Full Length Articles

MORPHOLOGICAL AND MORPHOMETRIC STUDIES ON THE PELVIC GIRDLE OF CHINESE GOOSE (*ANSER CYGNOIDES*)

O.R. Sathyamoorthy*[1], R. Richard Chruchil[2] and S. Dhamotharan[3]

Department of Veterinary Anatomy
Madras Veterinary College
Tamil Nadu Veterinary and Animal Sciences University
Chennai, Tamil Nadu, India

ABSTRACT

The pelvic girdle of Chinese goose was a large, elongated bone, narrow cranially (3.0 cm) and wide (8.0 cm) caudally. It consisted of two os coxae, each of which was made up of an ilium, an ischium and a pubis. The ilium of the Chinese goose was the largest and longest (14 cm) bone of the os coxae. The pre-acetabular part of the ilium was 6.80 cm long and 2.0 cm wide. The post-acetabular part of ilium was 7.2 cm long. The ilioneural canal was slightly broad in front and narrow caudally.The pelvic surface of ilium showed six openings on either side of the bodies of the lumbosacral mass. The ischiatic foramen was 3.60 cm long and 1.20 cm wide. The ischium was triangular in shape and 7.50 cm long. The caudal border of the pelvis was wide (7.50 cm) and showed a deep notch. The pubis was long (12.0cm), thin, bent rod-like bone, projected well beyond the caudal border of the os coxae and bent medially. The pectineal process was short and rounded. Pneumatic foramina were absent in the os coxae of the Chinese goose. The acetabulum was large and formed by all the three bones. The anti-trochanter was quadrilateral in shape and prominent.

Key words: os coxae, pelvic girdle, ilium, ischium, pubis

INTRODUCTION

The Chinese geese are the most graceful and beautiful member of the goose family and referred to as ‘swan geese’ or ‘weeder geese’. They are identified by the knob at the base of its beak. There are two varieties of Chinese geese, brown and white. The white variety has blue eyes, pure white plumage, and bright orange feet, knobs and bills. Sexes are similar but the males have larger knob at base of bill (Holderread, 1981). The pelvic girdle of the birds is related to their bipedal standing posture because their hind limbs are only structure for support and walking. Hence, they require a solid connection between the pelvis and the vertebral column but also maximum area for the insertion of the muscles which bear the bulk of the body weight. At the same time the ventrally open pelvis forms a dorsal, roof-like covering for

* Corresponding author, Email: drsathya1971@gmail.com
[1] Professor
[2]Professor, Directorate of Research, Tamil Nadu Veterinary and Animal Sciences University, Chennai - 51
[3]M.V.Sc Scholar, Department of Poultry Science

a large part of the body cavity and the organs contained in them (Nickel *et al*., 1977).

The present study was undertaken because the anatomical information available on this bird was scanty.

MATERIALS AND METHODS

The carcasses of three Chinese geese were utilised for the present study. After the post-mortem examination the carcasses were allowed for biological maceration. The disintegrated skeleton was cleaned with fresh water and soaked in 10-15% NaHCO3 solution for whitening. Then the skeleton was dried and morphological and morphometric studies were performed by using vernier caliper and ruler.

RESULTS AND DISCUSSION

The pelvic girdle of Chinese goose was a large, elongated bone, narrow cranially (3.0 cm) and wide (8.0cm) caudally. It consisted of two equal bones, and was made up of an ilium, an ischium and a pubis (Fig.1), as reported by Nickel *et al.* (1977) in birds.

The ilium was a thin, long plate of bone, the ischium was comparatively thick plate and the pubis was a slender rod–like bone. The space between the pelvic bones was occupied by lumbosacral mass (Fig.1) as reported by McLelland (1990) in fowl.

The ilium of the Chinese goose was the largest and longest (14 cm) bone of the os coxae. It had a pre-acetabular and a post-acetabular part. The pre-acetabular part was 6.80 cm long, 2.0 cm wide and concave in its length. The post-acetabular part was 7.2 cm long and 1.0 cm wide in the cranial half and 1.50 cm wide in the caudal half (Fig.3). It is in agreement with the observations of Barvalia and Panchal (2019) in emu. In contrary, in cattle egret the pre-acetabular part was longer and post-acetabular part was short and broad (Rezk, 2015), and in crested serpent eagle and brown wood owl the pre-acetabular part was much longer than the post-acetabular part (Keneisenuo *et al.,* 2019).

