

OSTEOLOGY OF THE INDIAN MOUNTAIN LIZARD
JAPALURA VARIEGATA GRAY (REPTILIA : AGAMIDAE)

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(With 9 Text-figures)

INTRODUCTION

Japalura variegata Gray is a terrestrial lizard found in Eastern Himalayas up to an altitude of 3000 metres. The range of distribution of this species includes Sikkim, Darjeeling and Jalpaiguri district of North Bengal. The specimens used in the present work were from Darjeeling.

Beddard (1905) worked out the cranial osteology of *Uromastix* and *Chalmydosaurus kingi*. Boulenger (1890) described the skull of *Calotes jubatus*. Broom (1922) studied the osteology of *Agama hispida*. De Beer (1937) described the osteology of the skull of *Draco*, *Ascalobates* and *Tiliqua*. El-Toubi (1945, 1947) has given the accounts of the osteology of *Uromastix aegyptia* and *Agama stellio*. Iyer (1943) described the osteology of *Calotes versicolor*. Prasad (1955) has given the account of the osteology of *Draco dussumieri*. Siebenrock (1895) presented an elaborate work on the osteology of *Agamids*. Tilak (1964) described the osteology of *Uromastix hardwicki*.

KEY TO LETTERINGS OF TEXT-FIGURES

AFBOC—articular facet for basioccipital ; AFEXO—articular facet for exoccipital ; AFO—articular facet for quadrate ; AN—angular ; API—acetabular part of ilium ; APIS—acetabular part of ischium ; APP—acetabular part of pubis ; ARI—articular facet of ilium ; AROP—articular process for odontoid process ; ART—articular ; AT—atlas ; AX—axis ; BF—basipital fossa ; BP—basisphenoid ; CART—Cartilage between quadrate and paraoccipital process ; CB—chevron bone ; CBOC—part of occipital condyle formed by basioccipital ; CC—conca- vity ; CD—Coracoid ; CDF—coracoid foramen ; CEXO—part of occi- pital condyle formed by exoccipital ; CFI—condyle for fibula ; CJ— cartilaginous joint ; CL—clavicle ; CO—Coronoid ; CP—clawed distal phalanges ; CRI—1st cervical rib ; CR2—2nd cervical rib ; CT—Cent-

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rale ; CTI—condyl for tibia ; D—Dentary ; DCI—1st distal carpal ; DC5—5th distal carpal ; DR—deltoid ridge ; DT—distal tarsal ; EAP—extra acetabular portion of ilium ; ECD—epicoracoid ; ECTPT—ectopterygoid ; EPB—epipubis ; EPS—episternum ; EPT—epipterygoid ; ESTS—extra stapes ; EXO—exoccipital and opisthotic, EXOPR—paroccipital process ; F—foramen ; FC—fibrous covering between supraoccipital and parietal ; FCS—foramen between Coracoid and scapula ; FE—femur ; FI—fibula ; FIB—Fibulare ; FM—foramen magnum ; FMCK—fossa meckelii ; FOR—foramen rotundus ; FOV—Part of foramen ovalis ; FR—frontal ; FV—foramen for vagus ; GF—Glenoid fossa ; H—head ; HP—hypocentrum ; HU—humerus ; HYPI—1st hypophysis ; HYP2—2nd hypophysis ; HYP3—3rd hypophysis ; HYPS 1—HYPS 2, HYPS 3—the anterior, the medial and the posterior parts of hypoischium ; IM—intermedium ; IOS—cartilagenous interorbital septum ; IP—interparietal ; IPT—interpterygoid space ; ISS—ischial symphysis ; ITF—infratemporal fossa ; ITR—internal trochanter ; J—jugal ; LAC—lachrymal ; LG—ligament ; MC—metacarpal ; MC 1—1st metacarpal ; MC 5—5th metacarpal ; MCK—meckel's cartilage ; MIP—metaischial process ; MPIS—medial arm of ischium ; MPP—medial arm of pubis ; MPR—medial process ; MT 1—1st metatarsal ; MT 5—5th metatarsal ; MX—maxilla ; N—Nasal ; NC—Neural canal ; NCA—nasal capsule ; NP—neurapophysis ; NS—neural spine ; OF—obturatar foramen ; OP—odontoid process ; OPR—olecranon process ; ORSPH—orbitosphenoid ; P—parietal ; PAL—palatine, PAP—preacetabular process of ilium ; PBSPH—pterygoid process of basisphenoid ; PEC. AR—pectoral arch ; PEP—pterygoectopterygoid projection ; PAF—palatine foramen ; PF—parietal foramen ; PFR—prefrontal ; PL—phalanges ; PL 1—1st phalanx ; PL2—2nd phalanx ; PM—process messetericus ; PMX—premaxille ; POR—post orbital ; PPR—prepublic process ; PPT—palatine process of pterygoid ; PRO—prootic ; PS—pisiform ; PSPM—parasphenoid ; PT—pterygoid ; PTF—posttemporal fossa ; PTL—ptellae at the knee joint ; PUS—pubic symphysis ; PVO—prevomer ; PZS—prezygapophysis ; PZT—postzygopophysis ; QD—quadrate ; QPT—quadrate process of pterygoid, R—radius ; RC—radial condyle ; RD—radiale ; S—sternum ; SC—sterno-costal element ; SCDF—supracoracoid foramen ; SMX—septomaxillary ; SN—surangular ; SOC—supraoccipital ; SP—scapula ; SQ—Squamosal ; SR—sternal portion of rib ; SS—suprascapula ; ST—supratemporal ; STF—supratemporal fossa ; STP—supratemporal process of parietal ; STS—stapes ; T—teeth ; TI—tibia ; TIB—tibiale ; TP—transverse process ; TYP—tympanic process ; U—ulna ; UC—ulnar condyl ; UN—ulnare ; VP—ventral process ; VR—vertebral rib.

MATERIAL AND METHOD

The skeletal material used for this study was obtained by maceration of alcohol preserved specimens from Darjeeling.

THE OSTEOLOGY

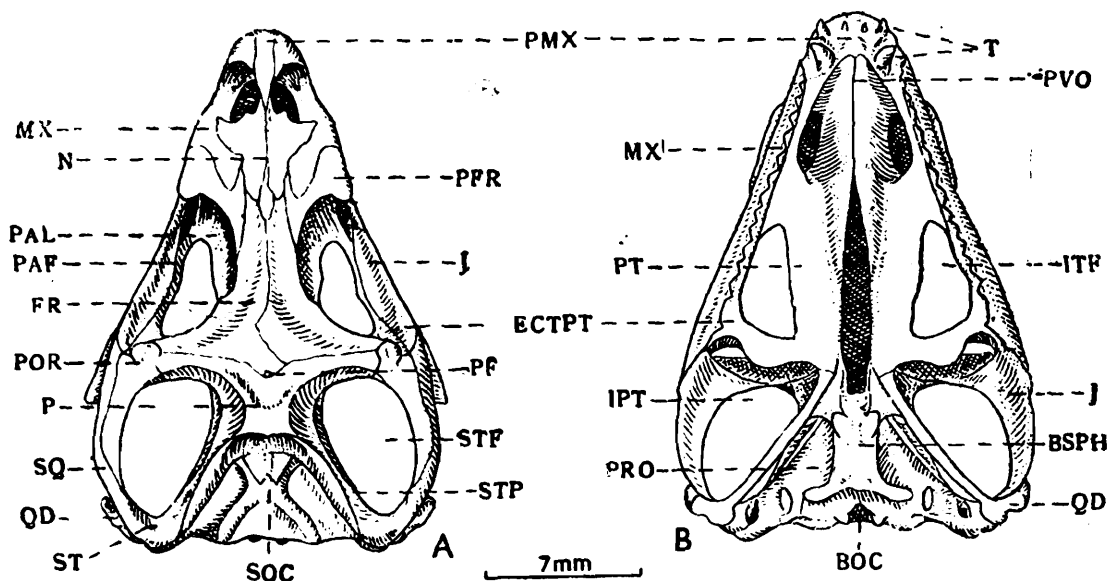
(A) The Skull

(Text-figs. 1 & 2)

(1) General

On measuring the 15 skulls the observed ranges are as follows : Length (occipital condyl to tip of snout) 2.3-2.4 cm., width (behind the orbits) 1.55-1.65 cm., and height (between the lower jaw and parietals) 1.6 cm.

