

Study of morphometric biology of cotton Pygmy-Goose *Nettapus coromandelianus coromandelianus* Gmelin

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ABSTRACT:

Morphometric of Cotton Pygmy-goose, *Nettapus coromandelianus coromandelianus* was studied during 2006 to 2008. The males are comparatively bigger in size than the females. The average weight was found to be 226.50 gm and 219.50 gm for male and female respectively. The primary (wing) feather arrangement in male was found to be P1 < P11 < P10 < P9 < P8 < P7 < P2 < P6 < P5 < P3 < P4. The females have a more or less similar arrangement except the P2 and P6 where P6 < P2. The mean length of the middle toe in male was found to be 34.32±0.194 mm; where as in female the same remains 0.5 mm shorter (±0.163). The wing expansion was ranged between 424 mm to 426 mm in both male and female, but with slight variation in mean value (male- 425.17±0.753 mm; female- 425.53±0.816 mm). Since no morphometric studies has been done so far on this species, the present paper was hypothesized to the study of morphometric variation in various aspects of Cotton Pygmy-goose indicating the relation of wings, hind-limbs, head neck, beak, tarsus, different types of toes and tail in respect to the habitat utilization and ecology of the wetland.

Keywords:

Eco-morphology, middle toe, tarsus and wing expansion.

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INTRODUCTION

Avian morphology was a major focus of interest within avian biology during the last century and the first decades of this century. The study of morphology provides the data to understand the evolutionary as well as ecological questions. Though the morphology of various birds including the anatid have been studied by various ornithologists the morphology of the Cotton Pygmy-goose, *Nettapus coromandelianus* Gmelin still awaiting a detailed study. This species is very poorly described for which it was considered as bird of Least Concern (Birdlife International 2004). Though there is no extensive research have been done so far in this bird, the works of Ali and Ripley (1983), Whistler (1986) and Ali (2002) are quite remarkable in this regard. More importantly, theoretical analyses of questions relating to evolutionary morphology were published during the 1950's. These includes the study on pre-adaptation (Bock 1959), and adaptation (Bock and von Wahlert 1965, Bock 1980). There lies a seasonal variation in weight, body measurements and condition of free-living Teal (Fox et al. 1992). Ecologists were analyzing a series of questions on the concept of the niche, habitat partition, community structure, diversity within the taxa etc., and uses simple morphological measures as tools.

The *N. c. coromandelianus* Gmelin is the smallest of our wild ducks (Anon. 1965) with a length of about 13-inches (Ali 2002, Whistler 1986). The breeding male has a blackish brown crown and back face, neck and under parts white, with prominent black collar round base of the neck, and white wing-bar (Ali and Ripley 1983). The male has broad white band across the wings (Grimmett et.al. 1999) but during winter it loses its collar and resembles the female except for the white wing bar and some of the green gloss on the upper plumage and wings. The female don't have a colorful body. The females have a brown top of the head and a line through the eye, the rest of the head and neck being speckled with the brown marks. Upper parts of the body wings and tail are brown in color (Whistler 1986). The present paper deals with the study of morphometric variation in various aspects of Cotton Pygmy-geese viz. wings, hindlimbs, head, toes, neck, beak or bill, tail, etc. and correlation between different parameters in male and female so as to explore its relation with the wetland environment.

The non-protected areas of Sonitpur district of Assam (India) were selected for the morphometric study of Cotton Pygmy-goose. The Sonitpur District of Assam, with an area of about 5,25,520 hectares, is located in between $93^{\circ}2'80''$ E to $93^{\circ}57'1''$ E longitude and $26^{\circ}22'1''$ N to $26^{\circ}42'2''$ N latitude. The district is bounded by Hawajan tributary in the east, Pachnoi tributary in the west, the mighty river Brahmaputra in the south and the state Arunachal Pradesh (previously North Eastern Frontier Area or NEFA) in the north. Physio-graphically, major parts of the district are plain area with a number of tributaries like Pachnoi, Mora-Bhoroli, Jia-Bhoroli, Ghiladhari, Buriganga, Borgang, Buroi, and Satrang arose from the hills of Arunachal Pradesh and joins with the river Brahmaputra. Physically, a massive part of its area is covered with evergreen and semi-evergreen type of forests accounting about 20.52% of its area.

METHODOLOGY

The morphometric of *Nettapus c. coromandelianus* Gmelin was studied as per methods explained by Bibby et al. (1992) and Balachandran (2002). The birds were collected from different parts of the Sonitpur district. Only living or naturally died birds were selected for the study. Living birds were released after observation. The body temperature was recorded with the help of a Centigrade thermometer from the living birds at the field. The body weight was measured with the help of a spring balance (capacity 500 gm). The body length, wing length and wing expansion were measured with the help of a meter scale (least count 0.1 mm). The length of bill, neck, tarsus, middle toe, wing feathers and rectrices were measured with the help of a pointer and slide calipers (0.001 mm accuracy).

The data so obtained were arranged and mean, standard deviation and co-efficient of correlation (Relief 1965) were calculated to detect the relationship amongst various aspects of their body parts using computer software package MS-excel.

