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Characterization of Two Indian Native Chicken Breeds for Production, Egg and Semen Quality, and Welfare Traits

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ABSTRACT The present study was conducted to characterize and compare the two important native chicken breeds of India for growth, production, egg and semen quality and welfare traits. *Aseel* breed showed ($P < 0.001$) higher body weight at different ages, shank, radius and toe lengths at 40 weeks, egg weight at 28, 32 and 40 weeks of age than those of *Kadaknath* breed. While *Kadaknath* breed had ($P < 0.001$) early age at sexual maturity, higher 40 weeks egg production, higher ($P < 0.05$) specific gravity of eggs, higher albumen ($P < 0.001$) and shell percentage ($P < 0.009$) while *Aseel* breed had higher yolk index ($P < 0.004$), yolk percentage ($P < 0.001$) and yolk to albumen ratio ($P < 0.001$). Concentration of sperms ($P < 0.01$), live sperm counts and appearance of semen were higher ($P < 0.05$) in Aseel than those of *Kadaknath* breed. *Aseel* breed showed higher incidence of feather pecking behavior under floor rearing and that was negligible or mild in *Kadaknath* breed. Broodiness under cage rearing was noticed (8.42 %) in *Aseel* breed. With regard to welfare trait *Aseel* male birds had significantly ($P < 0.05$) lesser T.I. duration than *Kadaknath* male birds. Furthermore, *Aseel* male birds had lesser ($P < 0.001$) T.I. duration than *Aseel* female birds whereas; *Aseel* female birds had higher ($P < 0.05$) T.I. duration than that of *Kadaknath* female and male birds. From this study it was concluded that both breeds differed for various growth, production egg and semen quality traits and behavioral trait but not for welfare trait although female *Aseel* birds exhibited higher fear response.

(Key words: *Aseel, Kadaknath*, production, egg and semen quality, welfare)

INTRODUCTION

Aseel and *Kadaknath* are two important native chicken breeds of India. *Aseel* breed is known for its stamina, pugnacity, majestic gait and dogged fighting qualities (Panda and Mahapatra, 1989). The pure breeds of *Aseel* are still found in its breeding tract i.e. in Andhra Pradesh and in some areas of Rajasthan and Madhya Pradesh states. *Aseel* (Yellow) and *Aseel* (Black) are commonly available varieties among eight varieties of *Aseel* breed described in the literature (Panda and Mahapatra, 1989). This breed is blessed with hardiness, ability to thrive under adverse climatic conditions and its meat is considered to have desirable taste and flavor. On the other hand *Kadaknath* breed also known as '*Kalamashi*' in Hindi due to its black colored meat. It is being reared by tribal communities in its breeding tract of Jhabua and Dhar districts in western Madhya Pradesh and adjoining areas of Gujarat and Rajasthan states. The meat of this breed is although appears to be unattractive but has delicious flavor (Panda and Mahapatra, 1989). The meat and eggs are considered to be rich source of protein and Iron. It has been reported that the meat of *Kadaknath* contains high percentage (25.47) of protein and believed to have aphrodisiac properties (Mohan *et al.*, 2008b).

Although *Kadaknath* breed is blessed with many unique characteristics it has been neglected due to its poor production potential.

Of late there is a renewed interest in native germplasm among consumers and farmers due to their uniqueness in the hardiness, ability to thrive under adverse climatic conditions and desirable taste and flavor of eggs and meat. Hence there is a significant demand for the products of native chickens like *Aseel* and *Kadaknath* breeds. However, in order to increase the productivity of backyard/rural farming, improved/exotic birds are being introduced in the rural areas or in their breeding tracts leading to dilution of their genetic purity or complete replacement of native germplasm and hence these breeds are under threat of extinction (Singh, 2009). Few reports are available in literature about their performance at intensive (Mohan *et al.*, 2008a, 2008b) and free range system of rearing (Singh *et al.*, 2000a). Further, it appears from the literature that there is a lot of variation in production traits of these native breeds of chicken. As recently pointed out by Mohan *et al.*, (2008a and 2008b) that more investigations are required to establish the base line values of production parameters and general performance characterization of *Aseel* and *Kadaknath* breeds. Therefore, these two breeds of native chicken need to be systematically evaluated for their various growth, production and reproduction traits. Also, there is a need to measure the welfare parameter in native chickens as that will help understand their ability to adjust to system of intensive rearing. Hence the present study was conducted to evaluate and compare *Aseel (Yellow)* and *Kadaknath* breeds for various growth, production, reproduction, egg and semen quality, and fear response traits.

