Food and foraging of Coot *Fulica atra* on fish ponds during autumn migration

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Introduction

In West Europe Coot *Fulica atra* are partial migrants (Glutz von Blotzheim *et al.* 1973; Cramp and Simmons 1980). Autumn migration starts in August. Coot gather on large water areas initially, disperse over smaller, but more protected waters when it gets colder, and move again to large water areas (including the sea) in very cold weather. Coot are also well adapted to forage on land (Hurter 1972, 1979). Although it has been suspected that these changes of location relate to varying foraging conditions, there has been no conclusive demonstration that this was so.

Coot eat both plant and animal material and seem to take what is most abundant on each particular site (Campredon *et al.* 1982; Suter 1982). No detailed data have yet been published on their food on the small ponds which seem important during at least one stage of the autumn migration. Some data were collected on the diet and foraging behaviour of Coot on two small fish ponds in Belgium. Coot have several foraging strategies, but the relative importance of these has not yet been studied thoroughly. The idea was tested that decreasing abundance of Coot on fish ponds relates to depletion of food resources and/or the increased incentive to perform less profitable foraging strategies.

Additional data were provided on abundance and behaviour of Tufted Duck *Aythya fuligula* and Pochard *Aythya ferina* to look for possible interference with Coot. Suter (1982) found competition with these species, but this was not confirmed by Poysa (1983) and Draulans (1985).

Methods

Coot were studied between the end of August 1984 and mid January 1985, and additional information was collected between August and December 1985. The study area consisted of seven fish ponds near the river Dyle, south-east of Leuven in Belgium. The ponds were up to 2 m deep and between 1 and 20 ha in area, and used for the culture of Carp *Cyprinus carpio* and Roach *Rutilus rutilus*. Emergent vegetation is not abundant, although a few ponds have small *Phragmites* and *Scirpus* beds bordering the water, and one had a floating mat of *Lemna*.

The ponds were visited at least once weekly. On every visit, time, temperature, cloudiness, wind speed, and the position of the *Lemna* mat on the one pond, were recorded. Then, the numbers of Coot, Tufted Duck and Pochard were counted, and their general behaviour sampled by means of scans recorded on a Lab-counter. Behavioural patterns recorded included foraging, preening and bathing, sleeping, swimming, alert, aggression and flying. Foraging Coot were recorded as diving,

Table 1. Numbers of Coot and diving ducks on seven fish ponds.

	Monthly means						Season means		
	Aug	Sep	Oct	Nov	Dec	Jan	Coot	Tufted duck	Pochard
Pond 1	0	0	0	0	11	29	7	2	0
Pond 2	0	0	4	7	8	0	3	4	2
Pond 3	0	0	0	3	2	0	1	10	7
Pond 4	24	28	41	48	8	0	25	0	0
Pond 5	63	72	125	37	3	0	50	13	14
Pond 6	12	4	3	0	0	0	3	6	1
Pond 7	2	6	0	6	4	0	3	18	87
Total	99	110	173	101	35	29	92	53	111
Counts	5	7	5	5	4	4	30	30	30

pecking at the surface and upending, with either head submerged or both head and neck submerged. On several occasions, the duration of dives were recorded. The positions of Coot and diving ducks were marked on a grid map for each pond. The ponds were divided into sectors using reference points on the water's edge and the birds located therein by cross-reference from two different positions on the bank.

Stomach contents of 17 Coot from pond 7 and 1 from pond 5 were analysed after they were shot by hunters in November 1984. For each bird was recorded size, age and sex, volume of the stomach. Its contents were preserved in 4% formaldehyde for further analysis. Food items were identified using a binocular (up to 200x magnification) or a compound microscope (480x). Samples of vegetative material were taken from pond 7 to compare with the stomach contents of the birds shot there. The weight of the main food content of the stomach was established after centrifuging (to separate grit from the food) and drying for 30 minutes at 60°C.

Results

Number of Coot

The number of Coot in the area varied between 30 and 180 during the course of the season, with a maximum in October (Table 1). Some ponds held more Coot than others, and fluctuations in numbers were not necessarily common to all. The overall numbers seem to confirm that Coot are more abundant on small ponds in the middle of autumn migration.

