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Aquaculture ponds provide non-breeding habitat for shorebirds in Banyuasin Peninsula, South Sumatra, Indonesia

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To contribute to our understanding of the importance of aquaculture ponds as shorebird habitat in the East Asian-Australasian Flyway (EAAF), we monitored shorebird numbers found in aquaculture ponds in Banyuasin Peninsula of South Sumatra Province, Indonesia. During 2016–2020, 25 species of shorebirds were recorded, representing nearly half of the 52 migratory shorebird species in the EAAF, including eight Near Threatened species and two Endangered species. The total number of shorebirds counted in a section of aquaculture ponds, representing about 30% of all ponds, ranged from 886 in January 2016 to 13,745 in December 2020. Notably, in December 2020 a single square of aquaculture ponds held as many as 5,000 Black-tailed Godwits. With a total of about 250 aquaculture ponds, we estimated that up to 50,000 shorebirds could annually use the aquaculture ponds of Banyuasin Peninsula. With the continuing loss of shorebird habitats in the EAAF, identification of these ponds as non-breeding habitat for shorebirds signifies the importance of their management for shorebird conservation.

Keywords

artificial habitat

flyway population

East Asian-Australasian Flyway

waders

INTRODUCTION

An estimated 12.5 million shorebirds of 52 species travel annually along the East Asian-Australasian Flyway (EAAF; Conklin *et al.* 2014). Many migratory waterbirds, including shorebirds, in the EAAF are in decline and it has been suggested that the major driver of these declines is reduction of the quality and extent of their primary habitats, particularly coastal habitats (MacKinnon *et al.* 2012). Conversion of mangrove forests to aquaculture ponds has occurred throughout Southeast Asia (Richards & Friess 2015, Gandhi & Jones 2019). In Indonesia, the coastal area of mangroves and adjacent mudflats, coined the 'edible wetland', may have exceeded 4.3 million ha, however, due to overexploitation, conversion and mismanagement of this important coastal resource, nearly 43% or 1 million hectares of Indonesia's mangroves have been lost since 1800 (Tomascik *et al.* 1997, Ilman *et al.* 2016).

The Banyuasin Peninsular of South Sumatra Province in Indonesia is an important wetland habitat in the EAAF region (Bamford *et al.* 2008, MacKinnon *et al.* 2012). The mudflats of the Banyuasin Peninsula are known as important habitat for migratory shorebirds (Silvius 1988, Verheugt *et al.* 1990, 1993). Prior to anthropogenic activities, the mangrove-mudflat wetlands stretched 50–60 km and were tremendously productive, supporting at least 8,000 fishermen and their families who found full-time employment in coastal fisheries (Danielsen & Verheugt 1990). The mangrove forest in the coastal zone of Banyuasin Peninsula was still undisturbed until commercial fish farming businesses from Lampung province expanded their activities into the Banyuasin Peninsula in 1995 (Sutaryo & Purnomo 2001, Iqbal *et al.* 2019).

While mangroves may provide roosting habitat for some shorebird species, in general shorebirds forage on exposed mudflats and rarely use the densely vegetated mangrove