The skull is well ossified, and the fore skull is with a concavity ; its anterior extremity is pointed, thus forming an acute snout. Orbits are surrounded by strongly ossified bones ; distal surface



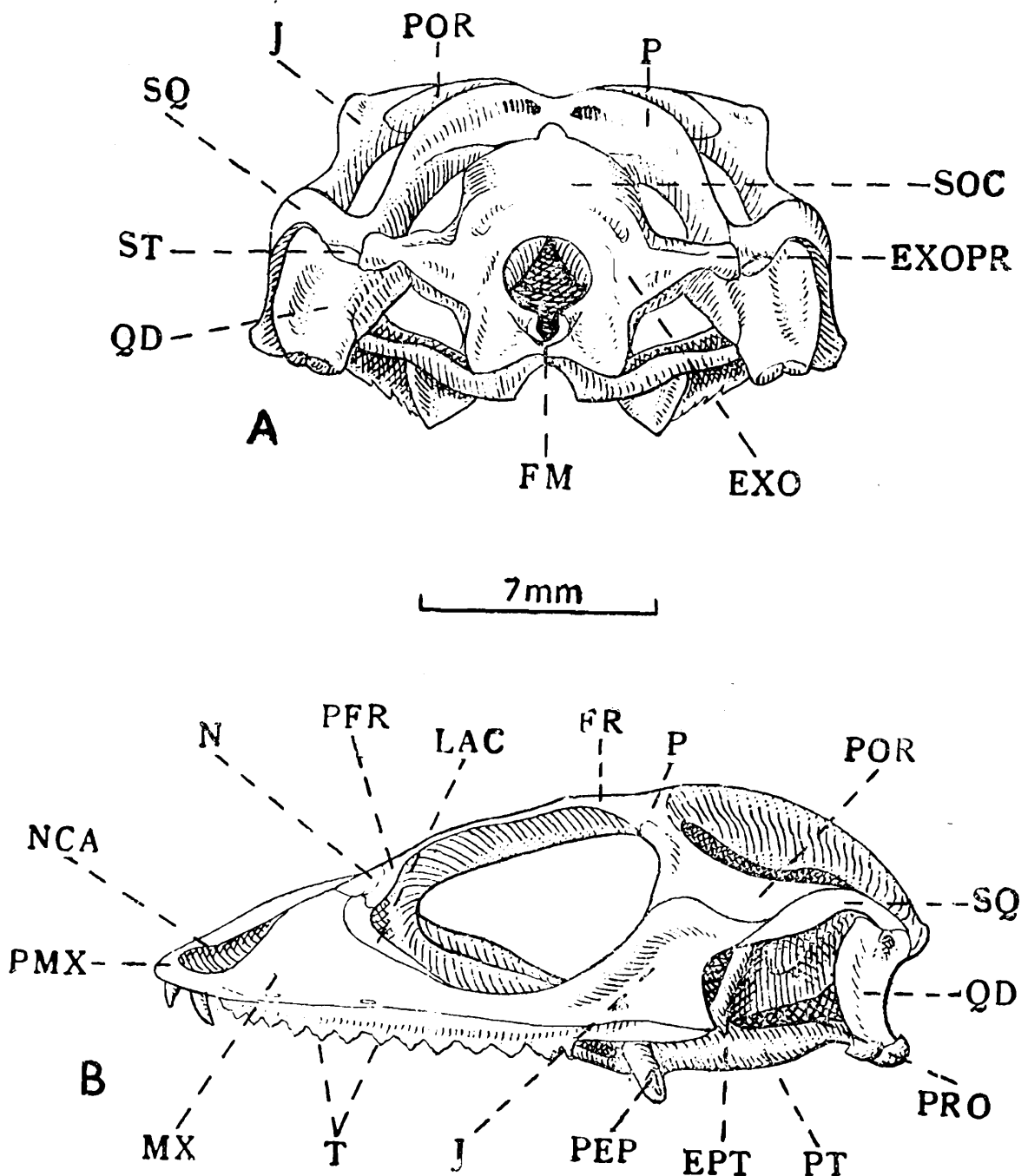
Text-fig. 1. A. Dorsal view of skull.
B. Ventral view of skull.

is flattened ; all sutures are obliterated due to ossification and overlapping of bones ; dorsal and lateral planes of the skull meet at a right angle and along that edge there is a prominent antero-posterior ridge ; mid-dorsal aspect, through parietals is a flat plane having steep slope towards occipital region and a gradual slope ending at the extreme tip of premaxilla.

(2) Occipital complex (Text-fig. 2 A)

Four elements, namely, a *supraoccipital* (Text-fig. 3 A), *basioccipital* (Text-fig. 3 E) and two *exoccipitals* (Text-fig. 3 G) form this region of

the skull. The foramenmagnum has a ridged border and *exoccipitals* form its superior, lateral and inferior margins. The base and the roof of the occipital condyl is formed by *basioccipital* and supraoccipital. *Supraoccipital* is a cross-shaped bone with three prominent dorsal ridges. The *occipital* crest forms the mid-longitudinal ridge as well as two prominent lateral ridges which from the continuity with the ridges on the anterior margin of exoccipitals. A minute



Text-fig. 2. A. The occipital region of skull
B. Lateral view of skull.

bony structure extends from the anterior cephalic margin of supraoccipital, providing a loose connection between the supraoccipital and parietal. Such a loose attachment provides a flexible and lever-like mechanism between *supraoccipital* and the parietal and also renders

slight movement in the fronto-parietal portion over the occipito-sphenoidal region of the cranium.

The much extended lateral part of *exoccipital* has been formed by its fusion with the opisthotic. The fan-shaped posterior part of *exoccipital* forms the lateral boundary of foramen-magnum and bears three minute foramina, which aids in orientating the positions of the fused elements. The much extended outermost process (*parotic process*) articulates independently with *squamosal* and *quadrate*. The small ridged basioccipital takes a major part in the formation of *occipital condyl*. A prominent tubercle on each of its lateral aspect demarcates it from the *exoccipital*. The posterior aspect of these tubercles is slightly convex and provides a flexible attachment to the articular process of the *atlas*. Anteriorly, the *basioccipital* articulates with the much serrated posterior margin of *basisphenoid*, while posteriorly it bears a curved ridge forming the basal margin of *occipital-condyle* and articulating with the *odontoid-process* of the *axis*.

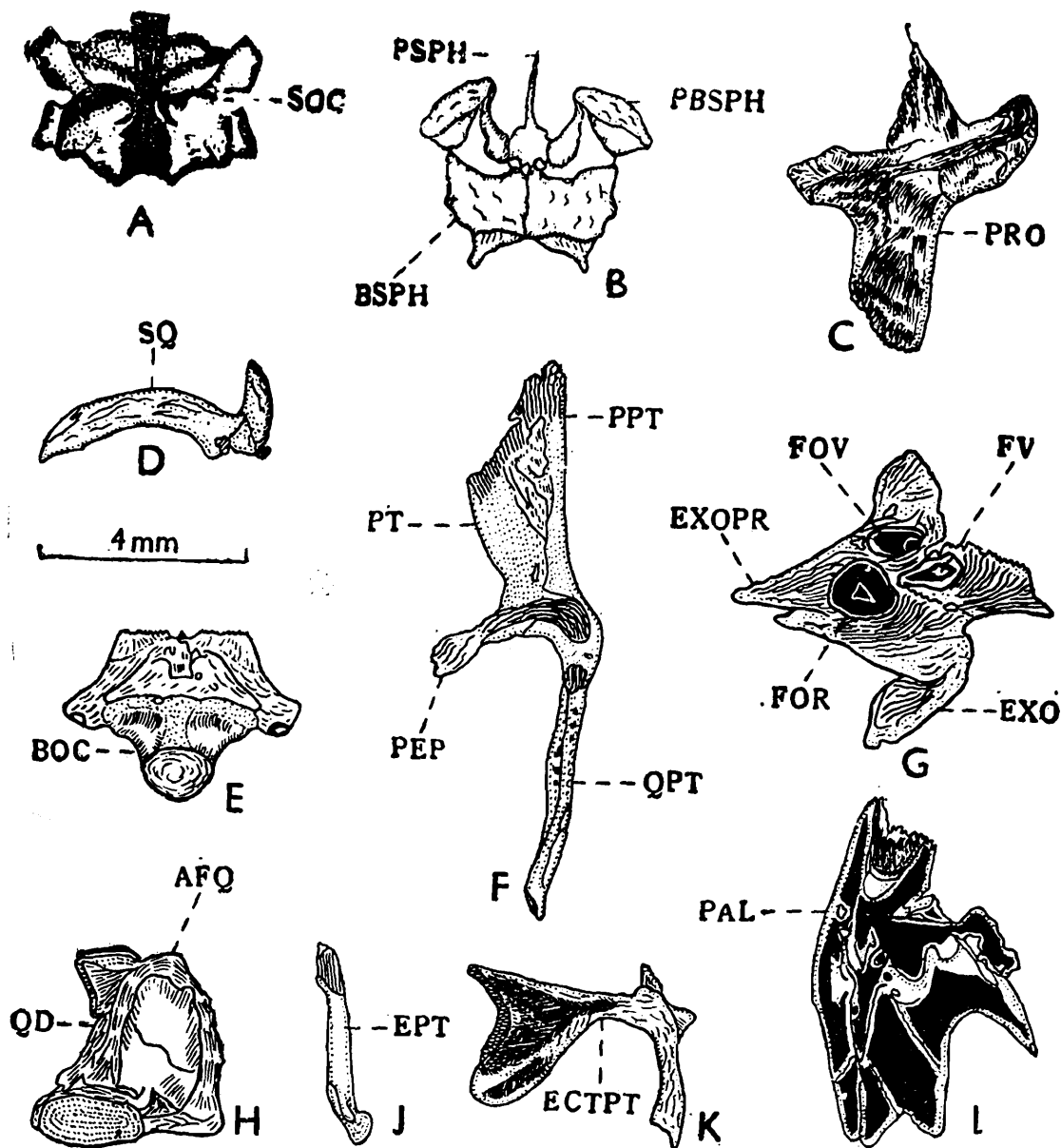
(3) *The frontoparietal complex* (Text-fig. 1A)