RESULTS

a. Body weight (BoW)

The mean BoW (irrespective of sex) of the Cotton Pygmy-goose was found to be $224.1 \text{ gm} \pm 13.5\text{SD}$ (range = 180.65 to 260.0 gm, n =42, Table 5.1, Figure 5.1). The mean BoW of male goose was estimated to $221.2 \text{ gm} \pm 16.4\text{SD}$ (range = 180.65 to 260.0 gm, n =27), whereas in female the

Table 1. Morphometric variation in male and female Cotton Pygmy-goose (n =42)

Parameters	Range (male)	Mean \pm SD	Range (female)	Mean \pm SD
1. BoW (gm)	180.6* - 260.0	221.2 \pm 16.4	215.5 - 236.34	227.0 \pm 6.9
2. BoL (mm)BT to TT	332.9 - 336.5	335.3 \pm 1.1	350.6 - 353.4	351.5 \pm 1.7
3. BoL (mm) N to A	143.3-147.0	145.7 \pm 1.1	162.0 - 165.0	163.5 \pm 1.2
4. NL (mm)	42.0 - 43.5	42.6 \pm 0.4	40.0 - 42.1	41.4 \pm 0.7
5. NC (mm)	86.7 - 87.2	87.0 \pm 0.2	86.5 - 87.0	86.8 \pm 0.2
6. BL (mm) BT to F	26.2 - 26.9	26.6 \pm 0.2	26.2 - 26.8	26.5 \pm 0.2
7. BL (mm) BT to FC	22.4 - 23.2	22.8 \pm 0.3	22.3 - 22.9	22.7 \pm 0.3
8. BD (mm)	15.1 - 15.6	15.4 \pm 0.2	15.1 - 15.4	15.3 \pm 0.1
9. BW (mm)	12.0 - 12.7	12.3 \pm 0.2	11.5 - 12.0	11.8 \pm 0.2
10. HC (mm)	93.6 - 94.2	93.9 \pm 0.2	92.7 - 93.2	92.9 \pm 0.2
11. TL (mm)	28.9 - 29.3	29.1 \pm 0.1	28.9 - 29.2	29.1 \pm 0.1
12. HTL (mm)	8.0 - 8.3	8.2 \pm 0.1	7.9 - 8.2	8.1 \pm 0.1
13. ITL (mm)	31.4 - 32.0	31.8 \pm 0.2	31.5 - 31.8	31.6 \pm 0.1
14. MTL (mm)	34.0 - 34.5	34.3 \pm 0.2	34.1 - 34.5	34.3 \pm 0.2
15. OTL (mm)	33.0 - 33.5	33.3 \pm 0.2	33.0 - 33.5	33.3 \pm 0.2
16. IWD (mm)	19.9- 20.6	20.2 \pm 0.2	19.0 - 20.6	20.2 \pm 0.2
17. OWD (mm)	16.2 - 16.8	16.5 \pm 0.3	16.2 - 16.8	16.4 \pm 0.2
18. WS (mm)	424.0 - 426.0	425.3 \pm 0.7	424.0 - 426.0	425.3 \pm 0.7
19. WL (mm)	168.0 - 171.0	169.3 \pm 0.9	168.0 - 171.0	169.1 \pm 0.9
20. PWF (mm)	107.1 - 107.3	107.2 \pm 0.07	101.1 -101.4	101.2 \pm 0.1
21. SWF (mm)	85.5 - 85.6	85.6 \pm 0.06	80.6 - 80.7	80.7 \pm 0.05
22. SFL (mm)	41.9 - 42.6	42.2 \pm 0.3	41.7 - 42.1	41.9 \pm 0.1
23. TaL (mm)	63.4 - 64.7	64.03 \pm 0.5	64.1 - 64.8	64.53 \pm 0.2
24. TFL (mm)	73.36 - 73.46	73.42 \pm 0.04	74.9 - 75.06	75.01 \pm 0.1

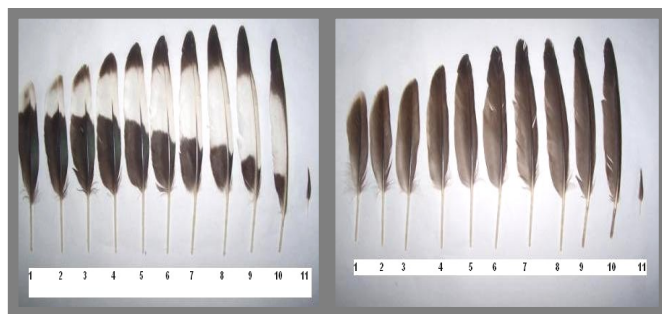
*Found after three days captivity in a poacher's resident (see text for explanation)

same found to be 227.0 gm \pm 6.8SD (range= 215.5 to 236.34 gm, n =15). A greater BoW (in either sex) was found during the monsoon season with a mean of 225.6 gm \pm 20.4SD (male: mean 222.1 gm \pm 22.2SD, range =180.65 to 260.0 gm, n =13; female: mean 229.08 gm \pm 18.6SD, range =221.7 to 234.5 gm, n =6).

b. Body length (BoL)

The mean BoL (BT to TT) of Cotton Pygmy-goose, irrespective of sex was 335.3 mm \pm 1.1SD (range =332.9 to 353.4 mm, n =42, Table 5.1, Figure 5.1). In male goose, the mean BoL (BT to TT) measured was 335.3 mm \pm 1.1SD (range