MATERIALS AND METHODS

Location of the Experiment

This experiment was carried out at the experimental poultry farm of the institute (Project Directorate on Poultry) located at Hyderabad (17^o 20' N, 78^o 30' E). The average maximum and minimum temperatures recorded during the experimental period of this area were 33.51 ^oC and 21.35 ^oC respectively. The average maximum relative humidity recorded in the morning and evening was 75.55 % and 45.40 % respectively with total rainfall of 663 mm during the period. The agro meteorological data was obtained from Agricultural Research Station, Hyderabad located at about two km from the study site.

Experimental Animals

295 chicks of *Aseel* (Yellow) and 463 chicks of *Kadaknath* were generated in two hatches and reared on deep litter system in open sided house with curtains hanging from out side during brooding period. Standard management practices were followed during brooding, growing and laying stages. Birds were transferred to individual layer cages in open sided house at about same age when the first egg in the flock was noticed. Around same time male birds were also transferred to individual cages in open sided house. Mixed (Male and Female) rearing (one male to three females) was done on floor until birds were transferred to the individual cages. Individual cage dimension (width x length x height at front x height at back) respectively for male and female birds of Aseel breed were 10 x 15 x 20 x 18 in and 7.5 x 15 x 20 x 18 inches. For Kadaknath male and female birds the cage dimension were 8 x 15 x 17 x 15 in and 8 x 15 x 17 x 15 inches.

The chicks were provided with *ad libitum* chick starter ration (2600 Kcal/kg M.E. and 18 % C.P. on calculated basis) up to eight weeks of age and grower ration (2500 Kcal/kg M.E. and 16 % C.P. on calculated basis) from nine to 25 weeks of age and layer ration (2600 Kcal/kg M.E. and 16 % C.P on calculated basis) from 26 weeks onwards. The feed ingredients used in ration formulations were maize, soybean meal, sunflower cake, de-oiled rice bran, salt and vitamin premix, lysine, DL methionine, trace minerals, shell grit and dicalcium phosphate. The layer ration was supplemented

with extra shell grit to make the calcium content to 3.5 % of the ration. Adult male birds were provided with the same layer ration with 1.0 % calcium in the diet.

Measurement of Traits

Economical Traits. Body weight was measured at day old, four, six, 16, 18, and 20 weeks of age on straight run basis. Sex-wise body weight was recorded at 24 and 40 weeks of age. Sex wise shank, radius and middle toe lengths were also measured at 40 weeks of age. Age at first egg, age at sexual maturity, egg weight at 28, 32 and 40 weeks of age and part period egg production up to 40 weeks of age were recorded. The weight of eggs was recorded using digital balance (nearest to 0.01g accuracy). Layer house mortality was recorded from the day of housing in cages to 40 weeks of age.

Egg Quality Traits. Various external and internal egg quality traits were measured at 40 weeks of age. Total of 69 eggs from 33 *Aseel* hens and 109 eggs from 55 *Kadaknath* hens were used for the egg quality analysis. The external characters like egg weight, length, width, shape index and specific gravity were measured. Specific gravity was determined using brine floatation technique as described by Hamilton, (1982). Subsequently, the eggs were broken and the internal traits like yolk weight, yolk height and albumin weight were recorded using standard procedures. Egg weight, Haugh unit, albumin height and yolk color were measured using egg quality tester (EMT 5200, Japan). Whole egg, albumen and yolk weight, yolk to albumen ratio, percent albumen, percent yolk and percent shell weights were also recorded. Length and breadth of eggs were measured using digital Vernier calipers (least count 0.01mm).

