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Cross-Sections of a 12-mm. Dolphin Embryo

By

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A 12-mm. embryo of a dolphin (Prodelphinus caeruleo-albus, Meyen) shown in Fig. 1 was embedded in celloidin, sectioned transversely and serially, 15 μ in thickness. Every other section of the series was stained with hematoxylin and eosin; and studied microscopically.

In the following, some of the important levels as indicated by guide lines on Fig. 2 are illustrated or photographed, together with brief descriptions. All sections are seen from the cephalic side. Hence the right side of the embryo is on the left side of figures.

There have been published only a few literatures upon the fetal development of whales or cetacea, among which Guldberg and Nansen's book (1894) is probably the most important and extensive one. They dealt mainly with the external features of dolphin fetuses (Lagenorhynchus acutus, Gray; Lagenorhynchus albirostris, Gray; Phocaena communis, Lesson; Orca gladiator, La Cépède; etc.), accompanied by some microscopic observation of partial sections.

In the present study, serial sections of a human embryo of some 10-mm. in length as well as of pig embryos of 11 and 13-mm. were used for comparison. Several books of embryology helped the observations, too. Among the referred are such books as written by Arey (1946), Baxter (1953), Boyden (1947), Grosser & Politzer (1953), Huettner (1952), Patten (1927, 48, 53), etc.

Fig. 3. Section through the Isthmus Rhombencephali and Pontine Flexure (Serial No. 57).

Because of the *pontine flexure*, the head is cut twice at this level. The section passes through the *mesencephalon*, *isthmus rhombencephali* and *metencephalon* on the anterior half, and the *myelencephalon* is cut on the posterior half. The cavity within the mesencephalon, the forerunner of the *aquaeductus mesencephali*, is still large, retaining the feature of the mid-brain vesicle. The *ventriculus quartus* is cut apart into two portions, each of which being covered by a very thin *ependymal roof* on one side.

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The wall of the neural tube has differentiated into three successive layers; (1) an inner, *ependymal layer*, (2) a middle, *mantle layer*, and (3) an outer, *marginal layer* (Plate I, 1). The ependymal layer, the contributor of neuroblasts and neuroglia to the mantle layer, is provided with multitudes of cells which are arranged radially. In the innermost zone of this layer, abutting on the internal limiting membrane, many mitotic cells are distinguished (Plate I, 2, 3). The mantle layer, which is to make up the gray substance in future, contains many cell bodies of the primitive neurons and neuroglial cells. The marginal layer, the progenitor of the white substance, is noncellular, consisting of processes of the mantle-layer cells or of the peripheral sensory cells.

The outer surface of the neural tube is surrounded by a thin, mesenchymal layer. This is the primitive *pia mater* or *leptomeninx* and its rich blood vessels in the area of the ependymal roof will participate in forming the *choroid plexus*.

In the mesenchyme between the neural tube and the epidermis are distributed many blood vessels, some of which are branches of the internal carotid or of the basilar artery, while others represent tributaries of the anterior cardinal vein (*anterior* and *medial dural plexus*).

The tip of the *endolymphatic duct* is cut along both sides of the ventral end of myelencephalon. The tiny section of the *trochlear nerve* is also noticed on each side of the rhombic isthmus.

Fig. 4. Section through the Fourth Ventricle (Ser. No. 69).

The *fourth ventricle* is sectioned nearly horizontally above its middle height. Due to the pontine flexure and probably also due to the shrinkage by the fixation, two fragments of its roof are cut.

Among new structures shown at this level are the rootlets of the *nervus oculomotorius* and of the *n. accessorius*. The former fibers are just leaving the wall of the mesencephalon.

The pricipal three-layered structure of the neural tube is a little rearranged in the anterior portion and the mantle layer is transformed to make up the primitive *nucleus n. oculomotorii*. Posterior to this is a part of the *trochlear nucleus*, too. A few of the mitotic cells are scattered in these primitive nuclei, although the mantle layer cells usually do not show cell-division. The primitive nuclei may be better regarded as outwards migrating cells of the ependymal layer.

The root fibers of the *accessory nerve*, emerging from the wall of the myelencephalon as well as of the spinal portion, form a somewhat thick trunk and run anterolaterad to join the vagus nerve.

Fig. 5. Section through the Apex of an Otocyst (Ser. No. 95).

On the right half of the section the apex of the left *otocyst* is cut laterally to the *endolymphatic duct*, while only a shaving of the left otocyst is in view on the opposite side.

The wide cavity occupying almost the middle one third of the section represents the metencephalic portion of the *fourth ventricle*, of which the inner surfaces of both sides bear *rhombic grooves* (III–VI) as well as the intervenient prominences, *rhombomeres* or *neuromeres* (III–VI).

Because of the cervical flexure, the anterior greater part of the *myelencephalon* is cut through the floor plate, although its posterior end is seen well as it approaches the spinal cord.

Alongside the myelencephalon are rootlets of the *nervus hypoglossus*, anterior to which the *n. vagus* leaves the brain wall. The *accessory nerve* is now adjacent the vagus trunk.

In the interval between the mesencephalon and metencephalon are the cut *oculomotor nerves*, surrounded by the *anterior dural plexus*. The left *trochlear nerve* is not grown down to this level, while the tip of the right one is still seen.

Fig. 6. Section through the Floor of Metencephalon (Ser. No. 109).

The section passes through the floor of the metencephalic portion of the fourth ventricle, leaving a narrow space on the median line. The fundamental three-layered structure of the neural tube is distorted not a little around here. For the nerve fibers begin to extend in all directions in the mantle layer, dividing the latter into more or less isolated cellular masses, which will become the so-called nuclei. Also the mixture of the gray and white substances, the formatio reticularis, will be formed.

About midway along the metencephalon is the *n. statoacusticus*, just issuing from the brain wall and directed to the *otocyst*. This nerve is composed of two nerves, the *nervi cochleae* and *vestibuli*.

The *endolymphatic duct* is now annexed to the otocyst. Posterior to the latter are the *nn. glossopharyngicus* and *vagus*, together with the *ganglia intracraniale* and *jugulare* respectively. The cells in the jugular ganglion are said to be sensory in function and to send fibers to the auricular branch of the vagus nerve. No trace of this tiny branch is, however, noticed in this dolphin embryo.

The *spinal cord* is cut obliquely at the level of the first cervical ganglion, although the corresponding ventral root does not occur yet. Along the inner margin of the spinal ganglion is the tiny cut of the *spinal accessory nerve*, which can be traced a little more distance below the present level.

Considerable number of mitotic cells are identified in the *spinal ganglia* (Plate I, 4). The same holds good for the semilunar ganglion as well as for the nodosoal, jugular, extra- and intracranial, sympathetic ganglia.

Fig. 7. Section through the Infundibulum, Ganglia Semilunare and Geniculi (Ser. No. 135).

The metencephalon has disappeared and the wide interval between the two cuts of the neural tube, the *diencephalon* and *spinal cord*, is occupied by the mesenchymal area.

On the midplane of this area are the *notochord* and *arteria basialis*, both of which cut lengthwise. The unpaired basilary artery is formed by the fusion of the paired vertebral arteries. On each side of the basilary artery is the *n. abducens*, which has emerged from the floor of metencephalon and is directed anterolatero-caudad to the primitive eye muscles.

Anterior to the *otocyst* in the middle of the section is the ganglion associated with the statoacoustic nerve. The *n. facialis*, situated lateral to the ganglion just mentioned and cut longitudinally, bears the *ganglion geniculi* on its anterior end.

The *ganglion semilunare* stands out as a large, oval cell mass circumscribed sharply. The *portio minor* of the trigeminal nerve is attached to the inner side of this ganglion.

The vascular space between the semilunar and geniculate ganglion represents the *vena capitis prima* that is the main tributary of the anterior cardinal vein and receives the anterior as well as the medial dural plexus.

The anterior cut of the neural tube, the diencephalon, has a midventrally directed pouch, the *infundibulum*, which will furnish the posterior lobe of the hypophysis.

Between the facial nerve and spinal cord, named in order, are the *n. glossopharyngicus*, *anterior cardinal vein* (vena jugularis interna), *nn. vagus* and *accessorius*, *n. hypoglossus*, the first cervical nerve and the *vertebral artery*. The 1st cervical nerve is seen as it divides into the vental and dorsal rami, surrounded by the thick, mesenchymal cell mass destined to form the cervical muscles.

Fig. 8. Section through the Fornix Pharyngis, Ganglia Extracraniale and Nodosum (Ser. No. 145).

New structures occurring on the present section are the *fornix pharyngis*, the *ganglion extracraniale* of the glossopharyngeal nerve, the cranial end of the *ganglion nodosum* of the vagus nerve, the *1st* *branchial groove*, the *1st pharyngeal pouch*, the *nervus petrosus superficialis major*, the primitive *eye muscles*, a bit of the *Rathke's pouch*, etc.

The *n. petrosus superficialis major*, whose existence in the adult whales or dolphins is not yet ascertained, is represented distinctly in the present fetus by a tiny nerve bundle that has arisen from the geniculate ganglion of the facial nerve and runs anteromedio-caudad.

The *1st branchial groove*, the future external acoustic meatus, is cut midway along each side of the embryo. Althogh it seems to be continuous with the lateral end of the *1st pharyngeal pouch* lined with thick epithelium, this communication must be due to the artificial rupture of the *closing membrane*.

The *Rathke's pouch* which has originally budded from the stomodeal epithelium and is destined to furnish the glandular hypophysis shows on this section as two cuts that flank the *infundibulum* on both sides.

The *semilunar ganglion* is bordered mediad by the *cavernous sinus*. Anteromedial to these structures is the accumulated mesenchymal mass representing the primordial *eye muscles*, *nn. abducens* and *oculomotorius* being located within it.

Fig. 9. Section through the Optic Cup (Ser. No. 153).

Inside the *pharyngeal cavity* is a shaving of mesenchymal tissue lined with epithelium, which represents the *root of tongue*.

Anterior and posterior to the pharynx are two cuts of the *notochord*, the anterior one of which is close to its cranial end.

The *facial nerve* located lateral to the pharynx has just given off a small branch, the *chorda tympani*, which is, like the n. petrosus superficialis major, not yet ascertained in the adult whales or dolphins. The *1st pharyngeal pouch* and the *internal carotid artery* are cut lengthwise, the latter being crossed externally by the *n. petrosus superficialis major*.

The semilunar ganglion has disappeared at this level and two branches of the trigeminal nerve, *nn. maxillaris* and *mandibularis*, have occured. The mesenchymal condensation surrounding the latter nerve represnts the primordium of the *chewing muscles*.

The *Rathke's pouch* shows now as a vesicle, of which the anterior and posterior wall will furnish respectively the *anterior lobe* and the *pars intermedia* of hypophysis (Plate II, 5).

Anterolateral to the primordial eye muscles is the cut *optic cup* that is a double-walled vesicle now. The inner thick layer of this vesicle is the forerunner of the *retina* and the outer thin coat, the progenitor of the *pigment epithelium*, is provided with pigment granules already (Plate II, 6).

Among new structures appeared on the dorsal half of this section is the sympathetic nerve which is situated close to the vagus nerve. Traced caudad it joins the *ganglion cervicale craniale* of the *sympathetic trunk.*

Fig. 10. Section through the Root of Tongue and Lens Vesicle (Ser. No. 163).

This section passes approximately 150 μ below the previous level. What marks this level is the wide *pharyngeal cavity* with the cut *first* and *second pharyngeal pouches* extending respectively anteromediad and posterolaterad. Needless to say, the former pouch is to furnish the *tympanum* as well as the *tuba pharyngotympanica,* while the latter one foreshadows the *tonsillar sinus.*

The root of tongue shows as a large, separate mass in the pharyngeal cavity. Its anterior portion must be the *tuberculum impar* and the middle, lateral expansions may represent the *copula.*

Posterior to the 2nd pharyngeal pouch are *nn. glossopharyngicus, vagus* and *hypoglossus.* The nerve bundle cut lengthwise laterally to the left vagus nerve is the *ramus externus of the accessory nerve.* On the right side the whole accessory nerve is still accomanying the vagus trunck. The *cranial cervical ganglion* of the *sympathetic trunk* has come into view on the dorsal side of the vagus.

In the anterior part of the section, *n. maxillaris* is diminishing in size considerably. The *optic vesicle* is cut nearly through its center and therefore the *lens vesicle* is sectioned on this plane. A thin ectodermal layer, the *corneal epithelium,* borders outside.

Fig. 11. Section through the Origin of Rathke's Pouch, Epiglottis and Optic Stalk (Ser. No. 173.)

Characteristic of this section is the division of the pharyngeal cavity into two parts. The anterior one is the *oral cavity* or *stomodeum,* of which the epithelium is ectodermal. Although the *oral* (or *pharyngeal*) *membrane* marking the boundary between the ectodermal and entodermal epithelium has disappeared at this stage, the *Rathke's pouch* that has arisen just in front of this membrane is shown to continue with the anterior wall of the oral cavity on the midline.

The *pharynx* is now a transverse slit compressed antero-posteriorly and the prominence boundering its anterior wall represents the *epiglottis.* Antero-laterad to this pharyngeal slit is the cut apex of the *2nd pharyngeal pouch.*

Flanking the vagus trunk mediad are two arteries, of which the anterior and the posterior are respectively the *3rd aortic arch* and the *internal carotid artery.*

The *glossopharyngeal nerve* has given rise to a small branch, *n. tympanicus,* to the antero-medial direction. The main trunk of this nerve is diminishing in the size.

The *optic stalk,* the connection between the *optic cup* and the *diencephalon,* is a thin tube, of which the lumen continues with the third ventricle on one side and with the space between the inner and outer layer of the optic cup on the other side.

Fig. 12. Section through the Foramen Interventriculare, Oral Opening, 3rd Pharyngeal Pouch and Glottis (Ser, No. 187).

The *telencephalon* is cut at the level of the *foramen interventiculare* connecting the *3rd ventricle* with the *lateral ventricle.* So the *cerebral hemisphaerium* is cut near its caudal end.

The *oral cavity* is now open to the external through the slit between the *maxillary* and *mandibular process.* The *n. mandibularis* in the mandibular process is still within view as tiny rootlets, while the *n. maxillaris* in the maxillary process does not reach this level.

The *pharynx* is an inverted V-shaped slit, of which the both feet represent the *3rd pharyngeal pouches.* The apex of this pouch is provided with two wings, the ventral and the dorsal, that are to furnish the *thymus* and the *parathyroid gland* respectively (Plate II, 7). Also the fourth pouch participates in this formation.

The triangular space located on the midline anterior to the pharynx represents the cranial portion of the *larynx,* while the linear, epithelial connection between the pharyngeal and laryngeal lumen is the primitive *glottis.* This is bordered on each side by a pair of the *arytenoid swellings,* which are said to be of the fourth and fifth arch origin.

The *3rd aortic arch* has shifted its position anterior to the 3rd pharyngeal pouch. Needless to say, it has crossed above the latter. Anterior to this aortic arch is the *external carotid artery,* the cranial extension of the ventral aorta. The *dorsal aorta* is located posterolateral to the pharynx, being flanked posteriorly by the *sympathetic trunk.*

Fig. 13. Section through the 4th Aortic Arch, 4th Pharyngeal Pouch and Thyroid Gland (Ser. No. 203).

On each side of the *pharynx* and *larynx* which are now separated completely from each other the *4th aortic arches* are cut lengthwise. Obviously the left one is larger than the right one. The anterior and posterior end of this arch are continuous with the *ventral* and *dorsal aorta,* although the right aortic arch meets the right ventral aorta slightly below the present level. The ventral aorta at this level is the progenitor of the *common carotid artery.*

Between the ventral aortae on each side is a mass of cell cords that represents the primordial *thyroid gland* (Plate II, 8). This is originally an entodermal pocket invaginating from the ventral floor of the pharynx, although the epithelial connection between this gland and the pharynx has disppeared already. The site of origin was in the midplane at the level of the 1st pharyngeal pouches.

The pharynx is sectioned through the proximal portion of the *4th pharyngeal pouch.* A portion of the primordial *parathyroid* derived from the dorsal wing of this pouch is also seen. The mesenchymal cell mass surrounding the larynx foreshadows the *laryngeal cratilages* and *muscles.*

Lateral to the 4th aortic arch are the *n. vagus, n. hypoglossus* and *vena jugularis interna.* The hypoglossal nerve has continued to shift ventrad and is now cut lengthwise as it courses ventromedio-caudad. The *ramus communicans* connecting between the *spinal nerve* and the *sympathetic trunk* is seen on the left side.

On the left side of the embryo a proximal portion of the *upper limb bud* is coming into view. The *mandibular nerve* in the same-named process is now beginning to disappear.

Fig. 14. Section through the Ventral Aorta and Primitive Choana (Ser. No. 215).

The section passes through the paired *dorsal aortae* and the single *ventral aorta.* The right dorsal aorta is, together with the right fourth aortic arch, to form the *right subclavian artery,* while the left one is to persist as the cranical portion of the permanent *descending aorta.* The *ductus arterious,* the sixth aortic arch of the left side, is also cut as it joins the left dorsal aorta. The unpaired ventral aorta is the cranial extension of the aortic trunk. It may be called the forerunner of the *ascending aorta.*

The *pharynx* and *larynx* are sectioned close to the caudal ends. Both of them are traced caudad respectively to the *oesophagus* and *trachea.* Ventromedial to the larynx is a portion of the primordial *thymus* which belongs to the ventral wing of the fourth pharyngeal pouch.

Nerve rootlets situated between the larynx and the dorsal aorta represent the *n. recurrens,* a branch of the vagus nerve. The vagus trunk is located laterally together with the caudal end of the *ganglion nodosum.*

The *mandibule* is now separate from the body of the embryo and retains no trace of the mandibular nerves.

The head is cut through the *nasal vesicle* and the *primitive choana.* The latter is the site of the ruptured *bucco-nasal membrane.*

Fig. 15. Section through the Apex of Pericardial Cavity (Ser. No. 223).

The section is marked by the appearance of the *pericardial cavity* as well as of tip of the *heart.* In the left portion of the pericardial cavity is a shaving of the *left atrium,* within which are many sinusoids filled with blood. The atrial wall and the trabeculae partitioning the sinusoids are provided with primitive muscles.

When the ventral aorta shown on the preceding section is traced caudad, it joins the *aortic trunk* which at the present level makes a prominence into the pericardial cavity.

On the midplane posterior to the pericardial cavity are, named in order, the *trachea* and *oesophagus* lined with thick epithelium. The mesenchymal masses surrounding these tubes foreshadow the connective tissues, cartilages or muscles of the tracheal and oesophageal walls.

The *right vagus* nerve is sectioned at the level of the caudal end of the *nodosal ganglion.* The branching of the right *recurrence nerve* and the right *cardiac rami* are shown, too. On the left side a portion of the *ductus arteriosus* or the left sixth aortic arch is still in view.

The *upper limb bud* is encountered on each side of the embryo : a nerve bundle belonging to the *brachial plexus* is inside the left one. The right and left *mandibular processes* are cut apart from each other.

In the head the *fila olfactoria* make connection between the brain wall and the epithelium of the *nasal vesicle.* The medial wall of the nasal vesicle lined with thick epithelium represents the *Jacobson's vomero-nasal organ.*

Fig. 16. Section through the Pulmonary Trunk (Ser. No. 235).

What characterises this section is the *pulmonary trunk* or the *common pulmonary artery* cut lengthwise on the left side of the aortic trunk. The distal or posterior end of this trunk divides into the *right* and *left pulmonary arteries* that have originated from the ventral halves of the 6th aortic arches. A little distance above the present level, the dorsal half of this arch or the connection between the pulmonary artery and the dorsal aorta is preserved well on the left side as the *ductus arteriosus,* while it has disappeared on the right side. On the anterior of the pulmonary trunk is the primordial *semilunar valve.*

Medial to the *anterior cardinal veins* which are now flowing into the *common cardinals* are the *vagus nerves.* This nerve on each side has just given rise to the *tracheal* and *oesophageal rami* caudad.

Fig. 17. Section through the Bulbus Cordis, Common Cardinal Veins and Origin of Right Apical Bronchus (Ser. No. 249).

The section passes through the undivided *bulbus cordis,* in which the lumen of *aorta* and *common pulmonary artery* are connected with each other through a narrow slit. The parenchyme masses abutting on this intervening slit on both sides represent the ventral and dorsal *bulbar ridges,* which have shifted position to the right and left side respectively.

The apex of the *pleural cavity* has come into view on each side of the *trachea.* The latter is just giving off the *right apical* or *eparterial bronchus.* Ventral to the trachea are the paired *pulmonary arteries.* The pleural cavity is continuous with the *pericardial cavity* through the *pleuro-pericardial communication* which is guarded laterally by the *pulmonary ridge* of Mall.

Lateral to the pleural cavity is a large space representing the *common cardinal vein* or the *duct of Cuvier.* This is approaching the sinus venosus now.

The *upper limb bud* is sectioned on each side of the embryo, provided with mesenchymal condensations foreshadowing the future bones and muscles. Also the cranial end of *brachial plexus* as well as the *phrenic nerve* is encountered on the section.

The head is cut through the *fronto-nasal process,* retaining only tips of the *nasal vesicles* inside. The cerebral hemisphaeria are lost to sight.

Fig. 18. Section through the Foramen Ovale I, Bifurcatio Tracheae and Nasal Pit (Ser. No. 261).

What marks this level is the *foramen ovale I* that is a perforation in the *septum primum.* Thus the right and left atrial chamber are partitioned incompletely from each other at this level. The right *common cardinal vein* has emptied into the right horn of the *sinus venosus,* while the connection between the sinus and the right atrium is to occur a little more caudad. The *right vertebral vein* is seen as it flows into the right common cardinal.

The root of the *bulbus cordis* is cut together with the apexes of right and left *ventricles.* In the center of the cut bulb is the triangular space of the aorta, while pulmonary trunk has just joined the right ventricle. The slit between the ventricles and artia represents the *transverse sinus.*

Posterior to the heart, on the midline, is the *bifurcatio tracheae*, and the cut apical bronchus is on each side. The *bronchial buds* in the primordial lung are continuing to grow and branch. They are lined with thick, ciliated epithelium at the present stage (Plate III, 9). The mesenchymal mass surrounding the bronchial buds is to furnish the cartilages, muscles, vascular channels as well as the interstitial tissues for the lung.

The head is sectioned close to its rostral end, and the *nasal pits* or the primitive *external nasal orifices* are shown at this level.

Fig. 19. Section through the Sinus Venosus (Ser. No. 273).

The *heart* is marked by the *sinus venosus* (right horn), which now drains into the right atrium through a silt-like opening. The projections guarding this opening on both sides represent the right and left *valves of the sinus venosus*. The *left common cardinal* is located in the pericardial cavity. Caudad it is traced to the *left horn* of the sinus venosus. *The septum primum* is complete at this level.

The *ventricles* have increased in size, the *aorta* being sectioned on the midplane. In the right ventricle a portion of the *atrioventricular canal* is cut obliguely. In the thich ventricular wall three layers can be discriminated, 1) the external, *pericardial* layer, 2) the middle, *myocardial* layer, and 3) internal, *endocardial* layer. The external furrow marking off the ventricles from the atria is the *coronary sulcus*.

In the primordial lung the left main bronchus is seen to give off craniad the *left apical bronchus*, of which the distal cut was observed already on the preceding section.

Among other structures which mark this level is the apex of the *peritoneal cavity*, which lies antero-lateral to the left dorsal aorta. Posterior to the dorsal aortae which are still separate from each other are the *vertebral arteries* and the *postcardinal veins*.

Fig. 20. Section through the Trunk of Pulmonary Vein (Ser. No. 287).

The section passes through the *trunk of the pulmonary vein*, which drains into the postero-caudal wall of the *left atrium* at the left of the *septum primum*. Later, this venous trunk will be progressively drawn into the left atrium, as the latter grows.

The septum primum is attached to the *endocardial cushion*. The structure just mentioned is originally endocardial thickenings which bulged from the ventral and dorsal walls of the common atrio-ventricular canal and have fused midway, dividing the single canal into the right and left one.

The *sinus venosus* (right horn) as well as some of the trabeculae are shown in the right atrium. The sinal valves are elongated ventro-caudad. The *right valve* will remain even in the adult heart, being subdivided and forming the *crista terminalis*, the *Eustachian valve* of the inferior vena cava as well as the *Thebesian valve* of the coronary sinus. *The left valve* is merely to fuse with the septum primum and secundum, in order to form a portion of the permanent atrial septum.

The internal cavity of the left ventricle has come into view, connected with the left atrium through the *left atrio-ventricular canal*, the primordium of the left atrio-ventricular ostium. This canal is guarded on each side by the cut endocardial cushions which foreshadow the *mitral valve*. The opening of the *aorta* into the left ventricle is also seen.

The thick, muscular partition between the ventricles represents the *septum interventriculare*. Posteriorly it joins the endocardial cushion.

Postero-lateral to the left atrium is attached the *left horn of the sinus venosus*, which has received the left common cardinal vein. This sinal horn is destined to disappear excepting its tip that is to furnish the stem of the *Marshall's vein*.

The *peritoneal cavity* occurs on each side, being separated from the pleural and pericardial cavity by the *pleuro-peritoneal membrane* and the *septum transversum* respectively. Both of these partitions will participate in forming the *diaphragma*, in cooperation with derivaties from the body wall and a part of the meso-oesophagus. At the left of the left phrenic nerve the *diaphragmatic muscle* is foreshadowed by a mesenchymal condensation.

Fig. 21. Section through the Anastomosis between Right and Left Dorsal Aortae (Ser. No. 293).

Most characteristic of the section is the confluence of the right and left *dorsal aortae*, thus forming the unpaired *descending aorta*. The *peritoneal cavity* has increased in size and a shaving of the left part of the *liver* occurs on the left side. In the primordial diaphragma the left phrenic nerve is cut close to its peripheral end, while the right one is still considerably large.

The heart is sectioned through the *transverse portion of the sinus venosus*, which is destined to receive the veins of the heart itself and is, roughly speaking, foreshadows the sinus coronarius.

The *right horn* of the sinus venosus is seen to receive the cephalic end of the *common hepatic vein*. The connection between the transverse portion and the right horn of the venous sinus is, however, not in view. It occurs slightly caudal to the present level.

Fig. 22. Section through the Pleuro-peritoneal Communication (Ser. No. 303).

The section is marked by the distinct appearance of the *liver* on each side as well as of the *common hepatic vein* on the miplane. The *heart* is cut through its basis and shows, excepting the caudal extension of the transverse portion of the sinus venosus, only the dorso-caudal walls of the ventricles.

The partition between the pleural and peritoneal cavity by the *pleuro-peritoneal membrane* is now incomplete on each side. For these two cavities are connected through the intervening foramen, the *pleuro-peritoneal communication*. The latter increases in size as the sections are traced caudad.

The *vagus nerves* adjacent to the oesophagus have shifted position to some extent, the left one moving to the ventral surface of the oesophagus and the right one dorsad. It means that the alimentary canal itself has rotated clockwise around its longitudinal axis.

Fig. 23. Section through the Ductus Venosus (Ser. No. 315).

Ventral half of the section is occupied by the *liver*, although a slice of the *heart* is still in view, restricted to the ventral border of the embryo. The liver nearly fills the *peritoneal cavity* and its parenchyme is permeated with network of cell cords and the intervening sinusoids (Plate III, 10). The former is a spongework of the primordial hepatic cells with oval nuclei and is stained lighter than the sinusoids, while the latter, filled with proliferative blood cells such as megaloblasts, normoblasts, myeloblasts, etc., is stained darker. Nucleated erythrocytes are found also in the circulating blood (Plate III, 11).

Even though traced the whole length of the liver, it does not show any sign of lobulation, while it is plainly lobulated in the human and pig embryos of the similar size.

The large vescular space in the center of the liver represents the *ductus venosus*, which receives several efferent veins from inside the liver and continues craniad with the common hepatic vein.

The right *vagus nerve* dorsal to the oesophagus bears peculiarly several ganglion cells at the present level. The *lung buds* approach their caudal ends and the *mesonephric ridges* have occured posterior to the former. Furthermore, the cranial tip of the left *mesonephros* or the *Wolffian body* is already in view.

Fig. 24. Section through the Stomach (Ser. No. 341).

The section is marked by the appearance of the *stomach, bursa omentalis, vena cava inferior, genital ridges*, etc., while the lung and heart are now lost to sight.

The *stomach* is a dilated portion of the fore-gut, which is connected with the liver and the dorsal body wall by the *omentum minus (gastrohepatic ligament)* and the *dorsal mesogastrium* (*omentum majus*) respectively. The internal surface of the stomach is lined with entodermal epithelium, although the foveolae and the gastric glands are not yet indicated.

The *vena cava inferior* is cut slightly below its confluence with the ductus venosus. Traced caudad it takes its course dorsad through the *caval mensentery*. The narrow space flanked by the caval mesentery, liver, omentum minus and the stomach represents the rostral extension of the *bursa omentalis* or the *lesser peritoneal sac*.

On each side of the *descending aorta* is the distinctive *mesonephros*. Together with secretory and collecting tubules, a *glomerulus* is also seen. The aorta supplies it with the *mesonephric artery*. Ventromedial to the mesonephric ridges occur the *genital ridges*.

The ventral attachment of the liver to the body wall is the *mesohepaticum ventrale*, on both sides of which the mesothelial lining of the liver reflects to the internal surface of the body wall.

Fig. 25. Section through the Adrenal Cortex and Vestibule of Omental Bursa (Ser. No. 363).

Because of the rotation of the *stomach* about its long axis, the original ventral wall (lesser curvature) is on the right side and the primitive dorsal wall (greater curvature) is on the left. The cut *omental bursa* is necessarily enlarged at this level, bordered behind by the elongated *dorsal mesogastrium*. The right portion of the bursa reprents the *vestibule* and it is bounded on the right side by the *caval mesentery*, within which the *inferior vena cava* passes.

On each side between the aorta and the mesonephros is the *adrenal cortex*. It is round in shape and consists of remarkable condensation of mesenchymal cells (Plate III, 12). This is not the primordium of the permanent cortex but represents the *provisional* or *fetal cortex* that is later to be replaced by cells of another type to furnish the permanent cortex. Both of these two kinds of cells are, however, thought to be traced origin to the same proliferative focus. The chromaffine cells to form the adrenal medulla are not yet identified. Very soon they will differentiate from the sympathetic ganglia and invade the medial side of the cortical mass.

Inside the liver the *umbilical vein* and the *portal vein* are cut as they flow into the ducts venosus.

Fig. 26. Section through the Foramen Epiploicum and Splenic Primordium (Ser. No. 371).

The Section passes through the *foramen epiploicum* which connects the omental bursa (vestibule) with the peritoneal cavity. Because of this communication the *inferior vena cava* is separate from the liver, although it still runs in the caval mesentery. *Right subcardinal vein* located just medial to the right mesonephros is seen to join the inferior vena cava.

The latero-dorsal surface of the dorsal mesogastrium shows a slight swelling which represents the primordial *spleen*. This swelling is due to the accumulated mesenchymal cells just beneath the lining, peritoneal epithelium (Plate IV, 13). Later on the splenic bulge increases in size and the mesenchymal mass will differentiate into red and white pulp, vascular channels, capsule, trabeculae, etc.

