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DIPLOMARBEIT

Titel der Diplomarbeit

Habitat requirements and population size of the Javan Plover *Charadrius javanicus* (Aves, Charadriidae) on Java, Indonesia

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Magister der Naturwissenschaften (Mag. rer. nat.)

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Abstract:

Based on current knowledge the distribution of the Javan Plover *Charadrius javanicus* is predominantly restricted to Java, where it occurs in coastal habitats. This study tried to quantify the species´ habitat requirements and to contribute to estimating its actual population size. During a survey of 0.5 km long transects along a total of 72.5 km of coastline, a total of 218 Javan Plovers corresponding to a mean (± SD) of 1.47 (± 2.64) birds per 0.5 km shoreline was recorded. However, the density of Javan Plovers differed significantly between surveyed coastal regions. Highest abundances were found on the south coast of Java. Furthermore, abundances of Javan Plovers differed significantly between coastal habitats. Wide (>50m), small-grained sandy beaches were the preferred habitat. The likelihood of Javan Plover occurrence on small-grained beaches increased with beach and flotsam width, while no effect of human disturbance could be found. A weak trend of a decline in Plover numbers towards beaches without any vegetation was found. GLMs indicated that beach width was the best explanatory variable for predicting the occurrence of Javan Plovers in 500 m transects. Along 76 transects of sandy beach habitat including lagoons, a total of 205 Javan Plovers or 5.39 individuals per 1 km shoreline were observed. A total of ca. 2000 birds were estimated for coastal habitats of Java. However, ca. 125 km are located very close to human settlements. Consequently, Javan Plovers may reach a much lower density in some coastal areas. This estimate does not include the part of the population which occurs at fishponds, which may represent an important artificial habitat for this species. The species does not yet seem to be endangered, nevertheless its populations have to be carefully monitored due to the risk of further coastal development and intensification of fishpond industry becoming a serious threat to the species.

Keywords:

Charadrius javanicus, Javan Plover, Java, Indonesia, coastal birds, shorebirds, tropical waders, population estimation, population size, habitat requirements,

Zusammenfassung:
Nach aktuellem Wissenstand erstreckt sich die Verbreitung des Java Regenpfeifers (Charadrius javanicus) überwiegend auf die Küstengebiete Javas. Diese Arbeit versucht artspezifische Habitats-anforderungen zu quantifizieren und aktuelle Populationsgrößen zu ermitteln. Während der Erhebung eines 0,5 km langen Transektes entlang von 72,5 km Küstenlinie wurden 218 Java Regenpfeifer - im Mittel (± SD) of 1,47 (± 2,64) Vögel pro 0,5 km Küstengebiet - erhoben. Höchste Dichte wurde an der Südküste Javas gefunden, wobei die Dichte des Java Regenpfiefer signifikant zwischen unterschiedlichen Habitatstypen variierte. Breite (>50m) kleinkörnige sandige Strände waren das bevorzugte Habitat. Neben dem bevorzugten Sandstrand-Habitat des Java Regenpfeifers spielte die Strand- bzw Strandgut-breite eine wichtige Rolle bei der Zunahme der Dichte des Vogels. Effekte durch menschliche Störung konnte nicht nachgewiesen werden. Wir stellten einen schwacher Trend zur Abnahme der Individuenzahl bei fehlender pflanzlicher Bedeckung fest. GLMs hat gezeigt, daß die Strandbreite die beste Erklärungsvariable für die Vorhersage des Vorkommens des Java Regenpfeifers innerhalb eines 500m Transektes ist. Entlang von 76 Transekten an Sandstrand-Habitaten inklusive Lagunen wurden 205 Java Regenpfeifer oder 5,39 Individuen pro Kilometer Küstenlinie beobachtet. Insgesamt 2000 Vögel wurden für die Küste Java erhoben, wobei 125 km durch menschliche Siedlungen stark geprägt sind. Dadurch könnten sich geringere Dichten in anthropogen geprägten Küstenabschnitten ergeben. Diese Schätzung beinhaltet nicht jenen Teil der Population, welcher in künstlich angelegten Fischteichen vorkommt, welche ein wichtiges Sekundärhabitat für die Art darstellt. Außerdem scheint es als ob die Art momentan nicht unmittelbar gefährdet sei, dennoch sollte die Population in naher Zukunft kontinuierlich erfasst werden bevor weitere küstennahe Entwicklung oder Intensivierung der Fischteich Industrie eine ernsthafte Bedrohung für das Tier darstellen.

Introduction

In insular Southeast Asia thousands of shorebirds, including resident as well as migrant species, depend on coastal habitats as feeding grounds. Humans not only exploit the organisms of such habitats, also depletion of sand, gravel or rocks from tidal mudflats is common and particularly tidal flats with soft bottoms can be easily enriched with pollutants, which can have serious effects on the entire community of organisms through poisoning (Gölthenboth et al. 2006). The tidal zones suffer particularly under human pressure since this land-sea transition zone is easily accessible and therefore often additionally strongly affected by coastal development, causing physical habitat degradation through the construction of fish and prawn ponds, harbours and moles, and though excessive tourism with land reclamation for hotels and golf courses (Göltenboth & Schoppe 2006, Gölthenboth et al. 2006).

Throughout Indonesia, larger settlements and villages are often concentrated along shorelines, particularly near estuaries, thereby taking advantage of sheltered moorings, fresh water supply and rich coastal fishing grounds (Göltenboth & Schoppe 2006). Related major threats are pollution, urban land fillings, and discharge of industrial and agricultural waste. The importance of these threats is continuously increasing throughout Indonesia, but is most striking on the island of Java (Göltenboth & Schoppe 2006) with one of the highest population densities globally. The current human population of 130 million inhabitants is still increasing (World Fact Book CIA, 2009). At the same time effects on biodiversity or the population size of species dependent on coastal habitats are largely unexplored.

Most likely, many species depending on such habitats are under enormous threat due to the fast decline of adequate undisturbed coastal habitats. Beaches are critical habitats for shorebirds and sensitive to disturbance (Hosier et al., 1981; ,Hubbard & Dugan, 2003). Shorebirds, such as waders depending on beaches for foraging and breeding, are one group particularly suffering from human activities along coastlines (e.g.Lafferty 2001). Predation risk for birds and disturbance effects vary both with distance from humans and the number of present humans (Beale & Monaghan). Besides, mortality including egg losses is implicated as a direct consequence of humans (Madsen & Fox 1995).

The Javan Plover (*Charadrius javanicus* Chasen, 1938) is a resident of the coastal lowlands of Java, including the Kangean Islands, and possibly Bali, Indonesia (Birdlife International 2008, del Hoyo et al. 1996, MacKinnon & Phillipps 1993). Until recently it was believed to be endemic to Java, but the species has recently been discovered on Sumatra and Sulawesi, and may possibly occur still further east (Bakewell & Kennerley 2008). Its exact taxonomic status is still unclear. Records of Javan Plovers are generally sparse; nevertheless, the species was recently found to be common in southern Madura (IUCN 2009). Although it may prove to be widespread, its population is expected to be small and declining, although precise data are not available (Birdlife International 2008). The main threat is human disturbance of coastal habitats within its limited and linear range (Birdlife International 2008).

