CHARACTERISATION AND EVALUATION OF INDIGENOUS DUCKS OF KERALA

By
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THESIS

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DECLARATION

I hereby declare that this thesis entitled "**CHARACTERISATION AND EVALUATION OF INDIGENOUS DUCKS OF KERALA**" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

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CERTIFICATE

Certified that this thesis, entitled "**CHARACTERISATION AND EVALUATION OF INDIGENOUS DUCKS OF KERALA**" is a record of research work done independently by **Dr. J.D. Mahanta** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

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Dedicated To My

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Introduction

INTRODUCTION

The present day domestic ducks (*Anas platyrhynchos*) which originated from Asian wild (Mallard) ducks have been improved and exploited for commercial enterprises through scientific breeding practices. Presently, the world duck population is estimated to be 573 million (FAO Statistics, 1990). Out of this about 85 per cent are found in Asia-Pacific region. In most of these South East Asian countries, indigenous ducks are usually used for producing eggs, meat being only a by-product. Traditional extensive duck rearing systems are still dominant in developing countries although there is a trend towards the more intensive systems which is predominant in the West (Edwards, 1986).

In India, ducks rank next to chicken in total egg production. According to 1987 census, the duck population in India is 23.48 million and forms about 8.52 per cent of the total poultry population in the country (Anon., 1994). Although ducks are reared all over the country, they are concentrated mostly in Eastern, North-Eastern and Southern states of India. The leading states in duck population are West Bengal, Assam, Bihar, Kerala, Andhra Pradesh, Orissa and Tamil Nadu. Compared to the growth of chicken production in the country, the duck production continues to remain neglected

in the absence of adequate attention from research workers, developmental agencies and private sectors. Duck production continues to remain in the hands of the poor and socially backward strata of society. Any effort to improve the duck industry will have a great impact on the lives of these farmers and will create ancillary job opportunity to many others (Sastry *et al.*, 1994). Bhat *et al.* (1980) identified and listed 24 breeds and 34 varieties of indigenous ducks in India. So far there is no systematic approach towards breed standardization. Duck rearing in controlled conditions is practically non-existent in the country.

Kerala with a coastal stretch of 580 kms has 8.46 lakhs of ducks, which constitute about 3.6 per cent of the country's duck population and ranks fourth position in India. An analysis of the distribution of duck population in Kerala state revealed that 80 per cent of the duck population is concentrated in Alappuzha, Ernakulam, Kottayam and Thrissur districts (Table 1).

Duck farming in Kerala state is unique and peculiar in nature. Only indigenous non-descript ducks which constitute 95 per cent of the total duck population in Kerala are maintained by the duck farmers of the state. Maintaining them under nomadic pattern of management, farmers claim an egg production of around 200 eggs per bird per annum though

Table 1. Distribution of duck population in Kerala (1987)

1.	Thiruvananthapuram	27,819
2.	Kollam	60,887
3.	Pathanamthitta	47,677
4.	Alappuzha	274,179
5.	Idukki	9,627
6.	Kottayam	131,876
7.	Ernakulam	180,390
8.	Thrissur	62,311
9.	Palakkad	13,131
10.	Malappuram	16,419
11.	Kozhikode	8,053
12.	Wayanad	2,659
13.	Kannur	8,426
14.	Kasargode	2,637
	Total	8,46,091

Source: Farm Guide, 1994. Information Bureau, Govt. of Kerala

authentic records are not maintained (Ramachandran and Ramakrishnan, 1982).

According to duck farmers in Kerala, there are two distinct groups of indigenous ducks known as Chara and Chemballi. These names were given based on their plumage colour. They are considered to be good layers and comparatively resistant to diseases. Other groups are admixture of these two or those which are herded by farmers from the neighbouring state of Tamil Nadu. Although local farmers have identified such distinct groups of indigenous ducks, systematic classification and characterization have not been carried out so far. Though some efforts were made earlier by few workers (George, 1977; Andrew, 1978; Ramakrishnan *et al.*, 1982 and Eswaran, 1983) to assess their production potential, it was not based on clearly identified phenotypic groups.

To explore the possibility of genetic improvement of the indigenous ducks and to develop viable breeding strategies for their improvement, characterisation of ducks in terms of its physical appearance and genetic capabilities as a layer must be understood. The present study, therefore, is undertaken with an objective to study basic characteristics of two distinct indigenous types of ducks of Kerala and to evaluate their production potential.

Review of Literature

REVIEW OF LITERATURE

Published reports are scanty documenting scientific study of indigenous ducks available in India (Ramakrishnan, 1982). In Kerala, some investigations were made earlier, to evaluate the production potential of the indigenous ducks but these have not taken cognisance of the presence of phenotypic groups. Subsequent surveys (Ramachandran and Ramakrishnan, 1982 and Ravindran, 1983) have given indication of possible presence of distinct phenotypic groups among the local ducks of Kerala. Therefore, a systematic investigation was undertaken in the present study for characterisation of the indigenous ducks of Kerala on the basis of their external morphology, growth, reproduction, production and biochemical characters. A review of the available informations on the parameters studied in respect of ducks have been attempted in this chapter.

External morphology

Chavez and Lasmini (1978) studied the external morphology of three varieties of native Indonesian ducks namely Tegal, Alabio and Bali. According to them the Tegal bird had a characteristic slender posture and erect gait with a total upright height of 45 to 50 cm. The body and head were small,

eyes bright and the bill was long and wide at the tip. The legs were short (5 to 6 cm long) and the females lay blue-green eggs. The major plumage colour was speckled brown with black bill and feet. Alabio was more squat in posture and gait than the Tegal. The female was speckled brown with a bluish-green speculum and the top of the head was dark brown. The bill was dull orange with a black spot at the tip. The drake had a glossy dark brown on its head, a white band on the front of its neck with uncompleted white collar, purplish brown breast, light brown body and black tail coverts. Alabio was also producer of blue-green eggs. Bali ducks resembled the Tegal ducks but with slightly shorter neck. They showed a wide variety of plumage colours. Some were totally black, others were pure white, but the majority were brown or fawn in many shades. Some birds had a tuft of feathers on their head. The main difference between the Bali and the Tegal was the colour of the eggs. It was white in the Bali and blue-green in the Tegal.

Michalic (1982) found correlation of lean, bone and fat percentage of the carcass of Pekin ducks of 8 weeks of age with different body measurements like body length, chest girth, head length and keel length.

Sharma *et al.* (1983) recorded phenotypic correlation of external body measurements with egg production and body weight in White Pekin ducks.

The body length recorded in male and female farmed mallards was 58.8 and 52.6 cm respectively (Bonczar, 1986).

Qiu *et al.* (1988) studied the plumage colour pattern in three strains of Jianchang ducks in China. Similarly, Tulacek (1990) investigated the inheritance of three principal colour types in Muscovy.

Indigenous duck eggs of Kerala had an average egg shape index of 72.99 (George *et al.*, 1980) and 75.32 (Eswaran *et al.*, 1985). Similarly, indigenous *Pati* ducks of Assam had an average shape index of 72.82 ± 0.46 (Mahanta *et al.*, 1993). These values were significantly higher as compared to egg shape index of Khaki Campbell.

Growth traits (Body weight and shank length)

Milby and Henderson (1937) reported that in duck and geese the early growth rate and quick attainment of the mature body weight is one of the main features of the species.

Hays (1952) opined that ducks under intensive system showed significantly higher body weight at the age of sexual maturity than those under semi-intensive system.

Day old White Pekin and Khaki Campbell ducklings had a mean body weight of 45.8 and 35.8 g respectively and they attained a body weight of 462.3 and 266.5 g at fourth week and 1935 and 1366 g at 12th week with the maximum gain between four and eight weeks of age (Kamar *et al.*, 1971).

Average body weights of White Pekin ducklings recorded at different ages by various workers are given below:

Age in days	Body weight (g)	Authors
53	2512	Majna *et al.* (1973)
49	1930	Moudgal and Singh (1975)
49	2365 (Males) 2262 (Females)	Rudolph and Hoppe (1975)
49	2465	Oplt *et al.* (1975)
49	1528	Veitsman *et al.* (1975)
84	1511	Abdel Malek and Yamani (1976)

Singh *et al.* (1976) reared White Pekin ducks under three systems of housing namely, intensive system, semi-intensive system and battery system. They reported that male and female ducklings attained 1851 and 1871 g body weight respectively at 49 days of age in intensive system, which were significantly higher than the body weights attained in the other two systems of housing.

Chavez and Lasmini (1978) recorded live body weight of Indonesian duck layers at different times as given below.

Production stage	Tegal	Alabio	Bali
Initial body weight (g)	1375 ± 10.0	1410 ± 10.7	1170 ± 8.9
9 months production (g)	1531 ± 12.5	1526 ± 14.8	1536 ± 15.9
12 months production (g)	1487 ± 16.4	-	-

Live body weight at the beginning of egg production was significantly highest for the Alabio followed by the Tegal and then the Bali ducks. After 9 months production no significant difference in the live body weight of the layers in these three flocks was observed.

George (1978) observed that the maximum body weight gains were obtained during the third and sixth week of age in desi ducklings and there was a decrease in the rate of body weight gain from seventh week of age onwards.

Sharma and Singh (1978) observed that White Pekin ducks reared under intensive management and semi-intensive management weighed 1794 g and 1683 g at seven weeks of age and body weights at 50 per cent egg production were 2203 and 2303 g respectively.

Reddy and Reddy (1979), while studying the growth pattern in Khaki Campbell, observed that the body weight of ducklings showed a linear increase with age, as in the case of chicken. They also found that the body weight of ducklings increased two-fold by the end of first week, four-fold in second week and about ten-fold by the end of third week (35, 70, 150 and 325 g at 0, 1, 2 and 3 week respectively) indicating their capacity to grow faster in the early stage of life.

George *et al.* (1979) studied the relationship between shank length and twelfth week body weight in desi ducks. They found highly significant difference between sex for shank length and body weight at 12 weeks of age. They also observed highly significant ($P<0.01$) and positive correlations of 0.26, 0.32 and 0.44 between shank length and body weight in male, female and straightrun respectively. Based on this information they developed a regression equation to predict twelfth week body weight of desi ducks from shank length.

Gonzalez and Marta (1980) reported that the body weight of female Khaki Campbell ducklings at 1, 4 and 7 weeks of age averaged 85.6, 585.1 and 1113 g, while that of males were 75.0, 594.4 and 1213.3 g for the same period.

In two separate trials (George *et al.*, 1980 and George *et al.*, 1981) growth of desi ducklings of Kerala were

evaluated. The pattern of growth under deep litter system of rearing could be seen from the following table.

Overall mean weekly body weight (g) of straightrun duckling from 0 to 12 weeks of age

Age in weeks													Author
0	1	2	3	4	5	6	7	8	9	10	11	12	
42	94	217	411	575	717	896	1033	1139	1201	1254	-	-	George et al. (1980)
41	82	126	361	496	655	770	861	1067	1145	1296	1376	1387	George et al. (1981)

The data indicated that the gain in weight was uniformly fast till around 11th week of age. Thereafter the increase was very insignificant indicating that desi ducks reached mature body weight at about 11th week of age. Hatch weight of desi ducks was significantly correlated with body weight at 1, 4, 8 and 12 weeks of age with correlation value of 0.46, 0.31, 0.35 and 0.25 respectively.

Body weight of White Pekin ducklings at sixth week of age averaged 1350 g and at seventh week 1718 g (Aggarwal *et al.*, 1981).

Andrews *et al.* (1984) reported adult body weight of desi ducks under intensive and semi-intensive system of rearing as 1311 and 1281 g respectively.

Pattern of growth in desi ducks of Kerala and Khaki Campbell was studied by Eswaran *et al.* (1984). The study revealed that though during initial period, the rate of growth was faster in Khaki Campbell than in desi ducks, after 4 weeks of age the weight gain was found to be higher among desi ducks. At 18 weeks of age Khaki Campbell females recorded a higher body weight than males, whereas a reverse phenomenon was noticed in desi ducks.

Farrell and Stapleton (1985) reported that ducks have exceptional capacity for compensatory growth.

In a survey study of duck farming in Andhra Pradesh Rithamber *et al.* (1986) recorded body weight at sexual maturity of desi ducks as 1250 to 1500 g.

Sivaselvam and Prabhakaran (1986) reported the body weight of desi ducks at hatch, 8th and 20th week of age as 36.88, 1156.90 and 1465.02 g respectively.

Sazzad *et al.* (1988) found no significant difference ($P<0.05$) between the growth rate of Bangladeshi desi ducks with Khaki Campbell ducks under scavenging system of rearing upto 9 weeks of age.

Hamid *et al.* (1988) recorded an average 20th week body weight for Khaki Campbell, Indian Runner and indigenous ducks

as 1788.44, 1743.28 and 1703.89 g respectively. The growth rate was significantly ($P<0.01$) better in Khaki Campbell (87.21 g) ducklings as compared to indigenous ducklings (83.44 g).

Rate of shank growth was comparatively higher in desi ducks than White Pekin ducks from hatching to 12 weeks of age (Sunanda *et al.*, 1989).

In Taiwan, body weight of Brown Tsaiya ducks at 30th week of age averaged 1397 ± 120 g (Tai *et al.*, 1989).

Day old body weight of Khaki Campbell and local ducks under intensive system of rearing averaged 29.41 ± 0.72 and 36.88 ± 0.72 g respectively. The corresponding figures at 20th week of age were 1402.75 ± 13.35 and 1465 ± 23.87 g respectively (Gajendran *et al.*, 1990).

Average live body weights of male and female desi ducks at slaughter age were reported as below.

Sex	Body weight (g)	Authors
Male	1250 ± 0.039	Nanda and Sharma (1990)
Female	1050 ± 0.055	
Male (Kashmiri)	2104 ± 009	Sahoo (1990)
Female (Kashmiri)	2077 ± 264	

Using linear and exponential equations Sunanda *et al.* (1991) predicted body weight of desi ducks through shank length data with a lower standard error value. In another similar study with White Pekin ducklings, Sunanda *et al.* (1991) indicated that body weight could be more accurately predicted from measurement of shank length using an exponential equation than using a linear equation. Later, modified exponential model was reported to be the best for predicting body weight through shank length (Sunanda *et al.*, 1991).

Studying with four strains of brown Tsaiya ducks, Lee *et al.* (1992) found significant strain differences in body weight at 30 and 40 weeks of age. At 40 weeks of age, body weight averaged 1410, 1330, 1380 and 1390 g in the four strains respectively.

Working with Pekin ducks, Gorski (1992) found significant correlation between body weight and shank length at 14, 28, 42 and 56 days of age (0.32 to 0.96) for both male and female lines.

Shinde *et al.* (1993) obtained relationship of shank length with body weight, egg weight and egg production in dwarf-type laying hens.

For 120 Bali, Mojosari and Alabio ducks, body weight at 8 weeks averaged 706.72, 701.53 and 702.68 g respectively (Astiningsih *et al.*, 1994).

Ducks reared in an aviary containing an artificial pond and without a pond, body weight at slaughter age of 95 days averaged 1050 and 965 g respectively (Vicenti *et al.*, 1996).

Reproductive traits (Age at sexual maturity)

Hays (1952) observed that ducks reared under intensive system matured earlier than those reared under semi-intensive system.

Monstageer *et al.* (1971) recorded the age at first egg for Pekin and Khaki Campbell as 206.3 and 151.3 days respectively.

Basanowa (1974) studied the production value of Cherry Valley and Pekin ducks and reported that all groups came to lay at 170 to 180 days of age when raised on litter floor.

Robinson *et al.* (1978) reported that Alabio ducks began to lay at seven months of age.

Sharma and Singh (1978) observed that for White Pekin ducks under intensive system, age at sexual maturity was 162 days and under semi-intensive system 172 days.

Chavez and Lasmini (1978) in a comparative study found that for three varieties of native Indonesian ducks, namely Tegal, Alabio and Bali, the age at first egg averaged 178, 179 and 189 days and number of days from first egg to 50 per cent production were 33, 32 and 24 days respectively.

In Papua New Guinea Villages, Muscovy ducks under semi-intensive system started laying at 30 to 32 weeks of age (Abdelsamie, 1979).

In Italy, Muscovy ducks started laying at about 6 months of age and lasted for about 6 months (Avanzi and Romboli, 1979).

Age at 50 per cent egg production recorded in Tegal, Alabio, Bali and Khaki Campbell duck was 132, 169, 148 and 142 days respectively (Hetzel, 1981).

Ramakrishnan *et al.* (1982) while studying some characters relating to egg production in desi ducks of Kerala observed that the age at sexual maturity in desi ducks was 182 days. The age at sexual maturity of crossbred (Khaki Campbell x Desi) ducks was 163.9 ± 2.67 days.

Local ducks of Malaysia (Itek Siam) started laying at 5 to 6 months of age (Awang, 1984).

The comparative reproductive performance of desi and Khaki Campbell ducks studied by Eswaran *et al.* (1984 and 1985) is given below:

Character	Desi	Khaki Campbell
Age at first egg (days)	134	163
Average age at first egg (days)	158	188
Age at 10 per cent production (days)	146	175
Age at 50 per cent production (days)	155	187

In a survey study of duck farming in Andhra Pradesh, Rithamber *et al.* (1986) reported average age at sexual maturity of desi ducks as 180 days for male and 240 days for female.

Sivaselvam and Prabhakaran (1986) in a comparative study found that the age at first egg in Khaki Campbell and Desi ducks averaged 140.16 and 145.21 days respectively.

In White Muscovy ducks the age at sexual maturity averaged 164 days (Wang and Xu, 1987).

In Taiwan, Tai *et al.* (1989) observed average age at first egg of brown Tsaiya ducks as 121 ± 11 days.

Gajendran *et al.* (1990) in a comparative study of local duck and Khaki Campbell found an average age at first egg 145.21 ± 2.70 and 140.16 ± 4.04 days respectively under intensive system of rearing.

Baruah *et al.* (1991) conducted a comparative study on productivity of an indigenous duck of Assam (Pati), Khaki Campbell and their crosses under farm condition. The reproductive performance of the above genetic groups was as follows:

Character	Desi (Pati)	Khaki Campbell	Cross
Age at first egg (days)	144.2	150.4	146.4
Age at 10 per cent production (days)	150.6	153.8	149.4
Age at 20 per cent production (days)	161.8	155.2	157.2
Age at 30 per cent production (days)	167.2	158.6	161.8

Haque and Hussain (1991), while evaluating the production potential of desi and Khaki Campbell ducks found an average age at first egg as 181.7 and 154.3 days respectively under scavenging system of management.

In Taiwan, age at first egg in four strains of Tsaiya ducks averaged 131, 121, 136 and 142 days respectively (Lee *et al.*, 1992).

Age at sexual maturity in Khaki Campbell, desi and their crosses was not affected by supplementary feeding under scavenging system of rearing in Bangladesh (Rashid *et al.*, 1995).

Production traits (Egg production)

Abakumov (1968) reported that ducks with access to ponds produced 137 to 230 eggs per year compared to 90 eggs produced by ducks which had no access to wallowing facilities.

Monstageer *et al.* (1971) recorded the egg production upto 300 days of age in Pekin and Khaki Campbell as 41 and 71.5 eggs respectively.

The yearly egg production from Cherry Valley and Pekin ducks was 179 and 196 eggs respectively (Basanowa, 1974).

Chavez and Lasmini (1978) compared the production traits of three most distinct indigenous breeds in Indonesia - the Tegal, Alabio and Bali duck. The overall mean production performance of these ducks was as follows.

Traits	Tegal	Alabio	Bali
Average egg number per duck	212 (in 365 days)	185 (in 318 days)	114 (in 273 days)
Average per cent intensity of egg production	58.0	58.1	41.8
Peak per cent egg production	83.2	92.7	58.6

Sharma and Singh (1978) observed that the intensive and semi-intensive system of management had no significant effect on egg production, egg weight, clutch size, length of laying pause or egg quality traits. It was found that egg production to 200 days was significantly correlated with that of 100 and 400 days.

Mahapatra (1978) opined that in Khaki Campbell, the individual egg production of almost an egg a day for over twelve months was very common and flock averages in excess of one hundred eggs per annum were obtained. He further stated that the average egg production from Indian Runner ranged from 250 to 300 eggs per duck per year.

Sivadas (1978) reported that the egg production for desi ducks after eight months of age and four months in production had reached a little under 15 per cent. He opined that the lower production in desi ducks was attributable to the effect

of exposure to aflatoxin contaminated feed very early in their life.

Robinson *et al.* (1978) reported that Alabio ducks began to lay at seven months of age, moulting was induced after an eight month laying season by feed restriction and ducks were brought back into production after three months by a high protein diet. They had further reported that the ducks produced about 500 eggs with an average egg production percentage of 70 over the two years of lay.

Kontecka (1979) obtained negative genetic correlations between egg production and egg weight (-0.04 to -0.087)in Pekin ducks of Poland.

Avanzi and Romboli (1979) reported annual egg number of Muscovy ducks as 69, 74 and 76 per female for three years.

Jung and Zhow (1980) reported that in White Pekin ducks, the annual egg production averaged 200 to 220 eggs.

Bonczar (1981) estimated the laying capacity of Mallard ducks under farm condition and found that annual egg production averaged only 32.3. Later, he concluded that wild Mallards were unsuitable for keeping under intensive farm conditions.

Hetzel (1981) compared egg production characteristics of Indonesian native ducks with Khaki Campbell and found egg number to 32 weeks of production as 117 (Tegal), 148 (Alabio), 153 (Bali) and 199 (Khaki Campbell). The corresponding figure for peak weekly per cent production was 66, 82, 84 and 86 respectively.

In a survey study Ramachandran and Ramakrishnan (1982) reported that duck farmers of Kerala claimed an average egg production of about 200 eggs per bird per annum.

Ramakrishnan *et al.* (1982) conducted preliminary studies on productive efficiency of crossbred (Khaki Campbell x Desi) duck under intensive farm condition. They recorded the egg number to 100 days from first egg as 38.7 ± 2.92 and that to 300 days of age as 47.4 ± 2.80.

In another short term study Ramakrishnan *et al.* (1982) assessed egg production trends in desi ducks of Kerala under semi-intensive system of rearing. They calculated weekly per cent duck-day and cumulative duck-housed egg production of desi ducks upto 49 weeks of production. These data revealed that the egg production of desi ducks widely fluctuated from week to week and the reason for these variations were attributed primarily to non-application of any systematic breeding procedures for stabilizing egg production. They estimated average production potential of desi ducks as 80

eggs per annum. They also computed the egg production from day of first egg to different periods as follows.

