | | √ | √ | | | | | √ | √ | | |
| | Afternoon | | | √ | √ | | √ | √ | √ | | | √ | | | | √ | √ | | | | | | √ |

Description: 1. Matchmaking display (making sounds). 2. Wing flapping. 3. Head nodding. 4. Allopreening. 5. Restlessness. 6. Spreading wings. 7. Face to face. 8. Billing (beak contact between male and female pigeons). 9.Chasing and harassing the female to attract attention. 10. Matchmaking Pecking (light pecking behavior). 11. Mounting (riding or climbing on top of the female).

**General Patterns of Behavior During the Breeding Period**

The observations show that (Table 1) the matchmaking process between male and female pigeons exhibits a complex and interrelated sequence of behaviors, reflecting the dynamics of communication and active mate selection. Behaviors such as matchmaking display (vocalizing), head nodding, wing flapping (Figure 4), billing, and mounting were observed at various frequencies in the morning and evening during the seven-day observation period. Males were more dominant during the early stages, frequently performing attractive movements such as puffing the chest and nodding the head, while females progressively responded with behaviors like allopreening and physical contact.

**Stages of Social Interaction in Matchmaking**

These patterns suggest structured stages in the pigeon matchmaking process from orientation and attraction to acceptance culminating in mating behaviors such as mounting. Billing and matchmaking peckin g(Figure 3, 5) observed later in the observation period indicate formation of stable social bonds, supporting previous findings by Murton & Isaacson (1962) and Fabricius & Jansson (1963) who emphasized the role of non-vocal signals in establishing avian pair bonds. The results also align with Ware et al. (2017) and Elie et al. (2020), who underscore the importance of multichannel communication including visual, tactile, and auditory cues in mate selection among birds. Such complex communication not only signifies reproductive readiness but also enables behavioral synchronization between partners.

Compared to prior studies focusing on single-channel signals (e.g., vocalizations in songbirds), this study offers a more integrative perspective, highlighting how behavioral coordination and proximity contribute to bonding. This supports the work of Ball & Balthazart (2010), who found that behavioral interactions significantly shape hormonal and neurological responses that facilitate pair formation.

**The Role of Nonverbal Communication in Mate Selection**

This study investigated the dynamics of social interactions between male and female pigeons during the matchmaking phase, emphasizing distinct behavioral expressions that are integral to the mate selection process. The findings revealed that several behaviors such as matchmaking displays, head-nodding movements, wing flapping (Figure 4), and billing serve as key indicators during the initial stages of pair bond formation (Ware et al., 2017; Bouchard et al, 2007). These nonverbal communication patterns play a crucial role in attracting potential mates and signaling reproductive readiness. The high frequency of behaviors such as chest puffing and physical approaches toward females underscores the dominant role of males in initiating mating interactions. The active role of males in sexual selection, where visual cues and attractive displays significantly influence reproductive success (Jacquin et al, 2010; Majewska & Drenikowski, 2016).

**Increased Interaction Intensity and its Implications**

This pattern is further reflected in the progression of interpersonal dynamics, which tend to intensify as the frequency of social contact increases. Throughout the observation period, interaction intensity between males and females gradually increased, particularly after both individuals were placed in close physical proximity within the same enclosure. This suggests that spatial closeness and repeated social encounters contribute substantially to the strengthening of pair bonds. In this process, pigeons utilize not only visual and vocal signals but also tactile communication, such as allopreening and mounting, which facilitate the development of social bonds and readiness for copulation.

According to Ware et al. (2017), these behaviors emphasize the critical role of social interaction in successful reproduction. The formation of stable pair bonds is highly dependent on reciprocal responsiveness and consistency in interaction between both sexes. High mutual responsiveness serves as a key indicator of reproductive readiness and the sustainability of mating partnerships, especially in the context of domesticated or captive breeding systems.

