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FEEDING BEHAVIOUR OF THE BLACK-FRONTED DOTTEREL

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ABSTRACT

Since its recent arrival in New Zealand the Black-fronted Dotterel has begun winter flocking, and a newly observed feeding technique has become common. This new feeding behaviour is used mainly on hard substrate. The bird taps the substrate before pecking at prey, and on hard substrate the capture rate is higher than by simple pecking. By imitating the tapping on soft, intermediate and hard surfaces, I found that vibrations from the tapping on hard substrate alone caused flies to jump, making them more visible.

In winter, birds were heard calling an hour before sunrise as they flew from sleeping sites scattered along the Manawatu River to the sludge ponds at the freezing works. The dotterels returned to the river after several hours of feeding but again visited the sludge ponds from mid-afternoon to almost an hour after sunset. At both the river and the sludge ponds most prey consisted of two species of fly.

Daily time budgets showed that birds were feeding for 38% of the day while incubating, 69% while tending chicks and 86% during a winter's day. It was estimated that during a winter's day, one apparently normal bird caught 28 737 insects. To do this it pecked at 31 579 insects and caught one insect every 1.5 seconds.

INTRODUCTION

The Black-fronted Dotterel *(Charadrius melanops)* is a bird of inland Australia and, although it is seldom seen on Australia's coastal beaches (Pringle 1987), it crossed the Tasman Sea and was first recorded in New Zealand near Napier in 1954 (Brathwaite 1955). Since then it has become established as a breeding species in both the North and South Islands.

In Australia the Black-fronted Dotterel is not gregarious (Maclean 1977, Pringle 1987); however, winter flocks of feeding birds were reported in New Zealand soon after its arrival (Mackenzie 1962). Flocks of 10-12 birds were seen in Hawke's Bay (Mackenzie 1963), 9 birds at the Masterton sewage ponds and 10-12 birds at the Greytown sewage ponds (Heather 1973).

Subsequent visits to the last site recorded a winter maximum of 25 feeding birds. This paper records the behaviour of still larger flocks at Longburn in the Manawatu. Recently, Heather (pers. comm.) has seen wintering flocks of similar size to those found at Longburn (about 100 birds) at Lake Hatuma, Lake Wairarapa and the Feilding sewage sludge ponds.

Heather (1977) noted for the first time that Black-fronted Dotterels would sometimes tremble one foot before pecking at prey, and he proposed that this was a response to some feature of the substrate. Because the foot of birds at Longburn usually touched the ground, the term foot-tapping used by Heather (1977) seems appropriate to separate the behaviour from leg-shaking, where the foot does not touch the ground.

As the numbers of dotterels at the Longburn sludge ponds were large and the substrate varied from hard to soft, the situation looked ideal for finding whether the birds were foot-tapping or leg-shaking. It also looked promising for finding out the purpose and advantages of foot-tapping and winter flocking. As the birds nested nearby on the shingle beds of the Manawatu River, I had the opportunity to look at parental feeding during breeding.

METHODS

Black-fronted Dotterels were studied at the Manawatu River and the Longburn Freezing Works sludge ponds, 1 km from the river (Figure 1). These ponds were ideal for the study because large numbers of Black-fronted Dotterels used them and the birds were more approachable than usual. In addition, the sludge varied in its hardness and so I was able to test the ideas of Heather (1977).

The sludge, built up from the floor washings of the freezing works, was composed largely of wool, with smaller amounts of faeces, blood, fat and other tissues. It was piped to and dumped between earth walls, where it formed a soft sludge. The further from the outlet pipe and the longer after pumping stopped, the harder the sludge became. Heavy or persistent rain would soften the whole surface.

To correlate feeding behaviour with the firmness of the substrate, I divided the sludge into three categories – hard, intermediate and soft. On hard substrate the birds' feet did not depress the surface. On soft substrate, the sludge covered more than the birds' toes. Intermediate was between the two.

The numbers of birds feeding, both normally (including "run and peck" and "walk and peck" methods) and by "tapping and pecking" were tabulated according to the hardness of the substrate they were on. Data were also recorded for the peck rate and success rate of the two feeding methods in relation to the hardness of the stratum they were on.