Semen Collection and Semen Quality Analysis

Semen Collection. Semen was collected following standard practice of massage method (Lake *et al.*, 1985) from cocks of each genetic group housed in individual cages. Cocks were trained three to four times by massaging the back and milking the cloaca before collecting semen samples. The semen was collected four days after removing semen from the birds. Semen was collected from total of 40 cocks of *Kadaknath* and 28 cocks of *Aseel* at 42 weeks of age. The collection and examination of the semen was done by single investigator during the study to avoid investigator's biasness.

Volume, Appearance and Sperm Individual Motility. The volume of the undiluted semen ejaculate was assessed by drawing the collected sample in to 1 ml syringe with an accuracy of 0.02 ml. The appearance of semen was scored on a scale of 1 to 5 by visual examination (McDaniel and Craig, 1959) In which semen with watery or clear semen given score 1, watery with white streak-2, medium-3, thick white- 4 and very viscous and chalky white semen samples given score of 5. Subsequently, individual samples were diluted four times using high temperature diluent (HT), which was then used for evaluation of below mentioned semen quality traits. Individual motility was recorded as percentage of progressively motile sperms, for this a drop of diluted semen was kept on a clean, grease free glass slide, and cover slip was applied to examine under high power magnification (40 X). The percentage of sperms with normal, vigorous, and forward linear motion was subjectively assessed to the nearest 5% at five different areas of the sample on each slide.

Sperm Concentration. The concentration of sperm was determined by computer-assisted semen analysis (CASA) (Motic CASA Plus, Motic Instruments, Canada). The MTT dye reduction test was carried out to assess the fertilizing ability of sperms since fertilizing ability and semen quality are considered to be correlated with ability of sperms to reduce tetrazolium dye 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide (MTT) (Hazary *et al.,* 2001). Reduction of MTT dye resulted in increased absorbance that was measured with a colorimeter at 570 nm wave length. Assay samples were run in duplicates.

Livability and Abnormal Sperm Count. Percentage of live, dead and abnormal sperms was estimated by differential staining technique using eosin–nigrosin stain (Campbell *et al.,* 1953). Briefly, a drop of semen was placed on a clean warm glass slide and mixed with a drop of 5% eosin and 10% nigrosin mixture. Smears were prepared from this mixture and dried in air. In each slide, 200 sperms were examined under oil immersion (100 X) microscope. Both fully and partially stained spermatozoa were counted as dead. The same slides were used for estimating the percent abnormal sperm count on the basis of noticeable abnormalities of head, neck, mid-piece, and tail region.

Welfare and Behavioral Traits. Induction of T.I. to measure fear response was carried out by keeping the bird in a U shaped wooden cradle in supine position (Jones and Faure, 1981) and by applying mild hand pressure on abdomen of birds for about 10 s. The duration of T.I. was recorded by stop watch if the bird remained motionless for initial 10 s subsequent to the release of experimenter's hands. If the bird did not stay motionless at least for 10 s after release of hand, the T.I. attempt was considered as unsuccessful and another attempt was performed. Like wise up to five attempts were made until induction of T.I. took place and the number of T.I. attempts was noted down. If five attempts were unsuccessful in inducing latency the T.I. duration was recorded as zero and number of attempts was considered as five. If the bird did not regain its normal position even after five minutes duration a maximum score of 300 s was given for latency time. Values of T.I. duration were transformed logarithmically before they were subjected to data analysis. Broodiness % under cage system of rearing was recorded by observing the behavior of birds. Birds which were not laying, sitting for longer duration and when approached made peculiar sound and raised their feathers were classified as broody hens. Empirically, feather pecking behavior was assessed by observing for presence of bare backs, feathers on the litter and pecking of birds and was subjectively compared between two breeds.