The *mesonephros* increases in size, too, and the *mesonephric duct* or *Wolffian duct* is cut inside the ventro-lateral margin of the mesonephric ridge. The *Müllerian duct* is, however, not identified.

Fig. 27. Section through the Root of Coeliac Artery (Ser. No. 379).

The *aorta* is cut as it gives off the unpaired *coeliac artery* and the paired *intersegmentary arteries* ventrad and dorsad respectively. These are originally ventral and dorsal intersegmentary branches of the aorta. The lateral branches are represented by the *mesonephric arteries*.

The *portal vein* is now shifting into the omentum minus and the *hepatic duct* is also seen anterior to the just mentioned vein.

The *adrenal cortex* and the primordial *spleen* are in almost the same condition as in the previous section. The vascular supply of the latter is through the *splenic artery* and *vein*, of which the former is a branch of the coeliac artery and the latter is a tributary of the portal vein.

The *gonad* in the genital ridge becomes larger as it is traced caudad. The gonad at this stage is indifferent or sxless. It's minute structure consists of internal cell mass lined with thick, *germinal epithelium* (Plate IV, 14, 15).

Fig. 28. Section through the Primordial Pancreas (Ser. No. 401).

The *liver* is cut near its caudal end, the right and left part being separate from each other. In the intervening space between these two is the *umbilical vein*, which is fastened to the ventral body wall by the *falciform ligament.*

The most conspicuous feature appearing on this section is, however, the primordium of the *pancreas* in the *mesoduodenum* (Plate IV, 16). It consists of two portions, the *ventral* and the *dorsal pancreas.* Both are originally outpouchings from the entodermal epithelium of the duodenum, and they are contorted as they grow. The duct of the ventral pancreatic primordium is shown at its union with the *hepatic duct* (antrum), thus froming the common duct for the bile and the pancreatic juice.

The *gall bladder* is not recognisible all through the series concerned, while it is well developed in the human and pig embryos in the similar stage of the fetal development. Therefore the lack of gall baldder must be characteristic of the whale or dolphin embryos as well as of the adult whales and dolphins.

The *portal vein* is now in the mesoduodenum, situated between the ventral and the dorsal pancreas. The *inferior vena cava* has, as already mentioned, fused with the right *subcardinal vein* which is located just medial to the right mesonephros. The left *subcardinal* is in view, too. The narrow spaces along the dorsal border of the mesonephroi represent the *postcardinal veins.*

Fig. 29. Section through the Exit to Superior Mesenteric Artery and Umbilical Cord (Ser. No. 419).

What marks the present level is the fusion of the *umbilical cord* with the fetus. The tip of the recurved *tail* of the embryo is also cut near the anterior border of the figure.

Concerning the body of the fetus itself, the mesenteric connection between the alimentary canal and the liver has disappeared, thus leaving only the dorsal mesentery or *mesoduodenum.* In this area the *duodenum* is cut just before its union with the *common bile duct.*

The splenic vein has jointed the portal vein already. So the caudal continuation of the portal vein at the present level represents the *vitelline vein.* The confluence of the superior mesenteric vein into the vitelline occurs still a little distance below the present section.

The *umbilical vein* is located in the ventral body wall of the fetus. It is large, being sectioned at the union of the right and left umbilical vein.

The cut *umbilical cord* shows such structures as the paired *umbilical arteries,* unpaired *urachus,* and the *extra-fetal coelomic extension.* Inside the last mentioned cavity are the shaving of the tip of the loop of herniated *small intestine,* the *superior mesenteric vein* as well as the rudimentary *vitelline vein.*

Fig. 30. Section through the Subcardinal Anastomosis (Ser. No. 443).

The section is characterised by the *subcardinal anastomosis* or the wide communication between the right and the left subcardinal vein. The *postcardinals* on both sides are also continuous with the anastomosis.

The *vitelline vein* cut somewhat lengthwise on the left of the small intestine is prominent into the peritoneal cavity. Traced caudad it becomes separate from the mesentery and runs independently in the coelom, although it receives the *superior mesenteric vein* while it is still in the mesentery. The distal portion of the vitelline is seen in the coelomic extension in the umbilical cord.

Inside the coelomic extension the small intestine is cut twice, the right section and the left one representing the cranial and caudal limb of the *intestinal loop* respectively.

Fig. 31. Section through the Coelomic Extension into Umbilical Cord (Ser. No. 469).

The section passes through the extra-fetal extension of the peritoneal cavity (*coelom*) into the umbilical cord. Within this cavity is the *instestinal loop* in the condition of the *physiological hernia.* The cranical and caudal limb of the loop are on the right and the left respectively. The former portion is the *small intestine,* while the latter may represent the *colon.*

The protrusion of the intestinal canal into the umbilical cord is thought to be caused by so rapid elongation of the intestine that the peritoneal cavity can no longer contain it. In case of the human fetus, the withdrawal of the hernia occurs at about ten weeks of the fetal life.

Along the intestinal canal are the *superior mesenteric artery* and *vein.* The latter is a tributary of the vitelline vein, which is no longer seen on the section.

In the cut *tail* of the fetus such features as *spinal cord, notochord, somite* and *caudal artery* are identified.

Fig. 32. Section through the Caudal Limb of Intestinal Loop (1) (Ser. No. 485).

In the center of the wide *coelom* protruding into the *umbilical cord* is the *caudal limb* of the intestinal loop (*colon*) and is connected to the dorsal body wall by the elongated mesentery (*mesocolon*). The *right umbilical vein* is peculiarly cut as it extends into the umbilical cord.

The *mesonephros* as well as the *gonad* is shown at about the largest section. The mesonephros or the *Wolffian body* consists of *glomeruli,* *mesonephric tubules*, *mesonephric duct* (*Wolffian duct*), vascular channels and intervening mesenchymal tissue (Plate V, 17). Needless to say, the mesonephric duct is the retained *pronephric duct*. It is lined with dark-staining, cuboidal epithelium.

In the perplexingly convoluted *mesonephric tubules* two different portions or segments can be discriminated. One is the thicker, light-staining *secretory segment* and the other is the thinner, dark-staing *collecting segment*. The former is proximal to the glomerulus and is nothing but the direct, tubular extension of the *Bowman's capsule*. The Bowman's capsule itself is, however, lined with low epithelial cells. The collecting segment is the distal continuation of the secretory segment and drains into the mesonephric duct.

Fig. 33. Section through the Caudal Limb of Intestinal Loop (2) (Ser. No. 501).

All the structures and features are almost the same as in the previous figure, excepting that the *mesentery* is somewhat shortened and the superior mesenteric blood vessels have disappeared.

The *urachus* or the *allantoic stalk* is an irregular, slit-like space with epithelial lining of cuboidal cells. This epithelial lining is entodermal. For the *allantois* is originally an outpouching from the ventral floor of the primitive gut, although it had furthermore an external layer of splanchnic mesoderm.

Figs. 34 & 35. Sections through the Root of Umbilical Cord (1, 2) (Ser. No. 525 & 541).

These two figures show sections through the root of the umbilical cord at different levels. So far as the body of the embryo is concerned, there are no remarkable differences from a couple of preceding sections. The only thing to be mentioned is that the *gonads* now dwindle away and disappear.

In the *umbilical cord*, which is decreasing in size, are umbilical blood vessels, urachus, etc. The *coelomic extension* is shown as one or two separate cavities.

The paired *umbilical arteries* and unpaired urachus are cut twice or thrice, depending on their courses and the height of section. The proximal portion of these arteries as well as of the urachus are now along the internal surface of the ventral body wall of the fetus.

The right *umbilical vein* is just rudimentary, while the left one is very large. The latter is the main venous channel carrying back the blood from the placenta.

Fig. 36. Section through the Metanephroi and Inferior Mesenteric Artery (Ser. No. 555).

The section is marked by the *metanephroi* or the primordium of the permanent kidneys. They arise from the caudalmost portion of the *nephrogenic cord*, from which also the pro- and mesonephros originate. On the section they are on each side of the aorta, just behind and somewhat mediad to the *mesonephros*.

The vetral margin of the mesonephric ridge has become prominent and the *mesonephric duct* is within it, turning its course ventro-caudad.

The *aorta* is cut at the level of exit of the *inferior mesenteric artery*. Like the coeliac and superior mesenteric artery this is one of the ventral branches of the aorta which were originally very imperfectly segmentary. While the former two supply the stomach-pancreas region and the small-intestine region respectively, the last one carries blood mainly to the large-intestine region.

Fig. 37. Section through the Metanephroi (2) (Ser. No. 565).

This section is slightly below the previous one, cutting the metanephros at about its middle height. The *mesonephros* has been lost to sight on the left, while the caudal tip of the right one is scarcely in view.

The *metanephros* is composed of two elements, 1) the tubular epithelial portion and 2) condensed mesenchymal tissue (Plate V, 18). The former is the distal end of an evagination from the caudal portion of the *mesonephric duct* and represents the primitive *renal pelvis* and *calyces*. It will further differentiate and furnish the *collecting segments* of the *uriniferous tubules*.

The second component of the metanephros or the condensed mesnchymal mass surrounding the epithelial tubules is the *metanephrogenic tissue* in narrow sense. For it is destined to make the *secretory segments* of the uriniferous tubules. The interstitial connective tissue as well as the renal capsule will differentiate from the external layer of the same mesenchymal mass.

Fig. 38. Section through the Ureter, Genital Tubercle and Hind Limb Bud (Ser. No. 577).

The section passes through the caudalmost portions of the *metanephroi*, and the *ureters* descending from the former are cut ventral in position. The epithelial lining of the ureter, which is continuous with the epithelial tubules in the metanephros, is formed by low cuboidal cells. A thin layer of accumulated mesenchymal mass envelopes it externally.

The ventral end of the section shows a peculiar prominence which represents the *genital tubercle*. Of course, it is sexless at this stage and two or three months will elaspe before the distinctive *penis* or *clitoris* is formed.

Another new feature occuring on the present section is the bud of *lower extremitiy*(1). As shown in several succeeding figures, too, it is internally just a somewhat condensed mesenchymal mass. So it is uncertain, whether or not there may occur some primordial cartilages or muscles belonging to the lower extremity before it dwindles away in accordance with the further growth of the fetus.

Fig. 39. Section through the Primitive Bladder (Ser. No. 583).

Because of the dorsal shifting of the *umbilical arteries*, the *coelom* is cut three times, being separated into the unpaired median and paired lateral parts. The *postcardinal veins* have also changed position gradually to the dorsal and are now alongside the *aorta*.

The *urachus* which has been kept in the midplane of the ventral body wall is enlarged and triangular in shape, lined with thick epithelium. It means that the cavity mentioned represents the cranial portion of the *urogenital sinus* or of the *cloaca*. This is the primitive *bladder*.

Fig. 40. Section through the Urogential Sinus and Membrane (Ser. No. 589.)

The *urogenital sinus* or *cloaca* is cut at the level of its fusion with the *mesonephric duct*. The communication between the urogenital sinus and the *ureter* is shown at the same time. In other words, the mesonephric duct and ureter make very short common stem just before they join the urogenital sinus. The sinus itself is connected with the outer surface of the *genital tubercle* by an epithelial cell. cord that represents the *urogenital* or *cloacal membrane*.

Strictly speaking, the bladder and the urogenital sinus are to be discriminated from each other, although the former is merely a cranial continuation of the latter. The joints of the mesonephric ducts and ureters to the urogenital sinus mark the caudal limit of the bladder, the remaining portion representing the urogenital sinus in narrow sense.

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(1) It is well known that the whale- and dolphin fetuses have rudimentary lower extremities in their very early fetal stage. C.f. Guldberg (1894, 99), Guldberg & Nansen (1894), Kükenthal (1895), Hosokawa (1952) and Ogawa (1953).

Fig. 41. Section through the Bifurcation of Aorta into Umbilical Arteries (Ser. No. 593).

In the middle of the section is the *aorta* which now separates away into the right and left *umbilical arteries.* On each side of the aorta is the *postcardinal vein.*

The intestinal canal (*rectum*) approaches its caudal end, surrounded by loop-like slit of the *coelom.* The *ureters* are lateral in position and show nearly tangential sections due to their concurve course.

The mesenchymal portion behind the *urogenital sinus* is the *cloacal* or *uro-rectal septum,* which fills the interval between the sinus and the hind-gut in the wedge-like fashion.

The section of the recurved tail of the fetus has increased in size. A couple of pairs of *somites* are seen alongside the cut *spinal cord* and *notochord.*

Figs. 42 & 43. Sections through the Caudal Artery and Tail Gut (Ser. No. 601 & 603).

These two figures show two successive sections around the caudal end of the alimentary canal. The features and structures in both are almost the same, and the only noteworthy difference is that the former shows the connection between the *rectum* and *urogenital sinus* (*cloaca*), while the latter is provided with a section of the *tail gut* or the *postanal gut.* This is the caudalmost extention of the entodermal canal a little beyond the cloacal membrane and is destined to dwindle and disappear very soon.

The presence of the *caudal artery* in the center of these figures may be worthy of notice. It is the caudal continuation of the aorta.

Fig. 44. Section through the Lumbal Curvature (1) (Ser. No. 655).

The section passes through the curvature of the lumbal region of the fetus, the *spinal cord* being cut twice at the anterior and posterior ends of the section. The tangential shaving of the *notochord* is in the center.

On each side of the section is a series of *somites,* which comprises myotomes, sclerotomes and dermatomes. The *myotomes,* which are most conspicuous in the section, are oval condensations of *myoblasts* of the mesenchymal origin. Needless to say, it is the forerunner of the skeletal muscles in regions of the neck, trunk and possibly of the limbs.

The *dermatomes,* which from a layer of aggregated mesenchymal cells under the surface epithelium, have arisen from the external portion of each somite and will furnish connective tissue for the skin.

The *sclerotomes* have come from the ventro-medial walls of somites, migrated, and have surrounded the notochord. Each of them, lying in paired segmental masses, has furthermore differentiated into two parts, the *cranical looser* and the *caudal denser half*. When they proceed further in development, these two parts of each sclerotome will separate and the caudal denser half will unite with the cranial half of the next sclerotome, thus forming the primordium of the *vertebra*. It is well known that, because of these procedures, the myotome and the vertebra become to lie in alternation, and that this alternation makes it possible for the myotomic muscles to move the spine.

Intersegmental arteries are cut in between the successive somites, while the spinal, *segmental nerves* are within each somite.

Figs. 45 & 46. Sections through the Lumbal Curvature (2, 3) (Ser. No. 669 & 673).

These figures show two sections of very close levels. The main difference consists in the fact that the *spinal cord* is cut twice in the first figure, while it is cut longitudinally extending almost the whole length of the second section.

In both of them *spinal ganglia* arranged serially are shown, together with some of the *ventral roots*.

Other features and the arrangement of *somites* resemble that of the previous figure very much, excepting that the *sclerotomes* have *lateral projections* which lie intervening the myotomes. These projections are possibly to be regarded as the primordia of the *costal processes*.

Résumé

From the foregoing observation of serial sections, it may be concluded that the internal structures and features of a 12-mm. embryo of the Prodelphinus caeruleo-albus, Meyen, resemble very much that of human embryos of some 10–12 mm. in length (5–6 weeks in fetal age) as well as that of pig embryos of the similar size.

There are, however, several remarkable differences or interesting things worthwhile to be mentioned from the comparative anatomical view-point. Some of them will be summarized in the following.

1) All of the primordia of cranial nerves are present already, and even such nerves as n. petrosus superficialis major and chorda tympani, of which the existance in the adult whales is not yet ascertained, occur distinctly just like in the human and pig embryos.

2) The gall bladder, in which the adult whales lack, is not foreshadowed at all in the present fetus.

3) As in the adult whales, the fetus does not show any indication of hepatic lobulation, while the human and pig embroys of the similar size have distinctly lobulated liver.

4) The hind limb buds appearing only in the early developmental stage of whale's fetuses are represented by prominences permeated with accumulated mesenchymal mass inside, showing no indication of the primitive muscles or cartilages at the present stage.

References

Arey, L. B.: Developmental Anatomy. Fifth Ed., Philadelphia & London, 1946.

Baxter, J. S.: Frazer's Manuel of Embryology. Third Ed., London, 1953.

Boyden, E. A.: A Laboratory Atlas of the Pig Embryo. Third Ed., Philadelphia, 1947.

Grosser, O. and *Politzer, G.*: Grundriss der Entwicklungsgeschichte des Menschen. Vierte Aufl., Berlin-Göttingen-Heidelberg, 1953.

Guldberg, G.: Ueber temporäre äussere Hinterflossen bei Delphinembryonen. Verh. anat. Gesellsch., 8. 92–95. 1894.

———: Neue Untersuchugen über die Rudimente von Hinterflossen und die Milchdrüsen bei jungen Delphinembryonen. Internat. Monatsschr. f. Anat. Physiol., 16. 301–321. 1899.

——— and *Nansen, F.*: On the Development and Structure of the Whale. Part I; On the Development of the Dolphin. Bergen, 1894.

Hosokawa, H.: On the Pelvic Cartilages of the Balaenoptera-Foetuses, with Remarks on the Specifical and Sexual Difference. Scient. Repts. Whales Res. Inst., No. 5. 5–15. 1951.

Huettner, A. F.: Fundamentals of Comparative Embryology of the Vertebrates. Rev. Ed., New York, 1952.

Kükenthal, W.: Ueber Rudimente von Hinterflossen bei Embryonen von Walen. Anat. Anz., 10. 534–537. 1895.

Ogawa, T.: On the Presence and Disappearance of the Hind Limb in the Catecean Embryos. Scient. Repts. Whales Res. Inst., No. 8. 127–132. 1953.

Patten, B. M.: The Embryology of the Pig. 1st Ed., Philadelphia, 1927.

———: The Early Embryology of the Chick. Third Ed., Philadelphia & Toronto, 1948.

———: Human Embryology. 2nd Ed., New York & Toronto, 1953.

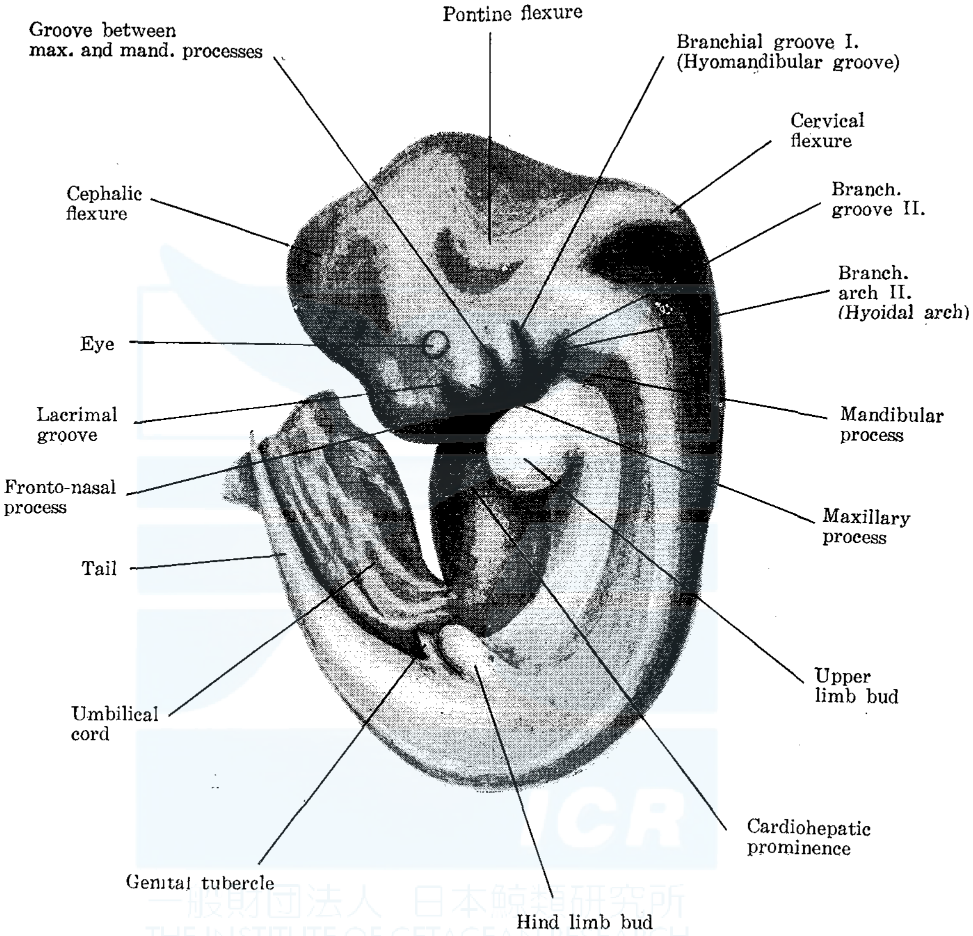


Fig. 1. 12 mm. embryo of Prodelphinus caeruleo-albus.

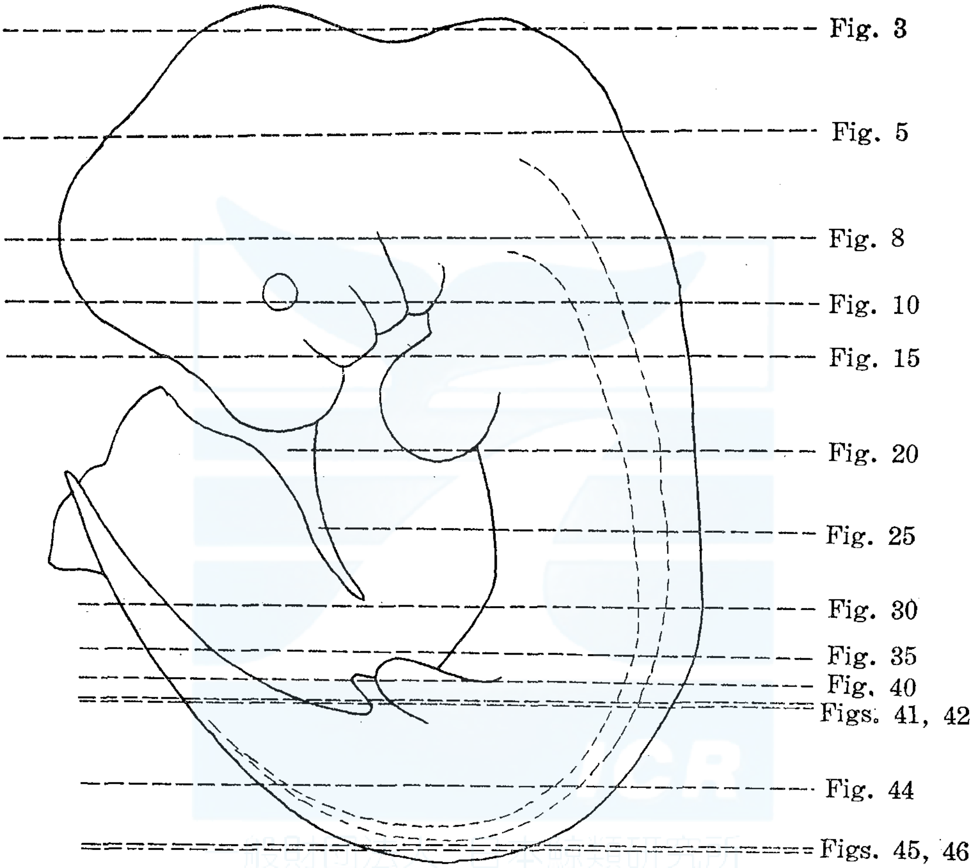


Fig. 2. Guide lines to indicate the levels of sections shown as Fig. 3—46.

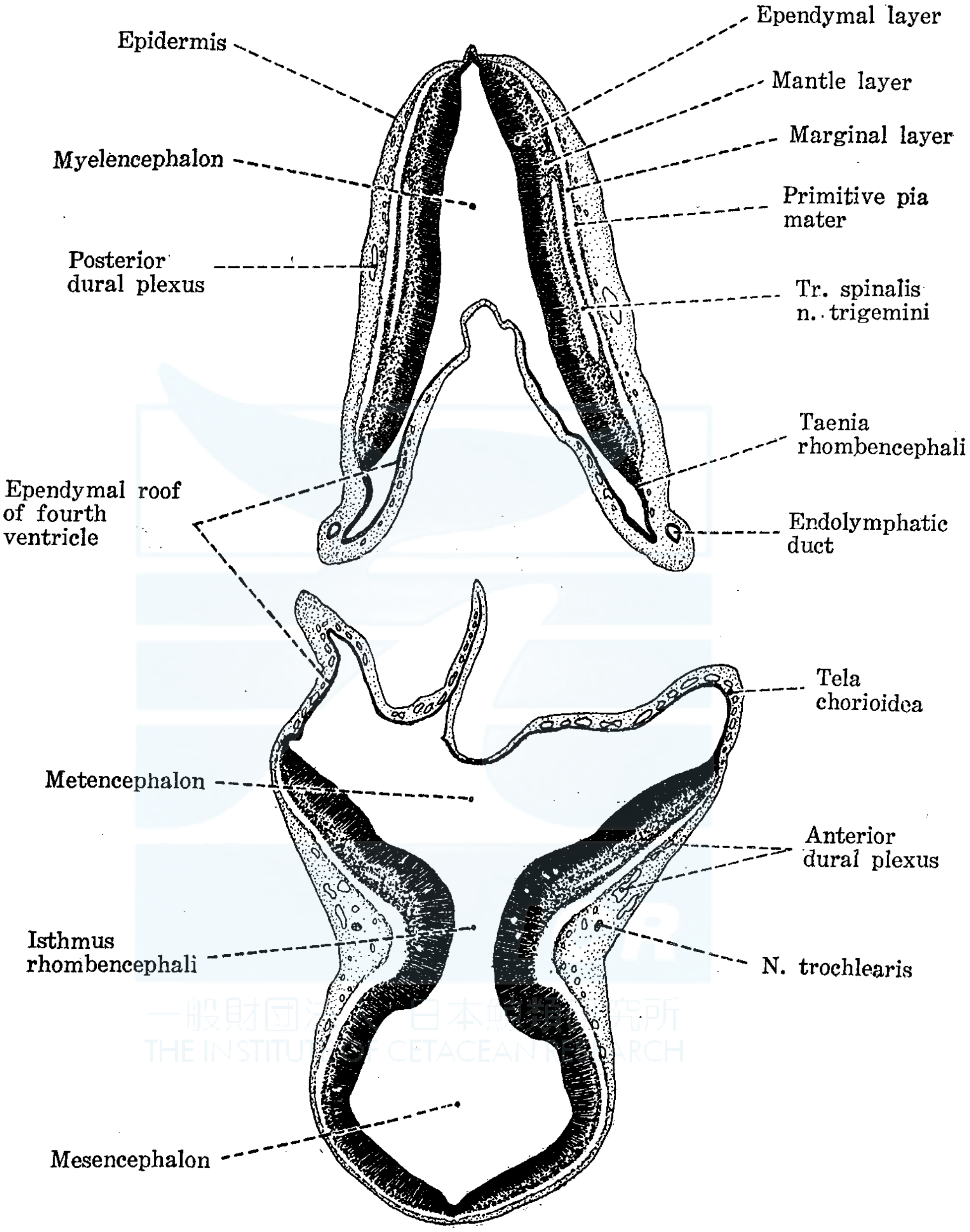


Fig. 3- Section through the isthmus rhombencephali and pontine flexure.

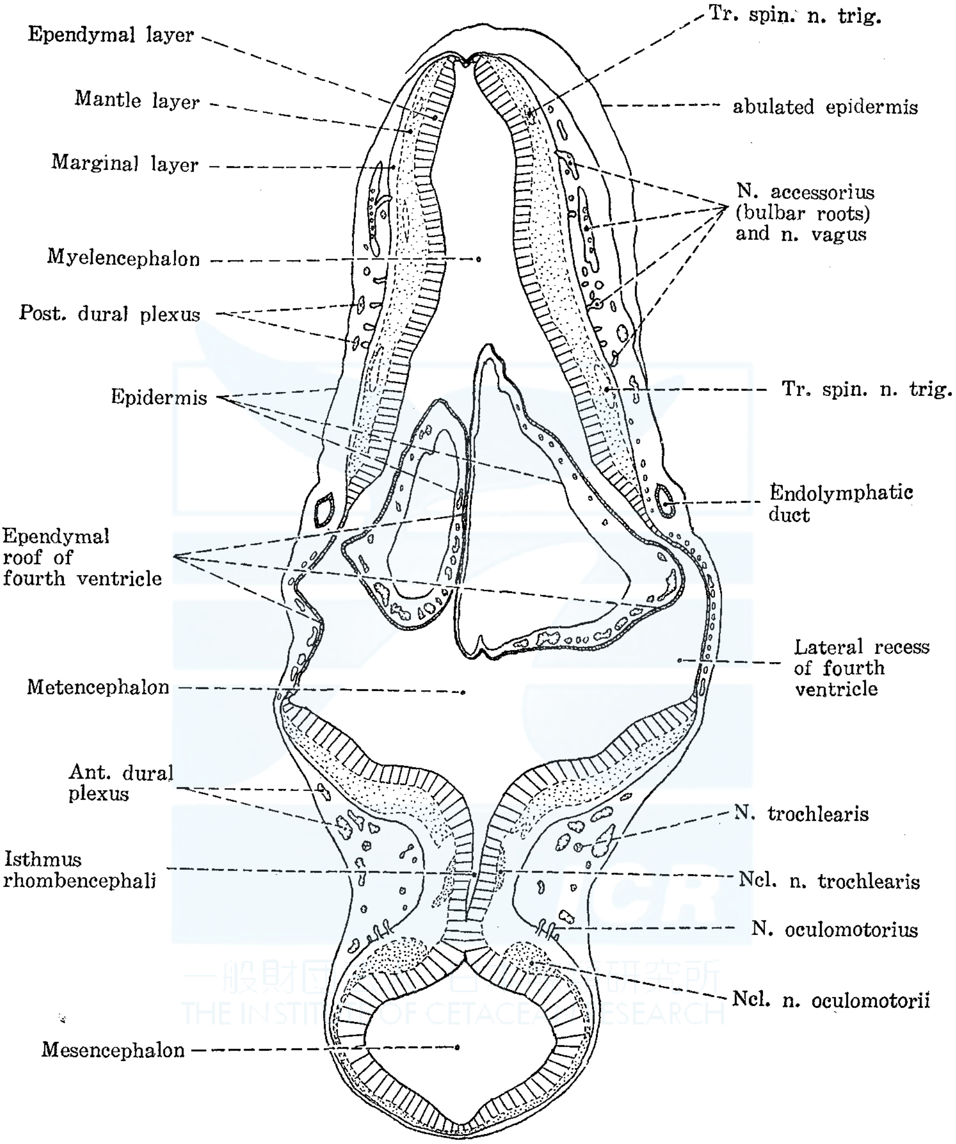


Fig. 4. Section through the fourth ventricle.

