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Review Article

The design of the avian respiratory system: development and morphology - a review

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Abstract

By every definition birds are extreme animals with singular adaptive morphologies and physiologies.The respiratory system is a good model for studying optimization from a functional perspective because it consists of linked structures with defined design parameters and an overall function that has a measurable upper limit, the maximum rate of oxygen consumption.The investigations of the respiratory tract concentrate on several aspects, viz. bioacoustics, neuroanatomical, respiratory physiology, morphological-ecological analysis of the relation of the respiratory tract structure to the life habits and rarely on the developmental descriptions. The evolution of the vertebrate respiratory system achieved its most efficient state in birds, with their constant volume parabronchial lungs and highly compliant air sacs having low pressure ventilation. These additional characteristics equipped the birds for sustained flight or buoyancy in water. The respiratory organs of birds differ from those of mammals in a number of specific features which are partly associated with the requirements of flight and the great work load that this form of locomotion demands, and partly with the voice production. Differences in the development of this system do exist among different orders or species or even birds of same species.

Key words: Respiratory system, Development, Parabronchi, Lungs

INTRODUCTION

The abilities of birds to sustain flight and to fly in the thin air of high altitude are striking evolutionary accomplishments. The respiratory system is vital to these strenuous feats and thus most research on the form, function, and adaptive significance of the avian lung has rightly focused on adaptations that enable rapid rates of gas exchange.

Since flight is one of the most energetically expensive forms of locomotion, birds have physiological and structural compromise solutions for the required energetic efficiency, environmental demands and lifestyle constraints.

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Birds increase oxygen consumption 10- to 20-fold from rest to flight (Bartholomew, 1954) with their mass-specific aerobic capacities being 2.5–3 times higher than those of non-flying mammals of the same size. To satisfy these high oxygen demands, birds must optimize the structure of the respiratory tract and the cardiovascular system. Although, relentlessly studied for well over four centuries in biology, few organs have withstood as much scientific interrogation as the respiratory apparatus of birds, the lung-air sac system and yet remained profoundly intractable. Historically, the avian respiratory system is highly ranked among the controversial organ-systems and has been investigated by scientists as long as they have been studying comparative anatomy. The functional design of the avian respiratory system remains abstruse, despite concerted efforts to unravel the mysteries of its architecture. In the course of attaining a singular respiratory capacity, the avian lung appears to have contracted certain fundamental structural and functional divestitures. Notably, the lung is noncompliant and takes two inspiratory and two expiratory cycles for the air to traverse the entire system and get out to the trachea. The physiological and anatomical explanations for this mechanism remain elusive and the topographical organization of the air conduits is recondite.

Among the morphoanatomical investigations of birds, a certain attention is devoted to the studies on the respiratory tract. The factors determining the designs of the vertebrate respiratory systems include the physiochemical characteristics of the respiratory medium used, the nature of habitat occupied and the lifestyle pursued. This in turn reflects the structural variations in animals and birds residing in a particular area. In fact, the birds are exceptionally susceptible to infections of the respiratory system. Vast economic losses in the poultry industry have been attributed to mortalities ensuing from pulmonary infections. These deductions have been based on circumstantial evidence and lack resolute experimental basis. The extensive anatomical plan of the lung air-sac system of birds has speculatively been alleged to predispose it to fast diffusion of air-borne diseases while intensifying the spread of harmful effects of toxic air pollutants.

Structural Components of Respiratory System

Air breathing has evolved in many animal taxa and lungs have evolved as an adaptation to hypoxia or anoxic conditions in the early hydrosphere (Randall *et al*., 1981b., Maina, 1988). In lungs, a large surface area is produced by internal subdivision of the parenchyma, giving rise to narrow terminal gas exchange components. The compact, in expansile state of the avian lung has allowed more intense subdivision of the gas exchange tissue into the air capillaries which range in diameter from 8 to 20mm (Duncker, 1974; Maina *et al.*, 1982).The normal development of the respiratory organs in birds was determined by an inductive process between the endothelial and the mesenchymal cell elements (Shannon and Deterding, 1997; Hogan 1999). Alcantara *et al*. (2013) stated that the respiratory system organs in chicken began to develop at the fourth day as a disorganized tissue and were undifferentiated. Their complete

differentiation was observed at 10 days of incubation.

By 3rd day of incubation in the Kuttanad duck embryo, the olfactory pits were observed at the junction of the lateral and ventral walls of the head and were anterior to the primordia of eyes. By 10th day of incubation the individual parts of the respiratory system were clearly observed with the stereozoom microscope. By day 14 of incubation it was evident that the primary bronchi, secondary bronchi, parabronchi, air sacs and pleura came into existence. By 21st day the parabronchi developed and underwent micro-architectural organization with cavitation that extended peripherally deep into the surrounding mesenchymal tissue all along the lung parenchyma (Firdous *et al*., 2015).

a. Nasal Cavity and Nares

In the embryo of zebra parakeet, olfactory placodes appeared at the 25-26 somite stage (Abraham, 1901) where as in duck Romanoff (1960) reported that the olfactory placodes which formed on the lateral walls of head, anterior to the eyes were first seen at 23-24 somite stage. A transitory depression in the four and fifth day chick embryo on the medial wall of each pit was interpreted as a rudimentary Jacobson's organ. A distinct anlage of jacobson's organ in the black-headed gull and in the European coot persisted up to the stage just prior to hatching. The organ just before hatching of black-headed gull was long and blind canaliculus strewn with stratiform cylindrical or cubical epithelium connected with lumen of the epithelial nasal tubulus by its rostral end (Beer, 1962). Romanoff (1960) explained that by active mitosis and proliferation, the placodes ectoderm gave rise to the sensory or olfactory epithelium and to the olfactory nerves. He also observed that the mesodermal tissue surrounding the nasal pits started to increase in mass on lateral and medial sides of each pit. The mesodermal protuberances adjacent to nasal pits were external and internal nasal processes. By fifth day, palatine process of the maxillary process started to grow and hid choanae from view on eighth day. On eleventh day, two thin plates extended medial ward from the palatine processes, and met in the middle without fusing and formed the split plate characteristic of birds. With the growth of the beak, the nasal fossae were elongated, especially in the vestibular region.

Mathes (1934) reported in domestic fowl that each half of the nasal cavity tends to expand slightly as it passed posteriorly and divided into three compartments, the vestibule, the middle chamber and the antorbital chamber. Das *et al.* (1965) reported in domestic duck that the oval nostrils were located on the dorsolateral aspect of the caudal one third of the bill. Nasal Septum was a very unique feature of petrels (Bang, 1971) but was absent in Japanese quail (Aysun *et al.*, 2007). Yokosuka *et al.* (2009) and Kondoh *et al.* (2011) found in Japanese jungle crow that the nasal cavity was completely divided by the nasal septum into the left and right cavities.

b. Conchae

Street (1937) opined that in chick the inferior concha was first to develop with the

primordiumseen as rounded protuberance projecting into nasal cavity from the lateral wall during the fourth day of incubation. On fifth day, the development of superior concha was initiated in the same manner in the fundus of the nasal cavity. Midtgard (1989) reported in chicken that the vascularity of the rostral and middle nasal conchae increased about 4-fold, while there was a progressive decrease in the relative size of the epithelium and connective tissue compartments, during the maturation period. Arteriovenous anastomoses (AVAs) were present already at hatching. Michael (2004) revealed that the olfactory conchae were present with a mostly completed morphology in 8 day old embryos and grew larger by day 12. The inferior conchae were in a primitive state of development at day 8. By day 12, the main structure of the inferior conchae was evident, and by day 14 they seemed to be in their final form. Nemours (1930) observed the presence of three turbinate bones or conchae in domestic fowl. The three compartments of the nasal cavity corresponded with these turbinates and the middle turbinate meets the definition of true turbinate, the others being pseudo turbinate type. Hodges (1974) revealed in domestic fowl that the anterior or ventral turbinate was attached to the dorso-lateral wall of the nasal passage inside the vestibule with slightly curved and strongly convex shape. Middle turbinate originated from lateral wall of the middle chamber as a lammeliform structure, shaped into a spiral of one and one half turns. Dorsal or posterior turbinate was simple, hollow, flattened projection from the wall of the cavity originating above and behind the middle turbinate but slightly overlapping. According to Bang and Wenzel (1985), the avian nasal cavity varied in structure among species and was divided by the anterior, middle and posterior concha with middle one occupied major part. Tasbas *et al*. (1994) also documented the middle nasal concha as the largest of the three conchae in domestic fowl, resembling a scroll. The caudal nasal concha was the smallest nasal concha in coturnix (Fitzgerald 1970), Aysun *et al.,* (2007) and was occasionally missing in Falconiformes and Swifts (King and Mclelland, 1984). According to King and Mclelland (1984) the rostral nasal concha of the domestic fowl, was simple branched, T- or scroll like with an additional vertical lamella of cartilage that arose from the ventral border of the nostril but in Japanese quail Aysun *et al.* (2007) displayed a C-shaped rostral nasal concha. In contrast, the structure corresponding to the posterior (olfactory) concha (Bang 1971., Bang and Wenzel 1985) usually observed in the nasal cavity of birds with well-developed olfaction, was quite indistinct in Japanese jungle crow (Yokosuka *et al.,* 2009) where he identified distinctive anterior and middle concha (MC) in both nasal cavities. In Japanese jungle crow, Kondoh *et al.* (2011) also reported three nasal conchae in each nasal cavity. The anterior concha protruded from the lateral wall near the nares was divided into dorsal and ventral branches, and covered with the keratinized squamous epithelium. The middle concha protruded from the lateral wall over a large area of the nasal cavity and mainly formed a scrolled structure. The posterior concha was distinguished as a small prominence of the lateral wall dorsal to the choana. In Kuttanad ducks each half of the nasal cavity

revealed the presence of rostral, middle and caudal conchae. The middle nasal concha was larger and narrower than other two conchae and was slightly dorsal to the rostral concha (Firdous *et al.,* 2014)

c. Nasal Epithelium and Nasal Glands

Street (1937) said that from the early developmental stages itself, the epithelium of the vestibule and the vestibular concha was non-sensory and the olfactory epithelium was confined to superior concha and the olfactory region of nasal cavity. It was also reported that the sensory epithelium was originally present over the portion of the inferior concha but soon receded from it. Weber (1950) found that in 10- day chick embryo the olfactory epithelium was pseudo stratified, with the inner most regions composed of nerve fibers and a region of low sensory epithelium formed a zone of transition between the olfactory and stratified epithelium of the inferior concha. Romanoff (1960) reported that the lateral nasal gland started to develop in the chick on the eighth day of incubation as a solid bud of tissue in the septal wall of the vestibule and attained the lateral wall of the nasal cavity on the tenth day. The seromucous glands in chicken were formed by a process of invagination of the epithelium during the first week after hatching. The glands continued to grow in size and an increased fraction of the cells became mucous-secreting (Midtgard, 1989).

d. Accessory Structures

No Jacobson's organ has been reported in the hatched chick or in the adult fowl (Nemours, 1930). McLelland *et al.* (1968) reported the presence of well-developed thin and flattened lateral nasal gland under the dorsal rim of the orbit in domestic fowl and whose diameter in adult varied from 1 to 2.5mm producing a non-serous, non mucoid secretion. Nasolacrimal duct had a relatively large orifice opening on the lateral wall of the nasal cavity below the middle turbinate. Maxillary sinus or infraorbital sinus was in the form of extensive diverticulum of each side of the nasal cavity.

e. Pharynx and Trachea-Larynx- Glottis Complex

Romanoff (1960) revealed that in domestic fowl the foregut within the head formed pharynx and the branchial region of the pharynx covered the area where the visceral pouches were evaginated as paired lateral expansions. The postbranchial portion of the pharynx was the site of evagination of the laryngo-tracheal groove. This groove was the first indication of the formation of respiratory system, which appeared as a mid-ventral groove in the pharynx of the three day old chick and remained attached to the pharynx only at anterior (laryngeal) end. Rosler (1911) believed that in fowl trachea was probably formed from the rear portion of the groove by the constriction of the pharynx. Locy and Larsell (1916a) reported that in domestic fowl, trachea which originated from laryngo-tracheal groove in the 72 hour chick embryo lay in the median ventral region of the postbranchial division of early pharynx. Towards the end of fourth day trachea became differentiated from the posterior portion of the laryngo-tracheal groove and might be definitely distinguished in an embryo with 39 somites and by the one hundredth hour it was well defined.

The pharynx in domestic duck as reported by Das *et al*. (1965) was directly continuous with the hard plate and had many small caudally directed papillae. McLelland (1965) revealed the presence of a well-defined transverse row of caudally directed papillae at the junction of esophagus. Getty (1975) found that the choanal opening in the avian species was an elongated opening consisting of a triangular caudal part and a slit - like rostral part. Baumel *et al.* (1993) reported in certain groups of birds including Galliformes that the choanal opening remained unfused forming a cleft connecting the nasal cavity to the oral cavity. Aysun *et al.* (2007) reported in Japanese quail that each choana displayed the slit like rostral part and the triangular caudal part, namely intrer-palatine cleft, possessed two openings communicating the nasal cavity with the oral cavity and pharynx.

The larynx in birds prevented the entry of food or any foreign body into the trachea, acted as airway during inspiration and assists the ingestion of solid particles by quickly movement. According to Bradley and Grahame (1960) in fowl, the foundation of the larynx was the cartilaginous ring composed of the cricoid and the arytenoid cartilages which ossified as age advanced. In turkey, duck, fowl, goose (King and McLelland 1984), domestic fowl (Hogg, 1982), denzil cock (Tasbas *et al.,* 1994), mallard (Pierko, 2007), long legged buzzard (Orhan *et al.,* 2010), goose (Onuk *et al.,* 2010) and in stork (Onuk *et al.,* 2011) the laryngeal skeleton consisted of four different cartilages with the cricoid and procricoid as single and the arytenoid as paired one. However, Bock (1978) reported that in corvus, a complex of eight skeletal elements (partially or completely ossified) constituted the skeleton of larynx. In ostrich it was composed of unpaired cricoid and paired arytenoids only (Tadjalli *et al.*, 2008; Pasand *et al*. 2010). According to Zweers *et al.* (1981), in pigeon (*Columba livia*) the glottal apparatus was an elastic ring of cartilage with the caudo-medial ridges of the cricoid wings tightly interconnected via the median caudaprocricoidea. The bilateral arytenoids were only hinged to the corpus procricoideus as a result of their particularly shaped articulation facets. The procricoid was tilted by changing the constriction of the ring. The large dilator muscle covered the apparatus as a continuous sheet. The constrictor muscle complex, however, had five discrete sections. Hogg (1982) detected the mineralisation in the laryngeal cartilages in domestic fowl during the early stages as foci or transverse bands. No mineralisation was detected before 105 days post-hatching. In one bird aged 105 days, foci were present bilaterally in the bodies of the arytenoid cartilages only. Mineralisation was next encountered at 126 days post-hatching. Taşbaş *et al.* (1994) reported that in denzil cock, the average distance between the oral part of laryngeal mound and papilla row located transversally at root of tongue was 34-55 mm. Hyolaryngicus, sterno-trachealis, traeheo-laryngeusdorsalis and ventralis muscles were extrinsic and dilator glottis was the intrinsic larynx muscle. Pierko (2007) said that the larynx of mallard and scaup**,** the entrances to the larynx lead through the rima-laryng is surrounded by two labia as labium laryngeumdextrum and labium laryngeumsisnistrum. The larynx was linked muscularly with two hyoid bones ossa-hyoidea. Kirk *et al.* (1993) reported

that in Kakapo, Kea and Kaka small papillae guarded the laryngeal opening. Cevik *et al.,* (2007) in Japanese quail reported several cone shaped papillae at each side of the mucosa of the laryngeal mound and margin of glottis. Tadjalli *et al.,* (2008) reported in ostrich that larynx protruded from the floor of the pharyngeal cavity and lay caudal to the tongue with a gap occupied by irregular mucosal plicae. A wide triangular slit as glottis was formed between two arytenoid cartilages. The cricoid cartilage was larger than arytenoid cartilages and forms lateral walls, caudal end and floor of the larynx. In ostrich as reported by Pasand *et al.* (2010), the larynx protruded from the pharynx contained wide glottis without any papillae. Onuk *et al*. (2010) observed in goose that the glottis was split, and circumscribed by the arytenoid cartilage from both sides being 15.32±2.04mm long and was 3.07±0.05 mm wide at the median part. The largest cartilage of the larynx was cricoid which formed the entire ventral and caudo dorsal roof of the larynx which when ossified in the mature goose was approximately 17.22±0.23mm long, 6.24±0.02 mm wide cranially and 11.38±0.32mm wide caudally. Intrinsic dilator and constrictor muscles of the glottis lay between the cricoid cartilage and arytenoid cartilage. The larynx had three pairs of extrinsic muscles; crico-hyoideus, cleido-trachealis and tracheo-lateralis).

