Nesting home range sizes of Wrybill (*Anarhynchus frontalis*) and Banded Dotterel (*Charadrius bicinctus*) in relation to braided riverbed characteristics

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ABSTRACT

Wrybill (*Anarhynchus frontalis*) and Banded Dotterel (*Charadrius bicinctus*) are territorial birds which breed on braided riverbeds in Canterbury, New Zealand. Home ranges of Wrybill pairs were bigger than those of Banded Dotterel pairs on the Rakaia and Ashley Rivers. For Wrybill there were no significant differences in home range size between years and rivers, but home ranges of Banded Dotterel pairs were larger on the Rakaia R. than on the Ashley R. Wrybill home range size on the Rakaia R. was related to the presence of preferred minor channel feeding habitats; small home ranges contained mostly minor channels and large home ranges contained mostly major channels. The larger home ranges for Banded Dotterel on the Rakaia R. is thought to be related to greater habitat instability compared to the Ashley R. If large scale diversion of water occurs from these rivers then flows need to be managed so that the characteristics of the natural flow regime are maintained.

KEYWORDS: Charadriiformes, nesting habitat, management.

INTRODUCTION

The braided riverbeds of the Canterbury Plains, on the eastern side of the South Island, New Zealand, are used by a wide range of wetland bird species for breeding, feeding and roosting. Among these are two regarded as "threatened" (Bell 1986, Tisdall 1994): Black-fronted Tern (*Sterna albostriatus*) and Wrybill (*Anarhynchus frontalis*). Several other species including the Banded Dotterel (*Charadrius bicinctus*) also occur on these riverbeds. Wrybills nest almost exclusively on these riverbeds. Removal of large amounts of water for irrigation have been proposed for the Rakaia River, a large alluvial, unstable river, which flows across the Canterbury Plains. The smaller Ashley River already experiences reduced flows, partly attributable to diverting water for irrigation. Factors affecting bird density were studied as part of investigations into the possible impacts of water abstraction on birdlife (Hughey 1997).

Assessment of the relationship between home range size of Wrybill pairs and various habitat factors can be compared to that of Davis (1982) who found that territory size of Belted Kingfisher (*Megaceryle alcyon*) was inversely proportional to the number and productivity of riffles along a single channel stream. Hay (1984) found that nesting territories of Wrybill, on the upper Rakaia River, were maintained constantly during breeding and concluded that breeding territories must be large enough to ensure sufficient food supply during periods of high river flow; he made no assessment of the territory size-habitat relationship because of the perceived difficulty of making suitable measurements on unstable, braided rivers. Sagar (1983) and Hughey *et al.* (1989) studied the aquatic invertebrates of braided rivers and found that minor channels have a greater biomass of macroinvertebrates per unit area than major channels. In spring and summer the mean number of invertebrates per m^3 in the drift was also greater in minor than in major channels (Sagar & Glova 1992).

Hughey (1985a) and Hughey & Duncan (unpubl. manuscript) compared the amount of preferred feeding habitat between minor and major channels of the Rakaia River. Minor channels contributed weighted usable area (roughly, a habitat's carrying capacity based on physical conditions alone) of feeding habitat out of all proportion to their relative discharge. Flows in minor channels averaged 10.6% of total discharge, but contributed an average of 62.6% of total weighted usable area for Wrybills (Hughey 1985a).

The presence and availability of large areas of the preferred aquatic habitats can be influenced in two main ways: floods destabilise channels and lead to minor channels becoming major channels, thereby reducing the area of preferred habitat (pers. obs.); and, extremely low flows may lead to minor channels drying up which also reduces preferred habitat area (Hughey 1985a). Hay's (1984) observations that territories must be large enough to ensure sufficient food supply during periods of high river flow support the super-territory concept of Verner (1977); but his conclusions related to the effect of floods only.

This paper examines home range sizes of two territorial species, Wrybills and Banded Dotterels, in relation to some aspects of river flow and channel morphology. The Banded Dotterel is sympatric with Wrybill on many braided rivers (O'Donnell & Moore 1983) and has some similar morphological characteristics (see Oliver 1955) and similar diets (Hughey 1997). The main aim of this work was to measure variation in home range size related to some aspects of river flow, as a basis for river management.

