DIVING BEHAVIOUR OF THE AUSTRALIAN COOT IN A NEW ZEALAND LAKE

By BRIGITTE J. BAKKER and R.A. FORDHAM

ABSTRACT

In a 1-day study of the Australian Coot (*Fulica atra australis*), the duration of dives increased with increasing depth, although the frequency of diving remained relatively constant. Duration and frequency of dives at given depths appeared not to vary with age. However, aggressive adults often drove young birds into deeper water. The duration of dives changed with the time of day, the birds preferring to dive in direct sunlight.

INTRODUCTION

Foraging diving birds have limited capacity to find food under water. The effort put into foraging can be assessed from the frequency and duration of their dives in both carnivorous and vegetarian birds. In these two groups diving is likely to differ because carnivorous birds dive to chase and catch live prey, which are often mobile, whereas the food of vegetarian birds is usually fixed at a certain depth or location.

Most studies of diving behaviour have been with carnivorous birds (Stonehouse 1967, Piatt & Nettleship 1985, Cooper 1986, Wanless *et al.* 1988, Wilson & Wilson 1988, Strong & Bissonette 1989), and relatively little attention has been paid to predominantly herbivorous birds, such as rails (Dewar 1924, Batulis & Bongiorno 1972). Coots, which are energetic diving rails with regular feeding bouts, forage mostly on benthic plant material and are therefore good subjects for studying diving behaviour in a vegetarian bird. Diving times and pauses in the American Coot (*Fulica americana*) were measured in relation to water depth by Batulis & Bongiorno (1972). They found that differences in water depth affected diving times and pauses although dive/pause ratios remained constant. Longer dives therefore required a longer pause period for birds to recuperate. In their study area, however, dives were restricted to depths between 25 and 74 cm, and coots can dive deeper (this study).

The Australian Coot (*Fulica atra australis*) is found in New Zealand on lakes and ponds. Stragglers from Australia were first recorded breeding at Lake Hayes in Central Otago in 1958, and the species has become widely established since then. They occupy inland lakes and ponds in both the North and South Islands with a total population of up to 2000 birds (Caithness 1985). Coots are aggressive to conspecifics and other waterfowl, especially at the height of the breeding season, when breeding pairs defend territories (Jackson & Lyall 1964, MacDonald 1966). Thus, aggressive behaviour could potentially affect diving patterns. This study aimed to better understand diving by the Australian Coot by describing diving patterns in relation to

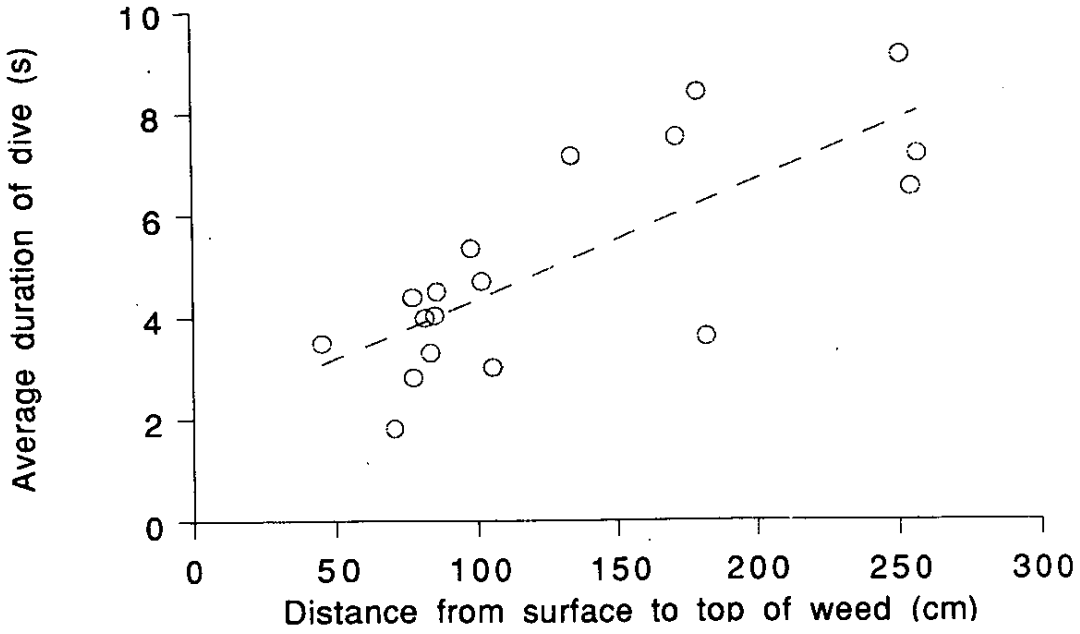

FIGURE 1 — Effect of average depth from the water surface to the top of the submerged weed on the average duration of the dive in the Australian Coot at Virginia Lake. Average values are from 15 min observation periods.