=332.9 to 336.5 mm, n =27), whereas the mean BoL (BT to TT) measured in female was 351.5 \pm 1.6 mm (range =350.6 to 353.4 mm, n =15). Seasonal variation was observed in BoL (BT to TT) of goose during the study period. In winter season, a greater mean BoL (BT to TT) was observed in female with 351.2 mm \pm 1.5SD (range =348.8 to 353.2 mm, n =9) than the male with a mean BoL (BT to TT) of 334.8 mm \pm 1.2SD (range =332.7 to 336.1 mm, n =14), while the case is reversed during monsoon (Female, mean: 351.8 mm \pm 1.7SD, range: 349.1 to 353.4 mm, n =6; Male, mean: 335.8 mm \pm 0.7SD, range: 333.9 to 336.5 mm, n =13). The mean BoL (N to A) of the goose was found to be 154.7 mm \pm 1.1SD (range =143.5 to 165.0 mm, n =42, Table 5.1, Figure 5.1) irrespective of sex and seasons. The mean BoL (N to A) was found higher in female with a mean length 163.6 mm \pm 1.2SD (range =162.0 to 165.0 mm; n =15) than the male which has a mean BoL (N to A) of 145.7 mm \pm 1.1SD, n =27) irrespective of the seasons (Table 5.1). The male and females were found with a greater BoL (N to A) during monsoon than the winter (male monsoon: mean BoL 146.0 mm \pm 1.1SD, range =143.3 to 147.0 mm, n =13; winter: mean BoL



(a)

(b)

Plate 1 Primary wing feathers of (a) male & (b) female CPG (from inner to outer)

145.4 mm \pm 0.9SD, n =14; female winter: 163.5 mm \pm 1.3SD, n =9 & monsoon: 163.9 mm \pm 1.1SD, range =162.7 to 165.0 mm, n =6).

c. Bill length (BL)

The mean BL (BT to F) of the Cotton Pygmy-goose was found to be 26.5 mm \pm 0.2SD (range =26.2 to 26.9 mm, n =42, Table 5.1, Figure 5.1) and BL (BT to F) between 22.3 mm to 23.2 mm (mean 22.7 mm \pm 0.3SD, n =12) with $p > 0.05$ (Students' t-test) in both the cases irrespective of sex and seasons of a year. The male goose was of greater BL (BT to F) than the females with mean length 26.6 mm \pm 0.2SD (range 26.2 to 26.9 mm, n =27) and 26.5 mm \pm 0.2SD (range 26.2 to 26.8 mm, n =15) respectively. The BL (BT to F) of the goose was found longer during monsoon with a mean length of 26.6 mm \pm 0.2SD (range =26.2 to 26.9 mm, n=19) than the winter period with a mean of 26.5 mm \pm 0.2SD (range =26.2 to 26.9 mm, n =23). No major differences were observed in the BL (BT to F) between the male and female during winter season (male: mean =26.5 mm \pm 0.2SD, range =26.2 to 26.9 mm, n =14; female: mean =26.5 mm \pm 0.2SD, range =26.2 to 26.8 mm, n =9). The mean BL (BT to FC) of the goose was found to be 22.8 mm \pm 0.2SD (range =22.3 to 23.2 mm, n =42). The BL (BT to FC) in case of the male goose was found greater with a mean 22.8 mm \pm 0.3SD (range =22.4 to 23.2 mm; n =27), than the females where the mean BL (BT to FC) was 22.6 mm \pm 0.2SD (range =22.3 to 22.9 mm, n =15, Table 5.1). The Cotton Pygmy-goose, during the monsoon were found with greater BL (BT to FC) than the goose observed during the winter (monsoon: mean 22.8 mm \pm 0.9SD, range =22.4 to 23.2 mm, n =19; winter: mean 22.7 mm \pm 0.3SD, range =22.3 to 23.2 mm, n =23). Again, the monsoon male were found to have greater BL (BT to FC) than the monsoon females (male: range 22.4 to 23.2 mm, mean 22.9 mm \pm 0.4SD; female: range 22.3 to 22.9 mm, mean 22.6 mm \pm 0.2SD).

d. Bill depth (BD)

In Cotton Pygmy-goose, the mean BD was found to be 15.4 mm \pm 0.1SD (range =15.1 to 15.6 mm, n =42, Table 5.1, Figure 5.1). The male goose has longer BD with a mean 15.4 mm \pm 0.2SD (range =15.1 to 15.6 mm, n =27), than the females who has a mean BD of 15.3 mm \pm 0.1SD (range =15.1 to 15.4 mm, n =15). During winter, the male goose has a mean BD of 15.4 mm \pm 0.2SD (range =15.1 to 15.6 mm; n =14), whereas the female has a mean BD of 15.3 mm \pm 0.1SD (range: 15.1 to 15.4 mm; n =9). The BD found slightly greater in male than the

female (male: mean 15.4 mm \pm 0.2SD, n =13; female: mean 15.3mm \pm 0.1SD, n =21) during the monsoon season of a year.

e. Bill width (BW)

The overall mean BW (at culmen) in Cotton Pygmy-goose was found to be 12.03 mm \pm 0.2SD (range 11.5 to 12.7 mm, n = 42, Table 5.1, Figure 5.1). The BW of the male goose was found to be 12.3 mm \pm 0.2SD (range =12.0 to 12.7 mm, n =27), whereas in females the same found to be 11.8 mm \pm 0.2SD (range =11.5 to 12.0 mm, n =15). The BW (at culmen) in case of male goose during monsoon was found to be 12.3 mm \pm 0.2SD (range =12.0 to 12.5 mm; n =13), whereas the mean BW remains at 12.4 mm \pm 0.3SD (range =12.0 to 12.6 mm; n =14). Again the mean BD of female goose during monsoon was found to be 11.4 mm \pm 0.2SD (range =11.4 to 11.9 mm, n =6) and during winter it remains at 11.8 mm \pm 0.2SD (range =11.5 to 12.0 mm, n =9).