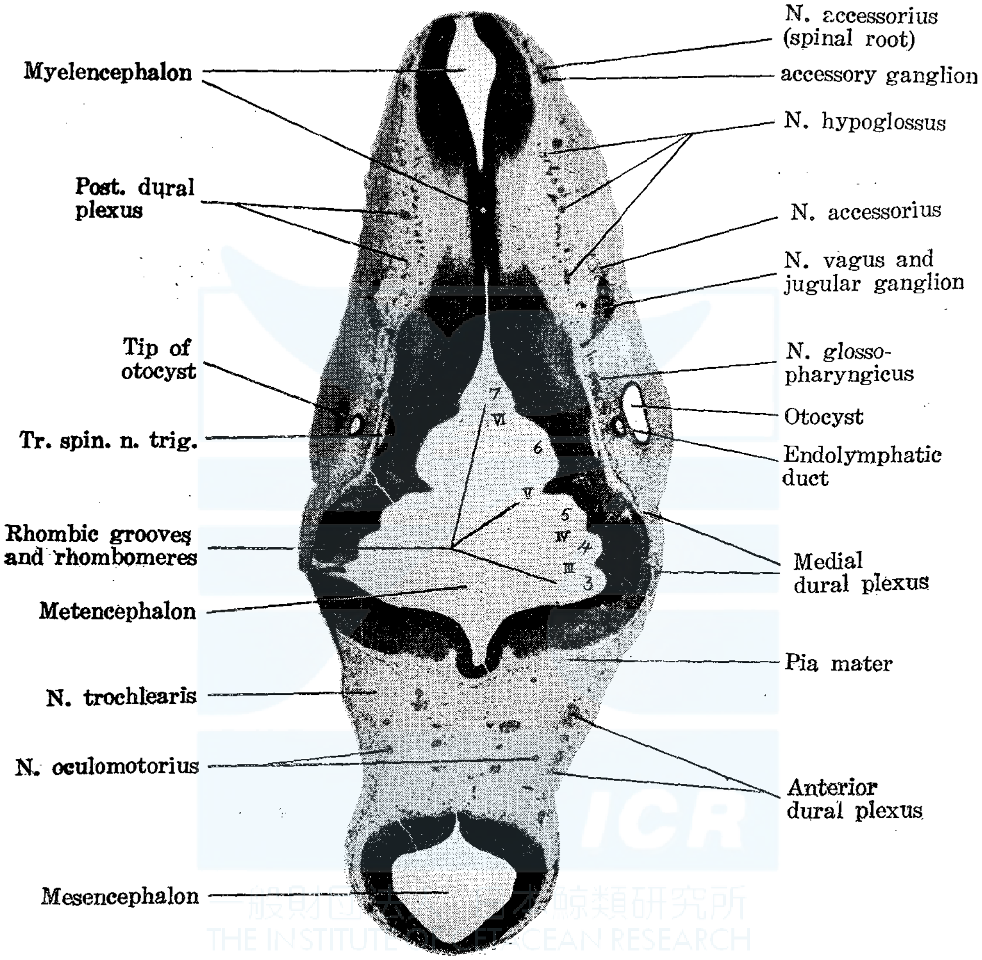


Fig. 5. Section through the apex of an otocyst.

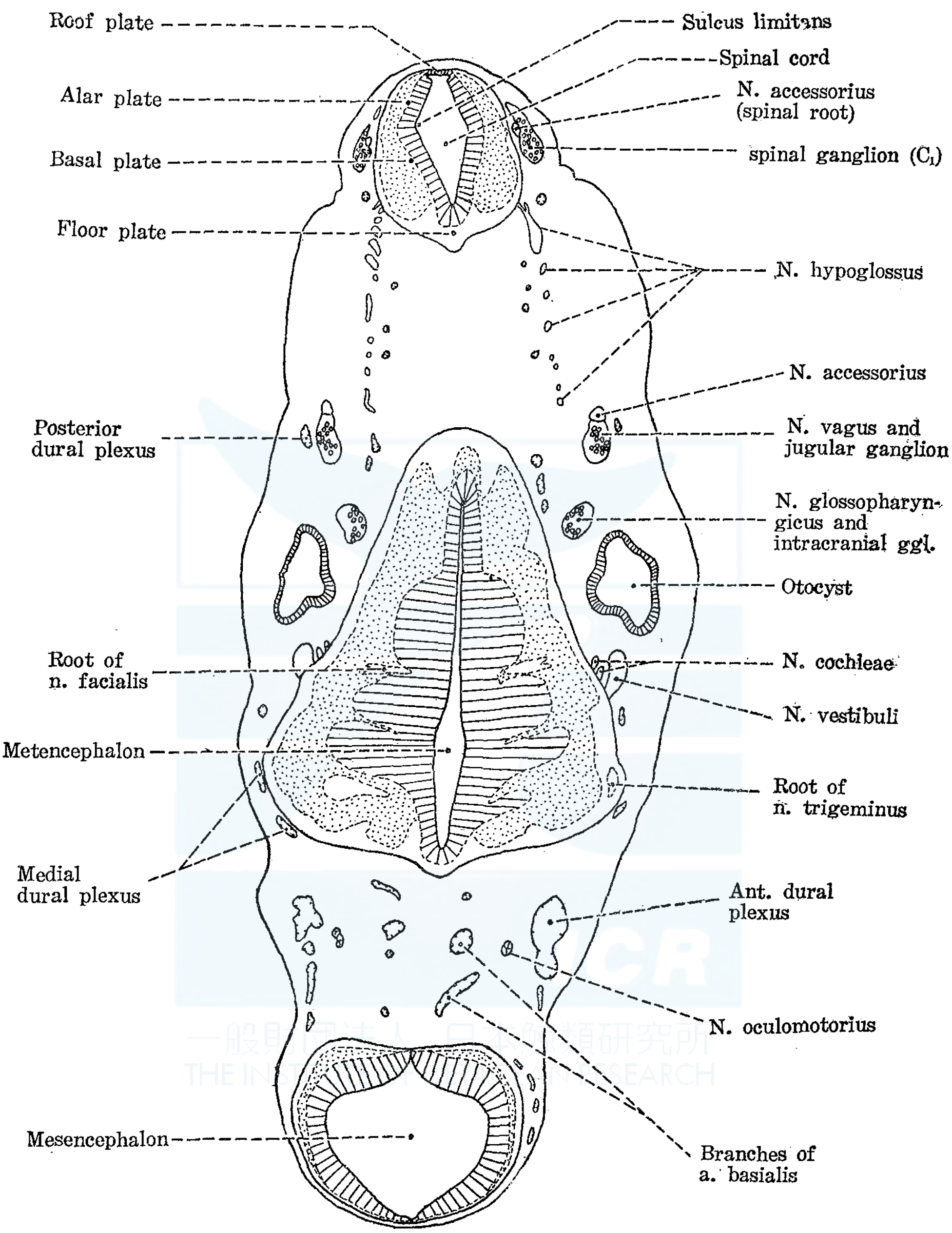


Fig. 6. Section through the floor of metencephalon.

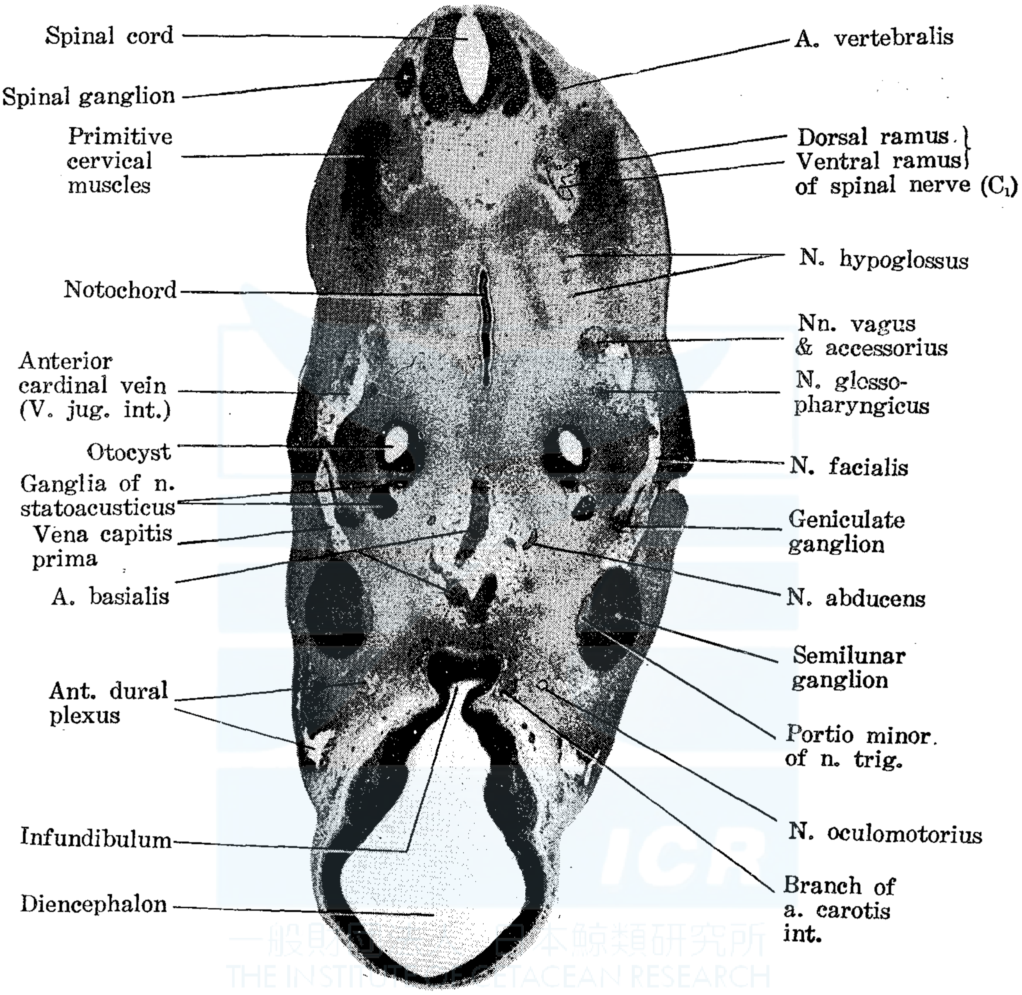


Fig. 7. Section through the infundibulum, ganglia semilunare and geniculi.

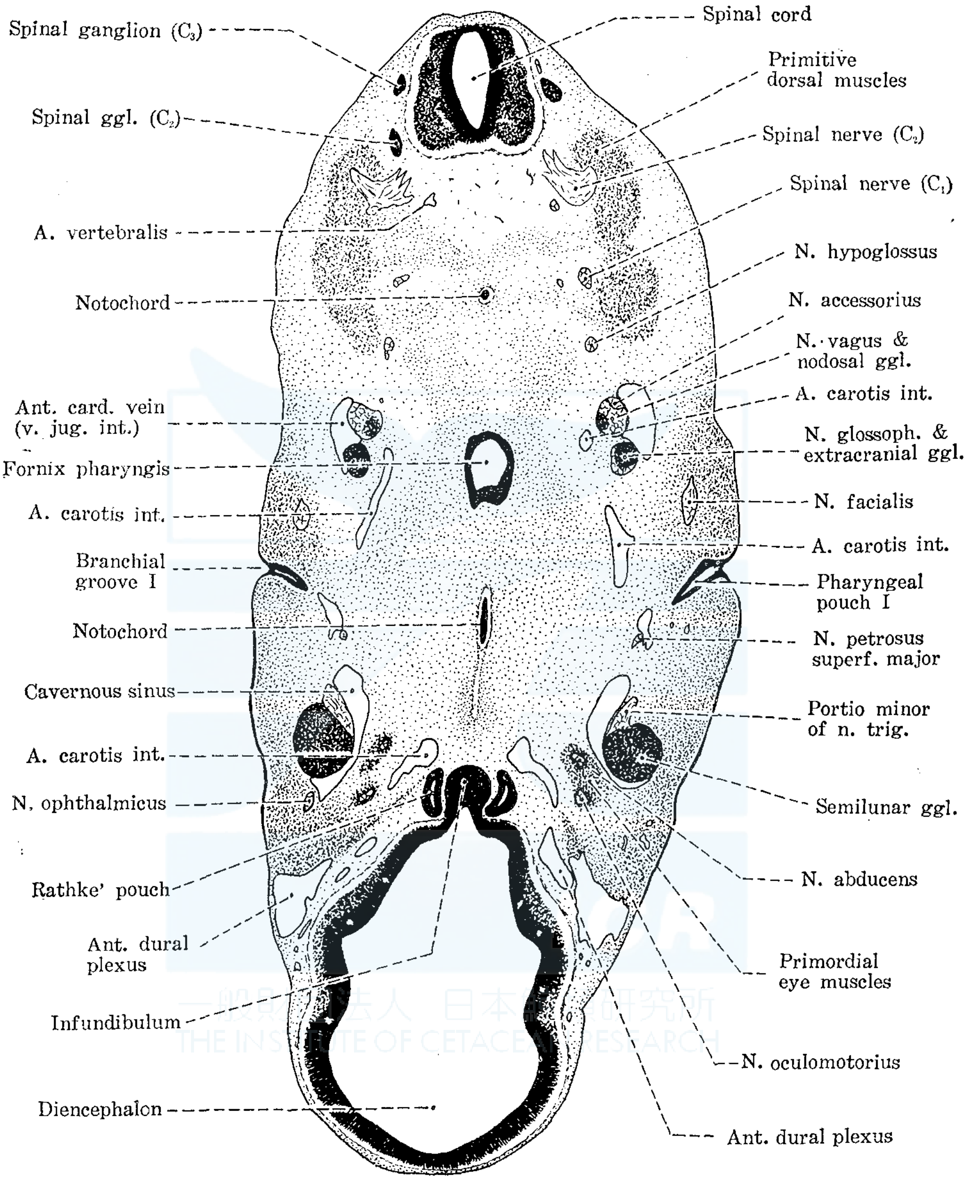


Fig. 8. Section through the fornix pharyngis, ganglia extracraniale and nodosum.

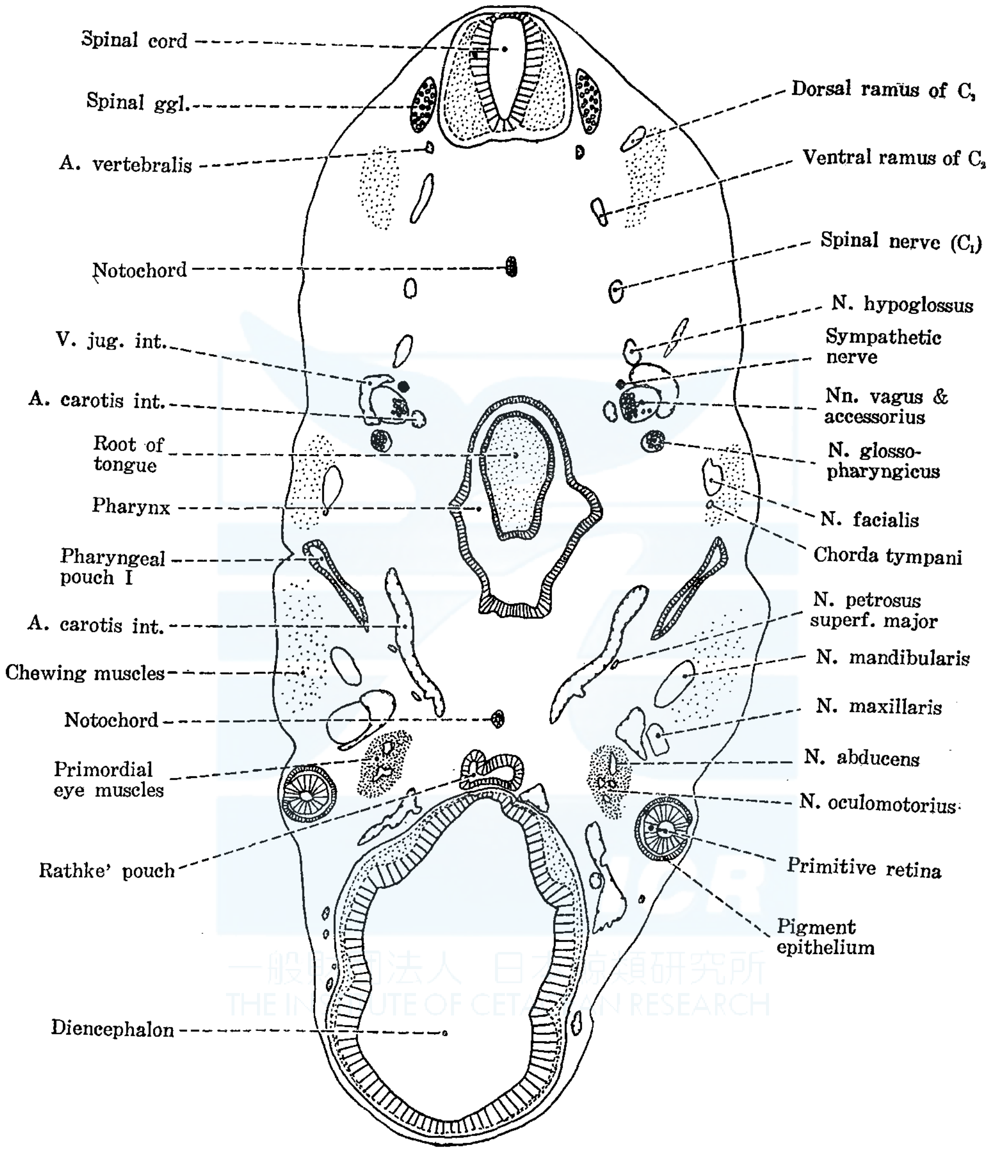


Fig. 9. Section through the optic cup.

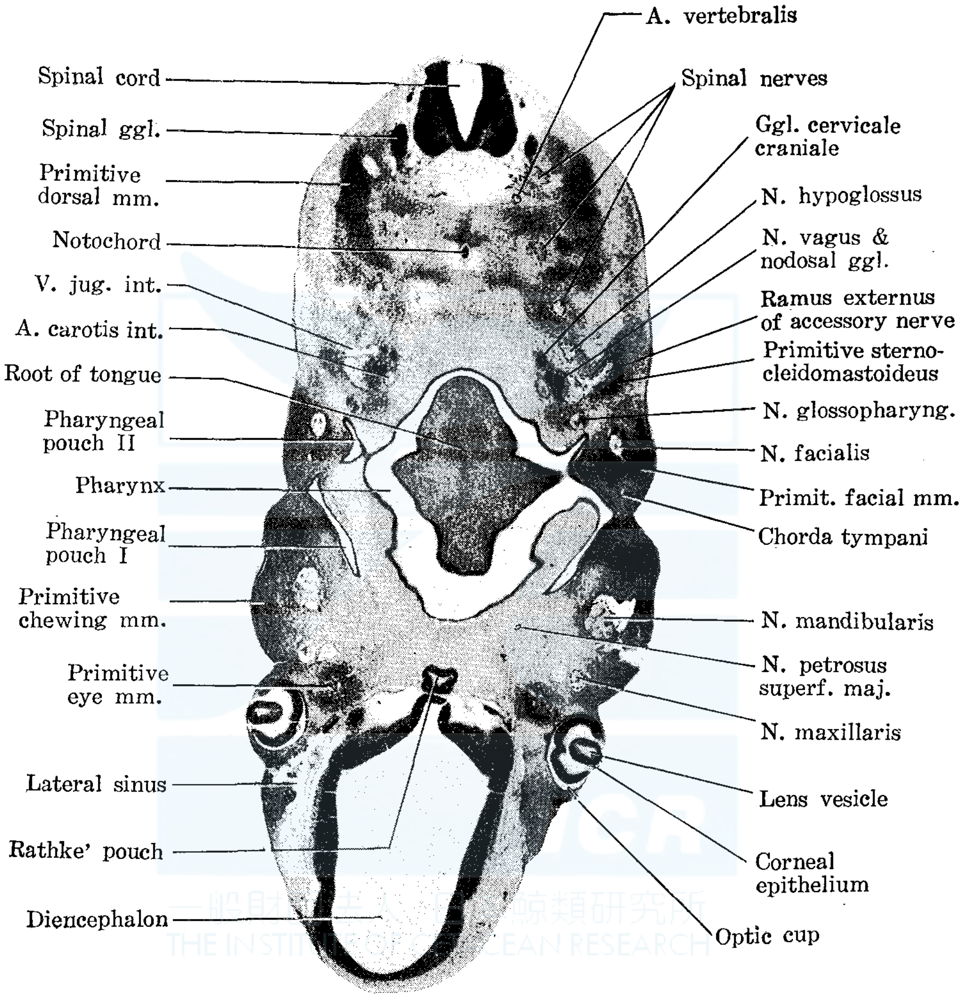


Fig. 10. Section through the root of tongue and lens vesicle.

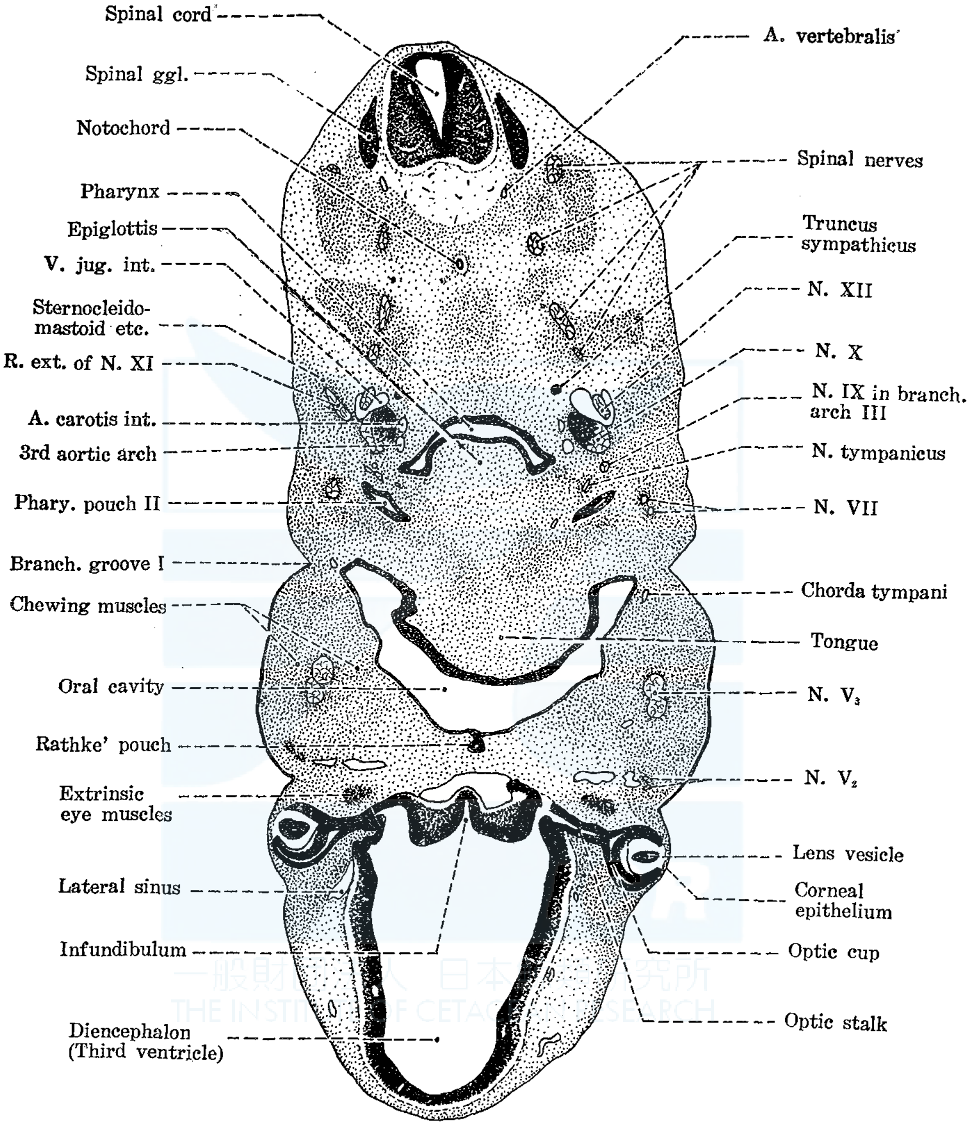


Fig. 11. Section through the origin of Rathke's pouch, epiglottis and optic stalk.

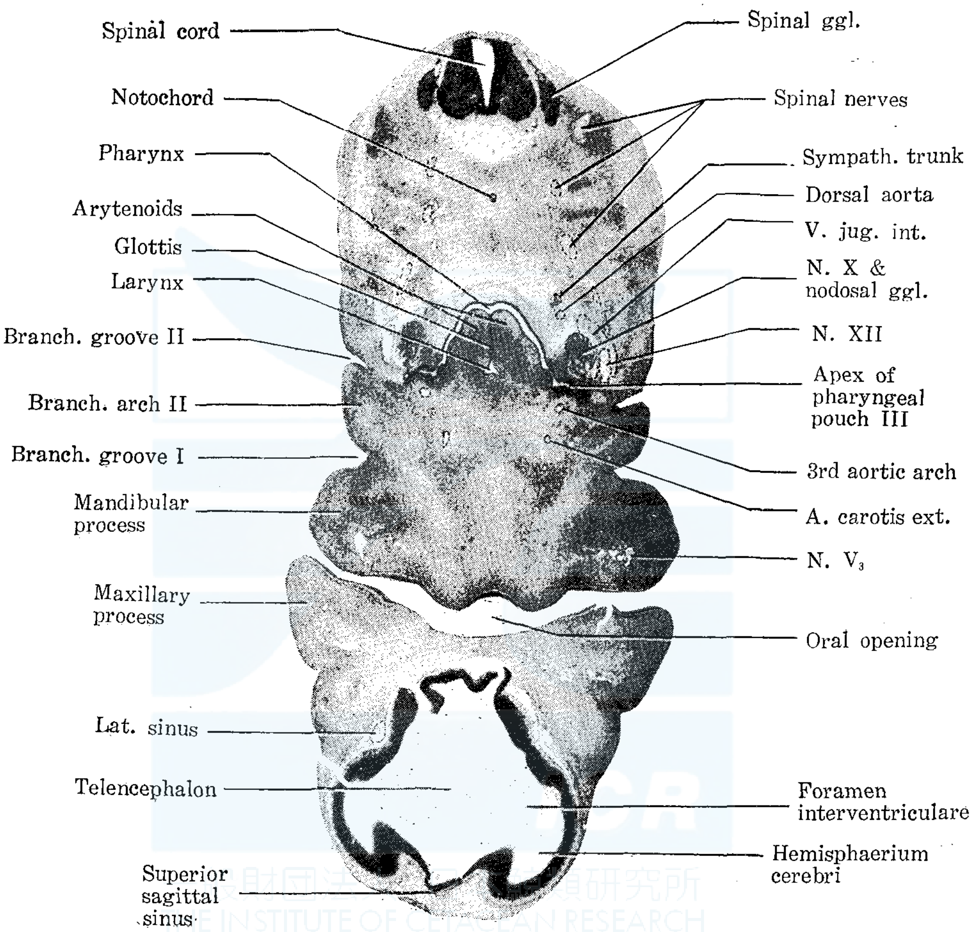


Fig. 12. Section through the foramen interventriculare, oral opening, third pharyngeal pouch and glottis.

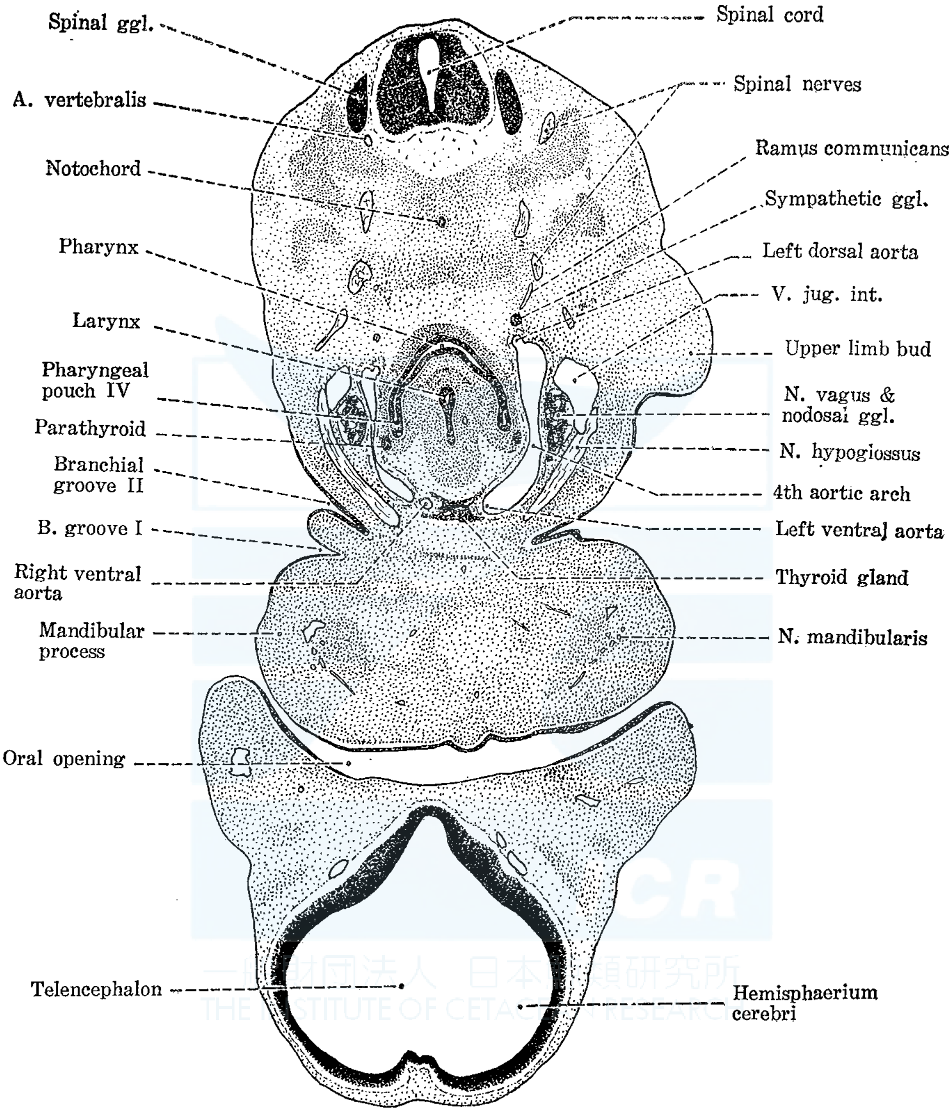


Fig. 13. Section through the fourth aortic arch, fourth pharyngeal pouch and thyroid gland.