Days from first egg	Per cent production	
	Duck-day	Duck-housed
100	25.08	25.08
150	24.89	24.72
200	31.30	30.32
250	34.92	31.72
300	34.48	29.89
347	36.46	30.40

The above part egg production record for 200 days and above were close to annual production. they also observed two peaks in the production cycle, one around June-July and the other during November. In certain weeks overall production was as high as 70 per cent indicating that desi ducks had the production potential for high egg production although the peak production was maintained only for a very short duration. They attributed these peaks to possible differences in the release of L.H. (Leutinizing hormone).

In a survey study conducted by Ravindran *et al.* (1984), the average egg production was reported to be 130 to 140 eggs per duck per annum.

Andrews *et al.* (1984) observed that desi ducks of Kerala reared under intensive system (14.9 per cent) gave better duck-day egg production than those under semi-intensive system.

Itek Siam ducks of Malaysia were known to reach duck-day production of 74.5 per cent and the duck-housed average during the first two months of lay were 60 per cent in the dry season (Awang, 1984). During the rainy season, laying rate dropped to 20 per cent.

Eswaran *et al.* (1985) studied comparative performance of desi and Khaki Campbell ducks and the egg production performance was as below.

Character	Desi	Khaki Campbell
Egg number to 100 days from first egg	35.13	61.50
Egg number to 280 days of age	51.66	60.16
Per cent duck-housed egg production to 280 days of age	42.70	65.70
Per cent duck-day egg production to 280 days	43.98	66.45

In a survey study conducted by Rithamber *et al.* (1986) reported annual egg production of desi ducks 150 to 200 in the first two years of laying and peak egg production occurred at 6 to 11 months of age.

Sivaselvam and Prabhakaran (1986) in a comparative study found the average egg number upto 40 weeks of age as 53.16 in desi ducks of Tamil Nadu.

Wang and Xu (1987) recorded annual egg number in Muscovy ducks as 110.2 ± 3.77. They obtained highly significant correlation (0.83) between egg number in the first three months and total annual egg production. The clutch size was 6 to 41 eggs and the commonest size was 10 to 20. The number of eggs laid in the first clutch was positively correlated with annual egg number.

The average egg number of brown Tsaiya ducks to 245, 280 and 360 days of age was 107 ± 13, 139 ± 15 and 207 ± 26 respectively (Tai *et al.*, 1989).

For Khaki Campbell and local ducks of Tamil Nadu egg number to 40 weeks of age was 57.3 ± 1.06 and 59.1 ± 1.78 respectively (Gajendran *et al.*, 1990).

Haque and Hussain (1991) evaluated production potentiality of Khaki Campbell and desi ducks of Bangladesh

under scavenging system of management. They found per cent duck-day egg production of Khaki Campbell and desi ducks as 22.4 and 16.8 respectively and the corresponding value for per cent duck-housed egg production was 18.1 and 13.2 respectively.

Baruah *et al.* (1991) assessed the productivity of an indigenous duck of Assam (Pati), Khaki Campbell and their crosses under farm condition. The study revealed that the total egg number of Pati and Khaki Campbell to 364 days of age averaged 51.57 and 109.49 respectively.

Sheriff *et al.* (1991) in a comparative study obtained significantly better egg production in Khaki Campbell than desi ducks of Tamil Nadu.

Kalita *et al.* (1992) observed high genetic correlation between annual egg production and weight of eggs at 240 days of age (0.75).

In four strains of brown Tsaiya ducks Lee *et al.* (1992) recorded egg number to 52 weeks of age as 207, 220, 200 and 201 respectively.

For 120 Bali, Mojosari and Alabio ducks, daily egg production was 55.21, 64.0 and 79.62 per cent (Astiningsih *et al.*, 1994).

Cheng *et al.* (1995) while studying the genetic parameters in brown Tsaiya ducks obtained significant positive correlation between egg number to 52 weeks of age and egg number to 40 weeks (0.948), negative correlation between egg number to 52 weeks and egg weight at 40 and 30 weeks (-0.323 and -0.200 respectively).

Velez *et al.* (1996) while studying the effect of crossbreeding on reproductive traits recorded egg production to 52 weeks as 214 ± 7 in brown Tsaiya ducks and 150 ± 8 eggs in Pekin.

Egg weight

Bose and Mahadevan (1956) reported that the mean weight of duck egg varied from 62 to 72 g.

Romanoff (1967) reported the egg weight of different breeds of ducks such as Pekin, Mallard, Muscovy and Runner as follows.

Breed	Egg weight (g)
Pekin	85
Mallard	80
Muscovy	70
Runner	60

Sullivan (1961) reported that the egg weights in four groups of Khaki Campbell duck eggs varied from 50 to 75 grams.

Monstageer *et al.* (1971) recorded the egg weight in Pekin and Khaki Campbell breeds of ducks as 70.24 and 58.55 g respectively.

Chavez and Lasmini (1978) worked with three varieties of native Indonesian egg type ducks and recorded an egg weight of 63.0, 60.0 and 59.4 g respectively.

Kontecka (1979) obtained highly significant genetic correlation between egg weight and body weight at 8 weeks (0.30 to 0.38) in Pekin ducks of Poland.

Egg weight of Khaki Campbell duck averaged 56 ± 0.4 g and was found to be significantly correlated with duckling weight at day-old age (0.38) (Reddy *et al.*, 1979).

George *et al.* (1980) reported the mean egg weight of 572 eggs collected from desi ducks as 68.86 g.

Hetzel (1981) compared egg production characteristics of Indonesian native ducks with Khaki Campbell and noted the egg weight at 32 weeks of age in Tegal, Alabio, Bali and Khaki Campbell duck as 66.7, 63.5, 64.5 and 63.9 g respectively. The corresponding figures at 60 weeks of age were 70.1, 65.8, 67.1 and 65.2 g respectively.

In Black and Sepia variety of Muscovy ducks egg weight averaged 81.8 and 79.6 g respectively (Romboli and Migliore, 1982).

In crossbred (Khaki Campbell x Desi) ducks, Ramakrishnan *et al.* (1982) recorded weight of first egg as 55.0 ± 2.62 g and that of 300 days of age as 67.6 ± 0.89 g.

Egg weight of desi ducks of Kerala recorded by Andrews *et al.* (1984) averaged only 60.54 g.

Panda *et al.* (1984) reported average egg weight of Khaki Campbell ducks as 58.14 g.

In another study, Eswaran *et al.* (1985) reported egg weight at 280 days of age as 71.40 g in desi duck and 62.41 g in Khaki Campbell.

Sivaselvam and Prabhakaran (1986) in a comparative study found the egg weight at 40 weeks of age in Khaki Campbell and Desi ducks as 57.30 and 59.16 g respectively.

In brown Tsaiya ducks, Tai *et al.* (1989) recorded egg weight at 30th (64.2 ± 4.3 g) and 40th (67.8 ± 4.3 g) weeks of age.

While comparing the production performance of Khaki Campbell and desi ducks, Gajendran *et al.* (1990) reported egg weight at 40 weeks of age as 37.8 and 43.9 g respectively.

Haque and Hussain (1991) in a similar study in Bangladesh reported average egg weight of Khaki Campbell and desi ducks as 55.8 and 52.3 g respectively under scavenging system of management.

Sheriff *et al.* (1991) observed significantly heavier egg weight of desi duck than Khaki Campbell.

Kalita *et al.* (1992) obtained high genetic correlation between body weight at 20th week of age and total egg weight at 240 days of age (0.87).

In four strains of brown Tsaiya ducks egg weight at 52 weeks of age averaged 66.8, 67.4, 68.1 and 67.5 g respectively (Lee *et al.*, 1992).

Average egg weight of indigenous ducks of Assam (60.55 ± 2.9 g) was significantly higher than Khaki Campbell duck eggs (Mahanta *et al.*, 1993).

Velez *et al.* (1996) estimated average egg weight of brown Tsaiya ducks at 30 weeks of age as 62 ± 0.8 g.

Broodiness

Sturkie (1954) reported that the hormone prolactin is responsible for manifestation of broodiness in birds.

Cayuga and Black Indian Runner are the two kinds of broody ducks which incubate their own eggs (Leslie, 1975).

Ubiquitous Entok ducks, commonly known as Manila or Muscovy ducks were known to be excellent broody and were exploited as an incubator machine to establish an intensive duck egg industry in Borneo (Robinson *et al.*, 1977; Kingston *et al.*, 1978).

Ravindran (1983) in his survey study on the status of duck farming in Kerala revealed no indication about the presence of broodiness character in desi ducks. Large sized desi broody hens were used by the farmers for getting their duck eggs hatched out.

Banerjee (1986) described broodiness in chicken as the external evidence of the maternal instinct. It is a dominant sex-linked character. If a bird is to lay well, it must not be broody much of the time. Unless breeders are selected for non-broodiness, the offspring will show more broodiness each year with a decline in egg production.

Arnold *et al.* (1987) observed that waterfowl began incubating their eggs before the clutch was completed. No current hypothesis can explain this phenomenon. It was seen that the egg viability of six duck species including *Anas platyrhynchos*, declined during the period of laying if eggs remain unincubated. The decline in egg viability associated with delayed incubation played an important role in determining the most productive clutch size in temperate breeding waterfowl.

Biochemical characters (Blood protein polymorphism)

Many authors (Robertson, 1966; Leuthold, 1972) have described the importance of biochemical polymorphism in the improvement of domesticated animals. Compared to large animals, less work has been published on the biochemical polymorphism in poultry specially on ducks (Rajan and Pingel, 1977). Crawford (1990) also mentioned that limited research has been conducted in blood constituents and in biochemical traits of various species of ducks.

Polymorphism of antigenic factors on red blood cells and of serum prealbumins have been reported (McGibbon, 1944; Przytulski and Csuka, 1979). Tanabe *et al.* (1988) investigated on biochemical polymorphism in blood proteins of various duck breeds of Asia by starch-gel and polyacrylamide electrophoresis. They observed polymorphism at ten loci and

more pronounced differences in relationship were reported between Indonesian breed and ducks of China and Japan.

Serum albumin (Alb)

McIndon (1962) reported occurrence of two plasma albumin in the domestic fowl and the alleles responsible for their expression were F (Fast) and S (Slow).

Quinteros *et al.* (1964) observed three phenotypes (A, B and AB) in blood serum of turkey. Phenotypes A and B were homozygotes and each contained two protein bands (A fastest and B slowest). The heterozygote AB contained three bands.

Zderchuk (1987) studied the polymorphism of serum albumin in White Cornish and White Plymouth Rock fowl by starch-gel electrophoresis. He found that albumin was controlled by two alleles in White Cornish (A and B) and by three alleles in White Plymouth Rock (A, B and C). Analysis of variance indicated a significant association between albumin phenotypes and seven month egg production (highest for AA bird and lowest for BC birds in both breeds) and body weight (highest for AA and lowest for AB birds in White Cornish breed; highest for BB and lowest for BC birds in the White Plymonth Rock breed).

Nikolov (1988) studied the genetic polymorphism of blood serum and its relationship to the performance of laying hens.

He typed 144 blood samples for serum albumin (Alb) and calculated the frequencies of Alb^{A} and Alb^{B} genes as 0.285 and 0.715 respectively. The frequencies of the Alb^{AA}, Alb^{BB} and Alb^{AB} genotypes were 11, 54 and 35 per cent respectively. The intraclass correlations of the polymorphic traits with egg production ranged from 0.01 to 0.16 and with egg weight from 0.09 to 0.37.

Mazumder and Mazumder (1990) compared the electrophoretic mobility of serum albumin types in chicken and quail by using starch-gel electrophoresis. In both species, one of the expected electrophoretic phenotype (AA in the fowl and CC in the quail) was found out. In the White Leghorn fowl, the frequency of the A gene had increased from 0.24 in 1972-73 to 0.98 in 1987-88.

Serum transferrin (Tf)

Ogden (1962) studied the expression of transferrin gene in the serum proteins of the chicken and found two alleles (A and B) for the locus symbol Tfs.

Csuka *et al.* (1972), while studying the variability of some enzymes in blood serum of ducks, identified two alleles (A and B) for the transferrin locus symbol Tf. They observed three phenotypes AA, BB and AB. Phenotypes AA and BB were

homozygotes and each contained three protein bands (AA fastest and BB slowest).

Polymorphism of blood plasma transferrins in Sussex hens indicated relationship with egg hatchability (Suvareva *et al.*, 1973).

Ahlawat (1983) reported that in blood serum of Karaknath and Aseel breed of indigenous origin no transferrin polymorphism was present, all birds belonged to type BB only.

Using polyacrylamide gel electrophoresis, Chen *et al.* (1987) studied serum transferrin polymorphism in Tsaiya ducks of Taiwan. They observed six transferrin phenotypes and were controlled by three codominant alleles (TfA, TfB and TfC). The frequencies of the three alleles were 0.47, 0.29 and 0.24 respectively. They also calculated the genotype frequencies of the genotype AA, BB, CC, AB, AC and BC as 6.46, 4.76, 0.34, 39.8, 40.48 and 8.16 per cent respectively. The genotype frequencies of the heterozygotes exceeded that expected on the basis of Hardy-Weinberg equilibrium.

Serum post-transferrin-2 (Ptf-2)

Chen *et al.* (1995) observed polymorphism for post-transferrin-2 in plasma proteins of Pekin ducks. They found that post-transferrin-2 was controlled by two alleles (PtfA

and PtfB) and the frequency of the A allele was higher than the other. While compared with body weight of the ducks, they opined that the homozygote AA genotype had a higher average body weight than the other post-transferrin genotypes.

Materials and Methods

MATERIALS AND METHODS

In order to study the basic characteristics of the two distinct indigenous types of ducks, namely Chara and Chemballi of Kerala and evaluate the production potential of the above indigenous ducks, 500 sexed day-old female and 100 male ducklings each from the above two types were brought from M/s Susan Roy Hatchery of Chennithala, Kerala.

The ducklings were wing banded and weighed individually to obtain the day-old body weight. They were reared under deep litter system of management adhering to scientific managemental practices till eight weeks of age. Thereafter they were switched over to semi-intensive system.

The feed ingredients used in ration were analysed for proximate composition. Based on these values three types of ration were formulated (Table 2) as per levels suggested by Reddy *et al.* (1979). While formulating the ration every care was taken to avoid aflatoxin in the feed. Screening of aflatoxin B_1 in compound feed and individual feed ingredients was done regularly. The ducklings were provided with duck-starter feed upto 8 weeks of age and thereafter duck grower feed. Wet mash feeding system was followed. Feed was provided *ad libitum* in shallow plastic trays. Additional

Table 2. Ingredient composition (per cent) of formulated rations

Crude protein (%)	20.00	16.00	18.00
Metabolisable energy (KCal/kg diet)	2750	2700	2650
	Duck starter (0-8 weeks)	Duck grower (9-18 weeks)	Duck layer (19 weeks and above)
Ingredients			
1. Yellow maize	40.00	48.00	42.00
2. Rice polish	20.00	20.00	20.00
3. Wheat bran	-	6.00	-
4. Gingelly oilcake	5.00	5.00	7.00
5. Soyabean meal	17.00	8.00	14.00
6. Coconut cake	6.00	5.00	-
7. Dried fish	10.00	6.00	10.00
8. Oyster shell	-	-	5.00
9. Mineral mixture*	1.75	1.75	1.75
10. Common salt	0.25	0.25	0.25
For every 100 kg add:			
(i) Indomix A B_2D_3 (g)**	30	30	30
(ii) Nicotinic acid (g)***	5	5	5

* Mineral mixture: Poultrymin (Aries Agro-Vet Industries Pvt. Ltd.) contained calcium-32%, phosphorus-6%, Copper-100 ppm, cobalt-60 ppm, manganese-2700 ppm, Iodine-100 ppm, zinc-2600 ppm, magnesium-1000 ppm and iron-0.1%

** Indomix AB_2D_3 : Piramal Health Care Ltd., Mumbai. Each gram contains Vit.A-40,000 I.U., B_2-20 mg and D_3-5000 I.U.

*** Nicotinic Acid: Lab grade, HiMedia Laboratories Pvt. Ltd., Bombay.

water was also provided in sufficient number of waterers. Ducklings were vaccinated against duck plague at four weeks of age and it was repeated at 8th week. Individual body weight was recorded at 4, 8, 12 and 16 weeks of age.

At 18 weeks of age 300 females and 30 males from each type were retained for further studies and the remaining were disposed off. The females from each type were divided into three groups of 100 birds each. The ducklings were wing badged at 18 weeks of age and were provided with individual nest to facilitate recording of individual performance. Drakes of each type were maintained as a separate flock to study the external morphology and growth traits. In each pen wallowing facility was provided (Fig.1). Wallowing tanks were cleaned thoroughly every alternate day and filled with fresh water.

From 19 weeks onwards they were provided with duck layer mash in sufficient number of plastic basins (Fig.2). Body weights of individual duck were taken at 20 weeks of age and was repeated at 30, 40 and 52 weeks of age.

The following observations were recorded till the end of 52 weeks of age.

Fig.1. Wallowing tank for ducks

Fig.2. Feeding of Experimental ducks

External morphology

At 20 weeks of age individual measurements of the following body parts (Fig.3) were recorded:

1. Bill length from tip of bill to base of bill
2. Length of head plus neck from tip of bill to base of neck
3. Length of neck from base of head to base of neck
4. Length of body from base of neck to end of tail
5. Length of breast from base of neck to tip of keel bone
6. Body circumference at back region
7. Shank length from hock joint to base of toe
8. Total upright height from top of back to base of toe

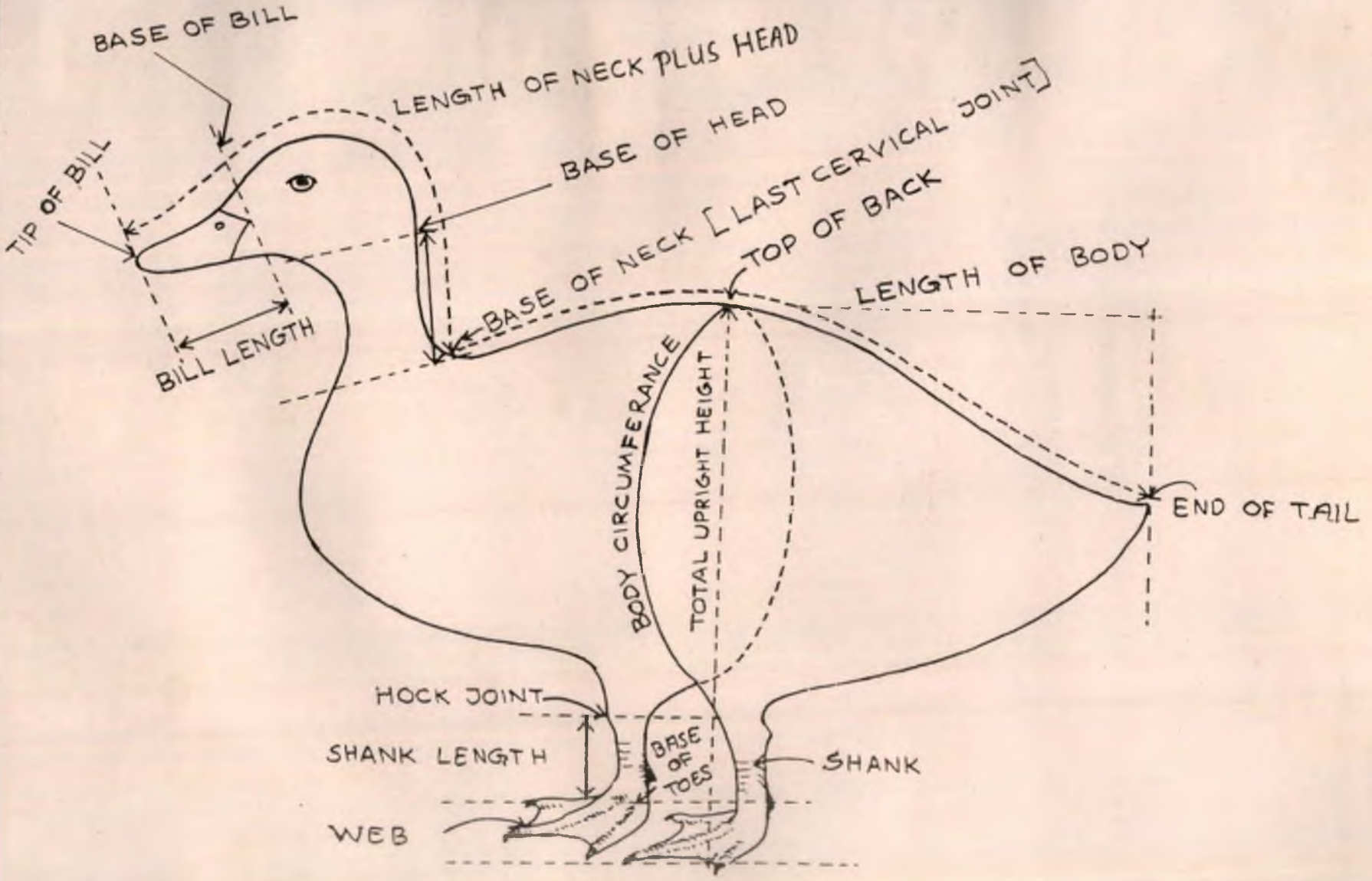
Plumage colour of head, neck, breast, back, wing and tail was recorded individually for both the types at 20 weeks of age. Colour and pigmentation of bill and feet of the ducks were also recorded.

The colour of egg shell was noted during 40 weeks of age.

Reproduction traits

From 18 weeks onwards, each duck was provided with individual laying nest and was put in the nest in the evening at about 4.30 pm and released the next morning at 7.30 am after recording eggs, if any, in the nest. Thus the individual age at first egg of both types of ducks housed in

Fig.3 DIAGRAM SHOWING THE POINTS OF MEASUREMENTS OF EXTERNAL BODY PARTS.



different pens was recorded. The average age at first egg was also calculated after taking all the individual records pooled together and noted separately for both the types.

The age at 5, 10 and 50 per cent production was worked out for Chara and Chemballi separately based on the number of eggs obtained from each whole flock of ducks housed.

Production traits

By nesting each bird (Fig.4), from beginning, the individual egg production was recorded. Total egg production for 100 days from date of first egg and that upto 364 days of age (52 weeks) was recorded. The duck-day number and per cent and the duck-housed number and per cent for each type was calculated. These records were maintained to calculate eight, 28 day laying period-wise and weekly per cent duck-day and duck-housed egg production. For constructing the production curve, records of egg production for eight periods comprising of 28 days each were used in both genetic groups.