Statistical Analysis

The mean and standard errors for various traits were calculated as per the standard statistical procedures (Snedecor and Cochran, 1994). The significant difference between genetic groups for various economical, egg quality and semen quality traits was tested by one way analysis of variance. Two way analysis of variance was used to test the significant difference between breeds and sexes for traits mentioned in Tables 2 and 5.

RESULTS AND DISCUSSION

Economical Traits

The mean values of body weight, age at first egg, average age at sexual maturity, 40 weeks part period egg production and broodiness are given in Table 1. Higher ($P < 0.001$) body weight was observed in *Aseel* at day old, two, four, six, 16, 18 and 20 weeks of age as compared to *Kadaknath*. Average values of sex wise body weight recorded at 24 and 40 weeks of age and shank, radius and middle toe lengths are presented in Table 2. Sex effect ($P < 0.001$) was observed in both the lines for body weights measured at 24 and 40 weeks of age. Sex wise body weights taken at 24 and 40 weeks of age of *Aseel* were higher ($P < 0.001$) than those of *Kadaknath* breed. Similarly, average combined as well as sex wise shank, radius and toe lengths measured at 40 weeks of age were higher ($P < 0.001$) in *Aseel* as compared to *Kadaknath* breed.

Higher body weight observed in *Aseel* breed right from day old to 40 weeks of age as compared to *Kadaknath* breed could be explained from the fact that *Aseel* breed has been selected naturally or by farmers in villages for their fighting capability and hence have longer legs, stronger bones and compact muscle mass. On the other hand *Kadaknath* is lesser in body weight and it is basically used for egg production besides using it for meat consumption in tribal or rural areas.

Similarly, shank, radius and toe lengths were also higher in *Aseel* both on individual as well as combined sex basis. Our findings were in agreement with previous studies on these traits (Mohan et al. 2008a, 2008b). Average 40 week's body weight of 1755 g for *Aseel* and 1407 g for *Kadaknath* was reported in previous study (Singh et al., 2007). The average body weights at 26 and 78 weeks of age were 1658 ± 40 g and 2298 g respectively were reported for *Aseel* breed (Mohan *et al.,* 2008a). While *Kadaknath* had average body weight of 1303 ± 26.39 g and 1555.50 ± 21.04 g respectively at 21 and 52 weeks of age (Mohan *et al.,* 2008b).

Age at sexual maturity was comparatively higher in both the breeds in the present study as compared to those reported by Mohan *et al.,* (2008a and 2008b) and this might be due to the fact that the later part of growing stage of birds was in decreasing day length prevailing at the experimental location and hence delayed the age at sexual maturity in both the breeds. However, the age at sexual maturity of *Aseel* breed is comparable to the findings of Singh *et al.,* (2000a) who reported the age at sexual maturity of 29 weeks under field conditions for *Aseel* breed. *Kadaknath* had significantly ($P < 0.001$) lesser age at sexual maturity despite having almost similar age at first egg in the flock in both the breeds (176 d in *Aseel* and 175 d in *Kadaknath*). This finding was on expected line since *Kadaknath* is egg type bird and hence had early sexual maturity. Mohan *et al.,* (2008a and 2008b) reported age at first egg production of 145 and 154 days respectively for *Kadaknath* and *Aseel* breeds.

The higher 40 weeks part period egg production in *Kadaknath* than *Aseel* breed is on expected line since *Kadaknath* is basically used by tribal community for egg production and more over it has early sexual maturity and hence had better 40 weeks part period egg production. Thakur *et al.,* (2009) reported the 40 weeks part period egg production in the range of 39 – 42 numbers for *Kadaknath* breed under intensive system of rearing. On other hand Singh *et al.,* (2000a) reported average egg production of 33.17 eggs per hen per year under field conditions for *Aseel* breed. Lower egg production in *Aseel* breed is due to broodiness condition observed in this breed. Commercial white leghorn chickens under Indian conditions lay about 108 eggs in 40 weeks with 22 weeks age at sexual maturity and 1.2 to 1.5 kg adult body weight.