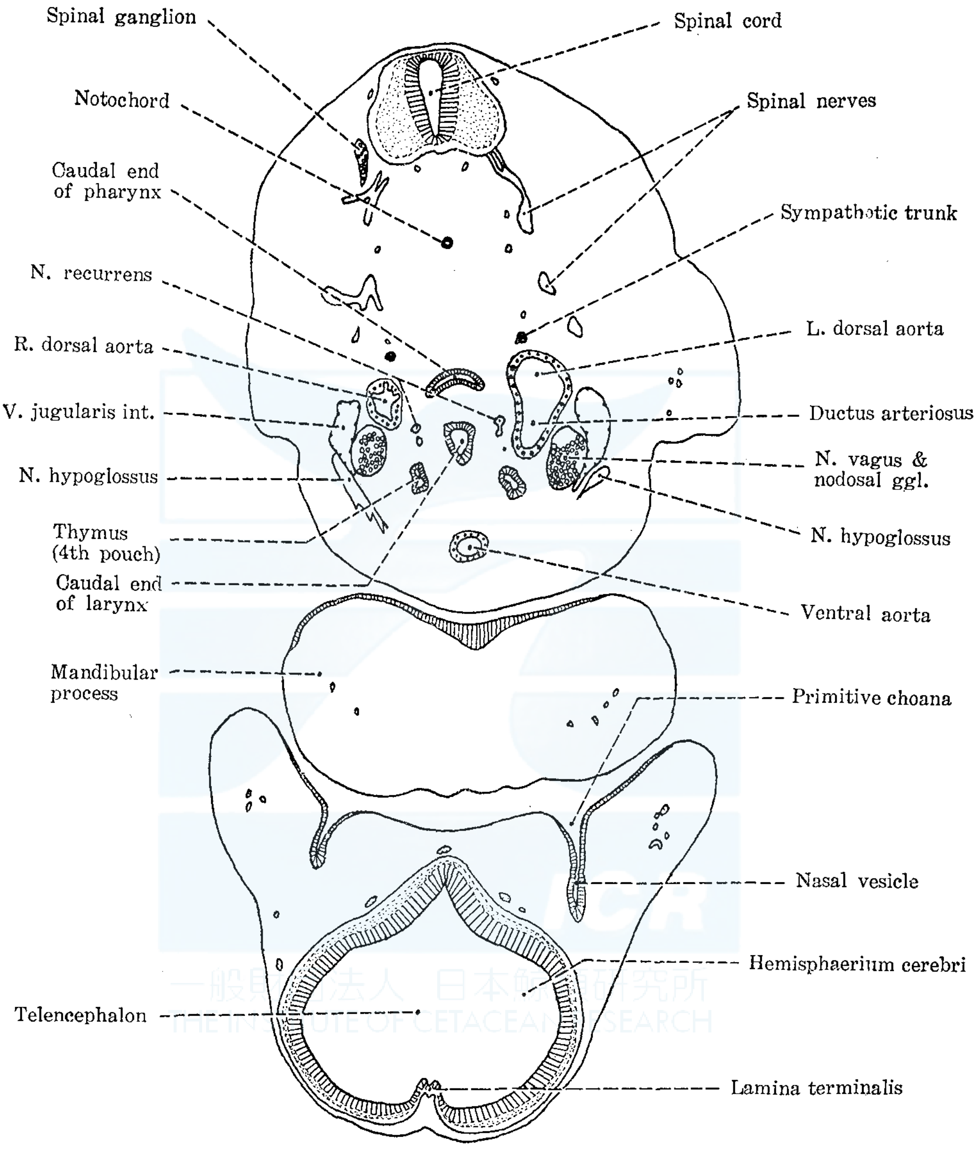


Fig. 14. Section through the ventral aorta and primitive choana.

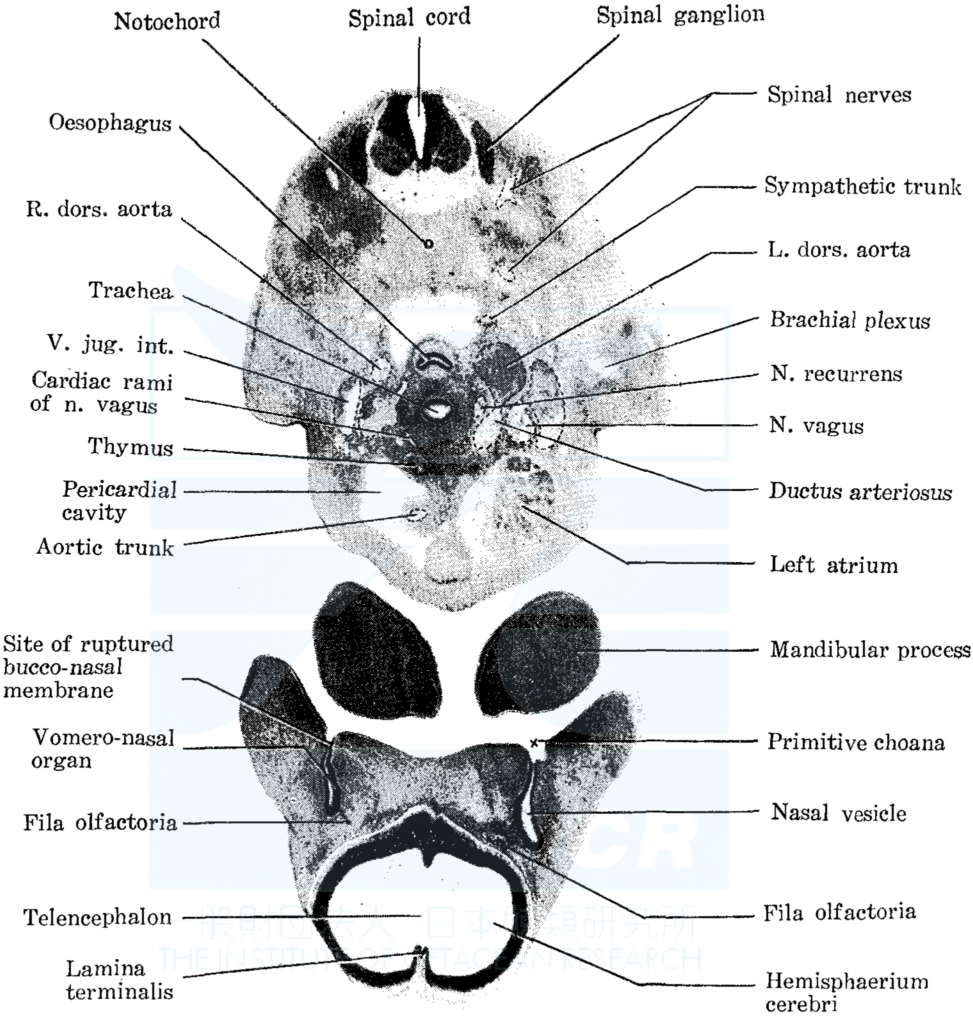


Fig. 15. Section through the apex of pericardial cavity.

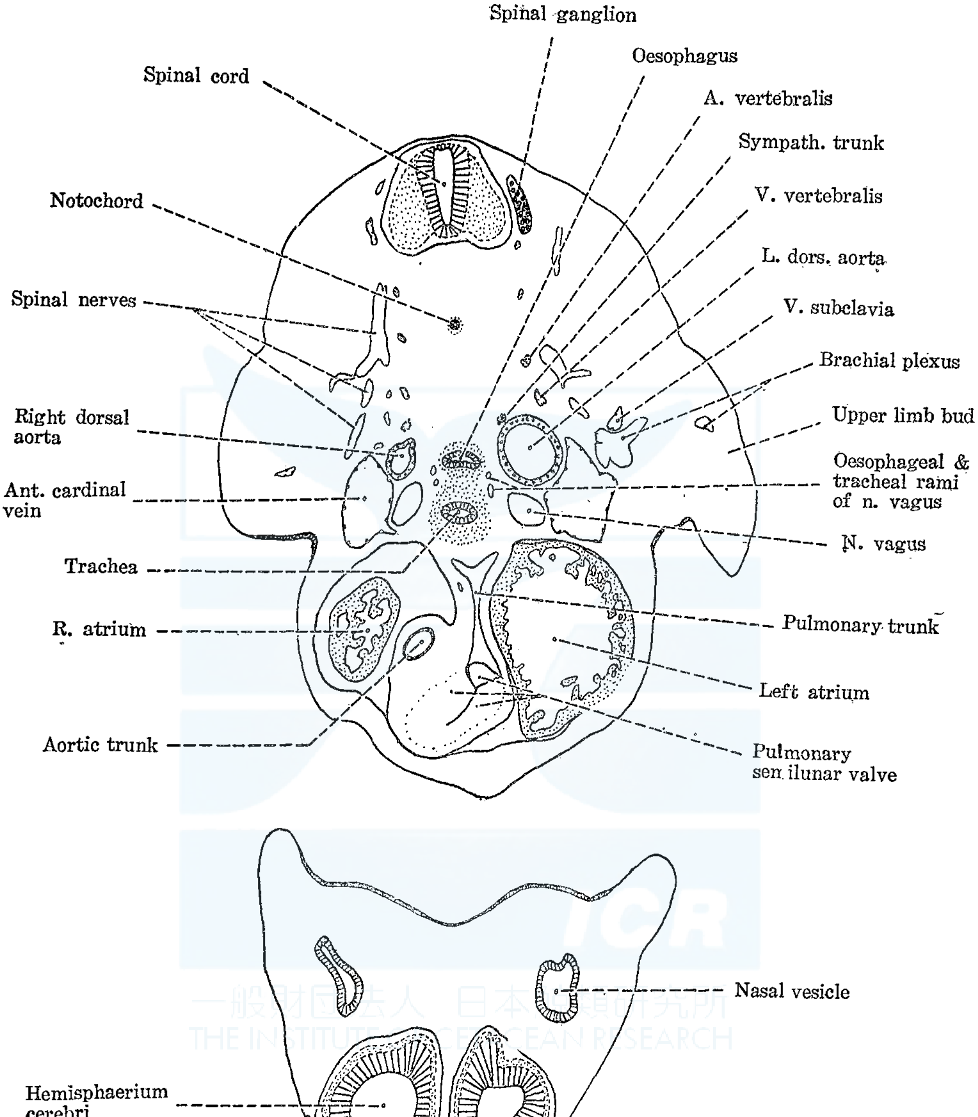


Fig. 16. Section through the pulmonary trunk.

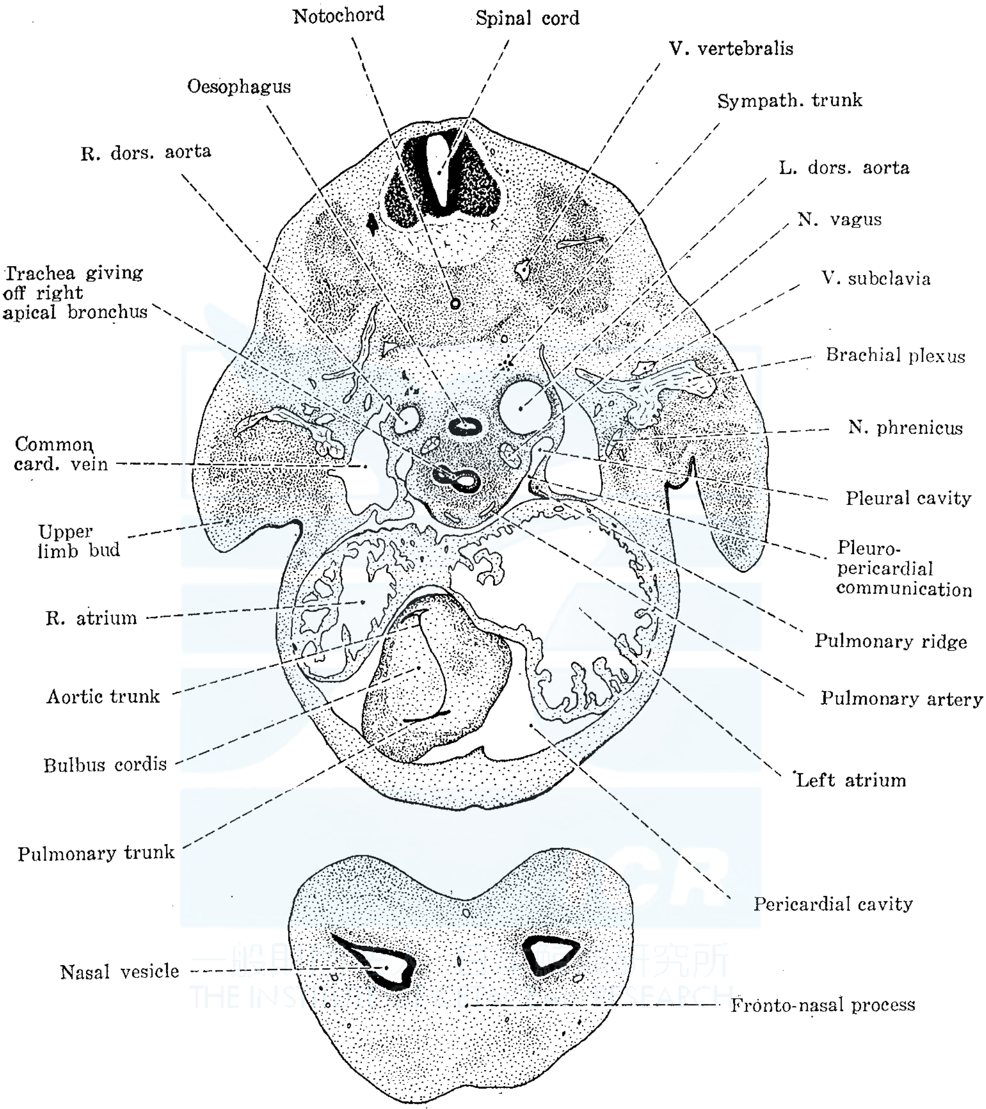


Fig. 17. Section through the bulbus cordis, common cardinal veins and origin of right apical bronchus.

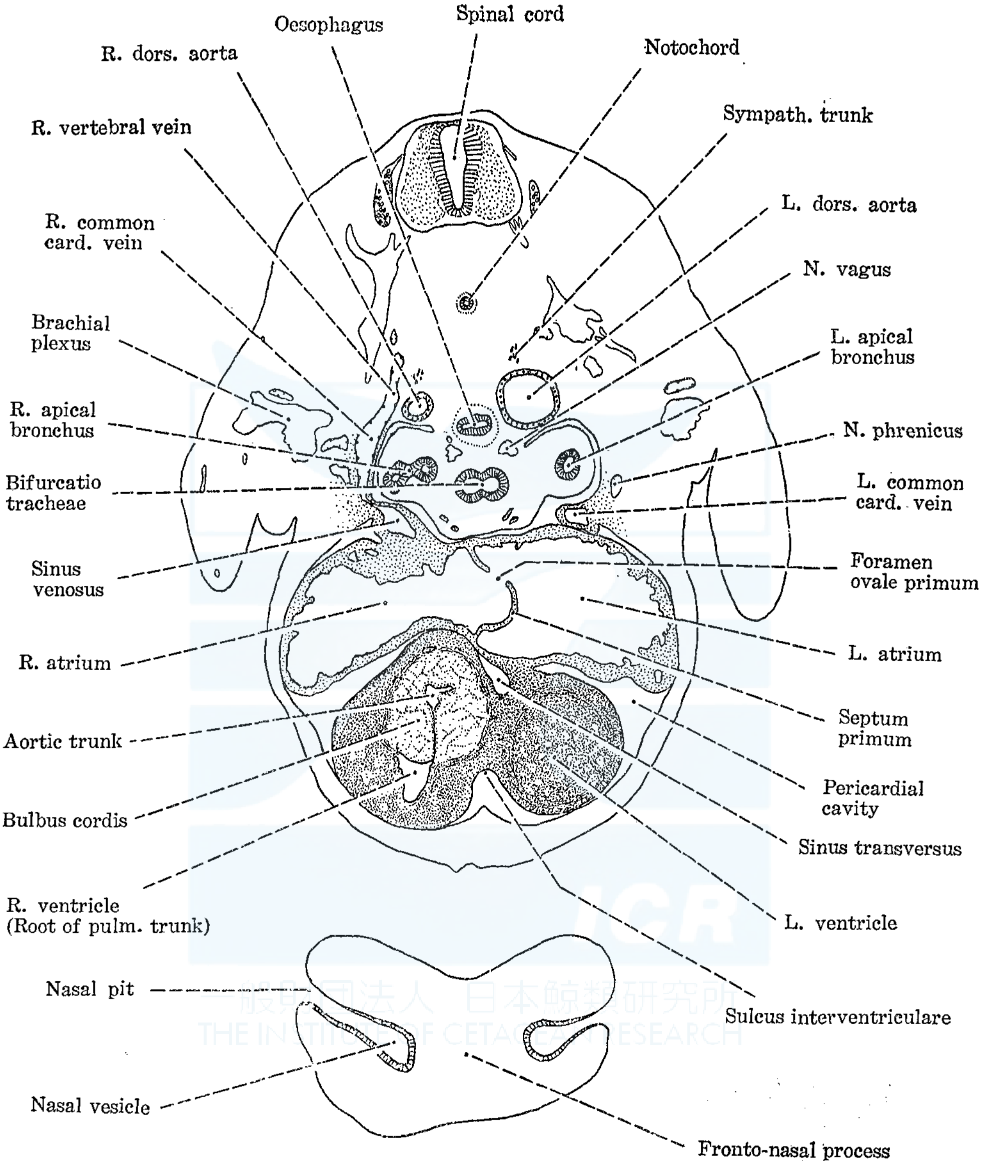


Fig. 18. Section through the foramen ovale I, bifurcatio tracheae and nasal pit.

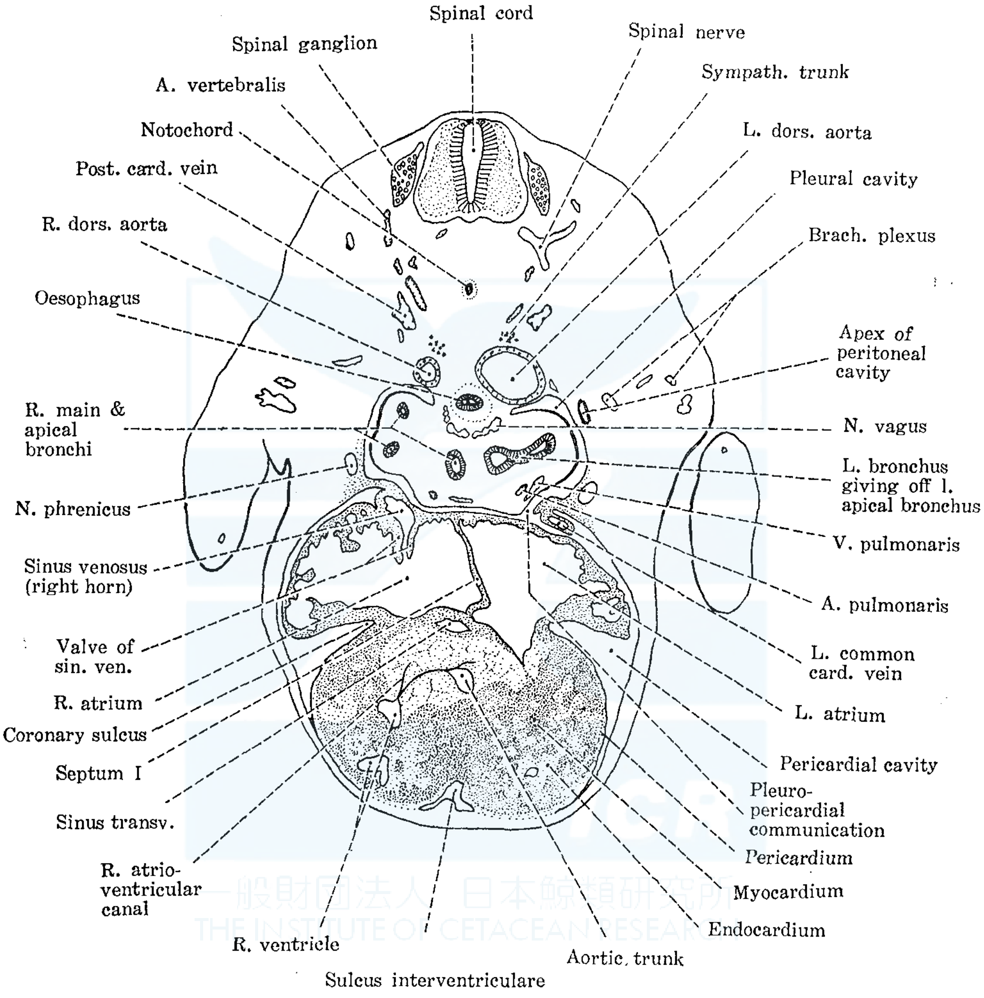


Fig. 19. Section through the sinus venosus.

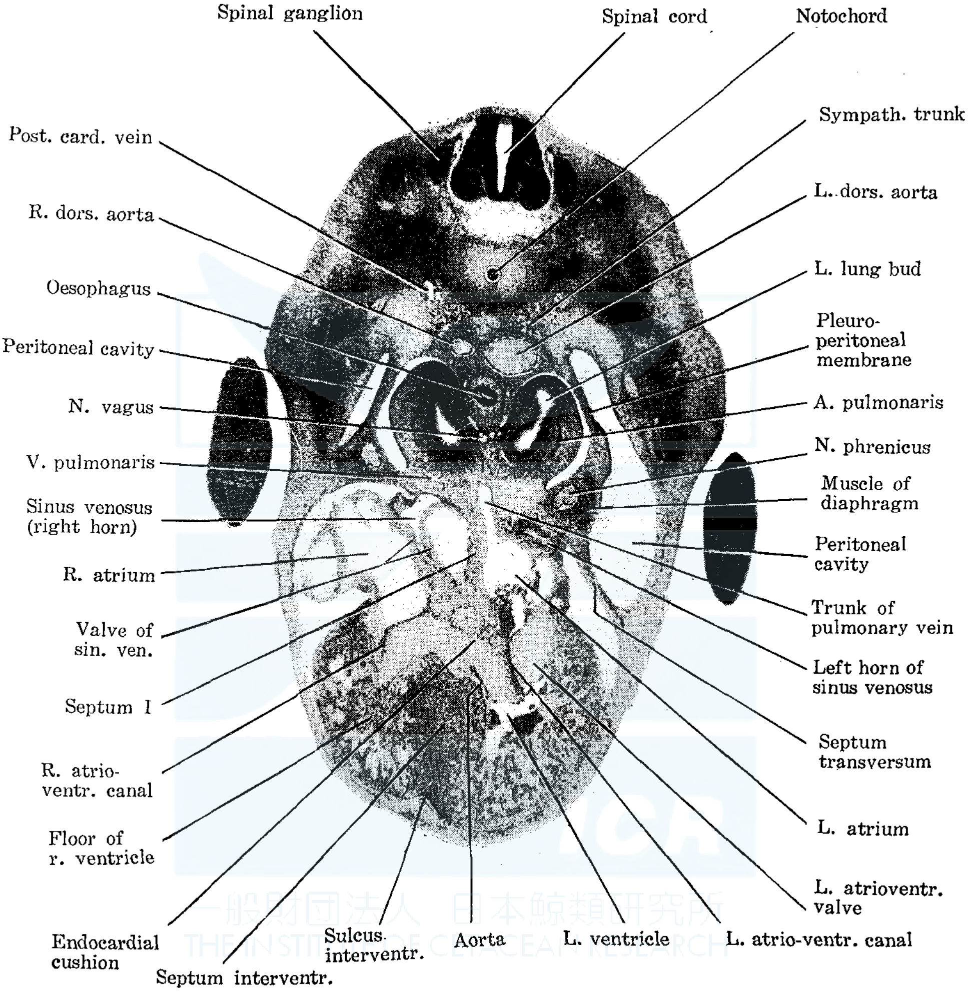


Fig. 20. Section through the trunk of pulmonary vein.

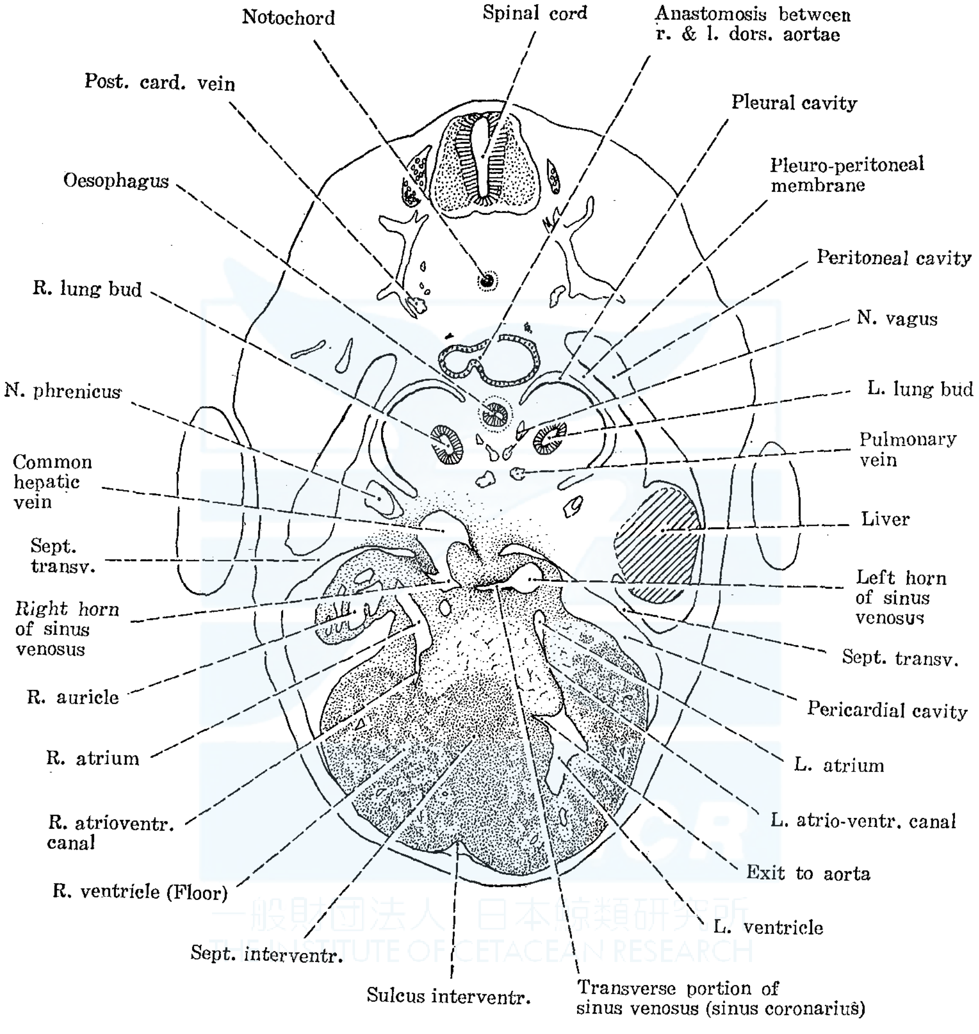


Fig. 21. Section through the anastomosis between right and left dorsal aortae.

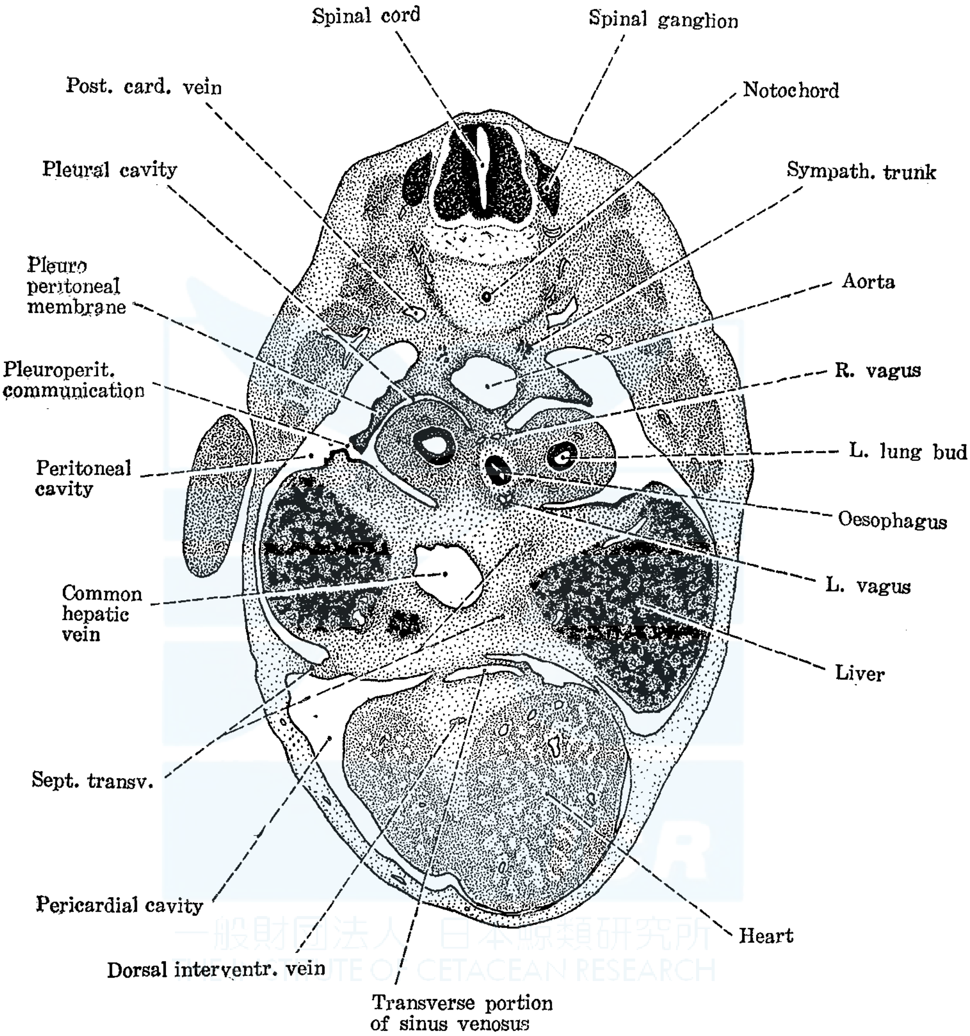


Fig. 22. Section through the pleuro-peritoneal communication.