Based on the individual egg production records attempts were made to measure intensity of egg production by clutch size, pauses and length of pause.

The weight of the first egg laid by individual ducks was recorded. The weight of eggs laid during 30, 40 and 50 weeks of age was recorded by taking the individual weight of eggs

Fig.4. Duck Layers in individual laying cages

laid during seven consecutive days. The eggs were weighed to the nearest 0.01 g. The shape index of individual eggs laid, during 40 weeks of age was calculated as per method suggested by Schultz (1953).

Broodiness trait was observed for all the individual ducks throughout the experimental period. The data on livability of all experimental ducks during brooding (0-8 weeks), growing (9-18 weeks) and laying (19-52 weeks) periods were recorded.

The data obtained from both Chara and Chemballi were subjected to statistical analysis as per Snedecor and Cochran (1980).

Biochemical protein polymorphism

One hundred fifty serum samples each were collected from group Chara and Chemballi ducks at 52 weeks of age for determination of polymorphism of non-enzymic components (albumin, transferrin and post-transferrin) of blood serum.

A method of horizontal polyacrylamide gel electrophoresis as described by Gahne *et al.* (1977) was followed with slight modification for simultaneous phenotyping of albumen, transferrin and post-transferrin-2. A discontinuous buffer system as described by Allen (1974) was used. During electrophoresis a constant current of 10 mA was applied with

a voltage of 150 V. The total time of electrophoresis was 18, 16 and 14 hours for getting clear bands of albumin, transferrin and post-transferrin-2 respectively. For standardization and identification of protein regions serum samples from cattle, chicken and ducks were run together. Gels were stained with one per cent naphthalene black 12 B for 10-20 minutes.

Gene frequencies were obtained by application of the Hardy-Weinberg equilibrium law. Analysis of variance was utilized for determination of correlation of albumin, transferrin and post-transferrin-2 phenotypes with the production traits. All nomenclature were proposed in accordance with the standard conventions.

Results

RESULTS

External morphology

The mean measurements of different body parts of Chara and Chemballi type of ducks are presented in Table 3. The plumage colour at various body parts like head, neck, back, tail, wing and breast and colour of bill and feet are shown in Table 4.

Chara Ducks

The Chara duck is so named by duck farmers based on their plumage colour.

The typical Chara drakes (Fig.5) were usually squat in posture and gait. The bill was dull orange with black spots and the feet were bright orange. The head was lustrous greenish black in colour. The neck was longer in drakes (21.10 cm from base of head to base of neck) than the female (18.70 cm) and had brownish black plumage with a full or half white band on the front of its neck. There was no difference in the length of body between the male (33.73 cm) and female (33.77 cm). The major plumage colour of back and tail was brownish black and occasionally blackish brown and greenish black were also found. Wing feathers showed a variety of colours and the majority of the males had brownish black and

Fig.5. Chara drake

grey feathers with primary and secondary feathers being deep and light brown, black and white and lustrous greenish black. The mean total upright height of the Chara drakes was 22.13 cm from the top of back to base of toe. The breast feathers were mainly light brown but few had brownish grey plumage. The drakes were usually bigger with a few tail feathers curled upwards and forwards, this being one of the characteristics used for sexing. The drakes emited a short hoarse and heavy sound.

The female Chara duck (Fig.6) had an erect gait (height 21.48 cm) and squat in posture. The general plumage colour of Chara female be described as blackish brown in the back, tail and wings, wherein black was predominant over brown. The bill was shorter (6.02 cm) than the male (7.0 cm) and was yellowish black, yellow with black spots and sometimes only yellow in colour. The feet were dull orange in colour. The head was mainly brownish black and occasionally blackish brown was also observed. The neck was usually brownish black and blackish brown with or without white band. The major plumage colour of back and tail was blackish brown. The wings adhered closely to the body and the ends of the feathers overcrossed each other on top of the tail. The wing feathers were blackish brown with primary and secondary feathers being lustrous greenish black, light black and white. The breast was primarily brownish black, but light brown and white were also observed. The toes rested flat on the ground and had a soft

Table 3. Mean (±SE) measurements (cm) of different body parts of Chara and Chemballi ducks at 20 weeks of age

External body parts	Chara		Chemballi	
	Male	Female	Male	Female
Bill length	7.00 ± 0.60	6.02 ± 0.52	7.00 ± 0.61	6.03 ± 0.56
Length of neck plus head	33.47 ± 0.16	30.78 ± 0.05	33.13 ± 0.21	30.96 ± 0.048
Length of neck	21.10 ± 0.157	18.70 ± 0.059	21.07 ± 0.21	18.95 ± 0.047
Length of body	33.73 ± 0.24	33.77 ± 0.086	33.90 ± 0.23	33.19 ± 0.078
Length of breast	15.83 ± 0.15	14.71 ± 0.097	16.23 ± 0.12	15.15 ± 0.071
Body circumference at back region	35.57 ± 0.22	35.37 ± 0.86	35.73 ± 0.16	34.43 ± 0.089
Shank length	7.07 ± 0.05	6.59 ± 0.034	6.98 ± 0.06	6.66 ± 0.025
Total upright height	22.13 ± 0.10	21.48 ± 0.051	22.36 ± 0.14	21.58 ± 0.034

Table 4. Sex-wise per cent distribution of plumage colour patterns of different body parts in Chara and Chemballi ducks at 20 weeks of age

Body parts	Chara				Chemballi			
	Male (N=30)	Per cent distri-bution	Female (N=300)	Per cent distri-bution	Male (N=30)	Per cent distri-bution	Female (N=300)	Per cent distri-bution
HEAD	Lustrous greenish black	100	Brownish black	96.67	Dull greenish black	100	Brownish black	91.67
			Blackish brown	3.33			Brown	8.33
NECK	Brownish black with full and half white bands	100	Brownish black with white bands	53.33	Brown with full and half white bands	100	Brown	45.33
			Brownish black	45.00			Brown with white bands	43.00
			Blackish brown	1.67			Brownish black	11.67
BACK	Brownish black	70	Blackish brown	94.67	Brownish black	66.67	Brownish black	71.67
	Blackish brown	30	Brownish black	3.33	Light brown	33.33	Brownish grey	28.33
			Blackish white	2.00				
TAIL	Brownish black	70	Blackish brown	97.00	Blackish brown	50.00	Brownish black	83.33
	Greenish black	30	Brownish black	3.00	Brownish black	26.67	Brownish grey	10.00
					Brown	23.33	Deep brown	6.67

Contd.

Table 4. (Contd.)

WING	Brownish black and grey	100	Blackish brown	100	Brownish grey	100	Brownish grey	100
BREAST	Light brown	66.67	Brownish black	73.33	Light brown	83.33	Light brown	48.67
	Brownish grey	33.33	Light brown	24.00	Brownish grey	16.67	Brownish black	46.33
			White	2.67			Brown and deep brown	5.00
BILL	Dull orange with black spots	100	Yellowish black	37.00	Yellow with black spots	100	Yellowish black	45.00
			Yellow with black spots	35.33			Yellow with black spots	28.33
			Yellow	27.67			Yellow	26.67
FEET	Bright orange	100	Dull orange	100	Bright orange	100	Dull orange	100

membrane webbing between them. The ducks emited a louder, more acute quacking for a longer time.

Females were observed to be more nervous than drakes. They laid white shelled eggs.

Chemballi Ducks

The Chemballi duck is also named based on their plumage colour.

The Chemballi drakes (Fig.7) were usually squat in posture and gait like Chara drakes. The bill was longer in drakes (7.0 cm) than the female (6.03 cm) and was usually with black spots. The feet were bright orange in colour. The head was dull greenish black. The neck was longer in drakes (21.07 cm) than the female (18.95 cm) and had brown plumage with full or half white bands. The body length in male and female (33.90 cm and 33.19 cm) was almost similar in measurement. The majority (66.67 per cent) of the drakes had brownish black plumage over the back region and the rest had light brown plumage. The usual plumage colour of tail coverts was blackish brown, while brownish black and brown coverts were also found. Wing feathers were mainly brownish grey with primary and secondary feathers being light and deep brown mixed with white. The total upright height of the Chemballi drake was 22.36 cm from the top of back to base of toes. The breast plumage was similar to that of Chara drake (light brown

Fig.7. Chemballi drake

and brownish grey). The major difference between the Chara and the Chemballi drake was the plumage colour of the head region. It was lustrous greenish black in Chara and dull greenish black in Chemballi.

The female Chemballi duck (Fig.8) had erect gait (height 21.58 cm) and little squat in posture. The general plumage colour of Chemballi female was brownish black and brownish grey in back, tail and wings, wherein brown was predominant over the black and grey. The bill was generally yellowish black, but yellow and yellow with black spots were also seen. The feet were dull orange in colour. The head was primarily brownish black and the neck was brown with or without white band. The back and tail coverts were mainly brownish black. The wing feathers were brownish grey with primary and secondary feathers being light and deep brown mixed with white. The breast was usually light brown and brownish black. The average body circumference of Chemballi duck (34.43 cm) was comparatively lower than the Chara duck (35.37 cm). Chemballi ducks laid white shelled eggs.

Body weight

The mean live body weights of Chara and Chemballi male at day-old, 4, 8, 12, 16, 20, 30, 40 and 52 weeks of age are presented in Table 5. The male day-old body weight of Chara was 47.87 ± 0.61 g, while that for Chemballi was 47.88 ± 0.70 g.

Table 5. Mean body weight (g) of Chara and Chemballi male at different ages

Age in weeks	Chara Mean ± S.E.	Chemballi Mean ± S.E.
Day-old	47.87 ± 0.61[a]	47.88 ± 0.70[a]
4	564.86 ± 11.15	595.60 ± 13.18
8	1059.82 ± 16.40[a]	1090.46 ± 18.72[a]
12	1417.19 ± 19.20	1430.24 ± 18.84
16	1634.57 ± 16.58	1623.43 ± 15.21
20	1643.00 ± 16.09[a]	1657.71 ± 15.22[a]
30	1621.00 ± 15.61	1610.00 ± 14.26
40	1574.39 ± 14.91	1560.43 ± 15.15
52	1395.50 ± 11.33[a]	1421.70 ± 10.47[a]

Figures with similar superscripts in a line do not differ significantly

Table 6. Mean body weight (g) of Chara and Chemballi female ducks at different periods of growth and egg production

Age in weeks	Chara	Chemballi
	Mean ± S.E.	Mean ± S.E.
Day-old	47.67 ± 0.32[a]	45.95 ± 0.40[b]
4	553.07 ± 7.25	566.48 ± 8.15
8	995.36 ± 8.87[a]	946.17 ± 9.71[a]
12	1370.05 ± 9.22	1417.94 ± 9.25
16	1534.86 ± 7.42	1487.63 ± 8.05
20	1538.15 ± 7.06[a]	1497.51 ± 8.38[b]
30	1486.36 ± 8.84	1466.68 ± 9.04
40	1494.07 ± 7.34	1475.45 ± 7.88
52	1335.24 ± 7.44[a]	1328.81 ± 8.42[a]

Figures with different superscripts in a line differ significantly ($P<0.01$)

At eight weeks, the body weight of Chara male was 1059.82 ± 16.40 g and that of Chemballi male was 1090.46 ± 18.72 g.

At 20 weeks, the male body weight of Chara and Chemballi were 1643 ± 16.09 g and 1657.71 ± 15.22 g respectively.

At 52 weeks, the Chara male and and Chemballi male weighed 1395.50 ± 11.33 g and 1421.70 ± 10.47 g respectively.

The statistical analysis of the body weights of Chara and Chemballi male at day-old, 8, 20 and 52 weeks of age indicated non-significant difference between the two types of indigenous ducks of Kerala. In both the types the body weight was increasing almost uniformly in a similar manner and attaining peak at 20 weeks of age. Thereafter the body weights of both the types were declining gradually till 52 weeks of age. The growth pattern of Chara male and female from 0 to 52 weeks of age is depicted in Fig.9.

The mean body weights of Chara and Chemballi female at day-old, 4, 8, 12, 16, 20, 30, 40 and 52 weeks of age are shown in Table 6. The day-old Chara and Chemballi female ducklings weighed 47.67 ± 0.32 g and 45.95 ± 0.40 g respectively.

At eight weeks, body weight of Chara and Chemballi female averaged 995.36 ± 8.87 g and 946.17 ± 9.71 g respectively.

Fig.9 GROWTH PATTERN OF CHARA DUCKS FROM 0 TO 52 WEEKS OF AGE

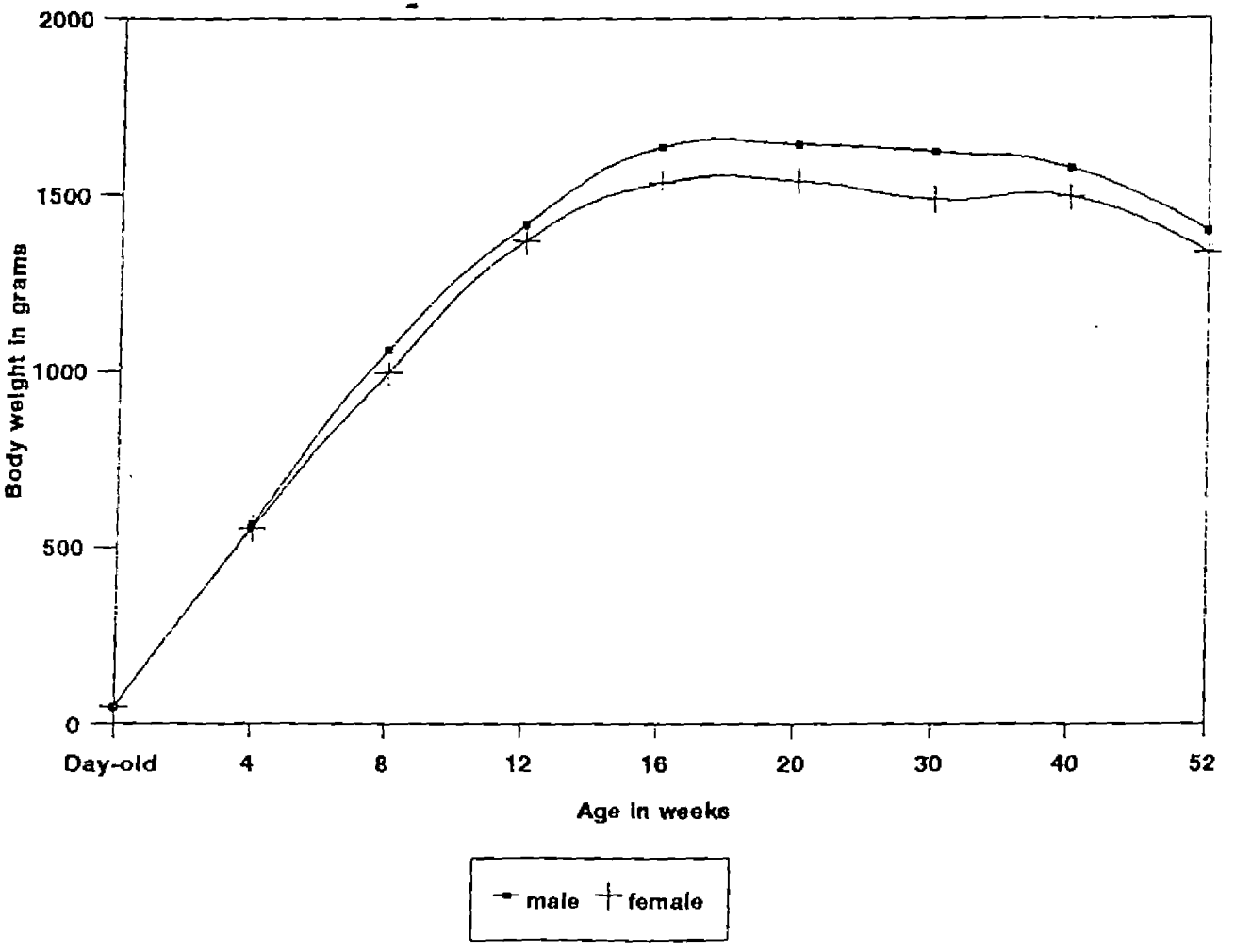
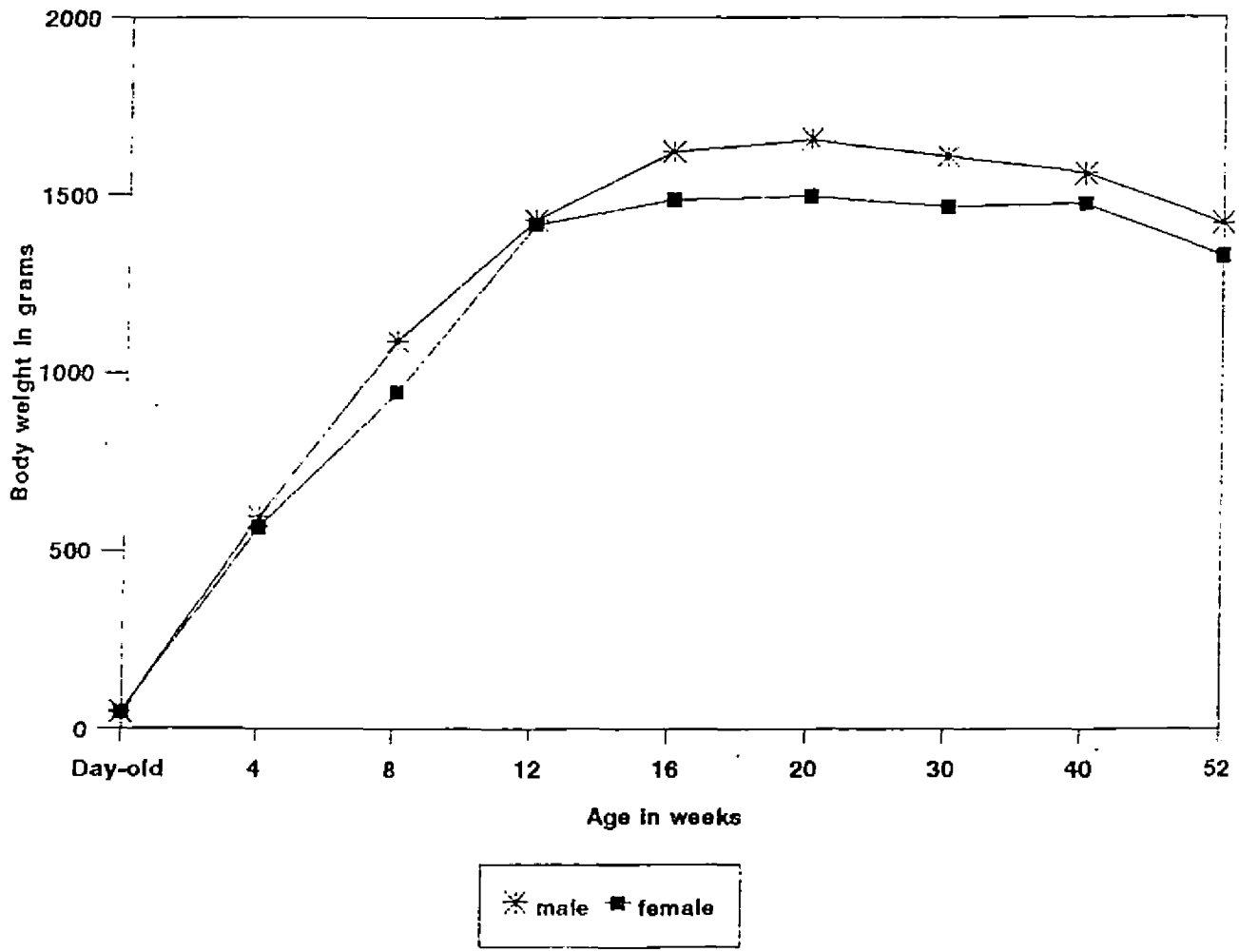


Fig.10 GROWTH PATTERN OF CHEMBALLI DUCKS FROM 0 TO 52 WEEKS OF AGE



At 20 weeks, mean body weights of Chara and Chemballi female were 1538.15 ± 7.06 g and 1497.51 ± 8.38 g respectively.

At 52 weeks of age the body weight of Chara female was 1335.24 ± 7.44 g, while that for Chemballi female 1328.81 ± 8.42 g.

The statistical analysis of the body weights at day-old, 8, 20 and 52 weeks of age showed highly significant ($P<0.01$) differences in body weights at day-old and 20 weeks of age between the Chara and Chemballi. Chara female ducks appeared to be having higher body weights than Chemballi except during 4 and 12 weeks of age. Significantly higher ($P<0.01$) body weight of Chara female was observed during day-old and 20 weeks of age. The body weights of Chara and Chemballi females were also increasing gradually and attaining peak at 20 weeks of age. Thereafter body weights were almost declining till 52 weeks of age. The growth pattern of Chemballi male and female from 0 to 52 weeks of age could be well predicted from Fig.10.

The coefficient of correlation between day-old body weight and 8, 20 and 52 weeks body weight of Chara and Chemballi were worked out and presented in Table 7. The table showed that the correlation between day-old body weight and 8 weeks body weight was higher in females (0.581 and 0.536) and males (0.452 and 0.472) of both the types of ducks. Thereafter, the correlation values were decreasing and found

Table 7. Coefficient of correlation between day-old weight and 8 weeks, 20 weeks and 52 weeks body weight of Chara and Chemballi ducks

Type of ducks	Day-old weight and 8 weeks body weight	Day old weight and 20 weeks body weight	Day old weight and 52 weeks body weight
Chara ducks			
Male	0.452	0.423	0.196
Female	0.581	0.495	0.160
Chemballi ducks			
Male	0.472	0.401	0.195
Female	0.536	0.443	0.174

Table 8. Coefficient of correlation between shank length and body weight at 20 weeks of age in Chara and Chemballi ducks

Type of ducks	Shank length and body weight at 20 weeks of age
Chara ducks	
Male	0.644
Female	0.635
Chemballi ducks	
Male	0.696
Female	0.589

minimum of 0.160 and 0.174 in females and 0.196 and 0.195 in males during 52 weeks of age.

Shank length

The average shank length of Chara and Chemballi at 20 weeks of age is presented along with the external body measurements in Table 3. The shank length of Chara male was 7.07 ± 0.05 cm and that of female was 6.59 ± 0.034 cm. The corresponding length for Chemballi male and female was 6.98 ± 0.06 cm and 6.66 ± 0.025 cm respectively.

