ON THE OSTEEOLOGY OF THERAPON PERCHES
(PISCES: THERAPONIDAE), THERAPON PUTA, T. JARBUA,
T. THERAPS AND PELATES QUADRILINEATUS

V. VASANTH AND P. SITA RAMI REDDY
Dept. of Zoology, Madras Christian College, Tambaram, Madras 600059.

ABSTRACT

Osteological studies on the Therapon perches Therapon puta (Cuvier, 1829),
T. jarbua (Forskal 1775), T. theraps (Cuvier 1829) and Pelates quadrilineatus
(Bloch 1790) revealed similarities and dissimilarities in both the axial and the
appendicular skeletons. The utility of comparative osteology in the taxonomy of
Therapon perches is discussed.

INTRODUCTION

The therapon fishes are otherwise known as the 'therapon perches' or
'gruners' (Munro 1955) or 'tiger perches' (Nelson 1976). They belong to the
Theraponidae (Weber and de Beaufort 1931, Munro 1955, Qureshi 1955, Nel­
son 1976). These are distributed in the Indian and the Western Pacific oceans,
from the Red Sea and east coast of Africa and Madagascar to the Pacific Islands,
some entering freshwater (Weber and de Beaufort 1931). Investigations on the
therapon perches of Indian waters are very meagre, being restricted to Prabhu

If the diagnostic features of the different stages of therapon perches were
well defined, it would be useful in identifying them in the brackishwater fish
ponds, where they are usually a menace. The present study is an attempt at
identifying the four common species, Therapon puta, T. jarbua, T. theraps
and Pelates quadrilineatus, based on the osteological features.

MATERIAL AND METHODS

A total of 12 specimens each of the four species, viz., T. puta (96-164
mm in total length), T. jarbua (91.5-194 mm in T.L.), T. theraps (139-144.5
mm in T.L.) and P. quadrilineatus (87-135 mm in T.L.) were collected from
Seidapat and Tambaram fish markets. Osteological preparations were made by
boiling them in water just enough to loosen and remove muscles from bones.
The bones of the neurocranium were carefully disarticulated. All the bones of
the neurocranium and the axial and appendicular skeletons are illustrated.
The osteological terminology employed in the present study is largely those of Gregory (1933), Ford (1937), James (1967), Collete and Chao (1975), Reddy (1977) and Vasanth and Reddy (1984).

COMPARATIVE OBSERVATIONS AND DISCUSSION

1. Neurocranium

General Features of the Neurocranium (Fig. 1; 1-4)

The shape of the neurocranium is triangular (narrower at the anterior region and broader at the posterior region). In *T. puta*, *P. quadrilineatus* and *T. theraps*, there is at the region of fusion of prefrontals with frontals a prominent constriction formed by inward curving of the frontal bone. This constriction is absent in *T. jarbua*. At the junction of ethmoid and vomer there is a depression in all the four species, which is very distinct in *T. jarbua*. In *T. puta*, the spine from the sphenotic bone is directed anteriorly whereas in the others it is directed posteriorly. In all the species except *P. quadrilineatus* there is a prominent, posteriorly directed spine on the epiotic bone. This spine is very short, in the form of a protrusion, in *P. quadrilineatus*. The posterior tip of the supraoccipital spine is pointed in *T. jarbua* whereas forked in the other three species.

Olfactory Region

The olfactory region is composed of ethmoid, prefrontal, nasal and vomer.

**Ethmoid** (Fig. 1; 5): Unpaired, median bone, forming the anterior-most part of the skull proper. The ethmoid bears a backwardly directed ventral process which fits into the anterior part of the vomer. Ethmoid is similar in structure in all the four species.

**Prefrontal** (Fig. 2; 6 and 7): Paired, fused in front with the vomer and behind with the frontals. They are also known as lateral ethmoids. At the anterior angle of the inner edge there is a spine which has a blunt tip in *T. jarbua*, whereas in the other three species the tip is pointed. In *T. jarbua* both the inner and the outer lateral margins are of the same length, whereas in the other three species the outer lateral margin extends posteriorly beyond the inner lateral margin.