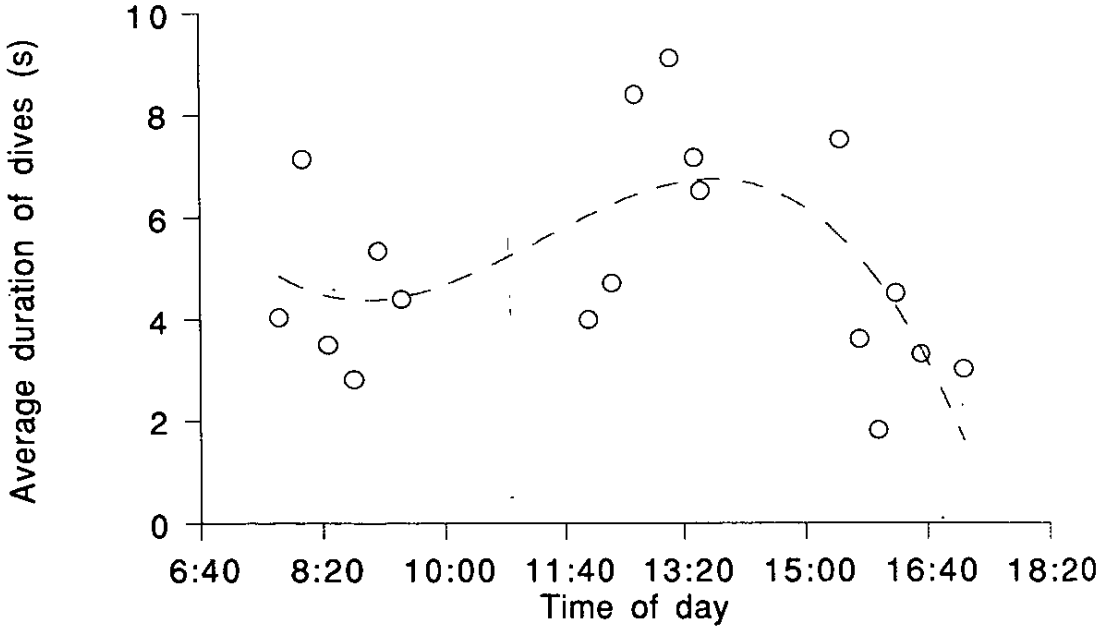

FIGURE 2 — Average duration of dives in the Australian Coot in relation to the time of day at Virginia Lake. For explanation, see text.

the age of the bird and the time of day. We assumed that coots dived to forage on benthic plants.

STUDY AREA AND METHODS

Observations were made at Virginia Lake in Wanganui (39° 55′ 175° 02′ W), New Zealand. The area of the lake is c. 1.5 ha and data were collected within a rectangular area of 42 x 14 m along one edge. The maximum depth of the lake is 52.4 m (Sutherland 1970). Coots, which have inhabited the lake since 1962, dive to forage on the benthic Canadian black weed (*Elodea canadensis*) which covered most of the study area and comprised the only aquatic macrophyte. About 60 coots were present during the study.

The coots were observed by BJB three times on 10 June 1990: 0730-0930 hours, 1200-1400 hours, and 1530-1730 hours. In each time block, individuals were randomly chosen and observed using focal animal sampling. Each individual was observed for 15 min with a 5 min break. Following Falla *et al.* (1979), birds were classed as adults if the frontal shield was relatively large and as juveniles if the shield was relatively small. As far as possible individual birds were not observed repeatedly. The duration of each dive was timed by stopwatch to the nearest second, and the location in the study area mapped precisely by using distance markers and a range finder. Successive dives were grouped as a feeding bout when the pause between dives lasted less than 1 second. Observations on a focal bird ceased if it left the study area. Using the map of dive locations, the depth of each dive (to the top of the weed and to the bottom of the lake) was subsequently measured to the nearest 5 cm with a graduated pole. Air temperature and general weather conditions such as cloud cover and wind were noted throughout the day.

RESULTS

All observed birds dived energetically, sometimes leaping from the water as described by Lyall (1963). Before diving, birds appeared to sight the weed by cocking their head sideways. After diving, a bird sometimes emerged holding in its bill a length of weed, which it proceeded to pick at. The results are based upon 18 observation blocks.