Getty (1975) in turkey, fowl, duck and goose, Bock (1978) in Corvus and Kabak *et al.* (2007) in long legged buzzard reported larynx in the form of mound at the caudal end of tongue containing glottis and is covered with numerous caudally directing papillae. Onuk *et al.* (2010) in goose found the laryngeal mound at the caudal side of the larynx divided in half approximately 9.05±0.58mm long by the sulcus laryngealis. Rows of 4-5 cone shaped papillae 25 to 28 papillae per row with tips facing caudally in each half of the laryngeal mound and extending in cranio caudal direction were determined in the sulcus-laryngealis. Nazan and Gulsun (2010) observed in sea gulls a transverse row of papilla called papillae pharynges caudoventrales in the caudal part of laryngeal mound, a sagittal row of papilla around the sulcus laryngeus and a protuberance named crista ventralis in the inner surface of cricoid cartilage.In stork, Onuk *et al.* (2011) reported one to three papillae in the caudal part of laryngeal mound but there was no papilla in the sulcus laryngealis. Crista ventralis was located in the inner surface of cricoid cartilage.

Myers (1917) defined that the trachea in *Gallus domiesticus* ended caudally at the fourth or third ring rostral to the intermediate cartilage of the syrinx. The latter presented four cartilages which united ventrally with the pyramid of the pessulus depending on sex of bird. According to Bradley and Grahame (1960) in domestic fowl a relatively long trachea, composed of complete rings of hyaline cartilage united by narrow membranous ligaments, connected the cranial larynx with the caudal larynx or *syrinx.* The cartilaginous rings were of different sizes, a large ring half overlaps a small ring, and nearly touches the end of the previous small ring. The rings had thick middle portions and thin edges. The ends of the rings were joined by a band of connective tissue. Cover (1953) noticed that in turkey, the trachea had complete, hyaline cartilage rings. The inner surface of each ring was flattened, while the outer surface

was flattened on one side and convex on the other side, the transition being dorsal and ventral. The flat and convex sides alternate from ring to ring and overlapped. Johnsgard (1961) reported that the Magpie Goose (*Anser anas semipalmata*) was unique with its externally convoluted trachea, but the syrinx was small and simple in both sexes. Anserinae had symmetrical tracheae in both sexes, which either lacked bullae (Anserini) or had symmetrical bullae which were larger in males than in females. The Coscoroba Swan (*Coscoroba coscoroba*) and the Cereopsis Goose (*Cereopsisnovae-hollandiae*) had trachea of the Anserini type whereas the Freckled duck (*Stictonetta naevosa)* presented an extremely simple and primitive type of trachea and syrinx in both sexes. Tracheal air sacs occurred in some stiff-tail.

McLeod *et al.* (1964) also described the trachea in aves was composed of large number of cartilaginous rings which tend to get ossified with age particularly ventrally. Mennega (1964) in chicken and Ibe *et al.* (2008) in West African guinea fowl reported that the trachea was made up of complete, hyaline rings, which were of two sizes. The large rings almost touched each other, while inside them the smaller rings also nearly touch, halfway between the openings of the large rings forming a double tube. McLelland (1965) reported in *Gallus domesticus* that the diameter of the trachea at the anterior end was greater than the posterior end. In cocks it measured about 175mm in length where as in hens the average length was 160 mm. Ibe *et al.* (2008) in West African guinea fowl reported that trachea laid mid-ventral to the esophagus passed to the right side of the neck as it extends caudally and then returns to the mid-ventral position as it approaches the thoracic inlet. Rajathi *et al.* (2009) concluded that in Japanese quail distal to a length of 1.5 to 2 cm, the trachea was directed slightly towards the right of the median plane with the oesophagus on its left side. Trachea entered the thoracic cavity between the two rami of the furcula.

Mathey (1965) reported in aves that each tracheal ring consisted of a flat, complete ring of hyaline cartilage, the edges of which are wafer-thin, signet shaped with constrictions lying dorsally and ventrally and each ring had one side narrower than other. The number of tracheal rings varied from 108 to 126. The narrow part of one ring fitted inside the wide portion of the wide ring. The only exception to this pattern was the first tracheal and last four rings as reported by McLelland (1965) in domestic fowl. Hogg (1982) studied the trachea in domestic fowl and described it as being continued caudally as the tympanum, which formed part of the syrinx. The numbers of rings ranged from 107 to 138.The vast majority of the rings were complete, occasionally incomplete ring and in some cases partial bifurcation of rings was observed. Mechteld *et al.* (1997) reported that the male trachea of Collared Dove was constructed of 108 rings and had a length of 77 mm, and the female trachea contained fewer than 102 rings and had a mean length of 71 mm. Tracheal rings that were part of the syrinx were often modified to have thickening of the rings over the ventral midline, seen in the most caudally positioned tracheal rings. Pierko (2007) reported in mallard that the tracheal cartilages were closed rings partially overlapping each other with different shapes. Closer to larynx they were elliptical

whereas caudally almost circular and linked with an inter-annularis membrane. In West African guinea the number of trachea rings ranged from 119-159and were irregular in size. Larger rings bifurcated at the ventrum into two small rings (Ibe *et al*., 2008).In Japanese quail the trachea had a skeleton of complete cartilaginous rings ranged from 110 to 116 of different sizes connected with each other by narrow annular ligaments. The larger rings almost touched each other and the smaller rings were inside halfway between the openings of the larger rings forming a double tube (Rajathi *et al.,* 2009). Onuk *et al.* (2011) reported in goose, there were 137-140 cartilage rings in the trachea and the rings in the anterior half of trachea could nest into each other in dorsal and ventral directions. Laterally the cartilage rings in middle of trachea contacted the previous or following rings and were "H"-shaped and some rings were dorsally and some rings were ventrally forked.

Garside (1968) has shown in domestic fowl that ossification of the tracheal rings may be initiated as early as 15 weeks of age progressing upto 104 weeks of age. In the studies of Hogg (1982), in domestic fowl the first indication of mineralisation was encountered at 98 days post-hatching then at 105 days, and at 112 days and in all birds examined thereafter. The process began at the caudal end of the tracheal series and spread cranially. The first ring was not involved until 126 days. The rings at the caudal end became fully mineralised whereas those in the cranial half of the trachea usually remained not more than 50 per cent mineralised, and often less, throughout the growing period. Pierko (2007) in mallard and Rajathi *et al.* (2009) in Japanese quail reported that both sides of trachea were covered by tracheo-lateralis muscle. Close to the end of the trachea there were right and left cleido-trachealis muscle and at the very end of the trachea were right and left sterno-laterales muscle. Besides trachea was covered with fourth muscle as cleido-hyoideus muscle located in the upper part of the trachea by the larynx.Onuk *et al.* (2010) observed in goosethat the three muscles *viz.,* sternotrachealis, cleidotrachealis and tracheolateralis allowed movement of the trachea. Sternotrachealis was narrow, thin structure, approximately 2.21±0.03 mm wide. Tracheolateralis was approximately 4.28±0.07 mm wide originated from cricoid cartilage of the larynx and the cleidotrachealis was approximately 4.20±0.05 mm wide originated on the clavicular.

f. Syrinx

Tymms (1913) reported that on the ninth day of incubation in fowl and eighth day in sparrow within the dense mesoblast, concentrations began to assume ring like form. It was also found that in the region of bifurcation of trachea, these rings became specialized to form the supporting structure of the syrinx. The pessulus formed between conjoining bronchi on the eleventh day of incubation. By the 12th day tracheobronchial rings appeared. As the rings of the syrinx developed further, supporting framework like membranes became differentiated and the first to appear was membrane externae between last tracheal ring and first bronchial semiring. By the fifteenth day of incubation of chick, the muscles of the syrinx started developing (Romanoff, 1960). Alcantara *et al.* (2013) stated that the respiratory

system organs in chicken were completely differentiated at the 10 days of incubation, however, until 19 days the syrinx was not observed.

Johnsgard (1961) reported that Anatinae exhibited sexual dimorphism in the syrinx, and males of most species except stiff-tails (Oxyurini) possessed asymmetrically enlarged syrinxes (bullae). Males of most Anatinae possessed entirely osseous bullae; partially membraneous (fenestrated) bullae were in all pochards and most sea ducks. The marbled teal and pink-headed duck also possessed fenestrated bullae which were intermediate between the dabbling duck and pochard (*Aythyaferina*). The syrinx is the vocal organ of songbirds, located at the base of trachea (Koch, 1973; Konig, 2001). Syrinx has been classified to be tracheobronchial in most common birds such as duck (Frank *et al*., 2007), hen (Hummel, 2000., King, 1989., Nickel *et al*., 1977), ostrich (Yıldız *et al*., 2003), Bursa roller pigeon (Yıldız *et al*., 2005), white turkey (Arican *et al*., 2007; Khaksar *et al.,* 2012), goose (Onuk *et al*., 2010), long-legged buzzard (Kabak *et al.,* 2007), quails (Bayram and Liman, 2000; Çevik *et al*., 2007) and in sea gulls (Ince *et al*, 2012).Studies reported that the number of cartilages in syrinx could be eight (Warner, 1972b; Lockner and Youngner, 1976) or ten (Frank *et al*., 2007). Frank *et al.* (2007) described this variation in the number of the rings depended on the fusion of the cartilages and concluded this variability to be normal due to the structural difference between male and female syrinx.

Bayram and Liman (2000) reported that quails had a tracheo-bronchial syrinx since it was based on both tracheal and bronchial elements. Two tracheal syringeal cartilages were attached at both ends to the pessulus in the tympanum. The internal or medial tympaniform membranes were present on the medial wall of the bronchus on either side of and behind the pessulus. Yildiz *et al.* (2003) in ostrich, Yildiz *et al.* (2005) in pigeon and Khaksar *et al.* (2012) in female and male turkey observed that, the syrinx was composed of three different cartilage groups, namely tympanum, tracheao-syringeal cartilages and bronco-syringeal cartilages. The pessulus did not contain any ossified or cartilaginous tissues and was made up of a double folded mucous membrane extending dorso-ventrally from median walls of primary bronchus into the cavumsyringis.

In pigeon the tympanum was formed from 5 oval-shaped cartilage rings pressed dorso-ventrally. The average length of the tympanum was 4.11 ±0.09 cm. An interbronchial ligament connected the right and left bronchus. Intrinsic muscles were absent but two extrinsic muscles, sternotracheal muscle located above pessulus and tracheolateral muscle located at the side of the trachea were seen (Yildiz *et al.,* 2005).Frank *et al.* (2007) reported in mallard that the syrinx consisted of a tympanum, a pessulus, medial tympaniform membranes, interanular membranes, an interbronchial ligament (bronchi desmus), and broncho-syringeal cartilage semi-rings. The syringeal valve was at the right lateral side of the tympanum by using frozen sagittal section. In male, the pessulus was massive and showed an elongated oval, transparent area ventrally. Khaksar *et al.* (2012) concluded that the tympanumin

in male and female turkey was composed of two tracheal cartilage rings. Tracheo-syringeal cartilages were composed of two cartilagous rings where latero-lateral length was longer than dorso-ventral length; four on each side were C-shaped. The syrinx was composed of two medial (internal) tympaniform membrane and two lateral (external) tympaniform membranes. There was no tympanic bulla in the turkey's syrinx. Yilmaz *et al*. (2012) reported in mallard that the tympanum was composed of four tracheal cartilage rings different from those described in the Bursa roller pigeon (Yıldız *et al*., 2005), long-legged buzzard (Kabak *et al*., 2007), sea gulls (İnce *et al.*, 2012), goose (Onuk *et al*., 2010) and Japanese quails (Çevik *et al*., 2007). The pessulus in the mallard was composed of boney tissue as in singing birds (Frank *et al*., 2007; Taşbaş *et al*., 1994; Warner, 1972b), but different from that in ostrich (Yıldız *et al*., 2003) and chickens (King, 1989). In sea gulls (*Larus*spp.) as reported by Ince *et al.* (2012), five trachea-syringeal cartilages were fused completely and shaped tympanum. Broncho-syringeal cartilages were formed from seven C shaped cartilage rings. The lateral tympaniform membrane was observed between first and second cartilage rings of broncho-syringeales. Medial tympaniform membrane was placed between the pessulus and 7th broncho-syringeal cartilages.

Hogg (1982) found mineralization of syrinx in domestic fowl at 98 days post-hatching. In all cases it was present only in the pessulus and the bases of the left and right first bronchial syringeal cartilages. Three birds showed bilateral separate centres in the shaft of the first bronchial syringeal cartilage. Two birds showed centres of mineralisation in the cartilages of the primary bronchi caudal to the three which constitute the bronchial syringeal cartilages. In one bird, these centers were present in the fourth and fifth cartilages.

g. Extrapulmonary Primary Bronchi

Batt (1926) reported in domestic fowl that the structure of the primary bronchus changed rapidly inside the lung. The cartilaginous rings were replaced by cartilaginous plates lying longitudinally within the wall. Payane and King (1959) and Akester (1960) reported in birds that primary bronchus enters the lung at hilus together with pulmonary artery and vein. Primary bronchus does increase in diameter in the second quarter of its intrapulmonary part there was no vestibule present. King (1957) reported in birds that pulmonary aponeurosis was pierced by the primary bronchus, by the pulmonary blood vessels and by the connections of the air sacs. Hodges (1974) reported in domestic fowl that bronchi pass diagonally backwards and upwards from the syrinx enter the lung on the medial edge of the ventral surface just anterior to midpoint of the length of the lung. The cartilaginous rings changed into circular or oval in cross section and did not overlap. They were roughly 'C' shaped as they do not pass round the medial side of the bronchi. On approaching to lung they get reduced on ventral side.

h. Lungs

Romanoff (1960) found that, in chick at the end of fourth day or at 41 somites the lungs were small, smooth pouches extending caudally along each side of the esophagus.

The distal end of the mesobronchus was enlarged to form the abdominal air sac. On fifth day of development, the lung began to show surface irregularities. At the distal end, a protuberance represented the beginning of the lobe containing mesobronchus. From day 8th day to 13th day of incubation lung changed to a rectangular organ. In domestic fowl, the lungs were paired from the very beginning and firstly appeared during the third day of chick incubation as on each side of the ventral surface of the primitive fore- gut or pharynx just caudal to the fourth pharyngeal pouch and below the broader branchial region of the foregut (Goldin and Opperman, 1980).Adamson (1997) observed that the lung-air sac system of birds at hatching was practically mature as against the mammalian lung where intensive growth of the terminal airways and important structural changes occurred postnatally. Maina (2003) revealed that at third day of incubationin *Gallus domesticus,* well defined mesothelium bordered the mesenchyme around the lung buds. The endoderm budded to provide the lining membrane of the bronchial tree. The lungs reached their definitive topographical locations in the coelomic cavity on day six and on day seven, lungs rotated, attached onto the ribs and by eighth day was deeply inserted.

In the developing avian lung, differentiation of mesenchymal cells into angiogenetic cells termed "vasoformative cells" (Gonzalez-Crussi, 1971) occurred very early. Hiruma and Hirakow (1989) observed that in the chick embryo, the pattern of vasculogenesis varied according to the developmental stage, the body region, local environmental conditions and proximity to certain cellular elements such as the endoderm. Locy and Larsell (1916a) reported that the pulmonary vein was the first to appear along blood vessel. The pulmonary artery was formed between the fourth and fifth days from two parts *viz*. The proximal end came from the sixth aortic arch and the distal end beginning in the lung wall and growing to meet the sprout from the aorta. De Ruiter *et al.,* (1993) reported in avian embryo that the splanchnic plexus consisted of endothelial cells and precursors were present around the foregut before the lung buds develop. This plexus gave rise to the pharyngeal arch arteries, the ventral pharyngeal veins, the pulmonary vessels, and the bronchial vessels, including the intrapulmonary vessel network. The splanchnic plexus was transiently connected to the systemic arteries and veins. The bronchial arteries and veins developed in the second period from these transient vessels. Makanya and Djonov (2007) stated that the pulmonary vasculature in domestic fowl originated from the splanchnic plexus by a process of vasculogenesis and angiogenesis. During the last week of incubation, together with the formation of air capillaries, the pulmonary vasculature underwent rapid growth by combining sprouting to a process of intussusceptive angiogenesis.

Payane (1960) reported in domestic fowl that lungs were spongy structures present in the antero-dorsal region of the thoracic cavity. They were closely apposed to the ribs and vertebral column so that dorsally and laterally the substance was strongly indented by the second to sixth pairs of ribs.Hodges (1974) in domestic fowl observed that ventral surface of lung

was slightly convex, covered by thin; double membrane of pleura and below, the lungs and separating them from the lower part of the thorax was the pulmonary aponeurosis, a musculo-tendinous sheet.

i. Bronchi

Juillet (1912) reported in chick that the sixth day of incubation marked the formation of buds from the primary lung tree representing the beginning of the secondary branches of the bronchial tree. The first bud from intrapulmonary bronchus was the primordium for first entobronchus and behind this was the smaller bud for second entobronchus. Afterward, third and fourth buds initiated the corresponding entobronchi. Locy and Larsell (1916a) stated that on the seventh day chick incubation the primordia of the ectobronchi appeared as a series of six to ten buds from the wall of the embryonic vestibulum, below the level at which entobronchi formed. Minute branches projected from the parabronchi into the lung parenchyma formed air capillaries and appeared on fourteenth and sixteenth day of development. Romanoff (1960) reported that in chick four entobronchi appeared on sixth day of incubation were larger and more conspicuous divisions of the bronchial tree. They were ventral in distribution. Six laterobronchi (Ectobronchi) from bronchial tree arised from the middle portion of the mesobronchus at the region of the expanded embryonic vestibulum. Two groups of dorsobronchi, four or five larger ones and twenty smaller ones were arranged in two rows with larger ones at the middle. Visschedijk (1968) reported the significant difference in the degrees of pulmonary development at hatching between altricial and precocial birds. In precocial birds the development of lungs was at a relatively more advanced stage which was critical for the survival of the chicks of the precocial birds since they don't get parental care after hatching. Jones and Radnor (1972) found that during the last 2 to 3 days incubation, the air and blood capillaries anastomosed and interdigitated profusely in birds. It was also reported that in the chicken, the type II (granular) pneumocytes were numerous from day 17 and at hatching the atrial, infundibular, and air capillary epithelial surfaces are lined by large quantities of trilaminar material. Scheid and Piiper (1986) revealed that the bronchi in birds were arranged partly in parallel and partly in series with each other, and unidirectional airflow within the lungs permits a gas exchange that is more efficient than the exchange in mammals. The earliest indication of the bronchial tree was seen in the hollow buds that formed the endoderm lining the lung pouches in chicks by third day of incubation. At 4th day of incubation bronchial tree was simple cylindrical tube of endoderm. At the proximal end of the lung bud a small part just outside the mesenchymal swelling formed the primordium of the extrapulmonary bronchus (Maina, 2003).