The average number of Tufted Duck and Pochard varied greatly between the seven ponds. There was no significant correlation between the abundance on a pond of Coot and Tufted Duck ($r=0.09$) or Pochard ($r=-0.14$). Coot seemed to prefer ponds not visited by both the diving ducks. The latter, however, did tend to visit the same ponds ($r=0.81$). Other waterbirds, including Mallard *Anas platyrhynchos*, were uncommon.

Distribution on the ponds

The distribution of Coot within a pond was studied on some occasions for the most frequently visited ponds (4 and 5) only. The ponds were divided into, respectively, 12 and 16 equally-sized sectors.

The proportion of Coot seen in each of these sectors varied between 12.8% and 21.1% for pond 4 ($n=109$) and between 23.1% and 41.0% for pond 5 ($n=319$), suggesting that Coot were not randomly distributed. The distribution correlated significantly with the proportion of birds seen foraging ($r_s=0.71$ and 0.76 for ponds 4 and 5), suggesting that it is caused mainly by food-related factors (such as diving depth and abundance of food). The Coot on pond 5 were highly significantly associated with the presence of a large floating *Lemna* mat ($r_s=0.83$), stressing that food is indeed important in determining their location on a pond.

On both ponds, there was a significant positive association of Coot with the distribution of both Tufted Duck and Pochard (pond 4: $r_s=0.62$ and 0.54, respectively, $P<0.05$; pond 5: $r_s=0.78$ and 0.84, $p<0.001$), suggesting that the three species tended to stay close to each other. (Tufted Duck and Pochard were also highly significantly correlated as far as their distribution on ponds 4 and 5 was concerned: $r_s=0.84$ and 0.87, respectively.)

Coot distribution on pond 4 was affected significantly by wind speed ($X^2=11.3$, $df=5$, $P<0.05$), the birds being more regularly distributed over the pond during calm conditions. In windy weather they probably seek shelter. This did not apply to pond 5 ($X^2=1.9$, $df=5$, $P>0.1$). There were no significant differences in distribution on pond 4 according to the variables month, time of the day, temperature, rain and flock size ($X^2=3.1$, 2.8, 9.5, 3.1 and 4.0, respectively, $P>0.05$). Distribution on pond 5 was unaffected by time of the day, temperature and flock size ($X^2=1.9$, 0.1 and 0.4, respectively, $P>0.1$), but did change during the course of the season ($X^2=8.9$, $df=2$, $P<0.025$), probably due to the depletion of the floating *Lemna* mat.

Activity

Coot were active during the day only, which facilitated recording. At night they slept in flocks either in the bordering *Phragmites* and *Scirpus* beds, or perched on various emergent features. More exceptionally, they remained on the water itself.

Table 2. Differences in Coot behaviour.

		Foraging	Preening	Swimming	Alert	Aggression	n
a)	Through the season						
	Aug/Sep	57.7	12.8	25.1	3.8	0.6	3133
	Oct/Nov	53.3	10.0	34.7	1.3	0.7	2668
	Dec/Jan	44.4	9.7	36.5	8.9	0.5	394
b)	Through the day						
	6–10 h	56.5	8.5	31.8	3.0	0.2	1134
	10–14 h	54.9	12.7	28.6	3.1	0.7	3966
	14–18 h	55.6	9.7	30.9	3.2	0.6	1081
c)	Between the ponds						
	Pond 1	35.7	11.2	40.1	12.3	0.7	269
	Pond 2	42.8	14.3	42.9	0.0	0.0	21
	Pond 3	44.1	8.8	43.4	2.6	1.1	1938
	Pond 4	41.7	11.7	44.7	1.9	0.0	103
	Pond 5	62.9	12.7	21.2	2.8	0.4	3758
	Pond 6	14.8	7.4	77.8	0.0	0.0	27
	Pond 7	48.1	13.9	38.0	0.0	0.0	79

The behaviour of Coot was recorded on 6,192 occasions during the study. Of these 55% were foraging, 30% swimming, 11% preening, 3% alert and 1% engaged in aggression. Sleeping and flying were never recorded during the scan samples. Their behaviour did not remain constant during the course of the season (Table 2a). Gradually, less birds were seen active (foraging and preening), but more were just swimming or alert. This shift was highly significant ($X^2=144.4$, df=8, $P<0.005$). There was also a clear change during the course of the day (Table 2b). Significantly less birds were foraging and swimming, but more were preening in the middle of the day, when compared to the morning and evening ($X^2=28.3$, df=8, $P<0.005$).