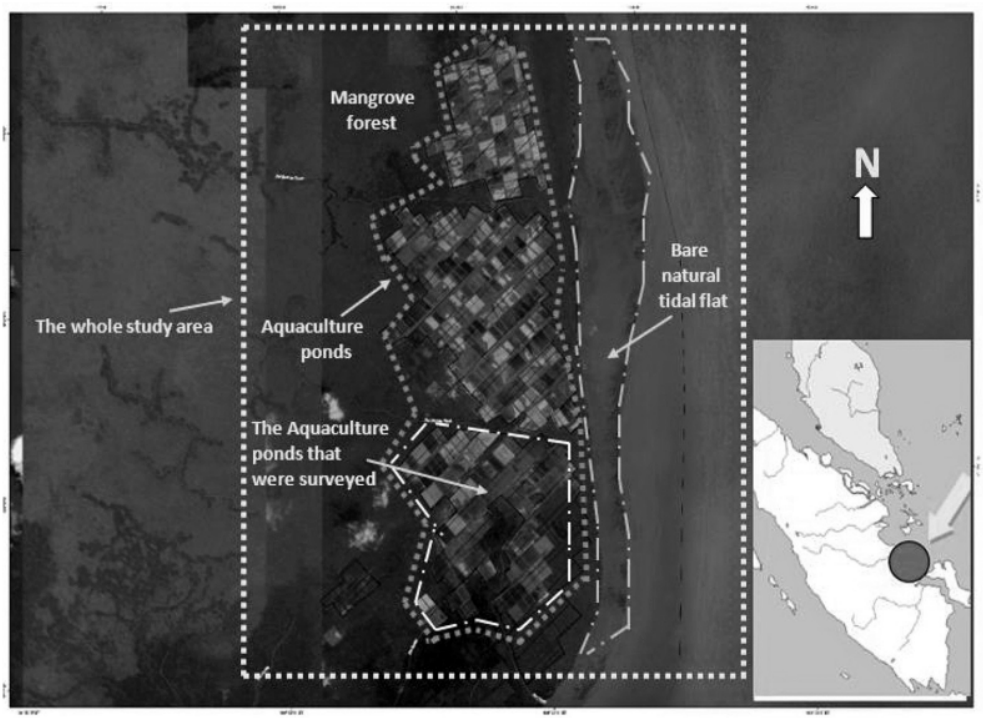

Fig. 1. Map showing the study area on the Banyuasin Peninsula, South Sumatra, Indonesia. The squares indicate aquaculture ponds.

forests for feeding. Indeed, the 27 shorebirds species with a maximum count of more than 75,000 birds recorded in Banyuasin Peninsula in October 1988 mostly used mudflats (Verheugt *et al.* 1990), while some visited aquaculture ponds to roost and/or feed. However, during the last two decades birds were found feeding in the aquaculture ponds in increasingly significant numbers (Iqbal & Martini 2018, Iqbal *et al.* 2019, Taman Nasional Berbak Sembilang 2019). The aquaculture ponds in mangrove forest now provide a total of *ca.* 40,000 ha of internationally important habitat to migrating shorebirds (Crossland *et al.* 2009, MacKinnon *et al.* 2012, Putra *et al.* 2015, Iqbal *et al.* 2020). Clearly, available feeding grounds in aquaculture ponds are important to many shorebirds in the EAAF that use this artificial habitat in the non-breeding period (Jackson *et al.* 2020). Here, we present an update of shorebird numbers found in aquaculture ponds in Banyuasin Peninsula of South Sumatra Province to contribute to our understanding of the importance of aquaculture ponds as shorebird habitat.

METHODS

Our study site is on the Banyuasin Peninsula, South Sumatra province, Indonesia (02°14'S, 104°50'E; Fig. 1) and stretches along the coast from the Banyuasin River to the Sembilang River. It encompasses 3,000 ha of aquaculture ponds (Wibowo & Goenner 2001). We surveyed *ca.* 30% of the area of aquaculture ponds (*ca.* 900 ha). The area of remaining mangrove forest in Banyuasin Peninsula is *ca.* 11,000 ha, with 4,507 ha of adjacent mudflats. Access to most aquaculture ponds is only possible by boat. The aquaculture ponds vary from around 100 x 200 m^2 (small or normal size) to 200 x 300 m^2 (large size), and there are *ca.* 250 ponds in total.

Shorebird surveys were conducted in the aquaculture ponds between September 2017 and December 2020, one to four times during the non-breeding season. The shorebirds were counted during low or high tide, during daylight hours and under favourable weather conditions, using binoculars, spotting scopes (40–60x) and long zoom cameras (50x optical zoom). Each monthly count covered the same subset of ponds, and ponds were counted more or less simultaneously by multiple observers in approximately two hours. Bird numbers were determined either by counting individual birds or estimated by counting groups of ten. Counts were conducted by professionals except in the winter of 2020; in October 2020, we trained local people to identify shorebirds. We taught them simple shorebird survey field techniques and provided them with a field guide, binoculars and a medium-long zoom camera (30x optical zoom). In November and December 2020, we encouraged local people to conduct shorebirds surveys by themselves, and they subsequently provided count information and (photo) documentation.

We then compiled and reviewed all information of the 2016–2020 shorebird surveys in the aquaculture ponds, adding published surveys (Taman Nasional Sembilang 2016, Iqbal & Martini 2018, Taman Nasional Berbak Sembilang 2019).

During surveys potential threats to the habitats and shorebirds were recorded, and local people were interviewed to assess practices in hunting and in pond management, including the use of fertilizers and other chemicals.

To review the importance of the aquaculture ponds on the flyway scale, we compared the maximum species counts with the relevant flyway population size for each species as published in Bamford *et al.* (2008) and Hansen *et al.* (2016). To assess each species/site combination, we used the Ramsar Convention criteria of a site regularly supporting either 1% of the individuals in a population of one species or subspecies of waterbird, or a total abundance of at least 20,000 waterbirds (Gaget *et al.* 2020).