In the present study, the pre-acetabular part was quadrilateral in shape, its gluteal surface was concave, vertical in the dorsal two-thirds and dorsally facing in the ventral one-third (Fig.3). In emu, the ilium was lying vertical to the long axis of the body (Santhilakshmi *et al.,* 2007).

The cranial border of the ilium was narrow, slightly convex, and triangular in shape and projected cranially.It formed the cranial iliac crest (Fig.3). In emu the cranial border of the ilium was notched at the middle and projected laterally (Barvalia and Panchal, 2019).

The dorsal border was convex and fused with the dorsal ends of the lumbosacral mass completely and formed a bony bridge.The dorsal borders formed the dorsal iliac crests. The dorsal iliac crest was less prominent and present on either side of the dorsal median ridge and extended from the cranial border up to the caudal border of the acetabulum. Caudally above the level of acetabulum it was thick (Fig.3) as observed by Mehta *et al.* (2013) in coturnix quail. Sreeranjini *et al*. (2011) noticed that in peahen, this ridge extended up to its posterior extremity. But in emu, there was no line of demarcation between the pre and post-acetabular parts (Barvalia and Panchal, 2019).

The lateral borders were thin and slightly convex cranially but became thick and rounded and concave near the acetabulum and formed the cranial acetabular rim and also joined with the cranial border of the pectineal process (Fig.3). In peahen the lateral border of the pre-acetabular part of ilium was highly concave and thin (Sreeranjini *et al*., 2011).

The pelvic surface of the pre-acetabular part of the ilium was fused with the spines and transverse processes of the lumbosacral mass, enclosing a space in between, the ilioneural canal (Fig.2). The ilioneural canal was slightly broad in front and became narrow caudally. It is in agreement with the findings of Fitzgerald (1969) in couturnix quail, Nickel *et al*. (1977) in chicken and Lavanya *et al.* (2017) in guinea fowl. In contrary in pigeon (Lavanya *et al*., 2017) and in peahen (Sreeranjini *et al*., 2011) the cranial one third of the dorsal border of the ilium did not fuse with the lumbosacral spines and hence the ilioneural canal was not formed.

The pelvic surface showed six openings on either side of the bodies of the lumbosacral mass for the exit of the spinal nerves (Fig.2). Four large foramina were noticed in Indian eagle owl (Sarma *et al*., 2018) and in brown wood owl (Keneisenuo *et al*., 2019) and five foramina were noticed in crested serpent eagle (Keneisenuo *et al*., 2019).

Caudally about the level of acetabulum the pelvic surface showed a deep depression, the renal fossa, which was oval in shape (Fig.2). It is in accordance with the observations of Rezk (2015) in cattle egret and Sarma *et al*. (2018) in Indian eagle owl. In contrary, in emu (Mehta *et al.,* 2013) and in bar-headed goose (Sasan *et al.,* 2017), no renal fossa was present.

In Chinese goose, the post-acetabular part of the ilium was quadrilateral in shape, long (7.2 cm), narrow (1.0 cm) cranially up to the level of the caudal end of the ischiatic foramen and wide caudally (1.5cm) and sloping downwards and placed more or less vertically (Fig.3). It is in agreement with the observations of Nickel *et al*. (1977) in duck and goose. Barvalia and Panchal (2019) reported that in emu the post-acetabular part was prismatic, narrower but longer than the pre-acetabular part. In coturnix quail (Fitzgerald, 1969) and in Indian eagle owl (Sarma *et al.*, 2018) the post-acetabular part was narrow and faced dorsally. Whereas in peahen, the pre-acetabular part was longer and wider than the post-acetabular part (Sreeranjini *et al.,* 2011).