As expected, coot dives lasted longer as water depth increased. The depth to the top of the weed and the depth to the bottom of the lake were both positively correlated with dive duration ($r = 0.404$ and $r = 0.543$ respectively), but when considered together the depth to the weed was more significant ($F = 36.59$ $p < 0.05$, Figure 1). the frequency of dives was independent of depth ($F = 1.52$, $p > 0.05$). The duration of dives did not influence diving frequency in either adults ($F = 1.98$, $p > 0.05$) or juveniles ($F = 0.00$ $p > 0.05$). Adults and juveniles averaged 8 ± 1.49 and 13 ± 2.21 ($n = 17$) dives respectively per observation block. When calculated as frequencies, diving was independent of the age of individuals ($t = 1.46$, $p > 0.05$), and the number of dives per feeding bout in adults and juveniles showed no significant difference ($F = 1.46$, $p > 0.05$). Further, age did not strongly influence the duration of dives ($F = 1.32$, $p > 0.05$) to similar depths. On average adults dived deeper than juveniles (adults $\bar{x} = 140.1 \pm 7.92$ cm $n_A = 9$, juveniles $\bar{x} = 97.1 \pm 5.95$ cm ($n_J = 8$) but the

difference was not quite significant ($t = 1.98$, $p = 0.067$.) The frequency of dives did not change significantly with the time of day ($F = 0.00$, $p > 0.05$) but dives were longest at midday. This change in the duration of dives over the day was highly significant ($F = 12.12$, $p < 0.05$, Figure 2).

DISCUSSION

The results show that, in the coots studied, the duration of a dive was related to its depth and the time of day. Feeding behaviour varies with the depth of the dive in shags *Phalacrocorax* spp (Stonehouse 1967, Wilson & Wilson 1988, Wanless *et al.* 1991), guillemots *Uria aalge*, puffins *Fratercula arctica* and razorbills *Alca torda* (Wanless *et al.* 1988), and common loons *Gavia immer* (Strong & Bissonette 1989), and with age in American Coots (Desrochers & Ankney 1986) and Common Loons (Strong & Bissonette 1989). Other factors may include weather and food availability (Kiel 1955, Horsfall 1984), but we assume that at Virginia Lake these were relatively constant.

For the Australian Coots, a strong positive relationship was apparent between the duration of dives and water depth, probably because of the time taken to commute between the surface and benthic plant material. There were large variations in depth (10 - 230 cm) between the top of the weed and the lake floor at each dive location. Consequently, the exact location of the food taken with each dive was difficult to assess. The strong correlation between dive duration and weed depth, rather than lake depth, indicates that the coots were foraging on the most accessible younger, higher tips of plants. The frequency of diving did not alter as dives became deeper or longer, and so longer periods underwater did not lead the coots to pause longer between dives. This finding is different from that of Batulis & Bongiorno (1972), who found that pause times increased with increasing depths in the American Coot. Ryan & Dinsmore's (1979) study on the American Coots showed that there were variations in feeding rates, depending on the time of year and the reproductive state of the individuals. Coots at Virginia Lake during this study were probably not diving at their maximum rate because they did not need food for energy-demanding activities like egg production or chick rearing. Birds sometimes pulled long lengths of weed to the surface after a dive and picked at it. This handling time (i.e. time taken to eat the weed) could thus represent recovery time from any possible oxygen debt. However, because the birds did not change their diving frequencies during active feeding bouts when they brought no plant material to the surface, they may have been diving well within their capability, well short of their physiological limit. Other studies on diving birds (e.g. Wanless *et al.* 1991) support this idea.

The age of individuals did not influence the frequency of diving. Adults and juveniles appeared similar in size and may have similar diving capabilities. Stonehouse (1967) observed smaller species of shags (Phalacrocoracidae) foraging in shallower water, and showed that a smaller body is less capable of longer, deeper dives. An increase in diving frequencies with age would also imply increased experience over time (Strong & Bissonette 1989). However, this was not evident in the Virginia Lake

population. Dive frequencies were the same in the different age groups, for juveniles had already acquired the adult level of experience. For the American Coot, Desrochers & Ankney (1986) showed significant differences in diving frquencies between adults and chicks (1-60 days). As chicks mature, motor co-ordination and experience improve, approaching adult levels before 3 months of age. Juveniles in the present study were aged 5-8 months. In the Moorhen (*Gallinula chloropus*), evidence suggests that juveniles achieve adult efficiency quite early (Sutherland *et al.* 1986).

Dominance hierarchies may account for young and old coots diving in water of different depth. In the breeding season adults hold territories by actively chasing intruders away (Macdonald 1968, Ryan & Dinsmore 1979). Cave *et al.* (1989) also showed that the ability to hold a territory in European Coots is age-dependent. Our data were collected outside the breeding season, and foraging in a patch was not exclusive because many adults fed in the same area. Juveniles showed a strong preference for shallow water, but were often forced into deeper areas when aggressive adults were present.

The pattern of dive durations observed may reflect locations where individuals foraged (see Figure 2). It appeared that all coots preferred to forage near the lake's edge, where weeds are closer to the surface, and during the morning, most dives were recorded in shallow water. But as the day progressed, the shallow area became shaded and coots moved to deeper areas where there was direct sunlight. At approximately 1500 hours, the entire study area was shaded and coots moved back to shallow areas. Birds that forage in shallow areas increase their foraging efficiency by maximising the energy gained from food over the energy expended obtaining it (Macarthur & Pianka 1966). The coots may have preferred sunlit water over shaded water because direct sunlight makes benthic plants more visible.

