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ABSTRACT

The present study evaluates the production performance of indigenous Nicobari fowls, Vanaraja and their various F_1 crosses under hot humid climate of Andaman and Nicobar Islands, India. Birds (600) with 60 in each group were used for the study. The birds were evaluated for weekly body weight (g) from 0 day to 8 weeks of age, monthly body weight (g) from first month to fourth month of age, shank length (mm), feed intake and feed conversion ratio (FCR) up to 8 weeks of age, age at sexual maturity (ASM in days), annual egg production as hen house egg production (AEP as HHEP), and different egg quality traits at 40 weeks of age. At the end of fourth month of age, the body weight of Vanaraja was highest (3,394.24±23.31 g) among all the genetic groups studied. White Nicobari × Vanaraja recorded significantly higher body weight (1923.10±18.81 g) in comparison to all the F_1 crosses except Vanaraja × White Nicobari. Age at laying was found lowest (136 days) in White Nicobari among pure varieties and White Nicobari × Vanaraja (146 days) among F_1 crosses. Annual egg production of Black Nicobari was found highest (192.14) among pure varieties and White Nicobari × Vanaraja (184.95) excelled in annual egg production among the F_1 crosses. The highest egg weight was observed in Vanaraja and White Nicobari × Vanaraja among the pure and crosses respectively. In conclusion, White Nicobari × Vanaraja was a very suitable and promising dual purpose bird under the local climatic condition of Andaman and Nicobar Islands.

Key words: F_1 crosses, Nicobari fowl, Production performance, Vanaraja

Backyard poultry farming is gaining wider importance and acceptance among the rural people of India as a source of income generation and supplementary livelihood activity (Niranjan *et al.* 2008). In Indian market, the demand for indigenous chicken and egg is higher compared to the broilers and layer eggs (Sapcota *et al.* 2002). Total poultry population of Andaman and Nicobar Islands, India is 9.30 lakh as per 2003 census; most of which belongs to the indigenous breed (Kundu *et al.* 2010), but there is an acute shortage of egg and chicken in these islands due to heavy inflow of tourists and more number of non- vegetarian populations (Kundu *et al.* 2012). Indigenous Nicobari fowl and introduced Vanaraja are very much prevalent in Andaman and Nicobar Islands. Nicobari fowl, an indigenous and endemic breed of poultry of Andaman and Nicobar Islands, produces the highest number of eggs among all the indigenous chicken breeds of India (Kundu *et al.* 2012). They are resistant to some of the deadliest diseases of poultry, very much adaptable to the local conditions of these islands (Ahlawat *et al.* 2004, De *et al.* 2013), and they easily escape predators as are able to fly. However, body weight, growth rate and egg size of these birds are very low. White, Black and Brown varieties of Nicobari fowl are generally found. Vanaraja, a dual purpose breed recently introduced in these islands, has high growth rate and productivity but are prone to predators and susceptible to diseases limiting their suitability as backward farming. De *et al.* (2013) also suggested that adaptability of Vanaraja to the local environment of Andaman and Nicobar Islands is lesser compared to Nicobari fowls. Nicobari fowl is unable to meet the demand of Andaman and Nicobar Islands due to the low productivity of indigenous birds. Therefore, it is very much urgent to increase their productivity. Earlier developed crossbred birds like Nicorock and Nishibari (Kundu *et a*l. 2012) were not very suitable to the local conditions of the Islands. No study has been done to explore the production potential of crosses of Nicobari fowl and Vanaraja. The present study was designed to study the production performance of Nicobari fowls, Vanaraja and their various F_1 crosses. Our results will be helpful to meet the increasing demand of animal protein, generate income among rural farmers and eliminate protein malnutrition in Andaman and Nicobar Islands.

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MATERIALS AND METHODS

All the present experiments comply with all relevant institutional and national animal welfare guidelines and policies. Blood samples from birds were collected aseptically following standard national welfare guidelines.