To record the success or capture rate of the two methods, I noted whether a peck was followed by a bill movement or a swallowing action; with either of these the peck was considered successful.

To determine the daily time budget for a winter's day, I spent two separate half-days at the river in a continuous watch and then added the two together. I did the same again for incubating birds and for a pair with

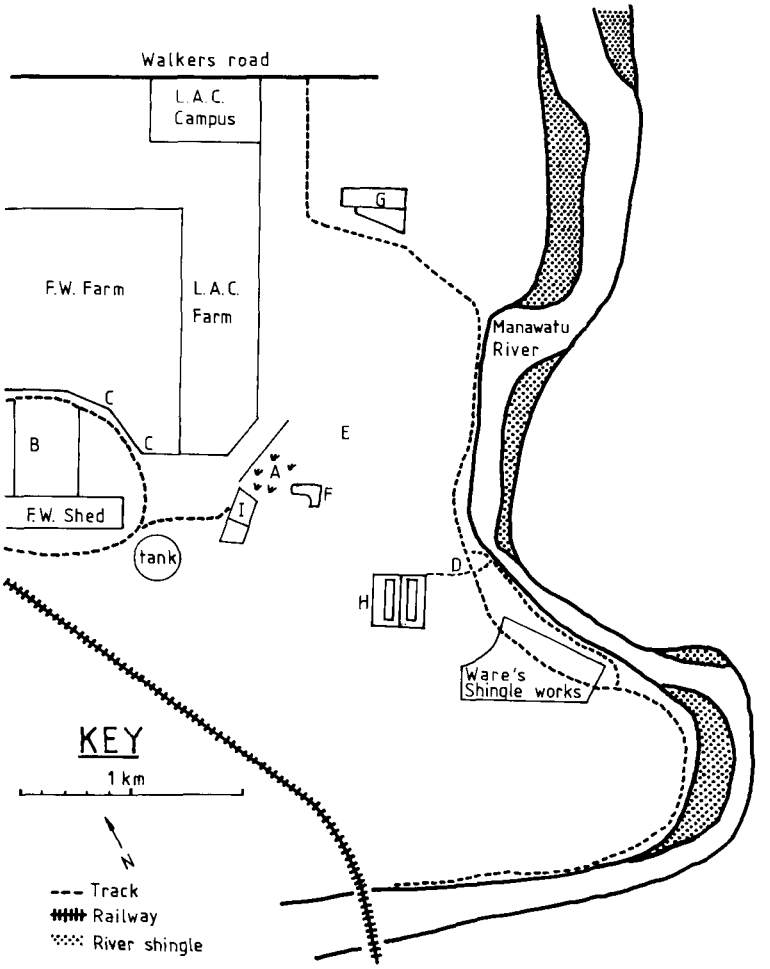

FIGURE 1 — Location of the Longburn Freezing Works sludge ponds and surrounding farm areas. F.W. = Freezing Works, L.A.C. = Longburn Adventist College. River census site 1 was north of point D and site 2 was south of that point

chicks about 8 days old. During these watches I timed all activities other than feeding, and then presumed that the birds had spent the rest of the time feeding. From a sample of the peck rates of birds feeding I calculated the average peck rates and the total number of pecks per day. The success rate was then used to estimate the number of prey taken in a day.

RESULTS

Feeding methods

Table 1 shows the numbers of birds found using each of the two feeding methods in relation to the hardness of the substrate at the Longburn Freezing Works sludge ponds.

TABLE 1 — Numbers of dotterels using each feeding method on sludge ponds at Longburn Freezing Works

Surface Hardness	Tap and Peck	Simple Pecking
Hard	193	9
Intermediate	59	72
Soft	5	175

The feeding method used depended on the hardness of the substrate (X_{22} = 394.1, n = 513, P <0.001). This does not mean that some individuals specialised in the "tap and peck" but rather that individuals varied their feeding method according to the substrate. There were times when all birds were using the tap and peck method on hard substrate and other times when all the same birds were using the simple peck method on soft substrate. In addition, birds moving from hard to soft substrate normally switched to simple pecking, although sometimes they gave an ineffective tap sequence or two before settling into simple pecking. It is clear that they chose the feeding method according to the firmness of the substrate.