The dorsal border of the post-acetabular part of the ilium was thick and fused with the lateral edges of the transverse processes of the lumbosacral mass in the cranial one third but thereafter a gap was present between the two which widened gradually towards the caudal end (Fig.1). In contrary, in peahen, only the caudal two-thirds of medial border united with the transverse process of synsacrum (Sreeranjini *et al*., 2011). Nickel *et al.* (1977) observed that, in fowl and pigeon they joined syndesmotically.

The post-acetabular parts of the ilium were separated by the transverse processes of the lumbosacral vertebra. They were widely separated about the level of the acetabulum, thereafter the width of the transverse processes gradually reduced so the gap between the dorsal borders of the ilia reduced gradually up to the level of the caudal end of the ischiatic foramen, thereafter they were placed more or less parallelly (Fig.1).

The ventral free border of the post-acetabular part of the ilium from behind the anti-trochanter was thin and enclosed along with the dorsal border of the ischium a large, elongated, oval opening, the ischiatic foramen (Fig.3), as reported by Nickel *et al*. (1977) in fowl. The ischiatic foramen was 3.60 cm long and 1.20 cm wide in Chinese goose. In peahen the ischiatic foramen was oval in shape and was 2.30cm long and 1.30 cm wide (Sreeranjini *et al*., 2011). McLelland (1990) reported that this foramen transmits the ischiatic nerves in birds. In emu, the ischium and ilium were separated and had the ilio-ischiatic incisure, rather than a foramen (Kumar and Singh, 2014).

Behind the ischiatic foramen the ilium and ischium were fused (Fig.3). The pelvic surface of the post-acetabular part of the ilium showed a long, narrow, shallow depression extended up to the level of the caudal border of the ischiatic foramen, the renal fossa (Fig.2). It is in accordance with the observations of Rezk (2015) in cattle egret, Sarma *et al*. (2018) in Indian eagle owl and Keneisenuo *et al*. (2019) in crested serpent eagle and brown wood owl. In contrary, in emu (Mehta *et al.,* 2013) and in bar-headed goose (Sasan *et al.,* 2017), no renal fossa was present.

The lateral surface of the post-acetabular part of the ilium was smooth, slightly convex in the cranial free part but concave in the caudal broad part. The caudal border of the ilium was concave and broad, its caudodorsal end was blunt and rounded and the caudoventral end showed a pointed projection extending downwards and backwards. This pointed projection looked similar to the caudal process of other birds (Fig.1).The caudal end of the ilium in fowl and pigeon (Nickel *et al.*, 1977), spot - billed pelicans (Sathyamoorthy *et al.*, 2012) and in guinea fowl (Lavanya *et al.,* 2017) showed a distinct and dorsally projected caudal process. But the caudal process was not very distinct in peahen (Sreeranjini *et al*., 2011).

In the Chinese goose, the median crest formed by the fused spinous process of the synsacrum and it was present cranially, but absent at the level of acetabulum and in the caudal one third it was present (Fig.1). Lavanya *et al*. (2017) observed that, in pigeon, the bony ridge was present throughout the length of the lumbosacral mass whereas in guinea fowl, the bony ridge formed by the spines of synsacrum was noticed only in the anterior part and caudally it was seen as a narrow groove.

The os coxae of the Chinese goose did not show pneumatic foramina. It is in agreement with the findings of Hogg (1984), who found that there was a very low incidence of pneumatisation in the os coxae of domestic fowl. In contrary, Sreeranjini *et* *al.* (2011) informed that the pelvic girdle of peahen present large number of air cavities.

The ischium of the Chinese goose was triangular, elongated plate of bone, narrow cranially and broad caudally. It was 7.50 cm long, 0.70 cm wide behind the acetabulum and 2.20cm wide at the caudal end. It extended from the acetabulum to the caudal border of the os coxae. Its cranial part involved in the formation of caudal rim of acetabulum (Fig.3), as observed by Nickel *et al*. (1977) in birds. It was placed in a slanting position and extended laterally. The caudoventral angle of the ischium presented a broad plate like projection, the angulus ischiadicus which joined syndesmotically with the dorsal border of the pubis (Fig.3). It is in accordance with the observations of Nickel *et al*. (1977) in duck and goose. But in peahen the angulus ischiadicus was blunt and did not fuse with the pubis (Sreeranjini *et al.,* 2011).