Payane and King (1959) and Akester (1960) reported in bird's primary bronchus increased in diameter in the second quarter of its intrapulmonary part there was no vestibule present. The primary bronchus after the point of entry to lung immediately gave rise to four large dorsal secondary bronchi. Posteriorly along the primary bronchus two further groups' arose. These together consisted of sixteen ducts, about

eight of which arose from the dorsal surface of the primary bronchus and about eight arose from its ventral surface. A third group of about thirty secondary bronchi as caudolateral secondary bronchi arose from the posterior half of the primary bronchus laterally and were generally small in diameter. Numerous tertiary bronchi arose from secondary bronchi and which in turn gave rise to air capillaries (King, 1957).

Bretz and Nielsen (1971) revealed that in aves the description of gas conduits (channel) in the avian respiratory system consisted of three levels of bronchi. The first level was primary bronchus or mesobronchus, secondary bronchi branched off from the primary bronchus and were cranio-medial and caudodorsal bronchi, which connected to the lung parenchyma. Tertiary bronchi (parabronchi) were branches at the level where gas exchange with the blood takes place, and with their surrounding air capillaries they made up the bulk of the lung parenchyma. Gerrit and Clark (1972) reported that in common crackle inside the lung the mesobronchus immediately gave rise to four ventrobronchi six dorsobronchi branched from the medial side of the mesobronchus and laterobronchi as discrete secondary branches of the mesobronchus. The largest laterobronchus came off the ventral surface of the mesobronchus anteriorly curved posteriorly and entered the posterior thoracic sac. Duncker (1974) found in domestic fowl that at the lung hilus the primary bronchus gave off four ventrobronchi, and posteriorly seven to ten dorsobronchi and the laterobronchi. Parabronchi originated from the internal surface of these secondary bronchi, connected ventrobronchi to dorso- and laterobronchi. The three anterior air sacs were connected to the ventrobronchi. The posterior thoracic and the abdominal air sacs were connected to the large latero-bronchus and to the end of the primary bronchus. Maina (1988) reported in aves that bulk of the intrapulmonary air flows through the parabronchial lumen and then centrifugally diffuse into the exchange tissue through the atria, the infundibula, and the air capillaries. The flow of blood was centripetally from the inter-parabronchial arteries, then into the intra-parabronchial arterioles, and finally into the blood capillaries, which together with the air capillaries constituted the functional terminal gas exchange units.

j. Air Sacs

In the adult avian lung there were five air sacs, all paired except interclavicular. The cervical and interclavicular arose anteriorly while the three pairs were on the caudal and ventral surfaces of the lungs. The first air sacs appeared in the 6.25 day chick embryo as projections of the lung wall. The abdominal and cervical sac came from the first entobronchus. The anterior thoracic and interclavicular sac appeared as bud of the third entobronchus (Larsell, 1914). According to Mania (2003) in domestic fowl, the abdominal air sacs appeared earliest by 5^{th} day followed by the cervical ones on 6^{th} day and other air sacs by 10^{th} day. After hatching, no further consequential structures formed.

King (1957) on his extensive review of the pneumatic bones of fowl considered that the cervical bones except atlas and axis, the thoracic vertebrae except the fifth, the lumbro-sacral mass, the pelvic girdle,

the first two vertebral ribs, the plate and the cranial processes of the sternum, the humerus and the distal half of the coracoid were aerated by air sacs. According to Akester (1960) the air sacs in domestic fowl were single cervical and interclavicular and paired anterior thoracic, posterior thoracic and abdominal. They were thin walled and connected to lung by primary bronchus (abdominal) by branches of the secondary bronchi (cervical, interclavicular and anterior thoracic) or by parabronchi. Murray and Fisher (1967) described in Laysan albatross the vertebrae were pneumatized as far anteriorly as the axis and as far posteriorly as the last sacral vertebra. The atlas, the coccygeal vertebrae and pygostyle were not pneumatic. Gerrit and Clark (1972) reported in common crackle that the abdominal, posterior thoracic, and cervical sacs were similar to those described for other birds. The interclavicular and anterior thoracic sacs were fused into one unpaired sac. All sacs except the cervical had several parabronchial connections to the lung and one direct connection with either the mesobronchus or a major branch of it. Mennega *et al.* (1964), Getty (1975) and Tasbas *et al.* (1994) did not mention any diverticula of the cranial thoracic sac in domestic birds. Nickel *et al.* (1977) noted that diverticula of cervical sacs pneumatized all the cervical vertebras in the domestic fowl. Ellenberger and Baun (1974) showed that the volume of the abdominal sac was larger at the right in domestic fowl but Murray and Fisher (1967) showed that the left was having a greater volume than the right side in Laysan albatross.

Kurtul *et al,* (2004) reported in rock partridge that all the air sacs except the cervical sac were paired, whereas the right and left clavicular sacs were ventrally fused. The cervical was located cranial to the lungs and ventral to the last two cervical and first thoracic vertebrae. It communicated with the lung via the first medioventral bronchus. The paired cranial thoracic sac possessed a distinct costal impression on its surface and was present underneath the lateral wall of the body. These were roughly triangular in shape and twice larger than caudal thoracic sacs and aerated by the first, second and fourth medioventral bronchi. The paired caudal thoracic sac received air via the second lateroventral bronchus and had no diverticula. The abdominal air sac extended from the caudal border of the lungs to cloaca and was the largest of all the sacs. The sac was connected to lungs via the third, fourth and fifth lateroventral bronchi. Cevik *et al.* (2006) opined that in mallard ducks the cervical air sacs with its diverticula was aerating the axis and the first two ribs. Cranial thoracic air sacs were smaller than the caudal sacs pneumatising the second to seventh ribs by their diverticula. The caudal thoracic air sac had no diverticulum. The left abdominal air sac had two portions, the cranial and caudal sacs, the later aerating the last three ribs and synsacrum, the former being smaller and narrower. The right abdominal sac was bigger than left sac.

Orhan *et al.* (2010) reported in long legged buzzard that cervical sac communicated with lungs via the first medioventral bronchus. The clavicular had several diverticula, which were divided into intrathoracic and extrathoracic. The cranial thoracic was paired extended to the sternal ribs at lateral to the lungs lateral and was ventilated through bronchi medio -

ventrales. The caudal thoracic sac was quite small without any diverticula and group of parabronchi and bronchi lateroventrales aired this sac. The abdominal sac was largest occupying most of the peritoneal cavity and was connected via lungs through lateroventral bronchi. Onuk *et al.* (2010) reported seven air sacs in goose. Cranial, caudal thoracic and abdominal were paired whereas cervicoclavicular sac was single. Cranial and caudal thoracic sac contained no diverticula and did not aerate any bones. The left and right abdominal sacs were of equal in size and located symmetrically.

Conclusion

The evolution of the vertebrate respiratory system achieved its most efficient state in birds, with their constant volume parabronchial lungs and highly compliant air sacs having low pressure ventilation. Together, properties like unidirectional and continuous ventilation of the gas exchange tissue, gas exchange designs like the crosscurrent and the multicapillary serial arterialization systems and highly refined pulmonary morphometric parameters such as a thin blood-gas barrier and a large respiratory surface area and capillary blood volume accord high gas exchange efficiency in the avian lung, permitting active flight even under extreme conditions of high altitude. These additional characteristics equipped the birds for sustained flight or buoyancy in water. The respiratory organs of birds differ from those of mammals in a number of specific features which are partly associated with the requirements of flight and the great work load that this form of locomotion demands, and partly with the voice production

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Full Length Articles

Duck farming in Tamil Nadu – problems and prospects

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ABSTRACT

Duck farming is more gainful than chicken farming and mutually beneficial to both paddy and ducks in the integrated rice cum duck farming. However, even in certain places where the duck farming is in practice, the system of integrated rice-duck farming is not adopted. Hence, it was aimed to analyse the problems and prospects in duck farming so as to take suitable measures to address the issues and create awareness on rice cum duck cultivation in SST (Srinivasan Services Trust- CSR arm of TVS Motor Company, Chennai) adopted villages of Tamilnadu. Twenty five duck farmers and their flocks in SST adopted villages / hamlets of Thiruvallur and Thiruvannamalai districts of Tamil Nadu were the study materials. Socio-economic aspects of the farmers, adoption level of scientific methods including duck-rice / duck-fish rearing, economics and associated problems and prospects in duck farming were analysed.

In the selected regions, only certain communities in BPL category (Below Poverty Line)are doing duck rearing under semi-intensive system as their family avocation. Most of them (84%) are nomadic, illiterate or school drop outs (80%) with family income varying from Rs.5000 -15,000 / month. There is no credit facility to these farmers from banking institutions. Mainly private money lenders financed their duck farming activity at a very high interest rate of 36% - 96% and their role existed at every stage of farming activity. Though adoption of scientific methods related to semi-intensive system is almost satisfactory, there is scope for further improvement in production. The economics of duck rearing worked out to Rs.7500 / month / 500 birds unit. Lack of credit facility from banking institutes, non-availability of good quality ducklings, and lack of awareness on rice-duck / fish – duck integration are considered major issues in optimising production.

Key Words*:* Duck farming, Socio-economics, Rearing systems, Scientific methods, Integrated rice-duck / fish-duck farming, Credit facility.

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INTRODUCTION

India has over 10 million ducks and ranks 2nd in the world in duck population next to Indonesia (Veeramani *et al.,* .2017)).Ducks are reared in different states of India like Tamilnadu, Kerala, A.P. (Andhrapradesh), Telengana,Gujarat, West Bengal, Orissa, Tripura, Assam, U.P.(Uthrapradesh), and Jammu & Kashmir. Duck population constitutes 10% of poultry population in India with 6-7% of total eggs produced in the country is from ducks (www.cpdosrbng.kar.nic.in). Duck farming is predominantly in the hands of small, marginal landless farmers and agricultural labourers and reared for meat and eggs. The technology in duck farming is far behind that of other farming enterprises in India. The farmers solely relied on their inherited experiences of their ancestors (Gopinathan *et al.,*.2015)). Duck rearing mostly coincides with monsoon and paddy cultivation and depends on the availability of water bodies, ponds and lakes. They are suitable for combined farming systems such as duck-cum-fish farming and rice-duck farming. Duck meat production increased from 0.034 million tonnes to 0.18 million tonnes in two decades (Srikanth *et al.,* 2018). Ducks are intellectual birds and hence can be trained easily to go to ponds and come back in the evening on their own.

Srinivasan Services Trust (SST), a CSR arm of TVS Motor Company has undertaken a survey type study in its adopted villages in Thiruvallur block of Thiruvallur district and East Arani block of Thiruvannamalai district in Tamilnadu. Though, SST has adopted 3928 villages / hamlets in the districts of Thiruvallur, Thiruvannamalai, Mayiladuthurai, Trichy, Krishnagiri, Dharmapuri, Thirunelveli and Tuticorin, there is no duck farming activity in the adopted villages of other districts. This study was undertaken with the objective of understanding the socio-economic status of the duck farmers, adoption level of scientific methods in rearing, economics of rearing and problems and prospects in duck farming so that suitable measures can be taken to integrate duck farming with paddy cultivation among the farming community

MATERIALS AND METHODS

The study was undertaken during January – March, 2020 comprising 25 farmers, whose stock position varied from 200-2000 ducks with 21750 ducks in total. There are 17 families in Thiruvallur block of Thiruvallur district and 8 families in East Arani block of Thiruvannamalai district. The specific villages are Vettakaranpalayam, Veppampattu and Kalyanakuppam of Thiruvallur district and Irumbedu, Piyur, Adanur, Vadugusathu, Parigalpattu, Thirumalaiand Rayankuppam of Thiruvannamalai district. All the ducks reared by these farmers are indigenous breed of dual type (used for meat and egg). Locally, they called it Arani ducks. The other colloquially used terms were Kulathuvathu and Current vathu, which were named after, by virtue of rearing in pond and hatched by artificial incubation respectively.

A specific proforma was designed to collect the data by personal interview with the farmers. The responses were quantified, wherever necessary in terms of percentage to derive useful information. The salient

information /observation collected belonged to the following categories:

Socio-economic aspects: Literacy level, Community & caste, arrangement of funds for duck rearing, family income and extent of land holdings.

Adoption of scientific methods connected to rearing: System of rearing, housing, feeding, breeding, egg production, improved breed / strain, hatching, brooding, health care, integrated farming and marketing needs

RESULTS AND DISCUSSION

Socio-economic aspects

The collected information on socio-economic aspects are presented in Table. All the 17 families of Thiruvallur district and 4 families in Thiruvannamalai district belonged to Scheduled Caste (SC) community coming under BPL category. The remaining 4 families in East Arani block of Thiruvannamalai district belonged to BC-Muslim community. A 15/17 families in Thiruvallur block belonged to Vettakkaran caste coming under SC. For all 25 families included in this study, duck rearing is a family avocation. The educational status of most of the farmers (80%) varied between illiterate to school drop outs concurring with earlier observation (Gajendiran *et al.,* 2005a)). Their (96% farmers) family income varied between Rs.5000 -15,000 per month. They (80% farmers) purchased ducks out of credit from the private vendors @ very high interest rates of 36 – 96%. During interaction with bank officials, it is understood that the credit facility can be extended to duck farming also under some of the existing schemes like Mudra, JLG (Joint Liability Group) etc. However, neither the farmers are aware of the scheme nor the bankers show interest to advance the funds to them as they are nomadic and move with the birds based on the availability/ scarcity of the foraging resource. As a consequence, the bankers presume that they may experience difficulty of tracing the farmer and his flock for their existence, if loans are not repaid in time. Most of the farmers (76%) are landless and the remaining 24% farmers possess, 1 acre land.

Table -1, Socio economic status of duck farmers

Parameter		Respondent	Percentage
Educational status	Illiterate /School drop out	20	80.0
	10^{th}	4	16.0
	12^{th}Std	0	0.0
	Graduate	1	4.0
Community	SC /ST	21	84.0
	MBC	0	0.0
	BC	4	16.0
	FC	0	0.0

Monthly Family income	< Rs.5000	03	12.0
	Rs.5000 -10000	18	72.0
	Rs10000 -15000	3	12.0
	>Rs15000	1	4.0
Arrangement of Funds	Own	3	12.0
	Banks	0	0.0
	Private money lenders	20	80.0
	Fiends & Relatives	2	08.0
Land holdings	Landless	19	76.0
	<50 Cents	3	12.0
	50-100 Cents	3	12.0
	>100 Cents	0	0.0

Some farmers are taking up duck rearing on coolie basis. The wage paid for rearing was Rs.350/day for a flock of 300 birds. Usually, children are also drafted into the farming activity. When the season is not suitable for duck rearing, they work as agricultural labourers. It is understood that the contract farming system similar to the one adopted in chicken is also prevalent. Here, all the inputs are provided to the farmers by the integrator and the rearing charges are paid to the farmer at the time of the disposal of the birds based on the prevailing marketing trend.

System of rearing

They rear the ducks by semi-intensive system. The flock size with majority of them (60%) ranged between 500-1000 (Fig.1). The ducks are taken for grazing / foraging (Fig 2) in the day time from 9am to 5.00pm and accommodated during night in the temporarily eructed night shelter nearer to the area of grazing. Basically, the system of duck rearing practised by the farmers is nomadic in nature and undertaken during June – February months coinciding with paddy cultivation and harvest. They have a very strong network with others involved in this activity in other parts of Tamil Nadu to know about the availability of water bodies and foraging requirement. Once the foraging resources are depleted in a particular area, they move to other areas with their birds on road by loading the birds in a vehicle, where the water bodies are available with / without paddy cultivation and harvest.

Fig 1. Flock size of duck farmers

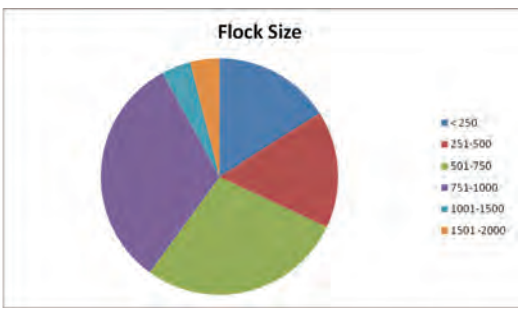

Fig 2. Duck foraging in the canal

Housing

The night shelter is a tent comprising pen and outside run with sufficient slope to provide adequate drainage away from the pen. It is a low cost shelter built by locally available materials like plastic sheet, bamboo sticks, coconut leaves or even cloths. The run was almost three times bigger than the size of the pen. None of the families in the study area reared ducks in the intensive system of rearing. It may be due to the lack of awareness about the fact that water for swimming was not necessary at any stage of rearing ducks and the higher cost of rearing under intensive rearing system.