TABLE 2 — Peck and capture rates

Location	Mean Number Simple Pecks/ Minute	SD	Minutes	Mean Number Tap & Pecks/ minute	SD	Minutes
Sludge Pond						
Peck rate (all surfaces)	51.0	14.9	197	29.6	6.1	116
Capture rate (all surfaces)	45.3	10.9	59	25.1	4.0	72
River						
Peck rate (hard surface)	18.3	8.8	31	26.8	7.3	22
Peck rate (all surfaces)	36.0	17.4	1046	32.4	7.6	8
Capture rate (all surfaces)	40.7	13.5	24	27.3	9.7	8

The average capture rate of the simple peck method (on all surfaces combined at both the sludge ponds and the river) was higher than that of the tap and peck method (Table 2). On hard surfaces at the river, the peck rate for tap and peck was significantly higher (t_{52} = 3.82, P <0.001) than that for the simple pecks.

At the freezing works, simple pecking was significantly more successful (n = 2934 pecks, success = 91%) than tap and peck (n = 1873, 86%, X_2 = 29.3, P <0.001). A similar analysis of 259 tap and pecks and 1182 simple pecks on the mud and shingle by the river showed that the success rate for tap and peck (85%) was not significantly greater (X_2 = 0.09, P > 0.5) than for simple pecking (83%).

The advantage of tapping on these hard surfaces became clear when I took a twig with two forks and similar dimensions to those of a dotterel's leg and foot and vibrated it on the hard substrate. This action caused flies of both the major prey species that were closer than about 300 mm to jump a short distance. As a result I could see more of them than before I imitated the tapping of the dotterels. I repeated this test on different parts of the hard substrate with the same results, but when I tapped soft substrate or water the flies made little or no response. Flies on soft substrate were easy to see.

Seasonal movements

Although Black-fronted Dotterels are on the shingle beds of the Manawatu River in any month of the year, their numbers vary seasonally on the river at Longburn. Monthly mean counts (Table 3) for two river sample areas (Figure 1) increased from January to July and then declined to a December low (Figure 2).

TABLE 3 — Summary of Black-fronted Dotterel counts on the Manawatu River at Longburn

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Site A												
$\bar{x}$	1.3	1.0	1.8	2.2	3.2	3.7	5.1	4.3	2.8	1.9	2.1	1.0
s.d.	1.4	1.3	1.5	1.9	2.6	6.1	5.0	3.5	1.5	1.5	0.6	0.0
max.	4	6	7	9	9	26	17	15	5	7	3	1
n	90	27	34	47	24	18	18	26	28	38	25	2
Site B												
$\bar{x}$	5.0	3.6	5.6	9.1	10.2	6.6	13.3	6.1	3.6	3.7	2.2	2.0
s.d.	-	3.9	3.6	7.3	7.3	3.6	5.1	5.9	2.4	1.7	1.5	-
max.	5	10	12	26	21	12	20	20	10	7	5	2
n	1	7	16	17	13	10	12	17	23	19	11	1

Numbers of Black-fronted Dotterels were highest at both the freezing works ponds and the silt areas of the river (Figure 2) during the winter months. Flocks were larger at the freezing works sludge ponds (I on Figure 1) than at the river but this did not stop them using very local and even very temporary sites where waterlogged soil had encouraged the congregation of those flies used as prey. At Longburn these sites included: the swampy paddock at A (Figure 1), the paddock at B after its grass was disturbed by building activity, small ponds at C after pipes had been laid, the clay patch at D after the freezing works drain had been deepened, bare areas in the Manawatu Co-operative Dairy Company paddocks at E, the pond in the

FIGURE 2 — Monthly averages (1981-1988) of Black-fronted Dotterels for both census sites on the Manawatu River at Longburn

disused shingle pit at F, and the sewage ponds (G) when their level fell enough to expose the earth below the concrete part of the wall. Towards the end of the study, the dotterels used the new freezing works effluent ponds at H. When the works closed down, the water and effluent levels of these ponds dropped below the concrete rim and were used daily by feeding dotterels.

