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OBSERVATION ON THE NEST CHARACTERISTICS, CLUTCH SIZE AND HATCHING RATE OF PIED STILT (*Himantopus leucocephalus*) AND JAVAN PLOVER (*Anarhynchus javanicus*) IN WONOREJO FISHPOND, EAST JAVA, INDONESIA

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ABSTRACT

Knowledge of breeding by the Pied Stilt (*Himantopus leucocephalus*) and Javan Plover (*Anarhynchus javanicus*) is limited. During fieldwork from 15 August to 10 November 2015 we studied nest features, hatching rate and clutch size of both species at the Wonorejo Fishpond in East Java, Indonesia. During the investigation 42 Pied Stilt nests and 27 Javan Plover nests were found. Pied Stilts build their nests in both mud and surrounded by water; the mud nests include a greater variety of components than nests on water. We provide the first description of the nest of Javan Plover nest on the ground and are made of wood, snail shells and shellfish. The Pied Stilt's clutch size is typically 2-4 eggs, while the Javan Plover's clutch size is often 2-3 eggs. The hatching rate of Javan Plover was 61.5%, and 75% in Pied Stilt with flooding the key factor influencing hatching rate.

Key words: breeding biology, flooding, hatching rate, nest materials, Wonorejo

INTRODUCTION

Indonesia has an exceptionally species rich avifauna with at least 1,849 bird species (Avibase, 2024). Ongoing field surveys and taxonomic studies continue to refine our understanding of the taxonomic limits of Indonesian birds, as well as their distribution within the country. However, there remains major gaps in basic biological of Indonesian birds including details of breeding. Almost 60 years ago Hellebrekers & Hoogerwerf (1967) published a major monograph on breeding by Javan birds, but little has been published in this field in the intervening years. Noske (2017) highlighted how little was known about the breeding ecology of the Wallacean region, but it remains true of all regions of Indonesia despite the historical efforts.

Pied Stilt (*Himantopus leucocephalus*) and Javan Plover (*Anarhynchus javanicus*) are resident shorebirds in Indonesia found breeding in Wonorejo Fishpond. Breeding data of Pied

Stilt in Australia and New Zealand has been well recorded (Maleko & Walter, 2023). However, there needs to be more data on breeding by the Pied Stilt in Indonesia (Hoogerwerf, 1949; Hellebrekers & Hoogerwerf, 1967). Iqbal et al. (2009) reported a review of the status of Pied Stilt in Indonesia, and Abdillah et al. (2012) reported the discovery of two nests in Deli Serdang District, North Sumatra, but the data has not reported on the characteristics of the nest, clutch size and hatching rate of Pied Stilt

Hellebrekers & Hoogerwerf (1967) described the egg size and weight of Javan Plover *Anarhynchus javanicus* (then considered a subspecies of Kentish Plover *Anarhynchus alexandrinus*) but included no other information on nests. Wiersma and Kirwan (2023) note that there is virtually no information on the breeding of Javan Plover apart from that included in an article on field identification (Iqbal et al., 2013). Febrianto et al. (2016) reported the breeding behavior of the Javan Plover but did not include nest characteristics and hatching rates. To increase knowledge of the breeding ecology of these two Indonesian resident shorebirds conducted a field study to understand breeding Pied Stilt and Javan Plover. Data collected in this study include nest characteristics, clutch size, and hatching rate of Pied Stilt and Javan Plovers at the Wonorejo Fishpond in East Java, Indonesia.

MATERIALS AND METHODS

Study Sites

The study was conducted from 15 August to 10 November 2015 in Wonorejo Village, Rungkut Subdistrict, Surabaya, East Java (7°31'14.82"S, 112°82'92.72"E) (Fig 1).