This includes the anterior and middorsal regions forming the muzzle and the roof of the skull. It consists of four unpaired (*frontal*, *parietal*, *basisphenoid* and *parasphenoid*) and two paired (*prefrontal* and *postorbitofrontal*) elements. The *parasphenoid* is practically fused with *basisphenoid*.

Frontal (Text-fig. 4A) : It is an elongated, crested, roughly pyramidal or inverted, T-shaped median bone, whose combined lateral borders, along with prefrontal, form the upper dorsal margin of the orbits. Its posterior aspect which bears a notch is a bow-shaped, elevated structure at the middle and fits into a semicircular depression on the anterior border of *parietal*. The articulation of *frontal* with *parietal* is sutural and the notch, in collaboration with a small pit on the anterior margin of *parietal* forms a foramen, the frontoparietal foramen. Its lateral process on each side articulates with *postorbitofrontal* (*postfrontal*) by a distinct suture. On the anterior margin it articulates with *nasals*, *premaxilla* and *prefrontals* by a much serrated, acute margin formed by the sharp pointed invaginations of bony elements. Overlapping of bones is extreme on the anterior margin, and dorsally it bears two strong lateral L-shaped ridges originating from the anterior margin and continuing upto the end of the posterolateral aspects.

Prefrontals (Text-fig. 4 J) : These are small roughly triangular bones situated on the anterolateral aspects of skull, bordering the inner anterior portion of the orbits. The antero-lateral apex and more than half

of the antero-median border of *prefrontals* closely touch the dorsal aspect of the *maxillae*. In the anteromedian region of the skull their dorsal fan-shaped aspects overlap the posterolateral margin of *nasal* and anterolateral margin of *frontal*. The posterolateral part of each *prefrontal* articulate with *lachrymal* and *jugal*, while its median posterior border overlaps the *palatine*.



Text-fig. 3. A. Supraoccipital ; B. Basisphenoid and Parasphenoid ; C. Prootic ; D. Squamosal ; E. Basioccipital ; F. Pterygoid ; G. Exoccipital ; H. Quadrate ; J. Epipterygoid ; K. Ectopterygoid ; L. Palatine.

Postorbitofrontals (Postfrontal or Postorbital, Text-fig. 4 K) : They are paired and each has been formed by the fusion of two elements, i. e. *postfrontal* and *postorbital*, and has sutural unions with *frontal*, *parietal*, *jugal* and *squamosal*. Its anterolateral aspect forms the posterolateral border of the orbit and its posterior aspect makes the anterolateral border of the *supratemporal fossa*. The posterolateral dagger-shaped

edge articulates suturally with the dorsolateral margin of *jugal* and, in coordination with *squamosal*, completes the posterolateral boundary of the *supratemporal cavity*. Its vertically directed, clubshaped process makes almost a right angle in forming a common sutural articulation with the narrow lateral aspects of *frontal* and *parietal*.

Parietal (Text-fig. 4B) : It is a single, median, butterfly-shaped investing bone. It possesses a much elongated, sharp, posterolateral process on each side, which articulate with the *supratemporal*, *squamosal* and the *paraoccipital* process of *exoccipital*, forming the posterior boundary of the *supratemporal fossa* and the anterior boundary of the *posttemporal fossa*. From either side of it a process runs downwards to meet the *epipterygoid*. In the front it articulates with the *frontal* and on the side with the *postorbitofrontals*, forming the anteromedian boundary of the *supratemporal vacuity*. A minute foramen is present in the middle of the transverse frontoparietal suture or coronal suture. On the middle of the posterior margin, it bears a small subtriangular notch, to which fits a small bone from the anterior cephalic margin of the *supraoccipital*. Such an attachment with the *supraoccipital* provides a flexible articulation to the parietal and occipital complexes.

Basisphenoid (Text-fig. 3B) : It is a W-shaped replacing bone resting just in the mid-ventral aspect of the cranium, thus forming the lower surface of the frontoparietal complex. Anteriorly, it bears a median prolonged spinose bony structure, the *parasphenoid process of basisphenoid* or *basisphenoidal rostrum*, which posteriorly forms a sutural articulation with *basioccipital*. Its two lateral processes, known as *basipterygoids* form a loose and cartilaginous articulation with the anterior margin of the pterygoid process.

Parasphenoid : It is perfectly ossified, anteriorly pointed, rod-shaped bone, emerging from the anterior margin of *basisphenoid*, close to the *parasphenoid* process.

(4) *The olfactory complex* (Text-fig. 1 A, B)

This complex forms the facial portion of skull and consists of *nasals*, *septomaxillaries*, *prevomer* and the *vomeronasal organ* (Jacobson's organ).

Prevomer (Text-fig. 4 D) : It is a single toothless, dermal, thin, leaf-like bone with a smooth surface articulating anteriorly with *premaxilla* and at the latero-posterior margin with *palatines*. Its posterior margin is much serrated and the articulation with *palatines* is sutural.

Vomeronasal organ (Jacobson's organ) : It is a distinct clubshaped and pocket like structure, situated between *prevomer* and *premaxilla*. It is a sense organ and has developed as an outgrowth of the nasal cavity.

Nasals (Text-fig. 4 E) : They are paired and triangular and are dorsally completely separated by the long *processus nasalis* of the premaxilla. Posteriorly they abut on the wide frontal. Ventrally they touch each other in the mid-posterior region.

Septomaxillary : These are minute, projecting bones lying on each side, slightly above the prevomer. They bound the hinder upper corners of nostrils and articulate with the anterolateral aspect of nasals.

(5) *The palatal complex* (Text-fig. 1B)

The bones of this region exhibit great structural modifications and they comprise the paired pterygoids, palatines and transpalatines (ectopterygoids or transversum). The pterygoids and prevomer are separated by palatines.

Pterygoids (Text-fig. 3 F) : On either side each toothless pterygoid is an elongated, triradiate, dermal bone which forms an oblique sutural articulation with palatine anteriorly while its lateral aspect forms a sutural contact with ectopterygoid. Posterolaterally, its long quadrate process articulates with the inner aspect of the upper end of quadrate. Medially it touches the pterygoid process of basisphenoid by means of a ligament. Its anterior arm is like a thin blade with sharp, oblique, anterolateral margins while the mediodorsal aspect bears an elevated ridge. An osseous thickening on its midlongitudinal portion sends two processes of which the smaller one articulates with ectopterygoid, while the other which is quite long, diverges posterolaterally so as to reach the quadrate. Its lateral process is a flat, roughly triangular structure, known as pterygotranspalatine process, and articulates with the notch-like inner aspect of the ectopterygoid. On the dorsal aspect of the pterygo-quadrate process, slightly posterior to its junction with pterygo-ectopterygoid process (just lateral to the articular facet of basisphenoid) lies a cavity for the articulation of epipterygoid.