By far the most popular feeding site away from the river was that of the freezing works sludge ponds. The first birds to use this site after breeding generally arrived between April and June. The largest feeding flocks assembled during July but there was a rapid decline in late August. In only one year were any birds seen at the sludge ponds after August (Table 4). The largest number of feeding birds I saw at one time was 91 on 18 May 1979. However, a week or two earlier Michael Dennison and Hugh Robertson (pers. comm.) had counted 104 birds on the same ponds.

TABLE 4 — Black-fronted Dotterel numbers at Longburn Freezing Works sludge ponds

Year	1977	1978	1979	1981	1982	1983	1984	1985	1986
Earliest	Jun 3	Jul 20	May 18	Feb 8	Jun 1	Apr 22	Feb 7	Apr 24	Jun 30
Latest	Aug 28	Oct 20	Aug 15	Aug 25	Aug 28	Aug 2	Aug 13	Aug 12	Aug 12
Maximum	54	65	91	26	52	27	62	43	11
Mean	18	38	76	9	10	6	26	16	6
s.d.	24	38	14	8	11	8	29	17	5
n	4	2	6	17	49	15	34	13	4

The most popular feeding site away from the river, apart from the sludge ponds, was the sewage ponds when they had completely emptied into the river (about 2 June 1983 & 16 July 1985). The first time up to 25 birds were seen feeding slowly and taking much longer rests than normal because the midge (chironomid) larva prey were abundant and large. The swampy paddock (A) provided food for up to 19 birds at one time during a particularly wet spell.

In one year only were any of the feeding sites away from the river seen to be visited between September and late March by more than four birds. As this is the time when the birds are defending territories and breeding on the river bed, I assumed that birds breeding on the adjacent river moved to these feeding sites during the breeding season. The only exception was March 1984 when six adult birds were seen at the sewage pond a few days before seven were seen at the sludge ponds. I assume these to be failed or early breeders.

Daily movements

Between 0630 and 0700 h (about 50 min before sunrise) on winter mornings, birds could be heard calling as they left the river and flew to the sludge ponds. The commonest calls given in flight were a short metallic *plink plink* and a drawn-out mechanical *ch-u-u-r-r-r*. Other calls such as *chink-oo-chink, churr-choo-ch* and *cler-it* had similar tones to the common calls and may have only been variations of them. How long the birds stayed at the ponds was not determined accurately but there were rarely any left when I checked the ponds between 1000 and 1400 h.

The dotterels arrived back at the ponds between 1400 and 1600 h. There was a trend to delay arrival times as August progressed. Departure times were more constant, most birds leaving for the river in one or two flocks about 50 minutes after sunset. The feeding behaviour of the birds could be watched for only 30-40 minutes after sunset, but the birds probably fed until they left.

Even when the river was in flood and the shingle was under water, the daily feeding routine did not change. During the middle of the day birds fed along the silt that had been deposited on the banks or nearby land. Even when large numbers were feeding at the sludge ponds during early morning or late afternoon one or two birds could still be found feeding along the river, and so winter censuses based at popular feeding sites such as the Longburn ponds will not give complete counts.

Daily time budgets

In winter and while tending chicks, the Black-fronted Dotterels on the Manawatu River spent most time feeding (Table 5). Observations at the nest showed that, like those breeding in Otago (Child & Child 1984), the birds were very nervous when incubating. This resulted in the eggs being unattended for 2.5 hours out of the 7 hours of observation on 7 November 1986. Two days later the eggs were left unattended for 5 hours 10 minutes out of 9 hours 38 minutes of observation. I do not know whether these eggs hatched or whether this is normal behaviour, though eggs left unattended

for 1 hour 45 minutes at a time have hatched (Child & Child 1984). In Table 5, the time spent incubating (and on the other activities) is divided equally between the two birds because they could rarely be identified. During another 4.5 hours, when I could tell the two brooding birds apart, one incubated 44% and the other 56% of the time.