Feeding

Ducks are allowed to graze on pre and post harvested paddy fields, ponds, lakes, canals and water logged barren land / land under preparation of paddy cultivation, and pre & post- harvest paddy fields. They thrived on fallen grains, insects, snails, earthworms, small fishes, fingerlings, tadpoles and water plants like algae. Ducklings are fed with chicken mash in the first month of age. They are allowed to the water bodies after 10-15 days of age. To begin with they are allowed for a short period and slowly the swimming time is extended. Broken grains or rice flour are introduced from the first week and they eat about 10-15g/bird/day during the first month, 80-100g/ bird /day during 2-5 months and 100-130g / bird / day later on. These quantities of feed were comparable to the guidelines provided by CPDO (Central Poultry Development Organisation), Bangalore. The quantity to be fed is that which can be cleared in about 10-15 minutes time (www.agritech.tnau.ac.in). Ducks are fed with broken grain supplement 3 times during the first 2 months and later on twice daily i.e in the morning and in the late afternoon after grazing. During the time of feeding, water is always left in the vessel so as to immerse its head in the water, but not the body. The feeding and watering practices adopted by these farmers concurred with Gopinathan *et al.,* (2015). However, a balanced feed prepared on scientific lines at home or of any commercial brand is lacking beyond 1 month of age.

Breeding

Sex ration of 1: 10 (M:F) is maintained for getting good fertility. However, there was no distinction between layer and breeder ducks. The drakes (male duck) are sold for meat at the age of 2.5 to 3.5 months, when they weigh 1.0 -1.5kg.Female start laying eggs by 5months and were maintained up to 2-3 years depending on their egg yield and availability of adequate forage. These findings are comparable to the report of Magendiran (2019).

Egg production

The ducks in this study produced 130-170 eggs / annum, thus concurring with the

previous reports(Gajendiran *et al.,* 2005b; Gopinathan *et al.,* 2015; Magendiran, 2019). However, it has been reported that Khaki Campbell and Indian runner ducks produce >300eggs and 250-300 eggs/ annum respectively. Hazarika *et al.,* (2020) reported that Khaki Campbell ducks reared under intensive and extensive system produced 250± 1.23 and 165±2.34 eggs /annum respectively. Some farmers have reported that even the local indigenous breeds of this study produce more eggs, if there is supplementation with commercial chicken mash or adequate forage availability.

Hatching

All the farmers of this study purchase ducklings from middle men, who are financiers. A few financially sound farmers have direct access to hatchery units. Hatcheries are available locally in Vettakkaranpalayam, Arani and near Chittoor (A.P). It is worthy to note that the traditional system of egg hatching by brooding ducks has been dispensed with and the scientific method of hatching as followed in chicken farming has been adopted by these farmers. Usually, the hatching units are kept by financially sound people in the society.

Brooding

It is not that all farmers purchase day old ducklings only.The age of the ducklings procured is related to the probable time of purchase and duration of water bodies likely to exist, the stage of paddy cultivation and harvest, the festival season etc.

When the ducklings are procured as day old they are provided heat by burning one 100 watts electric bulb for 30- 40 ducklings. The quantum of heat is steadily decreased by reducing the watts as they grow. Provision of heat during summer is stopped by 8-10 days, whereas it is continued for 2-3 weeks during winter months. However, the farmers do not actually control the room temperature by keeping the thermometer. Some farmers also do cold brooding i.etent brooding (Fig3)

Fig 3. Duclings under tent brooding

Health care

The ducklings are being given vitamin-mineral mixture supplementation during the first month of life. In general, the ducks are hardy birds and resistant to most avian diseases. The common contagious and deadly diseases of ducks are Duck Viral Enteritis (Duck Plaque) and Duck Cholera. The recommended Vaccination Schedule (Srikanth *et al.,* 2018)) was as follows:

Duck cholera (Pasteurellosis) - at 3-4 weeks of age s/c route

Duck Viral Enteritis (Duck plaque) - at 8-12 weeks of age s/c route

The above vaccines are available at a reasonable cost from the Institute of Veterinary Preventive Medicine (IVPM), Ranipet and the practice of vaccinating against these diseases is in practice among the duck farmers in this study area. However, many farmers are not adopting this practice as they want to reduce expenditure on health care.

The farmers also have reported the frequent occurrence of afflatoxicosis in their birds. Experts were approached to seek treatment and advice whenever their flock was affected by diseases in considerable numbers. Usually, they keep the empty drug bottles used on different occasions for reference and use the same drugs when a similar disease occurs later in the flock. This invariably resulted in multiple antibiotics being administered to the flock at the same time during a disease. The farmers of this study were not following deworming of their flock.

Marketing trends

The ducklings were purchased in different stages varying from day old to 3 months of age. Accordingly, the cost varies from Rs.20 -35 / day old, Rs.70-80 / 1 month old, Rs.90 / 40 days old and Rs.150 / 3 months old. The eggs fetch Rs 5-8 / egg and meat Rs.150 -210 / bird with weight varying from 1.5 – 2.0 kgs. The demand for duck meat is almost uniform round the year, though, the disposal of the birds for meat is planned to coincide with the festival time as it is likely to have maximum demand. Most of the farmers are dependent on the local financier –cum- vendors in order to meet their demands for duckling, duck eggs and sale of ducks for meat. In fact, they are mainly depended on vendors or middle men to reach the market outside Tamil Nadu especially Kerala state, because duck eggs and meat are not preferred by majority people in Tamil Nadu. In addition, the vendors exploited the ignorance of the farmers at every stage of operation.

Problems and prospects

The main problems of duck farmers in this study were non-availability of credit facility from banking institutions, high rate of interest for the funds advanced by private vendors, non-availability of high yielding breeds like Khaki Campbell and White pekin, shrinkage of land, declining water bodies, very low domestic consumption, disease outbreaks, mortalities during brooding and lack of awareness on scientific farming. Further, the modern youth population do not like to venture on duck farming as it is a labour intensive farming practice. These findings concurred with earlier reports (Gajendiran and Karthikeyan,2009; Veeramani *et al.,* 2017) that the major constraints faced by duck farmers were inadequate finance, non-availability of good quality ducklings and shrinkage of land for foraging.

Government should come forward to address the issues of credit finance, subsidies and organised marketing structure for duck egg and meat apart from creating

awareness among the farmers on scientific farming to optimize production. Separate breeder flocks should also be encouraged.

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Characterization of Kodi Adu goats of Tamil Nadu, India

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ABSTRACT

A detailed study on distribution and performance of Kodi Adu breed of goats were made in the 253 herds of co-operating farmers in the 36 selected villages in its breeding tract. The study revealed that the Kodi Adu goats were mainly distributed in Thoothukudi and Ramanathapuram districts of southern Tamil Nadu and were tall, long, lean and leggy animals with compact body. Based on body colour, they were classified into two colour varieties viz. Chem-Porai and Karum-Porai. The least-squares means for height at withers, body length, chest girth, horn length, ear length, face length and tail length of fully grown adult goats (full mouth), were 84.94 ± 0.49, 77.56 ± 0.43, 79.28 ± 0.48, 16.16 ± 0.33, 15.91 ± 0.24, 17.79 ± 0.19 and 17.90 ± 0.25 cm respectively. The least-squares means for body weight at birth, three months, six months, nine months and 12 months of age were 2.81 ± 0.04, 11.41 ± 0.16, 14.70 ± 0.23, 16.79 ± 0.3 and 22.95 ± 0.31 kg respectively. The statistical analysis revealed a highly significant effect (P<0.01) of sex on body weight of Kodi Adu goats at different stages. The averages for age at first kidding and kidding intervals were 15.37 ± 0.08 and 7.67 ± 0.03 months respectively. Kodi Adu goats serve as the sole or subsidiary source of livelihood for a large number of small and marginal farmers and landless labourers in the breeding tract. The present population status explicitly does not warrant immediate conservation measures, however, initiation of Open Nucleus Breeding Scheme (ONBS) and forage and range development programmes should be made in its breeding tract for better productivity.

Key Words: Kodi Adu, Goat, Breed Characteristics, Production, Reproduction, India

INTRODUCTION

India is one of the 12-mega biodiversity centres of the world. It is well marked off from the rest of Asia by mountains and the sea, which gives the country a distinct geographical entity. Goat is a multi functional animal and plays a significant role in the economy and nutrition of landless, small and marginal farmers in India. In pastoral and agricultural subsistence societies, goats are kept as a source of additional income and as an insurance against natural calamities. They are distributed in extremes of climates i.e., from tropical desert, characterized by temperature extremes (i.e

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., Thar desert) with insignificant rainfall and sparse vegetation to high altitude mountain areas up to 2,500 m above m.s.l such as the Himalayan region. Tamil Nadu state is endowed with three recognised breeds of goats' viz. Kanni Adu, Kodi Adu and Salem Black (Acharya, 1982; Mariadas, 1996; Jain *et al*., 2000; Thiruvenkadan *et al*., 2000a; Thiruvenkadan and Karunanithi, 2006) and all belongs to meat type goats. Kodi Adu goats are distributed in southern coastal region of Tamil Nadu and are docile and hardy with faster growth rate and early maturity. Barring a few preliminary studies on Kodi Adu goats (Mariadas, 1996; Jain *et al*., 2000; Report, 2002), information on the distribution, population status, morphological characteristics, economic traits and management practices of this breed in its natural ecological conditions are scanty. Hence, a detailed study on Kodi Adu goats in its breeding tract has been made.

MATERIALS AND METHODS

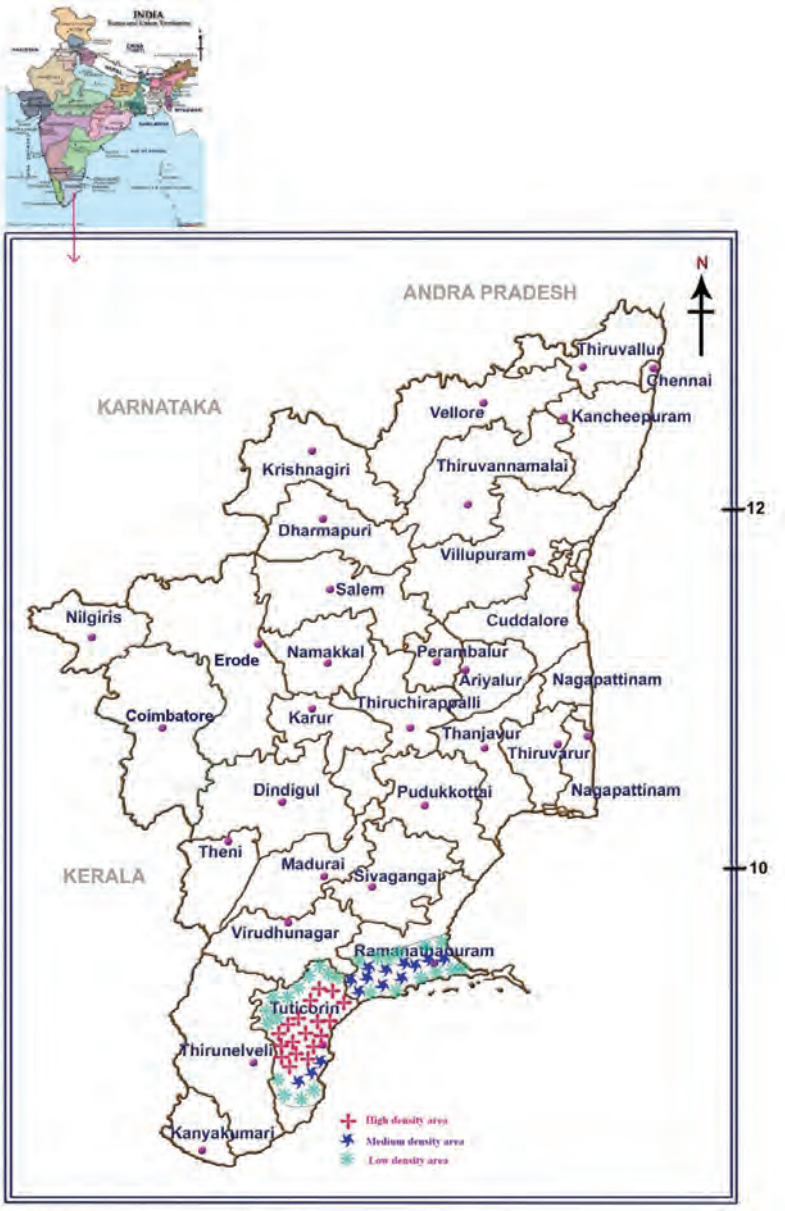
Survey on geographic and demographic distributions of Kodi Adu goats were made in Tirunelveli, Thoothukudi, Virudhunagar, Ramanathapuram, Sivagangai, Pudukkottai and Thanjavur districts of southern Tamil Nadu. Data on morphology as well as production and reproduction traits were collected in the 253 herds of co-operating farmers in the 36 selected villages in the breeding tract. The body measurements and body weight were made in 1526 animals of various age groups of both sexes. For analysis of body measurements and body weight, the kids were classified into birth , three, six, nine and 12 months and the adults were classified as 2-tooth, 4-tooth, 6-tooth and full mouth of age. Data on reproduction traits were collected from 317 males and 494 females. The reproduction traits of males viz. age at first mating and of females viz. age at first oestrus, age at first mating, age at first kidding, kidding interval, litter size, kidding percentage and life-time number of kidding were recorded from the yearlings and does present in the herd by observation and information provided by the herd owners. As the data were unequal and disproportionate in different subclasses, least-squares analysis (Harvey, 1990) was performed and Duncan's Multiple Range Test (DMRT) was applied (Kramer, 1957) whenever the effect was significant and the subclasses were more than two. The fixed effects considered for the study of metric traits were sex, colour variant (Chem-Porai and Karum-Porai) and location (Thoothukudi and Ramanathapuram districts).

RESULTS AND DISCUSSION

Origin, Habitat and Distribution

The survey revealed that the Kodi Adu goats were distributed in parts of Thoothukudi and Ramanathapuram districts of southern Tamil Nadu (Fig. 1). The total estimated Kodi Adu goat population was 1,67,104 numbers. The average herd size of Kodi Adu goats was 17.60 (range: 4 to 127), of which, there were 0.77 buck, 11.27 does and 5.56 kids. The percentage of farmers keeping Kodi Adu with a herd size of up to 10, 11 to 20, 21 to 30 and >30 were 9.91, 38.20, 34.89 and 17.00 per cent respectively. The overall male and female ratio at the age group of 0 to 3, 3 to 6 months and adults were 1: 1.57, 1:6.56 and 1:24.50 respectively.

Fig. 1. Breeding tract of Kodi Adu goats



Breed Characteristics

Morphology

Kodi Adu goats were tall, long, lean and leggy animals with compact body. Based on body colour, Kodi Adu goats were mainly grouped into two colour varieties viz. Chem-Porai and Karum-Porai. Chem-Porai goats were white in colour with

varying extent of reddish brown colour and intensity (Fig. 2), whereas, Karum-Porai goats were white in colour with varying extent of splashes of black colour (Fig. 3). The percentage of Chem-Porai and Karum-Porai goats in the herds studied were 72.82 and 27.18 per cent respectively. The ears were medium-long, leaf-like and semi-pendulous. There was no typical horn pattern; but majority of them had their horns directed upward, backward and curved downward or upward and sharply at the tip. They had long, lean and straight legs squarely set under the body. The legs were covered with short hairs. The tail was thin, medium-long and curled upward. Udder was not well-developed; it was round and tightly attached to the belly with small conical teats placed laterally.

Fig. 2. Kodi Adu buck -Chem-Porai (predominance of reddish brown splashes)

Body measurements

The least-squares means (±SE) of height at withers, body length and chest girth of Kodi Adu kids and adults are presented in Tables1 and 2. For fully grown adult goats (full mouth), the least-squares means for height at withers, body length and chest girth were 84.94 ± 0.49, 77.56 ± 0.43 and 79.28 ± 0.48 cm respectively. Least-squares analysis revealed that the colour of the kids had no significant effect on body weight at different stages of growth. Based on height at withers, goats are classified as large (>65 cm), small (51 to 65 cm) and dwarf (<50 cm) (Devendra and Burns, 1983). Accordingly, Kodi Adu can be grouped under a large breed category. On comparison, Kodi Adu goats were taller and longer than Kanni Adu and Salem Black goats of Tamil Nadu and Attappady Black goats of Kerala (Report, 2002; Stephen *et al.,* 2005; Thiruvenkadan and Karunanithi, 2006). The chest girth observed in Kodi Adu goats was comparable with the values reported for Salem Black goats (Gopu *et al*., 2008). In general, in kids and adults, height at withers was the highest followed by chest girth and body length. Similar pattern was also reported in Kanni Adu, Attappady Black and Salem Black goats (Gopu, 2002; Stephen *et al.,* 2005; Thiruvenkadan and Karunanithi, 2006) of southern India.