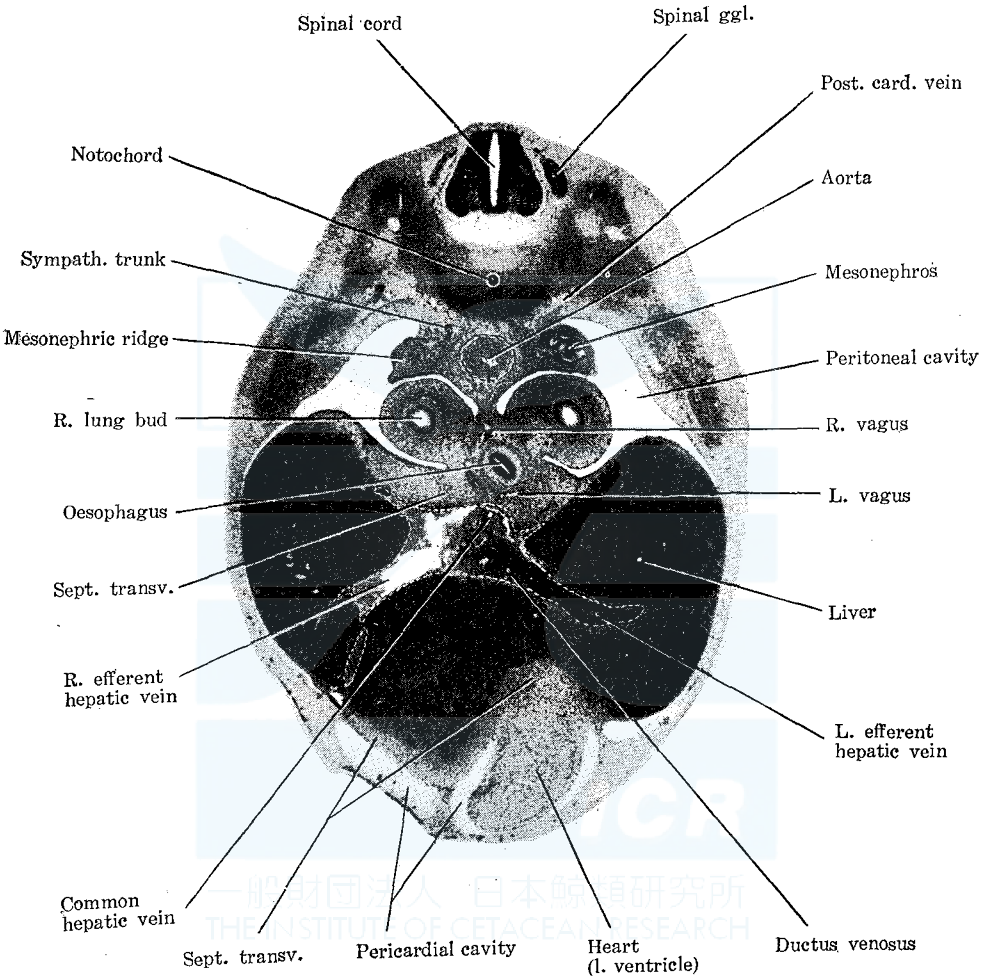


Fig. 23. Section through the ductus venosus.

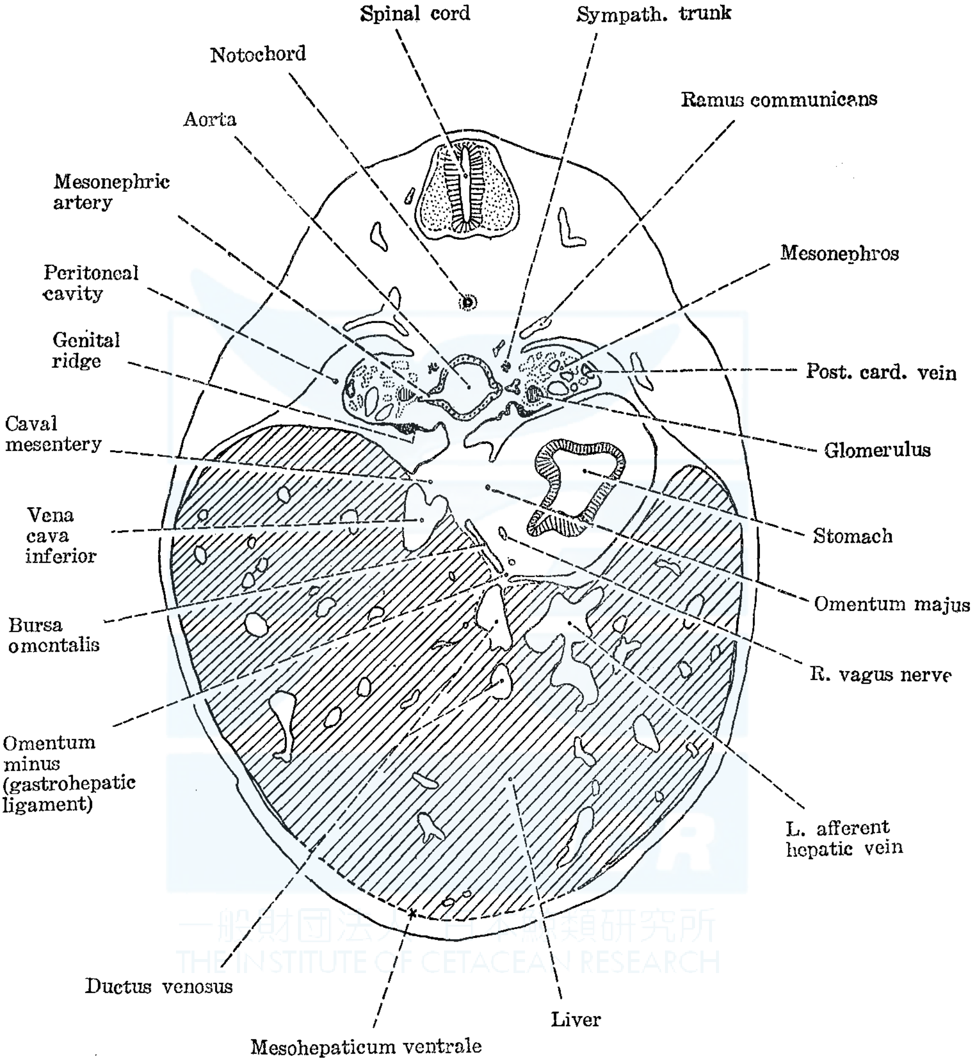


Fig. 24. Section through the stomach.

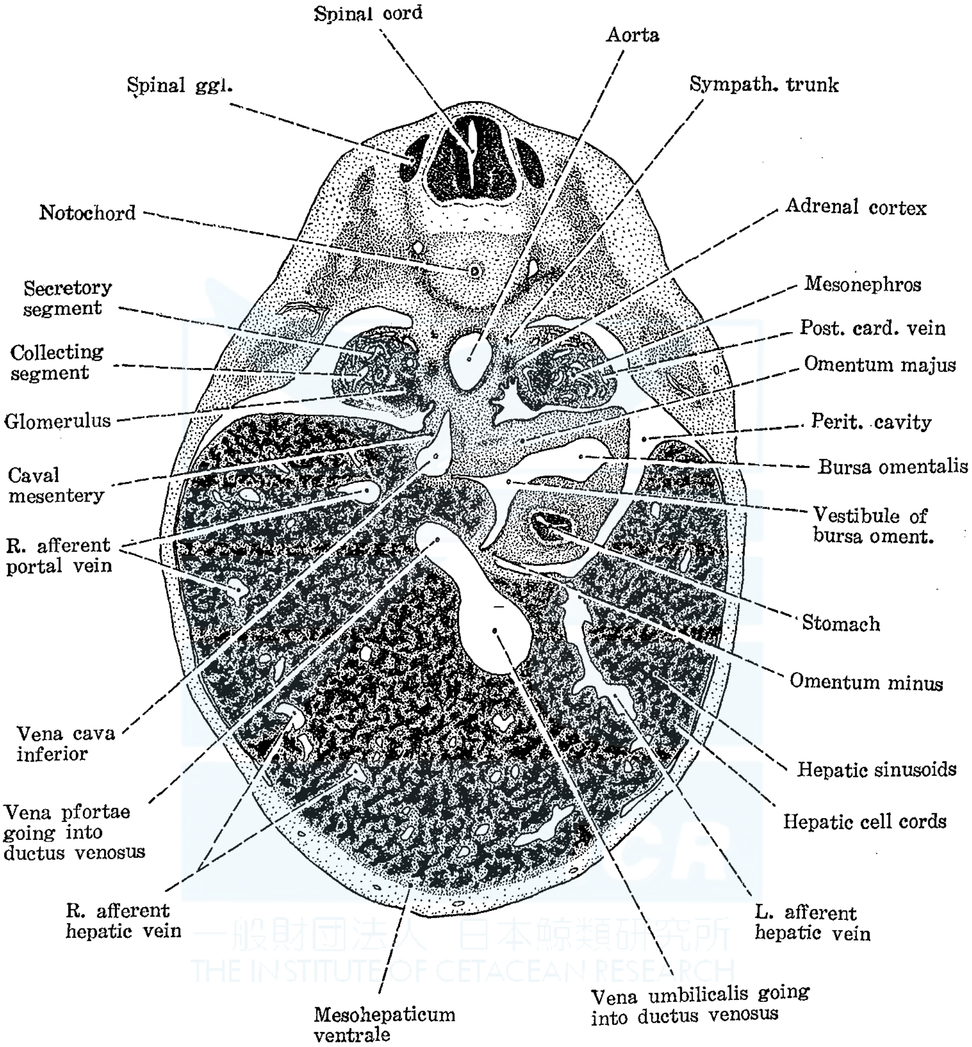


Fig. 25. Section through the adrenal cortex and vestibule of omental bursa.

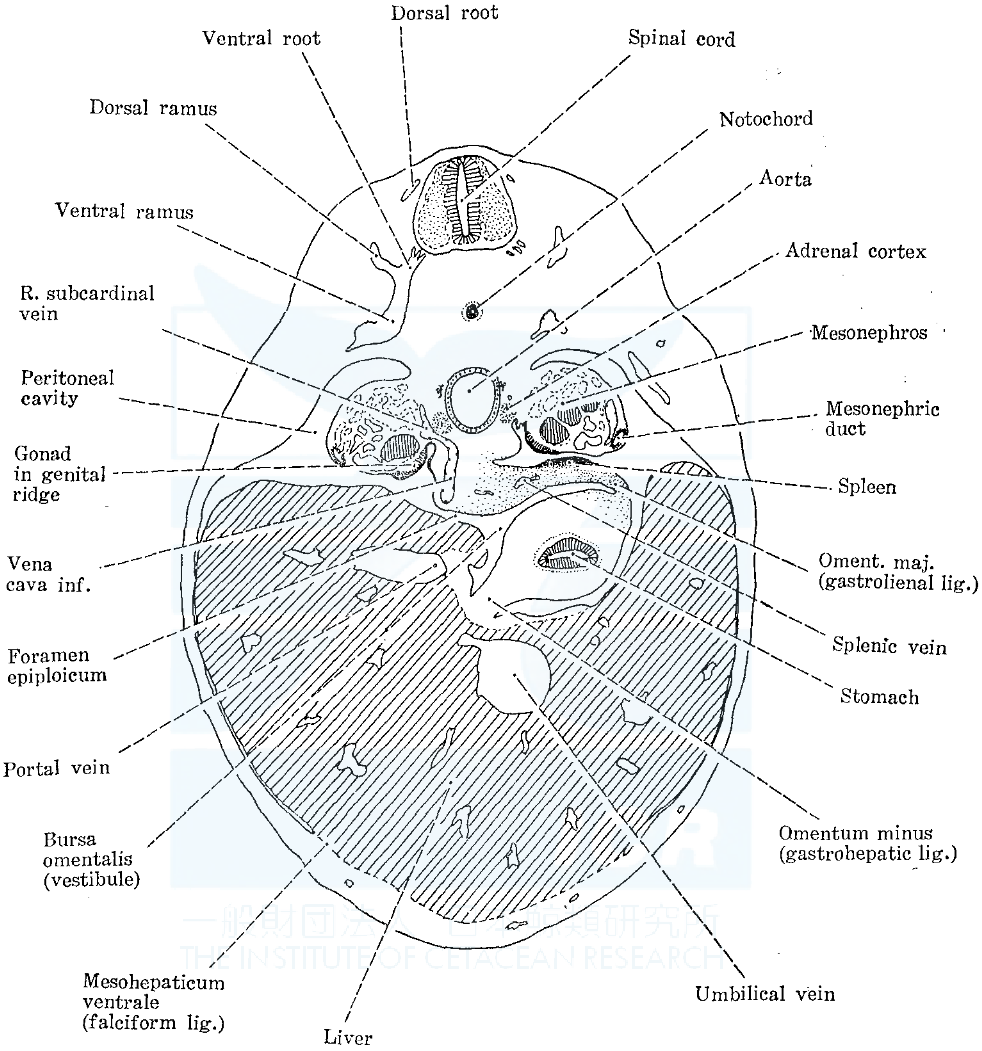


Fig. 26. Section through the foramen epiploicum and splenic primordium.

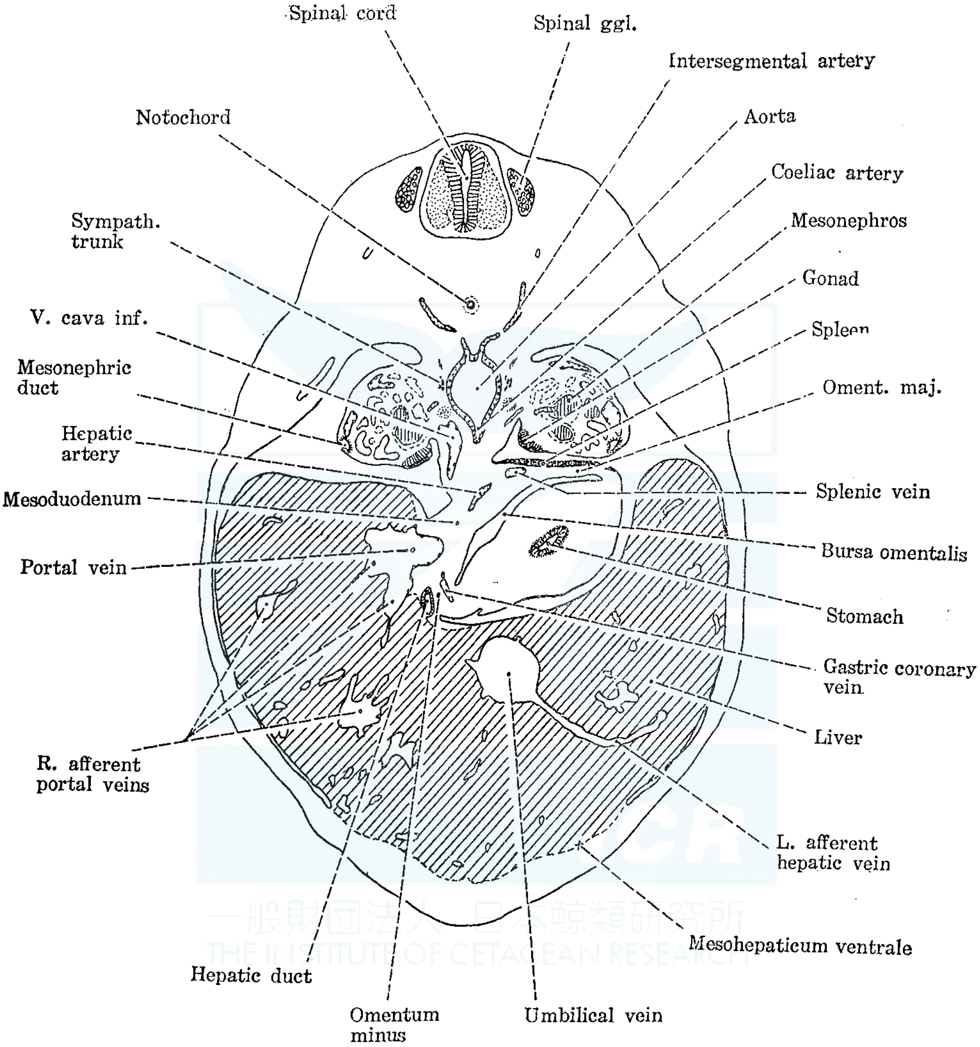


Fig. 27. Section through the root of coeliac artery.

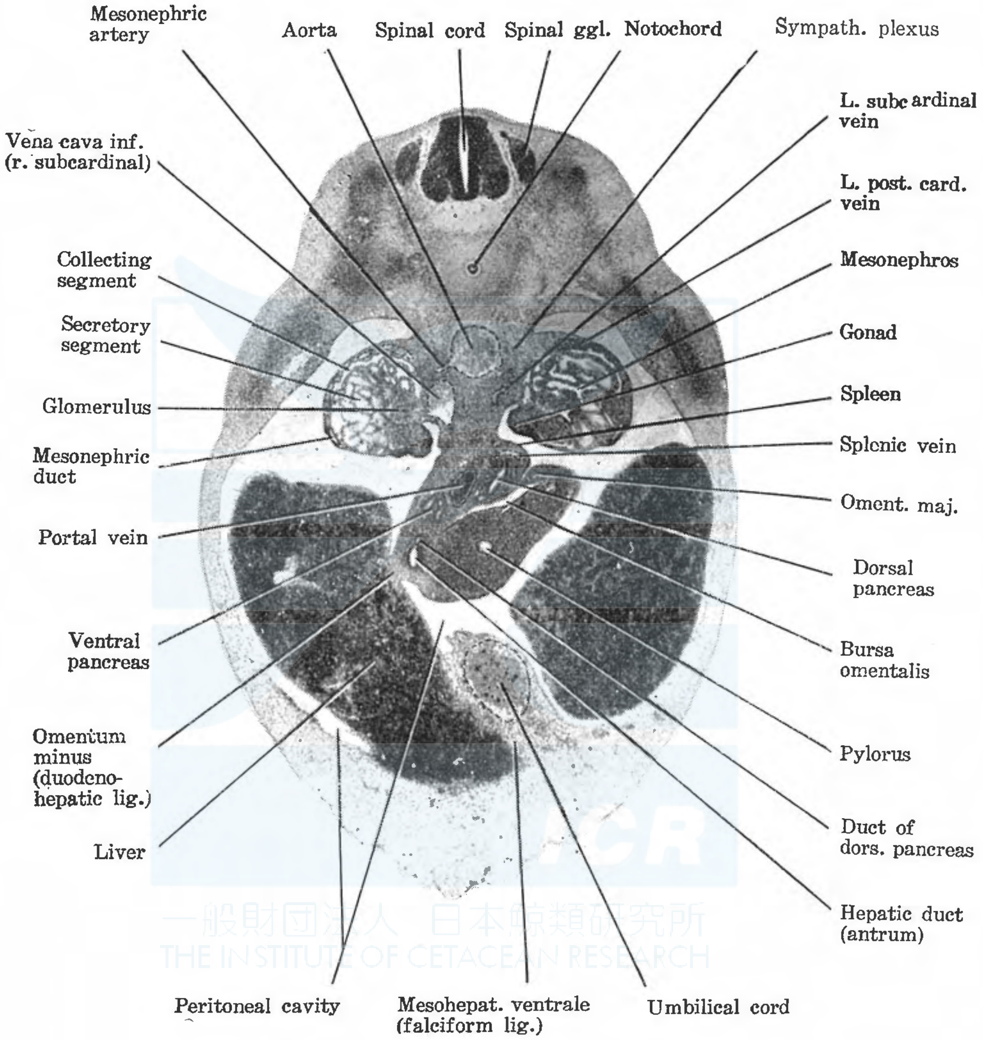


Fig. 28. Section through the primordial pancreas.

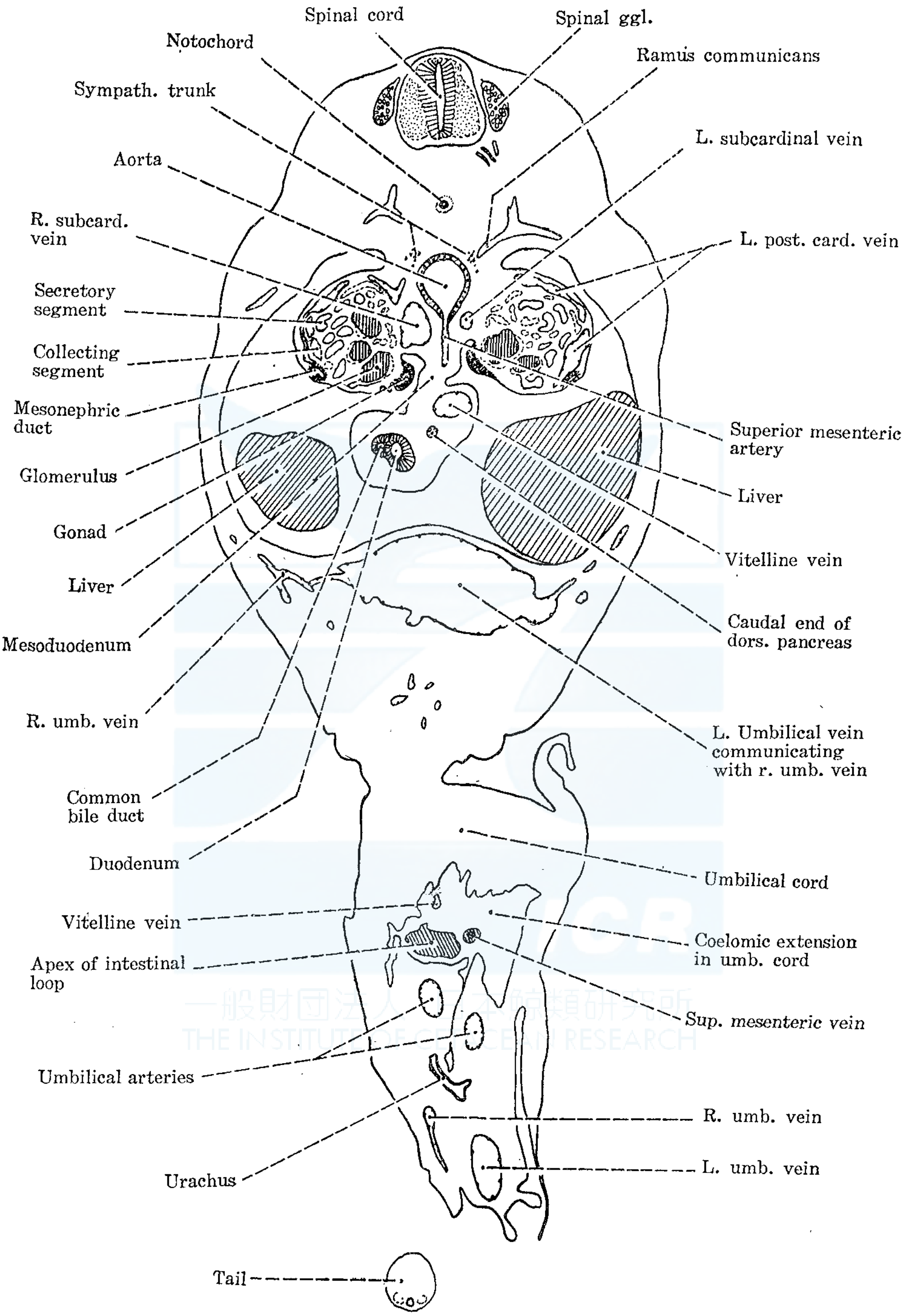


Fig. 29. Section through the exit to superior mesenteric artery.

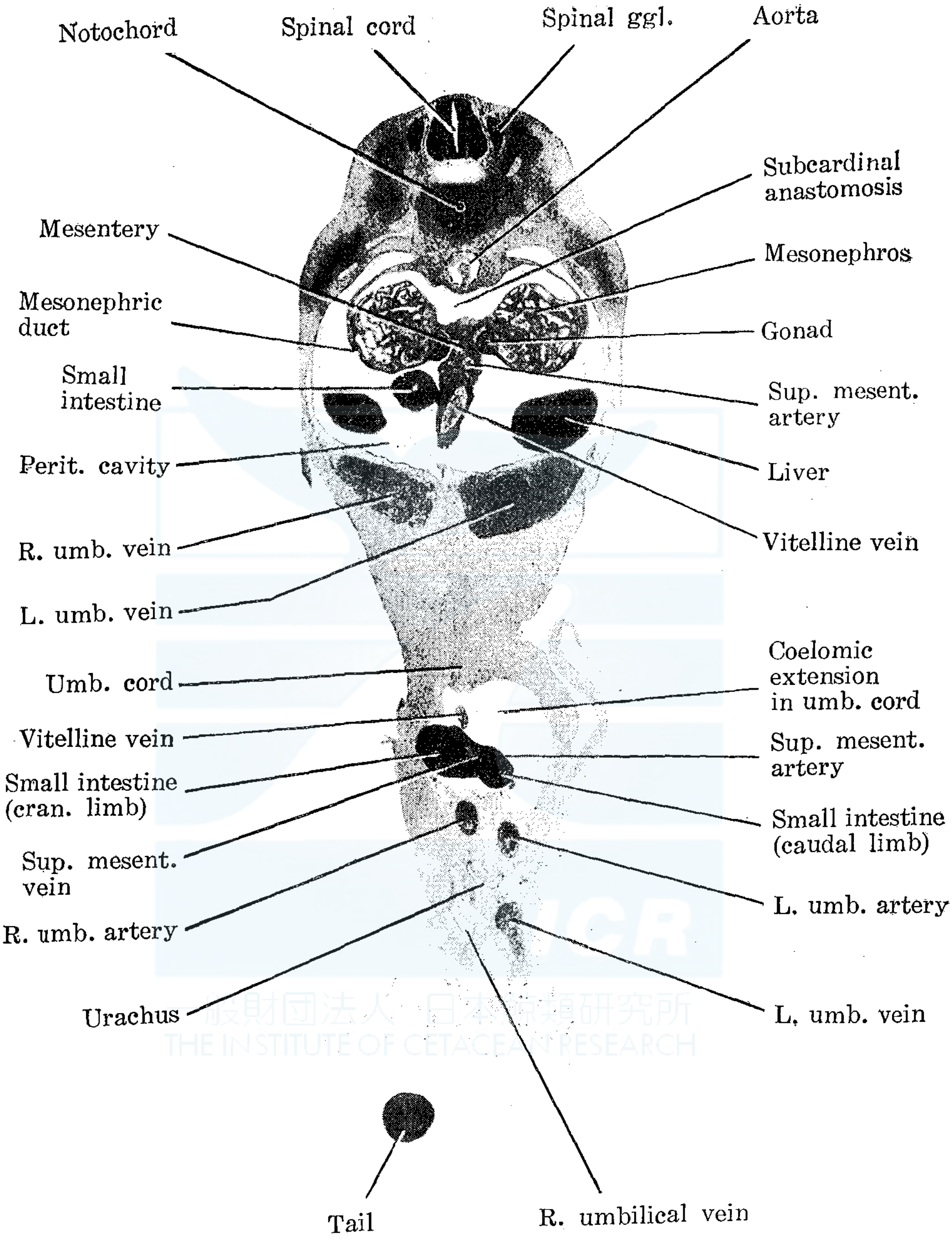


Fig. 30. Section through the subcardinal anastomosis.

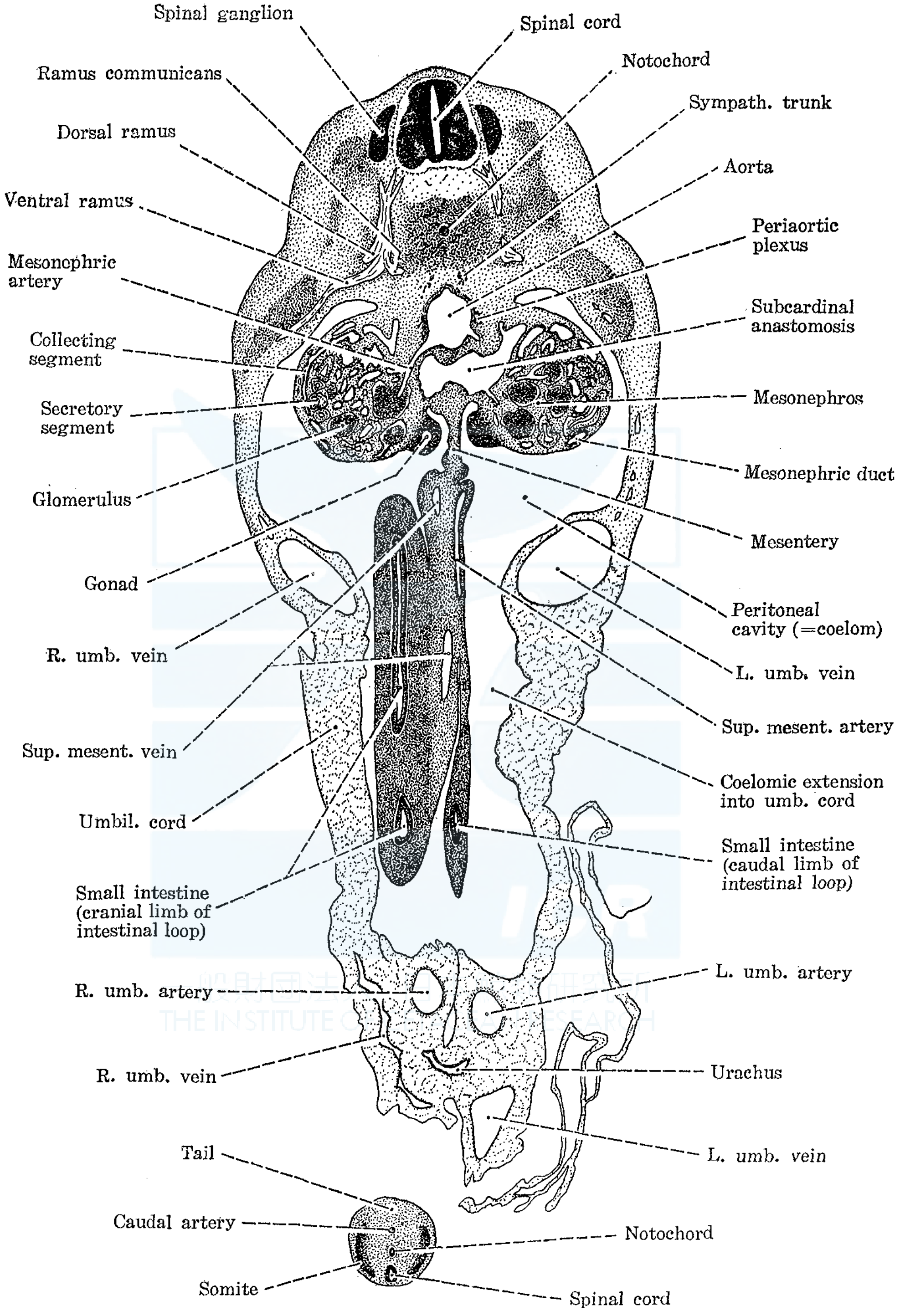


Fig. 31. Section through the coelomic extension into umbilical cord.