STUDY AREAS AND METHODS

Most of the larger braided rivers, such as the Rakaia, have their headwaters in the Southern Alps. They are partly glacially fed but are also influenced by westerly storms in the headwaters that usually cause large floods during the spring and early summer (September to December) breeding season. River flows are highly variable during this period and average discharges are greater than at other times of the year. In contrast, some of the smaller rivers, such as the Ashley, drain eastern foothill catchments and do not receive the full effects of these storms; they usually have declining flows over the breeding season (mainly September-December), but nevertheless may flood at any time of the year.

The alluvial braided rivers of Canterbury, along the eastern South Island of New Zealand, are highly unstable and often several kilometres wide. The rivers usually flow in one or two major and several minor channels. The temporary islands between these channels persist from only a few days to occasionally many years. Recently formed islands have no vegetation, but older ones are colonised almost exclusively by exotic plants, mainly lupins (*Lupinus* spp.), broom (*Cytisus scoparius)*, gorse (*Ulex europaeus)* and willow (*Salix* spp.). Rates of colonisation appear much quicker than in some upper catchments where native prostrate mat and cushion plants are the early colonisers (pers. obs.). On lowland rivers Wrybill and Banded Dotterel nest in the open areas of mainly bare alluvium. Stead (1932) thought a reduction in Wrybill numbers on the lower Rakaia River in the early 20th century could be attributed directly to the spread of exotic vegetation, a factor even more prevalent today (Balneaves & Hughey, 1990).

The Rakaia River (length = 140 km), with headwaters in the Southern Alps, has a mean flow of 203 m^3s^{-1} (G. Horrell, pers. comm.) and is up to five kilometres wide in the lower Rakaia study area (Hughey 1997). It is the most important Wrybill breeding habitat (O'Donnell & Moore, 1983) containing more individuals and habitat than other rivers, found along much of its course. The 10 km long study area in the lower reaches, approximately 25 km from the river mouth contained about 30 pairs each of Wrybill and Banded Dotterel. The smaller Ashley River (length = 90 km), with its source in the foothills, has a mean flow of 13 m^3s^{-1} (Horrell, pers. comm.). Six pairs of Wrybill and 40-50 pairs of Banded Dotterel nested in the 5 km long and <1 km wide study area, located approximately 12 km from the river mouth.

Measurements of home range size were based on the Al index, the simplest, and perhaps most widely used, method of estimating home range size (Jennrich & Turner, 1969). The smallest convex polygon containing all of the capture points (p_1,p_2,p_3,.....,p_n) for an animal is drawn to, provide an index, by area, of the animal's home range (Southwood, 1978). All location points of breeding pairs were mapped for pairs where one or both adults had been individually colour banded (Hughey, 1985a). When observing unbanded birds, I followed each individual until it either rejoined its mate or returned to the nest site. For the purposes of this study I was interested in home range size, irrespective of sexual differences. Therefore there was no need to differentiate between males and females. Observations occurred at different river flows: high (greater than 400 m^3s^{-1} for the Rakaia R. and greater than 40 m^3s^{-1} for the Ashley R.); medium (150-400 m^3s^{-1} for the Rakaia R. and 10-40 m^3s^{-1} for the Ashley R.); and low (<150 m^3s^{-1} for the Rakaia R. and <10 m^3s^{-1} for the Ashley R.). No records were made during large floods. Flood flows normally last only a few days and it was behaviour of birds at medium to low flows, when diversion of water for irrigation has most effect on habitat (Glova & Duncan 1985, Hughey 1985a), which was critical for this study. A minimum sample size for further analysis was set at 20 locations per pair. Initial observations of five pairs (i.e. male and/or female seen feeding) for each of Wrybill and Banded Dotterel showed that at least 90% of home range size was explained by 20 observations made on separate days for each pair but only 50% with 10 observations (Hughey unpub. data). At the end of each observation the location of the other partner of each pair was confirmed, normally by observing the known nest or chick locations, or otherwise by searching within the home range area.