Ectopterygoids (Transpalatine or Transversum Text-fig. 3 K) : They are paired, dumb-bell-shaped, lateroventral in position and articulating firmly with maxilla and jugal on the outer and pterygoid (through pterygo-ectopterygoid process) on the inner aspects.

Palatines (Text-fig. 3 L) : They are somewhat flat and roughly triradiate, ridged structures forming the anteriormost part of the palatal complex along with prevomers. The anteromedial border of each palatine articulates with dorsolateral margin of prevomer. Their posterior blade-like arm is connected by a broad oblique suture with the

pterygoid. Their serrated anterolateral border makes a sutural articulation with maxilla through the maxillo palatine process, while dorsally they are in contact with the prefrontals.

(6) *The orbital complex* (Text-fig. 2 B)

The bones of the circumorbital series exhibit great modifications and form a capsule-like structure to provide a suitable socket for the eye ball. The supraorbital arch is formed by frontal and prefrontal. The anterior margin is shared by pre-frontal and lachrymal. Postorbitofrontal forms the posterior boundary of the orbit and the architecture of its flooring is shared by the posterior projections of lachrymal, jugal, transpalatine, pterygoid and palatine.

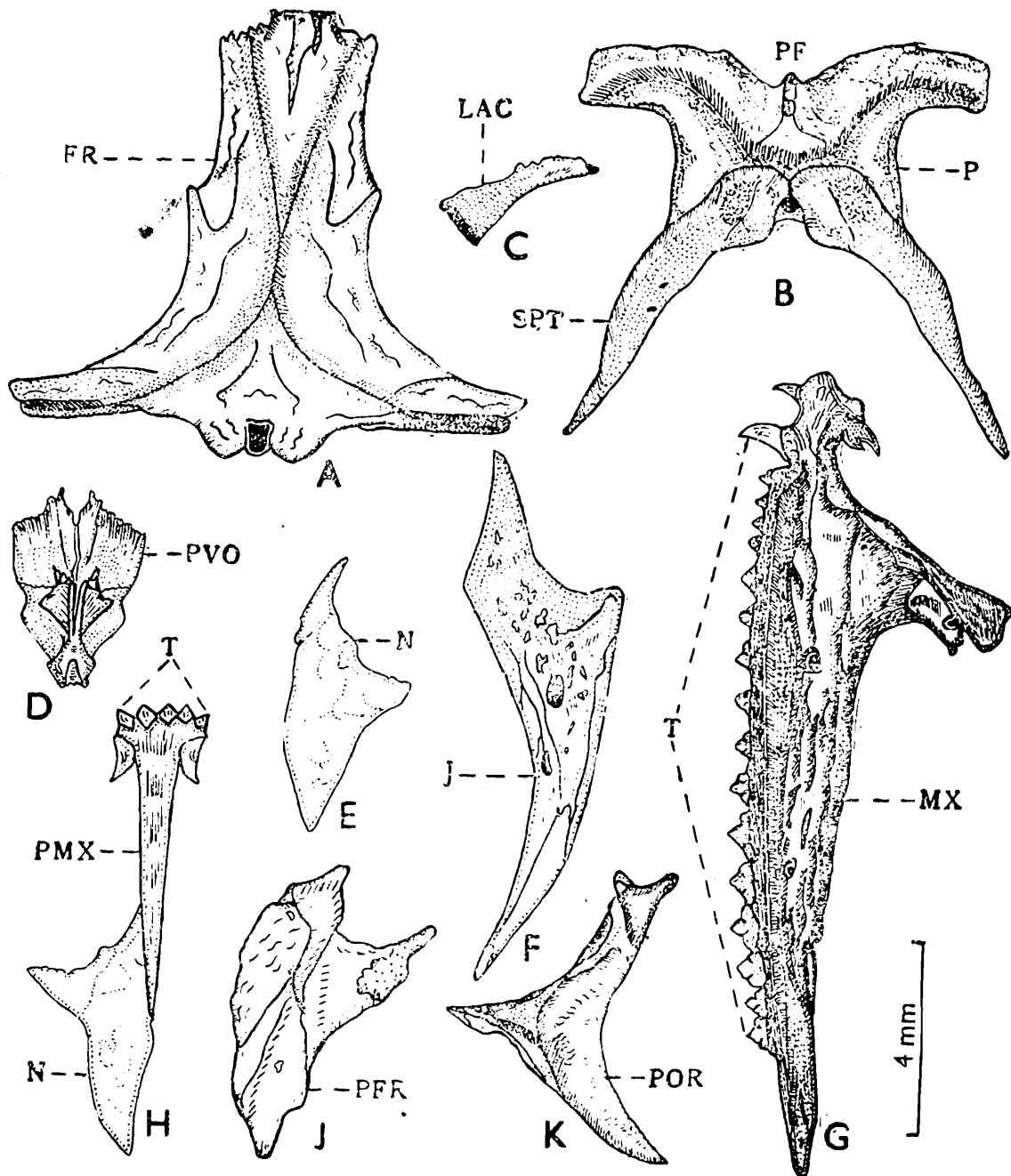
Lachrymals (Text-figs. 2 B, 4 C) : Consists of a pair of bones. Each one is a small, roughly triangular bone, which antero-ventrally articulates with maxilla, dorsally with prefrontal by means of sutures, posteriorly, through a narrow projection, with the elongated anterior projection of jugal, thus completing the interorbital arch. Each labra bears an orifice at the anterolateral corner of the orbit for the passage of the lachrymal canal.

Jugal (Text-figs. 2 B, 4 F) : They are paired roughly dagger-shaped bones suturally articulating with squamosal, postorbitofrontal, ectopterygoid, prefrontal, lachrymal, maxilla and palatine. The posterodorsal portion of jugal is a flat serrated structure bearing a ridge on its dorsal expanded margin which articulate posteriorly with squamosal and dorsally with postorbitofrontal. The posterodorsal suture formed by the union of postorbitofrontal and jugal, is bow-shaped. The anterolateral arm of postorbitofrontal sends a lateral arm over jugal in the midposterior part of the orbit. The projected extreme posterior end of jugal articulates obliquely with the anterior facet of squamosal, thus forming the dorsal boundary of the infratemporal fossa. The anterior portion of jugal is a narrow projection which with its entire ventral margin articulates firmly with the maxilla. The extreme anterior tip of this projection just touches lachrymal, prefrontal and palatine. At its inner median aspect, almost at the middle of infraorbital arch, it articulates with ectopterygoid.

(7) *The auditory complex*

The auditory complex is composed of tympanum, protic and opisthotic, forming an auditory capsule on either side of the occipital region.

Prootic : It is a somewhat cross-shaped bone forming the anterior part of the auditory capsule. On its posterior margin lies the exoccipital, while on the latero-ventral aspect the basis-phenoid. Postero-dorsally, it articulates with the exoccipital, supraoccipital, parietal and epipterygoid.



Text-fig. 4. A. Frontal ; B. Parietal ; C. Lachrymal ;
D. Prevomer ; E. Nasal ; F. Jugal ; G. Maxilla ;
H. Premaxilla and Nasal ; J. Prefrontal ;
K. Postorbitofrontal.

Opisthotic : The opisthotic does not carry a separate identity and is represented only by a postero-lateral thickening on the preoccipital process of exoccipital. It forms a well marked exterior prolongation (parotic process) along with prootic and exoccipital. The columella auris is composed of two things a slender rod-like stapes and a cartila-

ginous tubercle, the extrastapes. The flac and disc-like proximal invagination of the stapes remains in close contact with the membranous lid of fenestra ovalis. The distal end of stapes extends up to the capitula of quadrate. The extrastapes is also an important replacing bone of the auditory capsule, attached on one side with stapes and on the other with tympanic membrane. The tympanum is not exposed.

(8) *The maxillary complex* (Text-fig. 2 B)

A single premaxilla and a paired maxilla share in the formation of this complex.

Premaxilla (Text-fig. 4 H) : It is a median peg-like bone with a broad dentate anterior part which forms the tip of snout, and a posterior thin and much elongated nasal process. The nasal process articulates with the anteromedian margins of nasals. The anterolateral border of premaxilla articulates with maxilla by a suture and with prevomer on the posteroventral aspect. The anterior broad margin possesses four sharp pointed acrodont teeth.