f. Head circumference (HC)

The mean HC of Cotton Pygmy-goose was found to be 93.5 mm \pm 0.1SD (range =92.7 to 94.2 mm, n =42, Table 5.1, Figure 5.1). The mean HC of male goose was 93.9 mm \pm 0.2SD (range =93.6 to 94.2 mm, n =27) and of female goose was 92.9 mm \pm 0.2SD (range =92.7 to 93.2 mm, n =15) irrespective of seasons of a year. The HC was found greater during the monsoon season (93.5 mm \pm 0.2SD, n =19) than during the winter season (93.4 mm \pm 0.2SD, n =23) irrespective of the sex. During the monsoon the male goose has a greater HC with a mean of 93.9 mm \pm 0.2SD (range =93.6 to 94.2 mm, n=13) than the female goose of the same season which has a mean HC of 93.0 mm \pm 0.2SD (range =92.7 to 93.2 mm, n =6).

g. Neck length (NL)

The mean NL of the Cotton Pygmy-goose was found to be 42.1 mm \pm 0.6SD (range =40.0 to 43.5 mm, n =42, Table 5.1, Figure 5.1) irrespective of sex and seasons of a year. The mean NL measured in male Cotton Pygmy-goose was 42.6 mm \pm 0.4SD (range= 42.0 to 43.5 mm, n =27), whereas in female goose the mean NL found was 41.4 mm \pm 0.7SD (range =40.0 to 42.1 mm, n =15). During the winter season, the mean NL of the male was found to be 42.6 mm \pm 0.4SD (range =42.0 to 43.2 mm, n =14), whereas the female has a mean NL of 41.3 mm \pm 0.7SD (range =40.0 to 42.1 mm, n =9). The female has mean NL of 41.8 mm \pm 0.7SD (range =40.5 to 42.1 mm, n =6), the male goose during monsoon has a mean NL of 42.7 mm \pm 0.5SD (range = 42.0 to 43.5 mm, n =13).

h. Neck circumference (NC)

The mean NC of Cotton Pygmy-goose was found to be 86.9 mm \pm 0.2SD (range =86.5 to 87.2 mm, n =42, Table 5.1, Figure 5.1) irrespective of sex and seasons of a year. The NC was slightly of greater value in male goose with a mean of 87.0 mm \pm 0.2SD (range =86.7 to 87.2 mm, n =27) than the female with a mean value of 86.8 mm \pm 0.2SD (range = 86.5 to 87.0 mm; n =15). During monsoon season, the male goose has a greater NC with a mean of 87.0 mm \pm 0.2SD (range =86.7 to 87.2 mm, n =13) than the female goose of the same season with a mean NC of 86.8 mm \pm 0.2SD (range =86.5 to 87.0 mm, n =6).

i. Wing span (WS)

The mean WS of the Cotton Pygmy-goose was found to be 425.3 mm \pm 0.7SD (range 424.0 to 426.0 mm, n =42, Table 5.1, Figure 5.1) during the study period. The male goose have a mean WS of 425.278 mm \pm 0.7SD and female goose with 425.26 mm \pm 0.7SD (range =424.0 to 426.0 mm in both sexes, n =27 & 15). The mean WS of male during winter was found to be 425.428 mm \pm 0.6SD (range =424.5 to 426.0 mm, n =14), whereas the female has a mean WS of 425.388 mm \pm 0.8SD (range =424.0 to 426.0 mm, n =9) in the same season. Again, during monsoon the male goose has a mean WS of 425.11 mm \pm 0.7SD (range =424.0 to 426.0 mm, n =13) and female has 425.08 mm \pm 0.7SD (424.0 to 426.0 mm, n =6).

j. Wing length (WL)

The mean WL (flattened) in case of both the sexes of Cotton Pygmy-goose recorded was 169.2 mm \pm 0.6SD (range =168.0 to 171.0 mm, n =42, Table 5.1, Figure 5.1). The male goose has a mean WL of 169.3 mm \pm 0.85SD (range =168.0 to 171.0 mm, n =27), whereas the female has a mean WL of 169.1 mm \pm 0.92SD (range =168.0 to 171.0 mm, n =15). The WL of the female goose during the monsoon season was measured with a mean WL of 169.3 mm \pm 1.1SD (range =169.0 to 171.0 mm, n =6), whereas in male the same remains at 169.0 mm \pm 0.7SD (range =168.0 to 170.0 mm, n =13). During winter season, the mean WL of the male goose was found to be 169.5 mm \pm 0.9SD (range =168.0 to 171.0 mm, n =14) and in female the mean WL was found as 168.9 mm \pm 0.8SD (range =168.0 to 170.0 mm, n =9).

k. Wing feathers (WF) & wing feather length (WFL)

The number of WF in both male and female Cotton Pygmy-goose was 25 with 11-primaries