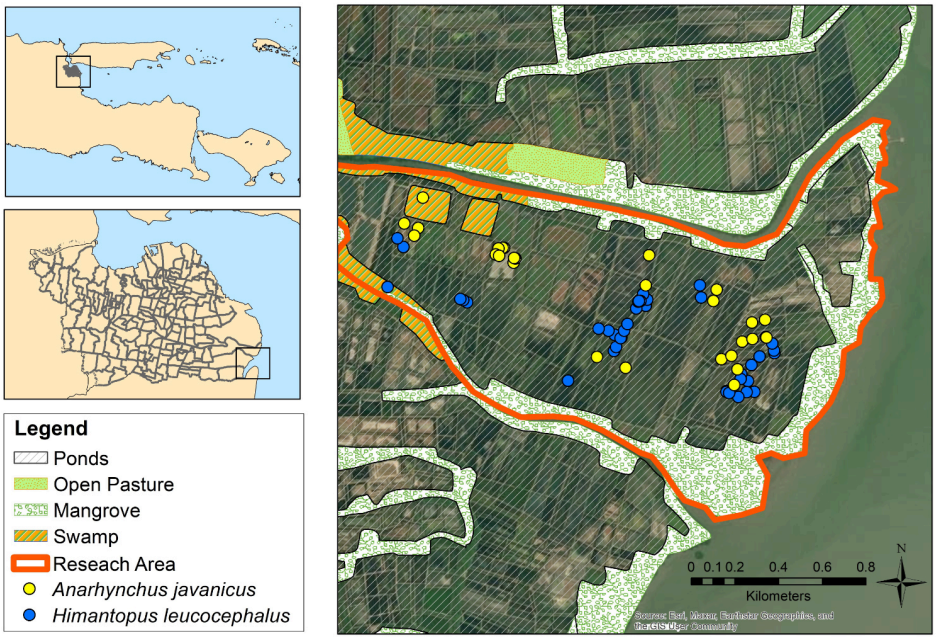

Figure 1. Map Location Research

Nest Searching

Nest searches and behavioral observations of Pied Stilt and Javan Plover are conducted twice a week for an average of six hours a day to determine their nesting locations. The behavior that has been seen involves both aggressive and nest-building behavior (breeding birds exhibit greater aggressive behavior). Two types of nests have been discovered: active and non-active. When birds are still using a nest, it is considered active (bird activity was observed in the nest). Eggs or young may be found in active nests. Nests that held eggs but were abandoned by the birds were considered non-active nests.

Nest Characteristics

Measurement of the nest characteristics was conducted when the nesting bird was away from the nest. Nest measurement included length, width, height, depth and the thickness of nest edge (Fig. 2). The length and width of the nest were measured meter tape (accuracy 1 mm), while nest height, thickness and depth were measured using a ruler (accuracy 0.5 mm). In addition, the composition of nest was observed to determine the component of nest and substrate type.

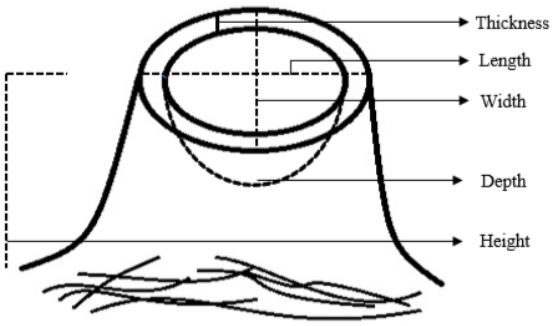

Figure 2. Measurement of Nest Parameter

Nest Characteristics

Clutch size was determined by counting the number of eggs in active nests. Egg measurement was conducted on eggs from active and non active nest. Measurement of the length and width of eggs was performed using caliper (accuracy 0.05 mm) (Fig. 3). Egg measurement at active nests was done when parents left the nests to forage. Until all of the eggs hatched or no more eggs were placed, nests were checked on twice a week. The egg will be marked as having failed to hatch if it does not hatch.

