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Effects of time of day and observer position on waterbird counts

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Abstract The effects of time of day and observer vantage points on recorded waterbird species diversity and numbers of individuals of each species (especially New Zealand scaup (*Aythya novaeseelandiae*), the most common species) from a New Zealand wetland were analysed statistically and compared using rank abundance plots. There were significant differences between counts of total numbers of species, total numbers of individuals, and numbers of New Zealand scaup made from three observer positions and this effect was attributed to differences in observer elevation. Time of day had no significant effect on total numbers of species, total numbers of individuals of all species, and numbers of New Zealand scaup counted. However, rank abundance plots indicated a time of day effect on counts made at the least elevated of the observer positions. Overall, these effects were sufficient to introduce bias into waterbird counts and to require they be assessed during long-term monitoring programmes.

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Keywords waterbird counts; bird community structure, rank-abundance plots; census method.

INTRODUCTION

In wetland monitoring and management, waterbirds are important indicators of changes in the aquatic environment (Koskimies 1989; Koskimies & Pöysä 1989). However, when censusing birds the accuracy, reliability, and efficiency of counting methods has to be tested (Verner 1985; Verner & Milne 1989). Many variables are known to affect bird counts, including time of day (Shields 1977; Rollfinke & Yahner 1990, Craig & Roberts 2001), weather conditions (O'Connor & Hicks 1980; Robbins 1981b), the behaviour and relative detectability of the species (Lynch 1995; McKinlay 2001), observer variability (Balph & Romesburg 1986; Verner & Milne 1990) and the census method used (Ralph & Scott 1981; Verner 1985).

Because assessment of these variables has mostly been conducted on forest bird species, I sought to test whether similar effects applied to counts of waterbirds. Specifically, the aims of my study were (1) to determine the best time of day to conduct waterfowl counts, and (2) to examine the influence of observer point on assessment of a wetland bird community.

STUDY AREA AND METHODS

Study area

This study was conducted at Sinclair Wetlands, part of the 2000 ha Lake Waipori - Lake Waihola wetland complex situated on the Taieri Plain, 33 km south of Dunedin, New Zealand (Fig. 1). The wetlands comprised several shallow ponds, channels, exotic willow forest and sedgeland, most of which is covered by by pukio (*Carex secta*), other sedges (*Carex* spp.), mingimingi (*Coprosma propingua*) and flax (*Phormium cookianum*). Ponds, an important habitat feature in this area, were shallow (up to 1.5 m deep) and often with a perimeter of raupo (*Typha orientalis*).

METHODS

Counting method

Counts of waterbirds were conducted from three different observer positions (OP1, OP2, OP3) during December 2001 - February 2002. OP1 was located at water level in the western part of the wetlands and provided a view of Square Pond (Fig. 1). OP2 was elevated approx. 30 m and provided a view over several ponds (Square Pond, Pukio Pond and Goodies Pond, Fig. 1). OP3, located on an adjacent property, was elevated approx. 20 m with clear views of Nevill's and Square Ponds, but more limited views of Goodies and Pukio Ponds (Fig. 1).

Sixteen pond-based bird counts were conducted from each observer position in each month to provide a total of 144 counts. The counts were all made within the same week each month, and comprised four counts at each morning (0600-0959 h), midday (1000-1359 h), afternoon (1400-1759 h), and evening (1800-2200 h). Counts represented a scan sample of birds visible from a given observer