Egg Quality Traits

Mean values of egg weights recorded at 28, 32 and 40 weeks of age and results of egg quality parameters measured at 40 weeks of age are given in Table 3. At all ages higher ($P < 0.001$) egg weight was observed in *Aseel* as compared to *Kadaknath* breed. The egg weight, yolk weight, albumen weight, shell weight, yolk to albumen ratio, yolk percentage ($P < 0.001$) and yolk index *(*$P < 0.004$) were higher in *Aseel* breed as compared to *Kadaknath* while specific gravity ($P < 0.05$), percentage of shell *(*$P < 0.009$) and albumen ($P < 0.001$) were higher in *Kadaknath* than that of *Aseel* breed.

Higher egg weight observed at various ages in *Aseel* as compared to *Kadaknath* breed could be explained from the fact that *Aseel* is having significantly higher body weight and hence had higher egg weight at respective age. However, Singh *et al.,* (2000a) reported an average egg weight of 41 g for *Aseel* breed, on the contrary Singh *et al.,* (2000b) reported an average egg weight of 47.81 ± 0.18 for same breed under field conditions. This variation in egg weight might be due to variation in the age of hens from which eggs were collected under the field conditions. While Mohan *et al.,* (2008a) reported average egg weight of 40 and 52 g respectively at 26 and 78 weeks of age for *Aseel* breed. In another study average egg weight of 47 g for *Aseel* and 43 g for *Kadaknath* breed at 40 weeks of age was reported (Singh et al., 2007). Smaller egg size of *Kadaknath* breed is in agreement with the findings of Mohan *et al.,* (2008b) who reported that the average egg weight at 21

weeks and at 52 weeks of age were 32.50 ± 0.70 and 46.11 ± 1.25 g respectively for *Kadaknath* breed.

Kadaknath breed had higher specific gravity indicating the better shell quality and it was reflected through higher percent shell weight despite having lesser shell weight in absolute terms. Percent yolk weight was higher while percent albumen was lesser in *Aseel* as compared to *Kadaknath* breed and hence significantly higher yolk to albumen ratio was observed in *Aseel* than that of *Kadaknath* breed. This finding is in contrast to the established fact that the smaller the size of eggs higher will be the proportion of yolk and smaller will be the proportion of albumen (Tharrington *et al.,* 1999). The higher yolk to albumen ratio observed in *Aseel* breed might be due to higher egg weight noticed in this breed**.** Parmar *et al.,* (2006) reported higher yolk weight (15.18g) and lower albumen weight (20.74 g) in *Kadaknath* breed and these values are different from the present findings. These authors have studied the egg quality traits of *Kadaknath* breeds reared under field conditions and have not mentioned the age of the *Kadaknath* hens reared by the farmers from which eggs were collected and also it was not known whether *Kadaknath* hens belonged to the same age group in their study.

There were no significant differences in shape index, albumen index and Haugh unit and yolk color in native breeds. Almost similar shape index (75.46) was reported for *Aseel* eggs collected from field conditions (Singh et al., 2000b) but once again no mention about the age of *Aseel* hens was made in their report. Parmar *et al.,* (2006) observed wide variation in Haugh unit values for *Kadaknath* birds starting form 62.58 to 90.00 on the eggs collected from field conditions. The Haugh unit values in the present study are with in the reported range. Yolk index was higher in *Aseel* in comparison to that of *Kadaknath* breed although yolk index values were comparatively lower than the normal values reported in literature for other breeds. Parmar *et al.,* (2006) also observed lower yolk index (0.37) for *Kadaknath* breed. However, reports about detailed study on external and internal egg qualities of these two important native breeds of India are lacking in the literature. This is the first report to our knowledge which compares the internal and external egg qualities of *Aseel* and *Kadaknath* breeds of chicken at same age and under same management conditions.