(PWF) and 14-secondaries (SWF). The mean PWF length was found to be 104.2 mm \pm 0.06SD (range =101.13 to 107.31 mm, n =42) irrespective of sexes and seasons. The male goose has a mean PWF of 107.2 mm \pm 0.07SD (range =107.07 to 107.31 mm, n =27), whereas the female PWF has a mean length of 101.21 mm \pm 0.06SD (range =101.13 to 101.31 mm, n =15). The PWF length was found statistically significant at both 99% and 95%CL ($p < 0.01$, Student's t-test) between the male and female. During winter season, the mean PWF length measured in the male was 107.2 mm \pm 0.07SD (range =107.07 to 107.31 mm, n =14), whereas in female goose the mean PWF length remains at 101.23 mm \pm 0.07SD (101.13 to 101.35 mm, n =9). During monsoon season, the mean PWF was found to be 107.2 mm \pm 0.07SD (range =107.07 to 107.31 mm, n =13) and 101.2 mm \pm 0.05SD (range =101.13 to 101.25 mm, n =6) respectively in male and female geese. The PWF length difference was found statistically significant in the male and female at 99%CL ($p < 0.01$, Students' Paired t-test) during winter and monsoon season. The length-wise arrangement of the PWF of male was found as PWF1 < PWF11 < PWF10 < PWF9 < PWF8 < PWF7 < PWF2 < PWF6 < PWF5 < PWF3 < PWF4 (Table 5.2 & Figure 5.2). A more or less similar arrangement was found in PWFs of female goose with a difference in PWF2 and PWF6, where PWF6 < PWF2.

The mean SWF length was found to be 83.1 mm \pm 0.06SD (range =80.5 to 85.7 mm, n = 42). The male goose have longer SWF length with a mean 85.6 mm \pm 0.06SD (range 80.6 to 85.6 mm, n =27) than the female goose with a mean 80.7 mm \pm 0.05SD (range 80.6 to 80.8 mm, n =15) irrespective of seasons. During monsoon, the male has a mean SWF length of 85.6 mm \pm 0.05SD (range =85.55 to 85.64 mm, n =13), whereas the female has a mean length of 80.6 mm \pm 0.03SD (range 80.6 to 80.7 mm, n =6). During winter the

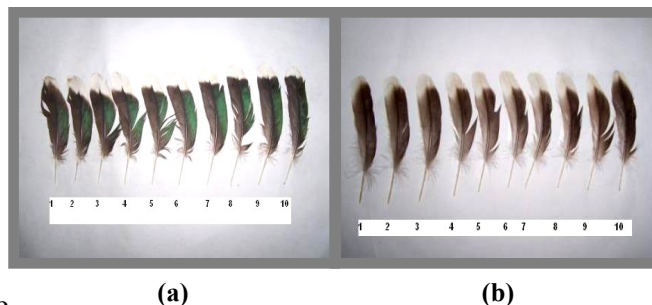


Plate 2 Secondary wing feathers of (a) male & (b) female CPG (from inner to outer)

Table 2. Lengths of primary wing feathers of Cotton Pygmy-goose (n =42)

Feathers*	Range (male)	Mean \pm S.D.	Range (female)	Mean \pm S.D.
PWF-1	28.0- 28.2	28.1 \pm 0.08	27.7 - 27.9	27.8 \pm 0.08
PWF-2	121.0- 121.1	121.13 \pm 0.05	118.3 - 118.5	118.4 \pm 0.11
PWF-3	127.2 - 127.5	127.4 \pm 0.11	122.0 - 122.5	122.3 \pm 0.17
PWF-4	128.4 - 128.7	128.6 \pm 0.12	123.3 - 123.5	123.4 \pm 0.10
PWF-5	125.3 - 125.6	125.5 \pm 0.10	119.2 - 119.6	119.4 \pm 0.20
PWF-6	121.2 - 121.5	121.4 \pm 0.12	115.4 - 115.8	115.6 \pm 0.14
PWF-7	117.0 - 117.3	117.2 \pm 0.1	109.4 - 109.7	109.5 \pm 0.10
PWF-8	111.1 - 111.2	111.16 \pm 0.05	103.4 - 103.8	103.7 \pm 0.14
PWF-9	104.3 - 104.6	104.48 \pm 0.12	97.3 - 97.5	97.4 \pm 0.08
PWF-10	99.1 - 99.5	99.3 \pm 0.16	91.0 - 91.2	91.1 \pm 0.09
PWF-11	95.2 - 95.5	95.37 \pm 0.10	84.9 - 84.1	85.0 \pm 0.06

*PWF= Primary wing feather

male goose has a more or less similar mean SWF length with the monsoon season (mean: 85.6 mm \pm 0.07SD, range =85.46 to 85.63 mm, n =14), whereas in the female goose the same remains at 80.5 mm \pm 0.07SD (range =80.52 to 80.75 mm, n =9). The length-wise arrangement of the SWF in male was found to be SWF14 <SWF9 <SWF10 =SWF13 < SWF8 < SWF7 < SWF6 < SWF5 < SWF4 <SWF1 <SWF3 <SWF11 <SWF2 <SWF12, while in female the arrangement was found to be SWF14 <SWF7 <SWF9 < SWF6 < SWF10 < SWF5 <SWF4 < SWF8 < SWF13 < SWF3 <SWF2 <SWF1 <SWF11 <SWF12 (Table 5.3 & Figure 5.2). The SWF length was found statistically significant at both 99% CL ($p < 0.01$, Student's t-test) between the male and female.

l. Scapular feathers (SF) and scapular feather length (SFL)

There are 6 (six) SF in both male and female Cotton Pygmy-goose with mean length of 42.0 mm \pm 0.25SD (range =41.7 to 42.6 mm, n =42, Table 5.1). The male goose has a mean SFL of 42.2 mm \pm 0.3SD (range =41.9 to 42.6 mm, n =27) whereas the female goose has a mean SFL of 41.9 mm \pm 0.1SD (range =41.7 to 42.1 mm, n=15) irrespective of the seasons of a year. During

monsoon season the male goose have greater SFL with a mean SFL of 42.2 mm \pm 0.3SD (range =41.9 to 42.5 mm, n =13) than the winter ones with a mean SFL of 42.0 mm \pm 0.1SD (range =41.9 to 42.2 mm, n =14). The scapulars found significantly longer in males by 0.27 mm \pm 0.13SD.

