GENERAL SUMMARY
Classification:

The three genera, *Xenentodon*, *Hemirhamphus* and *Exocoetus*, are intimately related and form the order Beloniformes among the Teleostomi (Berg, 1947).

D. 16-17; P. 11; V. 6; A. 17; C. 15.

External features and Integument:

- The sexes in *Xenentodon cancile* can be distinguished by the presence of a hump in the male between the head and the dorsal fin.

- Minute cycloid scales cover the body.

- There are two lateral lines of which one is latero-ventral in position.

- Lower jaw is provided with a labial fold. It is clearly
visible in the living condition and is constantly in motion and appears to be a balancing organ for the snout.

- The integument has an epidermis made up of stratified epithelium and regular malpighian and pigment cells. Mucous cells are present in the integument but Leydig's cells are absent.

**Skeleton system:**

- The skull is a narrow elongated structure.

- The olfactory region has nasals, ectoethmoids, lachrymals, a median ethmoid and a vomer.

- The orbito-temporal region has paired frontals, parietals, alisphenoids and the median basi- and parasphenoids.

- The post-temporal bone connects the skull to the supra-cleithrum of the pectoral girdle.

- The orbital ring is formed of supraorbital and postorbital bones.

- In the otic region are found the paired prootics, epiotics, sphenotics, pterotics and opisthotics bones.

- The occipital region includes the dorsal supra-occipital, paired ex-occipitals and the ventral basi-occipital.

- Each ex-occipital bears a small condyle. The ex-occipital meets the foramen magnum.
The basi-occipital has a condyle with which the centrum of the first vertebra is fused.

The palato-quadrate bar shows the paired palatines, pterygoid, metapterygoid and the quadrates.

Major portion of the upper jaw is formed by the premaxilla. No teeth are present on the maxilla.

The lower jaw is made up of a dentary, an articular, an angular and a supra-angular.

The presence of both the articular and angular as well as the supra-angular bone is noteworthy.

The supra-angular has a special pointed process for attachment of the adductor mandibulae muscles.

The hyoid arch on each side includes a hyomandibular, a symplectic, an interhyal, an epihyal, a ceratohyal, a hypohyal and a basihyal.

The hyomandibular and symplectic function as a support for the suspensorium.

The urohyal joins anteriorly with the hypohyal while on the posterior side it bifurcates to meet the cleithrum.

There are 11 branchiostegal rays.

Of the opercular bones (viz. opercular, preopercular and the interopercular), it is the opercular bone which shows
an interesting feature. On its inner side is present a process arising near the anterior margin and meeting the opercular again at the posterior margin, thus forming a hole or aperture.

- There are five pairs of branchial arches of which first four support the gill filaments while the fifth pair is reduced to small and median inferior pharyngeal bones.

- The fourth branchial arch is without a hypobranchial. A separate fourth basibranchial is also wanting.

- The vertebral column has sixty one amphicoelous vertebrae.

- First vertebra is fused with the basi-occipital bone.

- The pectoral girdle is made up of six bones; the supracleithrum, meta-cleithrum, cleithrum, coracoid, scapula and post-cleithrum or post-cleivcle.

- The pelvic girdle is made up of two halves, each corresponding to the ilium and ischium.

- Caudal fin is over all of homocercal type.

Muscular system:

Due to its elongated and cylindrical body, presence of a long snout and predatory habits, Xenentodon shows a number of interesting modifications in its morphology. The special myological features are as follows:
- Trunk musculature is of usual type showing myomeres, myocommae and the red muscle.

- M. supracarinalis is made up of two parts due to the presence of a single dorsal fin. The M. infracarinalis is found in three parts. The first two parts, anterior and medius, are little separated from the trunk musculature but the infracarinales posterior is distinct.

- Unpaired fins have the usual teleost musculature.

- The operculum and its musculature show an interesting mechanical device which allows for optimum action with little effort. M. adductor operculi slides through a latch-like process on the mesial (internal) side of opercular bone. The slight contraction of this muscle can adduct the operculum to any desired degree.

- M. adductor mandibulae are three in number.

- M. quadratomandibularis internus has two faciae.

- M. intermandibularis is found not at the tip of the mandibles but after about five to seven teeth. It appears to help in pushing the food material further inside the buccal cavity.

- Hyomandibular bone though small is surrounded by muscles on all sides. A slight movement of the hyomandibular results in larger movements of the pre-opercular, metapterygoid and the opercular bones.
- M. geniohyoideus or protractor hyoideus has a dividing septum.