Agro-climatic conditions of the region: The experiment was conducted at the Central Agricultural Research Institute, Port Blair, Andaman and Nicobar Islands, India. Andaman and Nicobar Islands are situated in the Bay of Bengal, around 1,200 km away from mainland India. These islands enjoy a uniform tropical, warm and humid climate. These islands receive 3,000–3,800 mm mean annual rainfall, which generally occurs during the South-West and North-East monsoons from April to November. The temperature ranges between 23 and 30°C. The mean relative humidity is about 78%, while mean wind speed is approximately 10.8 km per hour.

Experimental populations: In the present experiment the following genotypes of birds were utilized viz. 4 pure varieties viz. Vanaraja (Van), White Nicobari (WN), Black Nicobari (BN), Brown Nicobari (BrN) and six F_1 crosses of Vanaraja and Nicobari fowls i.e. Vanaraja male × White Nicobari female (Van × WN), White Nicobari male × Vanaraja female (WN × Van), Vanaraja male × Black Nicobari female (Van × BN), Black Nicobari male × Vanaraja female (BN × Van), Vanaraja male × Brown Nicobari female (Van × BrN), Brown Nicobari male × Vanaraja female (BrN × Van). Pure Nicobari fowls were hatched out following a natural *inter-se mating* of original stock at our institute farm. Vanaraja chicks (day-old) were procured from Department of Animal Husbandry, Andaman and Nicobar Islands. F_1 crossbred birds were produced by crossing of Vanaraja and Nicobari fowls in our institute farm. Birds (600) with 60 to each group (3 replicates of 20 birds each) were taken for the study. All the birds were provided uniform management conditions under deep litter system. Feed and water were provided *ad lib.* as per BIS (Bureau of Indian Standard) specifications. Chick were fed on starter, grower and layer ration as per standard (Table 1).

Production traits studied: Body weight at 0 day, 1,2,3,4,8,12, and 16 weeks of age were recorded; day-old body weight to the nearest 2 g accuracy while weekly and bi-weekly body weights to the nearest 5 g accuracy. Daily feed intake and feed conversion ratio up to 8 weeks of age was also assessed. Shank length of birds was measured using vernier calipers. Age at sexual maturity and annual egg production (on hen housed basis) were recorded.

Egg quality traits: Fresh eggs (15) of all the 10 genetic group of birds were collected randomly and used to study egg quality traits, viz. egg weight (g), egg length (mm), egg width (mm), yolk diameter (mm), yolk height (mm), yolk weight (g), albumen height (mm), albumen weight (g), shell weight (g), shell thickness (mm) and Haugh unit. The traits were determined following standard procedure and formula. Length and breadth of eggs, yolk diameter were measured using digital Vernier calipers (least count 0.01 mm). The shell thickness was measured using screw gauge (least count 0.01 mm) and heights of albumen and yolk were measured by spherometer (least count 0.01 mm).

Mortality and adaptability based on heterophil and lymphocyte ratio (H:L): The mortality of all the genetic groups was recorded every day. Blood samples were collected and immediately used for measuring the heterophil and lymphocyte.

Statistical analysis: All the collected data were analyzed with the SAS Software Release 8.2. The differences between treatments were analyzed using a one way analysis of variance (ANOVA). Differences with a confidence level of 0.05 or less were considered to be significant.

RESULTS AND DISCUSSION

Indigenous and local breeds are well-adapted to the scavenging husbandry conditions and can be maintained with very low levels of input (Besbes 2009). For rural farmers, indigenous chickens serve as an important source of protein and cash income (Olwande *et al.* 2010). Strengthening indigenous chicken production may be a strong step towards fighting poverty and malnutrition especially in rural areas of developing countries (Regassa *et al.* 2013). Nicobari fowl are the highest egg producer among indigenous poultry breeds of India under backyard condition, can fly and are resistant to most of the deadly diseases of poultry (Kundu *et al.* 2012). In spite of these favorable characteristics, they are losing popularity mainly because the adult body weight of the bird, growth rate and egg weight are very low though fetching higher price. Vanaraja was developed for free range poultry farming in rural and tribal areas. The body weight at 12 weeks of age ranges from 1.5 to 1.8 kg and they have a very good growth rate (Niranjan *et al.* 2008). The productivity of Vanaraja is promising but are very prone to predators and mortality in field conditions which is comparatively higher than Nicobari fowl. An immunocompetence study based on antibody response towards goat RBC confirmed that the disease resistance power of Vanaraja is lower than Nicobari fowl (De *et al.* 2013).