Fig. 3. Kodi Adu doe-Chem-Porai (note the leaf like ears)

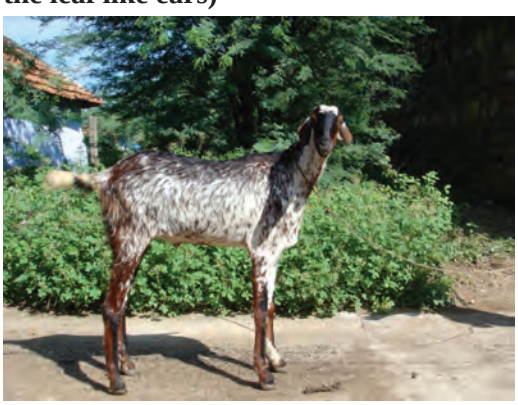


Table 1. Least-squares means (±SE) of height at withers, body length and chest girth (cm) of Kodi Adu kids

Effects	Birth	Three months	Six months	Nine months	12 months
Height at withers (cm)					
Overall	**35.83 ± 0.40 (140)**	**57.23 ± 0.37 (175)**	**64.24 ± 0.46 (175)**	**67.03 ± 0.54 (127)**	**73.04 ± 0.41 (163)**
Sex		*	*		**
Male	35.92 ± 0.48 (76)	57.84 ± 0.51[b] (80)	64.85 ± 0.56[b] (81)	67.21 ± 0.68 (60)	73.92 ± 0.53[b] (54)
Female	35.73 ± 0.56 (64)	56.63 ± 0.46[a] (95)	63.62 ± 0.58[a] (94)	66.84 ± 0.75 (67)	72.16 ± 0.47[a] (109)
Colour					
Chem-Porai	35.87 ± 0.40 (106)	57.13 ± 0.42 (119)	64.41 ± 0.49 (126)	66.78 ± 0.63 (84)	73.37 ± 0.39 (123)
Karum-Porai	35.79 ± 0.68 (34)	57.34 ± 0.57 (56)	64.06 ± 0.68 (49)	66.53 ± 0.82 (43)	72.72 ± 0.62 (40)
Location		*	*		
Thoothukudi	36.42 ± 0.45 (94)	57.61 ± 0.38[b] (130)	63.68 ± 0.40[a] (145)	67.01 ± 0.57 (92)	72.71 ± 0.36 (134)
Ramanathapuram	35.24 ± 0.60 (46)	56.86 ± 0.62[a] (45)	64.79 ± 0.81[b] (30)	67.04 ± 0.90 (35)	73.37 ± 0.68 (29)
Body length (cm)					
Overall	**30.81 ± 0.44 (140)**	**51.27 ± 0.35 (175)**	**58.98 ± 0.47 (175)**	**59.79 ± 0.55 (127)**	**65.68 ± 0.45 (163)**
Sex			**		*
Male	31.26 ± 0.52 (76)	51.63 ± 0.48 (80)	59.94 ± 0.56[b] (81)	60.42 ± 0.76 (60)	66.37 ± 0.59[b] (54)
Female	30.35 ± 0.61 (64)	50.90 ± 0.43 (95)	58.01 ± 0.59[a] (94)	59.15 ± 0.69 (67)	64.98 ± 0.52[a] (109)
Colour					
Chem-Porai	30.71 ± 0.43 (106)	51.30 ± 0.39 (119)	58.72 ± 0.49 (126)	58.98 ± 0.64 (84)	64.73 ± 0.43 (123)
Karum-Porai	30.91 ± 0.74 (34)	51.23 ± 0.53 (56)	59.23 ± 0.68 (49)	60.60 ± 0.83 (43)	64.34 ± 0.68 (40)
Location			**		
Thoothukudi	31.36 ± 0.49 (94)	51.56 ± 0.36 (130)	57.98 ± 0.40[a] (145)	60.41 ± 0.58 (92)	65.01 ± 0.40 (134)

Ramanathapuram	30.25 ± 0.66 (46)	50.97 ± 0.58 (45)	59.97 ± 0.81[b] (30)	59.16 ± 0.91 (35)	66.34 ± 0.76 (29)
Chest girth (cm)					
Overall	**30.91 ± 0.44 (140)**	**51.19 ± 0.34 (175)**	**58.58 ± 0.45 (175)**	**59.92 ± 0.53 (127)**	**65.94 ± 0.39 (163)**
Sex			**	**	*
Male	30.94 ± 0.52 (76)	51.67 ± 0.47 (80)	59.36 ± 0.55[b] (81)	60.64 ± 0.74[b] (60)	66.58 ± 0.52[b] (54)
Female	30.88 ± 0.61 (64)	50.71 ± 0.42 (95)	57.79 ± 0.57[a] (94)	59.21 ± 0.67[a] (67)	65.30 ± 0.45[a] (109)
Colour					
Chem-Porai	30.82 ± 0.43 (106)	51.06 ± 0.38 (119)	58.32 ± 0.48 (126)	58.34 ± 0.62 (84)	65.05 ± 0.38 (123)
Karum-Porai	31.00 ± 0.74 (34)	51.32 ± 0.52 (56)	58.84 ± 0.67 (49)	61.50 ± 0.81 (43)	65.83 ± 0.60 (40)
Location					
Thoothukudi	31.39 ± 0.49 (94)	51.45 ± 0.35 (130)	57.95 ± 0.39 (145)	60.14 ± 0.57 (92)	65.52 ± 0.34 (134)
Ramanathapuram	30.43 ± 0.66 (46)	50.92 ± 0.57 (45)	59.21 ± 0.79 (30)	59.71 ± 0.89 (35)	66.36 ± 0.66 (29)

* Significant ($P < 0.05$); ** Highly significant ($P < 0.01$)

Figures in parentheses are number of observations

Table 2. Least-squares means (±SE) of height at withers, body length and chest girth (cm) of Kodi Adu adults

Effects	2-tooth	4-tooth	6-tooth	Full mouth	Overall
Height at withers (cm)					
Overall	**76.41 ± 0.54 (154)**	**80.78 ± 0.76 (136)**	**81.38 ± 0.52 (181)**	**84.94 ± 0.49 (275)**	**80.45 ± 0.28 (746)**
Sex		**	**	**	**
Male	76.88 ± 0.68 (63)	84.20 ± 1.03[b] (48)	81.78 ± 0.74[b] (62)	88.07 ± 0.74[b] (63)	82.56 ± 0.39[b] (236)
Female	75.95 ± 0.68 (91)	77.37 ± 0.85[a] (88)	78.99 ± 0.59[a] (119)	81.81 ± 0.49[a] (212)	78.33 ± 0.32[a] (510)
Colour					
Chem-Porai	76.33 ± 0.56 (109)	80.89 ± 0.76 (101)	81.01 ± 0.54 (133)	84.97 ± 0.51 (196)	80.74 ± 0.29 (539)

Karum-Porai	76.50 ± 0.81 (45)	80.68 ± 1.16 (35)	80.45 ± 0.81 (48)	84.91 ± 0.69 (79)	80.15 ± 0.42 (207)
Location	**	*			*
Thoothukudi	75.50 ± 0.49[a] (124)	79.99 ± 0.68[a] (110)	79.59 ± 0.53 (136)	84.95 ± 0.46 (225)	79.97 ± 0.27[a] (595)
Ramanathapuram	77.33 ± 0.94[b] (30)	81.58 ± 1.28[b] (26)	81.17 ± 0.83 (45)	84.94 ± 0.79 (50)	80.92 ± 0.47[b] (151)
Body length (cm)					
Overall	**68.88 ± 0.50 (154)**	**72.01 ± 0.41 (136)**	**72.34 ± 0.46 (181)**	**77.56 ± 0.43 (275)**	**72.63 ± 0.23 (746)**
Sex	*	**	*	**	**
Male	69.72 ± 0.64[b] (63)	72.67 ± 0.58[b] (48)	74.94 ± 0.63[b] (62)	79.83 ± 0.66[b] (63)	74.20 ± 0.32[b] (236)
Female	68.05 ± 0.64[a] (91)	69.74 ± 0.52[a] (88)	71.34 ± 0.46[a] (119)	75.29 ± 0.43[a] (212)	71.05 ± 0.26[a] (510)
Colour					
Chem-Porai	68.81 ± 0.52 (109)	72.69 ± 0.46 (101)	72.43 ± 0.42 (133)	77.27 ± 0.45 (196)	72.82 ± 0.24 (539)
Karum-Porai	68.96 ± 0.75 (45)	71.04 ± 0.64 (35)	72.03 ± 0.70 (48)	77.85 ± 0.62 (79)	72.43 ± 0.34 (207)
Location					
Thoothukudi	68.27 ± 0.46 (124)	71.84 ± 0.41 (110)	71.86 ± 0.41 (136)	77.18 ± 0.41 (225)	72.27 ± 0.22 (595)
Ramanathapuram	69.50 ± 0.87 (30)	72.16 ± 0.65 (26)	72.84 ± 0.77 (45)	77.94 ± 0.71 (50)	72.98 ± 0.38 (151)
Chest girth (cm)					
Overall	**69.61 ± 0.51 (154)**	**74.72 ± 0.48 (136)**	**74.74 ± 0.46 (181)**	**79.28 ± 0.48 (275)**	**74.49 ± 0.24 (746)**
Sex		**	**	**	**
Male	69.73 ± 0.64 (63)	75.94 ± 0.65[b] (48)	77.22 ± 0.65[b] (62)	81.05 ± 0.72[b] (63)	75.85 ± 0.34[b] (236)
Female	69.49 ± 0.64 (91)	72.22 ± 0.53[a] (88)	73.54 ± 0.52[a] (119)	77.52 ± 0.47[a] (212)	73.13 ± 0.28[a] (510)
Colour					
Chem-Porai	69.38 ± 0.53 (109)	75.14 ± 0.48 (101)	75.23 ± 0.48 (133)	79.11 ± 0.5 (196)	74.65 ± 0.25 (539)
Karum-Porai	69.84 ± 0.76 (45)	73.94 ± 0.72 (35)	74.67 ± 0.73 (48)	79.45 ± 0.67 (79)	74.32 ± 0.37 (207)

Location		**			*
Thoothukudi	68.74 ± 0.46 (124)	73.34 ± 0.43[a] (110)	74.58 ± 0.46 (136)	78.95 ± 0.44 (225)	73.62 ± 0.23[a] (595)
Ramanathapuram	70.48 ± 0.88 (30)	76.10 ± 0.80[b] (26)	75.95 ± 0.73 (45)	79.61 ± 0.77 (50)	75.35 ± 0.41[b] (151)

* Significant ($P < 0.05$) ** Highly significant ($P < 0.01$) Figures in parentheses are number of observations

Production Performance

The least-squares means for body weight of Kodi Adu kids is presented in Table 3. Male kids weighed significantly ($P<0.01$) higher than female kids at all the age groups, but the colour of the kids had no significant effect on body weight at different stages of growth. Location of the animals had significant influence ($P<0.05$) on birth, six months and 12 months of age. On comparison, the body weight of Kodi Adu kids at different age groups were higher than those reported for Kanni Adu, Salem Black and Attappady Black goats (Report, 2002; Gopu, 2002; Stephen *et al*., 2005). However, colour of the animal had no significant influence on body weight at different adult stages. The body weight of Kodi Adu bucks and does observed at full mouth of age was comparable with the values reported for Kanni Adu goats (Report, 2002). However, higher than the values observed were also reported for Salem Black and Attappady Black goats (Stephen *et al*., 2005; Thiruvenkadan and Karunanithi, 2006).

There was no significant difference in dressing percentage and other carcass traits between males and females. The age of the animal had highly significant effect ($P<0.01$) on all the carcass traits. The overall dressing percentage observed in Kodi Adu goats (46.69 ± 0.25 per cent) was lower than those reported for Kanni Adu (48.23 ± 0.002 per cent) goats (Report, 2002) .

Table 3. Least-squares means (±SE) of body weight (kg) of Kodi Adu goats

Effects	Birth	Three months	Six months	Nine months	12 months	2-tooth	4-tooth	6-tooth	Full mouth
Overall	**2.81 ± 0.04 (140)**	**11.41 ± 0.16 (175)**	**14.70 ± 0.23 (175)**	**16.79 ± 0.30 (127)**	**22.95 ± 0.31 (163)**	**26.46 ± 0.33 (154)**	**29.39 ± 0.35 (136)**	**33.05 ± 0.55 (181)**	**36.99 ± 0.59 (275)**
Sex	**	**	**	**	**	*	**	**	**
Male	2.89 ± 0.04[b] (76)	11.56 ± 0.22[b] (80)	15.18 ± 0.27[b] (81)	17.29 ± 0.41[b] (60)	23.63 ± 0.36[b] (54)	26.98 ± 0.42[b] (63)	31.92 ± 0.47[b] (48)	34.65 ± 0.79[b] (62)	40.58 ± 0.89[b] (63)
Female	2.72 ± 0.05[a] (64)	11.25 ± 0.20[a] (95)	14.22 ± 0.29[a] (94)	16.29 ± 0.37[a] (67)	22.47 ± 0.41[a] (109)	25.95 ± 0.42[a] (91)	26.85 ± 0.39[a] (88)	31.46 ± 0.63[a] (119)	33.39 ± 0.59[a] (212)
Colour									
Chem-Porai	2.83 ± 0.04 (106)	11.35 ± 0.18 (119)	14.87 ± 0.24 (126)	16.85 ± 0.35 (84)	23.32 ± 0.3 (123)	26.47 ± 0.34 (109)	29.93 ± 0.34 (101)	33.73 ± 0.58 (133)	37.66 ± 0.62 (196)
Karum-Porai	2.78 ± 0.06 (34)	11.47 ± 0.25 (56)	14.53 ± 0.34 (49)	17.02 ± 0.45 (43)	22.58 ± 0.48 (40)	26.46 ± 0.49 (45)	28.84 ± 0.53 (35)	32.38 ± 0.87 (48)	36.31 ± 0.84 (79)
Location	*		*		*	**		**	
Thoothukudi	2.84 ± 0.04[b] (94)	11.34 ± 0.16 (130)	14.29 ± 0.20[a] (145)	16.85 ± 0.32 (92)	22.37 ± 0.28[a] (134)	25.44 ± 0.30[a] (124)	29.72 ± 0.31 (110)	31.40 ± 0.56[a] (136)	37.81 ± 0.55 (225)
Ramanatha-puram	2.77 ± 0.06[a] (46)	11.47 ± 0.27 (45)	15.11 ± 0.40[b] (30)	16.73 ± 0.49 (35)	23.52 ± 0.53[b] (29)	27.49 ± 0.57[b] (30)	29.05 ± 0.58 (26)	34.71 ± 0.89[b] (45)	36.16 ± 0.96 (50)

* Significant ($P < 0.05$); ** Highly significant ($P < 0.01$) Figures in parentheses are number of observations

Reproduction performance

The reproduction performance of Kodi Adu goats is presented in Table 4. The average age at first mating observed in males and females was slightly higher than the reported valuesof 9.90 ± 0.20 and 9.38 ± 0.11 months respectively for Kanni Adu goats (Thiruvenkadan *et al*., 2000b). About 48 per cent of the does in the herds studied were reported to have kidded well before the eruption of the first pair of permanent incisors. The age at first kidding observed in Kodi Adu goats is comparable with the values reported for Kanni Adu (14.63 ± 0.11 months), Attappady Black (413.0 ± 2.6 days) and Salem Black goats (14.8 ± 0.20 months) (Report, 2002; Stephen *et al*., 2005; Thiruvenkadan and Karunanithi, 2006). The mean litter size observed in Kodi Adu goats was comparable to the value of 1.6 ± 0.03 reported for Salem Black goats of Tamil Nadu (Thiruvenkadan and Karunanithi, 2006). Kodi Adu does showed non-seasonality of breeding and exhibited oestrus throughout the year with peak in October, September and November months. The number of animals mated in each season coincides with rainfall and is in accordance with the results obtained in Kanni Adu, Attappady Black and Salem Black (Thiruvenkadan, 2002; Stephen *et al.,* 2005; Thiruvenkadan and Karunanithi, 2006).

Kodi Adu goats are important goat genetic resources in south-eastern coastal areas of Tamil Nadu and the study revealed that the present population status explicitly does not warrant immediate conservation measures. Since, the average herd size of Kodi Adu goats is small, initiation of Open Nucleus Breeding Scheme (ONBS) is essential for further genetic improvement of this breed. In addition, forage and range development programmes should be implemented by involving local stake-holders, particularly goat breeders for increased fodder availability to the goats.