Behaviour also varied between the seven different ponds studied (Table 2c). Thirteen of the 21 possible combinations of the two ponds (61%) turned out to reveal significant differences in frequency of behavioural variables. The proportion of Coot foraging was relatively high on pond 5, but low on pond 1 and, especially, pond 6.

Weather variables also had a significant effect on Coot behaviour (Table 3). Increasing temperatures ($X^2=149.7$, df=8, $P<0.005$), rainy weather ($X^2=37.4$, df=8,

Table 3. Impact of weather and flock size on Coot behaviour.

		Foraging	Preening	Swimming	Alert	Aggression	n
a)	Temperature °C						
	−6 – −1	44.0	13.5	24.9	16.6	1.0	193
	0 – 10	51.3	6.7	39.0	2.0	1.0	957
	11 – 23	56.1	13.2	27.4	2.8	0.5	5042
b)	Cloudiness						
	Sunny	54.6	11.1	30.5	3.3	0.5	2143
	Partly clouded	53.5	11.8	31.3	2.9	0.7	3402
	Rainy	65.1	10.0	21.1	3.2	0.6	650
c)	Wind speed m/s						
	0	55.7	10.5	31.0	2.3	0.3	2663
	0–20	57.3	12.3	25.9	4.0	0.5	2728
	20–40	44.7	11.3	40.3	2.5	1.2	804
d)	Number of Coot						
	1	20.0	0.0	80.0	0.0	0.0	5
	2–50	44.8	10.0	40.3	4.0	0.8	2719
	51–100	60.9	11.6	23.7	3.5	0.3	1872
	More than 100	66.3	13.6	18.5	2.1	0.5	1579

$P<0.005$) and decreasing wind speed ($X^2=85.1$, df=8, $P<0.005$) caused an increase in the proportion of Coot seen foraging.

Finally, increasing flock size had a strong positive effect on the proportion of birds foraging and preening (Table 3d). This increase was highly significant ($X^2=352.4$, df=8, $P<0.005$), and probably resulted from foraging birds gathering to exploit profitable food patches.

Most of the variables considered were independent of each other. Only temperature and months were highly significantly correlated ($r_s=-0.66$, $P<0.001$), and time of the day and wind speed ($r_s=0.47$, $P<0.01$) and temperature and flock size ($r_s=0.42$, $P<0.01$) significantly.

As far as Tufted Duck and Pochard were concerned, fewer of these birds were seen foraging (respectively only 17.4% and 11.0% for n=2372 and 1572). This is a consequence of the ducks being more nocturnally active than the Coot (and they sometimes leave the ponds at night to forage elsewhere). They probably also need to forage less to fullfil their requirements. There was also no significant correlation between the proportions of Coot and diving ducks seen foraging on a pond (r=0.24 and −0.22 for Tufted Duck and Pochard). This, of course, limits the probability of interspecific encounters between the three species and hardly any were seen.

Foraging methods

Four different types of Coot foraging behaviour were distinguished. Of the sampled birds, 78% were pecking at the surface, 16% diving for food, 3% foraging with neck and head submerged and 3% with head only submerged (n=3160). It is clear that Coot largely prefer the less energy-demanding strategy of pecking at the surface.

However, there were highly significant differences between the application of different foraging methods for the three ponds for which most of the data were collected (Table 4a) ($X^2=20.4$, 20.4 and 24.5, respectively, df=3, $P<0.005$), the proportion of birds pecking at the surface varying between 48.0 and 88.5%. Including the (scattered) data from the other ponds a significantly positive correlation was indicated between the importance of the pond to Coot (average number present during the season) and the proportion of foraging birds pecking at the surface ($r=0.82$, df=4, $P<0.05$). This suggests that Coot tend to

Table 4. Variation in foraging methods of Coot.