**Nasal** (Fig. 2; 8 and 9): Paired, more or less triangular bones forming the roof of the nasal pit and dorsal border of the nostrils. There is a spine protruding from the antero-lateral end of the bone. In *T. jarbua* the truncated portion between the lateral margin and the anterior end is almost equal to the length of the lateral margin, whereas in the other three species this truncated portion is less than half the length of the lateral margin.

**Vomer** (Fig. 2; 10-12): Unpaired, median bone, with its anterior end slightly tapered to fit into the ventral process of the ethmoid. The posterior end is flat.

D - Dorsal view; EP - Epipotic; ETH - Ethmoid; FR - Frontal; L - Lateral view; P - Parietal; PA - Parasphenoid; PF - Prefrontal; SOC - Supraoccipital; SPH - Sphenoid; V - Ventral view.
(Contd. see Page 5)
and long, fixed into the grooves of the parasphenoid. In *P. quadrilineatus* and *T. theraps* the vomer has an enlarged anterior part and a narrow, elongated posterior part. In *T. puta* the posterior part is also enlarged but not as much as the anterior part, whereas in *T. jarbua* it is not enlarged and is of the same size at both the ends.

**Orbital Region**

The orbital region includes the alisphenoid and frontal bones.

**Alisphenoid** (Fig. 2; 13-16): Paired, flat bone; forms the posterodorsal angle of the orbit and is connected to the frontals above and to the sphenotic and the parasphenoid below. It is strengthened by ridges. In *T. puta* it is a triangular bone with an obliquely placed ridge. In *T. jarbua* it is more or less polygonal and has two ridges in the shape of ‘V’. In *P. quadrilineatus* it is rectangular with a diagonal ridge. In *T. theraps* it is semicircular and has a ridge on its outer lateral margin.

**Frontal** (Fig. 2; 17-19): Paired; covers the dorsal part of the orbit and forms the roof of the cranium; connected in front with the prefrontals, behind with parietals and supra-occipital and ventrally with the sphenotic and alisphenoid. A median ridge, dividing the bone into two, runs from the anterior to the posterior edge. On the dorso-lateral edge a small projection is present.

In *T. puta*, *P. quadrilineatus* and *T. theraps* the outer margin is concave and ends obliquely towards the posterior end with a short extension on the inner margin, where it is drawn into a pointed process. In *T. jarbua*, the concavity on the outer margin is less and continues to form a blunt end. In *T. theraps* the anterolateral angle is drawn into a spine-like projection, which is large and prominent, whereas in *T. puta* and *P. quadrilineatus* there are three spines, which are relatively less prominent. In *T. jarbua* there are three blunt projections which are not prominent.
Otic Region

The otic region consists of sphenotic, pterotic, prootic, epiotic, exoccipital, parietal and supraoccipital.

Sphenotic (Fig. 2; 20-22): Paired, anteriormost bones of the auditory capsule, connected to the frontals above, alisphenoid at the inner end and to the pterotic behind. They bear two ridges dorsally and a concavity ventrally. In \textit{T. puta} and \textit{T. jarbua} the sphenotics are similar. In \textit{P. quadrilineatus} the inner one of the two dorsal ridges is shorter than the outer, whereas in \textit{T. puta} and \textit{T. jarbua} both the ridges are of the same length. In \textit{T. theraps} the two ridges form an elevated structure of triangular shape.

Pterotic (Fig. 2; 23): Paired, hard bones with thick ridges, forming the outer wall of the auditory capsule; connected to the sphenotic and frontals in front and to the parietals and epiotic behind, and ventrally to the prootic. In each bone, both the ends are tapering and the middle portion is enlarged. This portion bears criss-cross ridges dorsally and two concavities ventrally. Pterotic is similar in all the four species.

Prootic (Fig. 2; 24): Large, paired, irregular bones, forming the anteromedian wall of the auditory capsule and having connection with the sphenotic and parasphenoid in front, basioccipital behind and pterotic above. Several ridges run along the middle region of the bone. Ventrally it bears three concavities. Prootic is similar in all the four species.