Maxilla (Text-figs. 2 B, 4 G) : It is a paired bone articulating with premaxilla, jugal, nasal, prefrontal, prevomer, lachrymal, palatine, septomaxilla and epipterygoid. It provides a definite symmetry to the sides of skull and keeps a close association with palatal and olfactory complexes. *Epipterygoid* serves as a bridge between maxilla and these complexes. It is an elongated ridged bone marked with coossified osteoderms and the labial foramina. Its anteriormost portion which articulates with premaxilla bears two distinct teeth (an insisor and canine). Most of its posterior portion is provided with 15 or 16 molars. Dorsally it articulates suturally with nasal.

(9) *The suspensorial complex* (Text-fig. 2 B)

The elements of this complex form a flexible attachment of the cranium with the lower jaw through quadrate. The bones which participate in the architecture of suspensorium are epipterygoid, squamosal, quadrate and supratemporal.

Quadrate (Text-fig. 3 H) : It serves as a hanger in providing a suspended articulation to mandibles and a streptostylic movement to the bones of head. It is a small bone with an outer concave and an inner convex margin. It articulates with squamosal, supratemporal and collumella auris by means of its somewhat flat and broad dorsal aspect. The ventral aspect, which is comparatively narrow and less flat, forms a ligamentous articulation with the articular portion of

the lower jaw. The articulation of quadrate with pterygoid has already been discussed under the palatal complex.

Squamosal (Text-fig. 3 D) : It is a small, smooth and paired bone, forming an arch-like postero-lateral boundary of skull, thus enclosing the supratemporal fossa on the dorsal aspect. The anterior-most facet of the anteriorly elongated and somewhat bow-shaped portion of squamosal articulates with jugal below while postorbito-frontal above. The end of its much smaller posterior part articulates with quadrate below and supratemporal and parietal above.

Supratemporal (Text-fig. 1A) : It is a small and splint-like paired bone almost fused to the extreme postero-lateral tip of the elongated lateral process of parietal, wedged between squamosal externally and ophisthotic medially. It articulates with quadrate by its postero-ventral aspect.

Epipterygoid (Text-fig. 3 J) : It is a rod-shaped paired bony structure. Each epipterygoid is situated adjacent to the auditory capsule, like dorsoventral pillars. It emerges from a notch on the dorsal surface of pterygoid, and ascends dorsally to form a ligamentous connection with a small process formed by supraoccipital.

(10) *The mandibular complex* (Text-fig. 5A & B)

Each ramus is an elongated and slightly curved structure formed basically by the combination of seven elements viz. prearticular, angular, articular surangular, opercular or spleniod, coronoid and dentary. The intermandibular articulation is ligamentous.

Prearticular and Articular (Figs. 5 A & B)

These two elements have fused into a single roughly triangular bone, which has been formed as a result of endochondral ossification. Its posteriorly tapering post-articular process articulates with quadrate and the dorsal aspect carries a rough flat area known as "fovea articularis". On the outer side of mandible, its anterodorsal aspect forms an oblique sutural union with surangular. In the same plane its anterior and anteroventral aspects articulate suturally with the angular. On the inner aspects its slightly curved and rod-shaped portion extends anteriorly to form the basal margin of the "Mecklian fossa" and ultimately forms sutural articulations, antero-dorsally with coronoid and antero-ventrally with angular and splenial.

Angular (Text-fig. 5 A & B) : It is an elongated, curved and distinct bone whose butt-shaped broad posterior part forms sutural articulations with the surangular dorsally and with the articular posteriorly and

ventrally. Its narrow and blade-like anterior portion recurves on the inner aspect of the mandibular ramus where it suturally articulates with the splenial dorsally and the dentary ventrally. Its anteriormost pointed end rests on dentary and extends little bit into the cavity for "Meckel's cartilage".

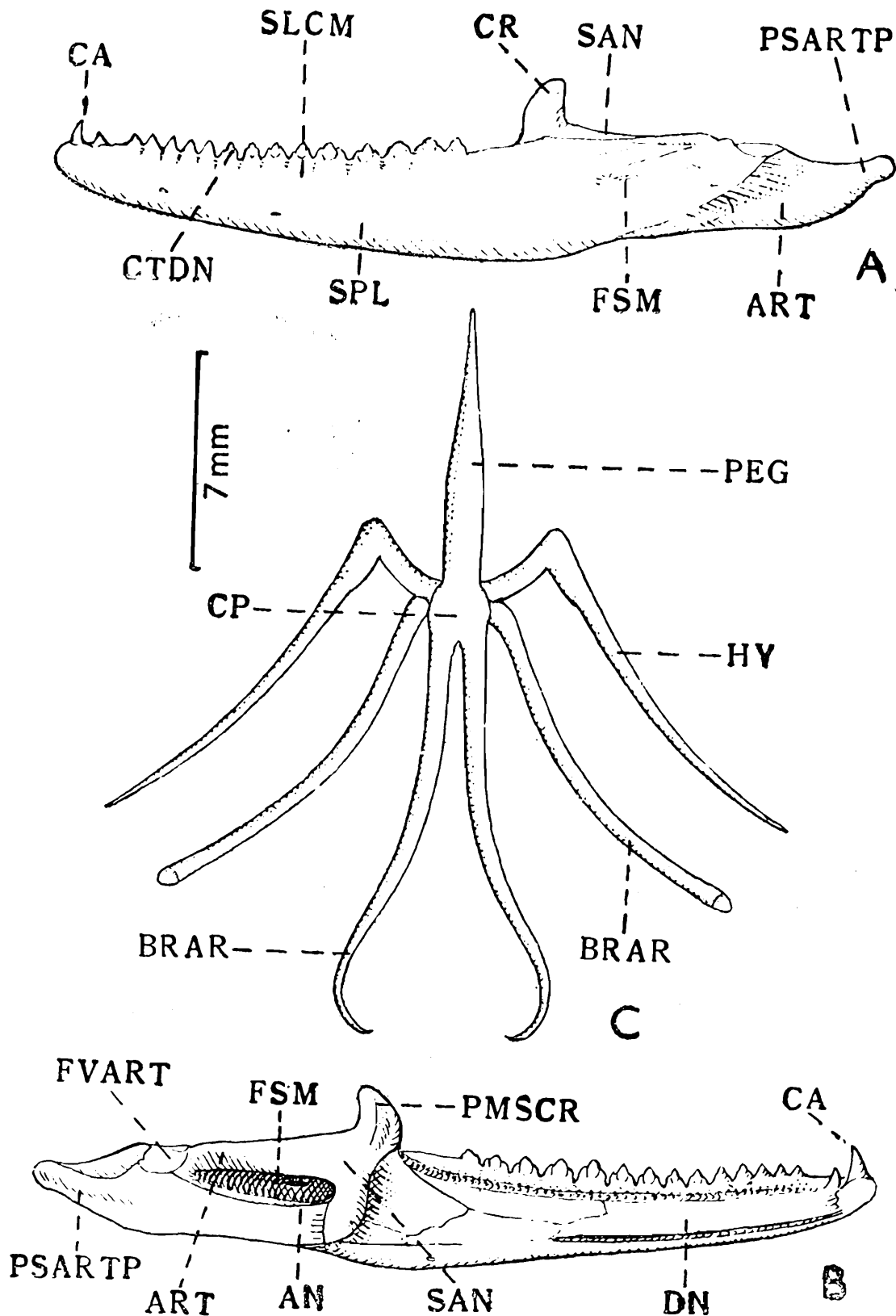
Surangular (Text-figs. 5 A & B) : It is a distinct bone whose median, oblique antero-dorsal and much serrated anterior margins articulate suturally with dentary. Most of its ventral bladelike margin, on one side articulates suturally with angular and on the other with the antero-dorsal portion of articular. The posterior ridged margin forms a tight articulation with the "fovea articularis" portion of articular. On the outer side of ramus, its uppermost anterodorsal margin articulates with coronoid by means of a curved suture originating at its anterodorsal outer aspect and passing on the inner aspect of the mandibular ramus. The inner surface is provided with an elongated and roughly oval depression (fossa Meckellii).