RESULTS

Species occurrence

From 2016 to 2020, 25 species of shorebirds were recorded in aquaculture ponds in Banyuasin Peninsula (Table 1) representing nearly half of the 52 migratory shorebird species in the EAAF. The four species found most frequently in the aquaculture ponds (each present in all but one survey) were Black-winged Stilt *Himantopus himantopus*, Lesser Sand Plover *Charadrius mongolus*, Terek Sandpiper *Xenus cinereus* and Common Redshank *Tringa totanus*. Other commonly occurring species were Common Sandpiper *Actitis hypoleucos* and Whimbrel *Numenius phaeopus*. The rarest species were Kentish Plover *Charadrius alexandrinus*, Green Sandpiper *T. ochropus* and Wood Sandpiper *T. stagnatilis*, which were each recorded only once.

Eight of the shorebird species using the ponds are listed as Near Threatened by Birdlife International (2021a): Eurasian Curlew *Numenius arquata*, Bar-tailed Godwit *Limosa lapponica*, Black-tailed Godwit *L. limosa*, Red Knot *Calidris canutus*, Curlew Sandpiper *C. ferruginea*, Red-necked Stint *C. ruficollis*, Asian Dowitcher *Limnodromus semipalmatus* and Grey-tailed Tattler *T. brevipes*. Two species are listed as Endangered: Far Eastern Curlew *Numenius madagascariensis* and Great Knot *Calidris tenuirostris*.

Population size and comparison with flyway population estimates

The total number of shorebirds counted in the aquaculture ponds of Banyuasin Peninsula during 2016 to 2020 ranged from 886 (Jan 2016) to 13,745 (Dec 2020; Table 1). In Nov–Dec 2020 the numbers in the ponds were 3 to 9 times higher than in Nov–Dec 2018 when 1,000 to 1,500 birds were counted. Generally more birds used the aquaculture ponds at high tide when the tidal flats are inundated, although some bird species (Black-winged Stilt, Lesser Sand Plover, Terek Sandpiper and Common Redshank) used the ponds throughout the tidal cycle.

The species that occurred in the highest numbers were Lesser Sand Plover (with a maximum count of 3,600) and three Near Threatened species: Eurasian Curlew (1,232), Black-tailed Godwit (5,000) and Asian Dowitcher (1,500). These four species met the 1% criterion, as did Black-winged Stilt (maximum count 544) (Table 1).

Threats

Thus far, we have not documented large-scale direct threats to shorebirds in the study area. The local people we interviewed realized that the area is part of a protected area under Berbak Sembilang National Park. Hunting of shorebirds is prohibited here. Local people said that they used fertilizer and some chemicals to maintain their aquaculture ponds, but there are no reports of shorebirds found dead in small or large numbers which might have been caused by these activities. Shorebirds were also not seen as competitors as they usually feed on worms or other small aquatic animals, and generally not on (commercial) shrimps and fish.

DISCUSSION

Our results demonstrated the important value of aquaculture ponds of the Banyuasin Peninsula as habitat for 25 species, including some key species in the EAAF. Prior to the 1980s, the mudflats of the Banyuasin Peninsula were already known as important habitat for migratory shorebirds (Silvius 1988, Verheugt *et al.* 1990, 1993), but our study is the first to document the presence of significant numbers of shorebirds in artificial habitats in this area.

Iqbal *et al.* (2020) recorded 29 shorebirds on the tidal flats of Banyuasin Peninsula. Of these, the five species that were absent in our surveys of the aquaculture ponds were Pied Avocet *Recurvirostra avosetta*, White-face Plover *Charadrius dealbatus*, Sanderling *Calidris alba*, Nordmann's Greenshank *Tringa guttifer* and Spotted Redshank *T. erythropus*. In Sumatra, shorebird species that are known to occur in aquaculture ponds are Black-winged Stilt, Pacific Golden Plover *Pluvialis fulva*, Little Ringed Plover *Charadrius dubius*, Javan Plover *Charadrius javanicus*, Common Greenshank, Common Redshank, Marsh Sandpiper, Wood Sandpiper, Terek Sandpiper, and Common Sandpiper (Iqbal *et al.* 2010, 2011, Putra *et al.* 2017). Furthermore, Putra *et al.* (2020) recorded some interesting species in aquaculuture ponds, including Sharp-tailed Sandpipers *Calidris acuminata*, Far Eastern Curlew, Grey-tailed Tattler and Great Knot. On the north coast of West Java, 23 wader species were recorded in August–September 1984, and an estimated 19,000 shorebirds used aquaculture ponds in this area (Bowler *et al.* 1985). Also, Desmawati *et al.* (2017) reported that the preferred habitats for migratory birds on the northeast coast of Java are mudflats and ponds.