Epiotic (Fig. 2; 25 and 26): Paired bones, more or less circular in shape and constitute the greater part of the roof of the auditory capsule. Fused with parietals, pterotics, prootics and exoccipitals. From the middle region of the bone ridges arise and run posteriorly, of which the inner one rises more than the outer one. Further, the inner ridge is drawn into a posteriorly directed spine. Ventrally it bears a concavity. In \textit{P. quadrilineatus} the posteriorly directed spine is relatively reduced, whereas in the other three species its structure is as described above.

Exoccipital (Fig. 2; 27): Paired, consisting of two parts, a large wing forming the lateral wall of the cranium and a small dorsal process enclosing the foramen magnum. Exoccipitals each bears a foramen arc similar in all the four species.

Parietal (Fig. 2; 28-31): A pair of large bones, each articulating anteriorly with the frontal, laterally with the pterotic and posteriorly with the supraoccipital and the epiotic. In \textit{T. puta} the bones are irregular in shape and bear ridges running triangular, whereas in \textit{T. jarbua} they are polygonal with ridges running rectangular. In \textit{P. quadrilineatus} they are flat with anterior margins drawn in the
form of a semicircle and the posterior margins straight with a small projection on both the ends. They have ridges like thumb impressions. In *T. theraps* the bones are more or less rectangular and have diagonally placed ridges.

*Supraoccipital* (Fig. 2; 32 and 33): Unpaired, median bone; forms the roof of the cranium at the terminal part of neurocranium. It rises into an occipital crest, which is posteriorly directed and has a ridge running dorsally along the median line. It articulates with the frontals, parietals, epiotic and basioccipital. In *T. jarbua* the posterior end is forked, whereas in the other three species it is pointed.

**Basicranial Region**

The basicranial region includes the parasphenoid, basisphenoid and basioccipital bones.

*Parasphenoid* (Fig. 2; 34): Median, unpaired, cross-shaped bone, forming the floor of the neurocranium beneath the orbit and articulating anteriorly with the vomer and posteriorly with the basioccipital. It bears two lateral wings almost at the region where it is slightly bent over the sphenotics. The posterior end is forked. Anteroventrally there is a groove for articulation with the vomer. The anterior end bears a ridge in the median line. Parasphenoid is similar in all the four species.

*Basisphenoid* (Fig. 2; 35): Median, unpaired ‘Y’ shaped bone, lying between the sphenotics and prootics. Basisphenoid is similar in all the four species.

*Basioccipital* (Fig. 2; 36 and 37): Median, situated ventrally on the posterior end of the neurocranium. It bears a concavity on the posterior end for articulating with the first vertebra and is connected with the exoccipitals laterally and covered by the posterior end of the parasphenoid. Ventrally it bears two laminated extensions and dorsally a median and two lateral ridges. In *T. theraps* the anterior and posterior parts are uniform in size, whereas in the other three species the anterior part is enlarged and the posterior part is narrow.

2. Branchiocranium

The branchiocranium includes the oromandibular, hyoidopercular and branchial regions.

**Oromandibular Region**

The oromandibular region includes premaxilla, maxilla, dentary, articular, angular, palatine, mesopterygoid, endopterygoid, metapterygoid, quadrate and symplectic.

*Premaxilla* (Fig. 2; 38 and 39): Paired bones forming the upper jaw. The end to which maxilla articulates is irregular. The part of the bone bordering the
mouth is concave and bears teeth. There is a thickened ‘L’ shaped ridge. The
two premaxillae join medially in front. The maxilla with its curved end is arti-
culated to the inner posterior surface of the premaxilla. In T. jarbua the pre-
maxilla bears prominent teeth, whereas in all the other three species the teeth
are not so prominent.

Maxilla (Fig. 2; 40): Paired bones behind the premaxilla. The anterior end is
bifurcated and embraces the backwardly directed process of the premaxilla. The
middle region is elevated and the posterior end is relatively broader. Maxilla is
similar in all the four species.