Zero day body weights of BN × Van and Van × BN were

Table 1. Ingredients and nutrient composition of the poultry feeds used in the study

Ingredients (%)	Chick	Grower	Layer
Maize	60	59	61
DORB (Deoiled Rice bran)	0	6	5
Soyabean Meal	32	21	18
Fish Meal (43% Protein)	0	0	8
Sunflower Meal)	5	11	5.7
CALCITE (CalciumD-pantothenate)	1.6	2	2
DCP(Di-calcium Phosphate)	1.6	1.4	0.4
DLM (DL-Methionine)	0.2	0.11	0.1
LY(Lysine)	0.06	0	0
Salt	0.4	0.4	0.1
Total(Kg)	100	100	100
ME (Kcal/kg)	2781	2642	2560
CP%	20.53	17.9	18
Calcium%	1	1.1	3.82
A.Phosphorous%	0.46	0.42	0.42

significantly higher in comparison to all the other groups (Table 2). In first week, Vanaraja and BN × Van recorded significantly higher body weights in comparison to all the other groups. In all the other periods of measurements, the body weights of Vanaraja were significantly higher compared to that of all the other groups. Among the F_1 crosses, WN × Van recorded significantly higher body weight in comparison to all the other crosses except Van × WN at the end of fourth month of age.

Shank length has positive correlation with body weight. Shank length of Vanaraja male was highest (Table 3) and among the F_1 crosses WN × Van male showed highest shank length. During 1–3 weeks of age, the FCR of Vanaraja among pure varieties and that of WN × Van among crossbreds was lowest (Table 4). In subsequent weeks also, same trend was found. Overall, the FCR of Vanaraja was lowest among pure varieties and among crossbreds, the FCR of WN × Van was the best.

Table 2. Body weight (g) of Vanaraja, Nicobari fowls and their various F_1 crosses

Group	0 Day	1st week	2nd week	3rd week	1st month	2nd month	3rd month	4th month
Van	33.50±0.52^{b}	63.50±0.78^{a}	127.50±1.49^{a}	255.00±3.23^{a}	423.87±5.51^{a}	1620.12±12.34^{a}	2195.50±14.45^{a}	3394.24±23.31^{a}
WN	29.44±0.61^{c}	48.89±0.82^{c}	83.33±1.02^{bc}	167.36±2.34^{c}	233.33±4.45^{c}	883.33±10.12^{c}	1147.44±11.23^{c}	1594.40±19.24^{cd}
BN	29.00±0.47^{c}	52.00±0.76^{bc}	107.50±1.21^{b}	192.00±4.11^{b}	291.03±3.31^{b}	995.50±9.78^{b}	1360.23±10.23^{c}	1705.00±18.78^{bc}
BrN	30.00±0.32^{c}	49.44±0.91^{c}	83.33±0.98^{bc}	131.11±1.98^{d}	201.42±5.34^{cd}	832.50±11.13^{c}	1268.54±17.23^{c}	1612.50±13.34^{cd}
Van × WN	35.89±0.39^{b}	48.52±1.02^{c}	73.70±1.76^{c}	103.13±2.34^{d}	155.24±2.21^{d}	601.27±9.19^{d}	1376.60±17.78^{c}	1833.70±10.20^{b}
WN × Van	35.46±0.82^{b}	48.64±0.53^{c}	89.44±1.33^{b}	125.48±3.31^{d}	194.84±3.89^{cd}	764.03±6.78^{c}	1511.77±15.98^{b}	1923.10±18.81^{b}
Van × BN	38.75±0.45^{a}	56.25±0.71^{b}	83.18±1.67^{bc}	167.1±3.34^{c}	221.48±3.12^{c}	524.14±8.90^{d}	1055.86±13.39^{cd}	1420.80±16.78^{d}
BN × Van	39.55±0.35^{a}	69.93±0.67^{a}	75.36±1.23^{c}	172.04±2.45^{c}	217.88±2.89^{c}	509.41±9.97^{d}	1029.76±16.31^{cd}	1517.30±17.25^{cd}
Van × BrN	33.00±0.67^{b}	52.14±0.98^{bc}	75.00±0.98^{c}	110.01±2.35^{d}	143.33±4.67^{d}	521.67±11.23^{d}	937.31±18.11^{d}	1341.30±13.75^{d}
BrN × Van	30.00±0.45^{c}	47.50±0.81^{c}	64.06±2.10^{c}	97.11±3.56^{d}	133.42±5.56^{d}	398.87±8.87^{e}	752.03±15.56^{d}	1083.90±12.23^{e}