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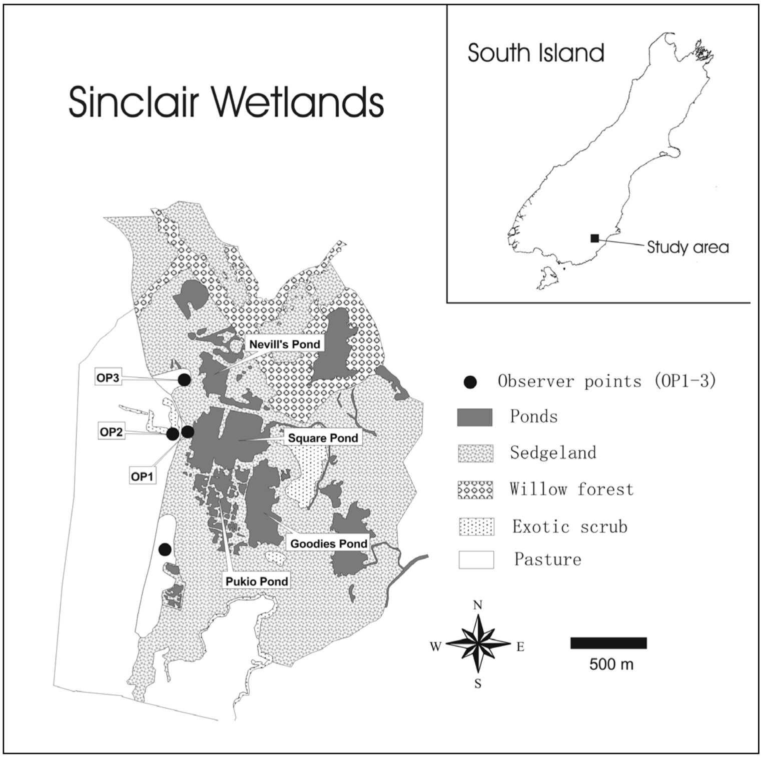

Figure 1 Location and map of Sinclair Wetlands illustrating main habitat types, local names, and the observer positions used in this study.

position during which the numbers of all visible individuals of each waterbird species were recorded. Counts were undertaken with 10x42 binoculars and a 20x spotting scope and each was completed within approximately 20 min.

Data analysis

The influence of observer position and time of day on total number of species counted, total numbers of individuals of all species, and total numbers of New Zealand scaup (*Aythya novaeseelandiae*) (most common waterbird), was examined using non-parametric 1-way ANOVA on untransformed data. Significance of inter-group differences was determined by multiple comparison testing using the equation given in Siegel & Castellan (1988: 8.6).

Additionally, effects of time of day and observer position on bird count data were assessed by comparing bird diversity, species composition and community structure using rank-abundance plots (Magurran 1988; Feinsinger 2001). For each species the mean number of individuals per time of day was used to calculate the species' proportion p_i of the assemblage (= abundance), and then transformed to $\log_{10} p_i$. Species were plotted from most abundant to least abundant within each sample. The points were labelled with a numerical code, which makes reference to Table 1, to indicate species identity. For the assessment of the observer position only the morning counts were used, whereas for the assessment of time of day all counts were used. Species richness (S) was derived from each rank-abundance plot and differentiated according to time of day (S_{MORN}, S_{MIDD}, S_{AFTER}, S_{EVEN}) and observer position (S_{OP1}, S_{OP2}, S_{OP3}).

RESULTS

Twelve waterbird species were recorded. Mean numbers of each species recorded from 16 counts at each of the three observer positions in each month are listed in Table 1.

Observer position

Total numbers of species, total numbers of individuals, and numbers of New Zealand scaup counted varied significantly between observer positions (Kruskal-Wallis test, χ^2 = 90.3, 91.0, and 56.2, respectively, $P < 0.001$). Multiple comparisons indicated significant differences ($P < 0.05$, critical value $z = 20.4$) in numbers of species counted between OP1 and the other two sites, but not between OP2 and OP3; whereas total numbers of individuals and numbers of scaup varied

Table 1 Mean numbers (± standard deviation, *sd*) of waterbird species counted at three different observer positions (OP1, OP2, OP3) in Sinclair Wetlands in December 2001, January and February 2002 (n = 16 per observer position per month).