Dentary (Fig 2; 41 and 42): Large, paired posteriorly forked bones forming the
lower jaw, bearing teeth on the dorsal arm. Each bears a socket into which the
articular fits in. The ventral arm is relatively narrower and both arms are
covered by the anterior end of the articular. The anterior end of the dentary
joins with its fellow of the other side by means of a symphysis. The dentary of
T. jarbua bears prominent teeth, whereas in the other three species the teeth are
not so prominent.

Articular (Fig. 2; 43 and 44): The articular is more or less spear-shaped with a
thick basal part and a sail-like broad anterior part. It fits into the socket of the
dentary and posteriorly articulates with the head of the quadrate. In T. puta the
width of the basal region of the articular is half of its length, but in the other
three species it is only one-third.

Angular: Paired, small bones, attached to the posterior end of the articular. The
angular is similar in all the four species.

Palatine (Fig. 2; 45-47): The palatine runs forward and hooks over the anterior
end of the maxilla and is immediately ventral to the nasal. Anteriorly it bears a
spinous process whereas the posterior region is finger-like and connected to the
pterygoids. In T. jarbua the anterior end of the palatine bears three spinous pro-
jections whereas in the other three species there is only a single spinous projec-
tion in the anterior end. In T. puta the anterior portion is enlarged to twice that
of the posterior end, whereas in the other three species the anterior end is en-
larged four times the posterior end. In T. theraps and P. quadrilineatus the
palatine is similar.

Mesopterygoid (Fig. 2; 48-51): Paired bones, plate-like, lying immediately be-
hind the palatine. It articulates on the ventral surface with the quadrate and
along its posterodorsal angle with the endo- and metapterygoids. It is similar in
T. puta, P. quadrilineatus and T. theraps, except for the margin of the post-
erior end, where it is undulated in T. puta. It has one dent in T. theraps and
bears no dent in P. quadrilineatus. In T. jarbua it differs in shape and structure
OSTEOLOGY OF THERAPON PERCHES

in having a thickened basal portion and a wing-like anterior portion. The basal thickened portion extends beyond the posterodorsal angle of the anterior portion. This is not so in the other three species.

*Endopterygoid* (Fig. 3; 52 and 53): Paired 'T' shaped bones, the horizontal arms of the 'T' forming the posterior end. They are connected dorsally to the mesopterygoid, laterally to the palatine, anteriorly to the quadrate and posteriorly to the metapterygoid. In *T. jarbua* the lateral margin that does not fuse with the quadrate is undulated. In the other three species this margin is entire.

*Metapterygoid* (Fig. 3; 54-56): Paired, irregular in shape; the posterior margin bears a fringe for the articulation of the stem of the hyomandibular. The anterior margin bears a spine-like structure in the middle. The ventral margin is also curved and borders the quadrate and symplectic. The dorsal narrow portion of the metapterygoid articulates firmly with the anterior lower angle of hyomandibular. The stem of the hyomandibular runs adjacent to the posterior margin of the metapterygoid. In *T. puta, T. jarbua* and *T. theraps* there are ridges in the middle of the metapterygoid, whereas in *P. quadrilineatus* these ridges are absent. In *T. theraps* the dorsal narrow part is entire and the ventral margin is more curved. In *T. puta* and *T. jarbua* the dorsal part is undulated and the ventral margin is less curved. But in *P. quadrilineatus* the dorsal narrow part is neither undulated nor curved.

*Quadrate* (Fig. 3; 57): Paired triangular bone, with two prominent 'V' shaped ridges on the inner face. It is more or less a central bone, articulated dorsally (by is broadest side) with the metapterygoid and the stem of the hyomandibular, posteriorly with the preopercles and ventrally with the articular and the angular. The articular and angular lodge a depression for the articulation of the quadrate. Anterodorsally the quadrate is connected to the endopterygoid. Along the posterior margin, there is a thickened, upward-directed, spine-like process which is grooved on its inner surface. This process provides articulation for the preopercle. Quadrate is similar in all the four species.

*Symplectic* (Fig. 3; 58): Small, narrow, paired bones, lodged in the groove on the inner surface of the quadrate. The dorsal projecting portion of the symplectic articulates with the lower end of the hyomandibular. The symplectic is similar in all the four species.