The Javan Plover is a shorebird breeding and foraging on sandy beaches, mudflats and adjacent open areas around coasts (del Hoyo et al. 1996, Birdlife International 2008). Breeding is recorded during June from West Java (del Hoyo et al. 1996) and from Trisik Beach, Yogyakarta, where two nests with one and three eggd respectively were photographed on 17 June 2007 (by Iman Taufiqurrahman: Oriental Bird Club 2008). The nests on Trisik Beach were built on sand surrounded by garbage, small branches and dry leaves, and some beach grass *Spinifex longifolius*. Another recent breeding record exists from Jrakah wetlands, Semarang, Central Java, where Karyadi Baskoro photographed a nest with one egg on 26 August 2006 on the bed of a dried pond. The species is also recorded from Wonorejo Mangrove ponds and mud flats next to Surabaya (by Iwan Londo; Google earth added photograph; http://www.panoramio.com/photo/11363310).

Because it is assumed that this plover is threatened by habitat loss, it was classified as “Near Threatened” in the IUCN Red List (Birdlife International 2008). This is justified by its narrow range in which coastal development and recreational activities are putting pressure on critical breeding habitats. Furthermore, the species is likely to have a moderately small population, and this is thought to be declining (Birdlife International 2008). Two conservation measures were proposed by Birdlife International (2008): (1) surveys to facilitate a better estimation of the species, current population size and its specific habitat preferences; (2) opposing development schemes which destroy sites where the species is found.

The aim of the study was to achieve a more precise estimation of the population size of *C. javanicus* by conducting standardized surveys in different parts of Java and to identify habitat variables important for this plover species. We expect that in addition to human disturbance, parameters such as beach substrate, beach width, flotsam and coastal vegetation may play an important role in limiting habitat quality, as documented for other plovers (Yasue & Dearden 2006).

Methods

Study areas

Surveys were conducted along representative coastlines covering a variety of different coastal habitat types, particularly sandy and rocky beaches and mangroves and areas exposed to a different intensity of human disturbance, ranging from relatively undisturbed areas inside national parks to areas with high human impact through tourism or the neighbourhood to settlements. Due to time restrictions, surveys were limited to nine coastal stretches in West Java and two in Central Java (Fig. 1). A detailed description of the study areas is provided in table 1.

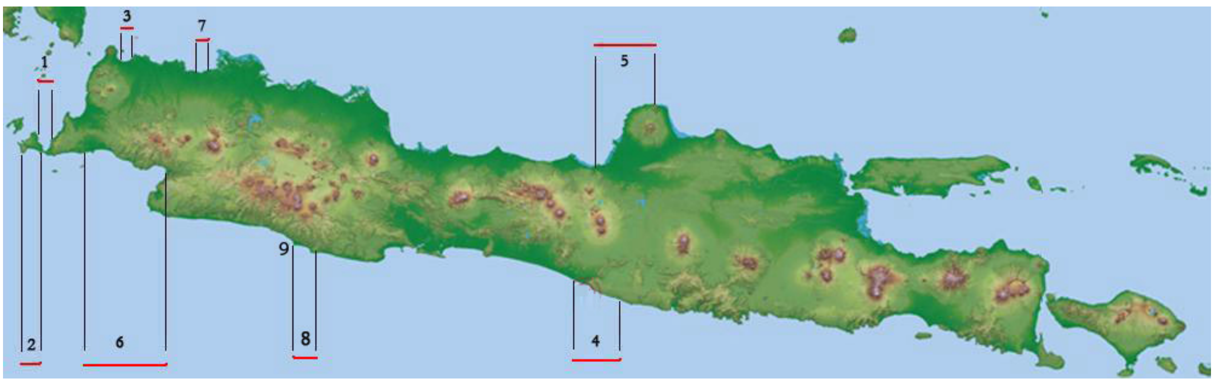

Figure 1. Coastal areas in Java where Javan Plover surveys were conducted. 1 – North coast of Ujung Kulon National Park, 2 – South coast of Ujung Kulon National Park, 3 – Pulau Dua (North-west coast), 4 – Trisik (Jogjakarta, south coast), 5 – Bandengan (Central Java, north coast), 6 – Malingping (Southwest Java), 7 – Muara Angke (North Jakarta), 8 – Leuweung Sancang Nature Reserve, 9 – Santolo Beach.

Table 1. Surveyed coastline stretches in Java (compare to Fig. 1).

Area code	***Location***	***Area description***	***Survey dates***
UKN	North coast of Ujung Kulon National Park	The conspicuous differences between the nearby north and south coast of Ujung Kulon Nationalpark is representative for the whole north and south shoreline of Java, The south is influenced by the strong Indian Ocean whereas the north coast is formed by the calm Javan Sea; Long stretches of nearly pristine coastal habitats, characterized by coastal scrub areas, narrow sandy and large grained beaches without flotsam; surveys between Dermaga Taman Jaya (S 06°46'49.4" E 105°30'12.2") and S 06°49'41,5" E 106°27'56.3"	19 Aug. 2008
UKS	South coast of Ujung Kulon National Park	Wide sandy beaches formed by big waves and covered partially by flotsam and by *Spinefex longifolios*; surveys between S 06°50'48.3" E 105°27'25.8" and (S 06°50'10.3" E 105°26'18.2")	20 Aug. 2008
PD	Pulau Dua	Characterised over fast stretches by brackish water ponds, which provide fish for a large proportion of the human population in Java (Whitten et al. 1996); the large fishpond areas characterized by relatively low extent of direct human disturbance; surveys between S 06°01'52.6" E 106°12'02.0" and S 05°01'06.6" E 106°12'05.2"	18 Aug. 2008
Tr	Trisik beach	From coast south of Yogjakarta 120 km westwards; wide beaches; disturbance particularly through fishermen; surveys between S 07°58'36.6" E 110°11'52.3" and S 07°51'53.2" E 109°56'33.1"	03-05 Sept. 2008
Ba	Bandengan	Predominantly narrow beaches; popular holiday destination; coastline characterized by hotels, bungalows and many private houses with direct access to adjacent beaches; surveys between Airport Semarang (S 06°57'15.7" E 110°21'52.8") and Lak Mlonggo (S 06°30'10.8" E 110°40'21.5")	23-25 Sept. 2008
Ma	Malingping	High variety of different coastal habitat types ranging from rocky shorelines to lagoons and beaches with varying degree of human disturbance; surveys between Cikiruhwetan (S 06°49'05.1" E	18–20 Sept. 2008

		105°54'38.3") and Pelabuhan Ratu (S 06°58'37.1" E 106°31'46.0")	
MA	Muara Angke	Relatively large mangrove areas and fishponds in the northern part of Jakarta; embedded in the large city of Jakarta and, therefore, with high extent of human disturbance; surveys between S 06°06'48.2" E 106°46'02.77" and S 06°03'35.95" E 106°41'56.96"	23 Aug. 2008
LS	Leuweung Sancang	Coastline of Nature Reserve with very narrow sandy beaches landwards directly bordered by forest; towards its western part wider beaches and several lagoons; surveys between S 07°44'07.8" E 107°50'39.6" and S 07°39'10.5" E 107°41'18.7"	06-07 Oct. 2008
SB	Santolo Beach	Steep sandy beaches; popular holiday destination; surveys between S 07°39'10.5" E 107°41'18.7" and S 07°38'43.7" E 107°41'01.2"	07 Oct. 2008

Bird surveys

Fieldwork was conducted from August to October 2009 along different shorelines of Java during a total of 15 days. Coastal shorelines of 500 m length were used as survey units (Fig. 2). All *Charadrius* Plovers were counted within these 500 m units and detailed notes were taken on behaviour (breeding, foraging, hiding etc.) and used habitat structures. Due to the risk of misidentification with other plover species, especially in non-breeding plumage, bird records were documented by photographs whenever possible (Canon equipment with a focal length of 670 mm). Species such as the Malaysian Plover (*Charadrius peronii),* Greater Sandplover *(Ch. leschenaulti),* Lesser Sandplover *(Ch. mongolus)* and especially the Kentish Plover (*Ch. alexandrinus*) could probably lead to confusion.

