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IJPBS |Volume 2| Issue 4 |OCT-DEC |2012|123-133

Research Article
Biological Sciences

DIVING PATTERN OF LITTLE GREBE, COMMON COOT, LITTLE CORMORANT AND DARTER AT VADUVOOR LAKE, THANJAVUR, INDIA.

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ABSTRACT

Underwater activity of diving birds is a fascinating field for researchers in ornithology. Although some dives are made during courtship or to escape from predators, most are made to capture prey. Diving birds may be considered as central-place foragers which make repeated foraging excursions from the surface, to which they must return to breathe. Data collection on the diving patterns of little Grebe, Common Coot, Little Cormorant and Darter was conducted from August 1999 to February 2001 by following the procedure described by Lea et. al.(1996) at Vaduvoor Lake (10.4^{0}N; 79.19^{0}E) situated 21 km east of Thanjavur and 21 km west of Mannargudi. Totally 410 dives comprising of 54 bouts, 262 dives comprising of 46 bouts, 307 dives comprising of 47 bouts and 134 dives comprising of 37 bouts were recorded for Little Grebe, Little Cormorant, Common Coot and Darter respectively, and their diving behaviour was studied. The mean dive and surface times recorded for the four species differed indicating differences in their feeding strategies. The mean efficiency values were 0.57, 0.8, 0.8, 1.0 for the Little Grebe, Little Cormorant, Common Coot and the Darter respectively. Results of the present study showed that the diving patterns of the four species of divers differed significantly. This indicated that provision or maintenance of different depth levels at different regions of the lake is essential to fulfil the requirements of different waterbirds and thereby to increase the avian diversity of the lake.

KEYWORDS

Diving Pattern, Vaduvoor Lake, Diving Birds.

INTRODUCTION

Underwater activity of diving birds is a fascinating field for researchers in ornithology. Although some dives are made during courtship or to escape from predators, most are made to capture prey. Diving birds may be considered as central-place foragers (Orians & Pearson 1979; Lessels & Stephens 1983) which make repeated foraging excursions from the surface, to which they must return to breathe.

Cormorants are foot-propelled pursuit divers (Ashmole 1971). They typically forage by undertaking a series of dives from the water surface interspersed with brief recovery periods of surface pauses (Cooper 1986). The duration of dives is positively related to surface pauses or resting time (Casaux 2004). Cormorants belonging to the family Phalacrocoracidae are well adapted to dive in shallow waters (Wilson et al. 1992). The diving behaviour of cormorants is said to be influenced by environmental features (Frere et al. 2002) and it is reported that Red-legged Cormorants are able to forage by selecting the appropriate tidal condition to

minimize foraging effort (Gandini et al. 2005). The Little Cormorant *Phalacrocorax niger* is widely distributed throughout the Indian subcontinent (Ali 2002; Kumar et. al. 2005) on inland waters, and also in brackish lagoons and tidal creeks. The Darters are very like the Cormorants except that it is more individualistic, less gregarious and does not hunt in cooperative flocks.

Little Grebe a good swimmer and expert diver. Vanishes below the surface with astounding rapidity, leaving scarcely a ripple behind. When fired at with a shot gun, the bird has often dived before the charge can reach it. Normally sedentary, but is capable of flying strongly and for long distances on its diminutive wings when forced by drought to change its habitation. But Common coot are skitters along the water to take off, half running half flying; rises with much labour and pattering, but flies strongly when properly launched. The diving behaviour is said to be influenced by environmental features. These two are widely distributed throughout the Indian subcontinent on inland waters. Understanding the diving pattern of these expert divers would be helpful in identifying its role in the wetland ecosystem, currently threatened by growing developmental activities. The aim of this study was to generate information on the diving pattern of Little Grebe and Common Coot.