The lateral surface of the ischium was slightly concave in the cranial half and slightly convex in the caudal half. Its medial surface showed a thick, rounded ridge throughout the length (Fig.2). The dorsal free border in the cranial half formed the ventral boundary of the ischiatic foramen. The ventral border of the ischium was thin and sharp. It showed a small, smooth area immediately behind the acetabulum, behind this it showed a small bony ridge and later it was continued by the long thin slightly concave ventral border of the ischium. Between it and the dorsal border of the pubis it enclosed a large ischio-pubic incisure and posteriorly closed by the junction between the angulus ischiadicus and the pubis. The ischio-pubic incisures was 7.0 cm long and 1.0 cm wide at the centre (Fig.3). It is in accordance with the observations of Nickel *et al*. (1977) in duck and goose, the pubo-ischiatic incisure was not divided but remained as a narrow elongated oval incision. In contrary in fowl (Nickel *et al*., 1977), guinea fowl and pigeon (Lavanya *et al*., 2017) and Indian eagle owl (Sarma *et al*., 2018) the ischio-pubic incisure was divided into an obturator foramen in front and an incisure behind. Deshmukh *et al*., (2016) reported that in pea fowl, the angulus ischiadicus, the ventral end of the caudal border of the ischium was blunt and did not fuse with the pubis. McLelland (1990) reported that the ischiatic foramen transmitted the ischiatic nerves in birds. In emu, the ischium and ilium were separated and had the ilio-ischiatic incisure, rather than a foramen (Kumar and Singh, 2014).

The caudal border of the pelvis was formed by the caudal borders of ilium and the ischium. The caudal border was very wide (7.50cm) and shallow (3.0cm height) because of the deviation of the caudal part of the ilium and ischium laterally. The caudal border presented a deep notch between the ilium and ischium (Fig.1), as reported by Nickel *et al*. (1977) in goose. In duck only a small notch was present (Nickel *et al*., 1977). Kumar and Singh (2014) reported that in emu, the posterior extremity of the os coxae was interrupted due to non-continuation of all the three bones.

In the present study, the pubis was long (12.0cm), thin, bent rod-like bone which followed the ventral border of the ischium and projected well beyond the caudal border of the os coxae and bent medially. It was thin cranially in the cranial one third, slightly thicker in the middle one third and formed a syndesmotic junction with the plate- like angulus ischiadicus and in the caudal one third free part its width increased and at the caudal end it ended in a shovel-like process which curved medially (Fig.3). It is in total agreement with the observations of Nickel *et al*. (1977) in duck and goose. Mehta *et al.* (2014) reported that, in Japanese quail the pubis did not project beyond the ilium and ischium. In Indian eagle owl the caudal end of the pubis was bent medially to meet with its fellow of opposite side (Sarma *et al*., 2018).

In Chinese goose the dorsal border of the pubis was concave cranially and convex caudally from the junction with the angulusischiadicus (Fig.3). Accordingly in ostrich (Tamilselvan *et al*., 2015) the pubis was a long slender bone, dorsally concave in front and convex behind. Its caudal extremity extended beyond the ilium and ischium and bent medially and formed pubic symphysis. The pubic symphysis supported the weight of the abdomen. The caudal one third of pubis also fused dorsally with the ischium.

The cranial end of pubis participated in the formation of acetabulum (Fig.3) as reported by Nickel *et al.*(1977) in pigeon and goose, but in fowl and duck it was fused with the ischium below the acetabulum.

In Chinese goose, the pectineal process was short and rounded in the Chinese goose (Fig.3). Nickel *et al.* (1977) reported that the pectineal process was long thorn-like in the fowl, absent in pigeon, and rudimentary in duck and goose. The pectineal process was rudimentary in peahen (Sreeranjini *et al.*, 2011), absent in Japanese quail (Mehta *et al.,* 2014), Indian eagle owl (Sarma *et al.,* 2018), and spot-billed pelicans (Sathyamoorthy *et al.,* 2012). Kumar and Singh (2014) reported that, in emu the pectineal process was slightly broader towards the cranial extremity of pubis to participate in the formation of acetabulum. He also informed that, under development of this process might lead to paralysis of hind limb.

