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Gross anatomical studies on thoracic, Synsacrum, coccygeal vertebrae and ribs of emu (*Dromaius novaehollandiae*)

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Abstract
Thoracic vertebrae were nine in number showed they were freely movable, except that the last two showed fused with each other. There was a gradual increase in its length of the body from first to last after which the length reduced. The dorsal spinous process was plate like. The ventral spinous was well developed in the first two. The transverse process were broad plate like with their lateral borders beared the fovea costales transversalis which is articulated with tuberculum costae of its corresponding rib. The lumbosacral mass was formed by last two fused thoracic, six lumbar, tenth sacral and first coccygeal vertebrae. the dorsal and ventral scaral foramina were nine in number. The transverse process of the last two thoracic, lumbar and sacrum were fused with the medial surface of ilium coccygeal vertebrae were five in number of which the last three were fused and the last coccygeal vertebrae was boat shaped. The ribs were ten pairs. The first, second, third, ninth and tenth were floating ribs. The fourth, fifth, sixth and seventh and eighth were true ribs with a vertebral and a sternal.

Keywords: Gross anatomical, Synsacrum, coccygeal, *Dromaius novaehollandiae*

Introduction
The rigidity of the backbone of birds is due to the fact that most of the vertebrae are fused. The rigidity furnishes support to the back and wings during its flight and enables to maintain an upright posture during standing. More over the fusion between cervical and thoracic vertebrae helps the birds to keep their trunk stiff. The fused lumbosacrum and fusion between bones of the pelvic girdle forms a light but strong plate which rests on the femur supporting the bird in its standing posture. The backbone terminates in the pygostyle which provides support to the tail feather. The present study on the gross morphological features of the of thoracic, synsacrum, coccygeal vertebrae and ribs of emu was undertaken as studies dealing in the above context is scarce

Materials and Methods
The present study was conducted on three adult emu birds brought for post morterm to the department of veterinary pathology at Rajiv Gandhi Institute of Veterinary Education and Research, Puducherry. Bones were collected was collected by the regular process of maceration, cleaned, dried and the various gross anatomical features were recorded

Results and Discussion
Thoracic vertebrae
They were ten in number (Fig 1) while Kumar and Singh (2014) [2] in emu had reported only nine thoracic vertebrae in emu. According to Nickel *et al.*, 1977 [3] they were seven in fowl and Pegion and 9 in duck and goose. McLelland (1990) [1] stated in chicken that the last cervical vertebrae and the first three thoracic vertebrae fused and formed the Notarium,

1. First thoracic vertebrae 2. Second thoracic vertebrae 3. Third thoracic vertebrae 4. Fourth thoracic vertebrae S. Fifth thoracic vertebrae 6. Sixth thoracic vertebrae 7. Seventh thoracic vertebrae 8. Eighth thoracic vertebrae 9. Ninth thoracic vertebrae 10. Tenth thoracic vertebrae

Fig 1: Lateral View of Thoracic Vertebrae

In the present study the last cervical was not fused with first thoracic and the articulations between the thoracic vertebrae were freely movable which is similar to the findings in duck and goose by McLelland (1990) [1]. But the present also showed the fusion between last two thoracic vertebrae. There was a gradually increase in the length of the body from 1st to 7th thoracic vertebrae and the length reduced in the caudal series.

The ventral spinous process (Fig 2) of the 1st thoracic vertebrae was bifid and that of the 2nd was united and tuberculate. According to Kumar and Singh (2014) [2] in emu had observed that the first two thoracic vertebrae had well developed ventral spinous process.

1. Lint Thoracic Vertebrae
2. Second Thoracic Vertebrae
3. Third Thoracic Vertebrae
4. Fourth Thoracic Vertebrae
S. Fifth Thoncic Vertebrae

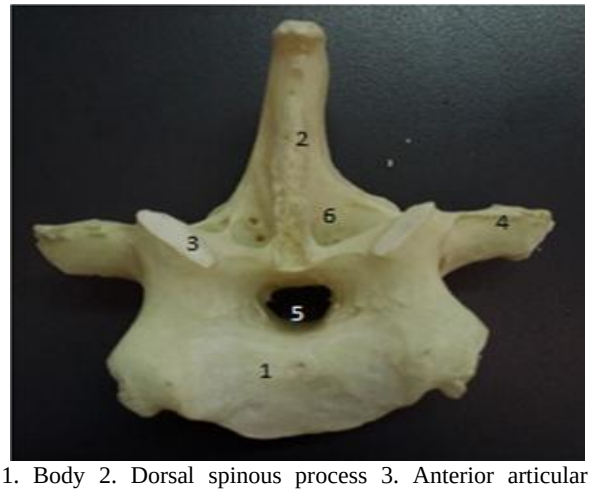
Fig 2: Ventral View of Ventral Spinout Process of Thoracic Vertebrae