m. Tarsus length (TL)

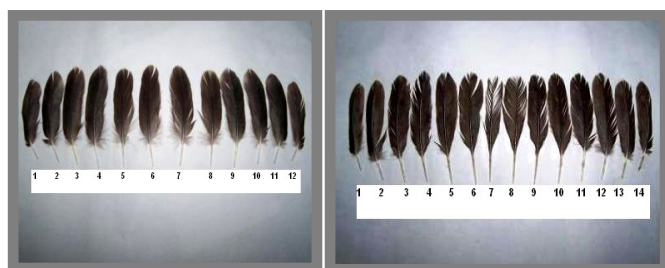
The mean TL in Cotton Pygmy-goose was found to be 29.1 mm \pm 0.1SD (range =28.9 to 29.3 mm, n =42, Table 5.1, Figure 5.1). The mean TL in both sexes of the goose was found to be 29.1 mm \pm 0.1SD with a range between 29.0 to 29.2 mm (male: n =27; female: n =15).

n. Hind toe length (HTL)

In Cotton Pygmy-goose the mean HTL or first toe length was found to be 8.1 mm \pm 0.09SD (range =7.9 to 8.3 mm, n =42, Table 5.1, Figure 5.1). The male goose have a slightly longer mean HTL with 8.2 mm \pm 0.09SD (range 8.0 to 8.3 mm, n =27) than the female goose which have a mean HTL of 8.06 mm \pm 0.09SD (range =7.9 to 8.2 mm, n =15) irrespective of the seasons of a year. During winter, the mean HTL of male goose was found to be 8.1 mm \pm 0.1SD (range =8.0 to 8.3 mm, n =14), whereas a mean length of 8.0 mm \pm 0.08SD (range =7.9 to 8.2 mm, n =9) was observed in female goose during the same season. The male has a greater HTL than the females during the monsoon (male: mean 8.2 mm \pm 0.08SD, n =13; female: mean 8.1 mm \pm 0.1SD, n =6).

o. Inner toe length (ITL)

In Cotton Pygmy-goose the mean ITL or second toe length was found to be 31.7 mm \pm 0.1SD (range =31.5 to 32.0 mm, n =42, Table 5.1, Figure 5.1). The male goose have a slightly longer mean ITL with 31.8 mm \pm 0.2SD (range 31.4 to 32.0 mm, n =27) than the female goose which have a mean ITL of 31.6 mm \pm 0.1SD (range =31.5 to 31.8 mm,



(a)

(b)

Plate 3 Rectrices of (a) male & (b) female CPG from right to left)

Table 3. Lengths of secondary wing feathers of Cotton Pygmy-goose (n =42)

Feathers*	Range (male)	Mean \pm S.D.	Range (female)	Mean \pm S.D.
SWF-1	88.9 - 89.7	98.3 \pm 0.33	82.1 - 83.3	82.5 \pm 0.43
SWF-2	91.0 - 91.5	91.3 \pm 0.23	82.0 - 83.3	82.3 \pm 0.51
SWF-3	89.2 - 89.5	89.4 \pm 0.12	80.2 - 81.3	80.9 \pm 0.39
SWF-4	87.1 - 87.5	87.3 \pm 0.15	79.1 - 79.6	79.3 \pm 0.17
SWF-5	86.0 - 86.7	86.3 \pm 0.26	77.2 - 77.9	77.6 \pm 0.27
SWF-6	84.3 - 84.6	84.5 \pm 0.09	75.3 - 75.6	75.4 \pm 0.12
SWF-7	83.4 - 83.8	83.6 \pm 0.15	74.9 - 75.4	75.1 \pm 0.18
SWF-8	82.3 - 82.5	82.5 \pm 0.10	79.3 - 79.5	79.4 \pm 0.08
SWF-9	80.4 - 80.8	80.6 \pm 0.16	75.1 - 75.6	75.3 \pm 0.19
SWF-10	82.1 - 82.5	82.4 \pm 0.15	77.1 - 77.5	77.4 \pm 0.16
SWF-11	89.3 - 89.7	89.5 \pm 0.13	95.8 - 96.2	96.0 \pm 0.13
SWF-12	94.2 - 94.5	94.3 \pm 0.12	97.0 - 97.2	97.1 \pm 0.08
SWF-13	82.2 - 82.5	82.4 \pm 0.12	80.2 - 80.5	80.3 \pm 0.12
SWF-14	74.8 - 75.2	75.0 \pm 0.14	71.3 - 71.5	71.4 \pm 0.11

*SWF= Secondary wing feather

n =15) irrespective of the seasons of a year. During winter, the mean ITL of male goose was found to be 31.7 mm \pm 0.2SD (range =31.4 to 32.0 mm, n =14), whereas a mean length of 31.6 mm \pm 0.1SD (range =31.5 to 31.8 mm, n =9) was observed in female goose during the same season. The male has a greater ITL than the females during the monsoon (male: mean 31.8 mm \pm 0.2SD, n =13; female: mean 31.6 mm \pm 0.1SD, n =6).

p. Middle toe length (MTL)