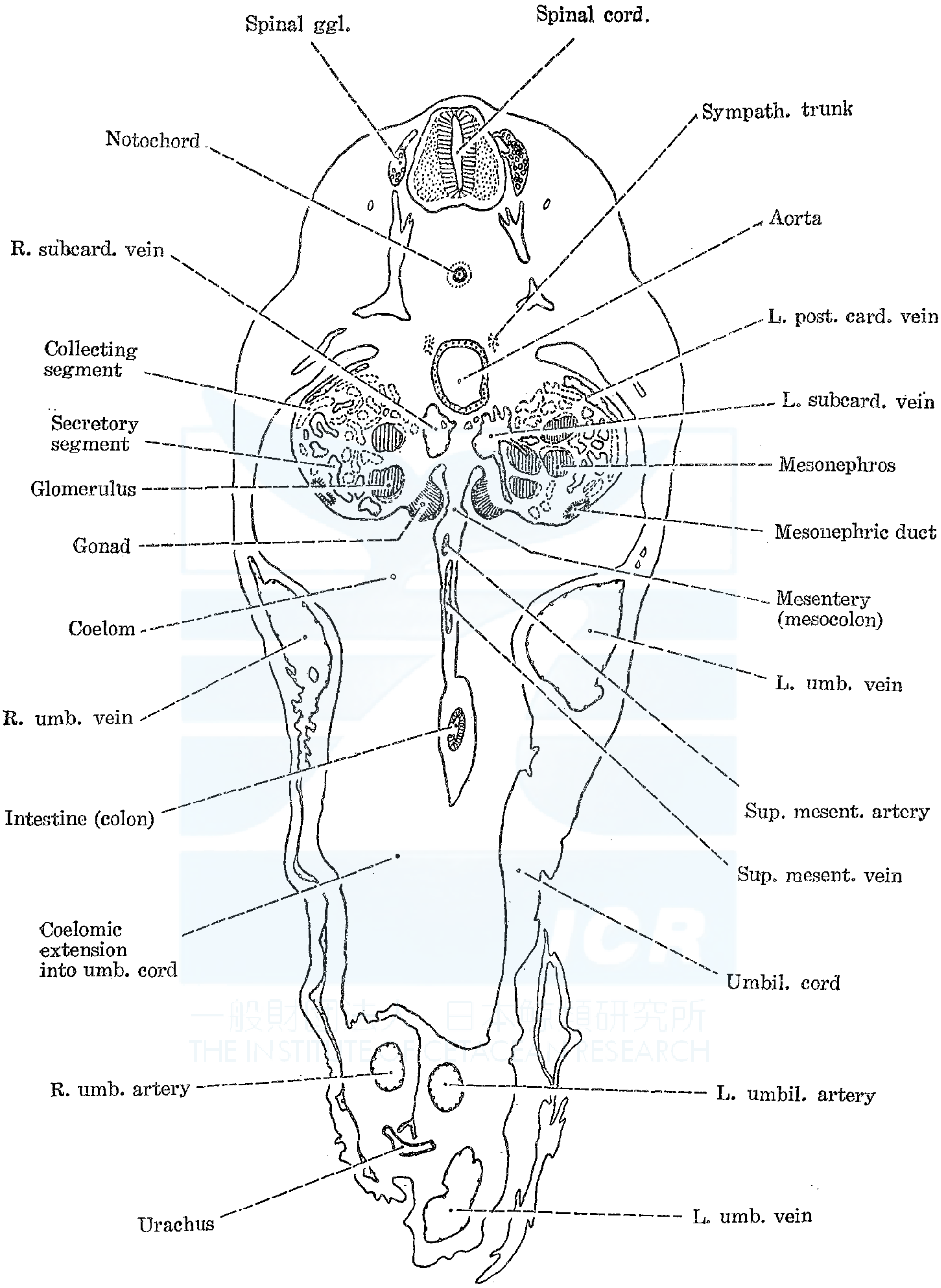


Fig. 32. Section through the caudal limb of intestinal loop (1).

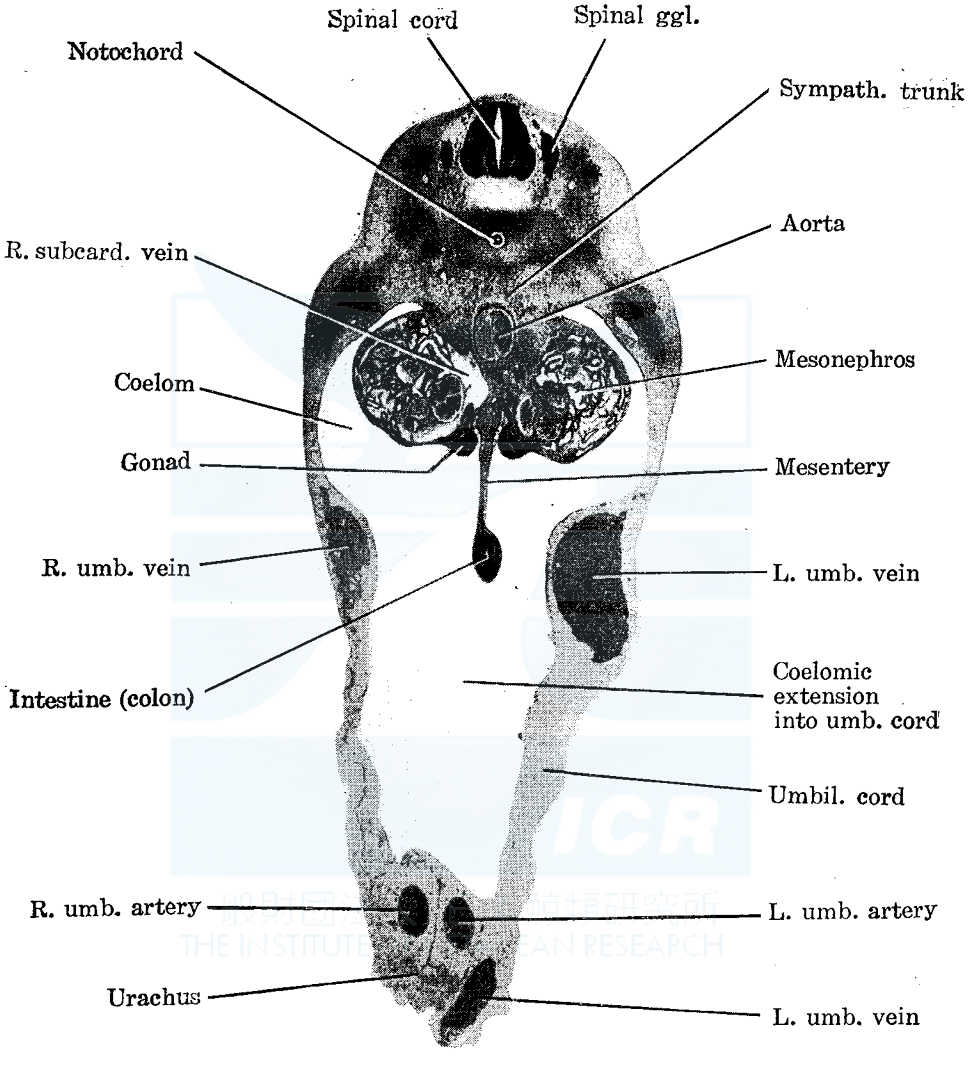


Fig. 33. Section through the caudal limb of intestinal loop (2).

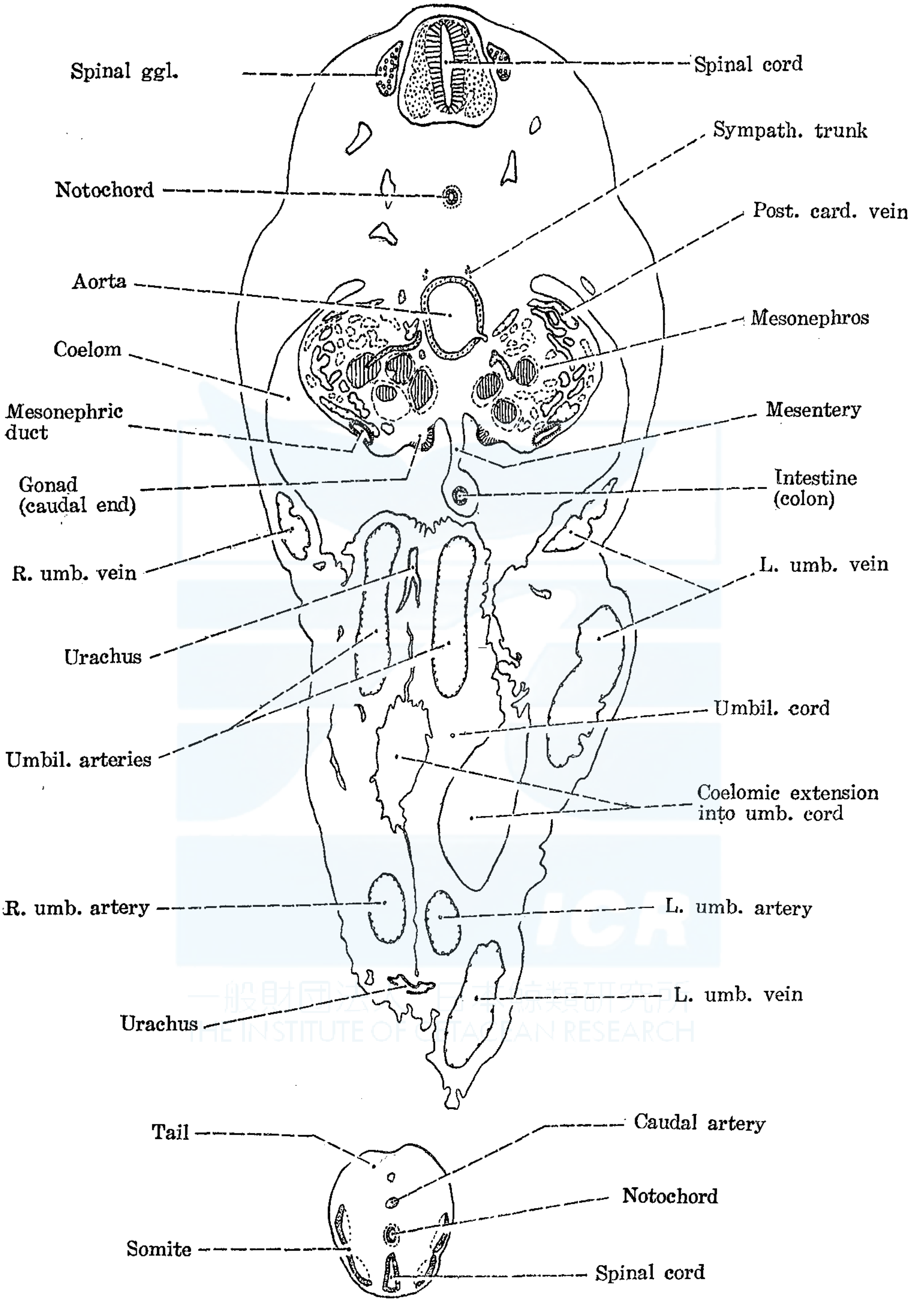


Fig. 34. Section through the root of umbilical cord (1).

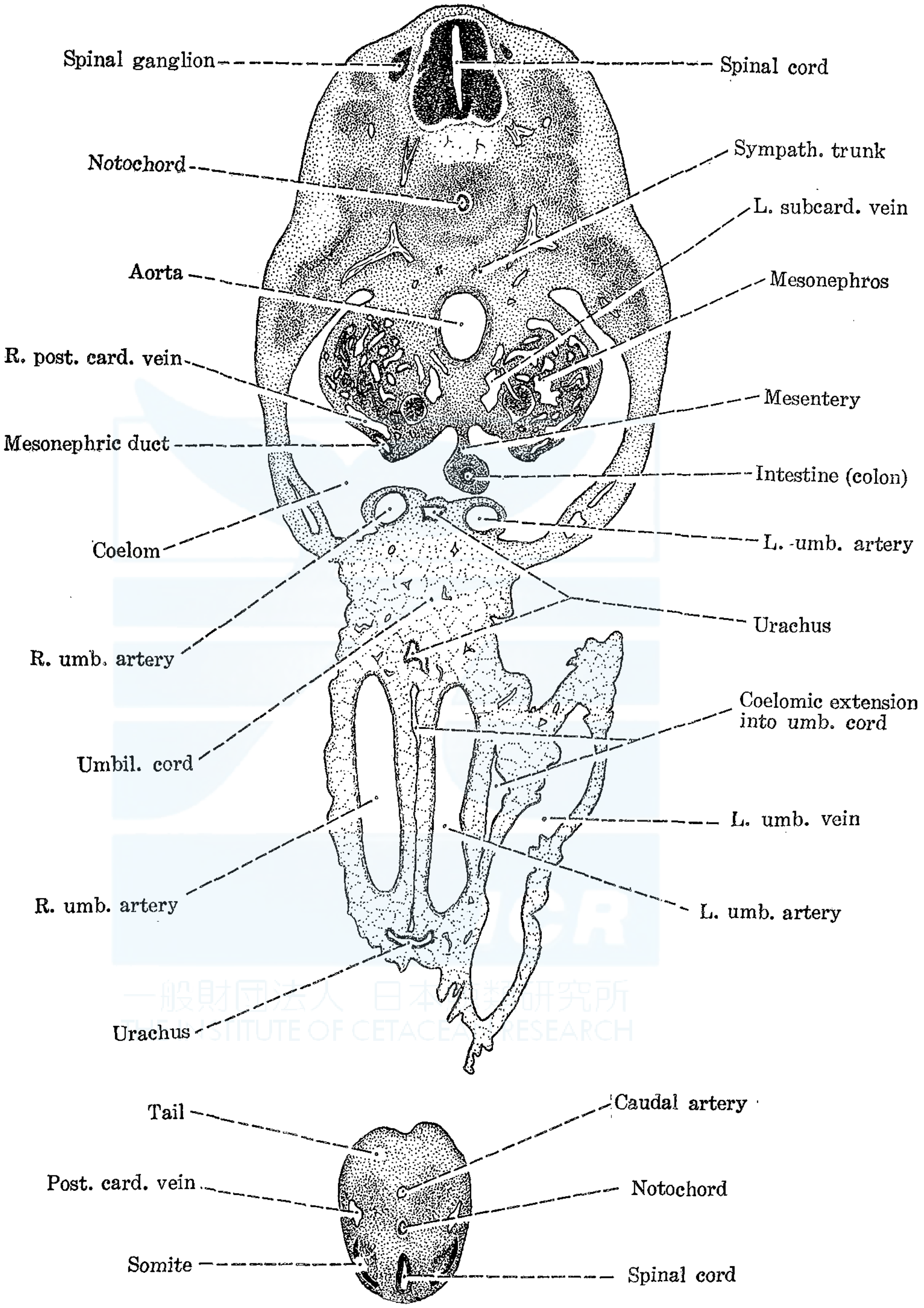


Fig. 35. Section through the root of umbilical cord (2).

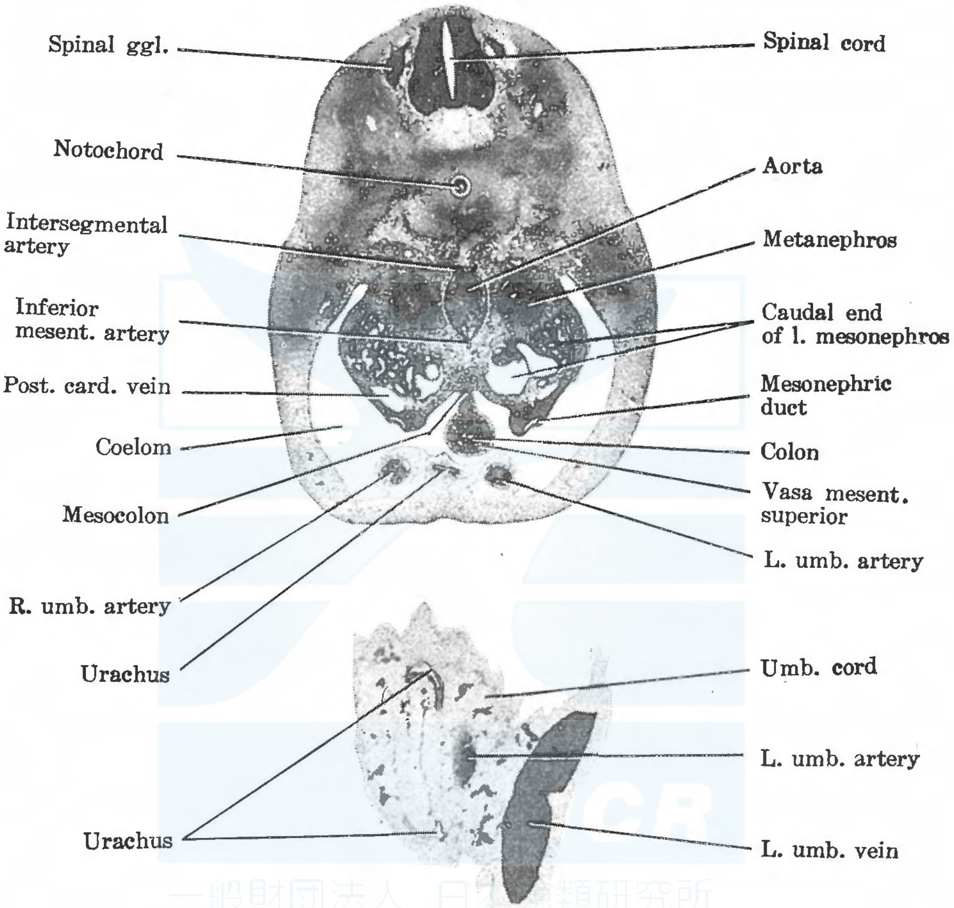


Fig. 36. Section through the metanephroi and inferior mesenteric artery.

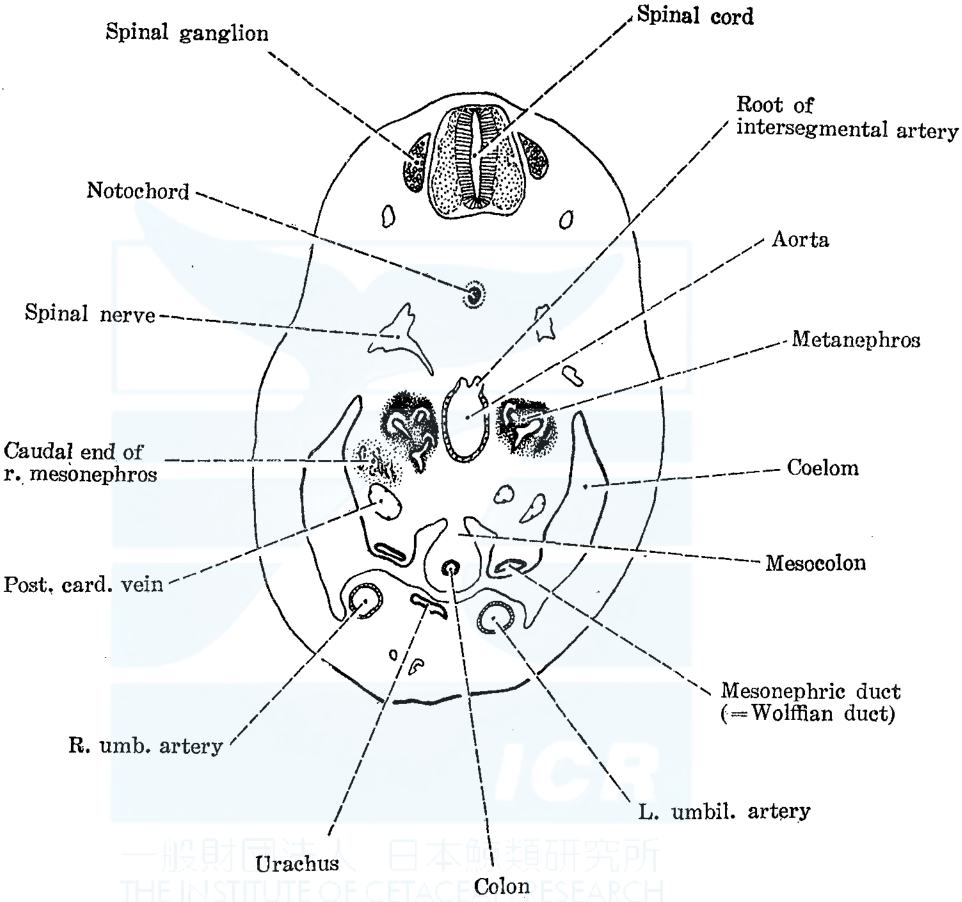


Fig. 37. Section through the metanephroi (2).

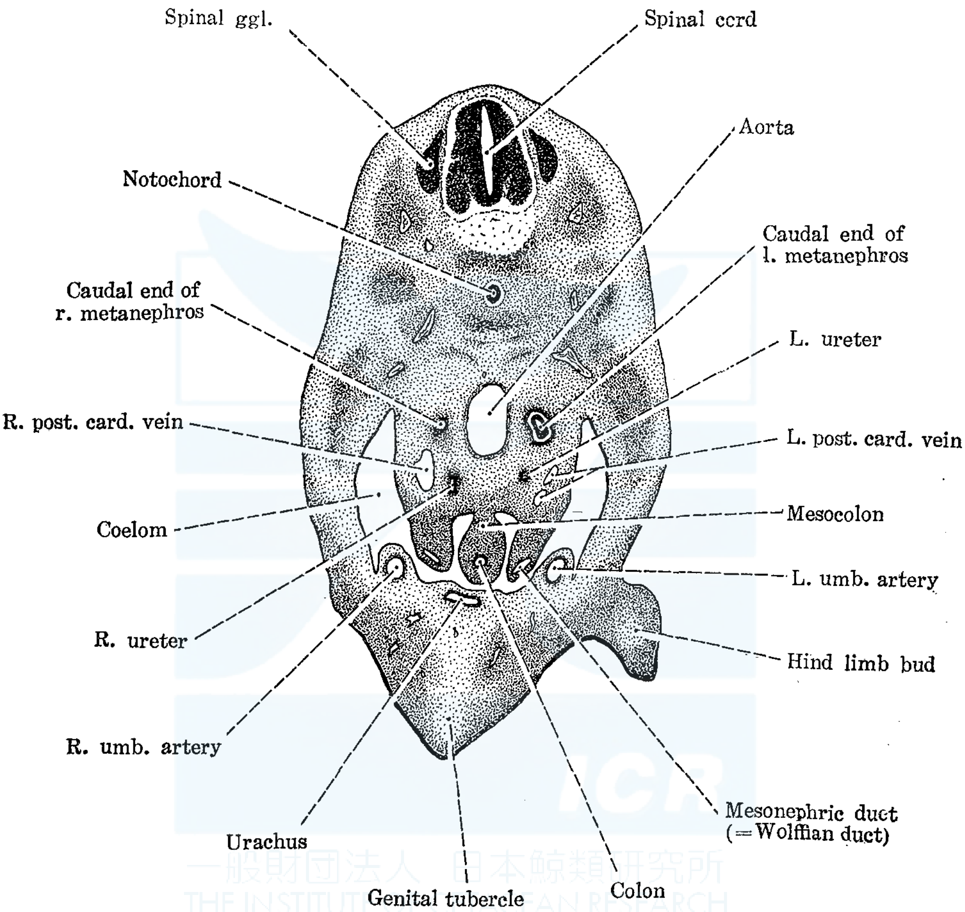


Fig. 38. Section through the ureter, genital tubercle and hind limb bud.

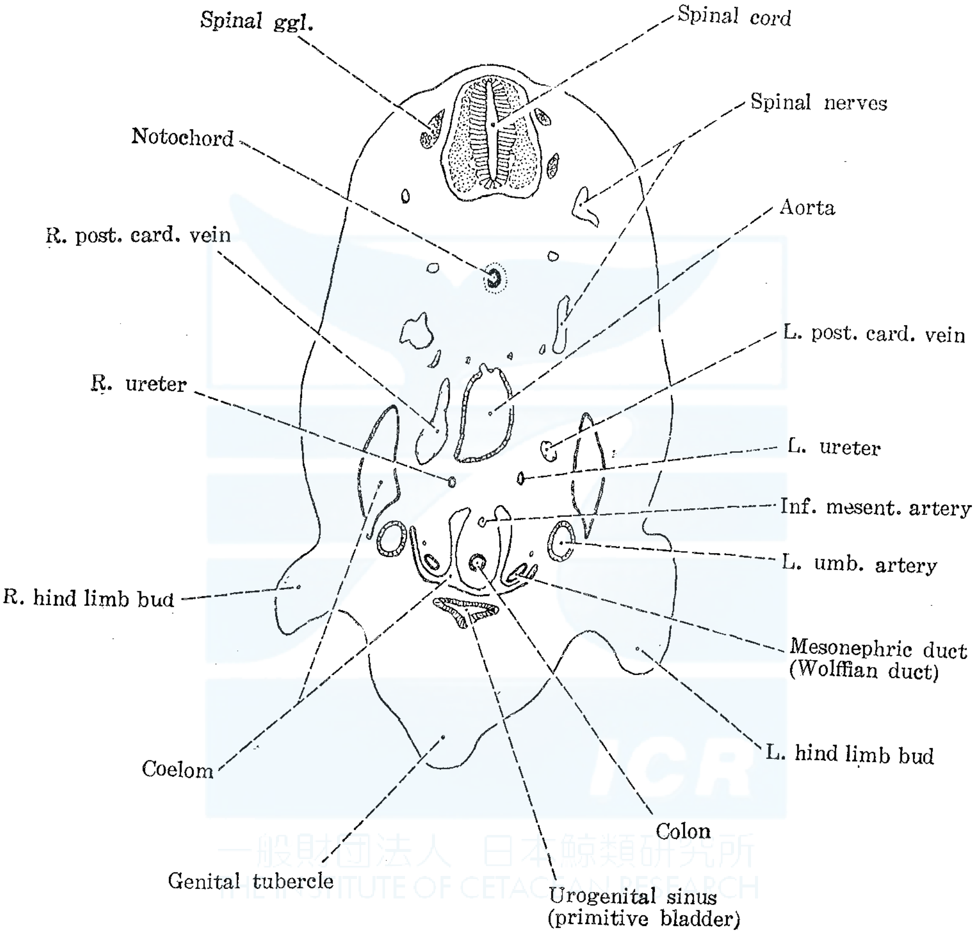


Fig. 39. Section through the primitive bladder.

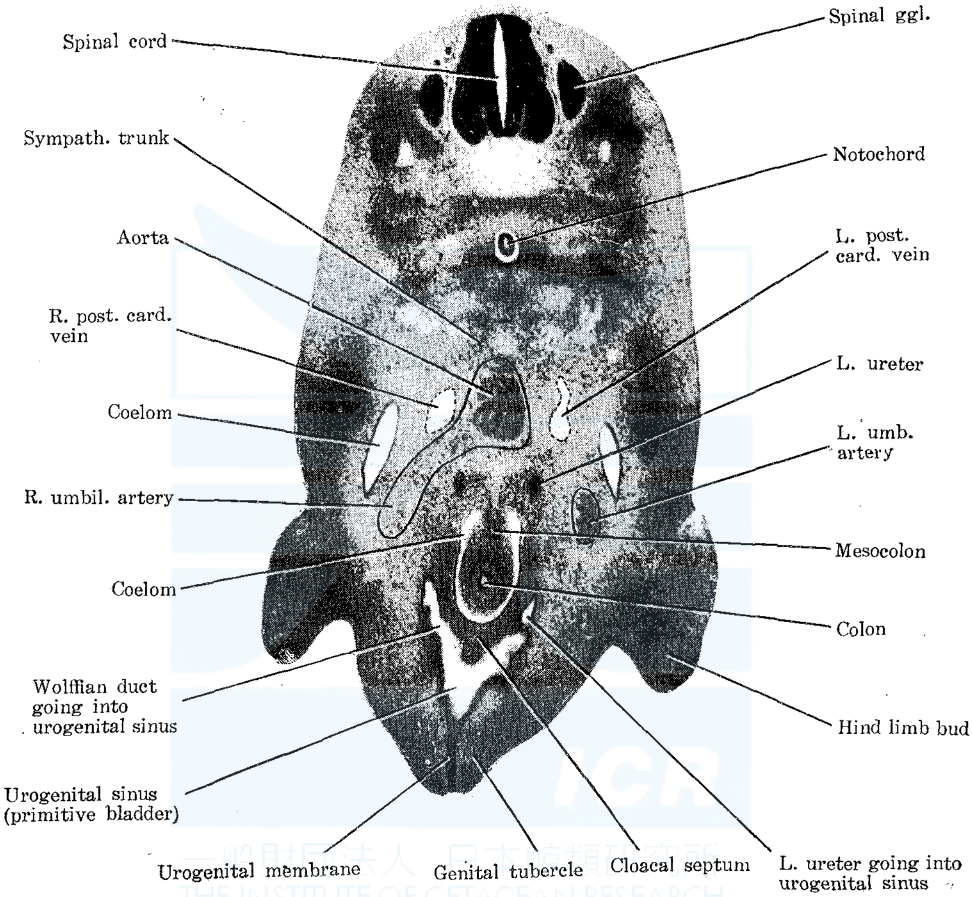


Fig. 40. Section through the urogenital sinus and membrane.

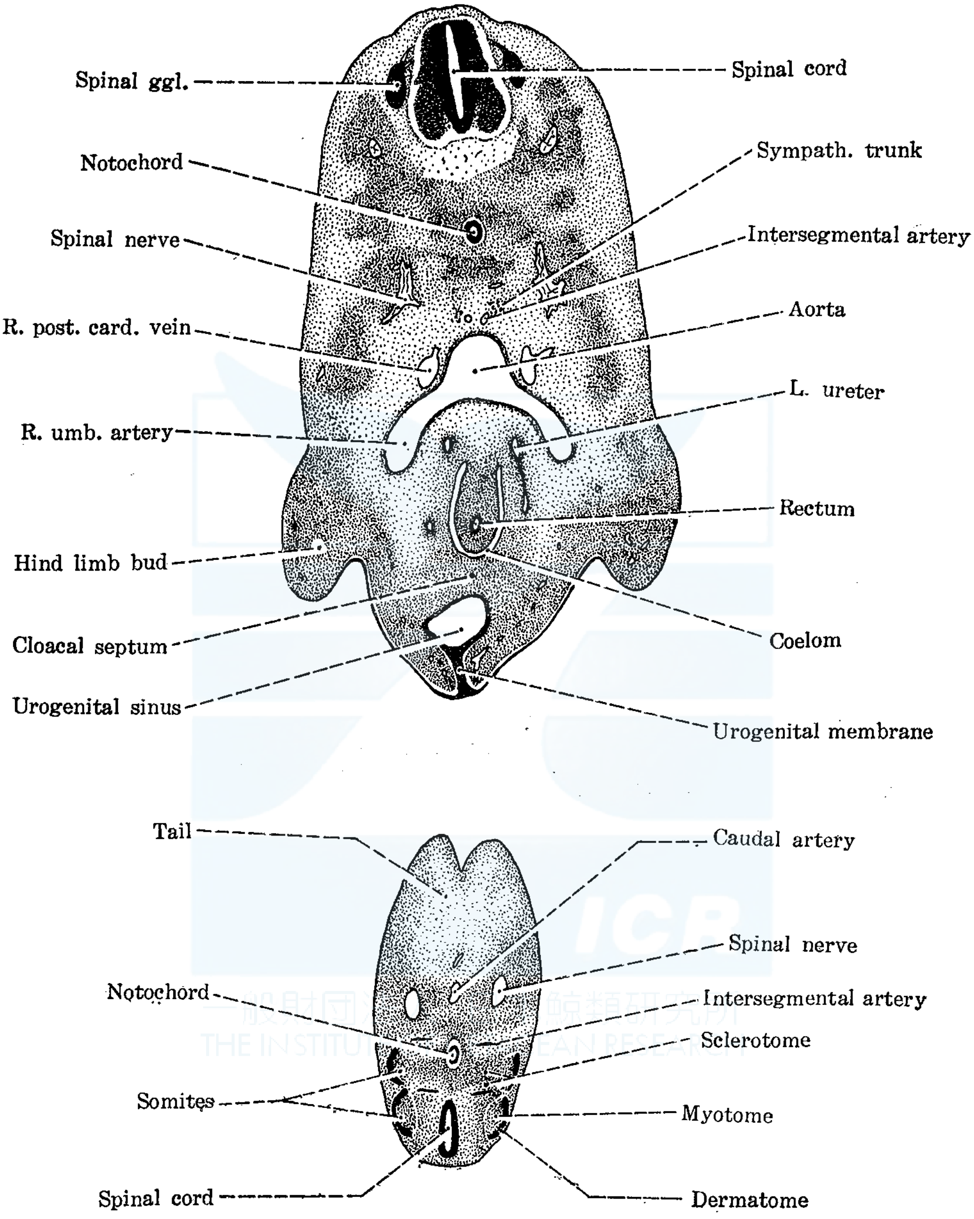
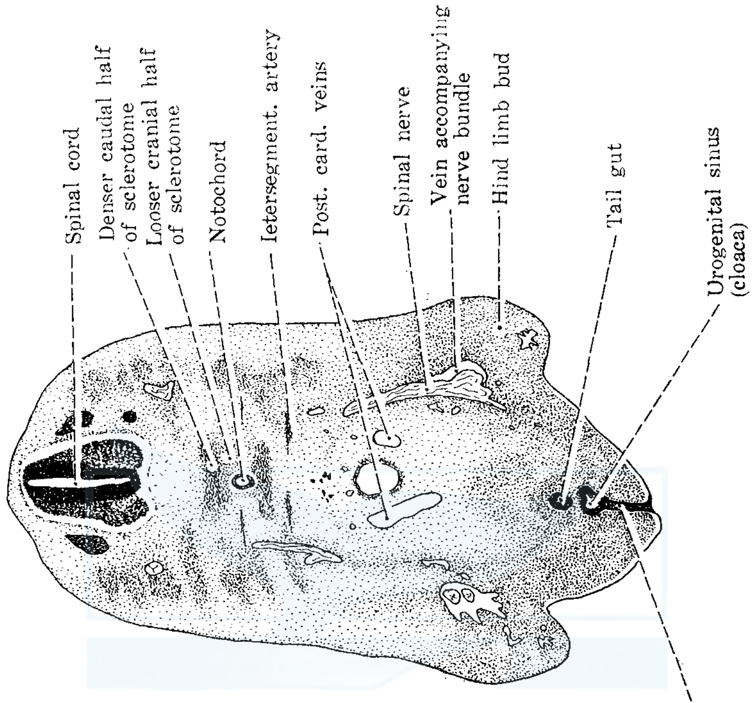


Fig. 41. Section through the bifurcation of aorta into umbilical arteries.