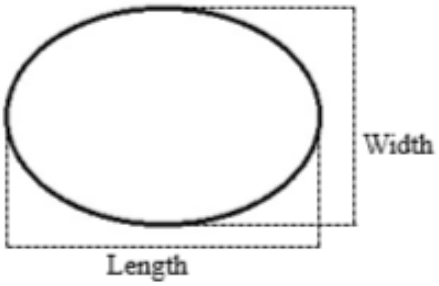

Figure 3. Measurement of Egg

Data Analysis

The range and percentage of eggs per clutch size were measured, along with the clutch size of the active nest. The percentage of eggs that hatch and the average number of eggs that hatch per nest were used to express the egg hatching rate (Wilcox, 1959)

$$\text{Percentage of hatching success} = \frac{\text{Number of eggs hatching}}{\text{Total number of eggs}} \text{ x } 100\ \%$$

$$\textit{Average hatching success} = \frac{\textit{Number of eggs hatching}}{\textit{Number of nests}}$$

RESULTS

Nest Characteristics, Clutch Size and Hatching Rate of Pied Stilt

Of the 42 Pied Stilt nests we discovered, eight had been harmed by floods, while 34 were still undamaged and measurable. Eight nests are categorized as active nests. Mud and water were the two substrate types on which Pied Stilt nests were found (Fig. 4). In the water, the nest's length and width are greater than in the mud. While the nest on the water can grow up to 38 cm above the substrate's surface, the nest in the mud has ranged in height from 0.5 to 3 cm (Table 1).

Table 1. Nest dimensions of Pied Stilt (n = 34) and Javan Plover (n=27)

Parameter (cm)	Pied Stilt			Javan Plover		
	Min	Max	Average ± std	Min	Max	Average ± std
Length	18	45	26.93 ± 7.86	7	20	15.33 ± 3.12
Width	13	36	22.32 ± 5.27	7	18	13.44 ± 2.97
Height	0.5	38	9.26 ± 9.08	0	1.5	0.58 ± 0.49
Thickness	3	14	6.84 ± 2.67	0.5	4.5	2.70 ± 0.96
Depth	0	4	1.83 ± 1.14	0	3	1.58 ± 0.88

Pied Stilts were found nesting solitarily (>50 m away from another nest) and in colonies (<50 m away from another nest); Pied Stilts that nested in colonies formed nest colonies with other Pied Stilt species (Fig. 4). Pied Stilts in colonies were found in as many as 35 nests and 7 nested solitarily. Up to 42 Pied Stilt nests in water are in mangrove root cuts and broken branches.

Pied Stilt gathers nest materials from the surrounding area, such as shell bivalvia (*Polymesoda erosa*, *Pharella javanica*), shell gastropods (*Telescopium telescopium*, *Cherithidea cingulata*, *Dostia violacea*, *Sermyla* sp.), pieces of wood, leaves (*Avicennia marina*, *Exoecaria agallocha*, *Passiflora foetida*, *Sesuvium portulacastrum*, *Fimbristylis dichotoma*, *Chloris barbata*), fishing line, rope, plastic, mud, and macroalgae. Fishing line (three nests), plastic (one nest), raffia rope (two nests), and rope (one nest) are examples of synthetic materials used in Pied Stilt.

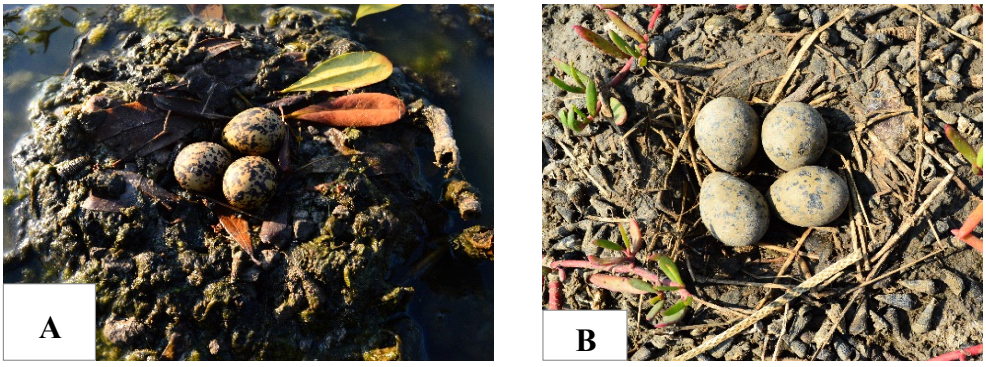

Figure 4. Nest location of Pied Stilt (A) Nest on the water (B) Nest on mud. (Photos by N.H Siregar, 2015)

Compared to nests in mud, the Pied Stilt nest in water has a lot more components. The main components of the nest in the water are macroalgae and shells from *Cherithidea cingulata*. In order to prevent the nest from being readily destroyed, macroalgae serve to bring the various parts of the nest together. In the meantime, relatively little macroalgae are used by the elements of the Pied Stilt nest in the mud.