In Cotton Pygmy-goose the mean MTL or third toe length was found to be 34.3 mm \pm 0.2SD (range =34.0 to 34.5 mm, n =42, Table 5.1, Figure 5.1). The male and female goose have a more or less similar measurement of MTL with a mean of 34.3 mm \pm 0.2SD in both (Male: range 34.0 to 34.5 mm, n =27; Female: range 34.1 to 34.5 mm, N =15) irrespective of the seasons of a year. During winter, the mean MTL of male goose was found to be 34.2 mm \pm 0.2SD (range =34.0 to 34.5 mm, n =14), whereas a mean length of 34.3 mm \pm 0.2SD (range =34.1 to 34.5 mm, n =9) was observed in female goose during the same season. The male has a

slightly longer MTL with a mean of 34.3 mm \pm 0.2SD (range =34.0 to 34.5 mm, n =13) than the female goose with mean of 34.2 mm \pm 0.2SD (range =34.1 to 34.5 mm, n =6) during the monsoon season.

q. Outer toe length (OTL)

In Cotton Pygmy-goose the mean OTL or fourth toe length was found to be 33.3 mm \pm 0.2SD (range =33.0 to 33.5 mm, n =42, Table 5.1, Figure 5.1). The male and female goose have a more or less similar measurement of OTL with a mean of 33.3 mm \pm 0.2SD in both (range =34.0 to 34.5 mm, n = male:27 & female:15) irrespective of the seasons of a year. During winter and monsoon season, the mean OTL of male and female goose was also found to be 33.2 mm \pm 0.2SD (range =33.0 to 33.5 mm, n =male: 14 & female: 9).

r. Inner web distance (IWD)

The mean IWD in Cotton Pygmy-goose was found to be 20.3 mm \pm 0.2SD (range =19.9 to 20.6 mm; n =42, Table 5.1, Figure 5.1) irrespective of sexes and seasons. The male and female goose have a more or less similar measurement of IWD with a mean of 20.3 mm \pm 0.2SD in both (range =19.9 to 20.9 mm, n = male:27, female:15) irrespective of the seasons of a year. During winter season, the mean IWD of male and female goose was found to be 20.2 mm \pm 0.2SD (range: male =19.9 to 20.4 mm, n =14; female =19.9 to 20.6 mm, n =9). Again during monsoon season, the mean IWD of male and female goose was found to be 20.3 mm \pm 0.2SD (range: male =19.9 to 20.6 mm, n =13; female =20.0 to 20.6 mm, n =6).

s. Outer web distance (OWD)

The mean OWD in Cotton Pygmy-goose



(a) (b)

Plate 4 (a) Dorsal & (b) ventral view of a dead CPG (male) recovered from poachers' hand near Borsola

was found to be 16.5 mm \pm 0.2 (range 16.2 to 16.8 mm; n =42, Table 5.1) irrespective of sexes and seasons. The male and female goose have a more or less similar measurement of OWD with a mean of 16.5 mm \pm 0.2SD in both (range =16.2 to 16.8 mm, n= male-27 & female-15) irrespective of the seasons of a year. During winter season, the mean OWD of male and female goose was found to be 16.5 mm \pm 0.2SD (range =16.2 to 16.8 mm, n =male -14 & female-9). Again during monsoon season, the mean OWD of male and female goose was found to be 16.5 mm \pm 0.2SD and 16.4 mm \pm 2SD (range: male =16.2 to 16.8 mm, n =13; female =16.2 to 16.7 mm, n =6).

t. Tail length (TaL), tail feathers (TF) or rectrices and tail feather length (TFL)

The mean TaL in Cotton Pygmy-goose was found to be 64.6 mm \pm 0.8SD (range =63.2 to 65.9 mm, n =42, Table 5.1, Figure 5.1). The male has a longer tail with a mean TaL of 64.6 mm \pm 0.8SD (range =63.4 to 65.9 mm, n =27) than the female with a mean TaL 64.5 mm \pm 0.5SD (range =63.2 to 65.3 mm, n =15). The goose studied during winter season has greater TaL with mean 64.6 mm \pm 0.6SD (range =63.2 to 65.9 mm, n =23) than the goose studied during monsoon season with a mean 64.5 mm \pm 0.6SD (range =63.2 to 65.9 mm, n =19). The male goose captured during winter has longer tail with mean TaL of 64.7 mm \pm 0.7SD (range =63.4 to 65.9 mm, n =14) than the female of the same season

with mean TaL 64.4 mm \pm 0.6SD (range =63.2 to 65.3 mm, n =9). The numbers of TF or rectrices in Cotton Pygmy-goose vary in both sexes. The male has 12 TF, whereas the female has 14 in numbers. The mean TFL was found to be 74.2 mm \pm 0.08SD (range =73.36 to 75.07 mm, n =42, Table 5.1) irrespective of sexes and seasons. The mean TFL of the male was 73.5 mm \pm 0.09SD (range =73.4 to 73.6 mm, n =27) and in female it remains at 74.9 mm \pm 0.08SD (range =74.8 to 75.1 mm, n =15). During winter, in male goose the mean TFL found was 73.5 mm \pm 0.09SD (range =73.4 to 73.7 mm, n =14) and in female the mean value found to be 75.0 mm \pm 0.08SD (range =74.9 to 75.1 mm, n =9). Again, the male goose studied during monsoon shows a mean TFL of 73.5 mm \pm 0.09SD (range =73.4 to 73.6 mm, n =13), whereas the female goose has a mean TFL of 74.9 mm \pm 0.09SD (range =74.9 to 75.1 mm, n =6).