**Figure 3.** Matchmaking Pecking

**Figure 4.** Flapping wings

**Figure 5.** Billing

The observed response patterns were not random but followed a structured and repetitive sequence of behaviors. The findings of this study indicate that the matchmaking process in pigeons occurs through a series of systematic phases, including orientation, approach, attraction, and acceptance. During the orientation phase, both males and females exhibit exploratory behaviors accompanied by initial vocalizations, serving as early forms of communication. This progresses into the approach phase, characterized by visual displays (e.g., body posture) and increasing physical proximity. The interaction culminates in the acceptance phase, marked by a notable increase in behaviors such as billing, matchmaking pecking (mutual pecking associated with matchmaking), and mounting (Figure 3).

These sequential stages support the view of Kroodsma and Byers (1991); Elie et al (2020), who emphasize that multichannel communication integrating vocal, visual, and tactile signals is fundamental in the mate selection process among birds. Such communication not only indicates reproductive readiness but also functions as a selection mechanism and contributes to the formation and reinforcement of pair bonds.

**Practical Applications in Pigeon Breeding Systems**

Addition to illustrating sex-based behavioral roles, this study highlights the significance of behavioral understanding for effective pigeon husbandry. Female responses, such as head pecking or body thrusting, emerged as important cues indicating acceptance and mating readiness signals that breeders can use to assess the success of the matchmaking phase (Wang et al, 2023; Shetty et al, 1990). These behavioral indicators can inform more responsive, efficient, and scalable management strategies in captive breeding settings. The findings reinforce the applied relevance of ethology as a scientific discipline, particularly in animal domestication and reproductive management contexts. As noted by Adkins-Regan (2005), healthy social interaction plays a crucial role in reproductive success among farmed animals. Thus, close observation of communication patterns and matchmaking behavior offers not only academic insight but also practical value for improving breeding outcomes in domesticated pigeon populations.

However, this study also has certain limitations. First, the observation period was limited to seven days, which may not capture long-term fluctuations in bonding behavior. Second, the study was conducted in a semi-confined space, which, while closer to natural conditions than a laboratory, may still influence behavior due to limited space and artificial grouping. Finally, hormonal and physiological correlates of behavior (e.g., testosterone or oxytocin levels) were not measured, which could have provided a more integrative explanation of the observed behavioral changes.

Overall, this study makes a meaningful contribution to ethological literature by presenting contextualized field data derived from direct observation in semi-natural environments. This approach contrasts with the tendency of earlier studies to rely heavily on laboratory-based experimentation. By focusing on naturally

occurring interactions between males and females, the study provides a more comprehensive understanding of pigeon matchmaking dynamics particularly in terms of social signaling, mate selection, and reciprocal behavioral responses (Murton & Isaacson, 1962; Fabricius & Jansson, 1963; Erdem et al, 2024).

Moreover, the results of this research create avenues for future ethological investigations, including the exploration of internal mechanisms such as hormonal regulation and neurobiological activity (Ball & Balthazart, 2010; Lynn, 2016), as well as applied research in developing strategies to improve reproductive outcomes in captive environments (Wang et al., 2023). Therefore, these findings not only enrich scientific discourse but also provide a solid theoretical and practical foundation for enhancing pigeon breeding practices through a behavioral lens.

## Conlusion

This study systematically identified and described the patterns of male and female pigeon matchmaking behavior, including the stages of orientation, approach, interest, and acceptance. Male pigeons show a dominant role as initiators through various visual and vocal displays, while females provide receptive responses that determine the success of pair bond formation. These findings reinforce the importance of social interaction and multichannel communication in the mate selection process and the establishment of stable reproductive relationships. This study not only enriches the ethological literature in the context of domestic birds, but also provides a practical contribution to the management of breeding and rearing pigeons in a captive environment.

This study has limitations in the limited number of samples and the relatively short duration of observation, so it does not fully cover behavioral variability based on environmental conditions, age, or hormonal status of individuals. In addition, the analysis used is descriptive in nature and does not reach the causal relationship between behavior and physiological factors. Therefore, it is recommended that future studies integrate interdisciplinary approaches, such as hormonal analysis, neuroethology, or environmental influences on pair bond stability. Further studies can also be conducted in more complex semi-natural or natural conditions, and involve larger samples to strengthen the generalizability of the findings.