In the present study, the acetabulum was formed by ilium, ischium and pubis as observed by Sathyamoorthy *et al.* (2019) in blue and yellow macaw. It was circular, large (1.0cm diameter) and perforated (Fig.3) Nickel *et al.* (1977) reported that, in fowl and duck, the pubis was not involved in the formation of acetabulum.

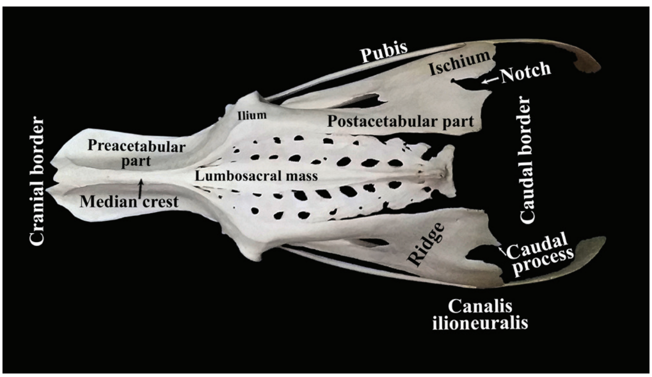

Fig. 1 Pelvic girdle of Chinese goose – dorsal view

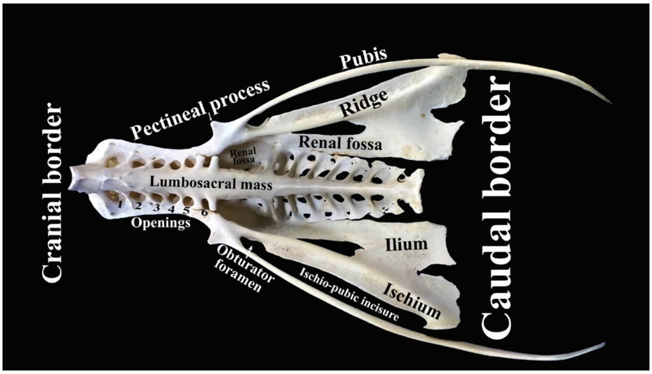

Fig. 2 Pelvic girdle of Chinese goose – ventral view

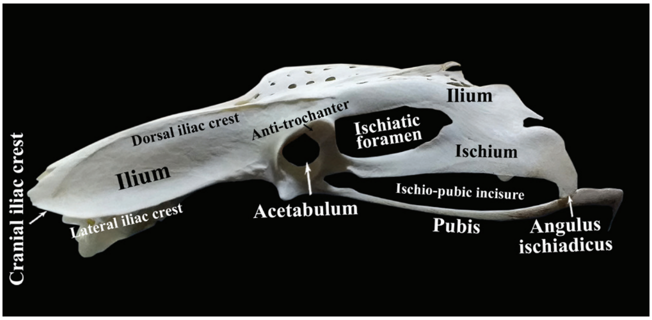

Fig. 3 Pelvic girdle of Chinese goose – Lateral view

The floor of the acetabular rim was broad, but the cranial and caudal parts of the rim were narrow. Caudodorsal rim of the acetabulum showed a bony prominence measured 0.9 cm long, with thick edges and carried a concave, elongated, quadrilateral shaped facet with rounded dorsal border and a straight ventral border, projecting dorsolaterally, the anti-trochanter (Fig.3) as observed by Rezk (2015) in cattle egret and Sarma *et al*. (2018) in Indian eagle owl. McLelland (1990) reported that, the anti-trochanter femur articulation reinforces weak adductor muscles and limits abduction of the limb. Hertel and Campbell (2007) found that, in birds, the anti-trochanter serves as a brace to prevent abduction of the hind limb and to absorb stress that would otherwise be placed on the head of the femur during bipedal locomotion.

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