Code	Species	Mean number per count (± *sd*) December			January			February		
		OP 1	OP 2	OP 3	OP 1	OP 2	OP 3	OP 1	OP 2	OP 3
1	Black shag	-	0.6	0.1	0.2	0.5	0.4	0.1	-	0.1
	Phalacrocorax carbo		±0.9	±0.3	±0.4	±0.7	±1.1	±0.3		±0.3
2	Little shag	-	0.3	0.9	0.3	1.7	1.4	0.7	0.8	1.1
	Phalacrocorax melanoleucos		±0.8	±0.8	±0.8	±1.6	±1.6	±1.3	±1.3	±0.8
3	Black swan	0.2	0.9	1.5	0.8	3.8	3.5	0.1	1.1	0.8
	Cygnus atratus	±0.8	±1.2	±1.4	±1	±1.8	±3.2	±0.5	±1.6	±1.6
4	Canada goose	-	0.3	-	0.6	0.3	-	-	-	0.5
	Branta canadensis		±1		±2	±0.8				±2
5	Feral goose	-	0.5	0.1	0.3	0.5	0.3	0.1	0.1	-
	Anser anser		±0.6	±0.3	±0.8	±0.8	±0.7	±0.5	±0.5	
6	Paradise shelduck	-	-	1.2	-	3.9	5.6	1.2	22	56.6
	Tadorna variegata			±3.1		±4.3	±4.5	±3.5	±19.1	±25.4
7	Mallard	-	0.2	0.4	0.5	3.2	7	0.1	5	9.3
	Anas platyrhynchos		±0.8	±0.8	±1	±2.9	±5.6	±0.5	±6.7	±5.4
8	Grey duck	-	-	-	-	-	0.1	-	-	-
	Anas superciliosa						±0.3			
9	Australasian shoveler	1.1	1.8	1.6	-	3	5.5	0.1	23.4	67.3
	Anas rhynchotis	±3.5	±3.7	±3.8		±6.8	±9.0	±0.3	±20.8	±43
10	Grey teal	0.4	1.1	4.6	0.1	1.3	5.3	-	0.9	6
	Anas gracilis	±0.6	±1.2	±3.1	±0.5	±1.8	±4.1		±1	±3.9
11	New Zealand scaup	40.6	62	92.63	9.5	30.8	40.8	9.3	22.8	49.4
	Aythya novaeseelandiae	±25.8	±21.8	±31	±7.8	±14	±15.3	±5.2	±9.9	±11.8
12	Pukeko	-	-	0.4	-	-	0.1	-	-	0.2
	Porphyrio porphyrio			±0.7			±0.3			±0.5

significantly between all three observer positions.

The rank-abundance plots derived from December morning counts show a similar shape for the three observer positions (Fig. 2), revealing strong dominance of New Zealand scaup (code 11) at all sites, however species composition differed slightly. Species richness was lowest at OP1 (S_{OP1} = 4) which resulted in a more compressed curve. OP2 and OP3 showed higher species richness (S_{OP2} = 8, S_{OP3} = 7).

The rank-abundance plots derived from January morning counts showed a similar shape at all observer positions (Fig. 2) and were dominated by New Zealand scaup. OP2 and OP3 revealed a similar species composition although there were differences in rank abundances whereas OP1 revealed a different composition at all. Species richness was lowest at OP1 (S_{OP1} = 6) and higher at OP2 (S_{OP2} = 9) and OP3 (S_{OP3} = 7).

For February counts, the OP1 rank-abundance curve was markedly different in shape from both OP2 and OP3 (Fig. 2). Species composition and dominance at OP2 and OP3 were similar, and rank abundance differed only slightly between both observer points. Species richness between observer points was more similar in February than in December and January (S_{OP1} = 7, S_{OP2} = 8, S_{OP3} = 9).

Time of day

Total numbers of species, total numbers of individuals, and numbers of New Zealand scaup counted did not vary significantly by time of day (Kruskal-Wallis test, χ^2 = 2.09, P = 0.55). This was partly due to low diurnal variation in data collected from the two elevated observer points. Nevertheless, variation in numbers of birds of each species counted throughout the day was reflected in diurnal variation in rank abundance plots, and was particularly evident at OP1.

The morning curve of the rank-abundance plot from counts at OP1 differed in shape, species composition and rank abundance from the midday, afternoon and evening curves (Fig. 3). New Zealand scaup was the dominant species at all times of day, but species composition and dominance differed. The degree of dominance was greater in afternoon and evening counts than in morning and midday counts. Overall, species richness was highest in the morning (S_{MORN} = 10) and lower during the rest of the day (S_{MIDD} = 6, S_{AFTER} = 6, S_{EVEN} = 7).