*Hyoid-Opercular Region*

The hyoid-opercular region includes the paired opercle, subopercle, interopercle, preopercle, hyomandibular and hyoid arch or cornu.

*Opercle* (Fig. 3; 59-62): The opercle is a thin bone, roughly triangular in shape. It is the most prominent bone among the opercular series. It is partly overlapped by the preopercle and its ventral border is bound to the subopercle. A facet for
Cont. see page 11
articulation with the hyomandibular is present on its inner face and there is a
spine at the centre of its outer margin. In all the species, the outer margin bears
a spine in the posterior angle. In *T. puta* the spine on the posterior angle of
outer margin is directed downwards, whereas in the other three species it is
horizontal. In *T. puta* the ventral face is very broad, whereas in the other three
species it is narrow. In *P. quadrilineatus* there is one more spine at the anterior
angle of the outer margin. In *T. thermops* there is an extra spine above in
the posterior angle of the outer margin. In *P. quadrilineatus* the spine at the
centre of the outer margin is very much reduced, whereas in the other three
species it is prominent.

**Preopercle** (Fig. 3; 63 and 64): It is a large, crescent-shaped bone, connected
anteriorly to the quadrate, posterodorsally to the hyomandibular and ventrally
to the opercle. Its anterior region fits into the hyomandibular. The fringed outer
margin bears teeth. There are ridges running along the ventral face of the bone.
In *T. puta* and *T. jarbua* the preopercle is similar but differs from that of *P.
quadrilineatus* and *T. thermops* in possessing 4-6 thickened conspicuous teeth.
The teeth are very minute in *P. quadrilineatus* and *T. thermops*.

**Subopercle** (Fig. 3; 65): Paired, long, thin bone, broad anteriorly and narrow
posteriorly. It is finely fringed along the posterior and inferior margins. Ante­
riorly it bears a small process that is directed forward and upward to articulate
with the preopercle. The subopercle is similar in all the four species.

**Interopercle** (Fig. 3; 66-68): It is a thin bone, forming the anterior and inferior
free margin of the gill cover. Along its inner surface it articulates with the epi­
hyal. The dorsal margin of interopercle is overlapped by the ventral posterior
margin of the preopercle and the posterior margin joins the subopercle and partly
the opercle (at its posterior dorsal corner). The inner margin bears a small pro­
jection at its centre. In *T. puta* and *T. jarbua* it is similar and the dorsal end is
almost pointed, whereas in the other two species it is blunt. The inner margin
is concave in *P. quadrilineatus* whereas it is straight in *T. thermops*. The inner
margin is irregular in the other two species; the anterior inner margin is in a
straight line but the posterior inner margin is convex.

**Hyomandibular** (Fig. 3; 69 and 70): The hyomandibular is typically cruciform
with three condyles, two of them for articulation with the neurocranium by fit­

---

D - Dorsal view; IF - Inner face; OF - Outer face; V - Ventral view.
ing into two facets, one in the posteroventral face of the sphenotic and the other on the ventral surface of the pterotic. The third condyle articulates with the opercle posteriorly. It is fringed in the angle of the anterior process and the stem of the hyomandibular. In *P. quadrilineatus* there is a downwardly directed spine in the anterior region just below the middle condyle. It is absent in the other three species.

**Hyoid arch or cornu:** This includes the paired interhyal, epiphyal, ceratohyal, basihyal and unpaired glossohyal and urohyal. The glossohyal is embedded in the tissue of the tongue and the urohyal supports the tongue and isthmus. The four paired elements are connected by sutures.

*Interhyal:* Small, paired, narrow bone which articulates the hyoid complex with the hyomandibular and the symplectic and is directed obliquely upward. It is similar in all the four species.

*Epihyal* (Fig. 3; 71): Triangular in shape, broad anteriorly and narrow posteriorly, where it bears a condyle at the tip, fitting into the corresponding facet of the interopercle. Epihyal is similar in all the four species.

*Ceratohyal* (Fig. 3; 71): The largest piece of the complex; it is broader at the posterior portion and slightly concave along its dorsal margin. The anterior end of the ceratohyal bears two short processes which articulate with the basihyal. The posterior end of the ceratohyal is firmly articulated with the epiphyal. Ceratohyal is similar in all the four species.