The most characteristic features of the Javan Plover are the dull russet-brown frontal bar, ear-coverts, lores and lateral breast patches of males in breeding plumage (Bakewell & Kennerely). Besides that the Javan plover males show a warm rufescent-brown wash to the lower crown, rear of the supercilium, and behind the ear-coverts. Furthermore the legs feature an olive-grey coloration (in contrary to Ch. Alexandrinus with black legs; MacKinnon & Philipps 1993). The Javan Plover is smaller than the Kentish plover, similar in size and structure to Malaysian Plover. In addition, the uniform upperparts are quite different to the variegated upperpart appearance of Malaysian Plover (Bakewell & Kennerely 2008). The Greater (*C. leschenaultii*) and the Lesser Sandplover (*C. mongolus*) are both considerable larger in body size than the Javan Plover. (MacKinnon & Philipps 1993)

Habitat variables

Habitat variables were estimated or measured for all surveyed 500 m shoreline transects (Fig. 2) for the entire distance from the land-water ecotone to the closed vegetation cover inlands. The following habitat parameters were quantified:

(1) Beach width was measured as the distance between the water-land ecotone and the next stands of higher vegetation (shrubs, trees etc.).
(2) Slope was categorized as flat (F), moderate (M) or steep (S).
(3) Four habitat types were classified: beach with small-grained sand (SG), beach with larger coralline sand (BL), beach with single rocks (BR), rocky shore (R) and beach with mangroves. Additionally, SG beaches were assigned one of the 3 different categories (SG beach >50m, SG beach 25-<50m, SG beach <25m wide.
(4) The width of the flotsam zone was estimated in meters.
(5) Plant cover was classified as no vegetation (0), single plants (1), sparse vegetation cover (2) and dense vegetation cover (3).
(6) Human disturbance was classified for the entire 500 m transects as 0 (no human disturbance: no human activities, no humans present), 1 (infrequent disturbance: 1-3 humans observed within transect), 2 (moderate disturbance: 3-10 humans) and 3 (high disturbance: >10 humans observed within transect or other high disturbance, e.g. by motor bikers)
(7) Distance from any part of transect to next settlement.

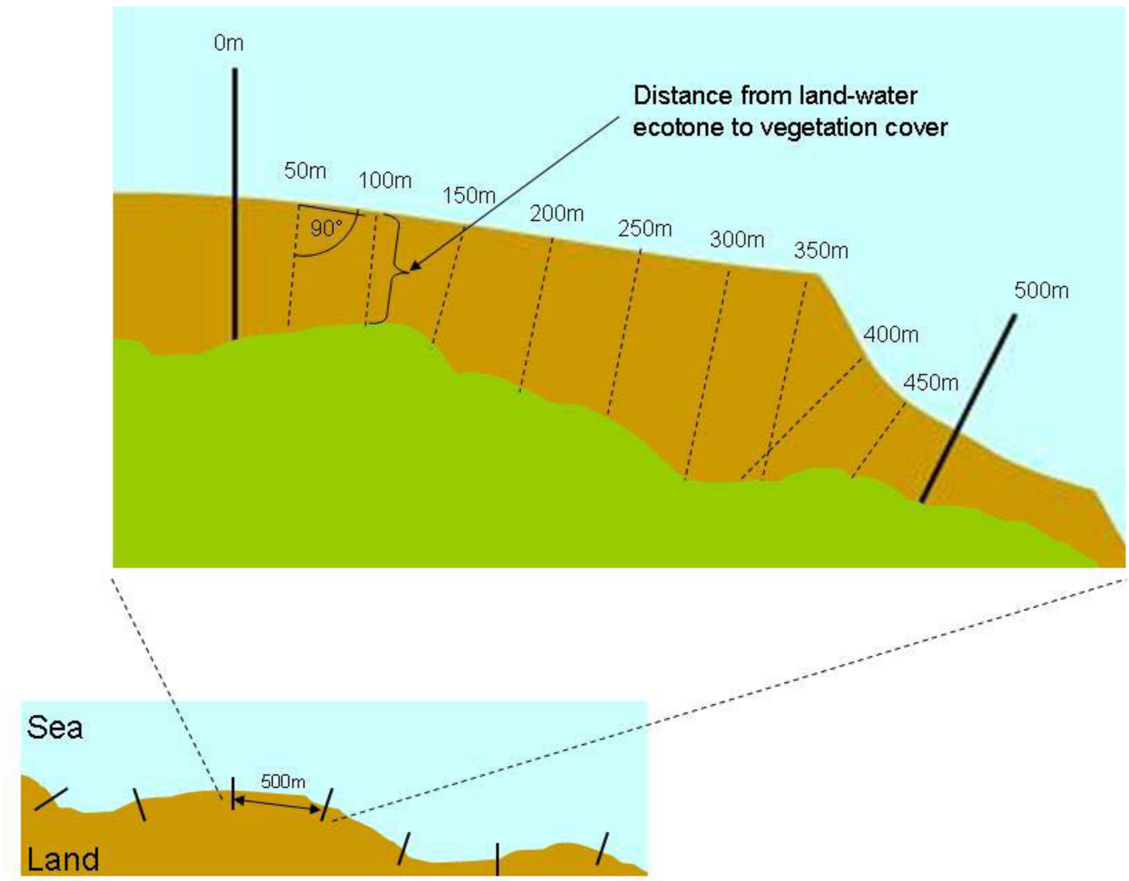

Figure 2. 500m transects surveyed for Javan Plovers. Habitat variables were measured or estimated for the entire 500m transect and 50 m sections.

Additionally, when a *Charadrius* Plover was recorded, habitat variables were measured or estimated for a 50 m long shoreline transects. The transect midpoint was defined by the location of the first sighting of a plover individual. In case a flock was observed, the transect midpoint was defined by the centre of the flock. Along the 50 m transects, habitat variables were measured or estimated from the water-land transition zone towards the border of closed vegetation (Fig. 2). Detailed notes were taken on the plovers' behaviour (breeding, foraging etc.) and use of habitat structures

Data analyses

Generalized linear models were calculated with Statistica 7.1 (Reference) and were used to quantify effects of habitat variables on the occurrence of Javan Plovers on sandy beaches. If variances were heterogeneous, Kruskal-Wallis ANOVAs were used.