Values are expressed as mean±standard error.^{a,b,c,d,e}Values within the same column with different superscript differ significantly ($p<0.05$) among genetic groups. Van, Vanaraja; WN, White Nicobari; BN, Black Nicobari; BrN, Brown Nicobari.

Table 3. Shank length (mm) of Vanaraja, Nicobari fowls and their various F1 crosses

Group	Sex	Shank length
Van	Male	73.96±1.74^{a}
	Female	51.04±1.41^{cde}
WN	Male	56.79±1.11^{bcd}
	Female	39.15±2.67^{fgh}
BN	Male	55.51±0.41^{bcd}
	Female	37.32±3.07^{gh}
BrN	Male	49.41±6.59^{de}
	Female	45.06±1.49^{efgh}
Van×WN	Male	55.68±5.12^{bcd}
	Female	47.19±4.66^{defg}
WN×Van	Male	61.77±2.22^{b}
	Female	47.80±2.73^{def}
Van×BN	Male	55.40±4.48^{bcd}
	Female	44.55±1.03^{efgh}
BN×Van	Male	59.47±2.83^{bc}
	Female	45.34±1.42^{efgh}
BrN×Van	Male	39.48±2.86^{fgh}
	Female	37.19±0.95^{h}
Van×BrN	Male	52.91±2.50^{bcde}
	Female	44.12±0.68^{efgh}

Body weights and growth rates of indigenous birds are generally lower than commercial poultry birds (Islam and Nishibori 2010). In our present study also, the body weights of local birds were low. The promising cross WN × Van recorded a 20.63% higher body weight than its Nicobari parent (Table 2). A significant effect of sex and genotypes on the shank length was observed, which is consistent with the result of indigenous chicken genotypes of North-eastern parts of India (Haunshi *et al.* 2009). Feed conversion ratio (FCR) of Vanaraja among pure varieties and WN × Van among crosses was the lowest. FCR of the indigenous varieties was comparable to that reported for Miri, Gramapriya and Vanaraja (Haunshi *et al.* 2009).

Age at laying was found lowest in White Nicobari among pure varieties and WN × Van among crosses (Table 5). Annual egg production of Black Nicobari was highest and WN × Van excelled in annual egg production among the F_1 crosses. Egg weight of Vanaraja was the highest among the entire genetic group studied. No significant differences were

Table 4. Mean feed conversion ratio, FCR (feed per kg live weight gain) of Nicobari fowl, Vanaraja and their F_1 crosses

Age	Van	WN	BN	BrN	Van × WN	WN × Van	Van × BN	BN × Van	Van × BrN	BrN × Van
1–3 week	2.1±0.12^{e}	3.3±0.18^{bc}	3.5±0.17^{ab}	3.9±0.18^{a}	2.8±0.15^{cd}	2.4±0.18^{de}	3.6±0.17^{ab}	3.3±0.12^{bc}	3.5±0.18^{ab}	3.6±0.20^{ab}
4–8 week	3.13±0.15^{e}	3.8±0.20^{cd}	4.3±0.12^{abc}	4.5±0.18^{ab}	3.6±0.23^{de}	3.6±0.18^{de}	4.0±0.15^{bcd}	3.8±0.15^{cd}	4.6±0.17^{a}	4.3±0.12^{abc}
Mean	2.6±0.25^{d}	3.6±0.17^{abc}	3.9±0.20^{a}	4.17±0.17^{a}	3.2±0.21^{bcd}	2.9±0.29^{cd}	3.8±0.14^{ab}	3.6±0.15^{abc}	4.1±0.28^{a}	3.9±0.18^{a}

Values are expressed as mean±standard error. ^{a,b,c,d,e,f,g,h}Values within the same column with different superscript differ significantly ($p<0.05$) among genetic groups; Van, Vanaraja; WN, White Nicobari; BN, Black Nicobari; BrN, Brown Nicobari.