*Basihyal* (Fig. 3; 73): Composed of two centres of ossification firmly united in a straight line. The two halves are nearly of the same size. The ventral ossification at its posterior end rests over a short process of ceratohyal, while the dorsal ossification attaches anteriorly with the glossohyal. Basihyal is similar in all the four species.

*Glossohyal* (Fig. 3; 74-76): Single, median bone which supports the tongue. Broad at the base and tapers anteriorly. It articulates posteriorly with the basihyal. In *T. puta* there is a prominent median ridge running end to end, whereas in the other three species it is reduced. In *P. quadrilineatus*, instead of being decreased gradually in size towards the anterior tip, it has a sharp reduction in the posterior one-third region; thereafter it is uniform.

*Urohyal* (Fig. 3; 77-79): Triangular, unpaired, median bone, situated medially between the basihyals, supporting the tongue and isthmus and connected posteriorly to the posterior end of the cleithrum by means of ligaments. It has a flat horizontal component and a thin vertical component and has the shape of an inverted 'T' in cross section. In *T. puta* the posterior end is forked, but in
P. quadrilineatus the posterior end is pointed, whereas in T. jarbua and T. theraps it gradually decreases to a blunt end. There is no difference between the urohyals of T. jarbua and T. theraps.

Branchial Region (Fig. 3; 80)

The branchial arches are enclosed within the hyoid arch with which they are connected at the base. They are composed of small elements supporting the gills. They are similar in all the four species.

Basibranchials (Fig. 3; 81): Unpaired, arranged in a linear series on the median line, the basibranchials are three in number which give support and attachment to the four branchial arches. The first basibranchial fits into a depression on the posterior face of the glossohyal. The second and third basibranchials bear deep oblique grooves on each side to receive the first and second hypobranchials, respectively. The third basibranchial is longer than the other two. All the basibranchials are narrowed in the middle region and broader at either end. Basibranchials are similar in all the four species.

Hypobranchials (Fig. 3; 82): Hypobranchials are three pairs. The first hypobranchial is attached to the posterior end of the first basibranchial and the second is articulated to the posterior end of the second basibranchial. The third hypobranchial is very short. Hypobranchials are similar in all the four species.

Ceratobranchials (Fig. 3; 83): A series of five pairs, the ceratobranchials are gently curved and attached to the hypobranchials. They constitute the major support to the lower or ventral half of the branchial arches. They increase in size from the first to fifth ceratobranchial. Ventrally, they bear a groove to their full length. Ceratobranchials are similar in all the four species.

Epibranchials (Fig. 3; 84): They are irregularly curved; a series of four pairs of bones, giving the main support to the upper or dorsal half of the branchial arches. Epibranchials are similar in all the four species.

Pharyngobranchials (Fig. 3; 85): Four paired elements, unequal in size, attach with the corresponding epibranchials. They connect the posterior region of the branchial arches with the ventral face of neurocranium. The first pharyngobranchial is a tiny, rod-like bone. The second upper pharyngobranchial articulates with the second epibranchial. The third and fourth upper pharyngobranchials are more or less united to form a single, long piece on each side and they articulate posteriorly with the corresponding epibranchials. Pharyngobranchials are similar in all the four species.

3. Appendicular Skeleton

Appendicular skeleton consists of pectoral and pelvic girdles.
Pectoral Girdle

The pectoral girdle consists of the post-temporal, supra-cleithrum, cleithrum, postcleithrum, scapula and coracoid.

Post-temporal (Fig. 3; 86-89): Paired, forked bones, which afford the principal articulation of the pectoral girdles to the neurocranium. The anterior end of the post-temporal is divided into a long and sharp dorsal process and a short and blunt ventral process. The dorsal process articulates with the epiotic, and the ventral process lies over the pterotic. The posterior portion is broader than both the anterior processes.