STUDY AREA

The observations were made at Vaduvoor Lake (10.4^0N; 79.19^0E) situated 21 km east of Thanjavur and 21 km west of Mannargudi. It is an important migratory waterbird habitat of Tamil Nadu, southern India. It has a water holding capacity of 38.88 million cubic feet. On the southern side of the lake is the road connecting Thanjavur and Mannargudi and on the other sides of the lake are bunds with *Acacia* plantations. The lake was declared as a bird sanctuary on 21.1.92 as it an attraction for a variety of birds such as Cormorants, Indian Darter, Painted Stork, Open bill Stork, White Ibis, Glossy Ibis, Spoonbill, Spot bill Duck, Red-crested Pochard, Cotton Teal, Common Coot, Grey Pelican, Black Winged Stilt and Little Tern. Based on the depth contour and on factors like pollution, vegetation and human interference three regions (A, B, C) were demarcated in the lake artificially by imaginatory boundaries for the present study. To have representative data, the regions A, B and C were further subdivided as above into three sub divisions each viz. A_1, A_2, A_3, B_1, B_2, B_3 and C_1, C_2 & C_3 respectively.

METHODS

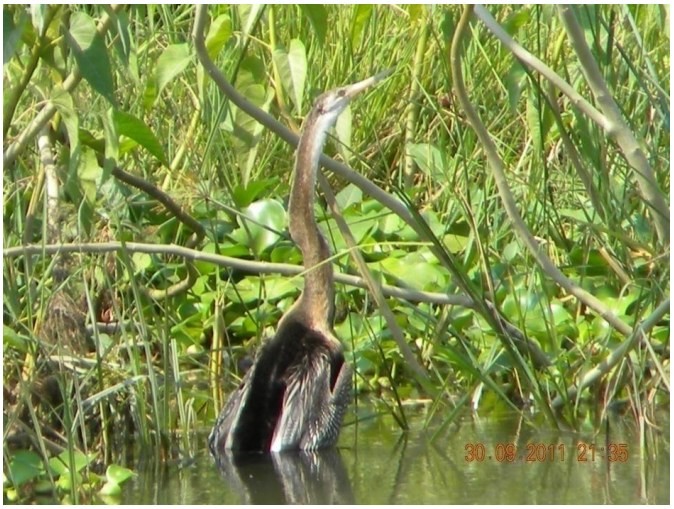
Data collection on the diving patterns of Little Grebe (**Fig. 1**), Common Coot (**Fig. 2**), Little Cormorant (**Fig. 3**) and Darter (**Fig. 4**) was conducted from August 1999 to February 2001 by following the procedure described by Lea *et. al.*(1996). Observations were made mostly by naked eyes, since during a dive, birds usually move out of the field view of binoculars. Binoculars were used for the identification of species and for observing diving at greater distances. Times of diving, preceding and following surface times of a dive were recorded to the nearest second by using an electronic stop watch. The place of dives water levels were recorded by inserting a pole which is marked in cm scale. A field assistant was always nearby during data collection to facilitate immediate spotting of the emerging bird and reduce error in time recordings. Surface times terminated by the bird flying off or disappearing from view were discarded as were surface times during which the bird interacted with another bird. Recording was abandoned whenever two birds started to feed close together.

Fig. 1: Little Grebe

Fig. 2: Common Coot

Fig. 3: Little Cormorant

Fig. 4: Darter



OBSERVATIONS & RESULTS

Totally 410 dives comprising of 54 bouts, 262 dives comprising of 46 bouts, 307 dives comprising of 47 bouts and 134 dives comprising of 37 bouts were recorded for Little Grebe, Little Cormorant, Common Coot and Darter respectively, and their diving behaviour was studied.

Diving Patterns

Mean bout values for various diving parameters for the four bird species had been given in the **Tables 1 to 5.**

Table. 1: Mean bout values for the diving parameters of the Little Grebe values are X ± 1 SD