Table 2. Eggs, Clucth Size and Hatching Success of Pied Stilt and Javan Plover

No	Species	Eff	Average		Clutch Size	Hatching Rate
			Length	Width		
1	Pied Stilt	30	41.6	30.5	2-4	2.63
2	Javan Plover	43	30.1	21.7	2-3	1.5

We found 30 eggs of Pied Stilt with an average length and width are 41.6 mm ± 1.3 mm x 30.5 mm ± 1.1 mm (Table 2). Clutch size Pied Stilt ranges between 2-4 eggs. The percentage of clutch sizes 2 eggs, 3 eggs, and 4 eggs are 12.5%, 50%, and 37.5% respectively.

Twelve of the 42 Pied Stilt nests that were discovered had eggs in them. One egg was found in each of the four Pied Stilt nests, but the parents had left them. Twenty-six Pied Stilt eggs from eight nests could be included in the hatching rate estimate; the remaining four eggs could not be included in the computation because the initial number of eggs is unknown, and the parents have abandoned the nests. The percentage of Pied Stilt eggs that hatch from a nest is 75%, however the average number of eggs that hatch is 2.63.

Nest Characteristics, Clutch Size and Hatching Rate of Javan Plover

We found 27 Javan Plover nests, and 20 of them were classified as active. Javan Plover nests were placed on the ground with the dry substrate in open spaces. Javan Plover nests solitarily (>50 m away from another nest) and in colonies (<50 m away from another nest), forming nesting colonies with conspecifics and Terns. Six Javan Plovers nested solitary, whereas 21 nested in colonies. The majority of Javan Plovers use wood, snail shells, and mussels to build their nests (Fig. 5). Five nests had shells surrounding them, and up to eleven nests were adjacent to wood.

Figure 5. Nest of Javan Plover on the ground. (Photos by N.H Siregar, 2015)

Some Javan Plover nests were located on fishpond embankments that the local village workers used as walkways, making their nesting sites less secure and more vulnerable to disturbance. Previously, nests were found solely in dry ponds, but the Javan Plover broke the record by depositing eggs on the fishpond embankment. Additionally, fish farmers released water, which caused some nests to become submerged in water and affected the hatching of Javan Plover eggs.

Avicennia marina, *Exoecaria agallocha*, *Sesuvium portulacastrum*, *Fimbristylis dichotoma*, *Sporobolus virginicus*, *Chloris barbata*, plastic, lumps of soil, fishing line, shell gastropods (*Telescopium telescopium*, *Cherithidea cingulata*), shell bivalvia (*Polymesoda erosa*, *Pharella javanica*), and pieces of wood and leaves are all components of Javan Plover nests. Wood fragments and *Cherithidea cingulata* are the most common nest components. One Javan Plover nest contained both plastic and string nest components.

We found 43 eggs of Javan Plover with average length and width of 30.1 mm ± 0.8 mm x 21.7 mm ± 0.5 mm (Table 2). The clutch size of Javan Plover ranges between 2-3 eggs. The percentage of clutch sizes 2 eggs and 3 eggs are 33.33% and 66.67% respectively.

Twenty of the 27 Javan Plover nests that were discovered contained eggs. Out of 16 nests, 24 Javan Plover eggs successfully hatched, while 19 others failed. Since it is unknown how many eggs were laid in the first place and some did not hatch, the remaining four eggs were excluded from the calculation of nesting success, which used 39 eggs in total. With a proportion of 61.5%, an average of 1.5 eggs hatch from a Javan Plover nest. Due to their immersion in water, nine Javan Plover nests were unable to hatch.