In *T. puta*, *T. theraps* and *T. jarbua* there is a thick laminated structure at the forked corner of the post-temporal. In *T. theraps* this is semicircular; in *T. puta* it is rectangular; and in *T. jarbua* it is 'U' shaped. In these three species the inner margin is denoted. In *P. quadrilineatus*, on the other hand, the posterior portion of the post-temporal bears two well-defined spines, the outer one being longer than the inner one. The posterior portion of the bone in the other three species bears only a fringed margin but not well-defined spines.

Supracleithrum (Fig. 4; 90 and 91): Paired, flat bone which articulates with the posterior end of the post-temporal. Its posterior end rests on the dorsal part of the cleithrum. In *P. quadrilineatus* the supracleithrum is slightly bent, whereas in the other three species it is straight.

Cleithrum (Fig. 4; 92): Paired, strong and bent, the cleithrum is the largest bone of the pectoral girdle. Its ventral portion is broader and is folded back to bear a concavity on the inner face. The cleithrum is similar in all the four species.

Postcleithrum (Fig. 4; 93 and 94): The postcleithrum is attached to the inner surface of the cleithrum and extends into the trunk muscle. It is directed posteroventrally. In *T. puta*, *T. jarbua* and *P. quadrilineatus* it is a flat bone with both ends convex, the anterior end being more so than the posterior, which end bears a dent at the centre. In *T. theraps*, it is irregular in shape.

Scapula (Fig. 4; 95): Paired, small quadrangular bone, articulates with the cleithrum and with the coracoid ventrally. It is pierced by a foramen. The scapula is similar in all the four species.

Coracoid (Fig. 4; 96): Paired bone, articulates with the tip of the cleithrum. The dorsal portion is expanded and the ventral portion is rod-like. The coracoid is similar in all the four species.

Pelvic Girdle

The pelvic girdle includes the basipterygium.

Basipterygium (Fig. 4; 97 and 98): Embedded freely in the flesh of the abdominal wall, it consists of two portions. The anterior portion is much shorter than
the posterior one. The basal part of the anterior portion is flattened and the lateral margins are folded back to enclose a groove and two lateral projections. The anterior end of the posterior portion is broader, to which the pelvic fins are suspended. It is similar in *T. puta*, *P. quadrilineatus* and *T. theraps*. In *T. jarbua* the spine which is present in the inner angle of the posterior region is in line with the inner margin and is distinctly longer than in the other three species. And also, in the other three species the spine is directed outward.

4. Vertebral Column (Fig 4; 99 and 100)

The vertebral column is well ossified and is curved in the anterior half of the body. It consists of amphicoelous vertebrae and can be divided into three distinct regions, viz., the trunk region, the precaudal region and the caudal region. The vertebral column of *T. puta* resembles that of *P. quadrilineatus* and differs from that of *T. jarbua* by a deep curvature in the middle region (beginning of the trunk region). In *T. jarbua* and *T. theraps* the vertebral column is gradually curved from the first vertebra to the caudal complex. *T. puta*, *P. quadrilineatus* and *T. theraps* have seven trunk vertebrae, three pre-caudal vertebrae (8th, 9th and 10th), 14 caudal vertebrae and a caudal complex (last vertebra). In *T. jarbua*, there are eight trunk vertebrae, two precaudal vertebrae (9th and 10th), 14 caudal vertebrae and a caudal complex.

Trunk Region

The trunk region consists of seven vertebrae in *T. puta*, *P. quadrilineatus* and *T. theraps*, and eight in *T. jarbua*. The second to the last trunk vertebrae are articulated with side ribs.

*Atlas (first) vertebra* (Fig. 4; 101): The first anterior vertebra is articulated to the skull by the occipital condyle. It has a small amphicoelous centrum. The centrum bears a dorsal groove, from the lateral borders of which arise the neural arches to form the neural canal. A pair of processes known as parapophyses extend ventrally from the dorsolateral angles of the neural arch. On the postero-dorsal angles of the centrum there are two blunt projections known as the postzygapophyses. The prezygapophyses are absent. The infra-central groove is present. There is a lateral depression on the centrum. Atlas is similar in all the four species.