## Acknowledgement

The authors would like to express their sincere gratitude to Universitas Veteran Bangun Nusantara for providing research facilities and logistical support during the observation process. Special thanks are also extended to the laboratory staff and student assistants who contributed their time and efforts in maintaining the pigeons and recording behavioral data. This study would not have been possible without their valuable assistance. The authors also acknowledge the constructive suggestions from anonymous reviewers, which helped improve the quality of this manuscript.

## References

Adkins-Regan, E. (2005). *Hormones and animal social behavior*. Princeton University Press. https://doi.org/10.1515/9781400850778

Andersson, M. (1994). Sexual Selection. Princeton University Press.

Ball, G. F., & Balthazart, J. (2010). Neuroendocrine regulation of reproductive behavior in birds. In M. D. Breed & J. Moore (Eds.), *Encyclopedia of Animal Behavior* (Vol. 2, pp. 559–567). Academic Press. DOI: https://doi.org/10.1016/B978-008088783-8.00025-5

Bouchard, J., Goodyer, W., & Lefebvre, L. (2007). Social learning and innovation are positively correlated in pigeons (Columba livia). *Animal cognition*, *10*, 259-266. https://doi.org/10.1007/s10071-006-0064-1

Catchpole, C. K., & Slater, P. J. B. (2008). Bird Song: Biological Themes and Variations (2nd ed.). Cambridge University Press.

Cooney, C. R., Varley, Z. K., Nouri, L. O., Moody, C. J. A., et al. (2019). *Sexual selection predicts the rate and direction of colour divergence in a large avian radiation*. Nature Communications, 10(1),

1773. https://doi.org/10.1038/s41467-019-09859-7

Dahrun, M., Langoy, M. L., & Wahyudi, L. (2019). Karakteristik gaya aerodinamika pada burung merpati (Columba livia). *Pharmacon*, *8*(3), 679-685. https://doi.org/10.35799/pha.8.2019.29392

Darwati, S., Martojo, H., Sumantri, C., Sihombing, D. T. H., & Mardiastuti, A. (2010). Productivity, repeatability of productive and reproductive traits of local pigeon. *Journal of the Indonesian Tropical Animal Agriculture*, *35*(4), 268-274. https://doi.org/10.14710/jitaa.35.4.268-274

Dial, K. P. (1992). Activity patterns of the wing muscles of the pigeon (Columba livia) during different modes of flight. *Journal of Experimental Zoology*, *262*(4), 357-373. https://doi.org/10.1002/jez.1402620402

Elie, J. E., Hoffmann, S., Dunning, J. L., Coleman, M. J., Fortune, E. S., & Prather, J. F. (2020). From perception to action: the role of auditory input in shaping vocal communication and social behaviors in birds. *Brain Behavior and Evolution*, *94*(1-4), 51-60. https://doi.org/10.1159/000504380

Erdem, E., Bulut, F. T. Ö., & Eser, E. (2024). Understanding The Behaviors Of Pigeons. *Innovative Multifaceted Developments in Veterinary Medicine*, 165.

Fabricius, E., & Jansson, A. M. (1963). Laboratory observations on the reproductive behaviour of the pigeon (Columba livia) during the pre-incubation phase of the breeding cycle. *Animal Behaviour*, *11*(4), 534-547. https://doi.org/10.1016/0003-3472(63)90276-8

Fernandez, E. J., & Lattal, K. A. (2025). Pigeon in a Box: Columba livia as Subject in Behavioral Research. *Perspectives on Behavior Science*, 1-14. https://doi.org/10.1007/s40614-025-00454-4

Goodwin, D. (1983). *Pigeons and doves of the world* (3rd ed.). Cornell University Press.

