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Foraging behavior of Hudsonian Godwit *Limosa haemastica* (Charadriiformes, Scolopacidae) in human-disturbed and undisturbed occasions in the Atlantic coast of Brazil

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RESUMO: Comportamento de forrageio do maçarico-de-bico-virado *Limosa haemastica* (Aves, Scolopacidae) em ocasiões com perturbação e sem perturbação humana na costa Atlântica do Brasil. O maçarico-de-bico-virado, *Limosa haemastica* é considerado uma das aves pernaltas mais pouco estudadas que se reproduzem na América do Norte. Durante a migração, esta espécie utiliza poucas escalas até alcançar áreas de invernada no sul da América do Sul. Desta forma, estudos biológicos no decorrer de sua rota de migração são escassos. O foco deste artigo foi analisar o comportamento de forrageio de três indivíduos migrantes do maçarico-de-bico-virado que fizeram escala em áreas de entre-marés da costa sul do estado de São Paulo. Eu utilizei uma câmera digital para filmar e quantificar precisamente as técnicas de forrageio, o tempo de forrageio em habitats e as distâncias percorridas pelas aves. Estas mesmas variáveis foram quantificadas em situações com e sem perturbação causadas por pessoas andando próximas das aves em forrageio. Os maçaricos-de-bico-virado utilizaram mais freqüentemente a técnica de “bicar superficialmente” em solo do que a técnica de “enterrar o bico” em solo. Eles forragearam a maior parte do tempo em solo úmido; alimentaram-se em média 31.91 ± 15.48 vezes por minuto e andaram em média de 4.40 ± 2.29 m por minuto. Os maçaricos-de-bico-virado andaram distâncias similares em ocasiões com perturbação e sem perturbação humana, porém eles forragearam menos em ocasiões com perturbação. Os resultados obtidos ressaltam a vulnerabilidade desta espécie durante os períodos de coexistência com humanos em locais com atividades recreação durante a migração.

PALAVRAS-CHAVE: América do Sul; ave neártica; escala filmagem; migração.

KEY-WORDS: South America; Nearctic bird; stopover; filming, migration.

The Hudsonian Godwit *Limosa haemastica* breeds from May through July in the tundra of North America from Alaska to the Hudson Bay, EUA, and spend the non-breeding season in southern South America. While in the south hemisphere, godwits rely on a few, very important wintering sites (Senner 2010). The majority of individuals concentrate on Chiloé Island, southern Chile and in Tierra del Fuego, southern tip of Argentina/Chile (Morrison and Ross 1989, Andres *et al.* 2009, Senner 2010).

In Brazil, godwits mainly stop at Lagoa do Peixe, state of Rio Grande do Sul while migrating to their breeding grounds (Morrison and Ross 1989, Belton 1994). In other states (*e.g.*, Amapá, Sergipe, São Paulo, Paraná, and Santa Catarina), the species has been recorded as individuals or small groups, especially along the Atlantic coast (Olmos and Silva 2001, Willis and Oniki 2003, Barbieri 2007).

The Hudsonian Godwit is one of the most poorly studied North America-breeding shorebird. Basic information of the species, such as migration routes, breeding and non-breeding places, and precise population estimates require research (Senner 2010). Previous studies in South America have presented data on relative abundance, habitat use, and feeding ecology of godwits (*e.g.*, Hayes and Fox 1991, Blanco 1998, Brayton and Schneider 2000, Hernández *et al.* 2008, Andres *et al.* 2009, Lizarralde *et al.* 2010). In this paper, I focus on the foraging behavior of three Hudsonian Godwits that used stopover sites on the southern coast of the state of São Paulo (southeast Brazil) during their southbound migration. Additionally, I compare feeding rates and walking distance of foraging godwits between sporadic periods of human disturbance (mainly caused by tourists on foot) and periods without disturbance. Several studies indicate

that human recreational activities affect the behavior of migratory birds using coastal environments (*e.g.*, Burger 1981, Burger and Gochfeld 1991, Burger *et al.* 2004). Therefore, I hypothesize that godwits decrease their feeding rate and increase their distance walked while foraging due to human disturbance.

Hudsonian Godwits were found in two intertidal sites: Grajaúna River at Juréia Ecological Station (24°31.4'S; 47°11.1'W) and a beach at Itanhaém municipality (24°13.3'S; 46°51.1'W). During the first occasion (19-20 October 2010), one individual foraged in a temporary lake connected with the Grajaúna river mouth. During the second occasion (15-17 November 2010), two individuals foraged on the shoreline of a severely disturbed sandy beach, mainly due to tourists walking along the beach. Both areas have soft sandy sediments, low declivity (4-6°) and tidal influence of 87 ± 9 m.