TABLE 5 — Daily time budgets for dotterels on the Manawatu River at Longburn

Activity	Non-breeding May		Incubation November		Tending chicks December	
	min.	%	min.	%	min.	%
Feeding	612	86	360	38	667	69
Preen/scratch	21	3	61	6	63	6
Flying	2	<1	16	2	17	2
Rest/watching	71	10	32	3	85	9
Running	6	1	8	1	19	2
Bathing	1	<1	<1	<1	<1	<1
Drinking	0	0	<1	<1	0	0
Copulation	0	0	<1	<1	0	0
Incubation	0	0	478	50	0	0
Brooding	0	0	0	0	121	12
Total	713	100	956	100	972	100

Concurrent with the activities shown in Table 5, incubating birds spent time escaping human disturbance (8 min), watching Australasian Harriers *Circus approximans* and Black-backed Gulls *Larus dominicanus* (0.2 min), performing displays and otherwise showing aggression to conspecifics (6.5 min) and to Banded Dotterels *Charadrius bicinctus* (0.1 min), as well as calling (6.5 min).

Prey species

I could not find any visible organisms in samples of the upper 80 mm of substrate at the sludge ponds, taken from where birds had been seen feeding. I could see on the surface of the sludge only three invertebrate species, which I later found to be common on most days. Adult moth flies (Psychodidae) were the largest (5 mm), another fly (Ephydridae) was next in size (3-4 mm), and the smallest but most numerous were springtails (*Collembola* spp.) (2.5 mm). Small black beetles, midge larvae (*Chironomus* spp.), mites and wood slaters present were too few to be major prey. As the birds ignored the springtails, even those common enough to form broad grey patches up to 2 metres long, adults and larvae of the two fly species formed the bulk of the prey.

On only four occasions was the captured prey large enough to be seen through the telescope. Two seemed to be bloodworms, the larvae of the midge, one was a freshwater snail at the river and the other was possibly a crustacean. On several occasions the surface was covered with earthworms (dead and alive) but the birds ignored them. Once a bird picked up an earthworm, worked it in the bill three or four times, and rejected it.

The same two flies were not common on the river feeding sites during some winter days but they were the only surface invertebrates present. Their numbers increased noticeably through September, the time when the number

of birds visiting the sludge ponds had declined. Also at this time a small kind of crane fly (Tipulidae) appeared at the river's edge and was occasionally taken for prey, though the other two flies were still the major food.

Through the telescope, I could on occasions see the bird's bill penetrate several millimetres into soft substrate. This became more frequent as the soft areas contracted into small pools, the birds making many pecks without taking a step, presumably at abundant immobile prey. On inspection, I found a high density of fly larvae about 4 mm long.

The prey that attracted the dotterels to the mud floor of the Longburn sewage pond when it emptied into the river was bloodworms. Their average length was 16.4 mm (*s.d.* = 3.0, n = 31) and their average weight was 0.020 g (*s.d.* = 0.008, n = 36). The mass of these worms was far greater than the average 0.001 g (n = 301) for the flies commonly taken.

DISCUSSION

Foot tapping

Foot-trembling has been recorded in at least ten plovers and one godwit species. The Lapwing *Vanellus vanellus*, Little Ringed Plover *Charadrius dubius*, Ringed Plover *Charadrius hiaticula*, Kentish Plover *Charadrius alexandrinus*, Golden Plover *C. apicarius*, Dotterel *C. morinellus*, Three-banded Plover *C. tricollaris* and Black-tailed Godwit *Limosa limosa* were reported by Simmons (1961a,b). Heather (1977) recorded it in the Black-fronted Dotterel and published Alan Jones's record of it in the New Zealand Dotterel *C. obscurus* (footnote to Searle 1984). Both Simmons (1961b) and Heather (1977) suggested that foot-trembling may cause camouflaged invertebrates to move.

My observations confirm these suggestions about foot-tapping. On Ninety Mile Beach, in December 1981, I saw a New Zealand Dotterel *C. obscurus* foot-tapping on the solid sand of a small driftline where sandhoppers congregate. It was clear that the foot movements were intended to flush prey, which were then taken in the bill just as the Black-fronted Dotterels did at Longburn.

Waders whose chicks have to run and peck for their food have been shown (Nol 1986) to have longer incubation periods than those species whose chicks beg. Nol (1986) predicted that a "run and peck" wader with an egg weight equal to that produced by the Black-fronted Dotterels (6.67 g) would have an incubation period of 23 days. This is close to the 23-26 days found by Child & Child (1984) and Pringle (1987). The extra time in the egg presumably allows for a greater development before hatching and so equips the young with abilities to catch their own prey. Young Black-fronted Dotterels certainly have high feeding activity, as demonstrated by the high peck rate of the 8-day-old chicks observed in this study. These chicks had a significantly higher (t_{77} = 3.3, $P<0.002$,) peck rate ($\bar{x}$ = 47.6) than their parents on the same day ($\bar{x}$ = 35.0). The chicks probably need more energy than their parents (for growth and building reserves) and their capture success rate might not be as high.