- M. interhyoideus is absent.

- Four epibranchial muscles are present in the pharynx.

- Oblique muscles in the arches are absent.

- A single large M. rectus subbranchialis is present.

- The muscles between the pharynx and the pectoral girdle, Mm. pharyngeoclavicularis externus and pharyngeoclavicularis internus are well developed.

- M. levator pectoralis is reduced.

- The pharynx is provided with a short protractor and long retractor dorsally on each side. These two, along with Mm. pharyngeo-clavicularis externus and pharyngeo-clavicularis internus are the main muscles used in swallowing the food material.

- The pectoral fin musculature shows three abductors, two adductors and two extensors.

Digestive system:

- Xenentodon is a purely carnivorous fish. Its alimentary canal is divided into -
  
  (a) Buccal cavity & pharynx  
  (b) Oesophagus  
  (c) Stomach-intestine  
  (d) Rectum.
- The inner lips are present but a typical palatine organ is missing. Instead the tongue mass forms a pad which fits into a corresponding depression in the roof of the mouth. The inner lip and the tongue mass not only help in respiration but also in holding the prey.

- There is a large sac-like structure representing both the stomach and intestine.

- The pancreatic and bile ducts open separately on a papilla in the stomach-intestine.

- An ilio-rectal value is present.

- Mucosa of the alimentary canal differs in the different regions.

- The mechanism of swallowing is quite interesting and shows adaptation for catching and swallowing a living prey.

- Buccal cavity is lined by stratified epithelium in which unicellular mucous glands, sensory papillae as well as the taste buds are present.

- The alimentary canal is composed of serosal, muscularis, submucosal and mucosal components. The thickness of these components varies in the different parts.

- Apart from the mucosal glands, cells resembling the perietal cells of the mammals, appear to be present in the stomach-intestine.
- The liver is enclosed in a fibrous tissue capsule. Two to three hepatic cells are found between any two blood sinusoids.

- Bile capillaries are minute canals between the hepatic cells.

- The gall bladder is made up of an internal epithelium, a large circular muscle layer and a thin peritoneal layer on the outside. The same layers are continued into the bile duct.

- Pancreas is mainly intrahepatic. Both the extra- and intrahepatic portion of pancreas have a thin outer covering.

- The endocrine portion of pancreas stains lighter than the exocrine portion.

- There is a single islet of Langerhans.

**Air bladder:**

- Air bladder is a single continuous structure but in some specimens two constrictions are seen on its outer surface.

- The diaphragm and the pneumatic ducts are absent.

- The anterior portion of the bladder has the red body leading to the retia-mirabilia and the gas gland.

- The resorption area is not specially marked off. The entire left dorso-lateral surface appears to perform this function.
Respiration system:

- It consists of four gills on each side.
- The hyoidean gill is modified into a pseudobranch which is of a closed type.
- Each branchial arch carries a double row of gill filaments which are maximum (129 x 2 in the first arch and only 75 x 2 in the fourth branchial arch).
- The connections of blood vessels in the pseudobranch of Xenentodon are such that appears to control the supply of blood to the brain.

Vascular system:

The vascular system of Xenentodon basically follows the normal teleostean pattern but at the same shows a number of important differences and exclusive features thus:

- There is single atrio-ventricular valve guarding the atrio-ventricular opening.
- Coelisso-mesenteric artery arises from the right posterior epibranchial artery just near the union of the third and fourth efferent branchial arteries.
- Efferent pseudobranchial arteries join the internal carotid.
- Hepatic portal system is very well developed and includes blood from the muscles and the kidneys.
- Spleen has a double set of veins. One set is connected with the hepatic portal system while the other set opens into the post-caval vein.

- There is a large vein resembling the post-caval vein as in Dipnoi.

- There is only a single post-cardinal vein on the right side. The left is absent.

- There is no renal portal system.

- There are a number of connecting loops in both the arterial and venous systems.

**Nervous system:**

- The brain of *Xenentodon* is divided into the telencephalon (olfactory lobes and cerebrum), diencephalon, mesencephalon and rhombencephalon (cerebellum and medulla oblongata).

- Olfactory lobes are small and the olfactory peduncles are absent.

- Cerebrum is divided into axial, parietal and occipital lobes by rhinal, occipital and frontal fissures.

- There is a single median and narrow ventricle in the cerebrum.