DISCUSSION

Nest Characteristics

In Wonorejo fishpond, Pied Stilt was found building nests in open areas in water and mud close to water. New Zealand is also the site to pied stilts, which construct their nests in mud and water. Soil, artificial wetlands, salt factories, water holes, twigs, sand, mud, grass mounds, branches, and the former nests of other birds are some of the locations where Pied Stilts construct their nests. Pied Stilts use a variety of substrates and habitats to construct their nests (Maleko & Walter, 2023). Pied Stilts have also been observed breeding near water in New Zealand, with 4.1 m along rivers and 0.3 m in swamps (Maleko & Walter, 2023). In this investigation, the distance between the nest and the water was not measured.

Figure 5 shows that Pied Stilt nests constructed in water are taller than those constructed in mud. By preventing nests from flooding, this tactic improves the success of nesting. In order to minimize flooding, Cuervo (2004) has discovered that the *Himantopus himantopus* nest will be larger when it is sealed off from the water. Pied Stilt nests range in height from 0.5 cm in mud to 38 cm in water. In New Zealand, Pied Stilt nests range in height from 8 cm in swamp habitat to 46 cm in river habitat (Maleko & Walter, 2023).

In order to prevent the nest from sinking, Pied Stilt was observed adding nest components. The nest can be kept from flooding by adding components. Two strategies were found by Tinarelli (1991) to keep nests from being flooded. Building a bigger nest above and near the water is the first strategy. The second strategy is to alter the shape and size of the nest, however this calls for an extremely small increase in water. BirdLife Australia (2023) and Maleko & Walter (2023) state that nest components can be added while the animal is incubating. As the male and female construct the nest together, the Pied Stilt gathers nest materials from the surrounding area.

Male and female Pied Stilts were found to incubate eggs alternately, similar to those found in New Zealand (Maleko & Walter, 2023). In order to drain their legs of water, foraging Pied Stilt parents were seen shaking their legs before going back to incubating eggs. Pied Stilts in Wonorejo Fishpond were not observed to colonize with other species, in contrast to those in Australia and New Zealand, where they do so (Maleko & Walter, 2023; BirdLife Australia, 2023). However, Javan Plovers constructed nests around the old Pied Stilt nests once the eggs hatched.

Javan Plovers were found building nests in open areas and mostly near pieces of wood or shells (Fig. 5). The eggs use this technique to hide and avoid predators. Shells are used as nesting material by *Charadrius melodic* (Wilcox, 1959). Nguyen et al. (2003) found that *Charadrius semipalmatus* nested on Akimiski Island in areas with a high gravel content. Gravel can help eggs hatch and hide them from predators.

On dry land, Javan Plovers construct nests that range in height from 0 to 1.5 cm. Javan Plover nests were discovered by Febrianto et al. (2016) in bare pond embankments and dry to slightly muddy ponds. Nests can be constructed by Javan Plover solitary or in colonies with Terns. Given that Terns are naturally aggressive, this is advantageous for Javan Plover. Nest defense strategy gives Semipalmated Plovers an edge when they nest with Artic Terns (Nguyen et al., 2003). Powell (2001) found that the Plovers' closeness to the terns contributed to their higher nest success. When the plover builds its nest near the nest terns, productivity increases. For the plover, living alongside terns has several advantages, such as improved behavior, decreased susceptibility to predators, and early predator detection (Burger, 1987).

The Javan Plover gathers both natural and artificial nest components from the surrounding area. Line fishing is one of the artificial elements that may trap hatching Javan Plover chicks. It has been observed that men and females alternate incubating eggs, with the parents wetting the bottom before doing so. Febrianto et al. (2016) this may be a way to keep cool in the heat. The

Javan Plover nest is only about 0–3 cm deep, which is less than the 4 cm depth of the nest discovered by Febrianto et al. (2016).

Javan Plovers are very aggressive when incubating eggs and after the eggs hatch. Terns and Egrets foraging near their nests have been attacked by Javan Plovers. During the breeding season, Javan Plovers attack the parents and chicks of *Sternula albifrons*, according to Wiersma & Kirwan (2023).