The 3rd had a low plate like spine and that of the 4th and 5th had a high broad sharp spine. On the 6th, 7th, and 8th thoracic vertebrae it was in the form of a faint crest, but was absent in the 9th and 10th thoracic vertebrae. The dorsal spinous process (Fig 3) was plate like similar finding by Kumar and Singh (2014) [2] in emu and gradually increased in height and broadened towards the caudal series. The spine of the last thoracic vertebrae showed the maxiumum height. The spine of 8th, 9th and 10th showed forward inclination.

I. Facet for bead of the rib 2. Fos', costal. traversal's 3. Dorsal spinets Process 1. Vtotral spinet's process 5.Aeterior articular process 6. Posterior articular process

Fig 3: Lateral in of Tboratie Vertebrae

The transverse processes were broad plate like and increased in width from the 1st to 3rd those of the 4th, 5th and 6th were larger in width and further in the caudal series they were of the same width. The root of the transervese processes were pierced by the anterior and posterior openings of foramen transversarium. The lateral borders of transervese processes bearded a groove, the fovea costales transversalis which articulated with the tuberculum costae of its corresponding rib. Similar observation were made in domestic birds by Nickel *et al.*, 1977 [3] According to Kumar and Singh (2014) [2] in emu reported that the transverse proceses of 4th to 7th thoracic vertebrae possessed additional facets for articulation with ribs. The lateral surface of the vertebral body articulated with head of the ribs. The anterior articular process of the 1st thoracic vertebrae were dorso medially placed similar to cervical vertebrae. In the 1st, 2nd and 3rd they were placed dorsolaterally. From the 4th onwards they again showed a dorsomedial position. The anterior articular process were oval, showed a downward inclination and were slightly concave transversely. The posterior articular process were oval and convex. Kumar and Singh (2014) [2] in emu observed the caudal articular facets were slightly convex and less deep than cranial articular process. Between the anterior articular process and dorsal spinous process on either sides there was a pocket like fossa which gradually deepended in the caudal series and also showed numerous foramen.



1. Body 2. Dorsal spinous process 3. Anterior articular process 4. Transverse process 5. Vertebral foramina 6. Fossa

Fig 4: Dorsal View of Tenth Thoracic Vertebrae

1. Body 2. Dorsal Spinous processes 3. Posterior articular process 4. Transverse process 5. Vertebral foramina 6. Fossa 7. Fovea Costal transverse

Fig 5: Posterior View of Tenth Thoracic Vertebrae

The intervertebral foramen formed connection with the vertebral canal. According to Nickel *et al.*, 1977 [3] in the duck the last two rib bearing thoracic vertebrae and in goose the last three formed a bony union with synsacrum, while in fowl and pigeon the 2nd to 5th were fused into a bony column, the sixth was free and 7th was fused to the synsacrum

1. Body 2. Dorsal Spinous process 3. Posterior articular processes 4. Transverse process 6. Anterior articular process 7. Fossa 8. Fovea Costal transverse S. Anterior opening of foramen transversarium 9. Posterior opening of foramen transversarium. 10. Articular facet for head of the rib

Fig 6: Lateral View of Tenth Thoracic Vertebrae

RIBS

There were 10 pairs of ribs of which 1st, 2nd, 3rd, 9th and 10th were floating ribs. Then 4th, 5th, 6th, 7th and 8th ribs were true ribs which had a vertebral and a sternal part (Fig 7) whereas Kumar and Singh (2014) [2] in emu observed that 9 pairs of ribs in emu of which1,2,3,8 and 9 were floating ribs and 4th to 7th were complete with vertebral and sternal portions. According to Nickel *et al.*, 1977 [3] fowls and pigeons had 7, duck and geese had 9 pairs of ribs. Each of the vertebral portion had a shaft/body and two extermities. The shaft was flat curved laterally and had two surfaces lateral was convex, medial concave surface and 2 borders cranial and caudal which were thin and thick respectively. The uncinate processes were absent in any of the true ribs similar findings were reported by Kumar and Singh (2014) [2] in emu while Nickel *et al.*, 1977 [3] observed a flat processus uncinatus in domestic birds. Proximal extremity had a head, neck and tubercle. The head presented a small transversely concave facet which articulated with the costal facet on the lateral aspect of the body of thoracic vertebrae and neck was short, distinctly concave while in fowl nickel *et al* observed long necked head. The tubercle showed a gradual increase in width from 4th to 8th vertebral rib. Nickel *et al.*, 1977 [3] had observed tuberculum costae as a short protuberance. The tubercles were placed at a higher level than the heads of the vertebral rib and articulated with fovea costales transversalis of the tranverse processes whose facet was also concave. There was a pneumatic foramen at the junction between the head and tubercle similar finding Kumar and Singh (2014) [2] in emu. Each vertebral rib articulated with its corresponding thoracic vertebra similar observations by Nickel *et al.*, 1977 [3].