Daytime home range size was measured for Wrybill on the Rakaia R. in 1982 and 1983 and on the Ashley R. in 1983, between September and December when birds were breeding. Measurements of home range size for Banded Dotterel occurred on both rivers during the same months in 1983. Observation points were mapped and home range boundaries delimited on aerial photos. All area measurements were made using the Leaf Area Index Machine, courtesy of the Ministry of Agriculture and Fisheries, Lincoln.

Variations in home range size on the Rakaia R. were then compared with differences in habitat quality and quantity measured by the presence of preferred areas of aquatic microhabitats used for feeding. As more than 95% of Wrybill foraging occurred in, or at the edge of, a range of aquatic microhabitats (Hughey 1985a) only aquatic habitats warranted examination. The size of Wrybill home ranges dominated by minor channels (defined for the Rakaia R. as channels having flows <5 m^3s^{-1}; Hughey 1985a) was compared with others dominated by major channels (defined as channels having flows >5 m^3s^{-1}). The length of each channel type was measured and used as an approximate index of habitat quantity and quality. Where the combined length of minor channels exceeded the combined length major channels then the home range was defined as being dominated by minor channels. Conversely, in home ranges dominated by major channels the length for major channels exceeded minor channels. A similar comparison was not made for home ranges of Banded Dotterel because only 70-75% of foraging occurred in aquatic microhabitats and the remainder on a range of terrestrial substrates, thus the relative areas were difficult to quantify (Hughey 1985a). The Mann-Whitney U test was used for statistical analysis.

Feeding sites in two Wrybill home ranges on the Ashley R., which contained or overlapped several Banded Dotterel home ranges, were studied in detail during breeding in 1983. Precise locations of feeding birds were mapped to determine key foraging sites, in relation to minor and major channels (defined as having flows <1 and >1 m^3s^{-1}, respectively).

RESULTS

Although the mean home range size for Wrybill pairs was larger for the Ashley R. than for the Rakaia R., no significant inter-year or between-river differences existed ($P>0.05$; Table 1). Home ranges of Banded Dotterel pairs on the Ashley R. were, on average, significantly smaller than on the Rakaia R. ($P<0.01$; Table 1). Wrybill home ranges were significantly larger than those of Banded Dotterels on both the Ashley and Rakaia rivers in 1983 ($P<0.001$ for both rivers).

The relationship between Wrybill home range size and channel character was determined for the Rakaia R. in both years. Home range sizes were significantly smaller when they were dominated by minor channels as compared for those dominated by major channels ($P<0.01$; Table 2). No significant differences occurred between years.

TABLE 1 - Nesting home range sizes (mean area (ha) plus standard deviation, range, and number of pairs in brackets) of Wrybill and Banded Dotterel on the Rakaia and Ashley riverbeds.

		Year	
Site	Species	1982	1983
Rakaia R.	Wrybill	5.2 + 1.5 5.3 3.1-8.2 (19)	4.5 + 2.5 4.6 1.0-11.3 (18)
	Banded Dotterel	Not measured	1.5 + 0.5 1.6 0.7-2.5 (15)
Ashley R.	Wrybill	Not measured	4.5 +2.5 4.6 1.0-11.3 (18)
	Banded Dotterel	Not measured	1.0 + 0.6 1.1 0.3-3.4 (28)

TABLE 2 - Size comparison of Wrybill home ranges on the Rakaia River in relation to channel character.

	Home range dominated by major channels		Home range dominated by minor channels	
	1982	1983	1982	1983
Mean area (ha)	6.0	6.4	3.6	2.9
s.d. (ha)	1.2	2.6	0.7	1.0
Range (ha)	3.9-8.2	3.9-11.3	2.4-5.1	1.0-4.1
Number of pairs	13	8	6	10

Wrybill home ranges overlapped with those of Banded Dotterel and for each species some intraspecific overlap occurred. The home ranges of two Wrybill pairs were studied intensively on the Ashley R. in 1983. In home range (a) (Figure 1) the nest was located at a considerable distance from the main foraging sites. This home range overlapped those of another pair of Wrybills and with several Banded Dotterel pairs. The nodes of greatest foraging intensity by Wrybill were generally outside, or at the edge of, Banded Dotterel home ranges and were not within the overlapping Wrybill home range. A similar pattern emerged for home range (b) although foraging was generally <100 m from the nest and the foraging area overlapped more with those of Banded Dotterel.