Table 5. Egg production performances of Vanaraja, Nicobari fowl and their various F1 crosses

Group	Age at laying (days)	Annual egg production (HHEP in Number)	Egg weight (g)	Annual egg mass (g)
Van	145	178.01	56.36	10032.64
WN	137	108.52	54.10	5870.63
BN	140	192.14	49.80	9568.37
BrN	202	159.40	48.07	7662.14
Van × WN	181	153.70	47.52	7303.895
WN × Van	146	184.95	50.49	9338.13
Van × BN	187	48.51	47.79	2318.221
BN × Van	191	159.51	50.21	8008.746
Van × BrN	184	180.36	42.03	7580.53
BrN × Van	165	117.31	36.83	4320.564

HHEP: Hen Housed Egg production. Van, Vanaraja; WN, White Nicobari; BN, Black Nicobari; BrN, Brown Nicobari.

found in egg length and breadth among pure varieties and F$_1$ crosses (Table 6). Albumin height was highest in White Nicobari, no significant difference was found in albumin weight among the pure birds. Among the F$_1$ crosses, a significantly higher albumin height was found in BN × Van than all the other varieties. Among the pure, no significant difference was found in yolk diameter (mm) of White and Black Nicobari but their values were higher than Vanaraja. Among the F$_1$ crosses, highest yolk diameter was in Van × WN. No significant difference was found in yolk height both in pure as well as in F$_1$ crosses. Yolk weight was highest in Black Nicobari among the pure and Van × WN among the F$_1$crosses. No significant difference in shell thickness (mm) was found among the pure. Shell thickness of WN × Van was the highest among the crosses.

Sexual maturity of other indigenous chickens found in India is as high as 193.35 days for Hill fowl of Uttarakhand (Pant *et al.* 2007), 202.58 days for Assel (Singh *et al.* 2000), 189 days for Naked Neck and 192 days for Frizzle fowl (Padhi *et al.* 2001). Effect of genotype on egg quality parameters was reported by various previous workers (Iqbal *et al.* 2012; Alewi *et al.* 2012). A nonsignificant (P>0.05) difference was found in age at sexual maturity amongst crossbred chickens of Rhode Island Red male × Fayoumi female (RIFI), Fayoumi male × Rhode Island Red female (FIRI) and White Leghorn male × FIRI female (RLH) (Khawaja *et al.* 2013). The egg weights of indigenous Nicobari fowls were lower as compared to improved Vanaraja. Among the F$_1$ crosses, egg weight of Van × WN was the highest. A positive correlation was found between egg weight and body weight of birds which agrees with the report of Nigussie *et al.* (2011). Egg weight variations among different genetic group of birds were reported by many authors (Padhi *et al.* 1998, Chatterjee *et al.* 2007a). Iqbal *et al.* (2012) found nonsignificant variations in egg

Table 6. Egg quality parameters of Vanaraja, Nicobari fowls and their various F$_1$ crosses