Bout No	Mean dive time (S)	Mean Preceding surface time (S)	Mean next surface time (S)	Total surface time (S)	Mean Efficiency
1	19.9±4.04	17.4±8.23	17.4±8.24	31.4±13.28	0.8±0.62
2	19.6±4.06	19.0±3.95	11.8±6.63	35.8±7.49	0.6±0.22
3	18.4±2.07	22.0±2.92	18.4±10.45	40.4±9.96	0.5±0.26
4	18.6±4.86	18.3±3.44	16.3±6.28	34.6±6.79	0.6±0.17
5	16.6±5.41	19.6±3.82	17.1±8.40	36.7±9.43	0.5±0.11
6	17.5±6.36	20.1±1.41	18.5±0.71	38.5±2.12	0.5±0.14
7	18.0±3.73	20.3±4.92	18.0±7.58	38.3±11.06	0.6±0.38
8	19.7±4.41	17.7±5.33	15.2±6.49	32.9±9.48	0.7±0.33
9	15.6±19.93	19.0±3.16	15.4±9.15	34.4±6.35	0.5±0.19
10	17.7±6.20	19.8±4.45	17.2±9.33	37.0±12.15	0.5±0.21
11	17.8±3.61	19.1±4.07	17.0±7.20	36.1±9.53	0.6±0.34
12	14.7±3.21	18.7±1.53	12.3±10.79	31.0±9.54	0.5±0.25
13	20.0±4.54	17.9±3.45	16.1±6.32	34.0±7.27	0.6±0.33
14	15.7±3.55	21.6±3.26	19.0±8.85	40.6±8085	0.4±0.17
15	18.5±5.77	21.5±3.30	19.3±7.09	40.7±7.52	0.5±0.13
16	16.5±4.20	19.0±20.94	15.0±0.23	34.0±11.11	0.5±0.24
17	18.5±3.98	19.6±5.16	17.5±7.67	37.0±11.90	0.6±0.46
18	14.8±5.46	21.2±3.97	17.7±9.52	38.8±9.79	0.4±0.11
19	17.0±4.55	19.3±4.40	17.5±7.55	36.8±6.36	0.5±0.09
20	17.6±4.03	18.0±5.27	15.5±7.58	34.5±8.47	0.5±0.21

21	18.3±2.31	24.0±3.61	14.7±12.74	38.7±13.80	0.5±0.13
22	18.4±4.11	17.9±5.01	15.6±6.82	33.6±7.42	0.6±0.26
23	20.4±4.30	17.9±3.02	16.0±6.02	33.9±5.65	0.6±0.22
24	20.8±5.03	21.3±1.89	19.6±6.98	40.9±6.79	0.5±0.21
25	15.5±5.07	21.0±4.69	15.5±11.33	36.5±13.00	0.5±0.15
26	19.4±5.35	17.4±4.30	15.7±6.75	33.1±7.71	0.6±0.31