The statistical analysis of the shank length indicated non-significant difference between the two types of ducks. The coefficient of correlation between shank length and body weight at 20 weeks of age in Chara and Chemballi is shown in Table 8. In males, correlation value of 0.644 and 0.696 was found for both Chara and Chemballi respectively. In females, slightly lower correlations of 0.635 and 0.589 were obtained for both Chara and Chemballi respectively.

Reproductive traits

Age at sexual maturity (ASM)

Informations on some reproductive traits of Chara and Chemballi are presented in Table 9. The first egg from the flock of Chara and Chemballi ducks was obtained on the same

Table 9. Reproductive traits of Chara and Chemballi ducks

Traits	Chara (N=300)	Chemballi (N=300)
Age at first egg of the flock in days	129	129
Average age of flock at first egg in days	148.59	147.50
Average age of flock at 5 per cent production in days	144	141
Average age of flock at 10 per cent production in days	153	148
Average age of flock at 50 per cent production in days	187	184
Days to reach 50 per cent production from the age at first egg	58	55

Table 10. Frequency distribution of age at first egg in days - the range and per cent among Chara and Chemballi ducks

Sl. No.	Age at first egg in days (Range)	Chara		Chemballi	
		Number	(%)	Number	(%)
1.	129-135	12	4.0	6	2.0
2.	136-140	24	8.0	33	11.0
3.	141-145	54	18.0	75	25.0
4.	146-150	75	25.0	81	27.0
5.	151-155	93	31.0	81	27.0
6.	156-160	36	12.0	21	7.0
7.	161-165	3	1.0	3	1.0
8.	166-170	3	1.0	-	-
Total	129-170	300	100.0	300	100.0

day i.e. at 129th days of age. The mean age at first egg was 148.59 and 147.50 days for Chara and Chemballi respectively.

The Chara and Chemballi ducks attained 5 per cent production at 144 and 141 days respectively and 10 per cent production at 153 and 148 days respectively. The average age of flock at 50 per cent production was 187 days in Chara and 184 days in Chemballi. The days to reach 50 per cent production from the age at first egg were 58 in Chara and 55 in Chemballi.

The frequency distribution of age at first egg recorded for Chara and Chemballi is presented in Table 10. It could be seen from the table that maximum number of birds (56 per cent) had their age at first egg in the range of 146-155 days in Chara type, whereas in Chemballi type 79 per cent of birds had their age at first egg in the range of 141-155 days. The birds that had the age at first egg at the two ends of the curve were very small.

Production traits

Duck-day egg production (period-wise)

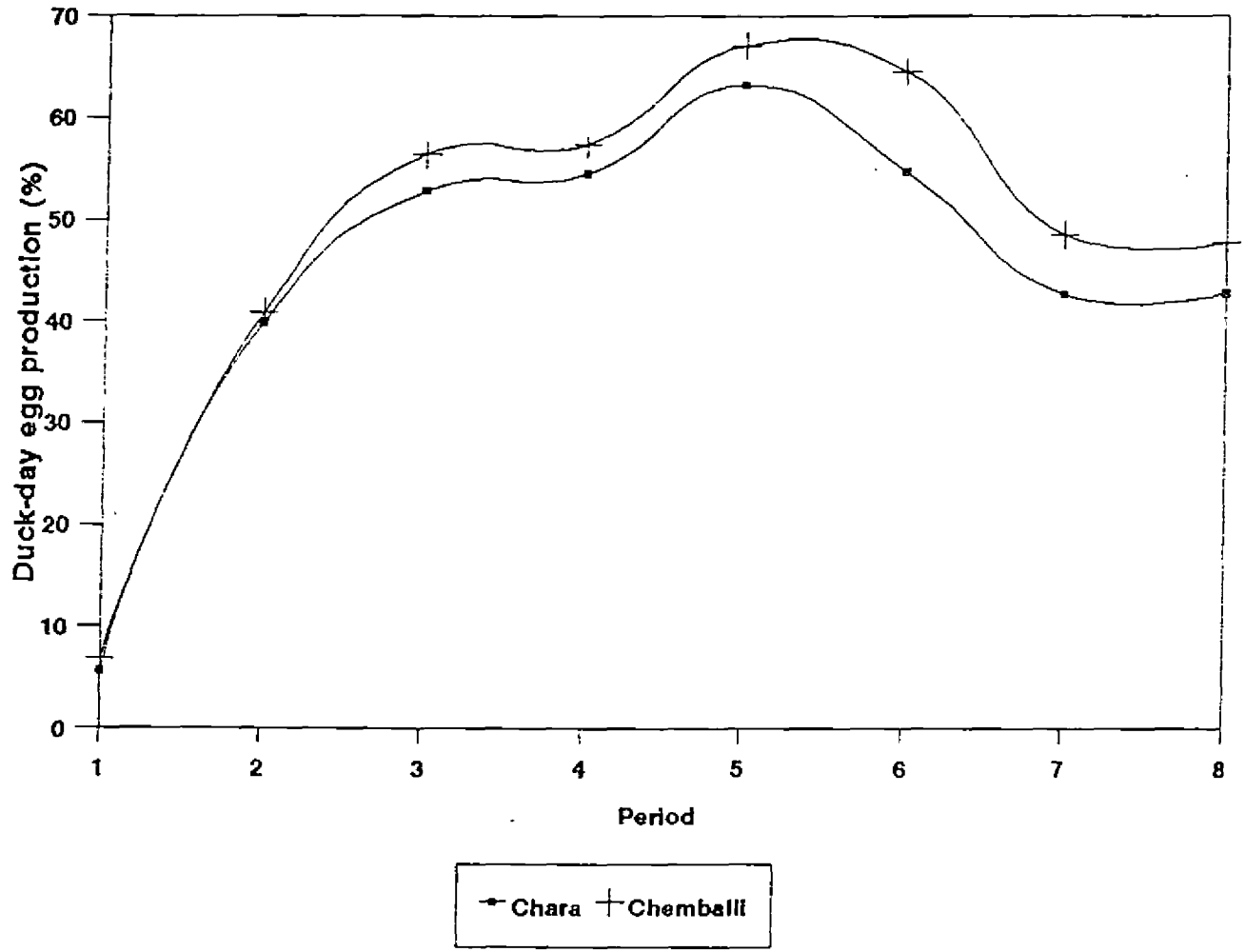
Mean egg number per duck and per cent duck-day egg production of Chara and Chemballi at eight 28-day laying periods from the date of first egg is presented in Table 11.

Table 11. Egg number per duck and per cent duck-day egg production of Chara and Chemballi at eight 28-day laying periods

Laying periods	Chara		Chemballi	
	Per duck	% Duck-day Mean ± S.E.	Per duck	% Duck-day Mean ± S.E.
1	2.01	5.70 ± 1.17 [a]	2.16	6.86 ± 1.25 [a]
2	13.07	39.92 ± 1.01 [a]	12.84	40.83 ± 1.07 [a]
3	16.50	52.83 ± 1.59 [a]	17.28	56.38 ± 1.82 [a]
4	17.86	54.51 ± 0.93 [a]	17.83	57.42 ± 1.16 [a]
5	21.16	63.22 ± 0.83 [b]	22.29	67.11 ± 0.97 [a]
6	18.07	54.76 ± 1.14 [b]	20.29	64.59 ± 1.28 [a]
7	14.97	42.68 ± 1.12 [b]	17.42	48.53 ± 1.48 [a]
8	12.45	42.75 ± 1.73 [a]	14.54	47.71 ± 2.08 [a]
Cumulative	116.09	-	124.95	-
Over all	-	44.49 ± 1.18 [b]	-	48.68 ± 1.29 [a]

Figures with different superscripts in a line differ significantly ($P<0.01$)

Fig.11 PERCENT DUCK-DAY EGG PRODUCTION OF CHARA AND CHEMBALLI DUCKS



The table revealed that in Chara ducks, mean egg number per duck and mean per cent duck-day egg production were gradually increasing from first period to fifth period and thereafter declining upto eighth period. During first period egg number per duck and per cent duck-day egg production was 2.01 and 5.70 ± 1.17 respectively. The egg number per duck per period was highest (21.16) during fifth period. During fifth laying period, per cent duck-day egg production was 63.22 ± 0.83 which was the highest among the eight laying periods. During eighth laying period egg number per duck and per cent duck-day egg production was 12.45 and 42.75 ± 1.73 respectively. The cumulative egg number per duck upto eighth laying period i.e. 50 weeks of age was 116.09 and the corresponding overall per cent duck-day egg production to 50 weeks of age was 44.49 ± 1.18.

In Chemballi ducks also similar trend of egg production was observed. The mean egg number per duck and mean per cent duck-day egg production was gradually increasing from first period to fifth and thereafter declining upto last eighth laying period. During first laying period the egg number per duck and per cent duck-day egg production was 2.16 and 6.86 ± 1.25 respectively. The highest egg number per duck (22.59) was obtained during the fifth laying period and the corresponding maximum duck-day production was 67.11 ± 0.97 per cent. During eighth laying period, the egg number per duck was 14.54 and the corresponding duck-day production was 47.71

± 2.08 per cent. The cumulative egg number per duck upto 8th laying period (50 weeks of age) was 124.95, which was higher than the egg number of Chara duck. The overall duck-day egg production of eight laying periods was 48.68 ± 1.29 per cent.

The statistical analysis of the period-wise per cent duck-day production between the two types of ducks indicated highly significant ($P<0.01$) differences in egg production during fifth, sixth and seventh period of laying. The overall duck day-egg production also differed significantly ($P<0.01$) between Chara and Chemballi. In Chemballi ducks significantly higher ($P<0.01$) per cent duck-day egg production was found during the above periods (5th, 6th, 7th and overall). The period-wise duck-day egg production pattern of Chara and Chemballi is presented together in Fig.11.

Duck-housed egg production (Period-wise)

Mean per cent duck-housed egg production of Chara and Chemballi at eight 28-day periods is presented in Table 12.

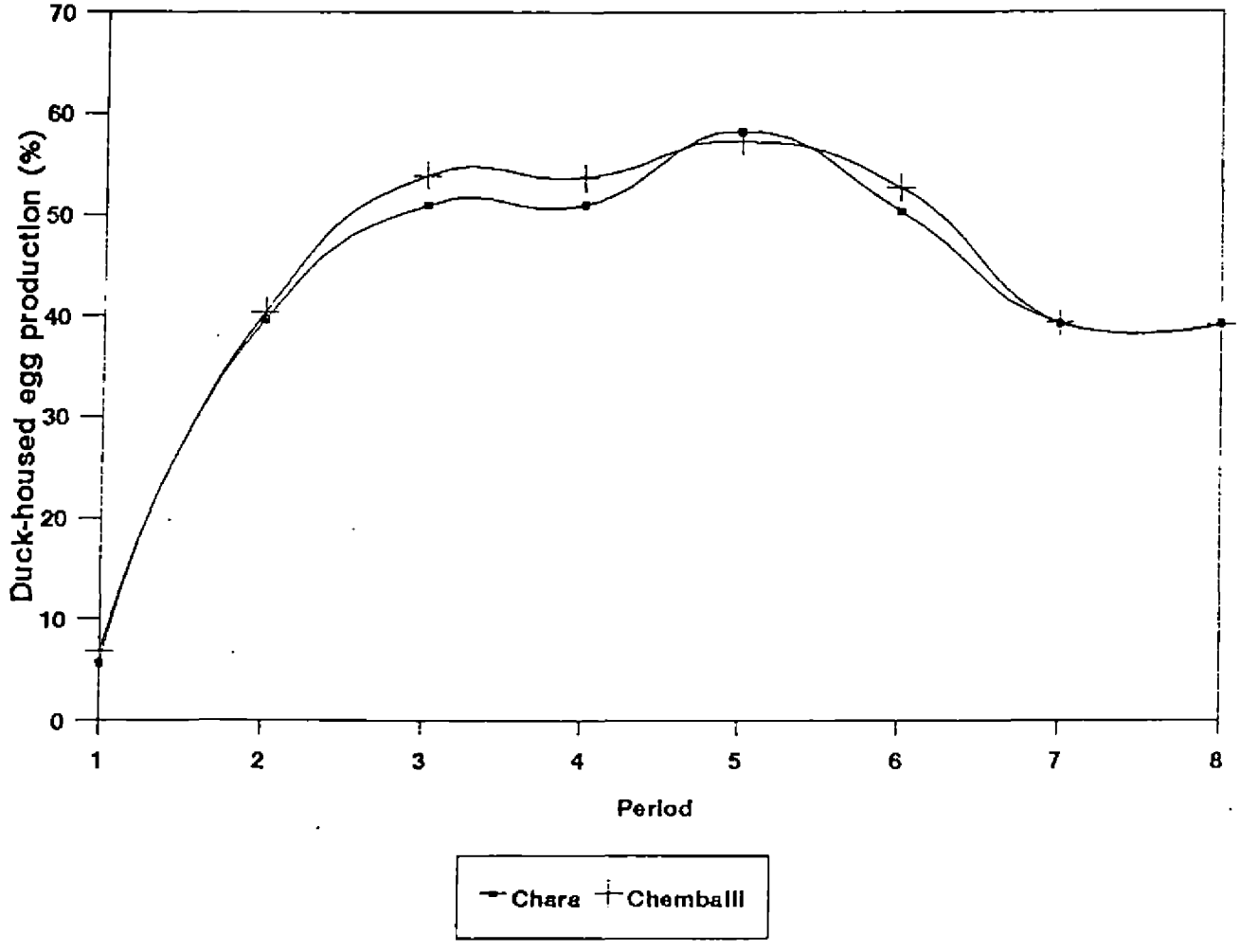
The result showed gradual increase in egg production from first to fifth laying period in both Chara and Chemballi. Thereafter gradual decline in egg production was observed upto seventh period and the production was almost similar at period 7 and 8. During fifth laying period maximum duck-housed egg production of 58.24 and 57.32 per cent was recorded in Chara and Chemballi respectively.

Table 12. Per cent duck-housed egg production of Chara and Chemballi at eight 28-day laying periods

Laying periods	Chara	Chemballi
	Mean ± S.E.	Mean ± S.E.
1	5.70 ± 1.17 [a]	6.86 ± 1.25 [a]
2	39.65 ± 0.98 [a]	40.38 ± 1.02 [a]
3	50.94 ± 1.50 [a]	53.88 ± 1.72 [a]
4	51.04 ± 0.83 [b]	53.69 ± 0.96 [a]
5	58.24 ± 0.76 [a]	57.32 ± 1.14 [a]
6	50.35 ± 1.06 [a]	52.69 ± 1.06 [a]
7	39.19 ± 1.03 [a]	39.35 ± 1.21 [a]
8	39.17 ± 1.59 [a]	39.08 ± 1.86 [a]
Overall	41.78 ± 1.09 [b]	42.91 ± 1.12 [a]

Figures with different superscripts in a line differ significantly ($P<0.05$ and $P<0.01$)

Fig.12 PERCENT DUCK-HOUSED EGG PRODUCTION OF CHARA AND CHEMBALLI DUCKS



The statistical analysis of the period-wise data of Chara and Chemballi showed highly significant ($P<0.01$) difference in duck-housed production during fourth laying period only. During this period Chemballi (53.69 per cent) had significantly higher egg production than that of Chara (51.04 per cent). The overall mean per cent duck-housed production of eight laying periods (upto 50 weeks of age) was significantly ($P<0.05$) higher in Chemballi (42.91 ± 1.12) than that of Chara (41.78 ± 1.09).

The highest egg production on duck-housed basis during the production period was 68 per cent in Chara at 252 days of age and 73 per cent in Chemballi ducks at 206 days of age (Table 14). These peaks were maintained for that single day alone.

The period-wise per cent duck-housed egg production pattern of Chara and Chemballi is depicted in Fig.12.

Weekly egg production

Mean weekly per cent duck-day and duck-housed egg production of Chara and Chemballi was calculated upto 52 weeks of age and is presented in Table 13. The table revealed that the weekly egg production of both Chara and Chemballi widely fluctuated from week to week. In chara, the average weekly duck day and duck housed egg production had gone upto 65.11 per cent and 59.91 per cent respectively. There were two

Table 13. Mean (±S.E.) weekly per cent duck-day and duck-housed egg production of Chara and Chemballi upto 52 weeks of age

Age in weeks	Chara		Chemballi	
	% Duck-day	% Duck-housed	% Duck-day	% Duck-housed
19	0.53 ± 0.08	0.53 ± 0.08	0.46 ± 0.08	0.46 ± 0.08
20	1.33 ± 0.34	1.33 ± 0.34	1.95 ± 0.51	1.95 ± 0.51
21	5.19 ± 1.04	5.19 ± 1.04	6.19 ± 0.63	6.19 ± 0.63
22	10.00 ± 1.69	10.00 ± 1.69	12.33 ± 0.99	12.33 ± 0.99
23	28.81 ± 1.04	28.81 ± 1.04	32.14 ± 1.01	32.14 ± 1.04
24	38.19 ± 0.62	38.16 ± 0.61	38.39 ± 1.27	38.28 ± 1.27
25	42.12 ± 1.35	41.76 ± 1.35	45.04 ± 1.05	44.53 ± 1.04
26	43.93 ± 0.94	43.33 ± 0.93	40.43 ± 1.49	39.67 ± 1.49
27	48.91 ± 1.89	48.00 ± 1.82	52.44 ± 2.60	50.52 ± 2.45
28	43.34 ± 1.69	42.43 ± 1.65	49.08 ± 2.01	46.99 ± 1.94
29	51.57 ± 3.09	50.14 ± 2.98	52.23 ± 2.72	49.81 ± 2.59
30	61.69 ± 1.06	59.57 ± 1.00	69.23 ± 1.58	66.00 ± 1.51
31	56.33 ± 1.22	52.76 ± 1.23	54.19 ± 1.53	51.67 ± 1.45
32	55.77 ± 0.64	52.71 ± 0.58	55.60 ± 1.14	52.99 ± 1.07
33	49.20 ± 1.43	46.84 ± 1.64	53.49 ± 1.07	49.86 ± 0.87
34	56.11 ± 2.21	51.95 ± 1.99	63.74 ± 1.91	58.48 ± 1.64
35	62.45 ± 1.44	57.67 ± 1.33	69.77 ± 0.87	62.72 ± 0.79
36	64.17 ± 1.95	59.19 ± 1.77	68.50 ± 1.12	59.67 ± 1.74
37	65.11 ± 1.21	59.91 ± 1.12	62.87 ± 1.28	51.76 ± 1.05

Contd.

Table 13 (Contd.)

Age in weeks	Chara		Chemballi	
	% Duck-day	% Duck-housed	% Duck-day	% Duck-housed
38	61.13 ± 1.69	56.24 ± 1.56	67.69 ± 2.79	57.24 ± 2.69
39	59.26 ± 1.62	54.38 ± 1.57	67.69 ± 1.82	55.48 ± 1.50
40	58.44 ± 0.82	53.76 ± 0.76	68.86 ± 1.56	56.24 ± 1.27
41	50.16 ± 1.66	46.14 ± 1.53	61.39 ± 2.25	50.05 ± 1.80
42	56.57 ± 0.79	52.05 ± 0.73	64.87 ± 1.38	52.76 ± 1.12
43	40.53 ± 1.32	37.29 ± 1.22	47.42 ± 1.73	38.57 ± 1.41
44	49.84 ± 1.14	45.86 ± 1.05	57.03 ± 1.71	46.33 ± 1.39
45	44.62 ± 1.29	40.90 ± 1.19	51.09 ± 2.82	41.30 ± 2.34
46	36.21 ± 1.17	33.19 ± 1.08	40.09 ± 0.64	32.48 ± 0.52
47	39.01 ± 0.98	35.76 ± 0.89	41.45 ± 1.26	33.57 ± 1.02
48	39.84 ± 0.97	36.52 ± 0.89	46.85 ± 1.97	37.95 ± 1.59
49	51.84 ± 1.64	47.52 ± 1.51	59.73 ± 1.32	50.11 ± 2.46
50	45.88 ± 2.25	42.00 ± 2.08	49.15 ± 2.68	39.81 ± 2.17
51	8.29 ± 3.68	7.57 ± 3.36	8.82 ± 4.07	7.14 ± 3.29
52	0.73 ± 0.08	0.67 ± 0.07	0.53 ± 0.08	0.43 ± 0.06
Overall	41.91 ± 3.02	39.71 ± 3.20	45.90 ± 3.71	40.46 ± 3.22

peaks in chara - one during 30th week of age (61.69 per cent duck-day and 59.57 per cent duck-housed) and another during 37th week of age (65.11 per cent duck-day and 59.91 per cent duck-housed). In Chemballi, the average weekly duck-day and duck-housed egg production increased upto 69.77 per cent and 66 per cent respectively. The first peak in Chemballi was obtained during 30th week of age (69.23 per cent duck-day and 66 per cent duck housed) and the second during 35th week of age (69.77 per cent duck-day and 62.72 per cent duck housed).

Egg number per duck for 100 days from first egg was calculated (Table 14) and was found as 44.82 in Chara and 46.06 in Chemballi.

The frequency distribution (%) of egg number per duck recorded in Chara and Chemballi upto 50 weeks of age is presented in Table 15. It could be observed from the table that percentage of ducks that laid less than 100 eggs was 33 per cent in Chara and 27 per cent in Chemballi. In Chara 56 per cent of the ducks laid between 100-139 eggs, whereas in Chemballi 52 per cent of ducks laid within this range. Percentage of ducks that laid more than 140 egg was 11 per cent in Chara and 21 per cent in Chemballi.