Semen Quality Traits

The findings of the semen quality traits measured at 42 weeks of age are presented in Table 4. *Aseel* breed was superior to the *Kadaknath* in appearance of semen ($P < 0.05$) and concentration of sperms ($P < 0.01$). Live ($P < 0.05$) and dead ($P < 0.05$) sperm percentage was significantly higher in *Aseel* and *Kadaknath* breeds respectively. However, no significant differences were observed in volume of ejaculate, abnormal sperm %, motility of sperms and fertilizing ability (MTT Formazan (nmol/min/million sperms) although numerically higher volume of semen was observed in *Kadaknath* breed. *Aseel* breed despite having higher body weight had no significant difference in ejaculate volume with that of *Kadaknath* breed, however slightly higher average ejaculate volume was observed in *Kadaknath* breed. This finding was somewhat unexpected as it was established that cocks with higher body weight will have higher ejaculate volume than their lower body weight counter parts (Haunshi *et al.,* 2010). However, lesser ejaculate volume was reported by Biswas *et al.,* (2009) for *Kadaknath* breed at about 30 weeks of age. In the present study we have noticed higher concentration of sperms, livability and lesser abnormal sperm percentage but higher dead sperm count in *Kadaknath* breed as compared the findings of Biswas et al., (2009). Reports regarding semen quality of *Aseel* breed are scarce in literature and to our knowledge this is the first study reporting on the semen quality traits in this particular breed and also about comparison of these two native breeds for semen quality traits.

Welfare and Behavioral Traits

The results of fear response measured in duration (s) of T.I., number of attempts to induce T.I. and cage house mortality up to 40 weeks of age are given in Table 5. No significant difference was observed for T.I. duration and number of attempts required for inducing T.I. on combined sex basis between the breeds. And also no significant difference was observed between male and female birds of *Kadaknath* breed for these two traits. However, *Aseel* male birds had significantly ($P < 0.05$) lesser T.I. duration than *Kadaknath* male birds. Similarly *Aseel* male birds showed significantly ($P < 0.001$) lesser T.I. duration than *Aseel* female birds. On the other hand *Aseel* female birds had significantly ($P < 0.05$) higher T.I. duration than that of *Kadaknath* female and male birds.

In the present study it was expected that *Aseel* breed being the game bird and known for its fighting qualities and courage should have lesser fear response than the *Kadaknath* breed which is some what shy and timid in nature. Since *Aseel* birds were tall in stature as compared to *Kadaknath* breed they were kept in cages having higher height. On the other hand male and female birds of *Kadaknath* breed were kept in cages having lesser height since their height is lesser as compared to *Aseel* breed. The only difference between cages where male and female *Aseel* birds kept was that the width of female cage (7.5") was lesser. Therefore, exhibition of significantly higher T.I. duration in female *Aseel* birds could be attributed to the stress or discomfort experienced by the birds due to lesser width of cages where they are kept and hence that lead to the longer duration of T.I. in *Aseel* females. To the knowledge of the authors it is the first report describing the welfare trait in Indian native breeds.

Feather pecking behavior was noticed more in *Aseel* breed under floor system of rearing which starts around four to five weeks of age and persists till they are housed in cages and this lead to the condition of bare-backs in the birds and resulting in mild form of cannibalism. However, very mild or negligible feather pecking behavior was observed in *Kadaknath* breed. This particular behavior might be inherent to the *Aseel* breed as this breed is a game bird and having aggressive behavior. Broodiness in cage rearing was higher in *Aseel* than that of *Kadaknath* breed. Higher broodiness observed in *Aseel* breed is in agreement with the findings of Singh *et al.*, (2000a) who has reported highest (58.01%) broodiness in *Aseel* breed under field (free-range) conditions.