27	19.0±4.05	18.0±5.97	13.7±8.08	31.7±10.88	0.7±0.22
28	20.3±10.42	19.6±3.75	17.4±6.71	36.9±7.91	0.6±0.34
29	21.0±2.00	21.0±4.58	12.6±11.37	33.7±15.95	0.7±0.36
30	17.9±4.65	17.4±5.06	15.6±7.46	33.0±10.28	0.6±0.34
31	14.0±3.61	16.8±4.92	13.8±9.09	30.6±8.62	0.5±0.12
32	14.5±9.26	17.3±4.57	12.8±9.46	30.0±13.29	0.5±0.22
33	12.6±1.14	17.4±5.98	13.0±9.06	30.4±7.09	0.4±0.13
34	13.8±3.70	18.8±5.17	16.6±6.69	35.4±8.62	0.4±0.14
35	16.7±6.95	17.4±5.19	14.9±8.36	32.3±11.61	0.6±0.42
36	16.2±4.79	19.1±4.94	17.2±7.48	36.4±99.32	0.5±0.16
37	16.2±3.19	19.2±7.00	15.3±10.09	34.5±13.72	0.6±0.37
38	20.2±6.71	16.5±304	15.4±5.82	31.9±4.99	0.6±0.21
39	16.8±5.25	21.0±4.55	14.5±10.15	35.5±11.09	0.5±0.19
40	20.7±6.37	18.3±2.43	17.1±8.51	35.4±8.75	0.7±0.49
41	17.3±8.26	19.3±3.56	13.5±9.47	32.5±8.39	0.6±0.46
42	14.0±4.00	15.3±3.72	11.8±6.31	27.2±7.55	0.6±0.22
43	20.4±4.07	20.0±5.12	17.9±8.43	37.9±7.39	0.6±0.11
44	19.6±4.50	19.9±6.20	18.1±9.30	38.0±10.04	0.5±0.16
45	17.3±5.98	17.9±6.95	17.1±8.47	35.0±6.96	0.5±0.17
46	19.3±5.43	16.3±3.50	13.5±7.8	29.8±6.97	0.7±0.42
47	24.5±8.02	17.7±7.06	15.8±9.97	33.5±8.83	0.8±0.30
48	16.8±5.12	15.5±4.51	11.0±8.45	26.5±7.85	0.7±0.19
49	26.7±6.42	17.1±4.91	15.8±7.45	32.9±9.24	0.7±0.36
50	16.6±4.75	19.0±4.75	17.1±8.24	36.1±9.75	0.5±0.27
51	17.3±5.28	22.6±5.50	18.3±9.20	40.9±12.32	0.5±0.19
52	18.9±4.73	20.9±6.17	18.6±9.66	39.5±11.86	0.5±0.11
53	17.8±4.79	16.9±4.78	15.7±6.96	32.6±8.04	0.6±0.13
54	21.5±5.96	15.3±6.15	11.8±7.99	27.2±5.98	0.9±0.44