Table 4. Least-squares means (± SE) of reproduction traits of Kodi Adu goats

Character	Overall	Variety		District	
		Chem-Porai	Karum-Porai	Thoothukudi	Ramanatha-puram
Male					
Number of observations	**317**	217	100	249	68
Age at first mating (months)	**11.17 ± 0.11**	11.15 ± 0.12	11.19 ± 0.17	11.20 ± 0.10	11.15 ± 0.19
Female					
Number of observations	**494**	336	158	356	138
Age at first mating (months)	**10.33 ± 0.08**	10.49 ± 0.09	10.16 ± 0.13	10.21 ± 0.08	10.45 ± 0.13

Age at first kidding (months)	**15.37 ± 0.08**	15.45 ± 0.09	15.29 ± 0.13	15.12 ± 0.08	15.62 ± 0.13
Interval from kidding to conception (months)	**2.80 ± 0.03**	2.85 ± 0.03	2.75 ± 0.05	2.81 ± 0.03	2.79 ± 0.05
Kidding interval (months)	**7.67 ± 0.03**	7.68 ± 0.03	7.66 ± 0.04	7.67 ± 0.03	7.67 ± 0.04
Gestation length (days)	**150.01 ± 0.17**	150.02 ± 0.18	150.01 ± 0.26	150.30 ± 0.17	149.70 ± 0.27
Lifetime number of kidding	**7.63 ± 0.05**	7.84 ± 0.05	7.42 ± 0.08	7.65 ± 0.05	7.61 ± 0.08
Average litter size	**1.63 ± 0.01**	1.80 ± 0.01	1.66 ± 0.02	1.72 ± 0.01	1.73 ± 0.02
Kidding percentage (%)	**152.70 ± 0.41**	153.40 ± 0.45	152.01 ± 0.65	152.90 ± 0.43	152.60 ± 0.68

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Influence of sex on carcass characteristics of Cochin bantam chickens

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ABSTRACT

Cochin bantams are the more attractive bantam chickens commonly reared in confinement for meat and fancy purpose. Influence of sex on carcass characteristics of Cochin bantam chickens was studied. A total of 20 Cochin bantam chickens comprising of ten male and female each at fortieth week of age were subjected for slaughter as per standard procedure. The results revealed that the sex had significant influence on pre slaughter live weight and per cent yield of giblet. Males had significantly ($P \leq 0.01$) higher pre slaughter live weight (895.30±17.86g) and females had significantly ($P \leq 0.05$) higher mean per cent yield of giblet (5.50±0.23%). However, no statistically significant differences between sexes were observed in per cent yield of New York dressed weight, eviscerated weight, ready to cook weight and organ cuts viz., breast, back, thigh, drumstick, wing and neck weights.

Key Words: Cochin bantam chickens, sex, carcass yield, cut up parts

INTRODUCTION

Bantam chickens are small variety of chicken breeds and are popular as pets as well as for show purposes because they have more varied and exotic colors and feather patterns than other chickens. Bantams are also suitable for smaller backyards as they do not need as much space as other breeds. In India, Cochin bantams are the more attractive bantam chickens commonly reared in confinement for meat and fancy purpose. Bantam chicken meat has a very fine texture and flavor. Their small carcasses cannot compete on the commercial market but surplus birds can be sold for meat purpose.

The marketing of poultry has been greatly diversified with a significant increase in cut-up (parts) and processed products (Le Bihan-Duval et al., 2001). Breed, strain, body weight, carcass weight, nutrition, sex, age, and environmental conditions influence the yield of broiler parts and carcass composition (Lopez et al., 2011). The study on the different carcass characteristics of different breeds of chicken is essential as it implicates various aspects of economics of chicken production and to offer solutions for improving meat yield both qualitatively and quantitatively (Singh *et al.,* 1980). Studies on the yields of different cut up parts of a carcass will give primary information on the value and preference of each cut and

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should form the basis for pricing policy. Carcass characteristics of Cochin bantam chickens need to be explored for their full utility in poultry production. Therefore, the present study was conducted to assess the effect of sex on the carcass traits of Cochin bantam chickens.

MATERIALS AND METHODS

Site of study

The experiment was carried out at Poultry Research Station, Tamil Nadu Veterinary and Animal Sciences University, Chennai to find out the influence of sex on carcass characteristics of Cochin bantam chicken reared under deep litter system of management.

Experimental Design

About 40 Cochin bantam chicks were hatched and reared on deep litter system of rearing from day one to forty weeks of age in open sided poultry house. All the Cochin bantam birds were kept under uniform management conditions throughout the experimental period. The birds were vaccinated against New castle disease as per the routine vaccination schedule.

Feed

Cochin bantam chickens were fed brooder mash diet up to eight weeks of age (2500 Kcal/kg M.E. and 18 % C.P.), grower mash diet from nine to nineteen weeks of age (2600 Kcal/kg M.E. and 16 % C.P.) and layer mash diet from twenty weeks of age onwards (2600 Kcal/kg M.E. and 16% C.P.). Feed ingredients used in ration formulations were maize, soybean meal, fish meal, de-oiled rice bran, salt and vitamin premix, lysine, DL methionine, trace minerals, shell grit and dicalcium phosphate. The birds were fed ad libitum feed and potable water.

Data collection

A total of 20 bantam chicken birds comprising of ten male and female each at fortieth week of age were subjected for slaughter hygienically to avoid contamination as per standard procedure for studying carcass characteristics. The birds were subjected to starvation of 12 hrs before slaughter without restriction of potable water and individually weighed to obtain pre slaughter live weight. The birds were stunned and immediately exsanguinated by manually severing both the carotid arteries and at least one jugular vein with a knife, and were allowed to bleed for 120 s. After bleeding, birds were scalded at 59°C for 180 s in a rotary scalder followed by carcass defeathering and the process was completed by removing the heads. In the evisceration room, the vent was cut with a plunging cylindrical knife and an eviscerator pulled the viscera from the cavity. The sex of each bird was determined by a visual examination of gonads during evisceration. The slaughter process was completed with several internal and external washings of the carcasses. The whole process was completed within 20 min from the hanging of live birds. The carcass was separated into breast, thighs, drumstick, back, wing, thigh, neck, head and giblets [liver (without gall bladder), gizzard (without mucous membrane) and the heart (after removal of blood clot and pericardium)]. Individual edible organs weights were recorded to the nearest 0.1 g accuracy. The per cent yield of New york dressed weight, eviscerated weight, giblet

weight, ready to cook weight, breast, back, thigh, drumstick, wing and neck weights were determined.

Statistical analysis

The percent values were transferred to arcsine values before statistical analysis. The data were analyzed statistically using Completely Randomized Design (CRD) described by Snedecor and Cochran (1994).

RESULTS AND DISCUSSION

The result of the effect of sex on carcass traits of Cochin bantam chickens is presented in table I. The overall mean pre slaughter live weight of Cochin bantam chicken was 817.75±22.49g. Significant difference (P<0.01) was found in pre slaughter live weight between males and females. Male Cochin bantam chickens had higher pre slaughter live weight (895.30±17.86g) than females (740.20±21.92g). The higher body weight recorded in males in this study might be due to higher growth rate and muscle mass than in female birds (Faria *et al.,* 2010; Lawrie and Ledward, 2006). The findings of this study indicating higher pre slaughter live weight in male chickens are in agreement with those of Moreira *et al.* (2003) in six broiler breeds (Cobb 500 Slow, Cobb Fast, Ross 308, Ross 508, Hybro Plus and Avian 48); Shahin and Elazeem (2005) in broiler chickens; Bogosavljevic-Boskovic *et a*l. (2006) in hybrid Hybro G chicken; Ojedapo *et al.* (2008) in Ross broiler strain; Debata *et al.* (2012) in Black Rock, Red Cornish and Vanaraja chickens; Isidahomen *et al.* (2012) in Nigerian Indigenous Chickens, Thutwa *et al.* (2012) in tswana chickens, Fernandes *et al.,* (2013) in broilers; Kuzniacka *et al.* (2014) in broilers; Maiorano *et al.* (2017) in Ross chickens and Cygan-szczegielniak *et al.* (2019) in Ross 308 chickens.

The overall mean per cent yield of Newyork dressed weight was 84.64±1.40 and there was no statistically significant difference between males (86.35±1.89) and females (82.94±2.02), which is in line with the finding of Thutwa *et al.* (2012) in Tswana chickens. The overall mean per cent yield of eviscerated weight was 65.89±1.03 and the sex did not have significant (P>0.05) effect. The mean per cent yield of eviscerated weight in males and females was found to be 65.80±1.75 and 65.97±1.20, respectively. Similar reports were also reported by Thutwa *et al.* (2012) in Tswana chickens; Fernandes *et al.* (2013) in broilers and Sanka and Mbaga, (2014) in Tanzanian local chicken. Bilgili *et al.* (2006) observed that the processing yields of broilers were influenced by strain-cross.

The overall mean per cent yield of giblet weight was 4.97±0.22. Sex had highly significant (P<0.01) influence and it was 4.45±0.29% for male and 5.50±0.23% female Cochin bantam chickens. Ojedapo *et al.* (2008) and Shahin and Elazeem (2005) reported that the differences in gizzard weight were higher in male than female in different broiler strains. The overall mean per cent ready to cook weight was 70.11±1.04. There was no significant difference observed between males (69.65±1.72%) and females (70.56±1.25%) on per cent ready to cook weight. Similar report was also recorded by Thutwa *et al.* (2012) in Tswana chickens.

The overall mean per cent value of 26.76±0.45, 21.89±0.42, 14.65±0.27, 14.25±0.25, and 14.13±0.41 and 8.05±0.31% was recorded for the organ cuts viz.,breast, back, thigh, drumstick, wing and neck, respectively. There was no statistically significant difference between males and females found on organ cuts viz., breast, back, thigh, drumstick, and wing and neck respectively. The results of this study showing non-significant differences in the yield of all carcass parts between sexes were in agreement with the earlier research findings of Bogosavljevic-Boskovic *et al.* (2006) in hybrid Hybro G chicken; Shahin and Elazeem (2005) in broiler chickens; Moreira et al. (2003) in six broiler breeds (Cobb 500 Slow, Cobb Fast, Ross 308, Ross 508, Hybro Plus and Avian 48). However, Lopez *et al.* (2011) reported that breast weight and percentages between females and males were significantly different. The carcass parts weights (except thigh weight) did not differ significantly between the males and females of Tswana chickens (Thutwa *et al.* 2012) The breast and wing parts weights did not differ significantly between the males and females of broiler strains (Fernandes et al., 2013). On the contrary, the results by Young *et al.* (2001) showed that broiler chicken females yielded larger proportions of forequarters, breasts and fillets, but smaller proportions of drumsticks than males, under commercial-like conditions.

CONCLUSIONS

The results revealed that the sex had highly significant (P≤0.01) influence on pre slaughter live weight and significant (P≤0.05) influence on percent giblet yield of Cochin bantam chickens . Male Cochin bantam chickens had higher pre slaughter live weight and Female Cochin bantam chickens had significantly (P≤0.05) higher percent yield of giblet. However no statistically significant differences between sex was observed in percent yield of New York dressed weight, eviscerated weight, ready to cook weight and organ cuts viz., breast, back, thigh, drumstick, wing and neck weights.

Table I. Mean (±S.E.) carcass characteristics of Cochin bantam chicken as influenced by sex

Carcass Traits	Male	Female	Overall mean
Pre slaughter live weight **	895.30±17.86	740.20±21.92	817.75±22.49
NewYork Dressed weight%^{NS}	86.35±1.89	82.94±2.02	84.64±1.40
Eviscerated weight%^{NS}	65.80±1.75	65.97±1.20	65.89±1.03
Giblet weight %*	4.45±0.29	5.50±0.23	4.97±0.22
Ready to cook weight%^{NS}	69.65±1.72	70.56±1.25	70.11±1.04
Breast weight %^{NS}	26.32±0.62	27.20±0.66	26.76±0.45
Back weight %^{NS}	21.47±0.73	22.31±0.41	21.89±0.42
Thigh weight %^{NS}	15.08±0.39	14.22±0.34	14.65±0.27

Drumstick weight % NS	14.53±0.46	13.97±0.21	14.25±0.25
Wings weight % NS	13.89±0.54	14.37±0.63	14.13±0.41
Neck weight % NS	8.49±0.52	7.62±0.30	8.05±0.31

Means having common superscript within the row do not differ significantly (P>0.05)

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Effect of different levels of energy and lysine on the laying performance of TANUVAS Namakkal Gold Japanese quail

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ABSTRACT

The aim of the present research was to study the laying performance by feeding different levels of energy (2600, 2700 and 2800 Kcal/kg) and lysine (0.8, 0.9 and 1.0 %) in laying TANUVAS Namakkal gold quail with 18% crude protein in all the treatments. A total of 360 Japanese quails aged 7 weeks old were divided into nine equal groups of four replicates each consisting of 10 quails. The laying phase of twenty weeks was divided into five periods with 28 days duration. No significant effect on the age at sexual maturity and age at 50% egg production. Low energy level recorded significantly (P<0.05) earlier age for 90 per cent egg production. Low energy and lysine showed significantly (P<0.01) higher hen day and hen housed egg production, feed consumption (g/bird/day), feed efficiency/dozen eggs and feed efficiency/kg egg mass.

Key Words: Energy, lysine, egg production, feed consumption and feed efficiency

INTRODUCTION

Genetic selection for higher body weight and egg production in Japanese quail is practiced during the last few decades (Hussain *et al.*, 2013). A new egg type Japanese quail strain "TANUVAS Namakkal gold Japanese quail" was evolved by the Department of Poultry Science, Veterinary College and Research Institute, Namakkal under Tamil Nadu Veterinary and Animal Sciences University. The actual nutrient requirement for these quails has not been worked so far and the NRC (1994) recommendations have been followed throughout the production cycle. Consequently, there is a need of updating optimal nutritional requirements to maximize the production potentiality.

Energy protein ratio and the ratio of energy to other nutrients are important in the formulation of the diet. Supplementing the required limiting amino acids in diet will reduce dietary protein content. The information on the amino acid nutrition

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of Japanese quail, as a whole, is scanty (Shrivastav and Panda, 1999). The ideal protein concept implies feeding the best ratios between lysine and other amino acids, thus reducing the crude protein content of the diet. Lysine in lower or excess levels may bring metabolic damages, which affects the bird's performance (Kidd and Kerr, 1998). Hence, the present study has been carried out to evaluate the effect of different dietary metabolizable energy and lysine levels, in "TANUVAS Namakkal gold Japanese quail".

MATERIALS AND METHODS

The experiment was conducted in "TANUVAS Namakkal gold Japanese quail" from day old to twenty six weeks of age. The whole experimental period was divided into three phases *viz.* chick (0-2 weeks), grower (3-5 weeks) and layer (7-26 weeks). Seven hundred and twenty day old quail chicks were divided into nine treatments with four replicates of 20 chicks each. Nine experimental diets were formulated in 3x3 factorial arrangements with three levels of dietary energy (2700, 2800 and 2900 Kcal/kg) and three levels of lysine (1.2, 1.3 and 1.4 per cent) during chick phase (0-2 weeks) and 2700, 2800 and 2900 Kcal/kg energy with 1.1, 1.2 and 1.3 per cent during grower phase (3-5 weeks). After five weeks, only 10 females were retained in each replicate, so a total of 360 birds were maintained during the laying phase. Nine experimental diets were formulated in 3x3 factorial arrangements with three levels of dietary energy (2600, 2700 and 2800 Kcal/kg) and three levels of lysine (0.8, 0.9, and 1.0 per cent) from 7-26 weeks during layer phase.

The quail chicks used for the experiment were housed in cage system and maintained under standard managemental conditions. The laying phase (7-26 weeks) was divided into five periods with 28 days duration. During the laying period, the egg production was recorded replicate wise each day and total feed consumption was recorded once in every twenty-eight days. Mortality was recorded at occurrence. With the data collected, feed consumption (g) per bird per day, hen day egg production, hen housed egg production, feed efficiency per dozen eggs and feed efficiency per kg of egg mass and livability percentage were worked out. The data were analysed statistically as per the methods described by Snedecor and Cochran 1994).

RESULTS AND DISCUSSION

The age at sexual maturity, age at 50 and 90 per cent egg production, production performance like hen day egg production (HDEP) and hen housed egg production (HHEP) percentage, feed consumption and feed efficiency and energy x lysine interaction results are shown in Table 1.