Aseel birds seems to have higher layer house survivability both on individual as well as combined sex basis as compared to *Kadaknath* breed under similar management conditions. Most of the post mortem cases in *Kadaknath* breed were diagnosed as egg peritonitis, colibacillosis, visceral gout, chronic respiratory disease. Reports about the survivability of these breeds under cage house conditions were sparse in literature to compare with present findings although it was speculated that *Kadaknath* birds were susceptible to Marek's disease (Mohan *et al.*, 2008b) but conclusive evidence is not available in the literature.

From this study it was concluded that both breeds differed for various growth, egg and semen quality traits and behavioral trait but not for welfare trait although female *Aseel* birds exhibited significantly higher fear response.

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Table 1 Body weights, sexual maturity and egg production of *Aseel* and *Kadaknath* breeds of chicken (mean ± S.E.)

Traits	*Aseel*	*Kadaknath*
Day old body weight (g) ***	33.19 ± 0.20 [a]	28.55 ± 0.12 [b]
2 weeks body weight (g) ***	72.88 ± 0.99 [a]	60.57 ± 0.48 [b]
4 weeks body weight (g) ***	150.62 ± 2.44 [a]	114.62 ± 1.40 [b]
6 weeks body weight (g) ***	267.19 ± 3.93 [a]	192.79 ± 2.05 [b]
16 weeks body weight (g) ***	1051.84 ± 16.22 [a]	619.31 ± 7.56 [b]
18 weeks body weight (g) ***	1178.99 ± 17.26 [a]	689.88 ± 14.03 [b]
20 weeks body weight (g) ***	1318.42 ± 22.24 [a]	769.11 ± 12.41 [b]
Age at first egg in flock (d)	176	175
Age at sexual maturity (d) ***	213.25 ± 0.54 [a]	200.61 ± 1.37 [b]
40 weeks egg production (Nos.)	36.23	49.40

[a, b] Figures bearing different superscript row-wise differ significantly (***$P < 0.001$).

Table 2 Sex wise body weights, shank, radius and middle toe lengths of *Aseel* and *Kadaknath* breeds of chicken (mean ± S.E.)

Traits	*Aseel*			*Kadaknath*		
	Male	**Female**	**Combined**	**Male**	**Female**	**Combined**
24 weeks body weight (g)***	1872.4 ± 38.4	1303.2 ± 20.1	1440.2±29.0	1231.4 ± 39.3	936.9 ± 21.7	1025.9 ± 24.1
40 weeks body weight (g)***	2736.9 ± 50.8	1831.6 ± 25.8	2105.5±44.9	1739.8 ± 30.9	1321.6 ± 18.4	1435.7 ± 21.5
Shank length (L+R) / 2 at 40 weeks of age (mm)***	125.3 ± 0.9	101.9 ± 0.6	109.2±1.1	108.4 ± 0.8	89.7 ± 0.5	94.8 ± 0.8
Radius length (L+R) / 2 at 40 weeks of age (mm)***	110.5 ± 0.7	95.1 ± 0.4	99.7 ± 0.7	86.8 ± 0.9	83.8 ± 0.4	87.1 ± 0.6
Middle toe length (L+R) / 2 at 40 weeks of age (mm)***	48.1 ± 0.5	41.9 ± 0.6	44.5 ± 0.6	41.3 ± 0.4	36.7 ± 0.2	38.3 ± 0.3

Note: Male and Female birds within the breed and respective sex between breeds differ significantly (***$P < 0.001$).

Table 3 Egg quality parameters of *Aseel* and *Kadaknath* breeds at 40 weeks of age (mean± S.E.)