Splenial (Opercular, Text-figs. 5 A & B) : It is an elongated, median and triangular bone, articulating suturally antero-dorsally and anteriorly with dentary, postero-dorsally with coronoid, posteriorly with articular and ventrally with angular. Its anterior end possesses a slight concavity, bifurcating the tip into two parts. The lower part of its anterior end forms the extreme posterior boundary of the cavity for Meckel's cartilage. The suture between it and the coronoid is much serrated.

Coronoid (Complementary, Text-figs. 5 & B) : It is a roughly X-shaped bone having a straight median crest and two arms, visible on the inner aspect of ramus. Its anterior, quite broad bladelike arm articulates with splenial by a much serrated oblique suture. The posterior, slightly curved and narrow arm articulates postero-ventrally with surangular. The extreme dorsal apex of coronoid is known as "processus massetericus" and makes the extreme upper end of the median ridge of coronoid, which descends gradually and ultimately forms a sutural connection with underlying articular.

Dentary (Text-fig. 5 B) : The dentary is a major and most important tooth-bearing element of the lower jaw and constitutes more than half of the mandibular ramus. On the outer side, its posterior margin articulates with surangular and with the median upper aspect of angular. The articulation with angular is continuous on the inner side of the ramus. The postero-dorsal outer margin articulates with coronoid. On the inner aspect of ramus, it articulates with coronoid and splenial. A distinct cleft, the crista-dentalis, is present on its dorsal aspect.

The crest possesses a row of regularly arranged 19 teeth, of which the posterior 16 are molars and the rest are pointed and slightly recurved canines. All the teeth are sheathed firmly above minute concave depressions. Just below the Crista-dentalis lies a narrow canal for the Meckel's cartilage.



Text-fig. 5. A. Outer view of the ramus of the mandible.
 B. Inner view of the ramus of the mandible ;
 C. Hyoid apparatus.

In lizards, the articulation of mandibles with skull and the intermandibular articulation has considerable taxonomic significance. The comparison of these structures with that of fossil forms might serve as an important tool in tracing the exact ancestry of modern lizards. The intramandibular region is a structure of importance in reptilian taxonomy and the further studies on it might also help in establishing, the proper place of lizards among reptiles.

(11) *The Hyoid apparatus* (Text-fig. 5 C)

All the three visceral cornua or arches of the hyoid apparatus are well developed and emerge on each side from corpus hyoideum extending backward and upward in the region of neck. The corpus hyoideum, which represents the main body of the hyoid apparatus, is cartilaginous medially and bony on the margins. The anterior portion of corpus hyoideum becomes narrow and gradually extends anteriorly into a slender tapering medial process, known as processus lingualis or processus entoglossus. The anteriormost cornua or the hyoid cornua, which emerges on either side of corpus hyoideum is formed by the union of two parts. The proximal part of the hyoid cornua is a short bony element having a cartilaginous connection with the long slender distal portion. The first branchial cornua is also composed of two parts, a much elongated proximal bony ceratobranchial and a minute distal cartilaginous epibranchial. From the posterior aspect of corpus hyoideum on either side emerges two parallel long whip-like bony extensions representing the second branchial cornua of the hyoid apparatus.

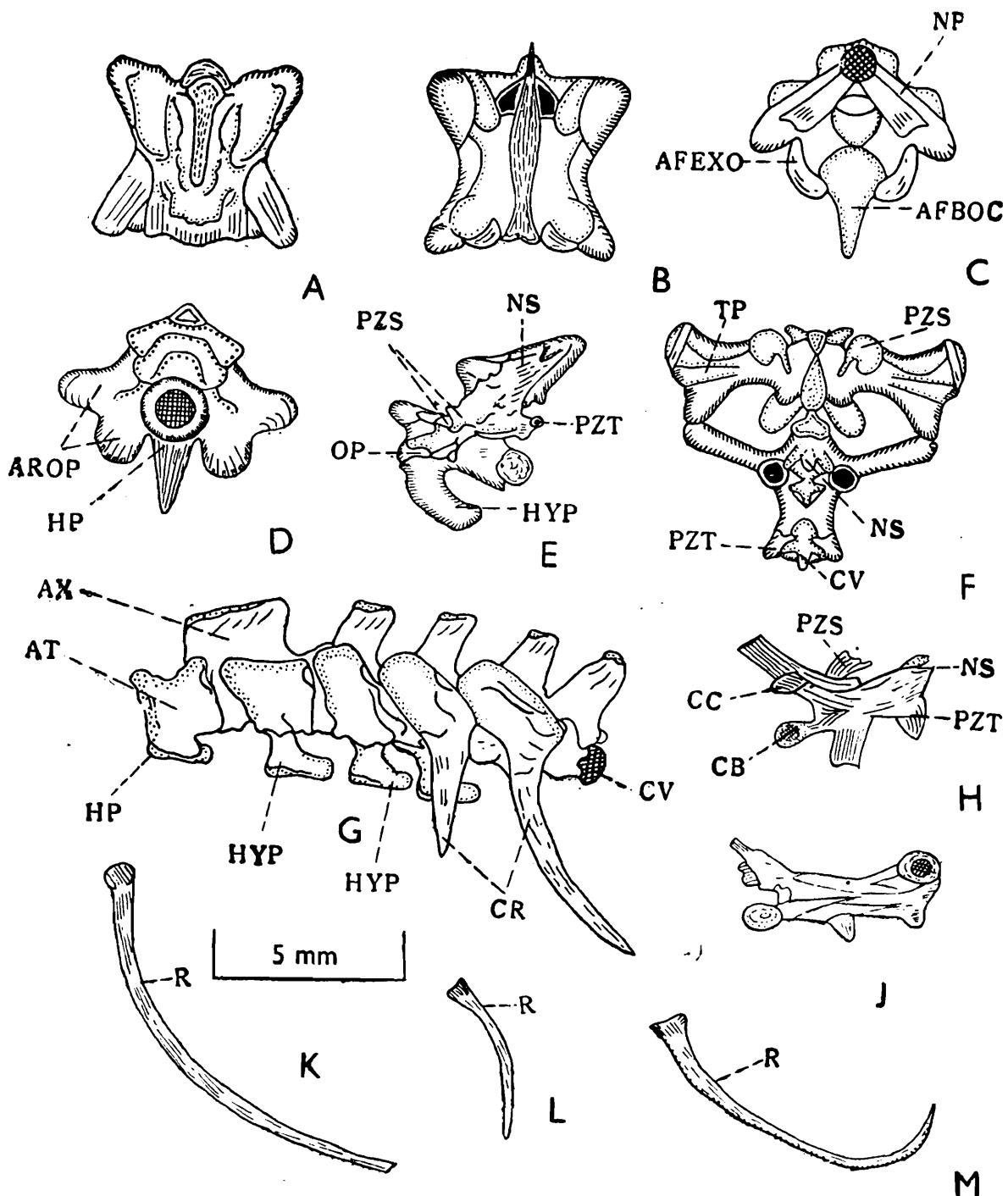
(B) **The Vertebral complex**

(Text-fig. 6)

The vertebral column is made up of 57 procoelous vertebrae (7 cervical, 18 thoracic, 1 lumbar, 2 sacral and 29 caudal). The posterior 4 cervicals and the anterior 17 thoracics bear ribs. The 6 posterior thoracic, the lumbar and both the sacral vertebrae possess enlarged transverse processes. In the posterior thoracic vertebrae the transverse processes are much enlarged and look like fused ribs. Out of the 29 caudal vertebrae, the 8 anterior ones possess transverse processes and neural spines, while the remaining 16 are devoid of such structures.

The Cervical vertebrae (Text-fig. 6 G) : The first 3 cervical vertebrae, viz. the atlas, the axis and the third one are devoid of ribs ; the remaining 4 possess free ribs.

The atlas (Text-figs. 6A, B, C & D) : It is devoid of neural spine and transverse processes. Its dorsal surface bears a flat neural arch formed by the union of the lateral neuropophysis. Basally both the neuropophyses have a bony connection with the hypapophysis. The dorso-



Text-fig. 6. A. Dorsal view of atlas vertebra ;
 B. Ventral view of atlas vertebra ;
 C. Anterior view of atlas vertebra ;
 D. Posterior view of atlas vertebra ;
 E. Lateral view of axis vertebra ;
 F. Dorsal view of scral vertebrae ;
 G. Mode of articulation in cervical vertebrae ;
 H, and J. Lateral aspect of caudal vertebrae ;
 K, L, and M. Ribs.

posterior portion of the neurapophysis (postzygapophysis) forms a firm articulation with the prezygapophysis (post-zygapophysis) forms a firm articulation with prezygapophysis of the axis vertebra. Certain bony thickenings on the anterior aspect forms the articular facets for the exoccipital and the basioccipital. On the same aspect a median, ventrally projected spine-like hypocentrum is visible. The posterior aspect bears articular facets for the odontoid process of the axis. Each dorsolateral portion of the atlas is formed by the union of antero-dorsal and postero-dorsal parts of the neurapophysis.