TABLE 6 — Peck rates and estimated daily catches

	Non-breeding (May)	Incubating (November)	Tending chicks (December)
$\bar{x}$ pecks/min	51.6	31.3	33.0
n (peck rate)	237	248	179
s.d.	18.8	10.4	16.4
n (feeding)	612	360	667
Est. total pecks	31,579	11,275	22,011
Est. daily catch	28,737	10,260	20,030

We might ask why these dotterels use the tap and peck method at all as it expends more energy and is performed at a slower rate than simple pecking. However, as this study has shown a higher success rate for tap and peck over simple pecking on hard substrate, it is clear that the birds benefit by resting the soft substrate while using the method most effective on the hard substrate, even though the average success rate for this method is less than that for simple pecking on soft substrate.

One exception to this situation was noted when both the sludge surface and the fly larvae were frozen in a severe frost. Under these conditions the prey were obvious and simple pecking alone was used on the hard icy surface.

Seasonal movements

The lower density of prey at the river (indicated by the lower peck rate) would explain why the dotterels leave the river bed to feed from the denser supply at the sludge ponds. But, why do the dotterels not stay at the sludge pond all day? Optimal foraging theory suggests that they should stay at the best site. My suggestion is that the dotterels are drawn to the river for part of each day to defend a nesting territory. In winter they tend to do this by wing displays rather than physically chasing other birds from their nesting area, which they do during breeding. This is more appropriate as not all birds are on their home territories and more tolerance would allow greater use of locally dense food supplies.

It is interesting to speculate on the origin of the birds that join the winter flocks at Longburn, for at least some of the South Island rivers used by this species are deserted during winter (Child & Child 1984). However, as 117 Black-fronted Dotterels were recorded (11/12 November 1978) by members of the Manawatu branch of the OSNZ on the Manawatu River between Hopelands Bridge and Opiki it is not essential to look to birds arriving from other river basins to make up the numbers found at Longburn. Alternatively, this does not rule out the possibility of a few birds travelling large distances as these birds are opportunistic and that they ever reached New Zealand is proof of this.

Time budgets

Parents of precocial self-feeding waders have been divided into those that constantly move with their young at the expense of their feeding time and those that watch their young from a distance and so lose little feeding time

(Winkler & Walters 1983). Plovers in the first group lost an average 42% of their foraging time, and Winkler & Walters (1983) suggested that this loss was the major factor limiting clutch size in those species.

Black-fronted Dotterel parents lost only 18% of their foraging day while tending their chicks, and so they should be classed in the second group where the reduction in the foraging time caused by chick tending duties is too small to reduce clutch size by restricting the number of chicks they can look after. Because one Black-fronted Dotterel parent stays within 2-3 metres of the chicks, the chicks have much less risk of predation than those of waders where the parents watch the chicks from a distance of 14-28 metres (Winkler & Walters 1983). While one Black-fronted Dotterel parent is tending the chicks the other is away feeding. Because the parents tend the chicks in turn fairly equally both parents lose little foraging time. This small loss is perhaps important and is possibly one factor that allows them to maintain a normal clutch size for plovers even though their prey is very small.

CONCLUSIONS

Black-fronted Dotterels may gather into large winter flocks in New Zealand. These flocks sometimes formed on the Manawatu River but more frequently at richer sludge ponds up to 1 km from the river at the freezing works and sewage plant. At all three sites a new feeding technique was observed.

The success of the "tap and peck" method was significantly greater than that of simple pecking only on hard substrates. This applied to both the river and the sludge ponds. The advantage of this technique derives from transfer of vibrations from the foot through the substrate to prey, which move and are seen by the feeding bird. These vibrations do not disturb prey on soft substrate. As prey are more visible on soft (wet) surfaces, they need not be disturbed, and the extra time and energy taken by this behaviour is unnecessary.

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