DISCUSSION

Home ranges of Banded Dotterel pairs were significantly smaller than those of Wrybill pairs on both rivers. The much greater proportion of foraging time spent on terrestrial microhabitats by Banded Dotterel meant they did not have to travel as far from the nest to feed; their home ranges were therefore relatively small. Furthermore, Banded Dotterel home ranges on the Rakaia R. were significantly larger than those on the Ashley R. The greater stability of river flows in the Ashley R. (Hughey 1985a) and its greater supply per unit area of aquatic (Hughey *et al.*

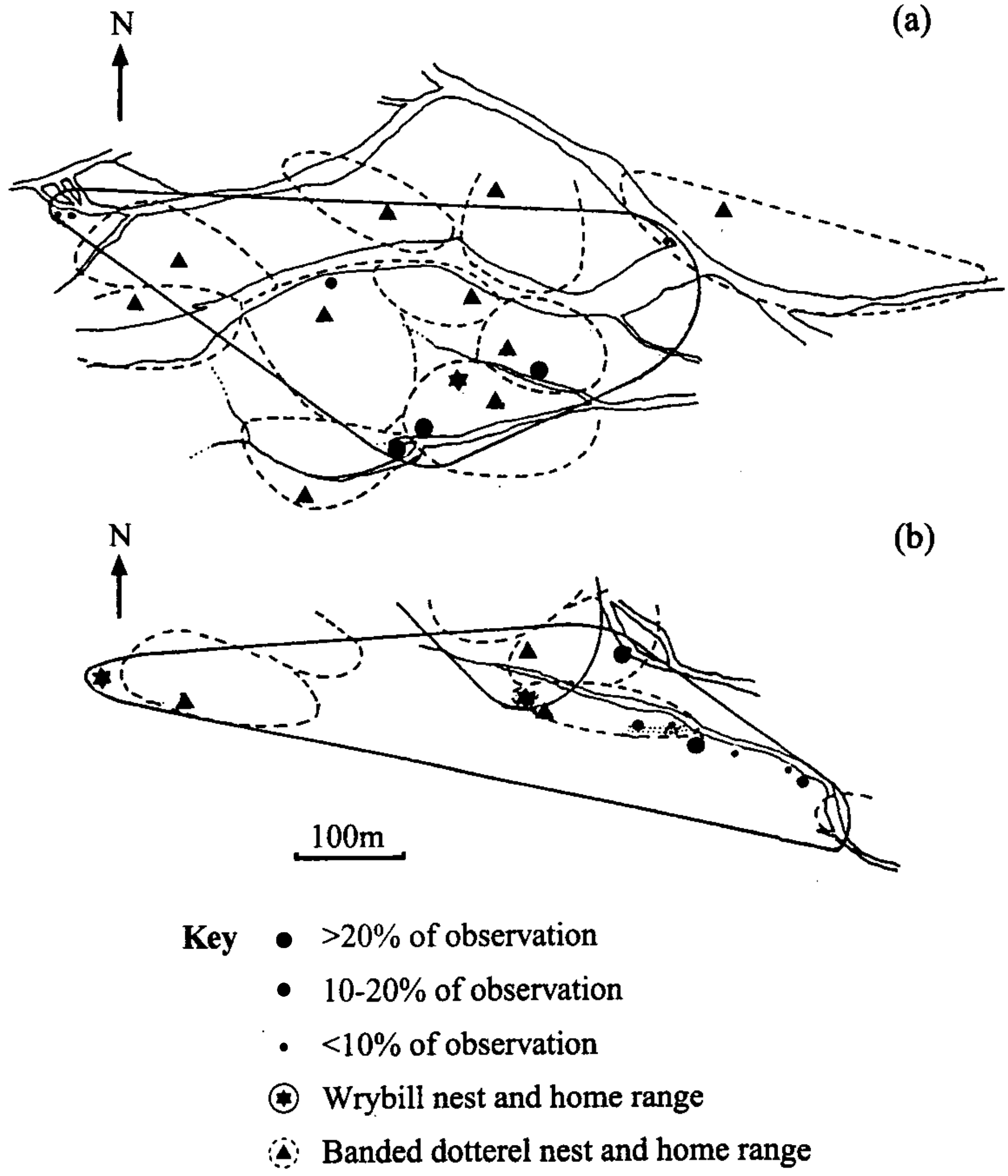

FIGURE 1 – Examples of pattern of space use for breeding pairs of Wrybills and Banded Dotterels on the Ashley River in 1983. The riverbed width was c.1km; direction of flow is from left to right; (a) and (b) are separted by c.500m; each home range is on the south side of the river; the riverbed is a complex of river channels, bare shingle areas and areas infested by various stages of exotic plant encroachment.