The Kruskal-Wallis ANOVA is a useful and general nonparametric test for comparing two or more independent samples. It can be used to test whether such samples come from the same distribution. It is a powerful alternative to one-way analyses of variance. The Kruskal-Wallis ANOVA uses the sum of difference between mean ranks of these samples as the statistic (Origin Lab, Data Analyses; http://www.originlab.com/).

Estimation of the population size

Wide sandy beaches included lagoons, which are by far the most important habitat for Javan plovers along the whole south coast. Due to the fact that sandy beach can considered to be a linear habitat, we were able to extrapolate the individuals along the whole south coast. We worked with the “ruler” tool Google Earth to detect and measure all potential “Javan plover habitats”. This habitat was identified by using the minimum beach width, on which the Javan plover depends. This way we received a rough impression of what the virtual plover habitat looks like, while at the same time considering human disturbance by classifying between natural and disturbed (conspicuous human settlements directly next to the beach) beaches. These heavily disturbed coastlines were not included in the estimation due to apparent destruction and complete loss of proper habitat, especially where villages were settled along the shorelines. To obtain the number of individuals per transect, all observed individuals on sandy beaches were divided by the total number of explored transects belonging to that habitat. Then we simply multiplied that data with the total detected number of kilometres of adequate sandy-beach-habitat on Java.

Results

Abundance of Javan Plovers

During all surveys 357 *Charadrius* plovers were recorded. A total of 218 birds (61.2%) were Javan Plovers, while the others either represented *Ch. mongolus* (113 birds), *Ch. leschenaultii* (24 birds) or *Ch. peronii* (2 birds). A mean (± SD) of 1.47 (± 2.64) Javan Plovers per 0.5 km shoreline was recorded during this study along a total surveyed coastline length of 72.5 km. However, the density of Javan Plovers differed between coastal regions. The highest proportions of 500 m transects with Javan Plover records were reached on the south coast of Java at Tr, Ma and UKS (Tab. 2). The mean abundance per 0.5 km shoreline differed significantly between the surveyed coastal regions (Kruskal-Wallis ANOVA: H_6 = 13.81, N = 145, p = 0.032). Highest densities of Javan Plovers were reached at Tr and Ma, while lower abundances were recorded from coastal areas of Ujung Kulon Peninsula and from Bandengan. A remarkable high density of Javan Plovers were recorded at Leuweung Sancang and 2 individuals were recorded nearby Santolo Beach (Fig. 3, Tab. 2).

Table 2. Survey intensity and abundance of observed plovers in different coastal regions (for area codes and location descriptions compare Tab. 1).

Area code*	**Surveyed 500 m transects**	**Transect number [%] with plover records**	**Total individuals**	**Individuals/ 500 m ± SD**
UKN	12	–	–	–
UKS	16	4 (25.0)	17	1.06 ± 2.17
Tr	30	11 (36.7)	78	2.60 ± 7.08
Ba	28	4 (14.3)	13	0. 46 ± 1.43
Ma	48	5 (10.4)	37	0.77 ± 2.42
LS	8	3 (37.5)	64	8.00 ± 11.60
SB	3	1 (33.3)	2	0.67 ± 1.15
Total	145	28 (19.3)	211	1.46 ± 4.76

* Additionally 7 Javan Plovers were observed at Pulau Dua.

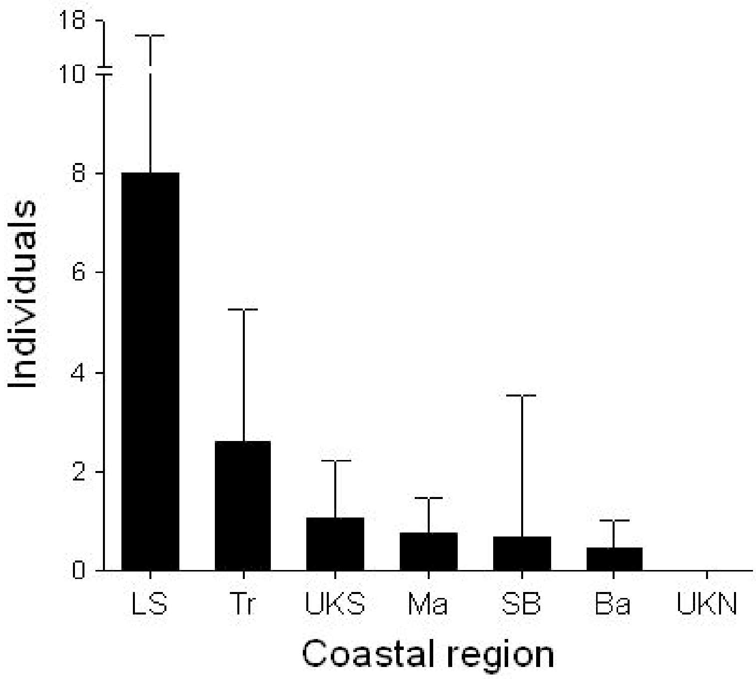

Figure 3. Mean number of individuals + 95% CI per 0.5 km shoreline stretch in different coastal regions: Trisik Beach (Tr), Malingping (Ma), south coast of Ujung Kulon Peninsula (UKS), north coast of Ujung Kulon Peninsula (UKN), Bandengan (Ba), Leuweung Sancang (LS) and Santolo Beach (SB).

Features of surveyed coastal regions

The 500 m transects differed significantly between coastal regions with respect to beach width (one-way ANOVA: $F_{6,138} = 33.69$, $p < 0.001$), flotsam width (one-way ANOVA: $F_{6,138} = 18.75$, $p < 0.001$), disturbance level (Kruskal-Wallis ANOVA: $H_6 = 52.10$, $p < 0.001$) and distance to settlements (Kruskal-Wallis ANOVA: $H_6 = 88.04$, $p < 0.001$). Largest mean beach widths were found at Trisik Beach and along the south coast of Ujung Kulon Peninsula, beaches of intermediate width were found at Malingping and Leuweung Sancang, narrowest beaches at the north coast of Ujung Kulon Peninsula, Bandengan and Santolo Beach (Fig. 4a). Mean flotsam width showed a very similar pattern (Fig. 4b). Flotsam width increased significantly with increasing beach width of 500 m transects (Pearson correlation: $r = 0.68$, N = 144, $p < 0.001$). Human disturbance was lowest at coastal areas in Unjung Kulon National Park. All other areas showed a moderate level of disturbance except Leuweung Sancang, where a high level of human disturbance was found (Fig. 4c). The estimated level of human disturbance was negatively related to the distance of 500 m transects to the next settlement (Spearman rank correlation: $r_s = -0.33$, N = 145, $p <$

0.001). Only 500 m transects on the south coast of Ujung Kulon Peninsular were located in larger distances to settlements. All other coastal areas were in close vicinity to settlements (Fig. 4d).