1. Head 2. Neck 3. Tubercle 4. Vertebral end 5. Sternal end 6. Shaft

Fig 7: Lateral View of Ribs

1. First rib 2. Second rib 3. Third rib

Fig 8: Lateral View of Floating Ribs

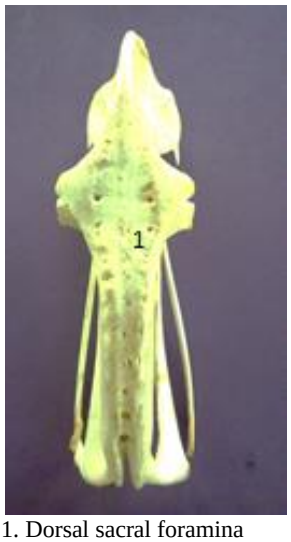
The distal extremity was narrow, thicker and had a facet which articulated with the corresponding facet of the sternal part similar observations by Kumar and Singh (2014) [2] in emu. The sternal part of the true ribs were thick, rounded slender bodies which showed a backward inclination and progressively increased in the length from 4th to 8th ribs. According to Nickel *et al.*, 1977 [3] they was a gradual increased in length of the rod like sternal costal bones from first to last The distal extremities of the 4th and 5th were more expanded than the others. The distal extremity of the sternal part presented pneumatic foramina. The bodies of the sternal part showed a vascular groove close to cranial border. Similar observations by Kumar and Singh (2014) [2] in emu. The floating ribs (Fig 8) were 1st, 2nd, 9th and 10th small triangular with a broad proximal extremity while distal extremity was thick, narrow and pointed the neck was absent. The vertebral portion of 3rd rib resembled that of the other true ribs

Lumbosacrals

The lumbosacral mass was formed by the last two fused thoracic, 6 lumbar, 10 sacral and 1st coccygeal vertebrae (Fig 9). Nickel *et al.*, 1977 [3] reported that lumbosacrum consisted of 14 to 15 vertebrae depending on the species which were fused into a bony rod the synsacrum. The transverse process of the last two thoracic, lumbar and sacrum were fused with the medial surface of the ilium. There were five ventral foramina between the transverse process of the adjacent lumbar vertebrae. The dorsal and ventral sacral foramina were 9 in number (Fig 9 and Fig 10).

1. Last Thoracic Vertebrae 2. Lumbar Vertebrae 3. Sacral Vertebrae 4. Ventral sacral Formina

Fig 9: Ventral view of pelvic girdle with fused Lumbosacrum



1. Dorsal sacral foramina

Fig 10: Dorsal view of pelvic girdle with fused lumbosacral

Coccygeal vertebrae

There were five coccygeal vertebrae in emu (Fig 11) which concurred with findings of Nickel *et al.*, 1977 [3] who reported five coccygeal vertebrae in domestic birds. The dorsal spinous process of first to fourth coccygeal vertebrae was double and transverse processes were directed downward and gradually reduced in its length and width. According to Nickel *et al.*, 1977 [3] coccygeal vertebrae had strong tranverse processes and distinct spines which were double in fowl. The duck also presented a ventral crest. The spinal canal (Fig 12) was narrowed and reached into last coccygeal vertebrae which was similar to report of Nickel *et al.*, 1977 [3]. The last three coccygeal vertebrae were fused and the last coccygeal vertebrae was boat shaped and was formed by fusion of several vertebrae. The dorsal spinous processes had fused to form a median crest with two lateral ridges on either sides of the summit of the crest. The crest was bulbous along its posterior limit. The ventral aspect of the bodies of fused vertebrae presented a median sulcus bordered by two sharp crests along its lateral aspect As per Nickel *et al.*, 1977 [3] the last member of coccygeal chain was the pyogostyle which was ploughshare resulted from fusion of variable number of individual vertebrae.

1. First coccygeal Vertebrae 2. Second coccygeal vertebrae 3. Third Coccygeal vertebrae 4. Fourth coccygeal vertebrae 5. Fifth coccygeal vertebrae

Fig 11: Ventral view of coccygeal Vertebrae

1. Dorsal Spinous process
2. Transverse process
3. Spinal canal

Fig 12: Dorsal view of coccygeal vertebrae

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