*Typical trunk vertebra* (Fig. 4; 102): A typical trunk vertebra consists of an amphicoelous centrum and a dorsolateral and a ventrolateral depressions. The neural arch is formed by a pair of processes, arising one on each side from the anterolateral border of the centrum. The neural arch continues dorsally into a backwardly directed neural spine, which is longer in the posterior region than in the anterior region. The base of the neural arch on the anterolateral angles is thickened to form a pair (one on each side) of blunt processes called prezygapophyses, which project upwards and forwards. Similar processes, called
postzygapophyses, are present on the posterolateral angle of the neural arch and are directed upwards and backwards. A pair of short parapophyses are present on the ventrolateral angles of the centrum, to each of which a rib is attached by means of a ligament. The parapophyses increase in length and breadth gradually from the first trunk vertebra to the last trunk vertebra. All the trunk vertebrae except the fourth are similar in all the four species.

Fourth vertebra (Fig. 4; 103-106): A plate-like structure is present on the ventral face of the centrum. This plate is circular in *T. puta*, semicircular in *T. jarbua* and rectangular in *P. quadrilineatus*. In *T. theraps* it is almost polygonal. In *T. jarbua* the plate does not extend beyond the centrum, whereas in the other three species it extends beyond the centrum posteriorly and embraces the anterior part of the centrum of the fifth vertebra.

Precaudal Region

*T. jarbua* has only two precaudal vertebrae (9th and 10th), whereas the other three species have three precaudal vertebrae (8th, 9th and 10th).

Typical precaudal vertebra (Fig. 4; 107): A typical precaudal vertebra resembles the trunk vertebra except that the parapophyses are directed downwards and are joined together by means of a transverse bridge known as the haemal bridge or parapophysial bridge, so as to enclose a haemal canal.

Eighth vertebra (Fig. 4; 108 and 109): In *T. jarbua* this is a trunk vertebra because of lack of haemal bridge, whereas in the other three species this is a precaudal vertebra.

Tenth vertebra (Fig. 4; 110 and 111): In all the four species this is a precaudal vertebra. In *T. puta*, *P. quadrilineatus* and *T. theraps* this is similar and differs from that in *T. jarbua* in the structure of the parapophyses. In *T. jarbua* it is simple and encloses the haemal canal (owing to the formation of haemal bridge). In the other three species the parapophyses form elaborate structures and are joined at two places so as to enclose two canals. However, the presence of the haemal bridge makes them precaudal vertebrae.

---


D - Dorsal view; F - Front view; IF - Inner face; L - Lateral view; OF - Outer face.
Caudal Region

In all the four species the caudal vertebrae are 14 in number, excluding the urostyle.

*Typical caudal vertebra* (Fig. 4; 112): A typical caudal vertebra has a well-developed amphicoelous centrum with median depressions on the dorsal, ventral and lateral faces. It has a well-developed neural arch, produced into a long, backwardly directed neural spine, and has pre- and postzygapophyses as in the trunk vertebrae. Ventrally, the centrum bears a haemal arch produced into a backwardly directed haemal spine. Haemal arch also bears haemal pre- and postzygapophyses. Except for the 11th vertebra, they are similar in all the four species.

*Eleventh vertebra* (Fig. 4; 113 and 114): This is similar in *T. puta, P. quadrilineatus* and *T. theraps*. In *T. jarbua*, the parapophyses are fused to form an elaborate, wide, forked haemal process, whereas in the other three species, it is narrow and pointed.

*Caudal complex* (Fig. 4; 115): The last vertebra (25th) is produced behind into an upturned, rod-like process called the urostyle, which probably represents the fused centra of several posterior vertebrae. The neural and haemal spines of the posterior caudal vertebrae are fused with the fin radials to form epurals and hypurals, respectively, supporting the caudal fin. Caudal complex is similar in structure in all the four species.

The dissimilarities listed above may be due to the differences between the species at their specific and generic levels. Apart from these dissimilarities, several similarities have also been observed. They may be attributed to the similarities at their familial as well as generic level. However, the utility of the osteological elements at various levels of taxonomy can be precisely determined only when all the representatives of the family Theraponidae are osteologically investigated.

*References*


OSTEOLGY OF THERAPON PERCHES