Group	L	B	Albht	Albwt	Yolk dia	Yolk ht	Yolk wt	Shell wt	Shell thick	Haugh unit
Van	55.88±0.49^{a}	41.84±0.45^{a}	5.53±0.65^{bc}	28.33±1.59^{a}	34.78±0.97^{c}	15.27±0.07	13.15±0.97^{c}	4.64±0.20^{d}	0.38±0.04^{ab}	74.33
WN	55.11±0.96^{ab}	41.65±1.39^{a}	6.37±0.47^{abc}	28.81±1.91^{a}	41.08±0.99^{ab}	15.53±0.09	16.59±0.79^{b}	5.95±0.01^{bc}	0.34±0.01^{ab}	81.23
BN	56.34±1.76^{a}	39.78±0.29^{ab}	5.18±0.37^{bc}	26.29±1.41^{a}	42.82±0.31^{a}	15.39±0.13	19.11±0.84^{ab}	6.05±0.23^{bc}	0.36±0.02^{ab}	74.24
BrN	55.09±1.57^{ab}	39.87±0.43^{ab}	4.53±1.11^{c}	23.41±1.45^{ab}	36.15±3.70^{bc}	15.65±0.11	16.42±0.74^{b}	5.40±0.09^{cd}	0.36±0.01^{ab}	69.64
BN × Van	50.70±4.17^{ab}	36.94±3.20^{ab}	8.23±0.52^{a}	28.39±1.30^{a}	41.53±1.69^{ab}	15.37±0.19	18.10±1.54^{ab}	7.19±0.71^{a}	0.32±0.03^{b}	93.22
Van × BN	52.68±1.05^{ab}	39.70±0.59^{ab}	5.17±0.41^{bc}	23.57±1.56^{ab}	40.06±1.07^{abc}	15.51±0.23	18.84±1.97^{ab}	5.82±0.03^{bc}	0.33±0.03^{b}	75.02
Van × BrN	51.18±1.22^{ab}	37.54±0.94^{ab}	7.34±1.22^{ab}	23.99±1.64^{ab}	39.97±0.40^{abc}	15.71±0.36	17.97±0.91^{ab}	6.25±0.21^{bc}	0.35±0.01^{ab}	90.99
WN × Van	53.65±0.36^{ab}	40.19±0.07^{ab}	6.04±0.42^{abc}	25.34±0.56^{a}	35.96±0.92^{bc}	15.68±0.15	12.47±1.12^{c}	5.57±0.25^{c}	0.42±0.02^{a}	80.27
BrN × Van	48.47±1.28^{b}	36.10±0.48^{b}	7.04±0.57^{abc}	19.03±1.99^{b}	41.54±0.76^{ab}	15.35±0.14	17.78±0.52^{ab}	5.73±0.16^{c}	0.31±0.01^{b}	91.12
Van × WN	52.34±0.91^{ab}	39.82±0.72^{ab}	4.84±0.41^{bc}	24.98±1.56^{a}	45.90±0.80^{a}	15.47±1.67	21.38±1.01^{a}	6.64±0.33^{ab}	0.31±0^{b}	72.51

L, Egg length; B, Egg breadth; Albht, Albumin height; Albwt, Albumin weight; Yolk dia,Yolk diameter; Yolk ht, Yolk height; Yolk wt, Yolk weight; Shell wt, Shell weight; Shell thick, Shell thickness. All the units are expressed in mm. Values are expressed as Mean±Standard Error. ^{a,b,c,d,e}Values within the same column with different superscript differ significantly (P<0.05) among genetic groups. Van, Vanaraja; WN, White Nicobari; BN, Black Nicobari; BrN, Brown Nicobari.