		Pecking surface	Submersion of head	Submersion of head and neck	Diving	n
a)	Between ponds					
	Pond 3	48.3	6.3	10.0	35.4	39
	Pond 4	69.2	7.7	18.0	5.1	833
	Pond 5	88.5	1.3	1.1	9.1	2327
b)	Through the season					
	Aug/Sep	79.2	2.6	2.7	15.5	1723
	Oct/Nov	77.5	2.5	4.0	16.0	1379
	Dec/Jan	46.6	6.5	13.8	32.8	58
c)	According to weather					
	Cloudiness					
	Sunny	83.8	1.7	0.3	14.2	628
	Partly clouded	75.3	3.0	4.3	17.4	2125
	Rainy	82.6	2.1	4.2	11.1	380
	Wind speed m/s					
	0	77.4	2.6	2.9	17.0	1132
	0–20	83.2	1.4	2.6	12.7	1483
	20–40	56.8	7.8	9.3	26.1	345
d)	According to flock size					
	2–50	60.6	4.2	8.0	27.2	1009
	51–100	82.2	3.3	2.3	12.1	1104
	>100	90.0	0.4	0.3	9.4	1047

prefer ponds where the application of this (easier) foraging technique is possible.

There was a significant decrease in the proportion of birds pecking at the surface during the course of the season (Table 4b). This change was highly significant (X^2=34, df=6, P<0.005) and probably related to the depletion of the available surface food (mainly *Lemna*). *Lemna* was depleted rapidly during the second half of November, and before the beginning of December it had disappeared (data obtained at pond 5). There was, however, no significant change of behaviour as a function of temperature (X^2=5.2, df=6, P>0.1). But as temperature fell and the ponds froze, Coot tended to move on to the land to forage. Only 49 birds were scanned in this period, of which 55% were foraging on land and 10% was pecking at the surface of the ice.

Other weather variables did affect foraging behaviour significantly (X^2=54.0 and 117.3 for cloud and wind effects, respectively, P<0.005), although it was very difficult to see any systematic trend in the recorded values (Table 4c).

Foraging behaviour did not vary significantly during the course of the day (X^2= 5.2, df=6, P>0.1), but the proportion of birds pecking at the surface increased significantly with flock size (X^2=314.2, df=6, P<0.005) (Table 4d), again suggesting that birds tended to congregate in areas in which feeding through pecking at the surface is possible.

The average duration of Coot dives was 5.2 seconds (±0.24, S.D.; n=457). Dive duration increased significantly during the course of the season (Figure 1), indicating that the birds had to spend longer time underwater to find food. There was no significant correlation between the proportion of birds pecking at the surface and the average duration of a dive (r=0.41), suggesting that surface pecking is not performed when diving for food becomes less productive.

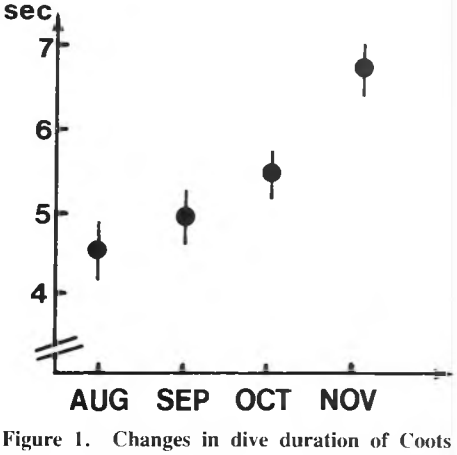

Figure 1. Changes in dive duration of Coots during the course of autumn (values are means ± S.E.).

Food

The stomach of the one (adult male) Coot collected on pond 5 contained almost exclusively *Lemna* leaves, which is in accordance with the abundance of *Lemna* there. Other vegetative matter found included remains of Poacea (mainly *Bromus*), *Trifolium*, *Ranunculus*, and a little *Potamogeton*. Diatomea and some vegetative detritus, but no Chlorophytae, were found.