The energy x lysine interaction and the influence of energy and lysine levels revealed no significant difference between the groups for age at sexual maturity and age at 50 per cent egg production. The age at 90 per cent egg production showed a significant ($P<0.05$) difference between the groups. Japanese quail fed with 2900 kcal/kg energy and 0.8% lysine (T_3) and 2900 kcal/kg energy and 0.9% lysine (T_6) recorded significantly delayed 90 per cent egg production (84.25 days), while all other groups reached 90

Table I: Egg production performance of "*TANUVAS Namakkal Gold Japanese Quail*" from 7 to 26 weeks of age under caged system of housing

Treatments	Parameters							
	Age at sexual maturity	Age at 50% egg production	Age at 90% egg production	Hen day egg production (%)	Hen housed egg production (%)	Feed consumption (g/bird/day)	Feed efficiency per dozen eggs	Feed efficiency per kg egg mass
General Linear Model (GLM) analysis of Energy X Lysine level interaction								
T_1	39.50±0.50	45.00±0.41	53.00^{a}±2.80	84.67^{A}±0.69	83.75^{A}±1.72	38.14^{a}±0.43	0.563^{A}±0.016	3.725^{A}±0.186
T_2	41.25±1.03	44.75±0.85	53.75^{a}±2.17	73.31^{B}±1.43	72.64^{B}±0.62	35.92^{bc}±0.38	0.641^{AB}±0.023	4.275^{AB}±0.184
T_3	43.00±1.73	58.75±4.92	84.25^{b}±9.21	60.15^{D}±2.17	58.00^{D}±1.15	33.45^{ef}±0.29	0.804^{BC}±0.050	5.458^{BC}±0.333
T_4	41.50±0.50	48.00±3.03	59.75^{a}±5.23	70.91^{BC}±3.22	70.62^{B}±2.98	36.84^{ab}±0.18	0.700^{ABC}±0.048	4.716^{ABC}±0.295
T_5	41.00±1.47	56.25±5.04	74.75^{ab}±7.48	59.45^{D}±0.69	58.18^{D}±1.48	34.71^{cde}±0.43	0.865^{C}±0.040	5.915^{C}±0.247
T_6	44.00±2.12	59.75±5.12	84.25^{b}±8.55	55.69^{D}±0.87	54.93^{D}±0.93	32.11^{f}±0.26	0.843^{C}±0.033	5.705^{C}±0.159
T_7	43.25±1.25	56.00±4.34	74.25^{ab}±5.53	63.34^{CD}±1.20	61.88^{CD}±1.40	36.03^{bc}±0.16	0.858^{C}±0.032	5.755^{C}±0.269
T_8	43.50±1.19	56.25±3.71	74.25^{ab}±8.73	69.27^{BC}±3.44	69.09^{BC}±3.33	35.29^{bcd}±0.51	0.708^{ABC}±0.057	4.689^{ABC}±0.414
T_9	42.75±1.18	51.75±2.78	67.50^{ab}±5.95	63.81^{CD}±2.48	61.95^{CD}±2.56	33.81^{de}±0.56	0.739^{BC}±0.049	4.904^{ABC}±0.356
General Linear Model (GLM) analysis of Energy levels								
2700	41.42±0.63	49.67±2.13	62.33^{a}±3.62	72.97^{A}±2.87	72.08^{A}±2.93	37.00^{A}±0.30	0.706^{a}±0.041	4.732^{a}±0.283
2800	41.92±0.73	52.42±2.51	67.58^{ab}±4.60	67.34^{B}±2.09	66.64^{B}±2.16	35.30^{B}±0.27	0.738^{ab}±0.036	4.960^{ab}±0.261
2900	43.25±0.91	56.75±2.54	78.67^{b}±4.82	59.88^{C}±1.44	58.29^{C}±1.24	33.13^{C}±0.30	0.795^{b}±0.027	5.356^{b}±0.185
General Linear Model (GLM) analysis of Lysine levels								
0.8	41.25±0.76	49.50±2.48	63.67±5.30	72.71^{A}±3.13	71.47^{A}±3.25	35.84^{A}±0.61	0.669^{A}±0.035	4.486^{A}±0.253
0.9	42.17±0.89	54.67±2.78	72.92±4.84	62.02^{B}±2.21	61.24^{B}±2.29	34.56^{B}±0.60	0.802^{B}±0.031	5.445^{B}±0.202
1.0	43.17±0.64	54.67±2.01	72.00±3.72	65.47^{B}±1.56	64.30^{B}±1.68	35.04^{B}±0.36	0.768^{B}±0.031	5.116^{B}±0.230

n = 4, Means within a column with different superscript small letters differ significantly ($P < 0.05$)
Means within a column with different superscript capital letters differ significantly ($P < 0.01$)

per cent egg production at an early age. The influence of energy levels showed that the low (2600 kcal/kg) energy level recorded significantly (P<0.05) earlier age at 90 per cent egg production (62.33 days) when compared to high (2800 kcal/kg) energy level (78.67 days). The medium (2700 kcal/kg) energy group was statistically comparable with other groups. The influence of lysine levels showed no significant difference for 90 per cent egg production. Aggoor *et al.* (2006) reported delayed age at 40 per cent egg production due to high energy which is in accordance with this study, while Olusoji (2011) and Bulus *et al.* (2013) found no significance in the age at sexual maturity.

Hen day and hen housed egg production (%)

The energy x lysine interaction data revealed significant (P<0.01) difference between the groups for hen day and hen housed egg production. The overall hen day and hen housed egg production (84.67 and 83.75%) was significantly higher in T_1 (2600 kcal/kg and 0.8%) when compared to all other groups. The influence of energy and lysine levels showed significantly (P<0.01) higher hen day and hen housed egg production (72.97 and 72.08%) in low energy (2600 kcal/kg) levels and 72.71 and 71.47% hen day and hen housed egg production in low lysine (0.8%) levels when compared to other levels of supplementation. Aggoor *et al.* (2006) reported high egg production in low energy (2700 kcal/kg) group while Azghadi *et al.* (2014) recorded high egg production in high energy (3050 kcal/kg) group which is not in concurrence to this trial. Lima *et al.* (2016) observed higher egg production in high lysine group which is in contrast to the results of the present study. Egg production increases as the protein level increases, but as the level increases too high or exceeds the need of the bird, it is wasted as it increases the burden for the birds and reduces the performance of the birds. The results of this trial recommend low energy and low lysine (2600 kcal/kg and 0.8%) for egg production in the layer phase.

Feed consumption and feed efficiency

The energy x lysine interaction revealed significant difference between the treatment groups for feed consumption (g/bird/day), feed efficiency/dozen eggs and feed efficiency/kg of egg mass from 7 to 26 weeks of age.

Feed consumption (38.14 and 36.84 g) was significantly (P<0.05) high in T_1 (2600 kcal/kg and 0.8%) and T_4 (2600 kcal/kg and 0.9%). Statistically (P<0.01) and numerically best feed efficiency/dozen eggs and feed efficiency/kg egg mass (0.563 and 3.725) was recorded in T_1 (2600 kcal/kg and 0.8%) when compared to all other groups. The influence of energy and lysine levels showed significant (P<0.01) increase in feed consumption in the low energy and lysine (2600 kcal/kg and 0.8%) groups. Energy groups recorded 37.00, 35.30 and 33.13 g and lysine levels recorded 35.84, 34.56 and 35.04 g, for low, medium and high levels respectively. Feed consumption was significantly higher in low energy (2700, 2600 kcal/kg) groups as recorded by Aggoor *et al.* (2006), Kadam *et al.*, (2006) and Abdel-Azeem (2011) whose findings are in agreement with the present

observations. On the contrary, Azghadi *et al.* (2014) recorded increase in feed consumption in high and medium (2900 and 3050 kcal/kg) energy. Sung-Taek *et al.* (2012), Ribeiro *et al.* (2013) and Nery *et al.,* (2015) observed no significant difference in feed consumption due to lysine levels.

Low and medium (2600 and 2700 kcal/kg) energy levels showed a good feed efficiency/dozen eggs (0.706 and 0.738) and feed efficiency/kg egg mass (4.732 and 4.960) when compared to high (2800 kcal/kg) energy (0.795 and 5.356) level. The medium energy (2700 kcal/kg) level was intermediate and statistically comparable to other groups. The influence of lysine levels showed significant ($P<0.01$) difference in lysine groups for feed efficiency/dozen eggs and feed efficiency/kg egg mass. Better feed efficiency/dozen eggs and feed efficiency/kg of egg mass (0.669 and 4.486) was observed in low (0.8%) lysine levels, whereas poor feed efficiency/dozen eggs (0.768 and 0.802) and feed efficiency/kg egg mass (5.445 and 5.116) was recorded in medium and high (0.9 and 1.0%) lysine levels. Low energy (2700 and 2610 kcal/kg) showed better feed efficiency in the studies conducted by Aggoor *et al.* (2006) and Yusuf *et al.* (2016), while Azghadi *et al.* (2014) has reported better feed efficiency in high energy (3050 kcal/kg) group, which is not in agreement with the present study. Better feed efficiency was reported in low lysine (1.100%) levels by Garcia *et al.* (2005) which is in agreement to this study, while linear improvement in feed efficiency was observed by Lima *et al.* (2016) with different levels of *D*-lysine, which is not in accordance to the results of the study.

It is inferred that, the low energy and low lysine (2600 kcal/kg and 0.8%) is recommended for optimum feed consumption (g/bird/day) and feed efficiency/dozen eggs and feed efficiency/kg of egg mass in the layer phase of "*TANUVAS Namakkal gold Japanese quail*".

CONCLUSION

The final recommendation based on the production performance is 2700 kcal/kg energy and 1.2 per cent lysine during chick phase; 2700 kcal/kg energy and 1.1 per cent lysine during grower phase and 2600 kcal/kg and 0.8 per cent lysine during layer phase.

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Short Communications

Hair dye as a choice of laboratory rodent animal identification method in experimental research

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ABSTRACT

Laboratory animal identification is a routine, but an important aspect in experimental research. To study the efficiency of a commercial human hair dye as a choice of animal identification method, twenty female Wistar albino rats in the breeding unit of Laboratory Animal Medicine unit were used. Ten rats were identified with conventional potassium permanganate dye and another ten were identified using commercially available hair dye and the persistence of dye was observed for a period of three months. Potassium permanganate dye persisted for a period of only four weeks whereas commercial hair dye persisted for a period of 12 weeks. In both the groups, no adverse effect towards the dye was observed. From this observation, it shall be concluded that commercial hair dye can be used as easy, cost effective, single application and long-standing identification method in animal research lasting up to 3 months period.

Key Words: Lab Animal – identification– hair dye

INTRODUCTION

In experimental research using laboratory animals, animal identification is done routinely. Animal identification is an important measure for maintaining accurate production records of the mischief/nest (group of rats/mice). Animal identification allows us to keep records on numerous parameters such as animal's parentage, birth date, litter records, health history and a host of other important managemental information (Neary and Yager, 2012). Laboratory animal identification is generally carried out with minimum invasive and cost-effective techniques like colouring dyes, tags, bands, removing fur, etc.

Invasive and costly techniques like tattooing, radio telemetry transmitters and passive integrated transponders are also being used as animal identification methods (Cameron *et al*., 2007). Each technique has its own advantage and disadvantage and in recent times researchers are sensitized on the issues of animal ethics. Hence, an animal

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identification method that would have minimum handling and stress to the animals will be ideal. It should be easy for researcher and should stay for long duration so that animals need not be handled frequently should also be cost effective. In this study, an attempt is made to evaluate the efficacy of hair dye as an identification tool against conventional potassium permanganate dye in laboratory animals.

MATERIALS AND METHODS

Commercial hair dye, Potassium permanganate ($KMnO_4$) and application brush were procured for the study from local vendors. Laboratory Animal Medicine Unit, Directorate of Centre for Animal Health Studies, TANUVAS is a breeding unit of laboratory animals like rat, mice and guinea pigs. Trio-mating is being followed in the unit with the ratio of one male rat to 2 female rats. As male rat in each cage is easily identified by the presence of testicles beneath the tail, there is need to identify the females in each cage to maintain breeding record of rats. One of the female rats in each cage was marked with either the conventional $KMnO_4$ dye or commercial hair dye and other female rat was left unmarked in every cage. Twenty female Wistar Albino Rats were used for the study. Cage numbers from 1 to 10 were marked as $KMnO_4$ identified cages and cage numbers from 11 to 20 were labeled as commercial hair dye identified cages.

Potassium permanganate dye was prepared as per the standards for usage as topical agent (Goodman and Gilman, 1975). One sachet of commercial hair dye was prepared for application as per the procedure of the manufacturer (Chemical - p-Phenylenediamine). The rat which has to be identified was taken to separate sample collection room. Hair dye or $KMnO_4$ dye was applied swiftly over hair coat on the scruff region of each rat using a brush. The dye was allowed to dry for 10 minutes and the animals were brought back to their respective cages.

The animals were observed daily to evaluate the persistency of the commercial hair dye in comparison with $KMnO_4$.

RESULTS AND DISCUSSION

The animals in both the groups were watched periodically for the persistence of colour for a period of three months. The animals were observed for adverse reactions on the day of application at frequent intervals. As both the agents were applied only on the hair coat of animal, no adverse skin reactions were observed in neither of the groups.

Potassium permanganate dye stained the hair coat with brown colour and was visible as an identification mark up to 4 weeks with minimum paleness and thereafter the intensity started to reduce and was difficult to be identified by 8^{th} week of the observation period. $KMnO_4$ colour completely became invisible during 12^{th} week of observation as shown in the figure 1-4. Similar observation was recorded in all the animals of $KMnO_4$ identified group.

Commercial hair dye stained the hair coat with black colour and was present prominently with little fading till 12 weeks of study and after that it started to fade

and only by week 15 the dye disappeared completely (figure 5-8). Similarly, all animals showed the same observation in hair dye identified group.

Tonguc Isken *et al*., (2008) recorded that hair dye as an animal identification method on different anatomical regions persisted with minimum paleness till eleventh week of the study. As grooming behaviour is well established in rats, there are increased chances of licking the dye and fading of colour if sites chosen are easily groomed. Therefore, in this study the scruff region is being chosen for identification which is not readily accessible for grooming. This prevents the intake of dye orally and also avoids fading of colour by grooming. The dark black colour of the dye is also advantageous owing to the contrast that it gives on an albino coat.

With minimum handling stress to animals and researcher and in short time, animals can be identified using freshly prepared hair dye. In studies involving multiple groups, different anatomical locations can be chosen to identify the animal provided for better differentiation and less accessible to grooming. Hence, hair dye will be an easy, cost effective, single application and long standing (period of 12 weeks) identification method in long term experimental research using animals.

Fig – 1 KMnO4 Day 1

Fig – 5 Commercial hair dye Day 1

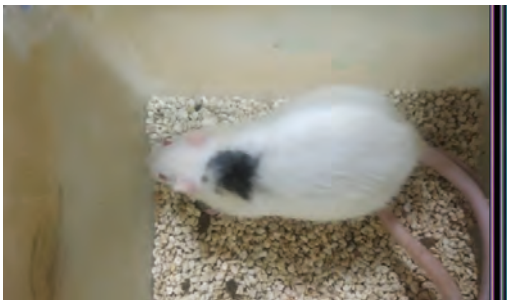

Fig – 2 KMnO4 Week 4

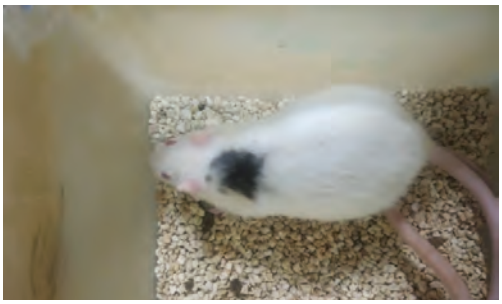

Fig – 6 Commercial hair dye Week 4

Fig – 3 KMnO4 Week 8

Fig – 7 Commercial hair dye Week 8

Fig – 4 KMnO4 Week 12

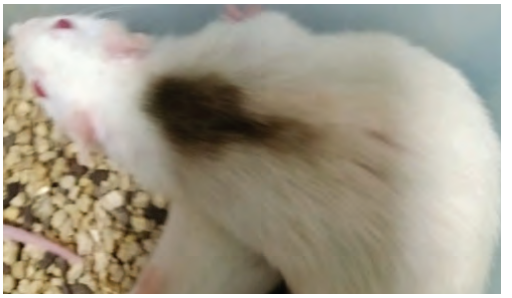

Fig – 8 Commercial hair dye Week 12

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Physical and ultrasonographic diagnosis of intussusception in a crossbred Jersey cow- a case report

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ABSTRACT

A six-year-old Crossbred Jersey cow was presented with the complaint of progressive in appetence to complete anorexia, reduction of faeces quantity followed by complete absence of faeces for a period of one week. No improvement was observed to prior medication with parenteral fluids and oral laxatives. The presence of firm mass and malodorous scanty blackish pasty dung, with evincement of pain cranial to the pelvic cavity on right dorsal flank was observed per-rectum. Transabdominal ultrasonography of the firm mass which was positioned per-rectally towards dorsal flank revealed a "bull's eye appearance". The intussuscepted intestine measured 4.42 cms in diameter while the inner intussusceptum measured 1.47cm in diameter.. Right flank exploratory laparotomy revealed a jejuno-ileal intussusception and end to end anastomoses was performed following jejuno-ileal resection. The animal had uneventful recovery without any complication and the appetite was restored to normalcy. In conclusion transabdominal ultrasound along with per rectal examination could be a valuable diagnostic tool in cows with intestinal obstruction.

Key Words: Cow, Intussusception, transabdominal ultrasound, Bull's eye

Centre case history and Observation

A six-year-old crossbred Jersey cow weighing about 320 kg in early lactation and calved twice was presented to Large Animal Referral Clinic, Veterinary Clinical Complex, Veterinary College and Research Institute, Orathanadu with the complaint of progressive in appetence to complete anorexia, reduction of fecal quantity followed by complete absence of faeces for a period of one week.

No improvement was observed to prior medication with parenteral fluids

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and oral laxatives for 3 days. Aseptic procedure (Wilson *et al.*, 1985) using 20G 1.5-inch needle to collect clear transu date for analysis was done. Whole blood was collected for hemato-biochemical analysis and Plasma fibrinogen (Fb) was assessed by heat precipitation method as described by Schalm (1980).

Clinical examination revealed congested conjunctival mucous membrane, sunken eyeball, dryness of muzzle and severe dehydration with scanty dung defecation. The vital parameters like temperature was 38.2°C, heart rate was 86 bpm (tachycardia) and respiratory rate was 20 bpm. Further, marked reduction of ruminal motility (1/ min) with occasional belly kicking were observed in the affect animal. The presence of firm mass and malodorous scanty blackish **pasty** dung (Fig.1), with pain evincement of cranial to the pelvic cavity towards the right dorsal flank was observed on per-rectal examination. Abdominocentesis was performed as per the standard in the animal.