Traits	*Aseel*	*Kadaknath*
Egg weight at 28 weeks (g) ***	42.71 ± 0.36 [a]	35.58 ± 0.34 [b]
Egg weight at 32 weeks (g) ***	45.80 ± 0.49 [a]	39.92 ± 0.38[b]
Egg weight at 40 weeks (g) ***	49.28 ± 0.53[a]	41.39 ± 0.37 [b]
Specific gravity *	1.0096 ± 0.0012[a]	1.1038 ± 0.0008 [b]
Shape index	77.36 ± 0.36 [a]	76.39 ± 0.57 [a]
Yolk Color	7.43 ± 0.13 [a]	7.82 ± 0.14 [a]
Haugh unit	75.43 ± 0.84 [a]	74.99 ± 0.69 [a]
Albumen index	0.076 ± 0.002 [a]	0.072 ± 0.002 [a]
Yolk index**	0.395 ± 0.006[a]	0.367 ± 0.008[b]
Yolk weight (g) ***	16.32 ± 0.24 [a]	12.49 ± 0.09 [b]
Albumen weight (g) ***	28.97 ± 0.59 [a]	26.29 ± 0.49 [b]
Shell weight (g) ***	4.94 ± 0.08 [a]	4.34 ± 0.04 [b]
Yolk percentage ***	33.12 ± 0.42 [a]	30.22 ± 0.29 [b]
Albumen percentage ***	56.88 ± 0.43 [a]	59.31 ± 0.33 [b]
Percentage of Shell **	10.00 ± 0.13 [a]	10.47 ± 0.10 [b]
Yolk to Albumen Ratio***	0.59 ± 0.011 [a]	0.51 ± 0.007 [b]

Note: Figures bearing similar super script row wise do not differ significantly (*** $P < 0.001$, ** $P < 0.01$, * $P < 0.05$).

Table 4 Semen quality traits of *Aseel* and *Kadaknath* breeds evaluated at 42 weeks of age (mean ± S.E.)

Traits	*Aseel*	*Kadaknath*
Ejaculate Volume (ml)	0.31 ± 0.029 [a]	0.36 ± 0.017 [a]
Appearance*	4.43 ± 0.14 [a]	4.05 ± 0.12 [b]
Motility (%)	83.57 ± 1.83 [a]	85.50 ± 2.07 [a]
Concentration (million sperms/µl)**	6.53 ± 0.29 [a]	5.58 ± 0.24 [b]
Fertilizing ability (MTT Formazan (nmol/min/million sperms)	28.59 ± 0.89 [a]	27.79 ± 0.81 [a]
Live sperms (%)*	93.49 ± 0.38 [a]	90.42 ± 1.66 [b]
Dead sperms (%)*	6.51 ± 0.38 [a]	9.58 ± 1.66 [b]
Abnormal Sperms (%)	1.48 ± 0.19 [a]	1.81 ± 0.31 [a]

[a,b]Means within a row with different superscripts differ significantly.
1Scored on a scale of 1 to 5, with watery or clear semen = 1, watery semen with white streaks = 2, medium white semen = 3, thick, white semen = 4, and very viscous, chalky white semen samples = 5. 2MTT = 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide. *$P < 0.05$; **$P < 0.01$

Table 5. Welfare and mortality traits of the Aseel and Kadaknath breeds (mean ± SE)

	Aseel			Kadaknath		
Trait	Male	Female	Combined	Male	Female	Combined
Log of TI[1] duration	1.50 ± 0.09[ac]	1.97 ± 0.04[bc]	1.83 ± 0.04[d]	1.76 ± 0.07[d]	1.85 ± 0.03[d]	1.82 ± 0.03[d]
Attempts (no.)	1.63 ± 0.17	1.62 ± 0.09	1.62 ± 0.08	1.37 ± 0.12	1.57 ± 0.08	1.52 ± 0.06
TI duration (s)	57.06 ± 11.02	130.82 ± 10.65	108.75 ± 8.72	91.20 ± 14.07	95.59 ± 6.81	94.50 ± 6.18
Layer house mortality at 40 wk of age (%)	1.67	1.07	1.31	14.08	13.43	13.66
Broodiness in cages at 40 wk of age (%)	—	8.42	—	—	0.80	—
Feather-pecking under floor rearing	—	—	Severe	—	—	Mild or negligible

[a,b]Aseel males and females differ significantly ($P < 0.001$).

[c,d]Aseel males and females respectively differ significantly from males and females of the Kadaknath breed ($P < 0.05$).

[1]TI = tonic immobility.