The coefficient of correlation between body weight at 20 weeks and egg production to 50 weeks of age was calculated and presented in Table 16. Negative correlation value of -0.208 and -0.335 was found between body weight at 20 weeks and egg

Table 14. Summary of Mean (±S.E.) production traits of Chara and Chemballi ducks upto 50 weeks of age

Traits	Chara (N=300)	Chemballi (N=300)
Egg number per duck upto 50 weeks of age	116.09 ± 1.15	124.95 ± 1.17
Egg number per duck for 100 days from first egg	44.82 ± 0.58	46.06 ± 0.75
Duck-housed per cent upto 50 weeks of age	41.78 ± 1.09	42.91 ± 1.12
Duck-day per cent upto 50 weeks of age	44.49 ± 1.18	48.68 ± 1.29
Weight of first egg (g)	61.27 ± 1.04	61.87 ± 1.01
Shape index of eggs at 40th week of age	75.45 ± 0.42	75.17 ± 0.40
Highest duck-housed per cent production	68.0	73.0

Table 15. Frequency distribution of egg number per duck for Chara and Chemballi upto 50 weeks of age

Sl. No.	Number of eggs (Range)	Chara		Chemballi	
		Number	(%)	Number	(%)
1.	Less than 100	99	33.0	81	27.0
2.	100-109	36	12.0	27	9.0
3.	110-119	51	17.0	36	12.0
4.	120-129	48	16.0	51	17.0
5.	130-139	33	11.0	42	14.0
6.	140-149	27	9.00	27	9.0
7.	150-159	6	2.0	24	8.0
8.	160 and above	-	-	12	4.0
Total		300	100.0	300	100.0

Table 16. Coefficient of correlation between body weight at 20 weeks and egg production upto 50 weeks of age in Chara and Chemballi ducks

Type of ducks	Body weight at 20 weeks and egg production upto 50 weeks of age
Chara ducks	-0.208
Chemballi ducks	-0.335

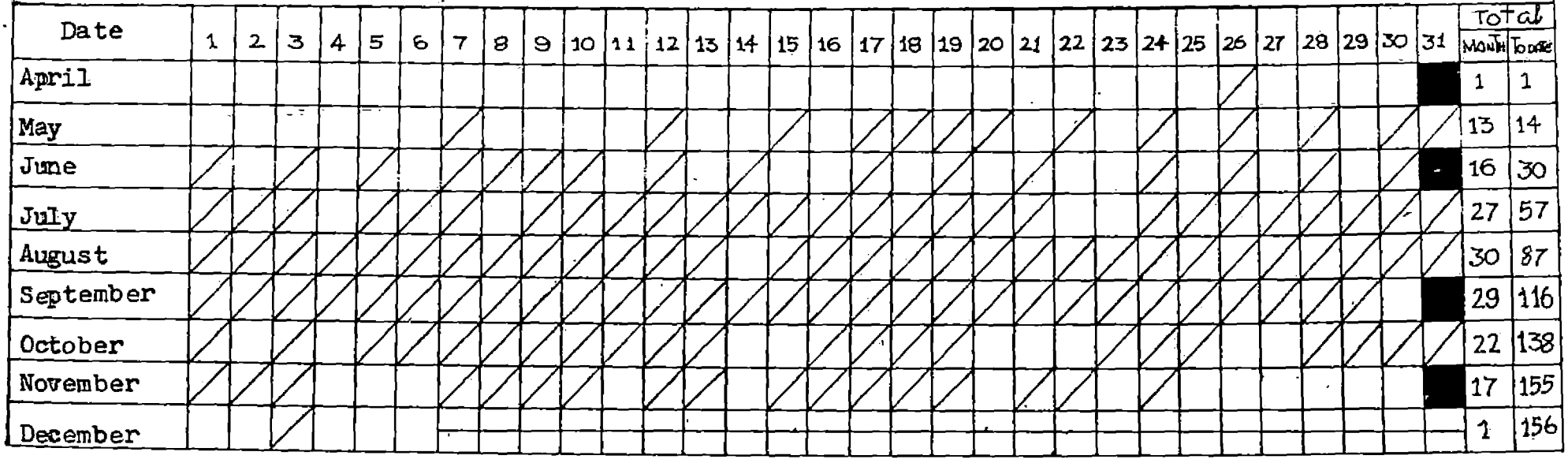
Table 17. Coefficient of correlation between egg production upto 40 weeks and egg production upto 50 weeks of age in Chara and Chemballi ducks

Type of ducks	Egg production upto 40 weeks and egg production upto 50 weeks of age
Chara ducks	0.887
Chemballi ducks	0.884

Fig.13. Individual Egg Record for Duck No.R-23

Breed/Type : Chara
Hatching Date : 9.12.1995
Maturity : 140 days

Wing badge No. R-23
20th week body weight : 1520 g
Year : 1996
Total days of recording from first egg : 225 days

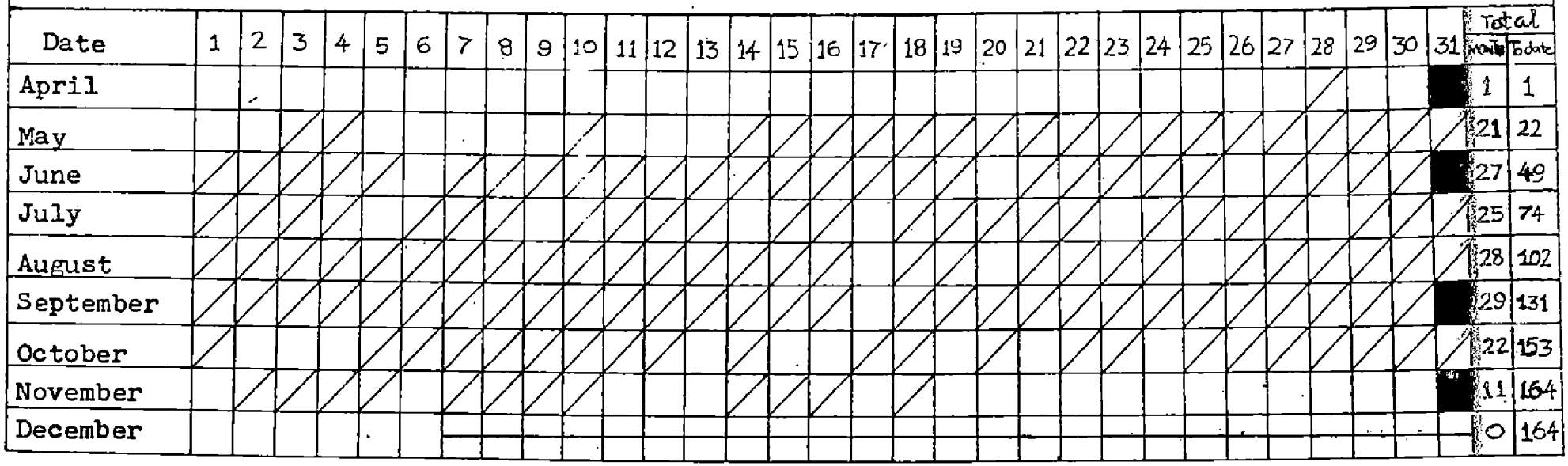


Date	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total Month	Total Upto
April																																1	1
May																																13	14
June																																16	30
July																																27	57
August																																30	87
September																																29	116
October																																22	138
November																																17	155
December																																1	156

Fig.14. Individual Egg Record for Duck No. L-111

Breed/Type : Chemballi
Hatching Date : 9.12.1995
Maturity : 142 days

Wing badge No. L-111
20th week body weight : 1490 g
Year : 1996
Total days of recording from first egg: 223 days



production to 50 weeks of age in both Chara and Chemballi respectively.

High correlation (0.887 and 0.884) was obtained between egg production upto 40 weeks and to 50 weeks of age in both Chara and Chemballi ducks (Table 17).

Intensity of egg production

The attempt to measure intensity of egg production using clutch size as criteria did not succeed since there were no discernible clutch size/pause either in Chara or Chemballi. Therefore, data collected from the best layer in Chara and Chemballi are presented in Fig.13 and 14. Fig.13 revealed that the best Chara duck (Wing badge No.R-23) laid 156 eggs in a production period of 225 days, while the best Chemballi record (Fig.14) indicated 164 eggs in 223 days of production (Wing badge No.L-111).

Egg weight

The average egg weights of Chara and Chemballi ducks during 30, 40 and 50 weeks of age are given in Table 18.

The average egg weight of Chara ducks during 30, 40 and 50 weeks of age was 68.19 ± 0.59, 69.94 ± 0.33 and 70.93 ± 0.55 g respectively with an overall average of 69.69 ± 0.47 g for the above age groups.

Table 18. Mean egg weight (g) of Chara and Chemballi ducks at different ages

Age in weeks	Chara	Chemballi
	Mean ± S.E.	Mean ± S.E.
30	68.19 ± 0.59 [a]	68.33 ± 0.56 [a]
40	69.94 ± 0.33 [a]	68.94 ± 0.20 [b]
50	70.93 ± 0.55 [a]	66.97 ± 0.65 [b]
Overall	69.69 ± 0.47 [a]	68.08 ± 0.45 [b]

Figures with different superscripts in a line differ significantly ($P<0.05$ and $P<0.01$)

Table 19. Frequency distribution of mean egg weight (g) in Chara and Chemballi ducks

Sl. No.	Egg weight (g) (Range)	Chara		Chemballi	
		Number	(%)	Number	(%)
1.	Less than 60.99	24	9.79	25	10.37
2.	61.00-65.99	66	24.18	65	26.97
3.	66.00-70.99	123	45.05	107	44.40
4.	71.00-75.99	41	15.02	35	14.52
5.	76.00-80.99	14	5.13	9	3.74
6.	81.00-85.99	5	1.83	-	-
Total		273	100.0	241	100.0

In Chemballi, the egg weight during 30, 40 and 50 weeks of age averaged 68.33 ± 0.56, 68.94 ± 0.20 and 66.97 ± 0.65 g respectively with an overall average of 68.08 ± 0.45 g at the age groups mentioned.

The statistical analysis of the egg weight data indicated that Chara ducks had significantly higher egg weight during 40 and 50 weeks of age and it was significantly comparable during 30 weeks of age between Chara and Chemballi. The overall mean egg weight of 30, 40 and 50 weeks of age was significantly ($P<0.05$) higher in Chara than that of Chemballi.

The frequency distribution of mean egg weight recorded for Chara and Chemballi is presented in Table 19. It could be seen from the table that maximum number of ducks had their egg weight within the range of 61.00-70.99 g in both Chara (69.23 per cent) and Chemballi (71.37 per cent) types. Percentage of ducks that had egg weight 71.00 g and above was 21.98 per cent in Chara and 18.26 per cent in Chemballi. In both Chara and Chemballi the percentage of ducks that had egg weight less than 60.99 g was 9.79 and 10.37 per cent respectively.

The mean egg shape index of Chara and Chemballi duck was 75.45 ± 0.42 and 75.17 ± 0.40 respectively (Table 14).

Coefficient of correlation between body weight and egg weight during 30, 40 and 50 weeks of age was determined and presented in Table 20. During 50 weeks of age lower

Table 20. Coefficient of correlation between body weight and egg weight during 30, 40 and 50 weeks of age in Chara and Chemballi ducks

Type of ducks	Body weight and egg weight during 30 weeks of age	Body weight and egg weight during 40 weeks of age	Body weight and egg weight during 50 weeks of age
Chara ducks	0.806	0.774	0.322
Chemballi ducks	0.791	0.812	0.363

Table 21. Per cent livability of Chara and Chemaballi ducks during brooding, growing and laying periods

Type of ducks	Brooding (0-8 weeks)	Growing (9-18 weeks)	Laying (19-52 weeks)
Chara (Total-600)	93.33	99.64	92.12
Chemballi (Total-600)	93.50	100.00	82.27

correlation (0.322 and 0.363) values were found in both Chara and Chemballi as compared to 30 (0.806 and 0.791) and 40 (0.774 and 0.812) weeks of age.

Pauses and length of pause

There were no definite and regular pauses during the entire laying period of Chara and Chemballi ducks. The erratic pattern of egg production might be the reason for such a trend of pauses or clutch sizes.

Broodiness

The presence of broodiness character among the flocks of Chara and Chemballi was observed only in 1.7 and 1.3 per cent of the birds. In Chara, the character was seen during 45 to 48 weeks of age, whereas in Chemballi, it was found little early (40 to 44 weeks of age). The broody ducks were reluctant to move and had a tendency to sit on the eggs. The overall egg production and body weight of these broody birds were found to be inferior compared to non-broody ducks.

Livability

The livability of Chara and Chemballi ducks during the three phases of growth - namely the brooding (0-8 weeks), growing (9-18 weeks) and laying period (19-52 weeks) are presented in Table 21. The table showed that the per cent livability during the brooding period for Chara and Chemballi

ducklings were 93.33 and 93.50 respectively. The corresponding figures for the growing period were 99.64 per cent and 100 per cent and for the laying period 92.12 and 82.27 per cent respectively. It was observed that the mortality during the early days of brooding was about 6.5 per cent in both the types and thereafter the losses were negligible except in Chemballi during the laying period (17.73 per cent mortality).

Blood proteins polymorphism

The electrophoretic pattern of transferrin, post-transferrin and albumin is shown in Fig.15, 17 and 19 respectively. The corresponding diagrammatic representation of the phenotypes is presented in Fig.16, 18 and 20 respectively. The variants of transferrin and albumin were clearly observed. The phenotype and gene frequency values for the transferrin, post-transferrin-2 and albumin are given in Table 22.

Transferrin (Tf)

In Chara ducks, no transferrin polymorphism was found, all birds were of type BB only. The phenotype BB contained two clear dark bands with slow movement followed by one very light weak band. The phenotype frequency of homozygote BB was 100 per cent.

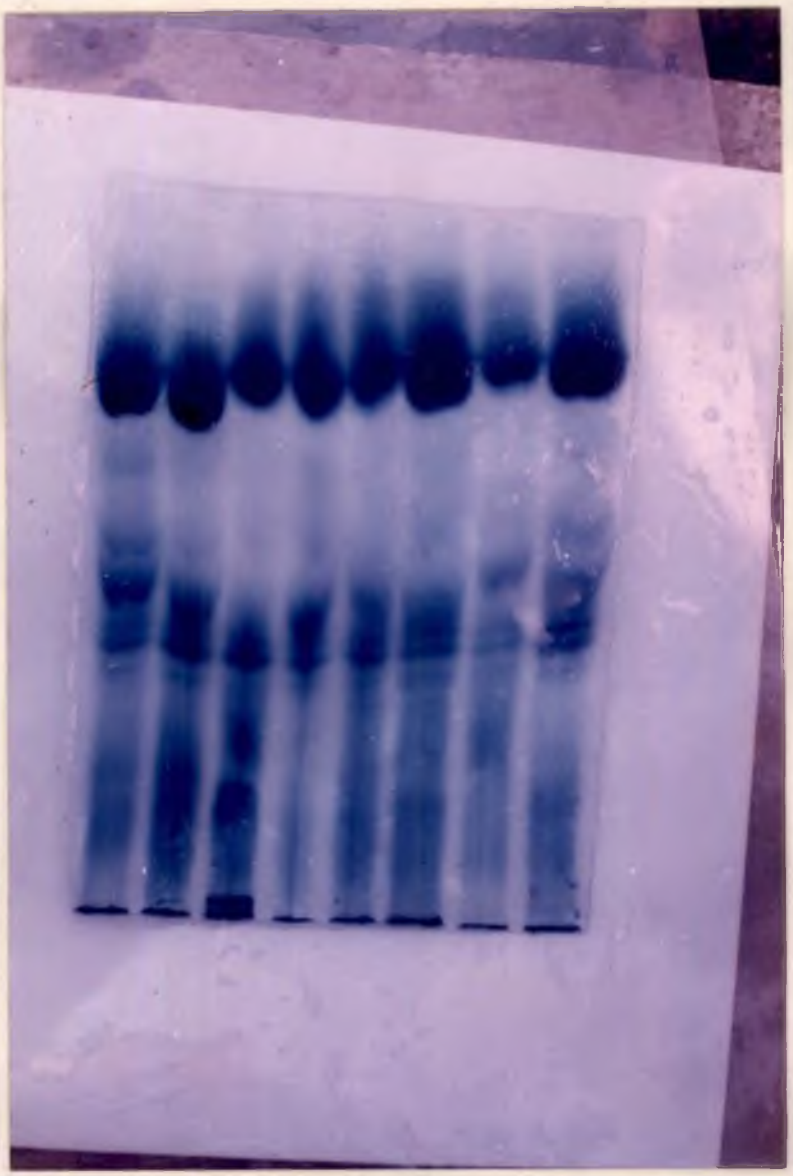


Fig.15. Phenotypes of serum transferrin (Tf)

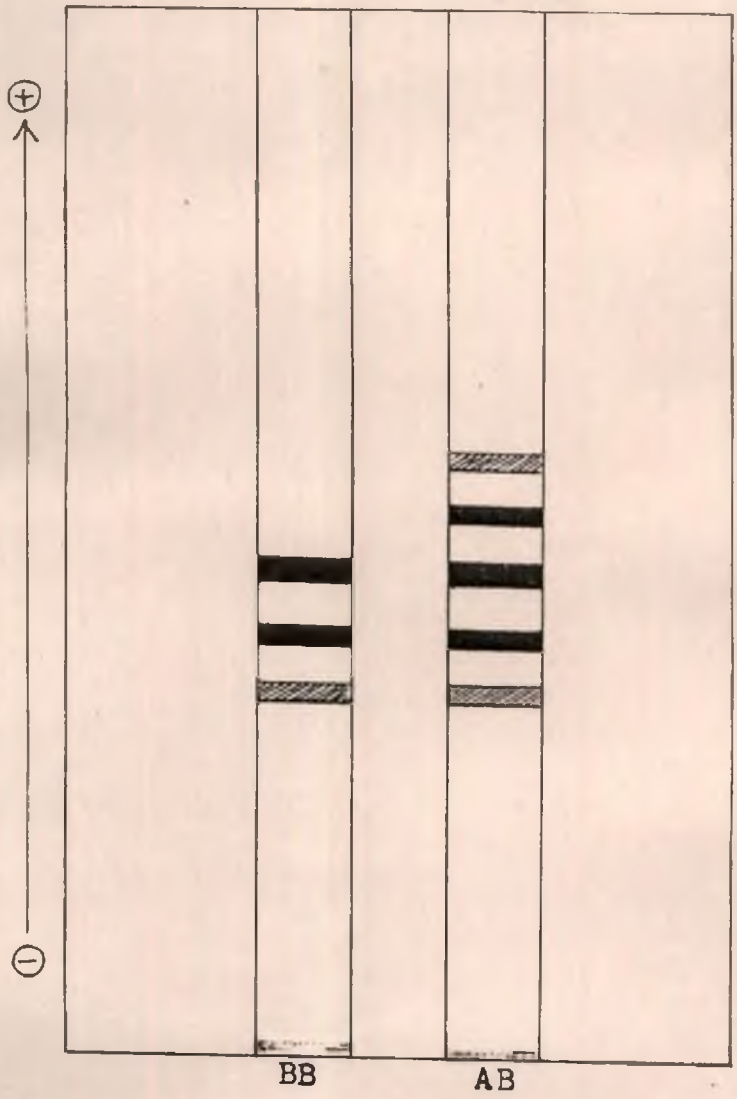


Fig.16. Diagrammatic representation of serum transferrin phenotypes

Table 22. **Phenotype and gene frequencies of transferrin, post-transferrin and albumin types in Chara and Chemballi ducks**

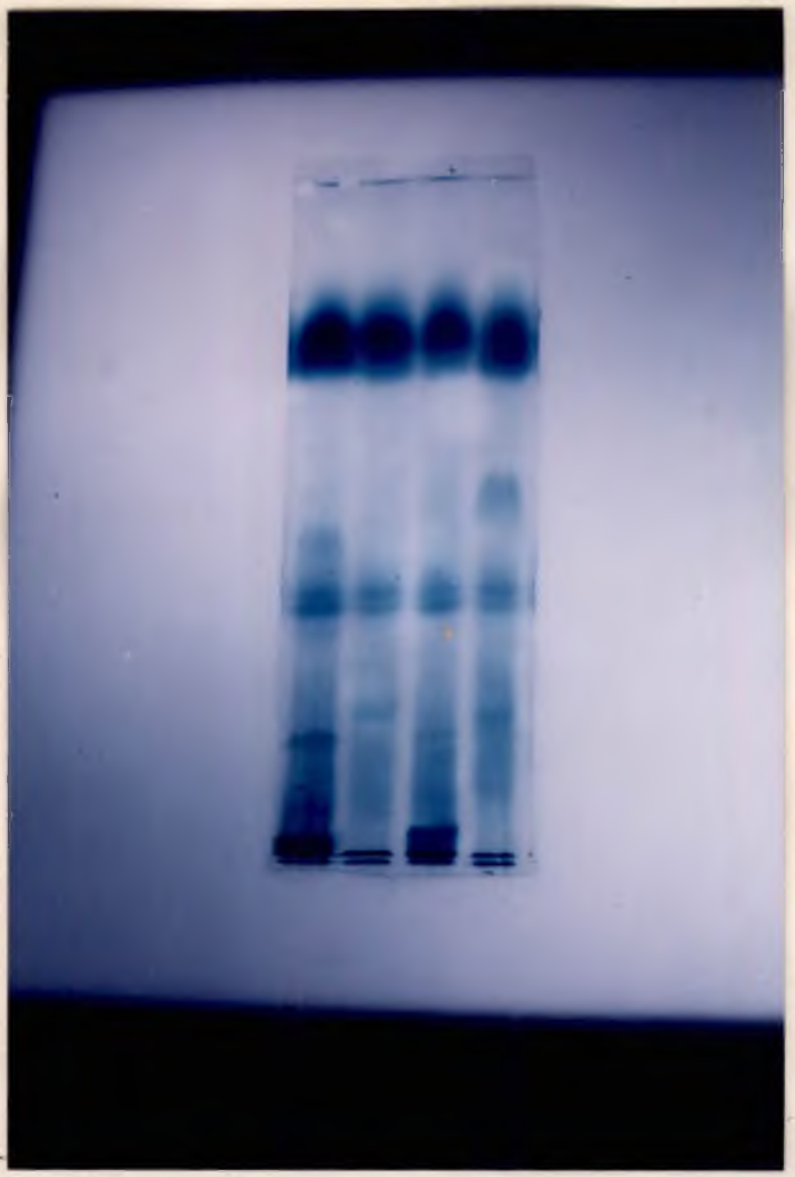
Population	Sample size/ no.of ducks	Transferrin phenotype frequencies			Transferrin gene frequencies		Post transferrin-2 phenotype frequencies			Post trans-ferrin-2 gene frequencies		Albumin phenotype frequencies			Albumin gene frequencies	
		AA	BB	AB	A	B	AA	BB	AB	A	B	AA	BB	AB	A	B
Chara	150	-	100.00	-	-	1.00	58.67	41.33	-	0.59	0.41	44.00	25.33	30.67	0.59	0.41
Chemballi	150	-	88.00	12.00	0.06	0.94	46.00	54.00	-	0.46	0.54	52.67	20.67	26.66	0.66	0.34

In Chemballi, two phenotypes BB and AB were found (Fig.15). One of the expected electrophoretic phenotype AA was not found. The heterozygote AB contained dark bands and two very light weak bands, one was fast moving and another one was slow moving. The frequencies of the Tf^{AB} and Tf^{BB} phenotypes were 12 and 88 per cent respectively. The frequencies of Tf^{A} and Tf^{B} genes were 0.06 and 0.94 respectively.