The axis : (Text-fig. 6 E) : It is devoid of transverse process and possesses a pointed, posteriorly directed, laminar neural crest on the dorsal aspect. A prominent, posteriorly curved hypapophysis and an antero-median somewhat conicervical vertebrae possess a pre- and postzygapophysis, a well developed neural spine and a hypapophysis on the ventral aspect except that the third one is devoid of ribs.

The thoracic vertebrae : These are 18 in number, and possess well developed pre- and postzygapophysis, neural spines, and cup-shaped sockets at the base of antero-lateral aspect of the cranium for providing movable articulation to ribs.

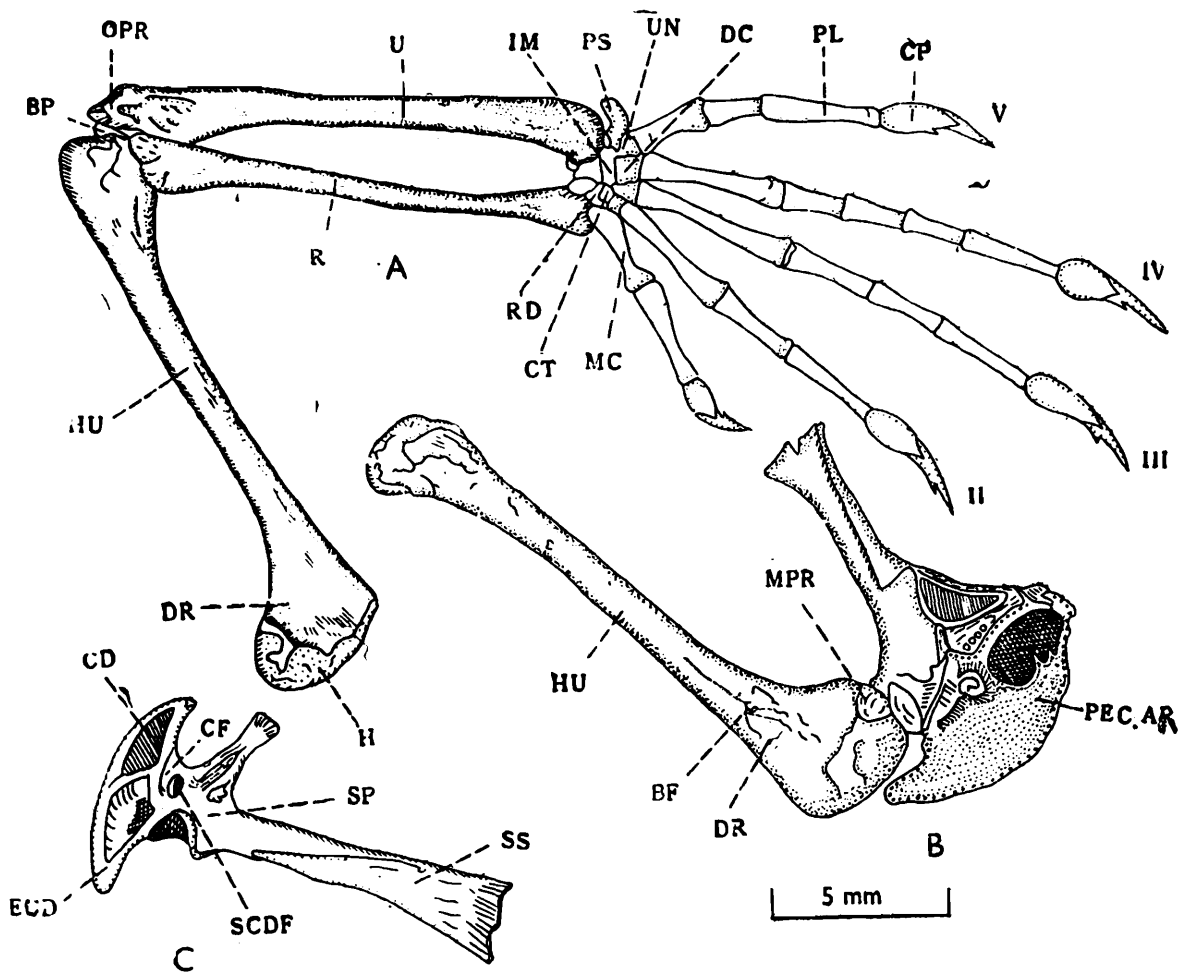
Lumbar : A single lumbar vertebra with a strong antero-dorsally pointed pre-zygapophysis and a well developed transverse process, lies between the thoracic and the sacral vertebrae. It does not bear ribs and its postzygapophysis is fused medially with a postero-dorsally directed neural spine.

Sacral (Text-fig. 6 F) : Sacrals are two in number and bear laterally well developed and expanded transverse process. Neural spines are less prominent. Haemal arches are lacking and pre- and postzygapophysis are well developed. The transverse process of anterior sacral is stronger than that of the posterior one.

Caudal vertebrae (Text-fig. 6 J) : The 29 caudal vertebrae are differentiated into three types, thus : (i) The Intermediate postacrals with a well developed transverse process, neural spines and devoid of haemal arches. (ii) The remaining anterior caudal vertebrae with transverse process, neural spines and haemal arches. The haemal arches or chevran bones are the ventral extensions which emerge from the centrum (intercentrum) and form a demarcation between the caudal muscles. (iii) The elongated tubular posterior tail vertebrae without transverse processes and neural spines but with well developed pre- and postzygapophysis.

suprascapula, coracoid, epicoracoid, clavicle and interclavicle participate in the formation of this girdle. The Supra-scapula and epicoracoid are cartilaginous structures while the other four are bony.

The Clavicles (Text-fig. 7) are curved bones on the ventral side, articulating medially with the anterolateral aspect of interclavicle. Dorso-medially clavicles rest just above the epicoracoids and extend laterally to touch at the middle of anterior margins of scapula. *The Interclavicle* (Text-fig. 7) is a roughly T-shaped median ventral bone lying beneath the sternum. *The Suprascapula* (Text-fig. 8 C) It is a thin cartilaginous



Text-fig. 8. A. Humerus, radius, ulna and bones of manus ;
 B. Humerus and pectoral arch ;
 C. the Ventral view of the pectoral arch.

bone attached to the dorso-lateral edge of scapula. *The Scapula* (Text-fig. 8 C) forms a dorso-lateral bony extension of pectoral girdle, and forms a sutural articulation with coronoid. *The Coronoid* (Text-fig. 7) is a large flat slightly convex structure bearing the glenoid fossa. Its thin sharp and curved median part articulates posteromedially with cartilaginous epicoracoid. A minute circular aperture, the coronoid fossa, lies above the glenoid fossa.

The Forelimbs (Text-fig. 8) : Each forelimb consists of the humerus, ulna, radius, carpals, metacarpals and phalanges. *The Humerus* (Text-figs.

8 A & B) is moderately elongated bone with a shaft and broad ends. The proximal end articulates with pectoral girdle. The deltoid ridge is quite prominent and bicipital fossa (depression between deltoid ridge and head) possesses many foramina. The bicondylar distal end articulates with radius and ulna.

Radius and Ulna (Text-fig. 8 A) are thin elongated bones lying parallel to each other. The radius is thinner than ulna and both articulate with each other proximally. The Ulna bears well developed postaxially projected olecranon process. On the distal aspect, ulna articulates with pisiform and the ulnare, and radius fits into a socket-like proximal aspect of radiale.

The Metacarpals (Text-fig. 8 A) are five in number. The first and the fifth ones are the smallest in size. Third metacarpal is the longest, while the second and the fourth are of equal size. The phalangeal formula is 2, 3, 4, 5, 3. Each distal phalanx of all the five digits is strongly clawed and bears a notch on the inner aspect of its terminal portion. *The Carpus* (Text-fig. 8 A) is formed of 9 elements viz., the pisiform, well developed ulnare and radiale in proximal series ; a small centrale in the middle row and 5 carpals in the distal row. Out of 5 distal carpals, first is very small ; second and third are of moderate size and compressed on sides ; fourth is biggest, compressed on sides and fifth is slightly rounded, smaller than fourth.