Jacquin, L., Cazelles, B., Prevot-Julliard, A. C., Leboucher, G., & Gasparini, J. (2010). Reproduction management affects breeding ecology and reproduction costs in feral urban pigeons (Columba livia). *Canadian Journal of Zoology*, *88*(8), 781-787. https://doi.org/10.1139/Z10-044

Johnston, R. F., & Johnson, S. G. (1989). Nonrandom mating in feral pigeons. *The Condor*, 91(1), 23–29. https://doi.org/10.2307/1368144

Kadri, M. H. M., Septinova, D., & Riyanti, R. (2016). Karakteristik dan Perilaku Merpati Tinggi Lokal Jantan dan Betina. *jurnal ilmiah Peternakan Terpadu*, *4*(2). DOI: http://dx.doi.org/10.23960/jipt.v4i2.p%25p

Kerfoot, EM (1964). *Beberapa aspek pemilihan pasangan pada merpati domestik* (Disertasi doktoral, Universitas Oklahoma).

Kroodsma, D. E., & Byers, B. E. (1991). The function(s) of bird song. American Zoologist, 31(2), 318–328. https://doi.org/10.1093/icb/31.2.318

Lynn, S. E. (2016). Endocrine and neuroendocrine regulation of fathering behavior in birds. *Hormones and Behavior*, *77*, 237-248. https://doi.org/10.1016/j.yhbeh.2015.04.005

Majewska, D., & Drenikowski, T. (2016). Analysis of reproduction and growth in fancy pigeons. *Acta Scientiarum Polonorum. Zootechnica*, *15*(1). https://doi.org/10.1139/Z10-044

Murton, R. K., & Isaacson, A. J. (1962). The functional basis of some behaviour in the Wood Pigeon *Columba palumbus*. *Ibis, 104*(4), 503–521. https://doi.org/10.1111/j.1474-919X.1962.tb08683.x

Pranoto, E. A., Susetyorini, R. E., & Prihanta, W. (2015). Identifikasi Burung di Kepulauan Kai Maluku Tenggara. In *Prosiding Seminar Nasional Pendidikan Biologi 2015 Program Pendidikan Biologi Fakultas Keguruan Ilmu Pendidikan Universitas Muhammadiyah Malang* (Vol. 772).

Sardell, R. J., Kempenaers, B., & DuVal, E. H. (2014). Female mating preferences and offspring survival: testing hypotheses on

the genetic basis of mate choice in a wild lekking bird. *Molecular Ecology*, 23(14), 3706–3718. https://doi.org/10.1111/mec.12652

Saxena, VL, Pandey, E., Agarwal, S., & Saxena, AK (2008). Execution of Breeding and Nidification Behaviour in Pigeon (Columba livia) and Dove (Streptopelia chinensis). *Asian J. Exp. Sci* , *22* (3), 405-410.

Shetty, S., Jacob, R. T., Shenoy, K. B., & Hegde, S. N. (1990). Patterns of breeding behaviour in the domestic pigeon. *Bird Behavior*, *9*(1-2), 14-19. https://doi.org/10.3727/015613890791749028

Shimizu, T., & Bowers, A. N. (1999). Visual circuits of the avian telencephalon: Evolutionary implications. *Behavioural Brain Research*, 98(2), 183–191. https://doi.org/10.1016/S0166-4328(98)00083-7

Syifa, N. (2022). *Kajian Metodologi Keilmuan Etologi* (Doctoral dissertation, UIN Raden Intan Lampung).

Unwin, M. (2011). *The atlas of birds: diversity, behavior, and conservation*. Princeton University Press.

Wang, L., Zhu, J., Xie, P., & Gong, D. (2023). Pigeon during the breeding cycle: behaviors, composition and formation of crop milk, and physiological adaptation. *Life*, *13*(9), 1866. https://doi.org/10.3390/life13091866

Ware, E. L., Saunders, D. R., & Troje, N. F. (2017). Social interactivity in pigeon matchmaking behavior. *Current Zoology*, *63*(1), 85-95. https://doi.org/10.1093/cz/zow066