Efficiency = Dive Time/Total Surface Time

Table. 2: Mean bout values for the diving parameters of the Little Cormorant values are X ± 1 SD

Bout No	Mean dive time (S)	Mean Preceding surface time (S)	Mean next surface time (S)	Total surface time (S)	Mean Efficiency
1	19.7±9.86	20.7±6.34	16.9±9.37	37.6±11.47	0.6±0.31
2	17.3±13.80	20.3±15.89	10.3±16.20	30.7±28.5	2.3±3.24
3	19.5±7.05	24.7±9.25	17.5±14.62	42.3±10.87	0.5±0.05
4	21.1±8.84	18.8±9.87	14.5±9.68	33.3±14.61	0.7±0.42
5	23.5±8.35	17.5±5.92	11.5±8.66	29.0±11.46	1.1±1.00
6	20.3±7.24	17.5±9.78	15.4±11.11	32.9±11.23	0.8±0.57

7	22.6±7.37	16.8±6.87	14.3±9.30	31.1±10.14	0.8±0.48
8	19.4±4.28	15.6±5.46	11.0±7.11	26.6±11.15	0.8±0.23
9	17.8±6.90	17.5±3.70	12.8±9.22	30.3±10.90	0.7±0.32
10	10.7±2.31	16.0±6.24	9.0±9.00	25.0±6.24	0.5±0.20
11	12.8±8.62	18.3±9.60	12.8±12.58	31.0±15.03	0.6±0.54
12	20.2±8.44	15.2±7.76	13.4±9.25	28.7±8.82	0.8±0.50
13	18.8±3.77	14.8±3.77	11.3±8.38	26.0±10.30	0.9±0.71
14	17.4±8.72	15.7±8.10	14.0±10.05	29.7±11.67	0.8±0.90
15	20.6±10.92	11.0±3.67	9.0±6.20	20.0±4.80	1.0±0.57
16	24.0±6.98	15.0±3.16	10.3±7.04	25.3±8.26	1.1±0.80
17	22.8±8.26	5.2±4.32	11.6±7.64	26.8±4.38	0.9±0.38
18	18.3±4.79	17.6±8.26	15.0±10.58	32.6±12.97	0.6±0.24
19	23.9±5.63	17.9±7.56	16.2±9.46	34.1±9.75	0.8±0.38
20	15.0±4.24	19.5±3.54	11.0±15.60	30.5±12.02	0.6±0.38
21	16.0±3.74	11.5±5.07	9.8±7.68	21.3±9.74	1.0±0.70
22	19.2±7.79	17.3±5.07	15.7±7.71	33.0±7.11	0.6±0.32
23	22.8±7.09	16.4±4.67	12.2±7.85	28.6±6.39	0.8±0.30
24	22.4±5.53	18.4±6.04	17.4±8.17	35.9±10.22	0.7±0.37
25	17.7±7.09	18.0±7.00	9.7±9.07	27.7±9.07	0.6±0.36
26	18.1±8.97	9.7±8.92	16.7±11.56	36.4±15.69	0.7±0.63
27	15.0±9.14	16.2±8.81	14.6±11.10	30.8±12.01	0.5±0.41
28	15.8±7.54	18.0±5.98	16.8±8.43	34.8±10.28	0.6±0.66
29	17.3±7.23	14.3±9.87	7.3±10.21	21.7±18.5	2.7±3.71
30	21.7±8.10	15.4±7.55	14.4±8.88	29.8±11.75	0.9±0.49
31	15.6±6.19	21.6±6.83	17.6±11.95	39.2±11.63	0.5±0.32
32	19.3±4.68	19.0±7.39	17.0±10.30	36.0±9.73	0.5±0.09
33	21.2±5.21	19.0±6.86	17.2±9.35	36.2±12.85	0.7±0.34
34	24.3±9.07	24.3±6.03	18.3±16.07	42.7±12.05	0.6±0.31
35	19.8±7.86	16.5±7.23	12.5±8.73	29.0±12.38	0.8±0.41
36	20.1±8.16	17.3±9.29	13.0±10.43	30.3±13.53	0.8±0.66
37	20.0±7.07	17.8±2.59	14.2±8.35	32.0±9.03	0.7±0.37
38	22.1±7.37	16.4±7.06	13.5±7.26	29.9±10.00	0.9±0.53
39	17.3±9.74	12.2±2.22	9.0±6.38	21.3±5.38	0.9±0.49
40	20.7±8.50	17.3±10.07	8.0±8.00	25.3±18.00	1.0±0.56
41	22.3±5.28	20.7±7.15	15.7±9.44	36.3±9.40	0.6±0.16
42	21.0±6.00	16.9±6.67	14.1±9.08	31.0±12.19	0.9±0.86
43	16.0±4.24	19.0±2.83	16.0±7.07	35.0±4.24	0.5±0.07
44	16.7±7.54	17.0±8.35	14.0±10.23	31.0±11.70	0.8±0.07
45	18.7±6.11	15.3±9.07	8.0±9.85	23.3±18.00	1.3±1.00
46	22.5±7.72	19.5±9.15	15.3±13.57	34.8±11.70	0.7±0.30

Efficiency = Dive Time/Total Surface Time

Table. 3: Mean bout values for the diving parameters of the Common Coot values are X ± 1 SD