Clutch Size

The Pied Stilt eggs in the Wonorejo Fishpond are nearly identical in size to those in Java in terms of both length and width (Appendix 1). Although Pied Stilts have been observed to breed in Chirebon, West Java (Hellebrekers & Hoogerwerf, 1967), and a few locations in Sumatra (Iqbal et al., 2009), there is no information available regarding the eggs' length or width. The length of the Pied Stilt eggs in the Wonorejo Fishpond was smaller than those found in Australia and New Zealand. The width of the Pied Stilt eggs in the Wonorejo Fishpond, Australia, and New Zealand did not differ much (Appendix 1). The clutch size of the Pied Stilt was relatively the same in habitat as that found in Australia and New Zealand. Although six eggs have been observed in a single nest, the Pied Stilt typically lays four eggs in a clutch, with a range of two to four eggs per nest (Maleko & Walter, 2023).

Between the middle of the year and the end of November, Pied Stilts breed in Indonesia. Due to opportunistic, Pied Stilt breeding times vary by region (Maleko & Walter, 2023). Seasonal breeding is possible for pied stilts, such as in tropical regions following the rainy season. Altitude also affects when Pied Stilts reproduce, but if the right circumstances are present, they can breed at any time. Depending on the state of the pond water surface, White-headed Stilts (also known as Pied Stilts) breed all year long in Ogan Komering Lebak, Indonesia (Iqbal et al., 2009).

While the length and width of the Javan Plover eggs seen in Wonorejo Fishpond differed significantly from those discovered by Febrianto et al. (2016) in Wonorejo Fishpond, they were nearly identical to those reported in Java, West Java, and the Kangean Archipelago (Appendix 2). In Indonesia, Javan Plovers breed from the middle of the year till the end of the year. May to August is when the Javan Plover's nesting season peaks (Iqbal et al., 2013). The breeding season has been recorded in East Java (June), West Java (May–July), Sumatra and Bali (young observed in July), Sulawesi (early October), Timor-Leste (young observed in July), and West and Central Java (August) (Hellebrekers & Hoogerwerf, 1967; Iqbal., et al. 2013; Wiersma & Kirwan, 2023).

Variations in bird egg size can be influenced by habitat quality. The mass, length, width, and volume of an egg can all be decreased by habitat degradation brought on by drought (Adamou et al., 2009). Another factor influencing egg weight is the size of the female; the egg weight rises in proportion to the female's weight (Ross, 1979). The parent bird's ability to incubate can affect the size of the egg; a proper egg size encourages more efficient incubation (Lislevand & Thomas, 2006).

Hatching Rate

In the fishpond area of Wonorejo, nesting locations are the primary element influencing the hatching rate; poor nest site selection will cause the eggs to fail to hatch because of flooding. Pond farmers have recently plucked Javan Plover and Pied Stilt nests in arid ponds. In order to prevent birds from estimating the increased water discharge in fishponds, pond farmers add water to the ponds. This is done by the fish farmers and is not a natural occurrence. Cuervo (2004) discovered that flooding and predation are the reasons why *Recurvirostra avosetta* and *Himantopus himantopus* eggs fail. Pagnon (2024) discovered that the primary cause of unsuccessful egg hatching is beach flooding during high tide, which is followed by predation.

In Texas, the main causes of nest failure are weather and predation (Saalfeld et al., 2011). Despite the presence of snakes, rodents, and lizards in the Wonorejo Fishpond, there was no indication that any nests had failed because of predators. *Didelphis marsupialis*, *Corvus brachyrhynchos*, *Vulpes fulva*, *Mus musculus*, and *Rattus norvegicus* were the predators of eggs (Wilcox, 1959; Cuervo, 2004). Wiens (2007) found that shorebird nesting success is more influenced by habitat selection. Toland (1999) illustrated how nesting is disrupted by motor boats, personal watercraft, tourists, anglers, and dogs.

Establishing a nesting colony with Sterna paradisaea benefits Charadrius semipalmatus because it can employ aggressive nest defense behavior to avoid predators from the nest (Nguyen et al., 2003). Burger (1987) found that plovers showed early warning of predators, decreased susceptibility to predators, and improved antipredator behavior. This will increase the success of plover nests (Powell, 2001).

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