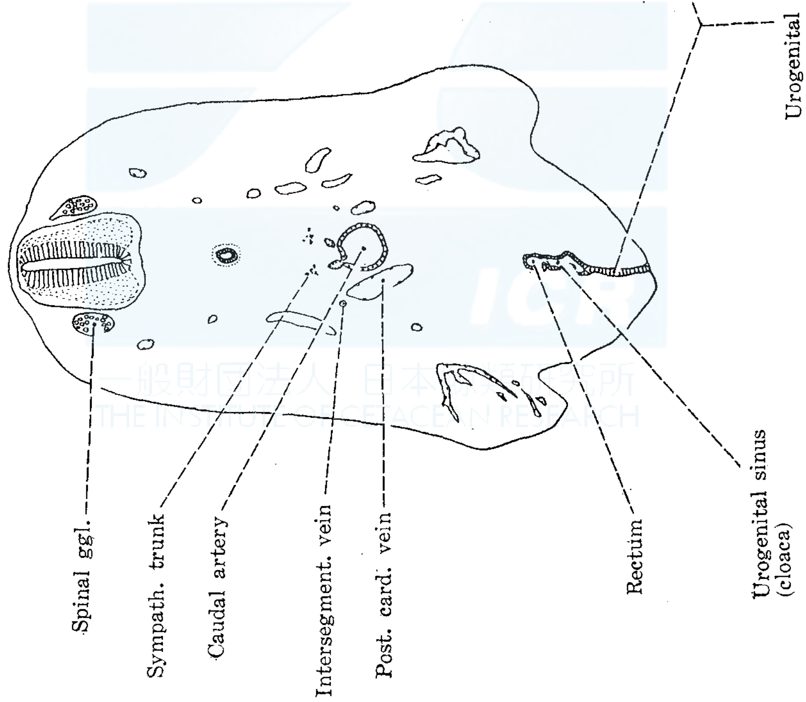


Fig. 42. Section through the caudal artery.

Fig. 43. Section through the tail gut.

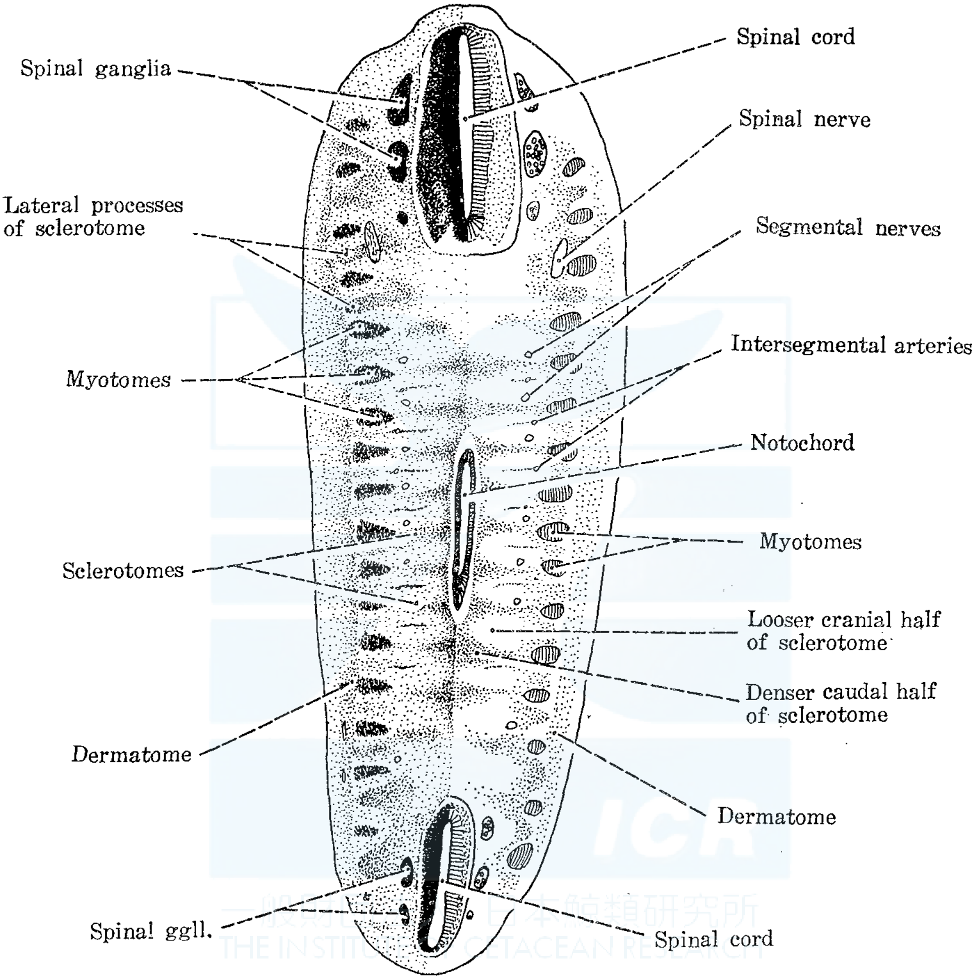


Fig. 44. Section through the lumbal curvature (1).

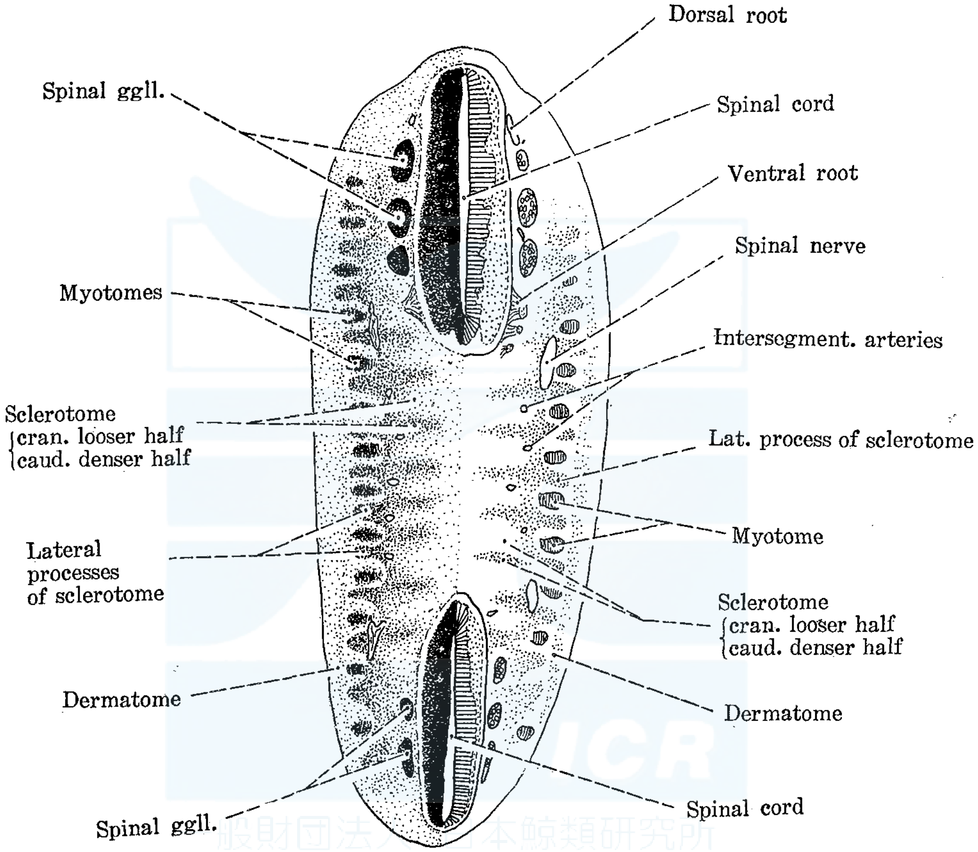


Fig. 45. Section through the lumbal curvature (2).

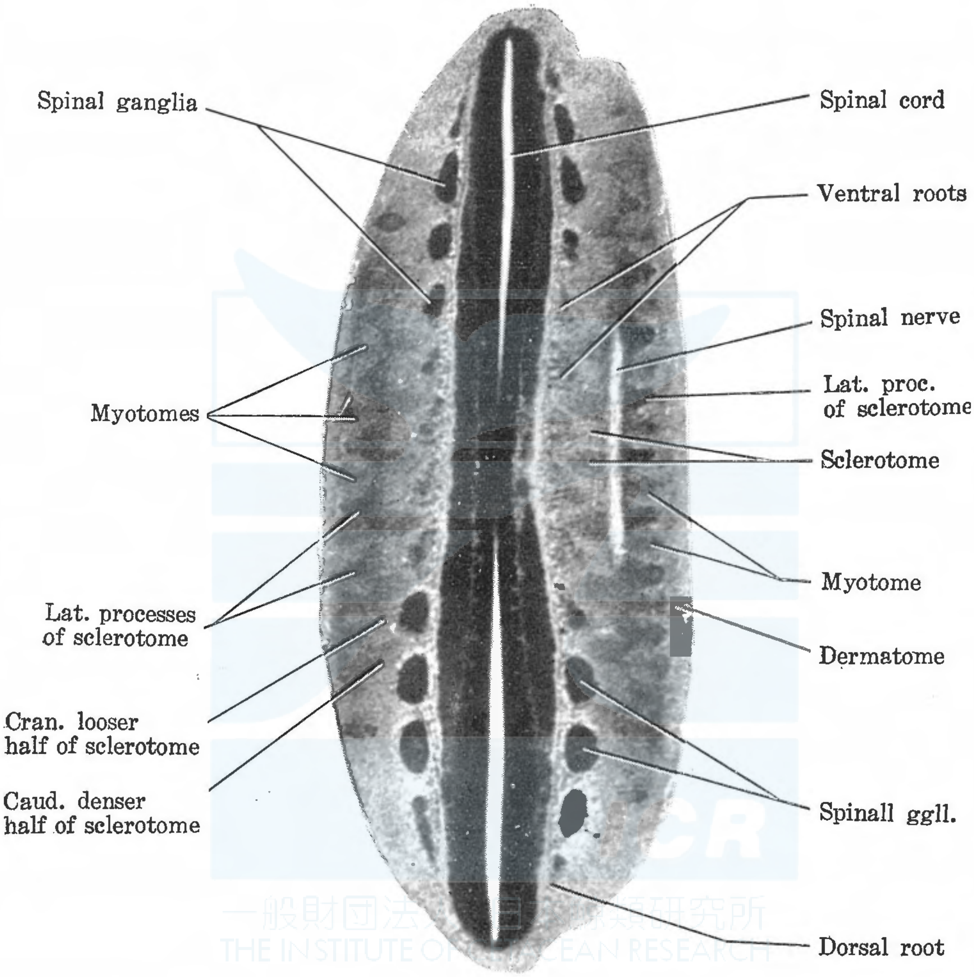


Fig. 46. Section through the lumbal curvature (3).

PLATE

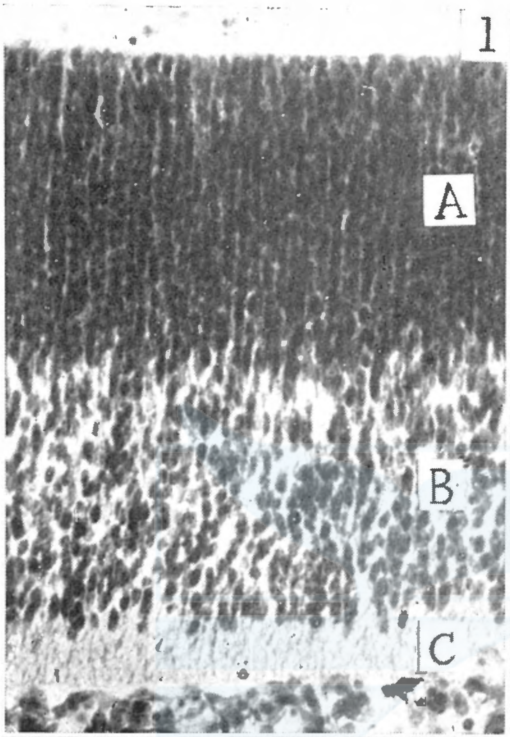
Explanation of Plate I.

1. Three-layered wall of the neural tube. A Ependymal layer. B Mantle layer. C Marginal layer. (Cf. explanation of Fig. 3)

2. Mitotic cells in the ependymal layer. The arrow points two mitotic cells in the innermost zone of the ependymal layer of the neural tube.

3. Mitotic cells in the ependymal layer, which is cut tangentially. Some twenty cells are found in various stages of mitosis.

4. Mitosis in the spinal ganglion. The arrow points a mitotic cell in the anaphase.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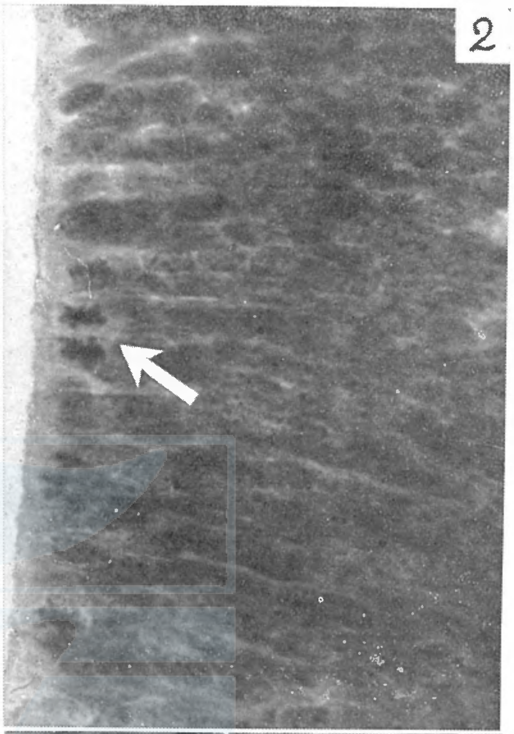
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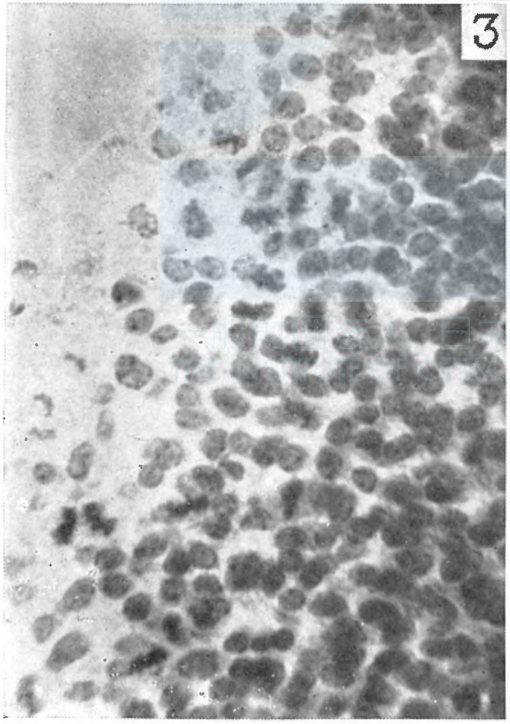
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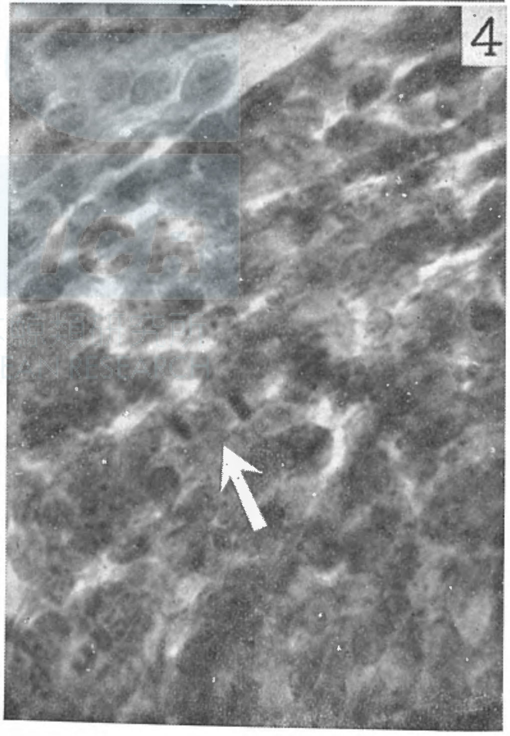
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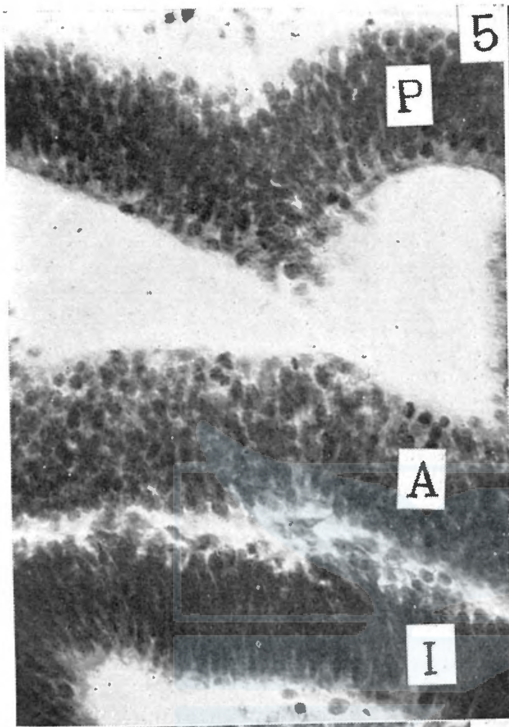
Explanation of Plate II.

5. Transverse section of the Rathke's pouch. (Cf. explanation of Fig. 9) P Posterior wall. A Anterior wall. I Infundibulum. Mitotic cells are encountered in these epithelial walls.

6. Optic cup. (Figs. 9-11) I Inner layer or the primitive retina. O Outer layer to furnish the pigment epithelium. The latter is provided in its inner zone with many pigment granules, some of which are indicated by the arrow.

7. Primordial thymus. (Figs. 12-15) It arises from the ventral wings of the third and fourth pharyngeal pouches. These cells of entodermal origin will proliferate and transform later into a syncytium that resembles reticular tissue, thus forming the framework of the thymus.

8. Primitive thyroid gland. (Fig. 13) It is represented by a cell mass which has originally invaginated from the ventral floor of the pharynx. Mitotic cells are scattered around. Several lumens inside the cell mass may be the remnants of the thyroid diverticulum. A couple of weeks will elaspe before the follicular cavities appear.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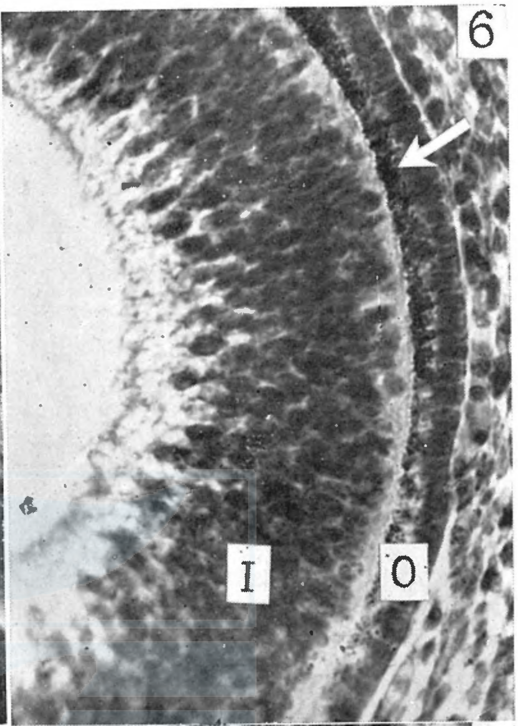
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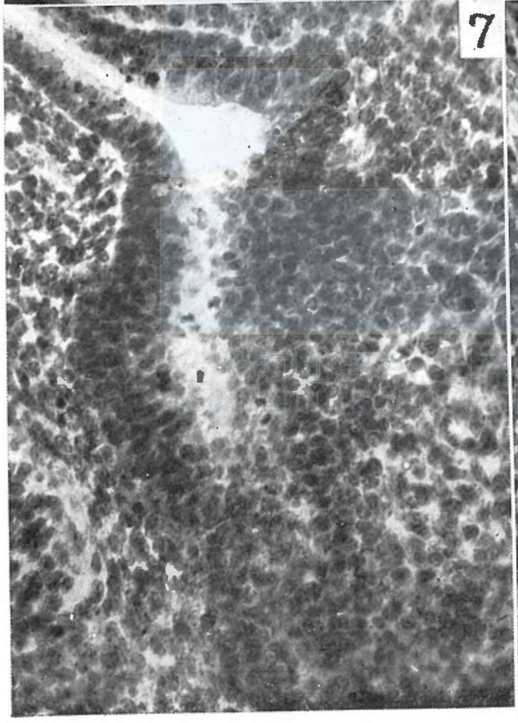
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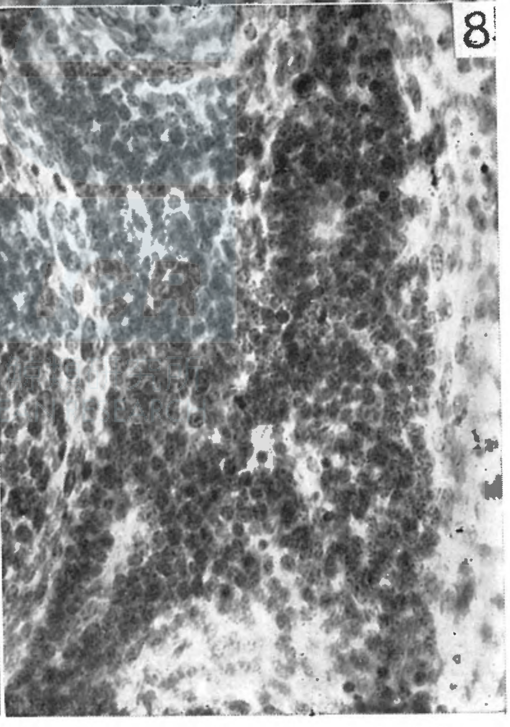
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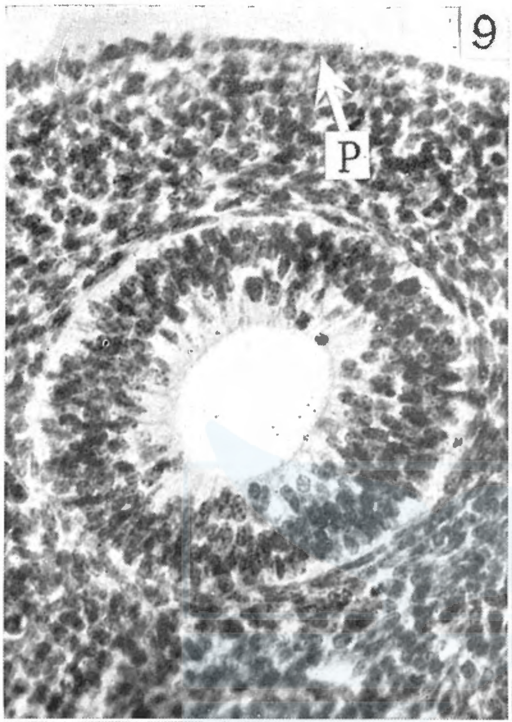
Explanation of Plate III.

9. Lung bud. (Figs. 17–23) The bronchial bud shown in the center of the figure is lined with ciliated, thich epithelium. When the bronchial buds continue to grow and branch, the epithelial lining of the terminal portions become thin-cuboidal; and the alveolar primordia will occur in the later half of the felal life. The mesothelial lining indicated by an arrow (P) represents the primitive pleura.

10. Liver. (Figs. 21–30) Larger cells with oval, coarse nuclei are the primitive hepatic cells, some of which are in mitosis. Hepatic cell cords are separated from each other by the intervening sinusoids, a couple of which are encircled by broken lines. The hepatic sinusoids are the site of hematopoiesis and are filled with various kinds of primordial blood cells. The mesenchymal invasion to furnish the interstitial tissues will be prosperous later on.

11. Nucleated red cells in the circulating blood. In addition to the nucleated erythrocytes (E), there can be identified megaloblasts with larger nuclei (M) and normoblasts with smaller, denser nuclei (N). The former is rather basophilic in the cytoplasm, while the latter is very rich in hemoglobin and stained deep red.

12. Primordial adrenal cortex. (Figs. 25–27) It is represented by mesenchymal accumulation, which is encircled by broken line. The invasion of the primitive medullary cells is not yet in view. (Cf. explanation of Fig. 25)



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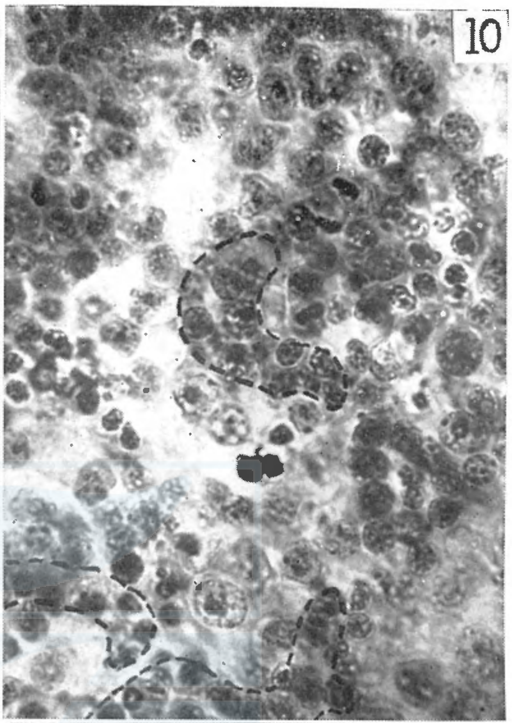

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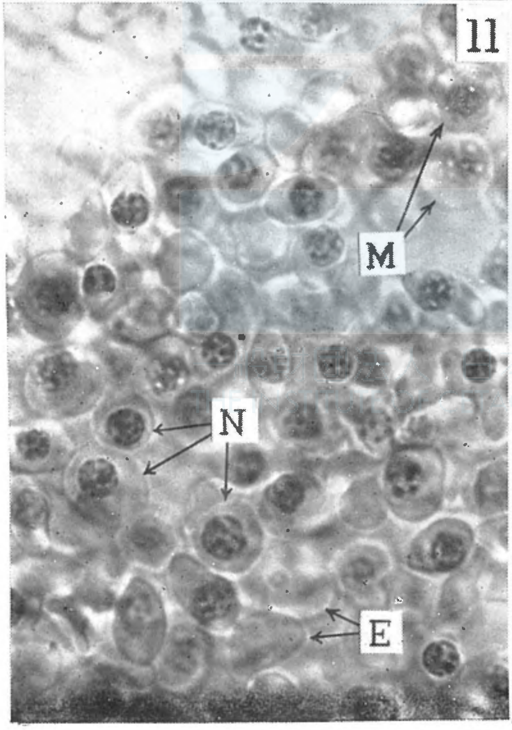

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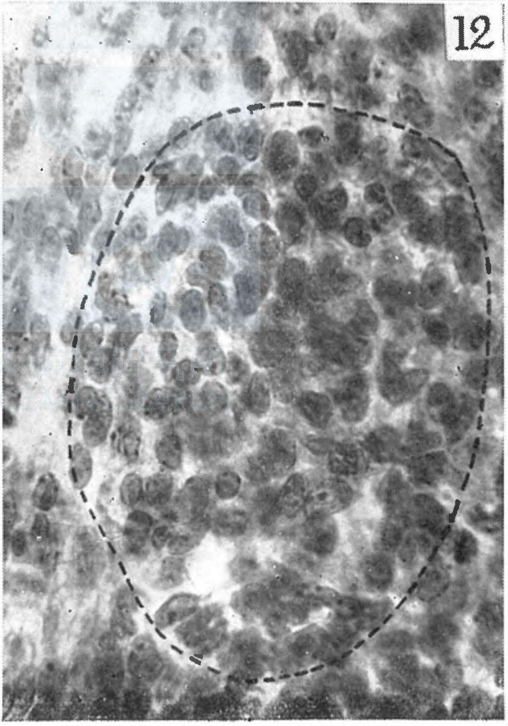

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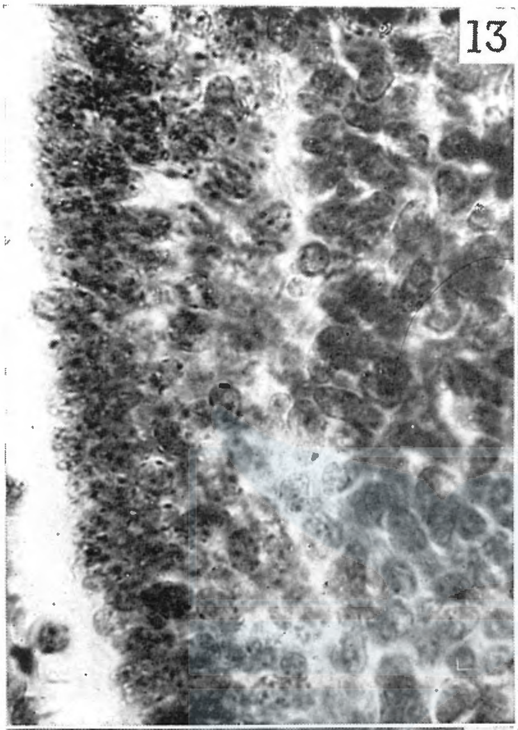
Explanation of Plate IV.