The Pelvic girdle (Text-fig. 9)

The Pelvic girdle is composed of two triradiate elements to form a bilaterally symmetrical composite structure. Each triradiate half consists of three bones viz., pubis, ischium and ilium. All these bones of each innominate fuse with one another on the lateral aspect and the sutures between them are not distinct.

Pubis (Text-figs. 9 B, C & D) : It is an anteroventral, dorsoventrally compressed and somewhat triangular bone. Its anteriormost tip bears a minute cartilaginous structure, the epipubis. The laterally directed angular process (prepubic process) is well developed and tipped with cartilage. The posterior arm of pubis ends into a ridge forming the anterior boundary of acetabulum and merges with the depressed anterior end of ilium. Posteriorly pubis bears a foramen for the obturator nerve.

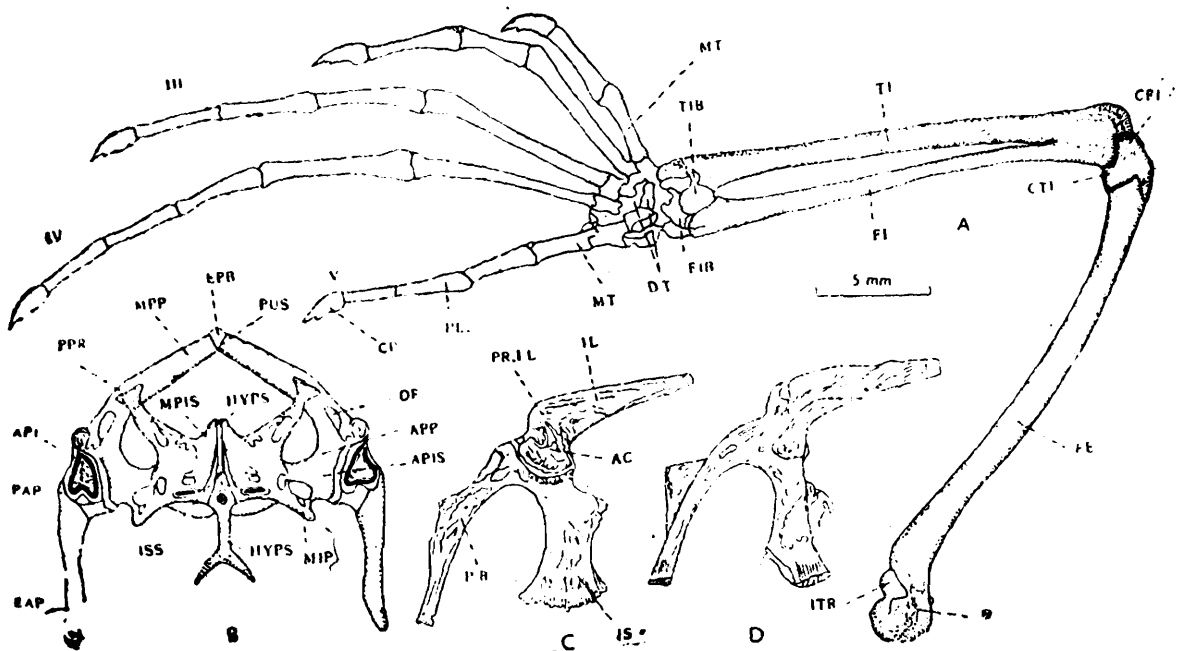
Ischium (Text-figs. 9 C & D) : Ischium is a broad and roughly fan-shaped bone, separated from its counterpart of opposite side by hypoischial cartilage. The bone is ridged at the acetabular end forming the anteromedial portion of the acetabulum.

The Hind limbs (Text-fig. 9)

Each hind limb is made up of femur, tibia, fibula, tarsus and pes.

Femur (Text-fig. 9 A) : It is a strong elongated and rod-shaped bone with a shaft and articular extremities. The proximal end possesses a head which fits into the deep acetabulum. On the preaxial aspect near the head is present a process, known as trochanter. The distal end is bicondylar articulating with the proximal ends of tibia and fibula.

Tibia and Fibula (Text-fig. 9 A) : The Tibia is a strong bone lying preaxially while the fibula is a thin postaxial bone. Both of them rest side by side articulating with each other at proximal and distal aspects.



Text-fig. 9. A. Femur, tibia, fibula and bones of tarsus ;
 B. Upper view of the pelvic girdle ;
 C. Dorsal view of the innominate of pelvic girdle ;
 D. Ventral view of innominate of the pelvic girdle.

Tarsus (Text-fig. 9 A) : It is made up of 6 parts namely, febulare, tibiale, and four nodular structures, situated on the proximal ends of metatarsals. Fibulare and tibiale are united by a median compact suture. The proximal aspects of fibulare and tibiale are provided with slight concavities which receive the distal ends of fibula and tibia. Tibiale is almost three times as large as fibulare and provides articulation to the distal end of tibia and almost half of the distal aspect of fibula. The remaining four pieces of tarsus form its distal row and articulate with the proximal ends of metatarsals. The first piece is very small and articulates with first metatarsal ; second is slightly bigger and articulates with second and third metatarsals ; third one is roughly triangular

central piece articulating with fourth metatarsal and fourth is small rounded, cartilaginous structure partly fused with fifth metatarsal.

Metatarsals (Text-fig. 9 A) : They are 5 in number, out of which third and fourth are of equal size ; second is smaller than third ; first is almost half of the second and fifth is the smallest, much ossified and hooked. The phalangeal formula is 2, 3, 4, 5, 4 (number of phalanges in first to fifth toe). All the digits are strongly clawed.

SUMMARY

1. The skull bones are well ossified.
2. A minute bony structure extending from the anterior cephalic margin of supraoccipital provides a loose connection between the supraoccipital and parietal.
3. The frontal articulates with nasals, premaxilla and prefrontals by a much serrated acute margin formed by the sharp pointed bony invaginations.
4. The median posterior border of prefrontal overlaps the palatine.
5. The postfrontal and postorbital bones fuse together and form a single bony structure, i. e., Postorbitofrontal.
6. A minute foramen is present in the middle of the transverse frontoparietal suture.
7. The Basisphenoid at its anterior aspect bears a median prolonged spinose bony structure, the basisphenoidal rostrum.
8. The Parasphenoid is perfectly ossified.
9. The Prevomer is toothless, dermal, leaf like bone.
10. The Vomeronasal organ is a club-shaped outgrowth in the nasal cavity.
11. The Nasals are completely separated by the processus nasalis of premaxilla.
12. The Pterygoids are toothless, triradiate dermal bones.
13. The Palatines articulate with prevomer.
14. Lachrymal bears an orifice at the anterolateral corner of the orbit for the passage of the lachrymal canal.
15. The opisthotic is represented by a posterolateral thickening on the paraoccipital process of exoccipital.
16. The Tympanum is not exposed.
17. The Maxilla is provided with one incisor, one canine and 15 or 16 molars.

18. The Quadrate has a ligamentous articulation with lower jaw.
19. The intermandibular articulation is ligamentous.
20. The Prearticular and articular are fused and have been formed as a result of endochondral ossification.
21. The Dentary possesses 3 pointed canines and 16 molars.
22. The Hyoid and the first branchial cornua are composed of two parts.
23. The vertebral column is made up of 57 procoelous vertebrae (7 cervical, 18 thoracic, 1 lumbar, 2 sacral and 29 caudal).
24. There are 22 pairs of ribs out of which five are attached to the sternum.
25. A separate Xiphisternum is present and sternum bears a pair of fontanelles.
26. The suprascapula and epicoracoid are cartilaginous.
27. The bicipital fossa of deltoidridge of humerus possesses many foramina.
28. The metacarpals are five in number ; the phalangeal formula is 2, 3, 4, 5, 3, and the Carpus is formed of 9 elements.
29. The pubis, ischium and ilium fuse with one another on the lateral aspect.
30. The tarsus is made up of 6 parts.
31. The metatarsals are 5 in number, the third and fourth are of equal size ; the phalangeal formula is 2, 3, 4, 5, 4.

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