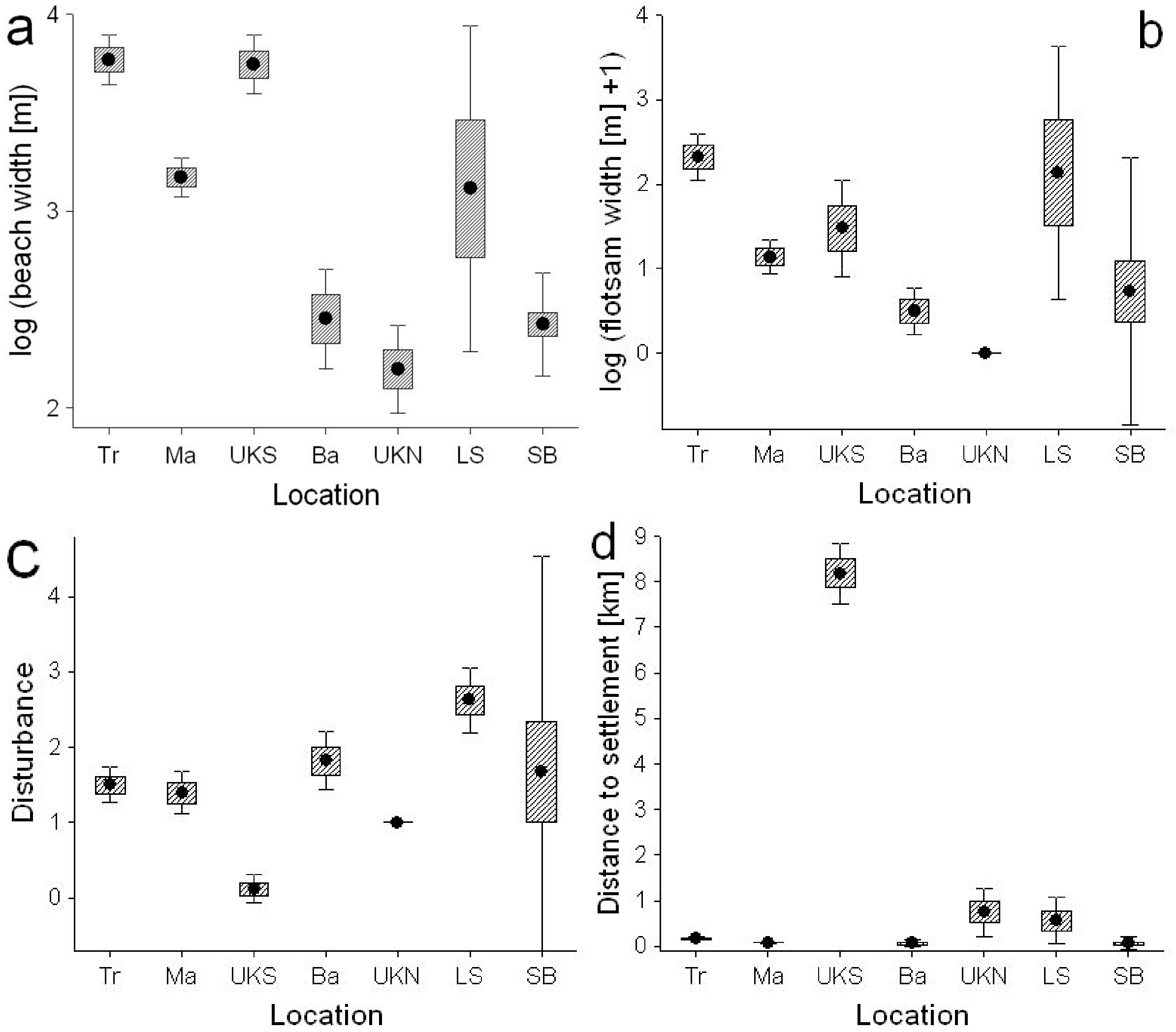

Figure 4. Mean beach width (log x transformed) (a), flotsam width (log x+1 transformed) (b), disturbance level (c) and distance to next settlement (d) of 500m transects ± SE (box) and 95% CI (whiskers) in different coastal regions. For abbreviations of coastal regions see Table 1.

The first axis of a principal component analysis on habitat parameters explained 43.31% of the variance of 500 m transects; the second axis explained 22.43%. PC1 mainly represents habitat variables related to beach structure, while PC2 represents the extent of human disturbance (Tab. 3). Both PC1 and PC2 values were significantly affected by coastal region (one-way ANOVAs; PC1: $F_{6,138} = 24.70$, $p < 0.001$; PC2: : $F_{6,138} = 58.31$, $p < 0.001$), indicating that habitat structure and human disturbance differed between coastal regions, which is also partly indicated by the segregation of surveyed 500 m transects into different coastal regions (Fig. 5). Abundance of Javan Plovers was significantly correlated with habitat structure (PC1 values; $r_s = 0.41$, N = 145, $p < 0.001$) and the degree of human disturbance ($r_s = -0.24$, N = 145, $p = 0.013$).

Table 3. Eigenvalues of the first three principal components (PC1–PC3) and contribution of each habitat variable to the ordination.

Habitat variables	**PC1**	**PC2**	**PC3**
log (beach width)[m]	**0.76**	-0.08	0.54
SG beach cover [%]	**0.76**	-0,27	-0.39
LG beach cover [%]	**-0.71**	0.06	0.56
log (flotsam width [m] +1)	**0.77**	-0.38	0.35
Disturbance level	-0.41	**-0.74**	0.14
Distance to settlement [m]	0.40	**0.76**	0.19
Eigenvalue	2.59	1.35	0.93
% Variation	43.31	22.43	15.50
Cumulative % variation	43.31	65.75	81.25

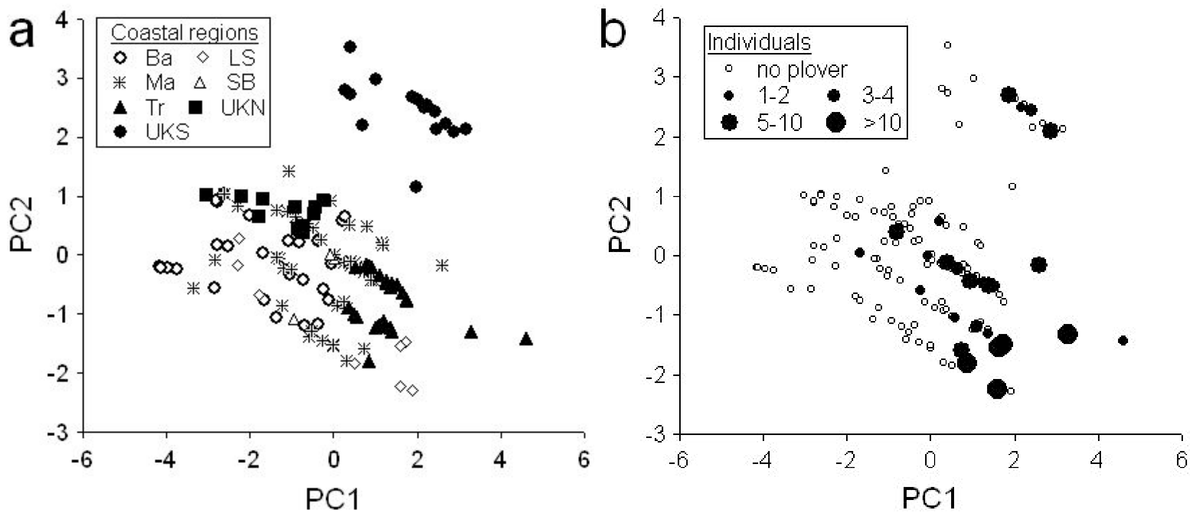

Figure 5. Principal component ordination of 500 m transects indicating coastal region (a) and number of recorded Javan Plovers (b). For abbreviations of coastal regions compare Table 1.