Post-transferrin-2 (Ptf-2)

Only one group of protein called Ptf-2 was observed in the post-transferrin region as shown in Fig.17. Two clear phenotypes AA and BB were recorded in both Chara and Chemballi. Each homozygote (AA and BB) contained only one protein band (AA fastest and BB slowest). No heterozygote individual was found.

In Chara, the frequencies of the Ptf-2 AA and Ptf-2 BB phenotypes were 58.67 and 41.33 per cent respectively and in Chemballi the corresponding frequencies were 46 and 54 per cent respectively. The frequencies of the Ptf-2 A and Ptf-2 B genes were 0.59 and 0.41 in respect of Chara and the corresponding frequencies in Chemballi were 0.46 and 0.54 respectively.



Ptf-2

1 2 3 4

BB AA BB AA

Fig. 17. Phenotypes of serum post-transferrin-2 (Ptf-2)

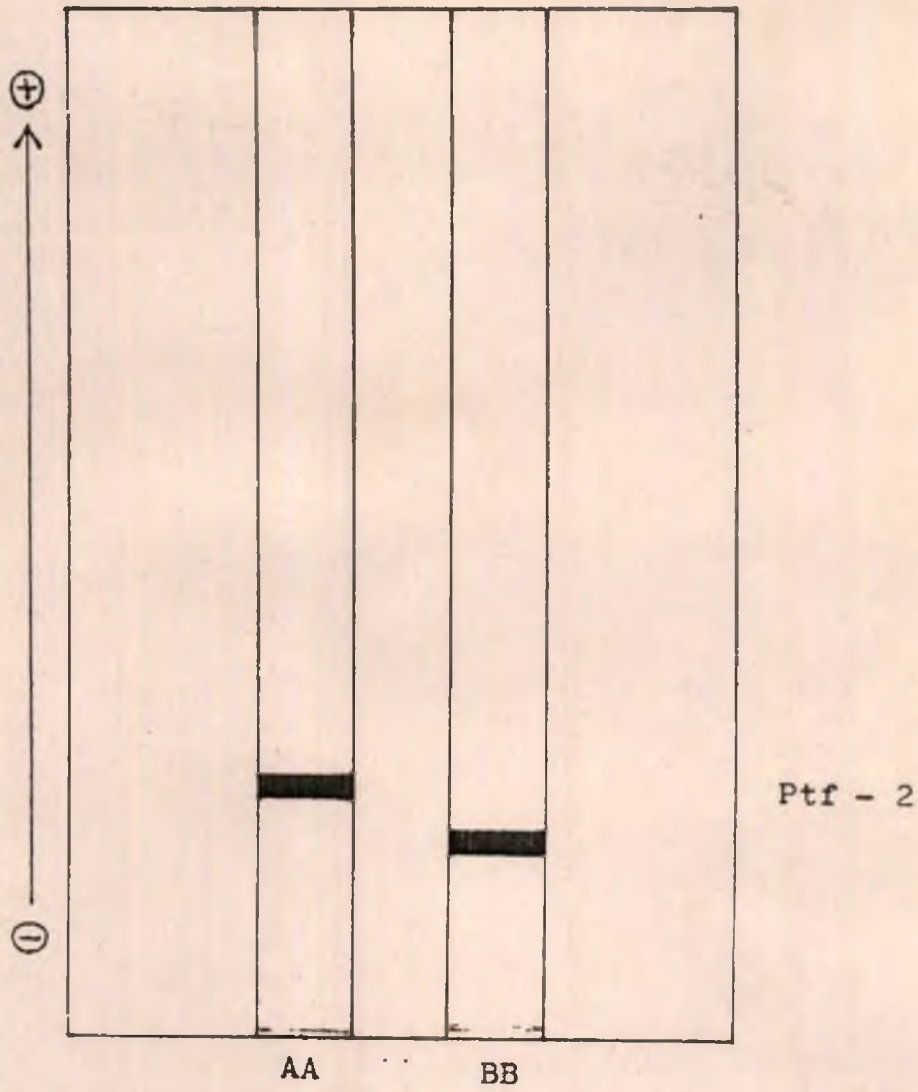


Fig.18. Diagrammatic representation of serum post-transferrin phenotypes.

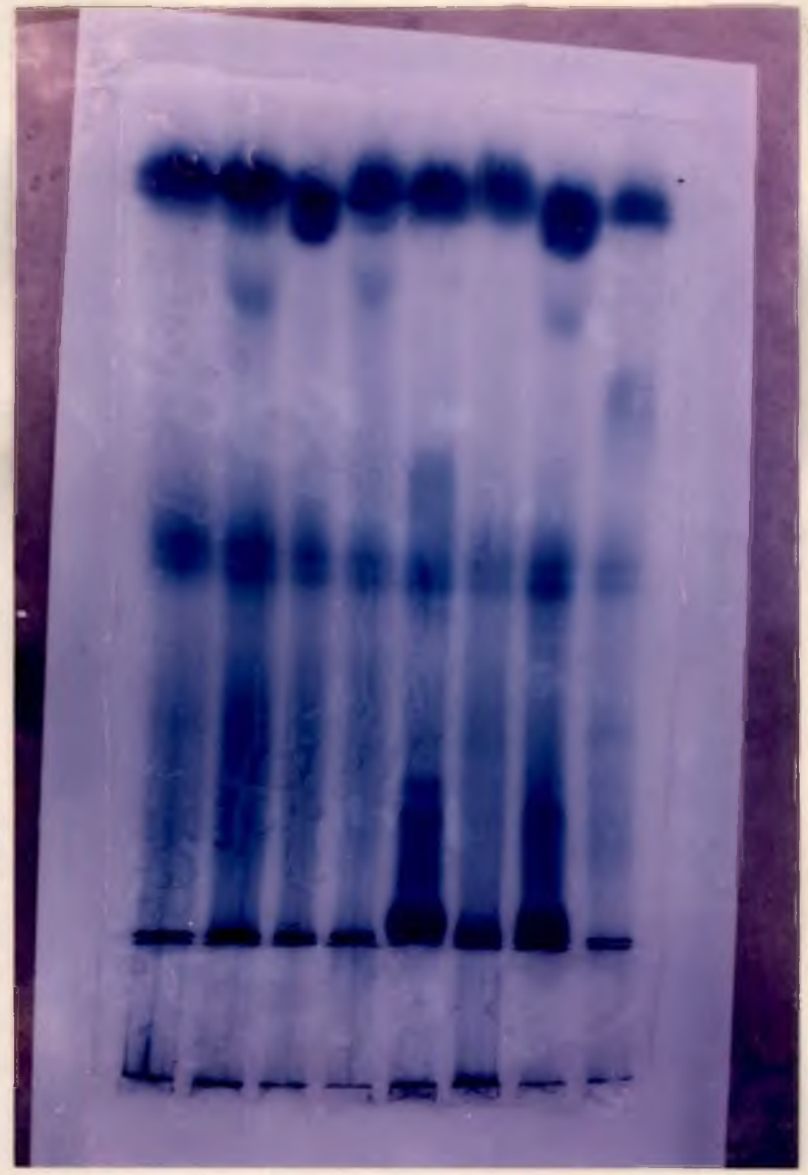
Albumin (Alb)

Three albumin phenotypes namely AA, BB and AB were observed (Fig.19) in both Chara and Chemballi. Phenotype AA and BB were homozygote and each contained two protein bands (AA fastest and BB slowest). Heterozygote AB contained three bands. Thus serum albumin in Chara and Chemballi was controlled by two alleles (A and B).

In Chara, the frequencies of the Alb^{AA}, Alb^{BB} and Alb^{AB} phenotypes were 44, 25.33 and 30.67 per cent respectively, whereas in Chemballi the corresponding frequencies were 52.67, 20.67 and 26.66 per cent respectively. The frequencies of Alb^{A} and Alb^{B} genes were 0.59 and 0.41 in Chara and the corresponding frequencies in Chemballi were 0.66 and 0.34 respectively.

Analysis of variance for serum transferrin phenotypes (BB and AB) and egg production, egg weight and body weight in Chemballi ducks indicated non-significant association between Tf phenotypes and production traits (Table 23). The mean values of the production traits under each of the transferrin phenotype is shown in Table 24.

Analysis of variance for serum post-transferrin-2 phenotypes (AA and BB) and egg production, egg weight and body weight in Chara and Chemballi duck is presented in Table 25. The table showed that in Chara, there was significant ($P<0.05$)



1.	2	3	4	5	6.	7	8
AA	AA	BB	AA	AA	AA	AB	AA

Fig.19. Phenotypes of serum albumin (Alb)

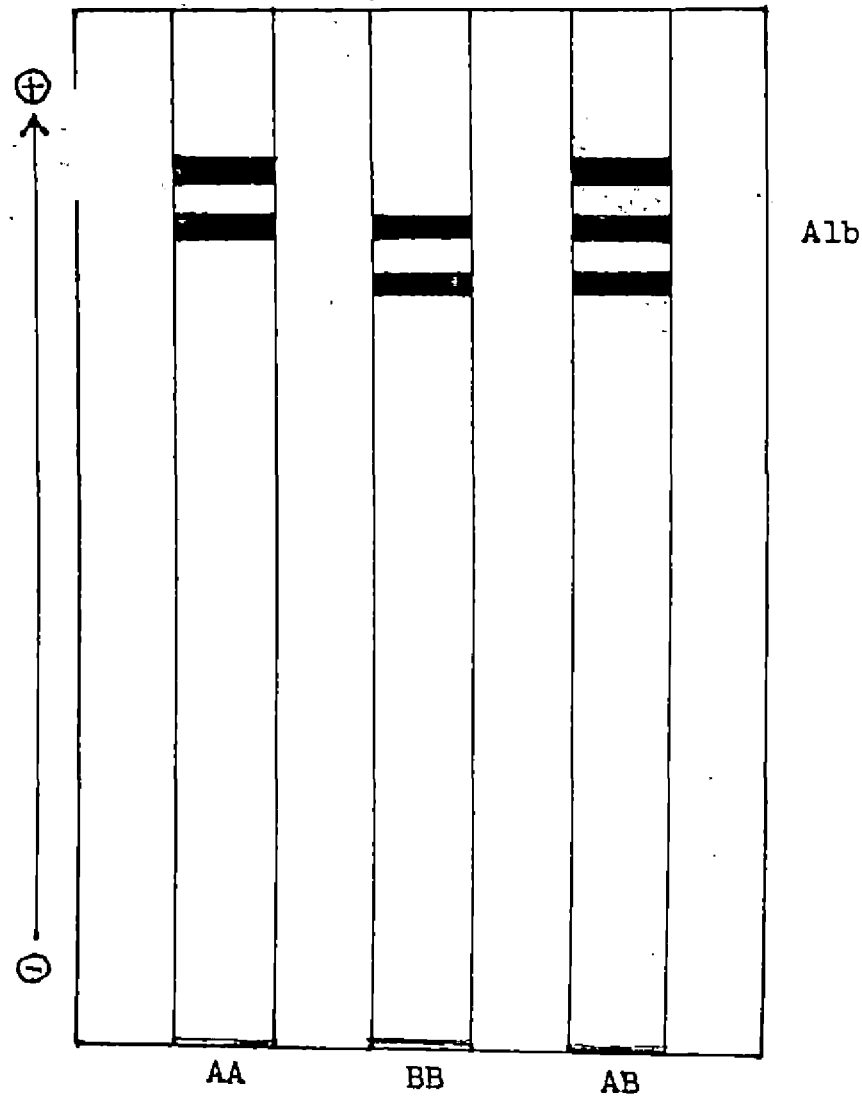


Fig.20. Diagrammatic representation of serum albumin phenotypes

Table 23. Analysis of variance for serum transferrin phenotypes and egg production, egg weight and body weight in Chemballi ducks

Source	Degree of freedom	Mean square		
		Chemballi		
		Traits		
		Egg production	Egg weight	Body weight
Between	1	1229.608 NS	0.033 NS	8078.273 NS
Within	148	948.277	24.457	27376.101

NS, Non-significant

Table 24. Mean values of egg production, egg weight and body weight for transferrin phenotypes in Chemballi ducks

Population	Trans-ferrin phenotype	Total number	Mean egg production upto 52 weeks of age	Mean egg weight (g)	Mean body weight (g)
Chemballi	BB	132	113.523	69.919	1461.774
	AB	18	122.333	69.871	1484.444

Table 25. Analysis of variance for serum post-transferrin-2 phenotypes and egg production, egg weight and body weight in Chara and Chemballi ducks

Source	Degree of freedom	Mean square					
		Chara			Chemballi		
		Traits			Traits		
		Egg production	Egg weight	Body weight	Egg production	Egg weight	Body weight
Between	1	1425.504 NS	97.203 *	240485.351 **	165.526 NS	2.985 NS	350575.460 **
Within	148	824.962	20.383	22082.991	729.397	37.701	19959.269

NS, Non-significant; *, Significant at P<0.05; **, Significant at P<0.01

Table 26. Mean values of egg production, egg weight and body weight for different post-transferrin-2 phenotypes in Chara and Chemballi ducks

Population	Post-transferrin phenotype	Total number	Mean egg production upto 52 weeks of age	Mean egg weight (g)	Mean body weight (g)
Chara	AA	88	110.659	70.915	1515.172
	BB	62	116.919	68.880	1433.279
Chemballi	AA	69	115.536	69.883	1436.087
	BB	81	117.650	69.530	1533.086

Table 27. Analysis of variance for serum albumin phenotypes and egg production, egg weight and body weight in Chara and Chemballi ducks

Source	Degree of freedom	Mean square					
		Chara			Chemballi		
		Traits			Traits		
		Egg production	Egg weight	Body weight	Egg production	Egg weight	Body weight
Between	2	45313.551**	113.387**	340833.216**	42990.869**	363.928**	508933.476**
Within	147	337.562	18.579	19156.741	223.599	19.448	18408.452

**, Significant at P<0.01

Table 28. Mean values of egg production, egg weight and body weight for different albumin phenotypes in Chara and Chemballi ducks

Population	Albumin phenotype	Total number	Mean egg production upto 52 weeks of age	Mean egg weight (g)	Mean body weight (g)
Chara	AA	66	131.303	70.319	1537.121
	BB	46	108.913	68.740	1502.174
	AB	38	70.000	67.314	1371.579
Chemballi	AA	79	133.810	68.391	1501.500
	BB	40	110.525	70.790	1527.468
	AB	31	72.032	64.673	1317.097

association between post-transferrin phenotypes and egg weight, whereas highly significant ($P<0.01$) association was found in respect of body weight. The mean egg weight and body weight were significantly higher in Ptf AA phenotype, but mean egg production did not show any significant difference between the phenotypes (Table 26).

In Chemballi only body weight had highly significant ($P<0.01$) association with Pft-2 phenotypes (Table 25). Unlike Chara, BB phenotype of Chemballi had significantly higher body weight than that of AA phenotype (Table 26).

Analysis of variance for serum albumin phenotypes and egg production, egg weight and body weight indicated highly significant ($P<0.01$) association between the albumin phenotypes and the production traits of both Chara and Chemballi ducks (Table 27).

The mean values of the production traits under each albumin phenotype are shown in Table 28. The critical difference test was also carried out between the albumin phenotypes in respect of all three production traits. In both Chara and Chemballi, mean egg production was highest for AA homozygote and lowest for AB heterozygote. The mean egg weight was highest for AA and lowest for AB ducks in Chara, whereas it was highest for BB and lowest for AB ducks in the Chemballi type. The mean live body weight was highest for AA

and lowest for AB ducks in Chara, whereas it was highest in BB and lowest for AB ducks in the Chemballi.

The frequency distribution of age at first egg recorded for three different albumin phenotypes (AA, BB and AB) in Chara and Chemballi is presented in Table 29. It could be seen from the table that the albumin phenotype AA was superior in both Chara and Chemballi in respect of age at first egg. In Chara type, maximum percentage (83.33 per cent) of Alb^{AA} phenotypes had their age at first egg within the range of 141-155 days, while in Chemballi 88.61 per cent of Alb^{AA} phenotypes had their age at first egg within the range of 136-150 days. The Alb^{AA} phenotypes that had the age at first egg at the two ends of the curve were very small.

The frequency distribution of egg number per duck upto 50 weeks of age recorded for different albumin phenotypes in Chara and Chemballi is presented in Table 30. It could be observed from the table that among the three albumin phenotypes Alb^{AA} was superior in respect of egg number per duck to 50 weeks of age. The percentage of Alb^{AA} phenotypes that had egg number within the range of 120-149 was 77.28 per cent in Chara and 68.35 per cent in Chemballi. However, number of birds which laid more than 150 egg was higher in Alb^{AA} phenotypes of Chemballi (19 per cent) than that of Alb^{AA} phenotypes of Chara (6.06 per cent).

Table 29. Frequency distribution of age at first egg in days for different albumin (Alb) phenotypes in Chara and Chemballi ducks

Sl. No.	Age at first egg in days (Range)	Chara						Chemballi					
		Alb^{AA}		Alb^{BB}		Alb^{AB}		Alb^{AA}		Alb^{BB}		Alb^{AB}	
		Number	(%)	Number	(%)	Number	(%)	Number	(%)	Number	(%)	Number	(%)
1.	129-135	2	3.03	2	4.35	-	2.53	2	2.53	-	-	-	-
2.	136-140	7	10.61	3	6.52	2	5.26	13	16.46	5	12.50	1	3.23
3.	141-145	15	22.73	6	13.04	3	7.90	29	36.71	6	15.00	2	6.45
4.	146-150	22	33.33	14	30.43	5	13.16	28	35.44	8	20.00	6	19.35
5.	151-155	18	27.27	15	32.61	13	34.21	7	8.86	12	30.00	10	32.26
6.	156-160	2	3.03	5	10.87	12	31.58	-	-	9	22.50	10	32.26
7.	161-165	-	-	1	2.18	1	2.63	-	-	-	-	2	6.45
8.	166-170	-	-	-	-	2	5.26	-	-	-	-	-	-
Total	129-170	66	100.00	46	100.00	38	100.00	79	100.00	40	100.00	31	100.00

Table 30. Frequency distribution of egg number per duck for different albumin (Alb) phenotypes in Chara and Chemballi ducks upto 50 weeks of age

Sl. No.	Number of eggs (Range)	Chara						Chemballi					
		Alb^{AA}		Alb^{BB}		Alb^{AB}		Alb^{AA}		Alb^{BB}		Alb^{AB}	
		Number	(%)	Number	(%)	Number	(%)	Number	(%)	Number	(%)	Number	(%)
1.	Less than 100	-	-	13	28.26	34	89.48	2	2.53	8	20.00	31	100.00
2.	100-109	3	4.54	11	23.92	-	-	4	5.06	10	25.00	-	-
3.	110-119	8	12.12	16	34.78	1	2.63	4	5.06	15	37.50	-	-
4.	120-129	21	31.82	3	6.52	-	-	21	26.58	6	15.00	-	-
5.	130-139	15	22.73	1	2.17	2	5.26	19	24.05	1	2.50	-	-
6.	140-149	15	22.73	2	4.35	1	2.63	14	17.72	-	-	-	-
7.	150-159	4	6.06	-	-	-	-	12	15.20	-	-	-	-
8.	160-169	-	-	-	-	-	-	3	3.80	-	-	-	-
Total		66	100.00	46	100.00	38	100.00	79	100.00	40	100.00	31	100.00

Table 31. Frequency distribution of mean egg weight (g) for different albumin (Alb) phenotypes in Chara and Chemballi ducks

Sl. No.	Egg weight (Range)	Chara						Chemballi					
		Alb^{AA}		Alb^{BB}		Alb^{AB}		Alb^{AA}		Alb^{BB}		Alb^{AB}	
		Number	(%)	Number	(%)	Number	(%)	Number	(%)	Number	(%)	Number	(%)
1.	Less than 60.99	-	-	3	6.52	2	5.26	2	2.53	-	-	4	12.90
2.	61.00-65.99	7	10.61	10	21.74	16	42.11	17	21.52	7	17.50	15	48.39
3.	66.00-70.99	26	39.39	21	45.65	16	42.11	28	35.44	14	35.00	12	38.71
4.	71.00-75.99	26	39.39	9	19.57	2	5.26	26	32.91	14	35.00	-	-
5.	76.00-80.99	6	9.09	3	6.52	2	5.26	5	6.33	4	10.00	-	-
6.	81.00-85.99	1	1.52	-	-	-	-	1	1.27	1	2.50	-	-
Total		66	100.00	46	100.00	38	100.00	79	100.00	40	100.00	31	100.00

The frequency distribution of mean egg weight (g) for different albumin phenotypes in Chara and Chemballi is presented in Table 31. The table revealed that in respect of egg weight Alb^{AA} phenotypes were superior in Chara and Alb^{BB} phenotypes were superior in Chemballi. Among the Alb^{AA} phenotypes of Chara 87.87 per cent had egg weight within the range of 66-80.99 g. In Chemballi 80 per cent of Alb^{BB} phenotypes had egg weight within the range of 66-80.99 g. There were no phenotypes in Alb^{AA} in Chara and Alb^{BB} in Chemballi that had egg weight less than 60.99 g.

The overall result of serum albumin polymorphism in Chara and Chemballi ducks indicated that in respect of age at first egg and egg production, the homozygotes AA were superior and the heterozygotes AB were inferior. In case of egg weight and body weight AA were superior in Chara and BB were superior in Chemballi. The AB heterozygotes were poor in egg weight and body weight.

Discussion

DISCUSSION

External morphology

The measurements of different body parts of Chara and Chemballi (Table 3) did not reveal any significant differences between the two types of ducks. However, Chara female ducks had comparatively higher body circumference (35.37 cm) than that of Chemballi (34.43 cm). The sexual dimorphism was clearly evident in males with higher measurements for head neck and body in both the types of ducks. Chavez and Lasmini (1978) also found sexual dimorphism in three native duck breeds of Indonesia.

The Chara and Chemballi drakes (Fig.5 and 7) were squat in posture and gait like that of the Alabio drakes of Indonesia. Chara and Chemballi drakes showed varying shades of similar plumage colour in different body parts. But the main difference between the two types of drakes was the plumage colour of the head. It was lustrous greenish black in Chara drake and dull greenish black in the Chemballi drake. Further, the bill was dull orange with black spots in Chara drake and yellow with black spots in Chemballi. Chavez and Lasmini (1978) differentiated the Alabio ducks and drakes from the plumage colour of top of head which was dark brown in females and glossy dark brown in males.