Twenty pairs of body parameters were studied and relationship was correlated which shows strong as well as negative relationship among them, and the value of 'r' ranges between - 0.9 to 0.9 (Table 5.4 & Figure 5.3). A strong relationship was observed in case of female (r=0.8, Pearson Correlation) between BoW and BoL, while in the case of male a less strong correlation (r=0.2) was observed. It shows a higher tendency of increase of body weight with an increase in BoL. There exists a strong correlation between BoL and

Table 4. The co-efficient of correlation (r) among various body parameters of CPG (male & female)

Parameters	'r' in male	'r' in female
1. Body wt. & Body length	0.2	0.8
2. Body length & Neck length	0.7	0.8
3. Body length & Bill length	0.9	0.1
4. Bill length & Bill depth	0.5	0.4
5. Body length & Middle toe length	0.7	-0.1
6. Tarsus & Middle toe length	0.1	0.5
7. Body length & Tail length	0.5	0.2
8. Wing length & Tail Length	-0.7	-0.4
9. Wing feather length & Tail feather length	-0.7	-0.1
10. Wing length & Body length	-0.8	0.5
11. Bill length & Bill width	-0.6	0.1
12. Wing Expansion & Body length	-0.8	-0.7
13. Bill depth & Bill width	-0.2	-0.1
14. Tarsus length & Hind toe length	-0.2	-0.2
15. Tarsus length & Inner toe length	0.1	0.2
16. Hind toe length & Middle toe length	-0.3	0.1
17. Tarsus length and Outer toe length	-0.5	0.1
18. Outer toe length & Middle toe length	0.4	
19. Hind toe length & Outer toe length	0.5	-0.7
20. Outer toe length & Inner toe length	0.5	0.9



**Plate 5 An adult CPG (female) during measurement
(in inset: an adult male)**



**Plate 6 A pair of adult CPG recovered from
a poacher of Kadamani area.**

NL in both male and female ($r=0.7$ & 0.8 respectively) and a less strong correlation between the BoL and BL in female ($r=0.1$). The NL is highly related with the BoL and vice-versa, while the tendency is lower in case of the male. A moderately strong correlation was observed in female ($r=0.5$) between TL and MTL. The coefficient of correlation between BoL and TaL was found strong in male ($r=0.5$) and in female ($r=0.2$), whereas the WS and BoL in both male ($r=-0.8$) and female ($r=-0.7$) are oppositely related and increase in WS decreases the BoL. An oppositely related WFL and TFL were found in male ($r = -0.7$) and female ($r= -0.1$). Similarly the BD and BW in both male and female were oppositely related ($r = -0.2$ & -0.1 respectively).

DISCUSSION

The present morphometric study on forty two Cotton Pygmy-geese, the average BoW of male and female is found to be 221.2 gm and 227.1 gm respectively. The study shows a low body weight of the Cotton Pygmy-goose in comparison to other goose. A lower body weight of the *Nettapus sp.* > 500 gm has been confirmed. The female Cotton Pygmy-goose was found heavier during the monsoon season than the male. This might be either due to excessive feeding for the developing eggs during monsoon season or food reservation which may occur for future use during incubation of the eggs. The present investigation also reveals that the female has slightly greater body weight than the male bird during breeding season prior to egg laying. The weight of the birds congregated in vegetation covers area found to be greater than the birds found in open area

irrespective of their sex except a male bird which may just arrived to the area and was trapped for the study. The greater weight in the birds of the vegetation cover area may be due to recent feeding on the vegetation available in the wetland. The Cotton Pygmy-goose studied from Borsola area were found greater weight than the goose captured from other areas during the study period. The reason might be the availability of food plants in the wetlands of Borsola area.

The sex-wise differences of body length, plumage characteristics were found to be prominent in the present context of the study. Deviations of the body lengths were more like those predicted by the competition hypothesis in wetlands with low food abundance than in the wetlands with high food abundance. The similar results were also discussed by Pöysä *et al.* (1994).

The functional significance of morphometric study shows that due to differences in neck and body length the Cotton Pygmy-goose use different feeding methods and depths for feeding. The present findings were further supported by the works of Pöysä (1983a, 1983b, 1986 & 1987). The wing span and the flattened wing length are found quite correlative in response to the flight adaptation. The relationship of wing span, wing length and tarsus length with the body weight is also supported by the works of Green *et al.* (2001). No relation was observed in between the outer web distance and inner web distance. Fox *et al.* (1992) found significance differences between male and female adult teal in tarsus and wing length. The present findings are also more or less supported by the findings of Moore and Battley (2003) in *Anas chlorotis*.

The assumptions of the present study demonstrate a conclusion on the adaptiveness of the morphological characteristics with relation to the ecology of the habitat area of Cotton Pygmy-goose. The morphology of birds has been greatly influenced by the environmental condition of a region. The new area eco-morphology of the broad subject ornithology provides the effects of various environmental as well as wetland factors on the morphological features of the wetland birds. The differences in their measurement from different wetland areas provide a clue for their adaptability of these birds with their natural habitat with niche characteristics. The various measurements can be used for the formation of silhouettes. Based on the various parameters a bird baseline can be formed and differences between two sexes can be visualized. Though the lengths of primaries, secondaries and tail feathers vary within limits across species, it is also true for population of an area. These measurements can be used in museum diagnosis for the identification of species and geographic races in light of sexual variations.

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