The conservation of artificial coastal wetlands such as aquaculture ponds is a viable approach for shorebird conservation (Masero 2003), especially in the EAAF (Green *et al.* 2015, He *et al.* 2016, Jackson *et al.* 2020).

Table 1. Number of shorebirds recorded in surveyed area (*ca.* 30% or 900 ha) of aquaculture ponds of Banyuasin Peninsula, South Sumatra, Indonesia, during 2016–2020. Data: this paper (2020), data derived from Taman Nasional Sembilang (2016; TNS), Iqbal & Martini (2018; IM), and Taman Nasional Berbak Sembilang (2019; TNBS). Species order follows taxonomy of del Hoyo & Collar (2014) rather than Gill *et al.* (2022) for ease of finding species details and Red List status based on Birdlife International (2021a). The highest count for each species is indicated in bold, and was used to calculate % of flyway population. Red List status: LC = Least Concern, NT = Near Threatened, EN = Endangered (BirdLife International 2021a). Criteria of 1% of Flyway population follows Hansen *et al.* (2016), except for four species not presented there (Black-winged Stilt, Kentish Plover, Eurasian Curlew and Green Sandpiper) for which we used Bamford *et al.* (2008).

Count information/species	**Jan 2016**	**8 Sep 2017**	**20 Feb 2018**	**16 Mar 2018**	**12 May 2018**	**22 Nov 2018**	**23 Dec 2019**	**15 Oct 2020**	**24–26 Oct 2020**	**16+25 Nov 2020**	**6+12 Dec 2020**	**1% of Flyway**	**% of Flyway population**
Data source	TNS	IM	IM	IM	IM	TNBS	TNBS	This study	This study	This study	This study		
Black-winged Stilt *Himantopus himantopus* (LC)		380	10	500	145	273	**544**	100	250	362	250	250	**2.2**
Grey Plover *Pluvialis squatarola* (LC)			10							**166**	10	800	0.21
Pacific Golden *Plover Pluvialis fulva* (LC)	40		3	6		6		64		35	**200**	12,220	<0.05
Kentish Plover *Charadrius alexandrinus* (LC)										**15**		1.1	<0.05
Lesser Sand Plover *Charadrius mongolus* (LC)	56	10	200	40		357	251	150	**3,600**	511	3,000	1,800	**2.0**
Greater Sand Plover *Charadrius leschenaultii* (LC)								10		**108**		2,000	0.05
Whimbrel *Numenius phaeopus* (LC)		23	15	10	3	200	2	20		107	**600**	650	0.92
Eurasian Curlew *Numenius arquata* (NT)	37							1		**1,233**	1,000	400	**3.1**
Far Eastern Curlew *Numenius madagascariensis* (EN)	3									56	**250**	350	0.71
Bar-tailed Godwit *Limosa lapponica* (NT)	200	6				200		2		5	**800**	3,250	0.24
Black-tailed Godwit *Limosa limosa* (NT)		5				1	20	10		1	**5,000**	1,600	**3.1**
Great Knot *Calidris tenuirostris* (EN)										156	**200**	4,250	<0.05

Table 1, continued

Count information/species	Jan 2016	8 Sep 2017	20 Feb 2018	16 Mar 2018	12 May 2018	22 Nov 2018	23 Dec 2019	15 Oct 2020	24–26 Oct 2020	16+25 Nov 2020	6+12 Dec 2020	1% of Flyway	% of Flyway population
Data source	TNS	IM	IM	IM	IM	TNBS	TNBS	This study	This study	This study	This study		
Red Knot *Calidris canutus* (NT)										2	**10**	1,100	<0.05
Broad-billed Sandpiper *Calidris falcinellus* (LC)				5							**40**	3,000	0.13
Curlew Sandpiper *Calidris ferruginea* (NT)			10	30			13	100		75	**300**	900	0.33
Red-necked Stint *Calidris ruficollis* (NT)								10			**25**	4,750	<0.05
Asian Dowitcher *Limnodromus semipalmatus* (NT)	400	50	12				20	20		12	**1,500**	140	**10.7**
Terek Sandpiper *Xenus cinereus* (LC)	30	10		10	33	14	2	20	50	76	**300**	500	0.60
Common Sandpiper *Actitis hypoleucos* (LC)		6	10	5				7		**45**	10	1,100	<0.05
Green Sandpiper *Tringa ochropus* (LC)								**3**				250	<0.05
Grey-tailed Tattler *Tringa brevipes* (NT)							**1**			**1**		700	<0.05
Common Greenshank *Tringa nebularia* (LC)		**30**		2		3				5		600	<0.05
Common Redshank *Tringa totanus* (LC)	120	235	4	50		22	**576**	100	400	19	200	1,100	0.52
Wood sandpiper *Tringa glareola* (LC)								**4**				1,000	<0.05
Marsh Sandpiper *Tringa stagnatilis* (LC)				3		4		1		4	**50**	1,300	<0.05
Total	886	755	274	661	181	1,080	1,429	622	4,300	2,994	13,745		