OP2 rank-abundance plots differed in shape between different times of day (Fig. 3). However, composition of dominant species was almost the same at all times of day. Species richness was consistently high (S_{MORN} = 10, S_{MIDD} = 10, S_{AFTER} = 10, S_{EVEN} = 9).

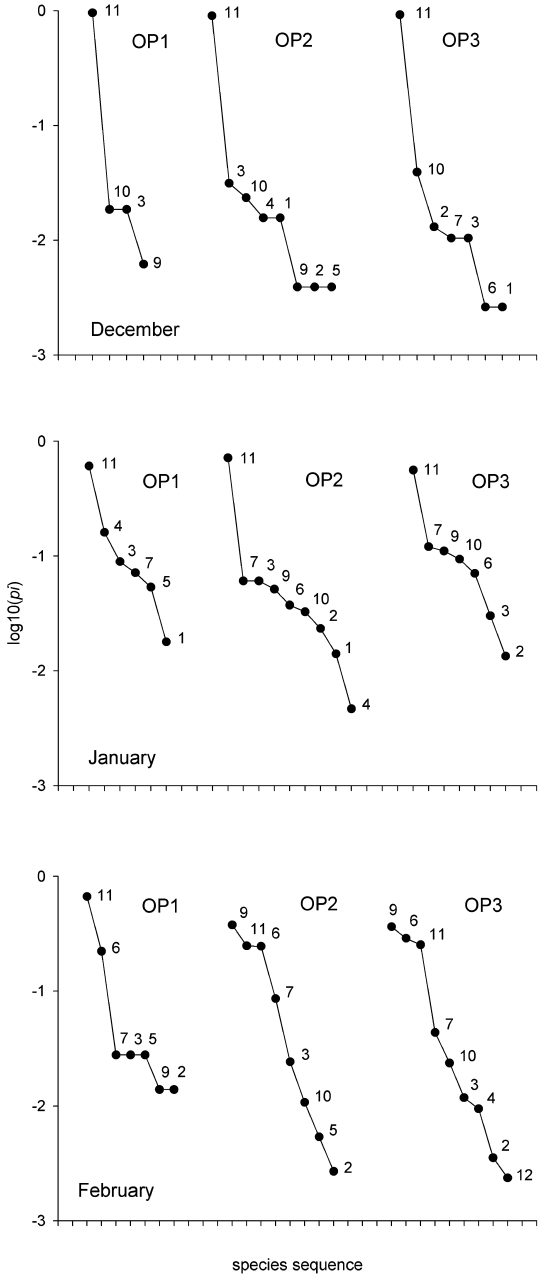

Figure 2 Rank-abundance plots of waterbird species diversity derived from counts made at three different observer positions (OP1, OP2, OP3) in Sinclair Wetlands during December 2001, January and February 2002. The mean number of individuals for each species from four morning counts per month was used to calculate its proportion p_i of the assemblage (= abundance), which was transformed to $\log_{10} p_i$ and placed in rank order. The numbers refer to species listed in Table 1.