Future work could usefully tackle several questions:

1. To what extent are young but maturing coots prevented from feeding in particular areas by adults?
2. Do coots feed more frequently in deeper water when sunlight shows up the weed clearly?
3. Is the type of diving seen at Virginia Lake widely characteristic of New Zealand coots?

In all cases, restriction of observations to zones where water and weed depth have been pre-recorded could remove a source of error. Underwater observation would, of course, reveal all.

ACKNOWLEDGEMENTS

Permission for the study was given by the Wanganui City Council. Mark Daniels provided equipment at Virginia Lake, and Dr E. Minot helped with data analyses. We thank Peter Meier, Tracey Meier, Rowena Dodgson and Dr I. Henderson for contributing in various ways. Tom Caithness, Barrie Heather and John Innes commented most helpfully on the manuscript. Mary-Lou Dickson and Petra van Kan typed various drafts.

LITERATURE CITED

BATULIS, J.C.; BONGIORNO, F. 1972. Effect of water depth on diving times in the American Coot (*Fulica americana*). Auk 89: 665-667.
CAITHNESS, T.A. 1985. Australasian Coot. *In:* Complete Book of New Zealand Birds p. 173. Sydney: Readers Digest Services Ltd.
CAVE, A.J.; VISSER, J.; PERDECK, A.C. 1989. Size and quality of the coot *Fulica atra* territory in relation to age of its tenants and neighbours. Ardea 77: 87-98.
COOPER, J. 1986. Diving patterns of cormorants Phalacrocoracidae. Ibis. 128: 562-570.
DESROCHERS, B.A.; ANKNEY, C.D. 1986. Effects of brood size and age on the feeding behaviour of adult and juvenile American Coots (*Fulica americana*). Can. J. Zool. 64: 1400-1406.
DEWAR J.M. 1924. The Bird as a Diver. London: Witherby.
FALLA, R.A.; SIBSON, R.B.; TURBOTT, E.G. 1979. The New Guide to the Birds of New Zealand and Outlying Islands. Wellington: Collins.
HORSFALL, J.A. 1984. Brood reduction and brood division in coots. Anim. Behav. 32: 216-225.
JACKSON, R.A.; LYALL, H. 1964. An account of the establishment of the Australian Coot in the Rotorua district with some notes on its nesting habits. Notornis 11: 82-86.
KIEL, W.H. 1955. Nesting studies of the coot in South Manitoba. J. Wildl. Manage. 19: 189-198.
LYALL, H. 1963. Coot behaviour at Okareka. Notornis 10: 353-354.
MACARTHUR, R.H.; PIANKA, E.R. 1966. On optimal use of a patchy environment. Amer.Naturalist. 100: 603-609.
MACDONALD, R. 1966. Australian Coots on Virginia Lake, Wanganui (September 1962 to May 1966). Notornis 13: 165.
MACDONALD R. 1968. The Australian Coot established on Virginia Lake, Wanganui. Notornis 15: 234-237.
PIATT, J.F.; NETTLESHIP, D.N. 1985. Diving depths of four alcids. Auk 102: 293-297.
RYAN, M.R.; DINSMORE, J.J. 1979. A quantitative study of the behaviour of breeding American Coots. Auk 96: 704-713.
STONEHOUSE, B. 1967. Feeding behaviour and diving rhythms of some New Zealand shags, Phalacrocoracidae. Ibis 109: 600-605.
STRONG, P.I.V.; BISSONETTE, J.A. 1989. Feeding and chick rearing areas of Common Loons. J. Wildl. Manage. 53: 72-76.
SUTHERLAND, E. 1970. Virginia Lake. Wanganui: Wanganui Historical Society.
SUTHERLAND, W.J.; JONES, D.W.F.; HADFIELD, R.W. 1986. Age differences in the feeding ability of Moorhens *Gallinula chloropus*. Ibis 128: 414-418.
WANLESS, S.; BURGER, A.E.; HARRIS, M.P. 1991. Diving depths of shags *Phalacrocorax aristotelis* breeding on the Isle of May. Ibis 133: 37-42.
WANLESS, S.; MORRIS, J.A.; HARRIS, M.P. 1988. Diving behaviour of guillemot *Uria aalge*, puffin *Fratercula arctica* and razorbill *Alca torda* shown by radio-telemetry. J. Zool. 216: 73-81.
WILSON, R.P.; WILSON, M.T. 1988. Foraging behaviour in four sympatric cormorants. J. Anim. Ecol. 57: 943-955.

BRIGITTE J. BAKKER and ROBIN A. FORDHAM, *Department of Ecology, Massey University, Palmerston North*