The Hudsonian Godwit is a medium-sized wader (37-42 cm in length) with a long, slightly up-curved bill from the middle to the tip (culmen of 7.35-7.55 cm in males, and 8.8-9.0 cm in females; Sutton 1968, Hayman *et al.* 1986). This bill length enables the bird to capture prey at a variety of depths. According to Baker (1977), Kinsella *et al.* (2007) and Hernández *et al.* (2008), godwits may feed primarily on benthic invertebrates from coastal environments. Hence, considering the above circumstances, I quantified the feeding rate per min of the three foraging godwits and detailed the foraging tactic they used to capture prey, according to the proportion of their bill inserted into soil substrate: 'Pecking' was defined as fast movement of the bill toward the sand surface to capture prey. 'Mid-probing' was defined as when the bird buried its bill in the sand up to half its length (3.5-4.5 cm). 'Deep-probing' was defined as when the bird buried its bill in the sand more than a half of its total length. In the latter, a bird may insert its entire head

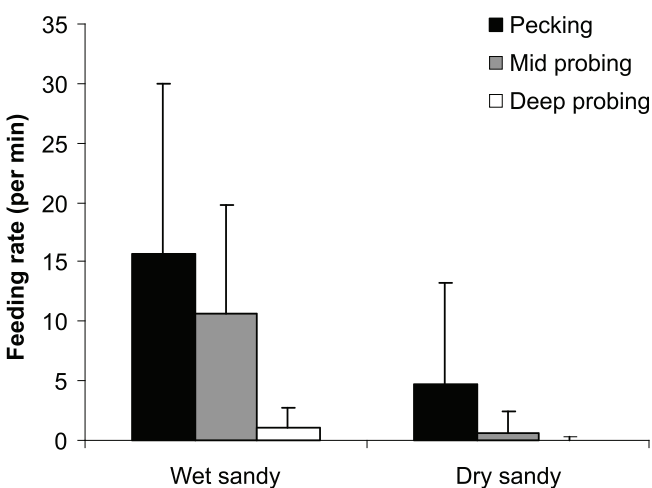


FIGURE 1: Feeding rate (per minute) using different foraging techniques performed by godwits in wet sand and dry sand habitats from the southern coast of the São Paulo State, Brazil.

in the water to probe. In addition to the feeding rate, the time and the distance walked by individuals while foraging on the wet sand (saturated sand or with surface layer of water) and dry sand (without wetness) were also recorded. The walking distance was calculated using the average distance of the species pace (= 4.60 cm, estimated from footprints in wet sand) multiplied by the number of steps.

I used a digital Sony DSC H50 camera to precisely record foraging godwits. To avoid influence birds behavior, all the recordings were taken at distance about 10 m. The above ecological traits (feeding rate, foraging time in each habitat, and walking distance) were later quantified for further analysis. I defined a sample as recording of one minute of foraging. The samples of time foraging and feeding rate with different foraging techniques between habitats (wet and dry sand) were compared using a Student's T-test with the Bioestat 4.0 software (Ayres *et al.* 2004). The same statistical analysis was used to compare the species' ecological traits (feeding rate and walking distance) during instances of human disturbance and without disturbance. Human disturbance was defined as when a person, or group of people, approached a bird to within less than five meters.

Hudsonian Godwits spent more time foraging on wet (50.76 ± 16.72 s) than on dry sand habitats (9.19 ± 16.68 s) ($t = -12$; $df = 92$; $P < 0.0001$) in a total of 93 min of recordings. They fed 31.91 ± 15.48 times and walked a straight distance of 4.40 ± 2.29 m per min. Pecking technique was used more than probing on both wet ($t = 2.13$; $df = 92$; $P = 0.03$) and dry sand habitats ($t = 4.54$; $df = 92$; $P < 0.0001$) (Figure 1). Birds walked a similar distance when foraging with and without human disturbance ($t = -0.50$; $df = 91$; $P = 0.616$), but