weight between 4 varieties of Assel under backyard condition of Pakistan. Significant effect of genotype on egg weight was observed in crosses of Naked-neck, Frizzle, normal feathered chicken from Nigeria, and exotic broiler breeder flock (Nwachukwu *et al.* 2006), between Naked-neck and normal feathered birds in free range system (Yakubu *et al.* 2008) and between indigenous Deshi, Cobb 500, Fayomi, RIR and Sonali (RIR × Fayomi) chickens (Islam and Dutta 2010). Yolk weight and albumen weight are very important from nutritional (Bain 2005) and cholesterol content (Sparks 2006) viewpoint. In the present study albumen weight of Nicobari and its crosses varied from 19.03±1.99 g in BrN × Van to 28.39±1.30g in BN × Van. Lower albumen weights (23.46 to 26.67g) were also reported by Chatterjee *et al.* (2007a) in indigenous fowls of Andaman. Yolk weight in the Nicobari fowls, Vanaraja and its crosses varied from 12.47±1.12g in WN × Van to 21.38±1.01g in Van × WN (Table 5). Chatterjee *et al.* (2007a) reported higher yolk weights in Naked Neck, Barred Desi and Frizzle Fowl and lower yolk weights in Brown and Black Nicobari breeds of Andaman and Nicobar Islands. The egg yolk heights were around 15 mm in all the genetic groups in the present study. Fayeye *et al.* (2005) reported the yolk height of Fulani-ecotype chicken as 14.27±1.45 mm, which is consistent with the results of the present study. The shell weight ranged from 4.64±0.20g in Van to 7.19±0.71g in BN × Van (Table 5) which was consistent with the reports in Naked Neck and White Leghorn (Padhi *et al.* 1998). Chatterjee *et al.* (2007a) also reported the nonsignificant breed difference in shell weight for 6 indigenous chicken breeds from Andaman. The shell thickness varied significantly ($P<0.05$) among different genetic groups in the present study. A significantly higher shell thickness was found in WN × Van in comparison to BrN × Van, Van × WN, Van × BN and BN × Van but did not vary significantly with other genetic groups. The mean shell thickness of 0.31 mm in Kadaknath (Parmar *et al.* 2006) and 0.31 mm in Naked Neck (Padhi *et al.* 1998) was reported. The higher shell thickness in the birds developed for backyard poultry was an indicator for their better suitability for rural/ backyard/free range farming due to its lower breaking proneness and better storage. Wani *et al.* (2007) reported lower shell thickness (0.32 mm) for Vanaraja birds than the values observed in the present study. Chatterjee *et al.* (2007b) observed nonsignificant variation in shell thickness between reciprocal crosses of ILI 80 and Brown Nicobari. Haugh unit is the measure of albumen quality that determines the quality of the egg. In the present experiment the average Haugh unit ranged from 72.51 (Van × WN) to 93.22 (BN × Van) among the genetic groups which were significantly higher than that of White Leghorn strains (Chatterjee *et al.* 2006). The genotypic differences in Haugh unit obtained in this study are consistent with the reports of Alewi *et al.* (2012) where different Haugh unit values were observed for local Kei (a red plumaged chicken) and its F_1 crosses with Fayoumi and Rhode Island Red (RIR) chicken breeds. Differences in Haugh unit among different genetic

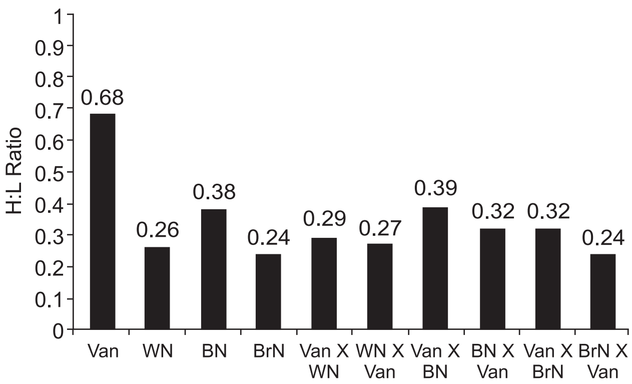

Fig. 1. Heterophil and lymphocyte ratio (H:L) of various genetic groups of chicken (Pure Vs crosses).

groups were also reported in direct and reciprocal crossbred Normal Local, Naked Neck and Frizzle Chicken × Exotic broiler in humid tropical climate of Nigeria (Nwachukwu *et al.* 2006). Parmar *et al.* (2006) reported wide range of Haugh unit values (62.58 to 90.00) for Kadaknath birds under field conditions in India which was consistent with the results of the present study. The Haugh unit values obtained for Nicobari fowls, Vanaraja and their crosses were above 70 indicating good albumen quality (North 1984).

Mortality of all the genetic groups was negligible during the period of study. H:L ratio of Vanaraja was higher (Fig. 1) in comparison to all the other genetic groups. The overall H:L ratio of the crosses were observed less in comparison to the pure breeds and among the pure breeds, the Brown Nicobari showed the lowest H:L and among the crosses, the BrN × Van showed lowest followed by WN × Vanaraja indicating the more adaptability than the others.

Among the pure breeds, Vanaraja, an introduced breed performed well in the island condition. But due to its some inherent weakness like predator proneness and higher mortality rate, its popularity is less than the indigenous Nicobari fowl or its crosses like White Nicobari × Vanaraja which has inherited both disease resistance property and higher adaptability from Nicobari parent and higher body growth and egg weight from Vanaraja parent which makes the cross product as most suitable dual purpose breed under hot and humid climatic condition of Andaman and Nicobar Islands.

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