Centre Ultrasonographic Examination

With the cow in standing position as described by Braun (2009) and Venkatesan *et al*., (2018) Transabdominal ultrasonography was performed and on the right dorsal flank, mid and lower ventral abdomen using Esaote My lab One Color doppler Ultrasound with 2.5 to 5 MHz curvilinear array probe.

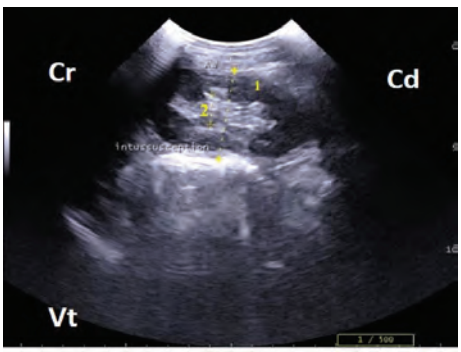
The firm mass was positioned by per-rectal manipulation towards the dorsal flank with simultaneous placement of the transducer on the mass. The sonogram revealed a "bull's eye appearance" or onion ring like appearence of the intussuscepted portion (4.42 cms in diameter as a whole part while the inner intussusceptum was 1.47 cms in diameter) (Fig.2a). Dilated intestinal loops were observed at right mid and lower ventral abdomen with the loops measuring greater than 3.61 cm diameter upon examination in different planes and in one plane circular movement of intestinal contents with reduced intestinal motility was noticed with the presence of anechoic fluid between the loops (Fig. 2b).

Centre Surgical Intervention

On the basis of history, clinical, physical, ultrasound and biochemical examinations a tentative diagnosis for intussusception was made and the cow referred to surgery ward.

The tentative diagnosis was confirmed by right flank exploratory laparotomy as per the standard procedure by Oehme (1988). The cow was operated in standing position without sedation by using right paravertebral anaesthesia with 2% lignocaine. Exploration of the abdominal cavity revealed the presence of mild peritonitis with clear transudate in the peritoneum.The (jejuno-ileal) intussuscepted mass with distended loops were exteriorized from the abdominal cavity (Fig. 3). However, the intussusception could not be corrected manually and hence end to end anastomoses was performed after jejuno-ileal resection.

Fig.1.Rectal examination shows a black tarry feces



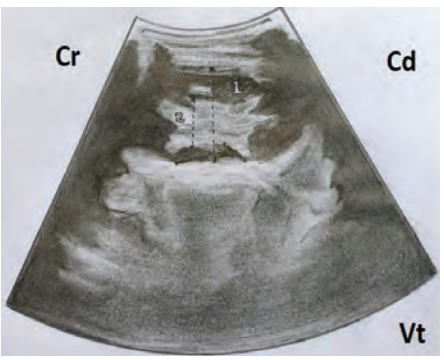
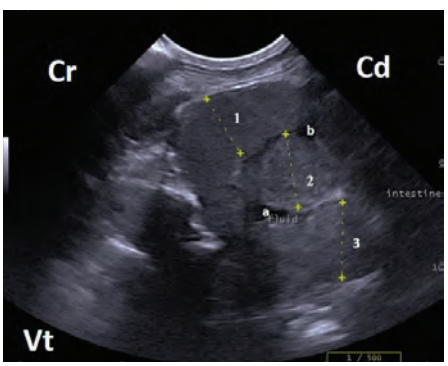


Fig.2a. Trans-abdominal ultrasonography and schematic representation of intussusception showing "bull's eye appearance" of intussuscepted portion of intestine{Intussusception - 4.42 cm diameter (1) and Intussusceptum - 1.47cm in diameter (2)}; Cr-Cranial, Cd-Caudal, Vt-Ventral



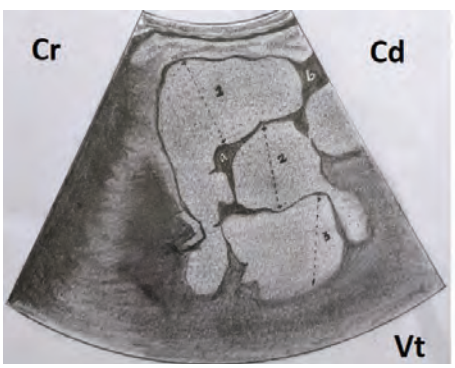


Fig.2b. Trans-abdominal ultrasonography and schematic representation of multiple dilated intestinal loops (1,2,3) (> 3.5 cm in diameter) along with mild peritonitis (a, b) at right paramedian region. Cr-Cranial, Cd-Caudal, Vt-Ventral

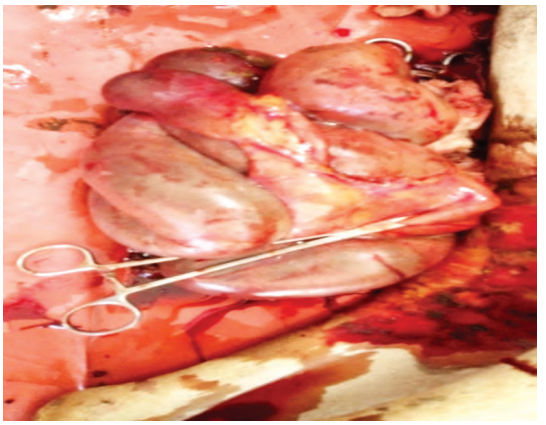


Fig.3. Jejuno-illeal intussucepted portion (purple-red colour) of intestion with distension of other loops.

Centre Treatment and Discussion

Complete blood count was normal and biochemistry revealed elevated glucose, Alkaline phosphatase (ALP), hypocalcemia, hyperphospaetaemia and increased protein levels in the peritoneal fluid (Table.1). A plasma protein: fibrinogen ratio of 5.75 indicated hyperfibrinogenemia which resulted due to acute inflammation of the intestine. This finding was in accordance with the previous study (Ramprabu *et al.,* 2003) where the plasma protein: fibrinogen ratio was 4.89±0.32 (localized traumatic peritonitis) and 4.68±0.23 (diffuse traumatic peritonitis) which indicated hyperfibrinogenemia was due to inflammation, necrosis and adhesions. Hirvonen and Pyorala (1998) reported that cows with plasma protein: Fb ratio of 10:1 or less was due to dehydration caused by traumatic reticuloperitonitis. The present case had normal plasma protein with elevated fibrinogen, while the plasma protein: Fb ratio was 5.75 which clearly indicated dehydration as a result of inflammation caused by intestinal obstruction. Oehme and Noordsy (1970) opined that total protein value greater than 3 g /dl in the peritoneal fluid was considered as positive diagnosis for peritonitis with 86 % accuracy. In the present study the total protein value of peritoneal fluid of 11.8 g/dl indicated peritonitis.

Tharwat (2011) demonstrated that ultrasonography in cattle and buffaloes suspected for intestinal obstruction had practical utility to confirm or tentatively diagnose intestinal obstruction, and to plan for surgical intervention. The ultrasound findings of the intestinal obstruction in the present case were in accordance with the observations of the previous study (Braun, 2009) who observed that cattle ileus due to intussusception appeared as bowel within bowel or bull's eye lesion or target patten or multiple layers or onion ring-type with varying echogenicity.

In the present study multiple dilated (average of >3.61 cm in diameter) intestinal

loops were observed in a single window on the right mid abdominal plane which was in agreement with the findings of Mann *et.al.* (2019) who also reported that presence of multiple dilated intestinal loops in a single scanning area and opined that it was a prominent ultrasound finding in intestinal intussusception.

Post-surgically the cow was administered with Inj. Streptopenicillin 5g IM (3 days), Inj. 5 % Dextrose fluid (5 Liters BID), Inj. Flunixin meglumine 1 mg per kg IM, Inj. Chlorpheneramine maleate 0.5 mg per kg IM, Inj. Vit.B_1, B_2, B_3 10ml IM for 5 days. The animal had uneventful recovery without any complications and restoration of normal appetite.

Table-1. Haematology and Serum biochemistry of cow with intussusception

Parameter	Intussusception cow	Reference value (Radostits*et al* 2010)
Hb (g/dl)	10.4	8-15
PCV (%)	47	24-46
RBC (mil/cmm)	5.4	5-10
WBC (/cmm)	6389	4000-12000
Neutrophils (%)	42	15-45
Lymphocytes (%)	55	45-75
Monocytes (%)	2	2-7
Eosinophils (%)	1	2-20
Basophils (%)	0	0-2
Total protein (g/dl) in serum	6.3	6-8
Total protein (g/dl) in plasma	6.9	6.5 -7.5*
Albumin (g /dl)	2.60	2.8-3.9
Globulin (g/dl)	3.70	3.0-3.5*
Albumin: globulin ratio	0.70	0.84-0.94*
Aspartate amino transferase (U/L)	72	45-110
Alkaline phosphatase (U/L)	767	0-500
Alanine transaminase (U/L)	56	30
Blood Urea Nitrogen mg /dl	22	7.8-24.6
Creatinine (mg /dl)	1.81	0.6-1.8
Calcium (mg/dl)	6.8	9-12
Phosphorus (mg/dl)	9.44	5.5-6.5
Fibrinogen (g /dl)	12	3.0-7.0
Plasma Protein:Fibrinogen	5.75	10 - 37*
Total protein in peritoneal effusion (g/dl)	11.8	3.06**
* Reference values from literature of (Hirvonen and Pyorala, 1998; ** Wilson *et al.,* 1985)		

Transabdominal ultrasonography along with per rectal manual positioning of the palpable mass in the abdominal cavity could be a valuable diagnostic tool in cows with intestinal obstruction.

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Ultrasound guided transvaginal follicular aspiration technique for chronic follicular cyst in a Holstein Friesian crossbred cow

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ABSTRACT

A ten-year-old pluriparous crossbred cow with the history of prolonged estrus signs was presented to the Madras Veterinary College Teaching Hospital. Per rectal examination revealed follicular cyst in the right ovary. On real-time ultrasonography, a large anechoic follicle and multiple follicles were visualized in the right and left ovary, respectively. The case was diagnosed as Cystic Ovarian Degeneration due to follicular cyst and treated with 20µg-GnRH intramuscularly. Re-examination after 10 days revealed persisted cyst on right ovary and even after second GnRH, the condition persisted. Further, the cow was treated with PGF2α @ 500µg intramuscularly but cysts the persisted. Then, the cyst was punctured and follicular fluid aspirated through ultrasound guided transvaginal probe with a needle and about 12 ml of follicular fluid was recovered but the cyst recurred again. Hence, from the study it was concluded that the case was non-responsive for either hormonal therapy or ultrasound guided transvaginal follicular aspiration which might be due to its chronic, secretory nature and thus the prognosis remains poor.

Key Words: Chronic Follicular cyst, Ultrasonography, Transvaginal follicular aspiration.

Cystic ovarian disease (COD) is a major cause of reproductive failure and it is characterized by the presence of large, persistent, anovulatory follicles in the ovaries due to malfunction of the neuroendocrine mechanism controlling ovulation and thus, interferes with the cyclicity. Ovarian Cyst was previously defined as enlarged anovulatory follicle like (<2.5 cm) and persisting for 10 or more days but currently defined as cystic follicular structures of at least 17 mm diameter that persist for more than 6 days in the absence of corpus luteum (Jeengar *et al.,* 2014). The diameter of the

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cyst may vary and reach up to 25 mm or larger (Youngquist and Threlfall, 2007). In most cases (62-85%), cows with luteinized cysts remain anoestrous (Watson and Cliff, 1997) as a result of the production of progesterone by the luteinized cysts.

The adverse effects of COD on fertility are related to increased intervals between calving and first service, and between calving and conception. The treatment of cystic ovary involves use of GnRH, hCG and progesterone but with variable outcomes (Honparkhe *et al.*, 2011; Singh *et al.,* 2012). Alternatively, puncturing the cyst and emptying of the cystic fluid may be advantageous in such cases (Cairoli *et al.*, 2002). In this regard, transvaginal-guided needle aspiration (Lievaart *et al.*, 2006) or transvaginal ultrasound guided physical ablation (Amiridis, 2009) of ovarian cysts have been considered safe as compared to manual rupture of cyst during trans-rectal palpation. Hence, the ultrasound guided follicular aspiration technique was attempted to correct this chronic follicular cystic condition.

Case history and clinical observations

A ten-year-old Holstein Friesian crossbred pluriparous cow was presented to Large Animal out-patient Gynaecology ward, Madras Veterinary College Teaching Hospital, Chennai-600 007 with the history of one calving a year before. The cow was artificially inseminated four times, bred to natural service on two ocssions, but the cow was exhibiting prolonged estrus signs and nymphomania for the past 3 months. On physical examination, all vital parameters were found to be normal. Per rectal examination revealed normal cervix and uterus but the right ovary has a large lemon sized fluctuating cyst with few follicles in the left ovary with absence of corpus luteum. On real-time ultrasonography, a large anechoic follicle with more than 32 mm diameter on an average (Fig.1) and three follicles of size 12.8 mm, 4.4 mm and 4 mm on an average (Fig.2) were visualized in the right and the left ovary, respectively (Table 1) . Based on the observations of rectal examination and ultrasonography, the case was diagnosed as Cystic Ovarian Degeneration with a follicular cyst.

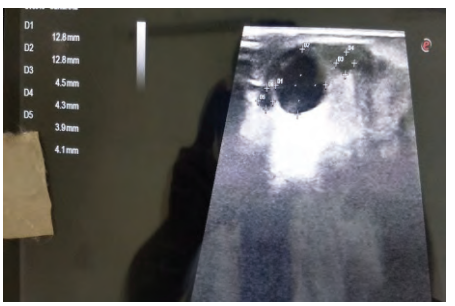

Fig.1: A large anechoic follicle with more than 32 mm average diameter in right ovary

Fig.2: Three follicles ranging from 4-13 mm in left ovary

Fig. 3a, 3b: Ultrasound guided Transvaginal probe connected with needle (Esoate, Italy)

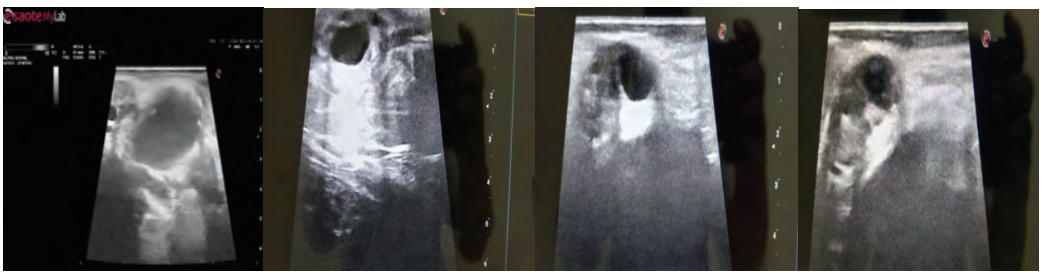

Fig. 5a, 5b, 5c, 5d: U/S images showing reducing size of cyst during aspiration

Treatment and discussion

The cow was treated with GnRH (Buserelin acetate) @ dose rate of 20µg intramuscularly on day 0 (Table 2) . Re-examination on 10th day revealed the persistence of the cyst on the right ovary pressure of CL in the left ovary. On ultrasonography examination it was found that and CL on left ovary, even after second GnRH treatment, the cyste condition persisted on day 20 with mild thickening of follicular wall of about 3.2 mm in the right ovary. Further, PGF2α @ dose rate of 500µg (Cloprostenol sodium) was administered intramuscularly on day 20 and ultrasonograhic examination on day 30 revealed persisted cystic follicle on the right ovary and cyst or the CL in this left ovary. Hence, the cystic follicle was punctured by aspiration (Fig.5a, 5b, 5c, 5d) through ultrasound guided transvaginal probe connected with a needle (Esoate, Italy) (Fig.3a, 3b) and around 12 ml of follicular fluid was aspirated (Fig.4). However, examination on day 40 revealed the recurrence of the follicular cyst.

Follicular cysts are most commonly treated with GnRH, which causes secretion of luteinizing hormone (LH) and luteinization of the cyst. This in turn makes the cyst sensitive to PGF2α, and regression of the cyst can then be brought about 8-9 days later with exogenous PGF2α (Brito and Palmer, 2004). In the present case, the attempt was made to bring about ovulation of the follicle by intramuscular injection of GnRH. But, only the follicles on the left ovary responded, while the cyst on the right ovary persisted. The cyst on the right ovary did not undergo luteinization despite a second injection of GnRH and CL formed only on the left ovary responsed to the

prostaglandin treatment. Many variables such as time of diagnosis, period of Ovarian cyst persistence, presence of mucometra and milk production determine the outcome of therapy (Purohit, 2008). Removal of the cyst will destroy the estrogen source, promoting new follicular development and ovulation (Amiridis, 2009). Hence the follicular cyst ablation technique was attempted in the present case, but it recurred due to its chronicity and secretory nature.

It was concluded that the cystic follicle not responsive to either hormonal therapy or ultrasound guided transvaginal follicular aspiration which might be due to its chronic, secretory nature and thus the prognosis remained poor. However, ultrasound guided transvaginal follicular aspiration technique can be tied in early cyst condition and to avoid repeated hormonal therapies in cows.

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