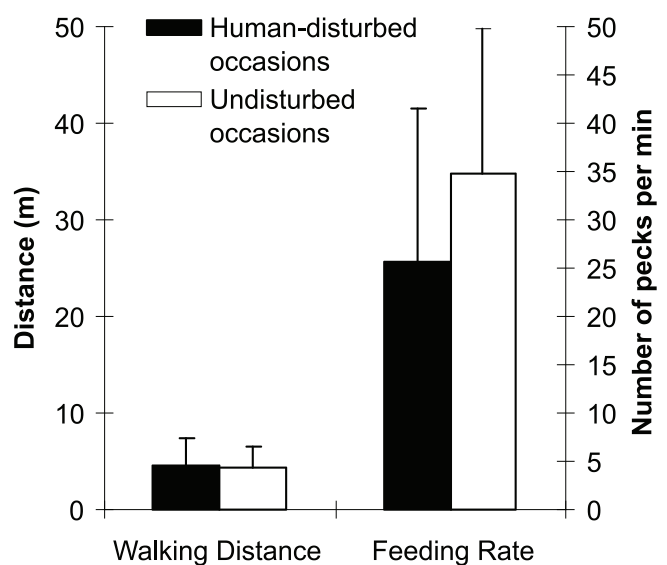


FIGURE 2: Walking distance and feeding rate of godwits that foraged with and without human-disturbance along the southern coast of the São Paulo State, Brazil.

they foraged less during periods of human disturbance ($t = 2.32$; $df = 91$; $P = 0.0226$) (Figure 2).

Hudsonian Godwits spent most of their time foraging on wet sand, sometimes in shallow water conditions. Their long bill and legs enable them to forage in up to 16.5 cm of water, presumably an unsuitable foraging condition for other shorebirds with shorter bills and legs. For instance, according to Brayton and Schneider (2000), godwits continued feeding on benthic invertebrates after the tide rose, while shorter-billed shorebirds, such as *Calidris* sandpipers, stopped feeding and flew to higher foraging sites.

Studies on predator-prey relationships have shown that deeply buried prey are less accessible to shorebirds (Waninck and Zwars 1985, Piersma *et al.* 1993). Probably, their long bill enables godwits to search for prey at a variety of soil depths. According to Brayton and Schneider (2000), amphipods, isopods, and ostracods were often found near the soil surface, while polychaetes were found deeper in the soil. Unfortunately, even after careful analysis of film recordings, I was unable to identify prey, due to their tiny sizes and fast movements of godwits. Studies of fecal droppings in Argentina pointed out that godwits mainly prey on bivalves (especially *Darina soleinoides*) and polychaetes (Hernández *et al.* 2008; Lizarralde *et al.* 2010).

The energetic costs of foraging by different techniques can differ considerably among migratory birds (Evans 1976). The fast and short-period movements of pecking more employed by godwits resulted in a higher feeding rate per minute than the probing technique. Thus, assuming that prey from different soil depths have similar energetic value, pecking may be important because birds may maximize energy and continue migration to reach prime non-breeding grounds in Argentina and Chile (Kokko 1999, Senner 2010).

Human recreational activities reduce the foraging time of migratory birds (see Burger and Gochfeld 1991, Yasué *et al.* 2008). As expected, the godwits showed a decrease in the feeding rate when disturbed by walking humans but they did not move (walk) more in these situations. Three non exclusive hypotheses might explain this finding: (1) tolerance and habituation to close approach of humans, (2) bad health condition of birds, and (3) higher availability of prey in patches of beach during the recordings.

Hudsonian Godwits spend much of their breeding season in remote locations of northern Canada, and south-central and western Alaska. For this reason, they are beyond the reach of most types of human disturbance during this vulnerable period (Senner 2010). Thus, individuals might not be able to identify humans as potential predators and they may tolerate close approaches (Frid and Dill 2002). In contrast, migrating individuals may face disturbances from tourists at important stopover sites

in Argentina and Chile during the boreal winter (Andres *et al.* 2009, Senner 2010). It also indicates the possibility that these birds are habituating to humans (Nisbet 2000).

Unhealthy birds are less efficient at responding to human disturbances (Gill *et al.* 2001a). However, some variations in bird behavior may also be confounded by prey abundance in the study area (Gill *et al.* 2001b). Thus, there is also the possibility that healthy godwits were foraging on patches of the beach with high prey availability, and a prompt move to another patch as a human approaches might be unrewarding. McArthur and Pianka (1966) assumed that an activity should be engaged in for as long as the resulting gain in time spent per unit of food exceeds the loss. During all the recordings, the godwits did not show any sign of unhealthiness. As a result, the first and third hypotheses mentioned above may better explain the lack of difference in the distance walked between godwits in situations with and without human disturbance.

Studies of the foraging behavior of Hudsonian Godwit in areas with human disturbance are scarce. The preliminary results of this study showed that godwits fed less frequently during short periods of coexistence with humans. Future studies involving the quality of habitats in terms of degree of human disturbances and the quantity and energetic value of godwit's prey are welcome.

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