- Diencephalon is demarcated by a velum transversum in front and by the posterior commissure behind.
Out of four regions of the diencephalon (epithalamus, ventral thalamus, dorsal thalamus and hypothalamus), dorsal thalamus is poorly developed.

Haebenular ganglia form two large ovoid masses in the epithalamus.

The hypothalamus is very well developed with an infundibulum and the lobi inferiores.

There is no saccus vasculosus.

On the roof of diencephalon there is some indication of the paraphysis but parapineal is absent.

The pineal is an elongated structure with a definite stalk. Numerous pigment granules are found in the pineal cells.

Tectum opticum is divided into two lobes. Torus semicircularis and tori longitudinales are well developed.

The cerebellum is roughly triangular in shape. Its antero-lateral corners form the acoustic-tubercles. The cerebellum throws out an anterior extension, the volvula cerebelli, into the cavity of mesencephalon. The volvula cerebelli are bifurcated anteriorly.

Posterior choroid plexus is more developed than the anterior choroid plexus.

There are ten pairs of cranial nerves and sixty one pairs of spinal nerves.
Sympathetic nervous system is indicated by a pair of sympathetic nerve cords which are connected to the spinal nerves by the ramii communicantes.

Receptor organs:

- The olfactory organ lies in a triangular depression in front of the eye.

- There is a special cutaneous fold arising from the middle portion of the ventral margin of olfactory pit which, when it falls upon the pit, divides the entire organ into an anterior and a posterior chamber.

- The olfactory epithelium is raised into a crescent shaped ridge which has special sensory bulbs.

- The water is guided towards the olfactory organ and onto the olfactory ridge by a minute gutter-like groove.

- The visual and stato-acoustic organs have the usual teleostean features.

- The lateral line canal system has the following components:
  
  (i) Lateral line canal
  (ii) Post-temporal canal
  (iii) Temporal canal
  (iv) Suprasorbital canal
  (v) Infrasorbital canal
  (vi) Pre-opercular canal
  (vii) Mandibular canal
- The infraorbital canal is incomplete.

- The ethmoid and the supra-occipital commissures are absent. The lateral line system opens by a number of pores.

- The neuromast organ is a mass of sensory cells placed on a basal epithelium. The entire neuromast organ looks like an elongated ampulla.

Endocrine organs:

- The endocrine glands in *Xenentodon* are hypophysis, pineal, thyroid, thymus, corpuscles of Stannius, interrenal, post-branchial, urophysis and the islets of Langerhans.

- The pituitary has the usual structure, however, the pars intermedia is centrally situated. Such a condition has so far been reported in only a few teleosts.

- Thyroid follicles surround the ventral aorta in the pharyngeal region.

- Thymus is present inside the pharynx dorsal to the branchial region on each side. It is without a peduncle and has simple structure.

- There are two corpuscles of Stannius one on each side of the median line. The internal cavity in each is filled with lamellae of simple epithelial tissue. The outer capsular wall is made up of flattened cells and is not fibrous.
- Post-branchial body lies squeezed between the oesophagus and the sinus venosus. Larger cells show lobulated nuclei.

- Urophysis forms a ventral enlargement at the caudal end of the spinal cord. There is great concentration of Dahlgren cells in the region of the Urophysis proper. The processes from these cells pass into the urophysis. Extensions of the pia mater into the urophysis are absent in this fish.

**Excretory system:**

- The kidneys are mesonephric. The anterior portion of each kidney has become modified into the interrenal body.

- Although renal in origin the interrenal bodies appear to function as the endocrine organs in the adult.

- In the nephron three parts that is distal neck, middle brush border and the proximal segments can be made out.

- The mesonephric duct lies in the median line. Anteriorly they separate and pass through or by the side of the interrenal body. Posteriorly the mesonephric ducts open separately into the urinary bladder, which opens to the outside by an independent urinary aperture.

**Reproductive system:**

- The testes are two in number of which the right is longer.

- Each testis is continued into a small vas deferens which
combines with that of the other side to form a common sperm duct.

- Seminal vesicles are absent.

- There is a separate male genital opening.

- The right ovary is slightly longer than the left.

- Connective tissue lamellae extend into the central cavity of the ovary. The central cavity is continued into a common oviduct.

- Six stages in the development of ova can be distinguished.

- The eggs of Xenantodon are remarkable due to the presence of external filaments. The formation of these filaments are quite interesting. The filaments are actually the out-growths from the vitelline membrane and not follicular structures for which they are likely to be mistaken.

- Atretic follicles are also found in the ovary.