1989) and terrestrial (Hughey 1985a) food is probably responsible for the higher density of Banded Dotterel. The small number of Wrybill nesting on the Ashley R. meant a similar comparison could not be made with the Rakaia R.

The findings are important for riverbed and flow regime management for these plovers. Wrybill home range size is correlated with the presence of preferred channel types, so that the smallest home ranges mostly contain minor channels. The greater availability of preferred habitat in minor channels helps explain why Wrybill home ranges are smaller when characterised by minor channels, and supports Davis's (1982) findings for Belted Kingfishers. However, evidence regarding the relationship between the number of channels in a river cross-section and discharge is conflicting. Mosley (1982) found no relationship over a wide range of flows in the Ohau River. Bowden *et al.* (1982) found that as the flow of the Ashley R. declined from 24.7 to 1.3 m^3s^{-1} the number of channels in a cross-section declined from 7 to 2. Hughey (1987) also demonstrated a clear correlation on the Ashley R. between discharge and the number of channels in highly braided cross-sections, the areas of highest bird densities. Findings from this study and Hughey (1985a) show application at low flows as well. At low or reduced flows some channels dry up but so long as some flow remains, the amount of preferred habitat in home ranges should provide sufficient food supply. Hughey (1985a) postulated that at some, unknown and presumably artificial, low flow this would not continue and there would be insufficient feeding habitat.

The annual pattern of Ashley R. flows (Hughey 1985b) suggest that without major water diversion or storage reservoir there should be no loss of preferred foraging habitat before December in most breeding seasons; flows decline quickly after that time. The situation for the Rakaia R. is not so well understood. Glova & Duncan (1985) found that over a range of median to low flows only one or two minor channels dried up, out of up to 18 in a single cross-section. Hughey (1985a) considered that at some extreme low flow significant habitat loss would occur.

Use of the A1 index

I consider heterogeneity and unpredictability of braided rivers to be the main limitations to using the A1 index. Nevertheless, in this study, correlation between home range size, especially in relation to food and feeding, and habitat was apparent. However, due to the nature of these limitations it is necessary to consider the influence of factors on home range size. Hilden (1965) suggested that habitat selection relies on an animal's assessment of certain environmental factors directly associated with food. Territory size of the Belted Kingfisher along stream habitats is consistently related to the proximity of productive food patches near the nest (Davis 1982). However, some species respond to habitat parameters, other than directly to food; nesting and roosting sites may also be important (e.g. Newton *et al.* 1977, Seastedt & Maclean 1979). Wrybill and Banded Dotterel had nests within the limits of the foraging home range, and nests were sited in habitat with particular characteristics, e.g. areas of mainly bare shingle for Wrybill and areas of bare or only lightly vegetated shingle for Banded Dotterel (Hughey 1985a, 1987). Consequently, while they may respond to other parameters, the availability of feeding habitat is likely to be the main reason for differences in home range sizes.

Implications for river management

Home range studies have been used in evaluating optimal foraging theory (Davies 1981), and territory size as a function of habitat quality (Davis 1982). This latter application has potential for the ongoing management of territorial waders and other birds on braided rivers. The results suggest that the density of both species are related to habitat factors which can be detrimentally affected by the diversion of water for irrigation, or by impoundment for multiple uses. Care should be taken to manage flows in such a way that the characteristics of the natural flow regime are maintained. In particular, the 'low' flow character of the rivers should be protected during the breeding season. Other research (e.g. Hughey 1987, Balneaves & Hughey 1990) reports on the complementary need for flood flows to provide suitable nesting habitat, and for the flow regime to provide essential food supplies and feeding habitat (Hughey 1997, Hughey & Duncan, unpubl.).

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