Bout No	Mean dive time (S)	Mean Preceding surface time (S)	Mean next surface time (S)	Total surface time (S)	Mean Efficiency
1	21.5±9.48	29.8±23.87	17.0±10.26	46.8±27.5	0.8±0.87
2	20.0±18.40	29.5±0.70	15.5±9.10	45.0±19.8	0.4±0.24
3	24.0±7.07	28.5±0.70	14.0±9.80	42.2±20.5	0.6±0.12
4	20.0±9.41	18.8±9.87	14.5±9.68	33.3±14.61	0.7±0.33
5	23.5±8.35	17.5±5.92	11.5±8.66	29.0±11.46	1.1±1.00
6	20.4±7.50	15.6±9.91	11.4±11.39	27.0±12.53	1.0±0.76
7	24.9±10.30	24.0±17.05	22.4±18.48	46.4±28.61	0.6±0.35
8	20.7±0.57	18.7±4.51	11.0±9.85	29.7±14.29	0.9±0.55
9	26.8±14.07	28.6±15.00	27.8±16.36	56.5±24.32	0.6±0.39
10	11.7±3.51	16.0±6.24	9.0±9.00	25.0±6.24	0.5±0.29
11	12.8±8.62	18.3±9.60	12.8±12.58	31.0±15.03	0.6±0.54
12	19.0±8.54	16.0±7.94	13.7±9.98	29.7±7.61	0.7±0.49
13	17.7±3.79	16.0±3.46	11.3±10.26	27.3±7.02	0.7±0.08
14	17.9±7.09	15.4±6.62	14.1±8.09	29.5±9.41	0.8±0.71
15	22.0±8.21	15.7±8.05	14.8±9.24	30.6±11.43	0.8±0.41
16	23.6±10.67	30.0±2.35	18.6±16.24	48.6±14.84	0.5±0.26
17	18.9±8.92	17.0±7.76	13.7±7.92	30.7±8.75	0.8±0.62
18	21.8±6.92	17.1±8.66	13.4±9.35	30.5±11.50	0.9±0.61
19	18.7±9.71	21.0±5.57	12.3±11.24	33.3±16.80	0.8±0.86
20	19.2±7.67	17.8±7.41	17.6±7.89	35.4±8.64	0.5±0.25
21	20.0±1.41	13.5±10.61	3.0±4.24	16.5±14.8	2.1±1.98
22	22.2±7.73	15.1±5.94	13.4±7.30	28.5±5.92	0.8±0.33
23	20.5±12.02	12.0±5.66	4.0±5.66	16.0±11.31	1.4±0.21
24	21.3±8.84	24.8±8.45	17.9±12.02	42.7±15.49	0.5±0.20
25	20.0±9.72	16.4±5.37	13.0±9.02	29.4±6.77	0.7±0.36
26	23.6±6.80	15.2±7.48	15.8±7.48	31.0±10.99	0.9±0.57
27	23.7±8.20	16.9±6.87	14.3±9.30	31.1±10.14	0.9±0.47
28	24.8±11.72	31.3±19.85	29.3±22.6	60.7±33.20	0.5±0.31
29	26.8±14.83	23.3±12.53	21.9±14.33	45.2±21.99	0.7±0.38
30	23.5±12.02	17.0±0.00	8.5±12.02	25.5±12.02	0.9±0.04
31	22.2±8.33	14.0±6.84	13.0±8.19	27.0±11.58	1.3±1.50
32	19.3±7.42	20.8±6.79	17.8±10.98	38.7±10.35	0.5±0.12
33	25.7±9.15	24.1±17.62	23.0±18.83	47.1±30.68	0.7±0.45
34	29.5±17.48	14.5±5.45	12.3±9.11	26.8±10.63	1.5±1.59
35	28.2±10.82	17.7±6.1	16.8±11.13	34.5±13.16	0.9±.052
36	18.5±7.79	14.5±6.89	12.8±9.06	27.3±7.63	0.7±0.37
37	23.3±8.37	21.2±10.66	17.7±12.25	38.9±13.09	0.7±0.32
38	18.5±16.66	18.8±10.59	11.3±10.59	30.0±9.97	0.8±0.76
39	35.9±28.1	40.6±22.52	33.7±26.80	74.3±30.10	0.5±0.27
40	37.3±13.60	35.4±14.98	31.4±19.06	66.9±3.080	0.7±0.38
41	40.9±28.89	26.9±12.03	23.6±11.32	50.5±16.90	0.8±0.49
42	26.7±5.51	21.7±7.23	9.3±8.62	31.0±3.61	0.9±0.22

43	18.1±9.42	21.6±12.79	17.4±14.56	39.0±16.79	0.5±0.28
44	37.4±27.40	32.1±17.54	29.7±20.85	61.9±16.99	0.6±0.20
45	64.8±28.80	29.0±8.80	23.0±15.57	52.0±6.89	1.2±0.47
46	59.8±25.18	27.0±13.72	26.3±14.97	53.3±18.21	1.3±0.76
47	85.0±11.27	22.0±14.73	15.7±19.90	37.7±25.30	4.5±4.99

Efficiency = Dive Time/Total Surface Time

Table. 4: Mean bout values for the diving parameters of the Darter values are X ± 1 SD