With the continuing loss of shorebird habitats in the EAAF, identification and management of important habitats is important for their conservation (Jackson *et al.* 2020). Indeed, at the north coast of East Java, Iqbal *et al.* (2013), extrapolating the number of aquaculture ponds determined from Google Earth, estimated that aquaculture ponds may support up to 25,000 shorebirds. A recent survey in Aceh Province of northern Sumatra found that aquaculture ponds showed strong potential to be considered as concentration sites of regional importance for shorebirds, given that they supported >5,000 individuals each (Putra *et al.* 2020).

As our surveys covered around 30% of the total area of aquaculture ponds (Fig. 1), the ponds in Banyuasin Peninsula could support up to 50,000 shorebirds. In December 2020, a single square of aquaculture ponds in Banyuasin Peninsula held as many as 5,000 Black-tailed Godwits (Fig. 2). We expect that the 2020 counts were higher than in earlier years due to an increase in survey effort when surveys were conducted by local people, who spent more time in the area to observe shorebirds, carefully chose the best period for their counts and documented their counts with photographs. With a total of about 250 aquaculture ponds, the 2020 counts suggest that possibly all Black-tailed Godwits wintering in Banyuasin Peninsula (estimated at 30,000 birds; Silvius 1988) could feed and roost in this area during high tide when the mudflats are covered. Continued counting in the future by local people will give a better understanding about population sizes of shorebirds in the aquaculture ponds in Banyuasin Peninsula.

Banyuasin Peninsula has greatly benefitted from the conservation status of this area as part of Berbak Sembilang National Park. Many assessments of the status of migratory shorebirds in Banyuasin Peninsula focus on the mudflats as their roosting and feeding habitat (Noor & Gumilang 2016, Birdlife International 2021b). However, aquaculture ponds also provide suitable habitat during the non-breeding period. Li *et al.* (2019) reported that anthropogenic coastal wetlands such as sustainably managed aquaculture ponds could play an important role in partially mitigating the loss of natural wetlands. A study in Singapore suggested that a small area (less than 1 km^2) can provide suitable and regionally important stopover habitats for migratory shorebirds (Lim & Posa 2014). However, they may not be a replacement for feeding areas, such as intertidal mudflats offering a multi-dimensional matrix of foraging opportunities for shorebirds through time and space (Mathot *et al.* 2019).

It is likely that previous or ongoing human modification of coastal habitat in Banyuasin Peninsula will have some effect on the populations of shorebirds. Ongoing maintenance of the aquaculture ponds with a sustainable scheme (e.g. reducing chemical activities, replanting mangrove trees) and simultaneous monitoring from authority staff are important for the conservation of aquaculture ponds as wintering habitat for shorebirds. In Banyuasin Peninsula, initiatives to replant aquaculture ponds with mangrove forest have been developed. In Java, for example, during recent decades, the development of shrimp ponds has affected much of the remaining mangroves, but when abandoned the dikes are replanted and recolonized by mangrove trees, which offer limited habitat for shorebird species (van Balen *et al.* 2006). As suggested by Green *et al.* (2015), optimizing aquaculture pond management for shorebirds could provide a more pragmatic, cost-effective and geographically extensive solution to conserving shorebirds than protected natural areas alone. Presumably, however, if replanted mangrove trees spread inside the aquaculture ponds, this would limit the habitat available for shorebirds. A partial removal of mangroves should be considered in the future. As by reported Huang *et al.* (2010), the species richness of wintering shorebirds on a restored mudflat increased dramatically from 2002 to 2007, which demonstrated that the transformation of a vegetated mangrove area into a small patchwork of mudflats and a tidal creek appears to benefit migratory shorebirds.

Fig. 2. Thousands of Black-tailed Godwits in an aquaculture pond of the Barong river, Banyuasin Peninsula, South Sumatra on 12 Dec 2020 (photo: Suyoko).

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