Of the Coot collected on pond 7, 86% were males, all adults. Their weight averaged 738.5±1 g, wing length 76±1 cm, stomach volume 67±2 ml and weight of the stomach contents 2.7±0.1 g. All intestines contained a large number of parasites, either Cestodae or Acantocephalidae. Most birds were quite fat. Feathers and pieces of grit (the latter sometimes up to 0.8 cm long) were present in all stomachs.

Food items found in all the 17 stomachs from pond 7 were the Chlorophyta *Rhizoclonium hieroglyphicum* and *Enteromorpha intestinalis*, Diatomea *Melosira varians* and *Amphora ovalis*, along with detritus of leaves and needles. In more than half the stomachs were also found the Chlorophyta *Hydrodictyon reticulatum*, Diatomea *Synedra ulna* and *Cocconeis placentula*. Items found in less than half the stomachs were *Juncus* spp., *Phragmites*, *Poa* sp., *Lemna* sp., *Tilia* sp.; the Diatomea *Fragilaria construens*, *Amphora commutata* and *Gomphonema constrictum*; Trichoptera larvae, Corixidae, Hymenoptera and other Insecta; *Daphnia* sp., Gasteropoda and Annelida.

The birds fed mainly on algae (Chlorophytae and Diatomea) and in an apparently unselective way, as there was no difference between the proportional distribution of species in samples from individual stomachs and from the ponds (Diatomea: r_s=1, df=5, P<0.01). Animal and other plant material were found only occasionally.

Discussion

Our observations confirm that Coot tend to visit small ponds during at least part of the autumn migration, but may move to other areas when food resources are becoming depleted or unavailable. Depletion of food resources also seems to affect foraging behaviour, as easy-foraging strategies (such as surface pecking) become less successful, or the Coot have to search (dive) longer to obtain food. This may cause some of the Coot to move to other areas. Nearby, large numbers of Coot were present on large ponds (more than 50 ha) created by sand extraction. The maximum numbers there were reached at the end of December and in the beginning of January, much later than in the present study area (Draulans 1985). The Coot on the large ponds foraged mainly on adjacent grassland, and used the ponds mainly as a refugia.

The results of the food analyses confirm that local food availability is of particular importance in determining diet (Hurter 1972, 1979; Suter 1982), as Coot do not seem to be selective. It is questionable whether differences in profitability between the most commonly recorded items are large enough to make selectivity adaptive. The Coot seem to concentrate on ponds and also on locations within a pond with a high abundance of food (Holzinger 1972), or where foraging is easier (Poysa 1983). Coot are probably diurnally active because of the need to locate food items visually due to 1) small size of the items, 2) the need for highly efficient searching in view of the low energy content of each item, 3) poor diving capabilities.

Coot did not seem to compete with diving ducks. The latter tended to select different ponds and foraging areas, foraged proportionally less in the same periods of the day as the Coot, and almost exclusively dived to obtain their food. The three species can thus live in the same areas of a pond without aggressive encounters. Similar conclusions were reached by Poysa (1983) and Draulans (1985), but not by Suter (1982), who worked in a situation in which several species together depleted an abundant source of Zebra Mussels *Dreissena polymorpha*.

In conclusion, during the course of autumn migration Coot may attend small ponds where sufficient easy foraging opportunities are available, in this case large concentrations of plants (*Lemna* or algae). The depletion of such abundant food sources may 1) induce the Coot to switch to more energy-demanding foraging strategies (diving instead of surface-pecking or increased duration of submersion), or 2) force them to leave the area and visit other (larger) ponds where foraging is often on adjacent grassland. Competition with diving ducks did not seem to be important.

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Summary

The abundance of Coot *Fulica atra* on small fish ponds in Belgium increased from August to a maximum in October, after which a sharp decrease was recorded. Coot abundance varied between and within ponds, mainly related to foraging conditions. The proportion of birds foraging decreased during the course of the season and was affected by weather conditions. On two ponds, Coot fed mainly on algae and *Lemna*. The depletion of these resources forced the Coot to shift to more energy-demanding foraging strategies, probably inducing at least part of them to switch to other areas. There were no indications of competitive interactions with Tufted Duck and Pochard.

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