Bout No	Mean dive time (S)	Mean Preceding surface time (S)	Mean next surface time (S)	Total surface time (S)	Mean Efficiency
1	38.0±36.80	33.5±7.78	14.0±19.80	47.5±27.60	0.7±0.37
2	57.0±35.40	39.0±4.24	18.0±25.50	57.0±29.70	0.3±1.32
3	59.0±33.10	28.0±12.49	20.0±21.10	48.0±26.20	2.1±2.44
4	55.7±22.50	33.3±8.08	24.7±21.90	58.0±16.00	0.9±0.13
5	55.3±16.65	33.3±12.01	22.0±22.50	55.3±30.40	1.6±1.12
6	52.3±25.7	38.0±8.72	23.3±21.40	61.3±16.77	0.8±0.24
7	61.0±12.36	32.0±7.79	22.1±12.36	32.0±15.23	1.9±0.22
8	91.0±7.07	32.0±22.60	24.0±33.90	56.0±11.31	1.6±0.21
9	48.7±36.00	33.5±13.50	21.5±17.16	55.0±22.2	0.9±0.47
10	54.4±31.00	28.6±16.94	25.0±21.14	53.6±22.80	1.1±0.61
11	26.0±2.83	24.5±16.30	6.5±9.19	31.0±25.50	1.2±0.90
12	47.0±45.00	58.0±16.37	43.3±39.10	101.3±27.20	0.5±0.46
13	39.0±15.08	39.0±14.98	33.9±21.11	72.9±26.80	0.6±0.24
14	36.0±16.81	28.6±12.30	23.0±17.79	51.6±7.70	0.7±0.29
15	54.8±30.80	27.0±10.89	17.0±13.11	44.0±22.80	1.7±1.03
16	71.0±13.25	12.0±1.23	15.8±12.66	12.0±2.56	1.9±0.21
17	68.7±26.60	35.7±5.51	22.0±19.30	57.7±24.6	1.5±1.21
18	73.3±15.04	24.3±6.11	16.7±15.63	41.0±19.20	1.4±1.98
19	57.4±31.2	27.0±16.22	18.6±17.34	45.6±5.03	1.3±0.79
20	30.0±2.83	42.5±6.36	23.5±33.20	66.0±26.90	0.5±0.15
21	58.7±21.20	19.7±8.62	13.7±14.57	33.3±6.66	1.7±0.48
22	84.0±10.44	30. ±9.85	19.0±19.00	49.0±9.85	1.8±0.57
23	74.5±24.70	23.0±9.80	47.0±14.10	70.0±33.90	1.3±0.98
24	26.0±1.35	48.0±2.36	12.3±9.65	48.0±12.36	0.5±0.32
25	47.7±37.10	39.3±41.60	37.3±44.10	76.7±45.00	0.6±0.29
26	32.0±19.80	42.0±14.10	26.0±36.80	68.0±22.60	0.5±0.47
27	29.3±13.79	35.7±15.96	32.2±21.25	67.8±25.40	0.5±0.24
28	40.6±26.90	26.6±13.01	17.0±10.79	43.6±19.32	1.2±1.03
29	38.0±41.30	37.3±18.57	24.7±23.30	62.0±16.27	0.8±1.02
30	19.2±12.22	39.5±19.62	30.2±23.20	69.7±33.60	0.4±0.35
31	34.6±22.75	54.6±25.12	52.1±29.80	106.7±37.60	0.3±0.19
32	55.0±25.90	24.3±3.51	16.3±14.57	40.7±17.10	1.8±1.62
33	40.6±25.55	63.1±33.20	56.7±40.80	119.9±57.70	0.5±0.56
34	64.0±33.70	54.3±16.09	59.7±22.90	114.0±28.90	0.6±0.27
35	28.0±34.80	66.0±33.00	48.8±41.40	114.8±63.50	0.3±0.38

36	32.0±15.39	28.3±9.81	17.0±17.00	45.3±26.00	1.0±0.68
37	32.4±20.11	60.6±14.82	52.6±27.40	113.2±20.10	0.3±0.21

Efficiency = Dive Time/Total Surface Time

Table. 5: Comparison of diving patterns of four diving bird species at the Vaduvoor Lake.