The Chara and Chemballi female ducks (Fig.6 and 8) had an erect gait and were more or less squat in posture. The Tegal ducks of Indonesia also had an erect gait but they were slender in posture (Chavez and Lasmini, 1978). The general plumage colour of Chara female could be described as blackish brown in the back, tail and wings wherein, black was the predominant colour over brown. The general plumage colour of Chemballi female was brownish black and brownish grey in back, tail and wing wherein brown was the predominant colour over the black and grey. The major plumage colour of Tegal and Alabio female was speckled brown with varieties of other colours (Chavez and Lasmini, 1978).

The egg shell colour of both Chara and Chemballi types of desi ducks in the present study was white. Most of the reports indicate that indigenous types of Indian ducks lay white shelled eggs. Among the Indonesian ducks, Bali laid white eggs but the Tegal and Alabio ducks laid blue-green eggs (Chavez and Lasmini, 1978).

Body weight

The data on the body weight of Chara and Chemballi males presented in Table 5 indicated that the body weight of day old Chara male ducklings was 47.87 g and that of Chemballi, 47.88 g. This showed no difference in day-old body weight of male ducklings of two types of indigenous ducks studied.

However, Eswaran (1983) reported lower day-old body weight (42.64 g) of male desi ducklings of Kerala compared to the present finding. He also observed that the Khaki Campbell male ducklings were having lower body weight (38.76 g) than the indigenous ducklings of Kerala.

The body weights recorded at four weekly intervals upto 20 weeks of age (Table 5) showed that the differences in body weights at any given age was not significantly different between the males of Chara and Chemballi types. The highest body weight of Chara (1643 g) and Chemballi males (1657.71 g) was recorded during 20 weeks of age. Eswaran (1983) observed the maximum average body weight of desi males of Kerala at 18 weeks of age (1525.79 g). The 16th week body weights recorded in Chara (1634.57 g) and Chemballi males (1623.43 g) in the present study were comparatively higher than that of Eswaran's (1983) findings of desi males (1507.22 g) of Kerala irrespective of any phenotypic types.

The differences in weight between 4 weeks interval at 4, 8, 12, 16 and 20 weeks of age in Chara male was 457, 495; 358, 217 and 9 g respectively. The corresponding figures in Chemballi male were 548, 505, 340, 193 and 34 g. These values indicated that in Chara males maximum weight gain was attained between 4 and 8 weeks of age (495 g), whereas in Chemballi maximum gain was between day-old and 4 weeks of age (548 g).

The rate of increase in growth of both types of males in the subsequent 4 week intervals was almost in the descending order. The higher rate of growth in both types was observed upto 12 weeks of age only and thereafter the rate of weight gain was comparatively less upto 20 weeks of age. Eswaran (1983) reported almost similar pattern of growth upto 11th week of age in both desi and Khaki Campbell ducks and thereafter reported comparatively lesser rate of gain upto 18 weeks of age.

The mean body weight of males after 20 weeks of age (Table 5) indicated that the body weights of males belonging to both genetic groups decreased gradually as the age of the birds advanced from 20th week to 52nd week of age. No significant differences in body weights were found between the two types during this period. The total decline in weight between 20 and 52 week of age was 247.5 g in Chara male and 226 g in Chemballi male. The maximum loss of weight after 20 weeks of age to the extent of 179 g in Chara and 139 g in Chemballi was observed between 40 and 52 week of age. This could possibly be attributed to the moulting that took place during this period. The 52 weeks body weight recorded in Chara and Chemballi male averaged 1395.50 and 1421.70 g respectively. Statistical analysis of the body weight data indicated that the difference in body weights at 52 weeks of

age between Chara and Chemballi males was not statistically different.

The mean body weights of Chara and Chemballi female ducklings from day-old to 52 weeks of age are presented in Table 6. The data revealed that the day-old body weight of Chara female ducklings was 47.67 g and that of Chemballi female, 45.95 g. It was also evident that the Chara female ducklings recorded significantly higher ($P<0.01$) weight than the Chemballi females. Eswaran (1983) reported lower day-old body weight of desi (43.33 g) and Khaki Campbell female (39.07 g) ducklings. He also observed higher body weight in female ducklings than that of males. In the present study a reverse phenomenon was noticed in Chemballi type but in Chara the day-old body weight in both males and females was almost similar. The average day-old body weights of straightrun ducklings; 42, 41 and 36.88 g recorded by George *et al.* (1980), George *et al.* (1981) and Sivaselvam and Prabhakaran (1986) respectively were also comparatively lower than the present findings.

The body weights recorded at four weekly intervals from day-old to 20th week of age also indicated that there was a gradual increase in body weight in both the types attaining a maximum of 1538.15 g in Chara female and 1497.51 g in Chemballi female at 20 weeks of age. The statistical analysis

revealed significantly higher ($P<0.01$) body weight in Chara females than that of Chemballi during 20 weeks of age. In Chara females, the gain in body weight between subsequent 4 weeks interval from day-old to 20 weeks of age was 505, 442, 375, 165 and 4 g respectively, whereas in Chemballi the corresponding figures were 520, 380, 472, 70 and 10 g respectively. In both the types of ducks higher rate of growth took place between day-old to 12 weeks of age and thereafter the gain was comparatively less. Similar trend of growth in Kerala desi was reported by Eswaran (1983) upto 11 weeks of age, whereas Reddy and Reddy (1979) studying with Khaki Campbell found significantly higher rate of growth upto fifth week of age only and afterwards the rate of increase was lesser.

The mean body weights of female ducks after 20 weeks of age given in Table 6 indicated that as the age of birds advanced from 20 to 30 weeks of age loss of weight to a tune of 52 g in Chara and 31 g in Chemballi females was observed. After 30th week the ducks maintained their weights upto 40 weeks of age. At 52nd week a loss of 159 g body weight in Chara and 147 g loss in Chemballi in comparison with 40th week body weight was recorded. This tendency among laying birds is a usual phenomenon. Eswaran (1983) also observed similar trends of growth pattern in Kerala desi during laying period upto 280 days of age.

The female body weight in general indicated that Chara ducks tended to be heavier than Chemballi eventhough statistically not different at all ages except 4 and 12 weeks. The rate of growth in both types was almost similar.

The correlation between day-old weight and 8th week, 20th week and 52nd week body weight of Chara and Chemballi pointed out that there was correlation less than 0.5 between day-old weight and weight at 8, 20 and 52 weeks in both genetic groups (Table 7). However correlation of 0.581 and 0.536 between day-old weight and body weight at 8 weeks were found in Chara and Chemballi females respectively. Significant correlations between hatch weight and body weights of desi males at first, 4th and 8th weeks were reported by George *et al.* (1977). However, he could not find any significant correlation in case of desi females at the end of 12th week of age. On the other hand, Eswaran (1983) reported non-significant correlation between the hatch weight and the weights at 8 and 18 weeks in both Khaki Campbell and desi ducks of Kerala.

In general, the pattern of growth, both in Chara and Chemballi showed a linear increase from day-old to 20 weeks of age (Fig.9 and 10). Similar pattern of growth upto 18 weeks of age was observed by Eswaran (1983) in Khaki Campbell and desi ducklings of Kerala, although the rate of growth in Khaki Campbell was found to be higher than the desi. In the present

findings, in both sexes and types the pattern of growth after 20 weeks of age was almost linear decrease upto 52 weeks of age.

Shank length

The mean shank length (Table 3) at 20 weeks of age showed non-significant difference between the two types of ducks. However, within types, the shank length was significantly ($P<0.01$) higher in males than that of females.

At 20 weeks of age, positive correlations of 0.644, 0.635, 0.696 and 0.589 between shank length and body weight were found in male and females of both Chara and Chemballi (Table 8). George *et al.* (1979) observed highly significant difference between sex for shank length at 12 weeks of age and found highly significant ($P<0.01$) and positive correlation of 0.26, 0.32 and 0.44 between shank length and body weight in male, female and straightrun, respectively. In male and female Pekin ducks, Gorski (1992) reported significant correlation (0.32 to 0.96) between body weight and shank length at 14, 28, 42 and 56 days of age.

Age at sexual maturity

The information regarding some of the reproductive traits of Chara and Chemballi (Table 9) ducks studied showed that the

average age at first egg among Chara and Chemballi were 148.59 and 147.50 days respectively. In this study, the first egg among the Chara and Chemballi ducks was obtained on the same day.i.e. at 129 days of age.

Significant differences in the age at sexual maturity for various breeds of ducks had been reported by earlier workers (Monstageer *et al.*, 1971; Sharma and Singh, 1978; Chavez and Lasmini, 1978; Ramakrishnan *et al.*, 1982; Eswaran, 1983; Sivaselvam and Prabhakaran, 1986; Tai *et al.*, 1989; Gajendran *et al.*, 1990 and Baruah *et al.*, 1991). In earlier studies with Kerala desi ducks, the average age at first egg was 182 days (Ramakrishnan *et al.*, 1982) and 158 days (Eswaran, 1983). But in the present study, the average age at first egg was only 148 and 147 days for Chara and Chemballi ducks respectively. The age at first egg (129 days) found in the present study was also comparatively earlier than the findings (134 days) of Eswaran (1983).

The age at first egg in Khaki Campbell ducks reported by various workers was 151.3 days (Monstageer *et al.*, 1971), 163 days (Eswaran, 1983) and 150.4 days (Baruah, 1991). While compared with the present findings, it could be interpreted that Chara and Chemballi ducks mature little earlier than Khaki Campbell and this variation might be due to genetic factors and changes in the management practices followed.

The average age of the flock of Chara and Chemballi at 10 per cent production was 153 days and 148 days respectively and that of 50 per cent production averaged 187 and 184 days respectively. Eswaran (1983) found 10 per cent (147 days of age) and 50 per cent (155 days of age) egg production in desi ducks of Kerala earlier than the findings of present study. The average age (150.6 days) of Pati ducks of Assam at 10 per cent production (Baruah *et al.*, 1991) was fairly similar with the results of the present study. Indonesian native ducks namely Tegal, Alabio and Bali attained 50 per cent egg production at 132, 169 and 148 days respectively (Hetzel, 1981), which were definitely earlier than the results of the present study.

In Khaki Campbell, age at 10 per cent egg production reported by Eswaran (1983) and Baruah *et al.* (1991) was 175 days and 153.8 days respectively, whereas age at 50 per cent egg production was 142 days (Hetzel, 1981) and 187 days (Eswaran, 1983). These indicated that there were great variations in the age at sexual maturity in Khaki Campbell ducks. Eswaran (1983) reported that Khaki Campbell duck came into lay at a much later age than the desi ducks of Kerala.

In the present study more days (58 days in Chara and 55 days in Chemballi) were required to reach 50 per cent egg production from the age at first egg, whereas only 33, 32 and

24 days were required to attain 50 per cent production in Tegal, Alabio and Bali ducks respectively (Chavez and Lasmini, 1978).

The frequency distribution of age at first egg recorded for Chara and Chemballi (Table 10) indicated that maximum number of Chara (55 per cent) and Chemballi (65 per cent) types had their first egg within the range of 129-150 days. Working with desi ducks of Kerala, Eswaran (1983) found only 34 per cent of birds had their first egg between 131-150 days of age. In the present study all birds had their first egg between 129-170 days of age. Contrary to this, Eswaran (1983) found the range of 131-200 days within which all ducks had their first egg.

On perusal of the frequency distribution table of age at first egg of the present study, it could be seen that there were wide variations in the age at first egg for both the types of ducks. Hence, for further improvement of age at first egg heritability of the trait has to be worked out and then appropriate selection may be practiced to attain an optimum range for this trait. From the present study it appears that the range of 129-135 days may be optimum for improvement of this trait in both the populations.

Egg production

Period-wise egg production

The average egg number per duck and per cent duck-day egg production of Chara and Chemballi for eight, 28-day laying periods from 129 days of age is presented in Table 11. The data indicated that Chara and Chemballi ducks during a production period of 224 days (32 weeks) laid 116.09 and 124.95 eggs per duck upto 352 days of age. The corresponding overall per cent duck-day production was 44.49 in Chara and 48.68 in Chemballi. The statistical analysis of duck-day egg production revealed that Chemballi laid significantly ($P<0.01$) more number of eggs than Chara. The period-wise egg number per duck and per cent duck-day egg production of both the types indicated that there was a gradual increase in egg production from first to 5th period and thereafter a decline in production was evident in both Chara and Chemballi. The highest egg production was found during 5th laying period in both Chara (63.22 per cent) and Chemballi (67.11 per cent). During 5, 6 and 7 laying periods Chemballi duck had significantly higher ($P<0.01$) egg production than that of Chara.

Earlier workers (Ramakrishnan *et al.*, 1982; Andrews *et al.*, 1984 and Eswaran *et al.*, 1985) assessed the egg production potential of desi ducks of Kerala irrespective of

phenotypic groups. Ramakrishnan *et al.* (1982) found an average egg production potential of 80 eggs per duck per annum, while Eswaran *et al.* (1985) recorded an egg number and per cent duck-day egg production to 280 days of age as 51.66 and 43.98 respectively. Comparatively higher egg production observed in the present study could be an indication of superior production potential of Chara and Chemballi types of ducks compared to an admixture of non-specific desi ducks. On screening the literature on production potential of desi ducks of Tamil Nadu, it was found that local ducks of Tamil Nadu laid an average number of 53.16 and 59.1 eggs per duck to 280 days of age as per reports of Sivaselvam and Prabhakaran (1986) and Gajendran *et al.* (1990), respectively, while the indigenous Pati duck of Assam during a period of eight 28-day laying periods laid an average egg number of 57.57 per duck to 364 days of age (Baruah *et al.*, 1991). The present record of egg number per duck to 352 days of age was almost double than the egg number reported in Pati ducks of Assam (Baruah *et al.*, 1991). In three native duck breeds of Indonesia, Hetzel (1981) recorded comparatively higher egg numbers (117, 148 and 153) to 32 weeks of production. Similarly, in brown Traiya ducks, Tai *et al.* (1989) and Velez *et al.* (1996) reported better egg production i.e., 207 number of eggs to 360 days of age and 214 eggs to 52 weeks of age.

In the present study, the egg number per duck for 100 days from first egg was 44.82 in Chara and 46.06 in Chemballi (Table 13), while Eswaran *et al.* (1985) recorded lesser egg number (35.13) for 100 days from first egg in desi ducks of Kerala.

The mean per cent duck-housed egg production of Chara and Chemballi at eight, 28-day laying periods (224 days) from the date of first egg indicated an overall duck-housed production of 41.78 per cent in Chara and 42.91 per cent in Chemballi (Table 12). The statistical analysis revealed significantly higher ($P<0.05$) duck-housed egg production in Chemballi than that of Chara. Ramakrishnan *et al.* (1982) obtained a duck-housed egg production of 31.72 per cent during a period of 250 days of laying from the first egg. The present finding of overall duck-housed egg production agreed closely with the per cent production records (42.70 per cent to 280 days of age) of Eswaran *et al.* (1985).

The duck-housed egg production of Chara and Chemballi increased gradually upto 5th laying period and thereafter declined. It was almost constant during 7th and 8th laying period. Except in period 4, per cent duck-housed egg production of Chara and Chemballi was statistically comparable. During 4th period Chemballi ducks registered significantly higher ($P<0.01$) egg production than Chara. The

highest duck-housed egg production was found in both Chara and Chemballi during 5th laying period. Absence of any significant difference in egg production in the subsequent periods could be due to higher mortality of Chemballi ducks occurred during these periods.

Weekly Egg Production

The mean weekly per cent duck-day and duck-housed egg production of Chara and Chemballi upto 52 weeks of age presented in Table 13 revealed that the egg production of both types widely fluctuated from week to week. While studying the egg production trait in desi ducks of Kerala reared under semi-intensive system, Ramakrishnan *et al.* (1982) also observed similar trends. They attributed the reason for such variation primarily to non-application of any systematic breeding procedures for stabilizing egg production. Moreover, ducks may react more sharply to variations in microclimatic environment.

Based on mean weekly egg production records, the Chara and Chemballi ducks attained 5 and 10 per cent production during 21st and 22nd week of age respectively (Table 13). The Chara and Chemballi ducks attained 50 per cent egg production during 29 and 27 weeks of age respectively. On perusal of the weekly egg production data it was also revealed that throughout the production period upto 52 weeks of age there

were two peaks in per cent egg production in both Chara and Chemballi type. The first peak was recorded in both types on 30 weeks of age in the Month of June-July and the second peak was found in Chara on 37th week in the month of August and in Chemballi during 35th week of age in the month of August itself. The present finding of two peaks in the egg production cycle of desi ducks was in agreement with the earlier report of Ramakrishnan *et al.* (1982), who observed that in the production cycle of desi ducks there were two peaks one around June-July and the other during November. In the present study first peak was found in the month of June-July and the second peak in August which was three months earlier than the findings of the second peak reported by Ramakrishnan *et al.* (1982). On the contrary, Eswaran *et al.* (1983) could observe only one peak in the production cycle of desi ducks during the month of June. He recorded the egg production only upto 40 weeks of age. This could be the reason for the absence of second peak in his study. The weekly per cent egg production average also indicated maximum production as high as 69.77 per cent duck-day and 66 per cent duck-housed in Chemballi, and 65.11 per cent duck-day and 59.91 per cent duck-housed in Chara. These production records were in par with the highest production (70 per cent) reported by Ramakrishnan *et al.* (1982), who indicated that desi ducks of Kerala have the genetic potential for egg production although the peak production was maintained only for a very

short duration. They attributed these peaks to possible differences in the release of leutinizing hormone (L.H.).

The highest egg production on duck-housed basis during the production period was 68 per cent in Chara at 252 days of age and 73 per cent in Chemballi at 206 days of age (Table 14). These peaks were maintained for that single day alone. These findings were comparatively lower than that of Tegal (83.2 per cent) and Alabio (92.7 per cent) but higher than the Bali ducks (58.6 per cent) of Indonesia (Chavez and Lasmini, 1978).

Egg production of both Chara and Chemballi during 52 weeks of age dropped below one per cent due to moulting of the whole flock that started from 50th week onwards.

It can be seen that the egg production performance of Chara and Chemballi ducks are comparable with high yielding Khaki Campbell ducks. Some workers (Monstageer *et al.*, 1971 and Baruah *et al.*, 1991) reported lower egg production in Khaki Campbell (71.5 number of eggs to 300 days of age and 109.49 eggs to 364 days of age). While few others (Hetzel, 1981 and Eswaran *et al.*, 1985) observed higher production of 199 number of eggs to 224 days of production and 65.7 per cent duck-housed production. Hetzel (1981) also observed a peak weekly production of 86 per cent in Khaki Campbell duck.

While analysing the production performance of the best layers (Fig.13 and 14) it was observed that high producers of Chara ducks laid 156 eggs in 225 days of production with an intensity of laying 69.33 per cent while Chemballi ducks laid 164 eggs in 223 days of production (73.54 per cent). Eswaran (1983) found comparatively lower intensity of production among highest egg producers of Kerala desi (56.4 per cent) and Khaki Campbell (68.05 per cent) during a period of 170 and 335 days of production respectively.

Genetic and environmental factors influence the overall egg yield of ducks. In the present study, every effort was made to keep the environmental variations to the minimum possible so that, differences in production characteristics occurred could be attributed to the genotypic differences inherent in the two types, relating to egg production traits.

The frequency distribution of egg number per duck upto 50 weeks of age recorded for Chara and Chemballi (Table 15) revealed that 33 per cent of Chara and 27 per cent of Chemballi ducks laid eggs less than 100 number. In a frequency distribution of egg production to 40 weeks of age, Eswaran (1983) also reported that maximum number of desi ducks of Kerala laid eggs towards the minimum range i.e., less than 50 eggs. In the present study 43 to 44 per cent of Chara and Chemballi ducks laid medium range (110-139) of egg number.

Only two per cent of Chara and 12 per cent of Chemballi had maximum egg number of above 150 eggs. The wide variation in egg production in both the flocks of ducks indicated non-application of any systematic selection and breeding practices under field conditions. Hence, for improvement of egg production of the flocks to the optimum range of 150 and above performance traits of the ducks may be recorded in an organised manner so as to apply appropriate selection and mating system taking cognisance of the genetic parameters to make refinement in this primary trait.

Coefficient of correlation between body weight at 20 weeks and egg production upto 50 weeks of age in Chara and Chemballi indicated negative correlation value of -0.208 and -0.335 (Table 16) respectively, whereas the correlation between egg production to 40 weeks and egg production to 50 weeks of age showed high positive correlation of 0.887 and 0.884 in both Chara and Chemballi respectively (Table 17). Cheng *et al.* (1995) also reported similar correlation value (0.948) between egg number to 40 weeks and egg number to 52 weeks of age in brown Tsaiya ducks of Taiwan.

Intensity of egg production as measured by clutch size

Although an attempt was made to determine the intensity of egg production by clutch size of eggs laid by the ducks, it was not possible due to non-existence of any definite clutch

size as revealed by Fig.13 and 14. These findings agreed closely with the observations of Eswaran (1983) in desi ducks of Kerala. The desi ducks were known to have definite seasons of egg production with intermittent pauses on range rearing. However, when they were reared in confinement, as revealed from the present study, better performance could be obtained in terms of early sexual maturity and egg number per duck. In a comparative study Eswaran (1983) found that Khaki Campbell ducks came into lay at a much later age (163 days), but they continued to lay at an increasing rate without any pause throughout the six 28-day laying periods. The Khaki Campbell ducks are well known for their intensity and persistency of production and are capable of producing about 300 eggs per annum.

Egg weight

Egg weights of Chara and Chemballi ducks presented in Table 18 revealed that the overall mean egg weights of Chara (69.69 g) was significantly ($P<0.05$) higher than that of Chemballi (68.08 g). The mean egg weight of Chara was significantly higher than that of Chemballi during 40 and 50 weeks of age, whereas it was significantly comparable at 30 weeks of age. The higher egg weight of Chara was possibly due to higher body weight observed in Chara over Chemballi. The egg weights observed in the present study were in close

agreement with those reported by Bose and Mahadevan (1956), George *et al.* (1980), Eswaran *et al.* (1985) and Lee *et al.* (1992). However, Andrews *et al.* (1984) and Mahanta *et al.* (1993) reported much lower egg weight (60.5 g) in desi ducks of Kerala and Assam respectively. The three native breeds of Indonesia (63.0, 60.0 and 59.4 g) also had comparatively lower egg weights (Chavez and Lasmini, 1978) than the present findings.