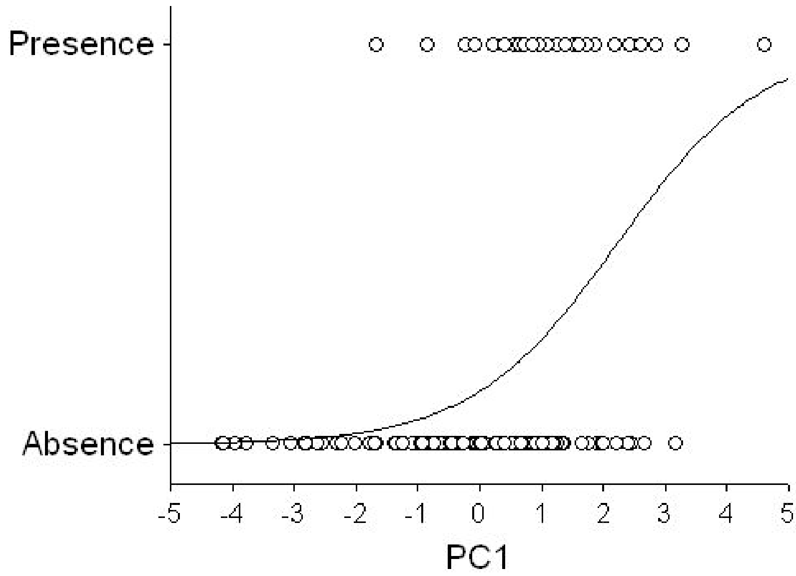

Figure 6. The likelihood of Javan Plover occurrence in 500 m shoreline stretches increased with increasing PC1 values (logistic regression; χ^2 = 25.76, df = 1, p < 0.001), but was not significantly related to PC2 values (χ^2 = 2.85, df = 1, p = 0.092).

Habitat preferences of Javan Plovers

Abundance of Javan Plovers differed significantly between coastal habitats (Kruskal-Wallis ANOVA: H_7 = 35.34, N = 145, p < 0.001; Fig. 7). Wide (>50m) small-grained sandy beaches were the preferred habitat. Additionally, the species was observed on beaches with mangroves and even on fishponds (not included in this analysis). No Javan Plovers were present at beaches with large-grained substrate and coastal stretches partially or completely covered by rocks (Fig. 7). Therefore, these coastal habitats were excluded from all further analyses of habitat requirements of Javan Plovers.

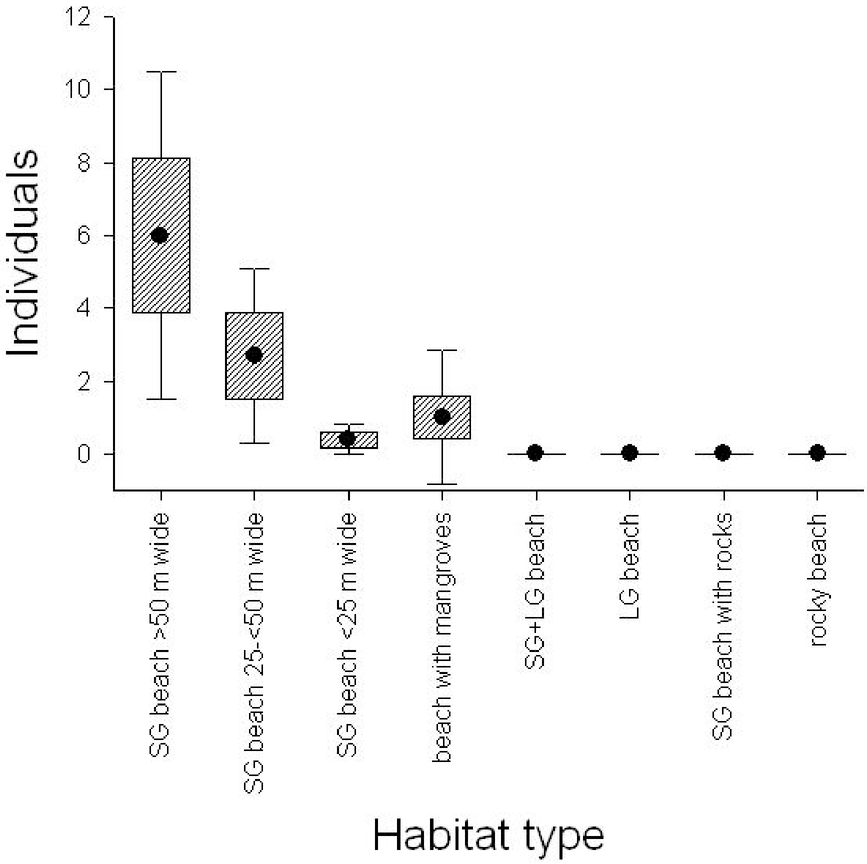

Figure 7. Mean number of Javan Plovers per 500 m ± SE (box) and 95% CI (whiskers) in different coastal habitats.

The occurrence of Javan Plovers in the 109 remaining 500 m transects was significantly related to beach width (Fig. 8a) and flotsam width (Fig. 8b). The likelihood of occurrence significantly increased with increasing beach width (χ^2 = 11.29, df = 1, $p < 0.001$; Fig. 8a) and flotsam width (χ^2 = 13.04, df = 1, $p < 0.001$; Fig. 7b). Also plant cover significantly affected abundance of Javan Plovers (Kruskal-Wallis ANOVA: H_3 = 13.34, N = 109, p = 0.004). Highest plover numbers were recorded on small-grain beaches with single plants (Fig. 9). The number of Javan Plovers recorded per 500 m transect was neither affected by the estimated disturbance level (Kruskal-Wallis ANOVA: H_3 = 1.12, N = 109, p = 0.773) nor by the distance of 500 m transects to settlements (logistic regression: χ^2 = 2.29, df = 1, p = 0.131).

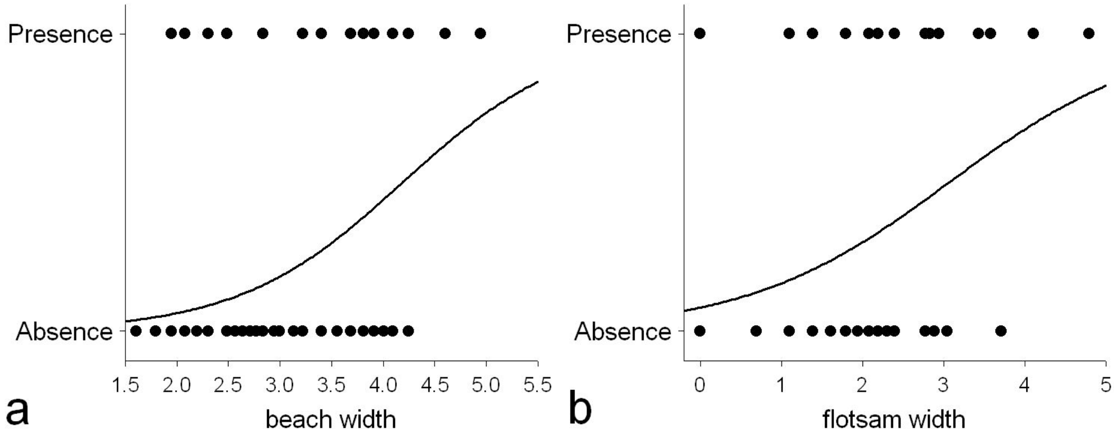

Figure 8. Likelihood of Javan Plover occurrence in 500 m transects in relation to beach width (log x transformed) (a) and flotsam width (log x+1 transformed) (b) described by logistic regression curves.