S.No.	Parameter	Bird Species	F	P			
		Little Grebe	Little Cormorant	Common Coot	Darter		
		(n=410)	(n=262)	(n=307)	(n=307)		
1	Diving time	18.2±5.27	19.7±7.30	26.2±16.98	46.4±27.45	150.17	0.00
2	Preceding surface time	18.8±4.74	17.4±7.10	21.6±12.50	38.9±20.79	138.45	0.00
3	Next surface time	16.3±7.65	14.03±9.16	18.1±13.84	30.1±26.41	46.94	0.00
4	Total surface time	35.0±9.13	31.4±11.40	39.7±20.45	68.1±37.68	136.37	0.00
5	Efficiency	0.57±0.28	0.8±0.71	0.8±0.79	1.0±0.96	15.68	0.00

Little Grebe

For Little Grebe, the mean dive time/bout varied between 12.6s and 26.7s, the mean preceding surface time/bout between 15.3s and 24.0s, mean next surface time/bout between 11.0s and 19.6s, total surface time/bout between 26.5s and 40.9s and efficiency between 0.4s and 0.9s (**Table 1**)

Little Cormorant

In the Little Cormorant, the mean dive time/bout varied between 10.7s and 24.3s, mean preceding surface time/bout between 5.2s and 24.7s, mean next surface time/bout between 7.3s and 18.3s, mean total surface time/bout between 20.0s and 42.7s and the mean efficiency values/bout between 0.5s and 2.7s (**Table 2**).

Common Coot

With regard to Common Coot, the mean dive time/bout varied between 11.7s and 85.0s, mean preceding surface time/bout between 12.0s and 40.6s, mean next surface time/bout between 3.0s and 33.7s, mean total surface time/bout between 16.0s and 74.3s and mean efficiency/bout between 0.4s and 4.5s (**Table 3**)

Darter

In Darter, the mean dive time/bout varied between 19.2s and 91.0s, mean preceding surface time/bout between 12.0s and 66.0s, mean next surface time/bout between 6.5s and 59.7s, mean total surface time/bout between 12.0s and 119.9s and the mean efficiency values/bout between 0.3s and 2.1s (**Table 4**).

DISCUSSION

Dive and Surface time

The mean dive and surface times recorded for the four species differed (**Table 5**) indicating differences in their feeding strategies. The values obtained for the Little Cormorants viz. 10.7s and 24.3s for dive and total surface times, respectively, were quite different to the ones reported for Cormorants by Lalas (1983), Cooper (1986) and Lea et al. (1996), the essential difference being the surface time under European condition was very low (around 7s) while the dive times was more or less similar i.e., (around 20s). This concurred with the views of

Wilson and Wilson (1988) that mean dive times vary so much with the foraging environment that they cannot be taken as characteristic of a species. However, comparison of the data collected in the present study with earlier reports showed that the diving patterns of bird species under the tropical conditions could be of different type, and this aspects warrants further detailed research.

Dive Efficiency

The mean efficiency values were 0.57, 0.8, 0.8, and 1.0 for the Little Grebe, Little Cormorant, Common Coot and the Darter respectively (Table 5). These values were very low when compared to earlier reports (Dewar 1924, Cooper 1986, Lea et. al. 1996). Dewar (1924) suggested 2.8 as typical for the genus *Phalacrocorax.* Efficiency was found to increase with dive time in all the four species. Since dive time increases with depth, this result is consistent with Kramer's conclusions that efficiency should increase with depth. But it is inconsistent with Wanless et. al's. (1993a) observation of decreasing efficiency with increasing dive time in the Shag. It may also be that efficiency first increases with depth and subsequently decreases, a pattern suggested as a generalization suggested by Dewar (1924) and reported for the Little Shag by Stonehouse (1967). On the contrary Wilson and Wilson (1988) argued that the notion of diving efficiency is unhelpful because it depends on the assumption of a linear relationship (indeed, a linear relationship with zero intercept) between surface time and dive time.

Significance of diving patterns

Results of the present study showed that the diving patterns of the four species of divers differed significantly (**Table 5**). This indicated that provision or maintenance of different depth levels at different regions of the lake is essential to fulfil the requirements of different waterbirds and thereby to increase the avian diversity of the lake.

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