The present egg weights of Chara and Chemballi were higher than the egg weights of Khaki Campbell ducks reported by various workers (Monstageer *et al.*, 1971; Reddy *et al.*, 1979; Hetzel, 1981; Panda *et al.*, 1984; Eswaran *et al.*, 1985; Gajendran *et al.*, 1990; Sheriff *et al.*, 1991 and Mahanta *et al.*, 1993).

The frequency distribution of mean egg weight recorded for Chara and Chemballi (Table 19) revealed that maximum number of birds in Chara (69.23 per cent) and Chemballi (71.37 per cent) type had their egg weight within the range of 61.00-70.99 g. In Chara, more number of ducks (21.98 per cent) had higher egg weight (71.00-85.99 g) as compared to 18.26 per cent of Chemballi that had egg weight between the range of 71.00-80.99 g. As the egg weight is a highly heritable trait, individual selection may be practiced for improvement of the trait to the optimum range of 75-80 g.

The mean egg shape index of Chara and Chemballi was 75.45 and 75.17 respectively (Table 14). This finding was in agreement with those reported by Reddy *et al.* (1979) for Khaki Campbell eggs and Eswaran *et al.* (1985) for desi duck eggs of Kerala. Contrary to this, George *et al.* (1980) recorded comparatively lower egg shape index values (72.99) in desi ducks of Kerala. Moreover, Mahanta *et al.* (1993) also reported lower egg shape index values for Pati ducks of Assam. The difference in the genome of the stock selected for these studies might be the reason for the varied egg shape index values for different stocks.

Correlation between body weight and egg weight at 30, 40 and 50 weeks of age in Chara and Chemballi revealed that it was highly correlated during 30 and 40 weeks of age in both the types (Table 20). Findings of Kontecka (1979) and Kalita *et al.* (1992) well supported the present findings in Pekin and Khaki Campbell ducks respectively.

Pauses and length of pauses

During the laying period, definite pauses could not be observed in both Chara and Chemballi types as revealed by Figs.13 and 14. The erratic pattern of egg production trends in desi ducks might be the reason for such type of pauses. The pattern of pauses observed in this study was well supported by the reports of Eswaran (1983) in desi ducks of

Kerala. Intermittent pauses of desi ducks are common in free range system of rearing.

Broodiness

The broodiness character in both Chara and Chemballi ducks of Kerala was practically absent. It was seen only in 1.7 and 1.3 per cent of the birds, respectively. Ravindran (1983) in his survey study of duck farming in Kerala reported no indication about the presence of broodiness in desi ducks.

Livability

Per cent livability of the two types of ducks presented in Table 21 revealed that Chemballi had comparatively lower livability (82.27 per cent) than that of Chara (92.12 per cent) during the laying period.

Blood protein polymorphism

The electrophoretic patterns of non-enzymic protein components of blood serum of chicken and quails were well established (Rajan and Pingel, 1977 and Singh, 1980) as compared to ducks. To date polymorphic variations have been identified for considerable number of proteins in domestic fowl and quails, and these marker genes were extensively employed for diversified genetic studies. But domestic ducks, an important poultry species of developing countries, has

received very little attention with respect to such studies. In the present study some of the polymorphic nomenclatures were given according to standard conventions followed in chicken. The observations of serum transferrin, serum post-transferrin-2 and serum albumin in two types of ducks of Kerala have been compared mostly with polymorphism studies of chicken due to scanty literature on ducks.

Transferrin (Tf)

In blood serum of Chara ducks no transferrin polymorphism was found, all birds belonging to type BB only. Similar findings were reported in blood serum of Karaknath and Aseel breeds of indigenous chicken (Ahlawat, 1983). In Chemballi, two transferrin phenotypes BB and AB were found (Fig.15). The phenotype BB exhibited two clear dark bands with slow movement followed by one light weak band. Supporting the present findings, Csuka *et al.* (1972) identified two alleles (A and B) for the transferrin locus Tf of ducks, and they found three phenotypes AA, BB and AB. The Tf band patterns of present study were similar to the observations of Csuka *et al.* (1972). Chen *et al.* (1987) observed six transferrin phenotypes and three alleles (A, B and C) for the transferrin locus Tf in brown Tsaiya ducks of Taiwan. In the present study phenotype frequency (88 per cent) of BB was significantly higher than the AB (Table 22), whereas Chen *et al.* (1987) reported higher

phenotype frequencies for heterozygotes. The frequencies of Tf^A and Tf^B genes of the present study were 0.06 and 0.94 respectively. The frequencies of Tf^A, Tf^B and Tf^C genes in Tsaiya ducks were 0.47, 0.29 and 0.24 respectively (Chen *et al.*, 1987).

Analysis of variance for serum transferrin phenotypes and egg production, egg weight and body weight in Chemballi ducks indicated non-significant association between transferrin phenotypes and production traits (Table 23). In chicken plasma, Suvareva *et al.* (1973) obtained relationship between transferrin polymorphism and egg hatchability.

Post-transferrin-2 (Ptf-2)

In post transferrin region only post transferrin-2 was observed in both Chara and Chemballi ducks (Fig.17) and was controlled by two alleles (Ptf^A and Ptf^B). Chen *et al.* (1995) also observed similar polymorphism pattern for Ptf-2 in plasma proteins of Pekin ducks. In Chara, the frequencies of Ptf^A gene (0.59) and Ptf^{AA} phenotype (58.67 per cent) were higher than Ptf^B gene and Ptf^{BB} phenotype, whereas in Chemballi a reverse observation was found (Table 22). In both the types of ducks, only two phenotypes AA and BB were found, the heterozygote AB phenotype was not seen.

Analysis of variance for serum post-transferrin-2 phenotypes and production traits showed significant association between Ptf phenotypes and egg weight and body weight in Chara, whereas in Chemballi only body weight was significantly associated with Ptf-2 phenotypes (Table 25). In Chara AA phenotype had higher egg weight and body weight, whereas BB phenotypes had higher body weight in Chemballi. Chen *et al.* (1995) also reported correlation of Ptf-2 phenotypes with body weight of Pekin ducks with the result the homozygote AA had higher average body weight than the other Ptf phenotypes.

Albumin (Alb)

Three albumin phenotypes (AA, BB and AB) existed in Chara and Chemballi ducks of Kerala as revealed by Fig.19. Similar observations were reported in turkeys by Quinteros *et al.* (1964) and in chicken by Nikolov (1988). Using starch gel electrophoresis, Mazumder and Mazumder (1990) did not find one of the expected electrophoretic phenotype in chicken (AA phenotype) and quails (CC phenotype). In Chara, the frequencies of Alb^{A} gene (0.59) and Alb^{AA} phenotype (44 per cent) were comparatively lesser than that of Chemballi (0.66 and 52.67) per cent). The frequencies of heterozygote phenotype Alb^{AB} were higher (30.67 per cent) in Chara than that of Chemballi (26.66 per cent). In chicken, Nikolov (1988)

found higher frequencies for Alb^{B} gene (0.715) and Alb^{BB} phenotypes (54 per cent).

Analysis of variance for serum albumin phenotypes and egg production, egg weight and body weight revealed highly significant ($P<0.01$) association between albumin phenotypes and the above three production traits (Table 27). Using starch gel electrophoresis Zderchuk (1987) also found significant association between albumin phenotypes and seven months egg production and body weight in blood serum of White Cornish and White Plymouth Rock fowl. Nikolov (1988) obtained intraclass correlations of the serum albumin phenotypes with egg production and egg weight in laying hens.

The homozygote albumin phenotype AA were superior in egg production in both Chara and Chemballi (Table 28). This indicated that the Alb^{A} gene had a favourable effect on egg production. In case of egg weight and body weight Alb^{AA} phenotype were superior in Chara and Alb^{BB} were superior in Chemballi. Hence, Alb^{A} gene also favoured egg weight and body weight in Chara while Alb^{B} gene favoured egg weight and body weight in Chemballi. The heterozygote Alb^{AB} were inferior for all the production traits in both Chara and Chemballi.

The frequency distribution of age at first egg (Table 29), egg number (Table 30) and egg weight (Table 31) recorded for three albumin phenotypes in both Chara and Chemballi

indicated that the homozygous Alb^{AA} phenotypes were superior in age at sexual maturity (ASM) and egg number in both Chara and Chemballi types. In the case of egg weight Alb^{AA} phenotypes in Chara and Alb^{BB} phenotypes in Chemballi were superior. Among the Alb^{AA} phenotypes in both Chara and Chemballi there were wide variations in ASM, egg number and egg weight. For improvement of these traits in both types of ducks serum albumin polymorphism may be another tool to enable easy selection in addition to the selection procedures based on quantitative traits. The ducks containing homozygous Alb^{AA} phenotypes that had ASM within the range of 129-135 days could be selected for to produce the next generation. Similarly Alb^{AA} phenotypes having egg number within the range of 150-169 could be selected for the overall improvement of the flocks.

Summary

SUMMARY

A study was carried out to characterise two distinct indigenous types of ducks, namely Chara and Chemballi of Kerala and to evaluate their production potential.

Five hundred sexed day-old female and 100 male ducklings each from Chara and Chemballi type were brought from M/s Susan Roy Hatchery of Chennithala. The ducklings were wing banded and weighed individually to obtain day-old body weight. Ducklings were reared under deep litter system of management adhering to identical scientific managemental practices till 8 weeks of age. Thereafter, ducklings were switched over to semi-intensive system. Individual body weights were recorded at every 4 weeks interval upto 20 weeks of age and thereafter at 30, 40 and 52 weeks of age.

At 18 weeks of age, based on body weight and plumage colour 300 females and 30 males from each type were retained for further studies and the remaining were disposed off. The females from each type were divided into three groups of 100 birds each. The ducklings were wing badged at 18 weeks of age and were provided with individual laying nests to facilitate recording of individual egg production. Drakes of each type were maintained as a separate flock to study the external morphology and growth traits. At 20 weeks of age individual

body measurements (Table 3) and plumage colour of different body parts (Table 4) were recorded. Egg weight was recorded at 30, 40 and 52 weeks of age. Shape index and shell colour of eggs were recorded during 40 weeks of age.

According to external morphological features the Chara and Chemballi drakes were usually squat in posture and gait. The main difference between Chara and Chemballi drakes was in the colour of plumage in the head region. It was lustrous greenish black in Chara and dull greenish black in Chemballi. The Chara and Chemballi females were erect in gait and more or less squat in posture. The plumage colour of Chara female was primarily blackish brown in the back, tail and wings wherein black was predominant over brown. In the case of Chemballi female, the plumage colour in general was brownish black and brownish grey in the back, tail and wings wherein brown was predominant over the black and grey.

The average body weight of Chara day-old male duckling was 47.87 ± 0.61 g and that of female was 47.67 ± 0.32 g. The corresponding average body weights of Chemballi male and female ducklings were 47.88 ± 0.70 g and 45.95 ± 0.40 g respectively. The mean body weight at 20 weeks of age in Chara male and female was 1643 ± 16.09 and 1538.15 ± 7.06 g respectively. The corresponding body weight in Chemballi was 1657.71 ± 15.22 g in male and 1497.51 ± 8.38 g in female. The

body weights of males between Chara and Chemballi revealed no significant difference (Table 5). However, in the case of females, Chara ducks tended to be higher in body weights than Chemballi eventhough they were statistically not different at all stages of growth (Table 6). The correlation coefficient presented in Table 7 revealed correlation of 0.581 and 0.536 between day-old body weight and 8 weeks body weight in females of both Chara and Chemballi respectively. Moderately high and positive correlation coefficient between shank length and body weight at 20 weeks of age was obtained in males and females of both types of ducks (Table 8).

Data on reproductive traits (Table 9) in Chara and Chemballi revealed that the average age at first egg (AFE) in Chara and Chemballi ducks was 148.59 and 147.50 days respectively. The first egg from the above two flocks was obtained on the same day i.e. at 129 days of age. In Chara ducks, the ages at 5, 10 and 50 per cent egg production were 144, 153 and 187 days respectively. While in Chemballi ducks, it was 141, 148 and 184 days in the above order. The frequency distribution of age at first egg recorded for Chara and Chemballi (Table 10) indicated that all birds had their first egg between 129-170 days of age.

Data on period-wise egg number per duck and per cent duck-day egg production (Table 11) in Chara and Chemballi

revealed that the cumulative egg number per duck in Chara and Chemballi upto 50 weeks of age was 116.09 ± 1.15 and 124.95 ± 1.17 respectively. The corresponding mean per cent duck-day egg production was 44.49 ± 1.18 in Chara and 48.68 ± 1.29 in Chemballi. The overall mean duck-housed egg production upto 50 weeks of age was 41.78 ± 1.09 per cent in Chara and 42.91 ± 1.12 per cent in Chemballi (Table 12). The mean weekly per cent egg production in Chara and Chemballi upto 52 weeks of age indicated that weekly egg production of both Chara and Chemballi widely fluctuated from week to week and there were two peaks in egg production in both the types (Table 13). The highest per cent egg production on duck-housed basis was 68.0 in Chara and 73.0 in Chemballi ducks (Table 14). These peaks were maintained for single day only. The coefficient of correlation presented in Table 16 revealed that there was negative correlation between body weight at 20 weeks and egg production to 50 weeks of age. High correlation was obtained between egg production upto 40 weeks and to 50 weeks of age (Table 17). The average egg weights of Chara at 30, 40 and 50 weeks of age were 68.19 ± 0.59, 69.94 ± 0.33 and 70.93 ± 0.55 g respectively with an average of 69.69 ± 0.47 g (Table 18). The corresponding weights in Chemballi were 68.33 ± 0.56, 68.94 ± 0.20 and 66.97 ± 0.65 g respectively with an average of 68.08 ± 0.45 g. It was found that there were no discernible clutch size/pause either in Chara and Chemballi.

Broodiness was not observed in both types during the period of study.

In respect of biochemical characters, polymorphism of three non-enzymic components of blood serum namely transferrin, post-transferrin and albumin was studied by horizontal polyacrylamide gel electrophoresis method. No transferrin polymorphism was found in blood serum of Chara ducks. Whereas two clear phenotypes BB and AB were observed in Chemballi (Fig.15). The frequency of homozygous Tf BB phenotypes was higher in both Chara (100 per cent) and Chemballi (88 per cent). The polymorphism in the case of post-transferrin-2 and albumin was evident in both Chara and Chemballi (Fig.17 and 19). Two clear Ptf-2 phenotypes AA and BB were found in both types of ducks. Regarding albumin, three clear phenotypes viz., AA, BB and AB were observed in both Chara and Chemballi. The frequency of homozygous Alb AA phenotype was higher in Chemballi (52.67 per cent) than that of Chara (44 per cent).

The correlation of the above biochemical variants with production traits (Table 23 to 28) indicated highly significant ($P<0.01$) association between albumin phenotypes and egg production, egg weight and body weight in both Chara and Chemballi ducks. In respect of egg production, egg weight and body weight the homozygous Alb^{AA} phenotypes were superior

in Chara. However, in Chemballi homozygous Alb^{AA} phenotypes were superior for egg production only. For egg weight and body weight the homozygous Alb^{BB} phenotypes were better in Chemballi. The heterozygous Alb^{AB} phenotypes were inferior for all the above three production traits in both Chara and Chemballi. Based on the above findings the following conclusions were drawn from the present study:

1. Chara and Chemballi were two distinct phenotypic types in terms of plumage colour. The colour of plumage in the head region of drakes was lustrous greenish black in Chara and dull greenish black in Chemballi. The Chara females were primarily blackish brown in back, tail and wings, whereas Chemballi females were brownish black and brownish grey in back, tail and wings.

2. The body weights of Chara and Chemballi drakes did not differ significantly; whereas the Chara females tended to be heavier in body weights at all ages except 4 and 12 weeks. Significantly higher weights at day-old and 20 weeks of age were recorded in Chara females over the Chemballi.

3. The ASM in Chara (148.59 days) and Chemballi (147.50 days) did not differ significantly.

4. Egg production upto 50 weeks of age was significantly superior in Chemballi ducks in comparison to Chara ducks.

5. Egg weights at 40 and 50 weeks of age were significantly higher in Chara ducks.

6. No transferrin polymorphism was found in blood serum of Chara ducks, all birds were of type BB only.

7. Significant associations between serum albumin phenotypes with egg production, egg weight and body weight were present in both Chara and Chemballi ducks. Homozygous Alb^{AA} phenotypes were significantly superior in egg production in both the types.

From the results obtained in this study it appears that the genetic distance between Chara and Chemballi types is very short indicating thereby that there has been inter breeding between these two types among the farmers' flocks and that farmers do not practice any strict regimen of mating among the two types. Nonetheless, there appears to be distinct phenotypic variation in respect of plumage pattern. Like-wise, there is also distinct advantage for Chemballi in so far as production traits are concerned. The duck farmers in Kerala have a preference for desi ducks over exotic ducks. Considering all these, there is scope for taking up further

research and development using Chara and Chemballi ducks. The information on biochemical protein polymorphism obtained in this study will be helpful as an additional tool in future selection programmes of these types of ducks.

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CHARACTERISATION AND EVALUATION OF INDIGENOUS DUCKS OF KERALA

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ABSTRACT OF A THESIS

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ABSTRACT

A basic study was conducted to characterise the two distinct indigenous types of ducks, namely Chara and Chemballi of Kerala and to evaluate their production potential. Five hundred sexed day-old female and 100 male ducklings each from Chara and Chemballi type were brought from M/s Susan Roy Hatchery of Chennithala. The ducklings were reared on deep litter system of management under identical conditions till 8 weeks of age. Thereafter they were switched over to semi-intensive system. The ducklings were wing banded and weighed individually at day-old, 4, 8, 12, 16, 20, 30, 40 and 52 weeks of age.

After 18 weeks of age, 300 females and 30 males from each type were selected for further studies. The females from each type were divided into three groups of 100 birds each. At 18 weeks of age, ducklings were wing badged and provided with individual laying nests to facilitate recording of individual performance. Drakes of each type were maintained separately to study the external morphology and growth traits. At 20 weeks of age, individual body measurements and plumage colour patterns of different body parts of both Chara and Chemballi were recorded. The age at first egg (AFE) of all individual ducks, the weight of first egg, egg weight at 30, 40 and 50 weeks of age, shape index and shell colour of eggs, age at 5,

10 and 50 per cent egg production, total egg production upto 52 weeks of age, per cent duck-day and duck-housed egg production at eight 28-day laying periods and at weekly mean basis of the flocks were calculated and recorded.

Morphologically, Chara and Chemballi drakes were squat in posture and gait and they differed in the colour of plumage of the head region. It was lustrous greenish black in Chara and dull greenish black in Chemballi. The Chara females were usually blackish brown in the back, tail and wing. The Chemballi females in general were brownish black and brownish grey in the back, tail and wings.

The average body weights and growth pattern of Chara and Chemballi males were almost similar upto 52 weeks of age, whereas the Chara females tended to be heavier in body weights at all ages except 4 and 12 weeks. Significantly higher body weights at day-old and 20 weeks of age was recorded in Chara females over the Chemballi.

The average age at first egg (AFE) in Chara and Chemballi was 148.59 and 147.50 days respectively. The ages at 5, 10 and 50 per cent egg production were 144, 153 and 187 days in Chara, while those in Chemballi were 141, 148 and 184 day respectively. The average egg number per duck upto 50 weeks of age was 116.09 in Chara and 124.95 in Chemballi. The corresponding mean per cent duck-day production in Chara and Chemballi was 44.49 and 48.68 respectively. The mean per cent

duck-housed egg production to 50 weeks of age in Chara and Chemballi was 41.78 and 42.91 respectively. The mean weekly per cent egg production of Chara and Chemballi upto 52 weeks of age widely fluctuated from week to week. It was also found that during the production period upto 52 weeks of age there were two peaks in per cent egg production in both Chara and Chemballi type. The overall mean egg weight of Chara (69.69 g) was significantly ($P<0.05$) higher than that of Chemballi (68.08 g). In the laying periods of Chara and Chemballi there were no discernible clutch size/pause. Broodiness as a trait was almost absent in both the types.

At the end of 52 weeks of age, 150 serum samples each from Chara and Chemballi were examined for polymorphism of non-enzymic protein components by horizontal polyacrylamide gel electrophoresis. No transferrin polymorphism was present in Chara, all birds were of type BB only. In Chemballi, two clear phenotypes BB and AB were found. In respect of post-transferrin-2 and albumin polymorphism two Ptf-2 phenotypes (AA and BB) and three Alb phenotypes (AA, BB and AB) were found in both Chara and Chemballi. Correlation of the above biochemical variants with production traits indicated highly significant ($P<0.01$) association between albumin phenotypes and egg production, egg weight and body weight. The homozygous Alb^{AA} phenotypes proved to be superior in egg production in both Chara and Chemballi. The heterozygous Alb^{AB}

phenotypes were inferior for all the above three production traits.

Based on the above findings it was concluded that Chara and Chemballi were two distinct phenotypic types in respect of plumage colour. The males of both Chara and Chemballi did not differ significantly in body weights, whereas the Chara females tended to be heavier at all ages except 4 and 12 weeks. Significantly higher ($P<0.01$) body weights at day-old and 20 weeks of age were recorded in Chara females. The average age at first egg in Chara and Chemballi did not differ significantly. The Chemballi was significantly superior in egg production to 50 weeks of age, whereas Chara was significantly superior in egg weight at 40 and 50 weeks of age. No transferrin polymorphism was found in blood serum of Chara ducks. Three serum albumin phenotypes namely AA, BB and AB were observed in both Chara and Chemballi, out of which the homozygous Alb^{AA} phenotypes were significantly superior in egg production in both the types of ducks.

From the results obtained in this study it appears that the genetic distance between Chara and Chemballi types is very short indicating thereby that there has been inter breeding between these two types among the farmers' flocks and that farmers do not practice any strict regimen of mating among the two types. Nonetheless, there appears to be distinct phenotypic variation in respect of plumage pattern.

Like-wise, there is also distinct advantage for Chemballi in so far as production traits are concerned. The duck farmers in Kerala have a preference for desi ducks over exotic ducks. Considering all these, there is scope for taking up further research and development using Chara and Chemballi ducks. The information on biochemical protein polymorphism obtained in this study will be helpful as an additional tool in future selection programmes of these types of ducks.