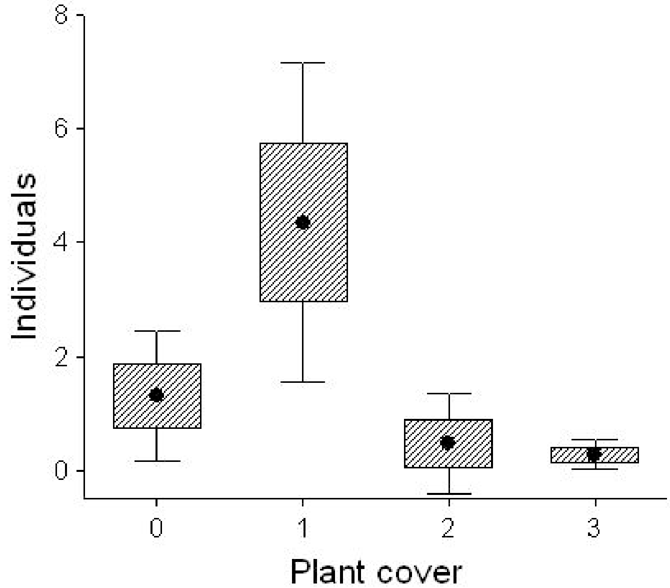

Figure 9. Mean number of Javan Plovers ± SE (box) and 95% CI (whiskers) in 500 m transects of small-grained beaches with different plant cover (0 – no vegetation, 1 – single plants, 2 – sparse vegetation cover, 3 – dense vegetation cover).

GLM selection based on AIC values indicate that flotsam width and beach width were the best explanatory variables for predicting the occurrence of Javan Plovers in 500 m transects. Both variables were included in 7 of the 11 best models (Tab. 4). Distance to settlement and plant cover only remained in 5 models. Disturbance level was not indicated as an important variable affecting occurrence of Javan Plovers; it was not included in any of the selected best models (Tab. 4).

Table 4. Performance of best GLMs evaluating effects of beach width (log x transformed), flotsam width (log x+1 transformed), disturbance level, distance to settlement (log x+1 transformed) and plant cover. All models with p < 0.01.

Variables included	**Df**	**AIC**	**Δ AIC**
flotsam width	1	115.17	0.00
flotsam width, beach width	2	116.25	1.08
flotsam width, distance to settlement	2	116.66	1.49
flotsam width, plant cover	4	116.73	1.56
beach width, plant cover	4	116.90	1.73
beach width	1	116.92	1.75
flotsam width, beach width, plant cover	5	117.85	2.68
flotsam width, beach width, distance to settlement	3	118.04	2.87
flotsam width, distance to settlement, plant cover	5	118.43	3.26
beach width, distance to settlement, plant cover	5	118.63	3.46
beach width, distance to settlement	2	118.76	3.59

Mean number of plovers per 500 m transects increased with mean beach width (r_s = 0.89, N = 7, p = 0.007) and mean flotsam width (r_s = 0.96, N = 7, p < 0.001). Also both beach parameters themselves were highly correlated (r_s = 0.86, N = 7, p = 0.013). These relationships are summarized in Fig. 10.

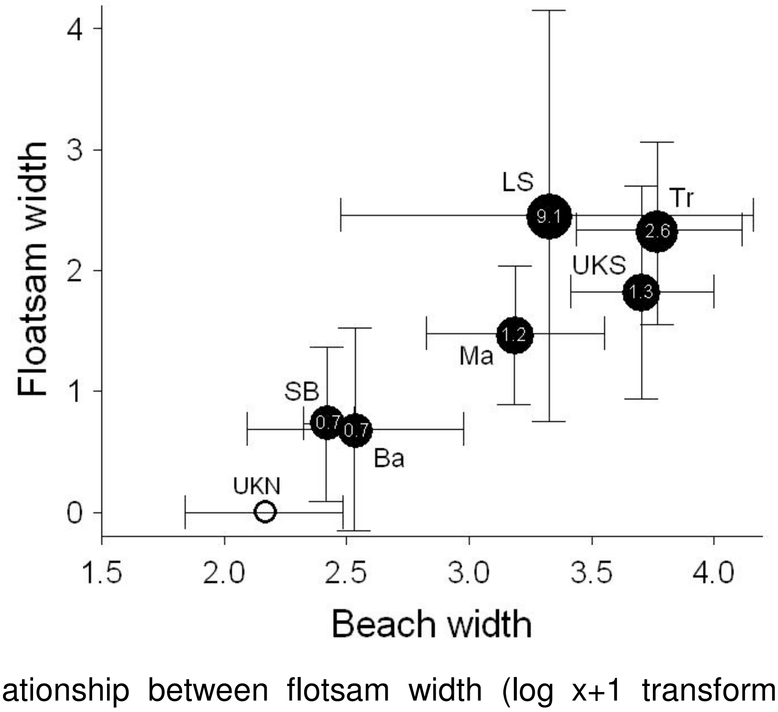

Figure 10. Relationship between flotsam width (log x+1 transformed) and mean beach width (log x transformed) ± SD and the mean number of counted Javan

Plovers (values in black dots; no birds recorded at UKN) in different coastal regions. For abbreviations of coastal regions refer to Table 1.

Estimation of total population size

A total of 205 individuals were recorded on 76 transects (sandy beach habitat included lagoons) resulting in a mean density of 2.67 birds per transect or 5.39 Javan plovers per kilometre of coastline providing adequate habitats. Subsequently, coastal stretches with adequate habitats (wide sandy beaches) were identified using aerial photographs (Google Earth; Fig. 11). All beaches > 30 meters were included in the estimation. Based on this rough estimate, a total of 361.7 km of coastline are expected to provide a potential Javan Plover habitat. When extrapolated to this length of adequate coastline, a total of ca. 1950 Javan Plovers was estimated to occur in coastal habitats of Java.

Figure 11. Red colour: Identified adequate SG habitat of the Javan plover

Discussion

Important coastal habitats and habitat structures for Javan Plovers

Our data provide clear evidence for the importance of wide small-grained sandy beaches as habitat for the Javan Plover. Furthermore, abundance of Plovers declined in coastal sections with beaches without any vegetation. The most common plant species in surveyed Javan plover habitats was *Spinifex longifolius, a coastal plant of sand dunes* (Connor & Jacobs 1991). In case of nearing danger (for instant observer), Javan plovers frequently used this plant as cover. Also in Malaysian Plovers, breeding success appeared positively to depend on vegetation structures, of a medium (0,5-5m) height (Yasue & Dearden 2006).