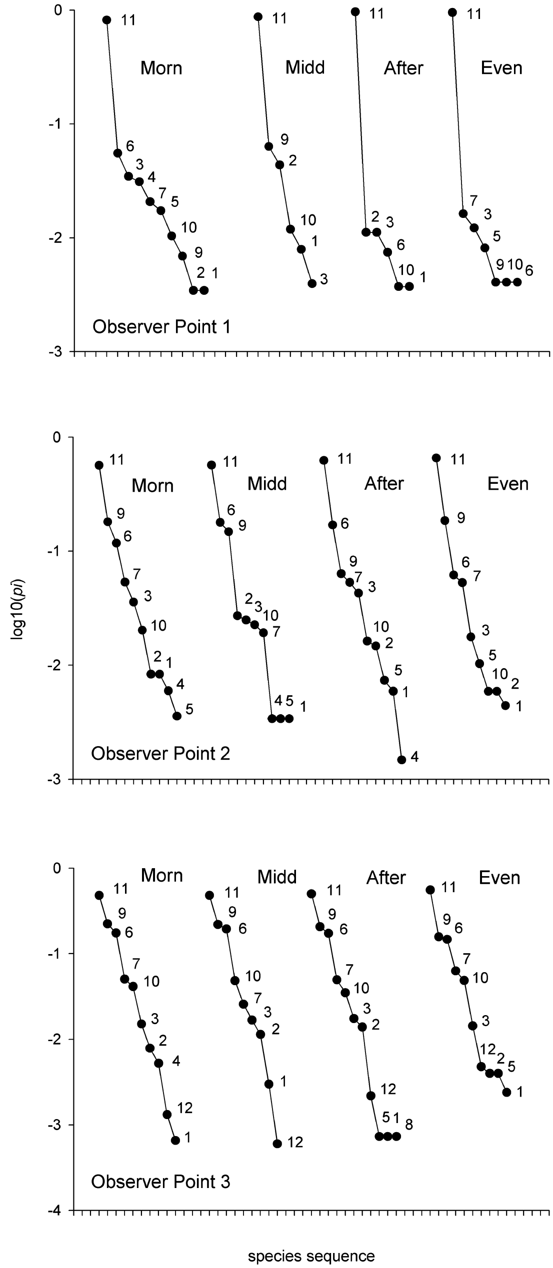

Figure 3 Rank-abundance plots of bird species diversity derived from counts at four different times of day (Morn = morning, Midd = midday, After = afternoon, Even = evening) from three different observer positions in Sinclair Wetlands. The mean number of individuals for each species from 12 counts (four per month in December 2001, January and February 2002) was used to calculate its proportion p_i of the assemblage (= abundance), which was transformed to $\log_{10} p_i$ and ranked afterwards. The numbers refer to species listed in Table 1.

All OP3 rank-abundance plots showed a similar shape throughout the day, although the evening plot was more compressed (Fig. 3). Species composition, rank abundance and degree of dominance were similar at all times of day. Species richness was consistently high (S_{MORN} = 10, S_{MIDD} = 9, S_{AFTER} = 11, S_{EVEN} = 10).

DISCUSSION

Observer position

This study showed that indices of numbers and species diversity of waterbirds were strongly dependent on the position of the observer. This was mainly attributed to the higher elevation of two of the observer positions but even they differed significantly in total numbers of birds counted and total numbers of New Zealand scaup. Location of the observer influenced the results of counts markedly. This is important since the effect of observer position has not been widely considered as a source of variation in bird studies (Ralph & Scott 1981).

Time of day

Variations in activity levels and behaviour throughout the day often cause changes in the detectability of bird species that biases the results of counts (Palmeirim & Rabaca 1994). Several studies have analysed time-of-day effects, with contrasting results (Shields 1977; Robbins 1981a; Skirvin 1981; Arnold 1989; Rollfinke & Yahner 1990; Deslauriers & Francis 1991; Palmeirim & Rabaca 1994; Lynch 1995; Bunn *et al*. 1995; Mills *et al*. 2000; Craig & Roberts 2001). The studies make clear that there is no consistent pattern to time of day effects on bird counts; they vary according to which group of bird, guild, species, and season being considered.

In this study, no significant differences were detected between different times of day. While evident at OP1, they were obscured by relatively large observer position effects. As indicated by rank abundance plots, the bird species composition, diversity and community structure as assessed from OP1 changed considerably between different times of day and hence reliance on counts during one time period only could lead to biased interpretation. In contrast, the results from OP2 and OP3 were relatively similar throughout the whole day, suggesting that, when a sufficiently large area can be sampled, mean activity levels do not differ and hence time of day has less impact on the results of waterbird counts.

The effect of time of day on the results of bird counts appears to be minimised when counting from elevated sites, but for consistency counts should be conducted at the same time of day. I hypothesise that effects of time of day and observer position will vary between sites, and suggest that all waterfowl monitoring programmes should incorporate an assessment of these effects to minimise bias.

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