Natural lagoons represent an important coastal habitat for many shorebirds (Bellio et al. 2009). In our study, lagoons appeared to be particularly important for Javan Plovers. Due to the large beach and flotsam width, occuring at lagoons, the plover finds excellent habitat conditions. Additionally, the expansion of foraging habitat through the presence of the second river-shore should also implicate a positive effect on Javan plover abundance. At lagoons, most individuals were found at the fresh water shore of the river and less frequently found at the sea coast.

Effects of human disturbance

The major threat facing sandy beaches is coastal squeeze which leaves beaches trapped between erosion and rising sea level (Healy 2002).
To evaluate and interpret effects of human disturbance on tropical wader populations, studies have to include habitat modelling, behavioural observations and nest monitoring (Yasue & Dearden 2006). However, due to our experiences we predict a considerable future decline of adequate remaining Javan Plover habitats. Particularly estuaries (Trisik), river mouths, lagoons and mangroves (Semarang) are under an enormous human pressure and a substantial proportion of such habitats will be converted to human-dominated habitats in the near future. For example, at Trisik two lagoons, where a high abundance of Plovers was found and breeding recorded, will be destroyed in the near future (NGO Kutilang, pers. communication). At North Semarang, a considerable part of the Jrakah wetlands was cleared currently before our observation, probably to make space for new settlements (own observation). Estuaries, which also offer a high diversity of coastal habitats, are highly disturbed due to their use by fishermen and for recreation, thereby significantly decreasing the area which can be used for foraging and breeding by Javan Plovers. Also other habitats used by Javan Plovers, such as long wide flat sandy beaches, are often characterised by an extremely high density of fishermen. For example, Trisik beach would be capable of supporting a large population of Javan Plovers, but, due to the

high density of fishermen, remaining areas for foraging and breeding are extremely small. At Trisik beach over many kilometres the density of fishermen was estimated as one per 50 m beach length (own observation). Although the beach appeared to satisfy all habitat requirements of the Javan Plover, not a single bird could be recorded with only one exception. Two birds were observed foraging on the beach in a 100–150 m gap within the otherwise continuous chain of fishermen. It seemed that some plovers adapted to this high human disturbance by shifting their foraging to the evening, when most fishermen have left. For example, at Trisik a remarkably high number of plovers was observed at around 5 p.m. when most fishermen had already left the beach. However, it is hard to imagine that this behavioural response can compensate the negative effects of human disturbance completely. Off road vehicles are commonly used on beaches (Godfrey & Godfrey 1980) and cause disturbance or injure on shorebirds (Williams et al. 2004). Also on many coast stretches on Java plenty of motorbikes were noticed. At a sandy beach habitat close to Leuweung Sancang, considerable road vehicle traffic could be observed in Javan plover habitat. These human activities caused alarm calls and escape flights of many Lesser Sand Plovers and Javan plovers. Further studies on Javan Plovers are needed to quantify the effects of disturbance on the plover's breeding performance. In other Plover species (e.g. Piping Plover) high human disturbance negatively affects reproductive success due to reduced foraging efficiency (Burger 1991, 1994).

This study could not detect an effect of human disturbance level on the occurrence of Javan Plovers in 500 m coastline stretches. However, this does not necessarily indicate a high tolerance of this wader against human disturbance, but may also emphasize that most surveyed areas are facing an enormous extent of disturbance. However, human disturbance may also generate areas with lower predator pressure due to a significant decline of raptors, carnivorous mammals (e.g. nest predators such as mongoose). For example two mongooses killed by locals were found during Plover surveys next to the beach at Trisik. On the other hand, egg collecting by humans and domestic mammals (e.g. dogs) preying on clutches and chicks may increase pressure on plovers in highly populated regions. A study on the breeding biology of Kentish plovers recorded nest predation through dogs (Fraga & Amat 1996). Also hunting, which is common in most parts of Java, can represent an important threat. Illegal hunters are able to catch more than 500 birds per day, representing a wide variety of species, including Javan Plovers. Also egg collectors may represent an additional threat, because the consumption of eggs of the Javan Plover appears to be particularly popular among locals (NGO Kutilang, Yogjakarta, pers. communication). However, foraging plovers were observed even in areas with high human disturbance, but it is doubtful if such coastal areas represent adequate breeding habitats.

Estimation of total population size

The estimation of nearly 2,000 Javan Plover individuals represents a very rough estimate of this part of the population using coastal habitats along the shoreline.
The estimate does not include the fraction of the total population, which occurs at fishponds, an artificial habitat, which expand along vast parts of the north and east coast of Java. During our surveys a total of 7 Javan Plovers were recorded at fishponds along a 1600 m transect at Pulau Dua and 2 were observed next to the airport at Semarang (Jerakah wetlands). Records form other fishpond areas include observations from Muara Gembong Bekasi (Adhy Maruly, see homepage of Oriental Bird Club; Images) and an individual photographed at a fishpond at Wonorejo next to Surabaya by Iwan Londo (Google earth added photograph; http://www.panoramio.com/photo/11363310). These records from different locations distributed from the very west coast to the very east coast all refer to the same habitat type, shallow ponds partially covered by mangroves. Our own observations along a 15 km long transect passing fishponds without mangrove patches (east of Semarang, Sidogemah, Gemulak) during high tide, did not result in any record of Javan Plovers. However, due to an estimated area of 700 km covered by fishponds on Java (estimates based on fishpond areas identified by using aerial photographs in Google Earth), it is assumed that a substantial proportion of the total population of Javan Plover might occur in fishponds. Further surveys have to focus on the potential importance of this secondary habitat for Javan Plovers.

The future of the Javan Plover

Further coastal development may represent a serious threat to the species´ coastal population. Human development is predicted to increase over the next few decades on sandy shorelines (Nordstrom 2000). For example, no plovers were found on beaches directly next to tourist areas (own observation). This may be particularly caused by the lack of any vegetation, which is removed to have “clean” beaches. In contrary, high vegetation (e.g. palms) is planted to provide shade, which also alters the beach to a habitat not providing adequate conditions for the plovers.

Natural lagoons proved to be particularly important for Javan Plovers. Human activities changing the physico-chemical profile of natural lagoons can have a negative impact on the densities of waterbirds, particularly shorebirds (Bellio et al. 2009). It remains to be shown how human activities affect occurrence and reproductive success of the Javan Plover breeding in lagoons. However, the increasing human population in coastal areas will certainly also negatively affect this sensitive ecosystem.

A glimmer of hope for the wader is its robustness against human disturbance allowing the species to use fishpond areas for breeding and foraging, at least when they are used extensively and provide some remaining patches of mangrove. A study about landscape change along the coastline in Banten (Northwest Java), showed an increase of fishponds of 40,000 ha from 1996 to 2001 (Doydee 2005). Perhaps this artificial habitat can compensate at least partly for the declining area of the species´ original habitat in the near future.

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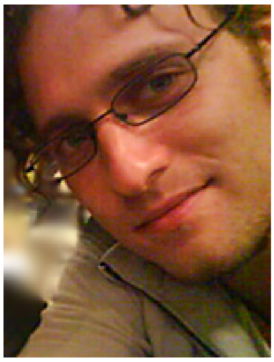
Lebenslauf



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