13. Splenic primordium. (Figs. 26–27) It consists of the mesenchymal condensation just beneath the mesothelial lining of the dorsal mesogastrium. (Cf. explanation of Fig. 26)

14. Gonad in the genital ridge. (Figs. 25–34) The sexual gland is indifferent or sexless at this stage, composed merely by inner cell mass covered by the germinal epithelium (G. E.). Some mitotic cells are found in the latter.

15. Inner cell mass of the gonad. These cells have derived by the proliferative ingrowth of the germinal epithelium. They are, however, not the progenitors of the real germ cells. For, the primordial germ cells are thought to originate in the yolk-sac entoderm, migrating afterwards into the genitial ridges.

16. Primitive pancreas. (Figs. 28–29) The future pancreas is indicated by outpouchings from the duodenum into the dorsal mesentery. As they continue to grow, they become contorted, thus forming the primitive pancreatic ducts lined with entodermal epithelium (D). Later on, the acini begin to appear as terminal and side buds from the ducts. Also the Langerhans' islands will differentiate from the same source.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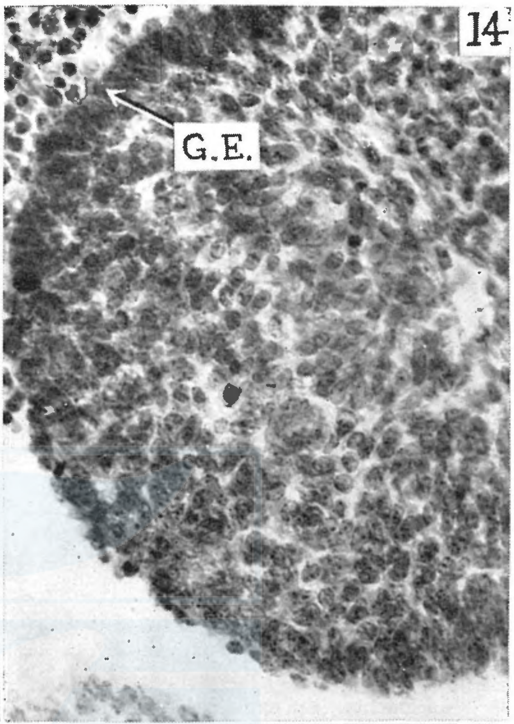
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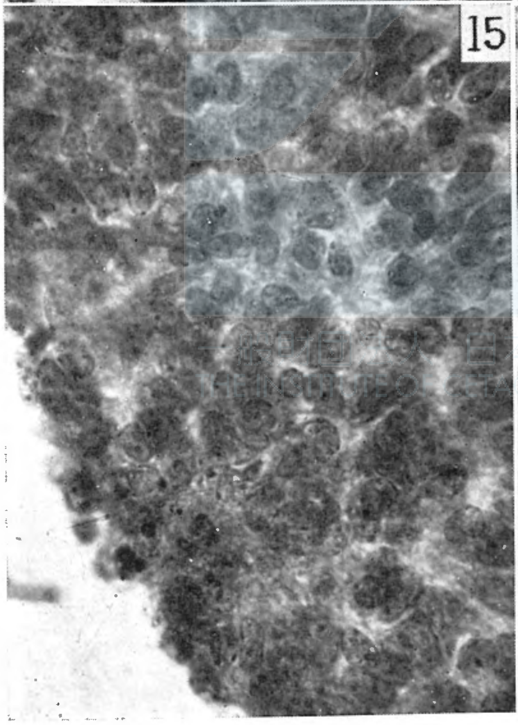
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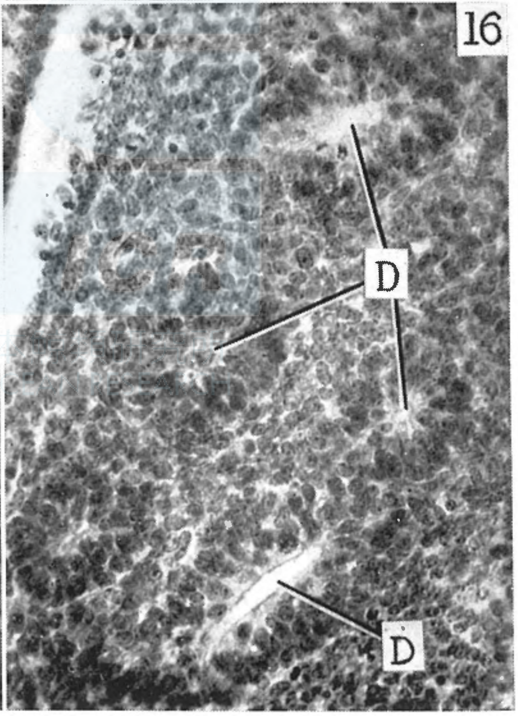
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Explanation of Plate V.

17. Cross section of the mesonephros. (Fig. 23–37) (Cf. explanation of Fig. 32) G Glomerulus. S Secretory segment. C Collecting segment. W Mesonephric or Wolffian duct. B Connection between the Bowman's capsule and the secretory segment.

18. Metanephros. (Figs. 36–37) The tubal, epithelial portion (C) is the primordial pelvis, calyces as well as of the collecting segments. The mesenchymal accumulation (S) surrounding the tubules represents the primordium of the secretory segments. (Cf. explanation of Fig. 37)


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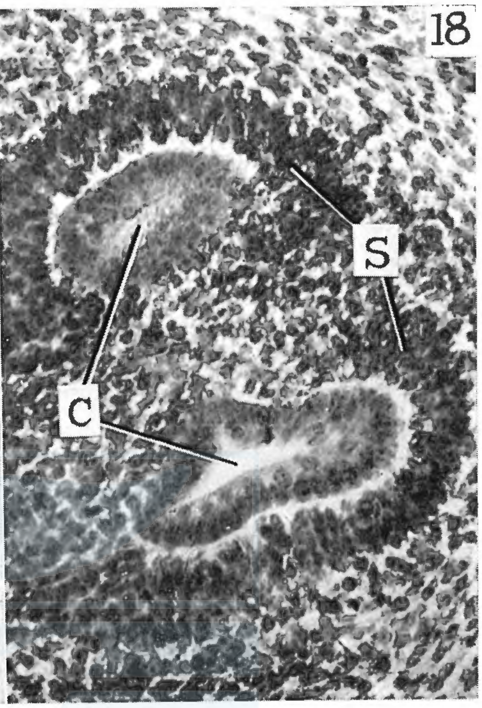

18

White Scars on Whales
(I) Lamprey Marks

By

TAKAHISA NEMOTO

The so-called white scars on the skin of whales have been reported on various species of whales and from various whaling grounds in the world. The cause of the formation of these scars has remained long in doubt. *Coronula*, *Pennella*, sucking fish or sharp rocks were suggested as probable causes in the early days, however, Mackintosh and Wheeler (1929) describe that it does not seem possible to explain the various stage of the scar by any of such theories and the balance of probability indicates that they are primarily the work of micro-organisms, the ciliated protozoa. But recently Pike (1951, 1953) reports that these oval white scars on whale were attributable to the attacks of parasitic lampreys and the open pits in the blubber of whales were interpreted as healing stages which succeeded the lamprey attacks. He also considers it is probable that ciliated protozoa aggravated those wounds by invading the previously punctured skin.

I had studied these lamprey marks on whales processed on the Japanese whaling factory ship "Baikal-Maru," which operated in the Northwestern part of the Northern Pacific in 1953 and from whales processed at various landstations in Japan in 1954, including those taken in the Okhotsk Sea. After having studied, I get to a conclusion that the marks caused by the attacks of the lamprey are identified from those reported by various authors previously as white scars, the details of which are reported in this paper.

I am much indebted to Dr. H. Omura, the president of the Whales Research Institute, who kindly read the draft of the manuscript and critisized it and to Mr. K. Fujino, a research member of the said institute for the precious suggestions. My sincere thanks are due to Dr. H. Yabe of the Nankai Regional Fisheries Laboratory, to whom I am indebted for the splendid photographs shown in Fig. 10. The crew of the whaling factory ship "Baikal-Maru" and the staffs of the landstations immensely aided me in the observations in the field. To all, I also extend my sincere thanks.

According to my observation, the same species of sea lamprey as reported by Pike (1951) attacks whales also in the western part of the Northern Pacific. This Pacific sea lamprey, *Entosphenus tridentatus* distributes in the broad region from the Arctic as far south as southern

California in the American side and down to about 35°N Latitude in the western side of the Northern Pacific. It is well known that this species attack also fish, e.g. salmon or cod, causing a great harm to the fishery, especially in the American side. Like the Japanese river lamprey (*Lamptera japonica*) its dorsal fin is separated into two regions, however, the species is identified by having three acute cusps in the supraoral lamina from the Japanese river lamprey.

The infraoral lamina has five sharp cusps. Amidst of the mouth there is lingual lamina in which many small denticles are present, and on both sides of the sucking disk there present four series of lateral teeth, usually consisted of the arrangement of the teeth of 2–3–3–2 (Fig. 1).

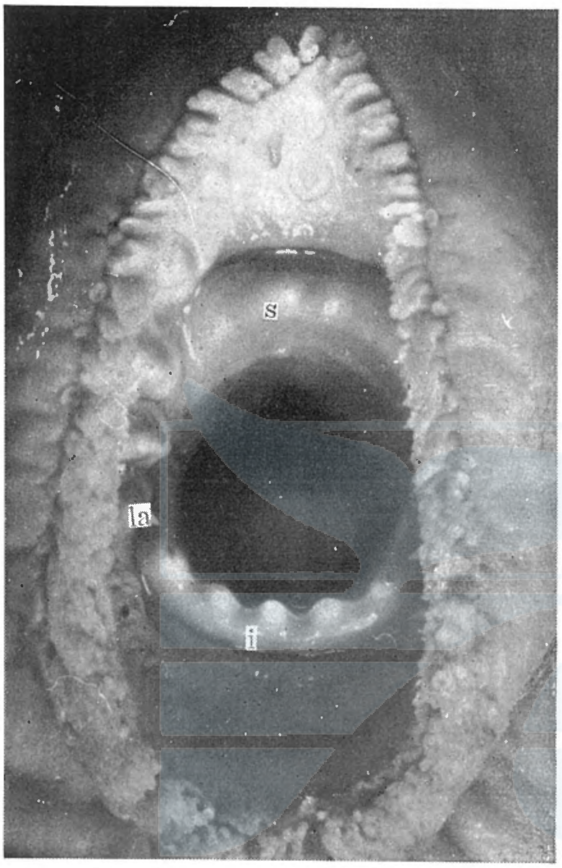


Fig. 1. Sucking disk of Pacific sea lamprey. (×4)
s) supraoral lamina.
i) infraoral lamina.
la) lateral teeth.

A typical lamprey mark is shown in Fig.2. This mark coincides closely with the structure of the sucking disk of the lamprey. It is thought that the lamprey sticks to the whale skin with its sharp teeth and cusps at first and then bite the epidermis of the whale with its lingual lamina, when it attacks

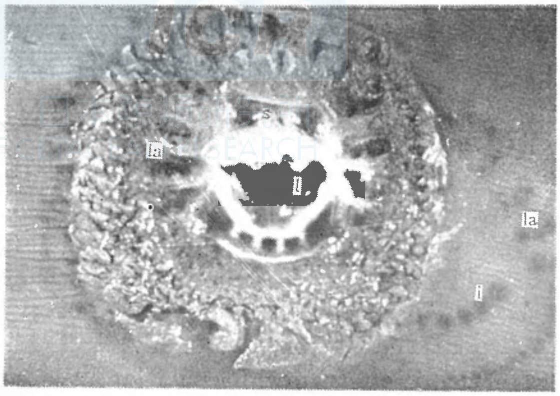


Fig. 2. Fresh mark of lamprey on a fin whale. (×1)
s) marks caused by the supraoral lamina.
l) hole by the lingual lamina.
la) marks by the lateral teeth.
i) marks by the infraoral lamina.

whale. The marks caused by such teeth are always left on the skin of the whale, even the lamprey shifted its sucking place to another by some reasons. In Fig. 2, there shown also some marks caused by the lateral teeth and by the infraoral lamina, outside the typical mark of lamprey's sucking disk. In the course of the sucking, the epidermis of the whale is abraded and also the blubber itself is rasped off, leaving there a round or oval open pit of about one centimeter deep. The skin around this pit is sametime injured by the suckers, showing a spongy appearance (Fig. 3).

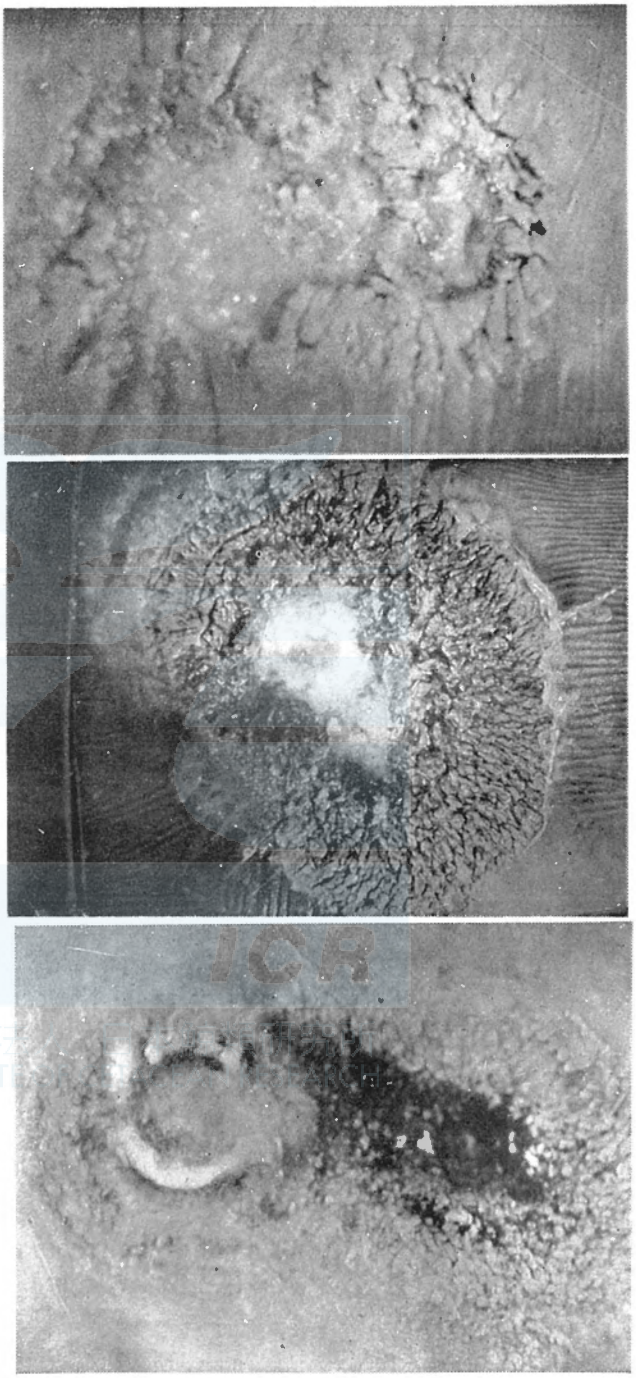


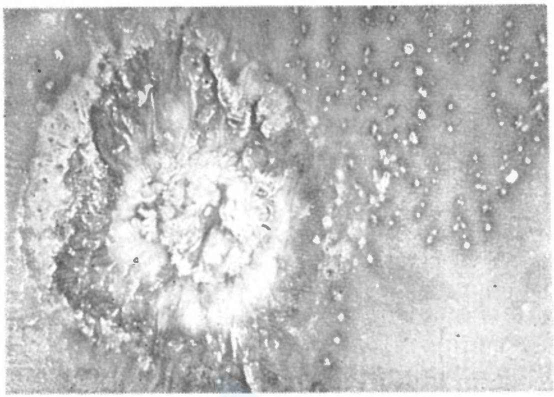
Fig. 3. Various types of irregular wounds by lamprey attacks on fin whales. (×2)

Various healing processes are observed according to the degree of the wounds caused by the lamprey's attack. In most popular case, the spongy portion of the skin turns into blownish in color and becomes very fragil in structure and finally replaced by the regenerated skin of decreased amount of pigmentation (Fig. 4).

However, in case of the blubber is scooped off deeply, the blubber fibres grow up and draw together causing a progressive closing of the pit, as reported by Pike (1951) (Fig.5). Such cases were observed only in very few occasions in the 1953 operation in the Northern Pacific.

There are some occasions in which the lampreys shifting their positions without losing hold, leaving there two types of wounds.

One type is reported by Pike (1951) as " during this process the teeth make parallel incisions in the epidermis as long as eight or nine feet ". These incisions are noticed usually as black lines on the epidermis and mostly ending as a usual sucking mark (Fig. 6). Another type is shown in Fig. 7 (a), in which the lamprey shifts its position as long as 10 centimeters in the progress of the sucking, continuing the abrasion of the skin. Unlikely to the former case, not only lateral teeth, but also lingual laminae are used for biting in this case, leaving there oval, horse-shoe-shaped, or belt-like white scars, usually running along the axis of the body and about 0.5 centimeters deep (Figs. 7, 8, 9). Also in this type of scars some marks of the lateral teeth are usually left on the skin (Fig. 7(b)).


(a)

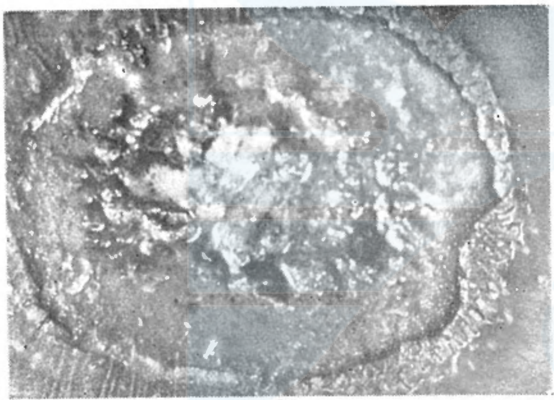

(b)

Fig. 4. Half healed scars on fin Whales. (×2)
(a) Notice the metamorphosis of spongy section in the hole.
(b) Notice the recovery of the black epidermis about the hole caused by lingual lamina.

These lamprey marks are identified from the so-called white scars, reported previously by various authors from the different part of the ocean, in the following three points :

(1) Although in almost all lamprey marks the teeth marks are present, but in the so-called white scars reported from southern hemisphere by Mackintosh and Wheeler (1929) or from the Bonin waters

by Omura (1950) no tooth mark is noted. Even the open pits on the whales from these waters bear no sign of teeth.

(2) Various shapes of scars are observed in the lamprey marks, e.g. round, oval, horse-shoe-shaped, or belt-like. However, in the so-called white scars its shape is generally oval.

(3) The open pits caused by the attack of the lampreys are more shallower than those reported from Saldanha Bay by Mackintosh and wheeler (1929) and Matthews (1938) or from Bonin Island by Omura (1950). Accordingly, the former scars are identified from the latter even after healed, by having a shallower mass of converging fibres in the blubber in sections.

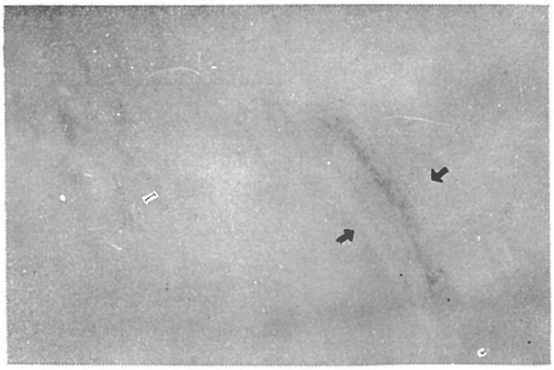


Fig. 5. Half healed lamprey scar on the white portion of a fin whale. (×1)
Notice, blubber fibers grow up from the both side of the scar.
1) lateral teeth marks caused by incomplete attacks.

Fig. 6. Typical white scars on a sei whale by the lamprey attack. (×1)
Healed white scar showing the sucking scar (w) and the changing of latteral teeth (1). Notice the lamprey scar (w) difinitely differ from the so called white scar on whales.

Furthermore, the open pits of the so-called white scars are seen most frequently in the Bonin waters than any other waters adjacent to Japan as reported by Omura (1950). If the causes of the white scars are attributable sorely to the attack of the sea lampreys as stated by Pike (1951), more open pits should be observed from the northern part in the adjacent waters of Japan, judged from the abundance and the distribution of this kind of fish, though details of which are left in future investigations. Quite recently, Dr. H. Yabe kindly forwarded me some photographs of open pits on the skin of the yellow-fin tuna shown in Fig. 10. These open pits resemble very closely to those found on the skin of whales from the Bonin waters and no teeth mark is left on

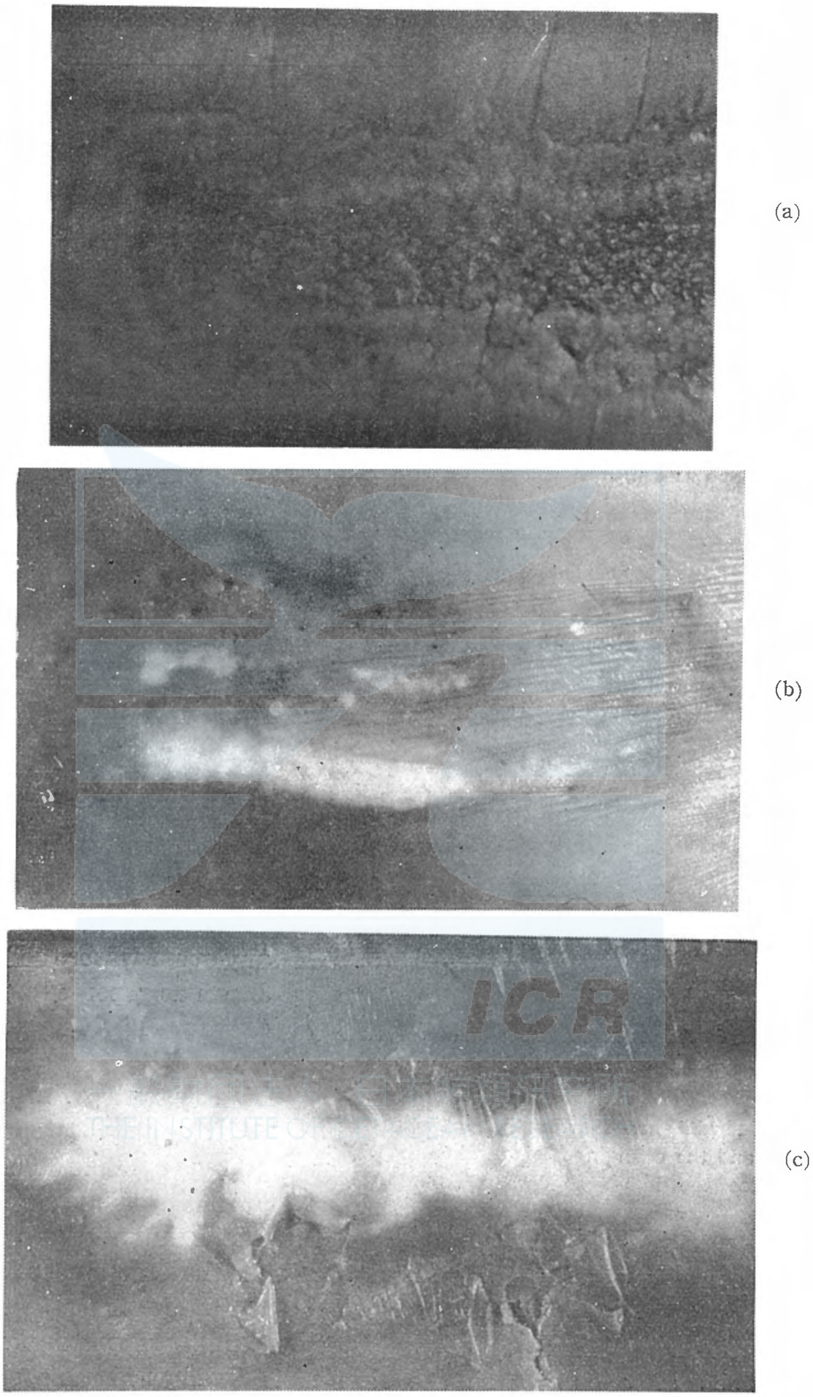


Fig. 7. Belt-like scars on fin whales. (×1)
Notice the marks by lateral teeth on a healed scar (b).

the surface of the body. The skin and meat is scooped out very deeply in these two fish, one pit near the operculum being reached to the abdominal neal cavity. These yellowfin tuna (*Neothunnus macropterus*) were caught in the Timor Sea, Indian Ocean at a point 9°39′S. Latitude and 122°19′E. Longitude, by the long line on 12th January 1953. One of these fish was 125 centimeters in length, measured in fork length. Another fish was not measured of its length, but was reported as nearly the same length.

Fig. 8. Horse-shoe-shaped lamprey scar. (×1) Notice the teeth marks about lamprey scar. 1) lateral teeth marks.

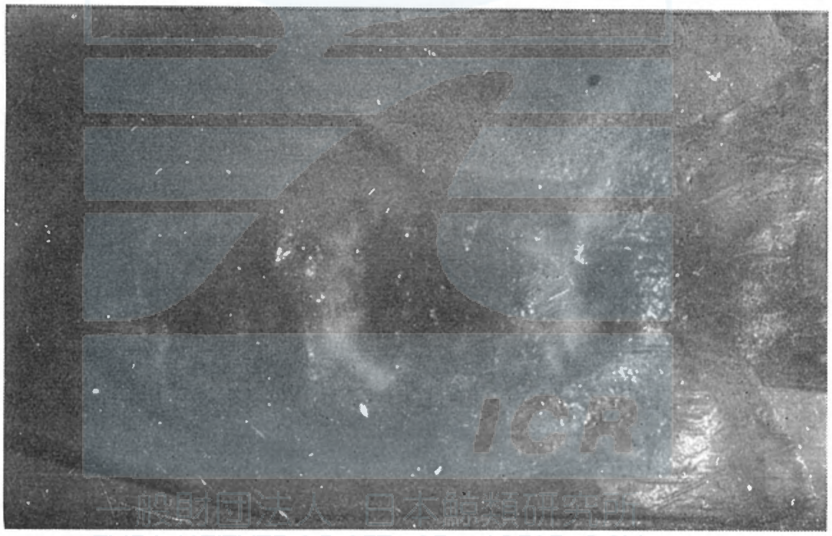
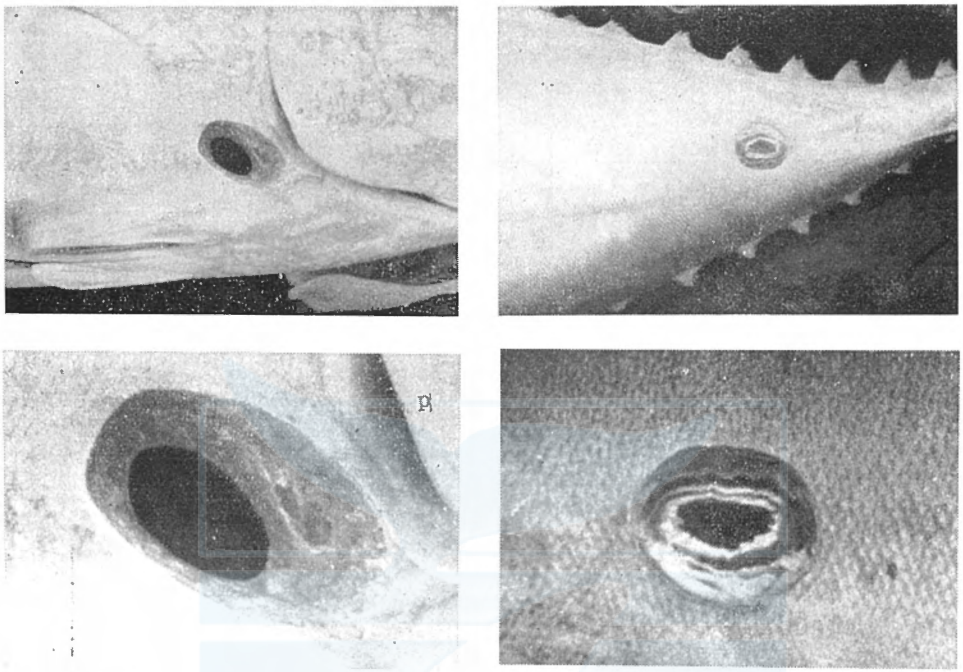


Fig. 9. Healed scar by slight lamprey attacks. (×1)

According to Dr. Yabe, these open pits or healed scars of these pits are observed on the body of the fish in these waters rather frequently. It is clear that these open pits can not be attributable to the attack of the sea lamprey. Pike (1951) describes that lamprey may constitute the universal cause for the scars, but it seems to me unlikely. My opinion is that the lamprey constitutes one cause for the scars and another causes are left still in doubt. The crescent-shaped scars were considered as the result of the insecure attachment of the lamprey by Pike (1951), however, I could not conclude so, because it is hardly suggested from Figs. 7 and 8 of the Pike's report. The teeth marks shown in Fig. 7 are not deemed as a cause of the crescent-shaped scars shown in Fig. 8, though the both shapes resemble very closely. Also the white scar shown in Fig. 4 in his report is thought as a healing stage of the open pit by unknown cause. It is reasonable to conclude that the scar shown in Fig. 3 in the same report is caused by the attacks of a lamprey, but it is thought to me to be incorrect that the white scar of Fig. 4 be attributed to the lamprey's attack, bearing no tooth mark around it.



H. Yabe, phot. (a)

H. Yabe, phot. (b)

Fig. 10. Open pits on yellow-fins from the Timor Sea.
(a) pit penetrated into the abdominal neal cavity near the operculum.
p) operculum of yellow fin.

According to my observation, the so-called white scars remain on the skin of the whales for several years as reported by various authors, but the lamprey marks does not last so long and become very difficult to identify after an interval of about one year, except those caused by heavy attacks.

In conclusion, one cause of the white scars on the skin of the whales should be attributed to the attack of the sea lamprey, but another causes are left still in the future investigations.

Literature

Andrews, R. C., 1916 : The Sei Whale (*Balaenoptera borealis* Lesson). Memoirs of the American Museum of Natural History.

Hatta, S., 1915: The review of lamprey. Japan Journal of Zoology, Vol. 27, pp. 324–325.

Mackintosh, N. A, and Wheeler, J.F.G., 1929: Southern Blue and Fin Whales. Discovery Reports, Vol. 1, pp. 257–540.

Matthews, L. H., 1938: The Humback whale (*Megaptera nodosa*). Discovery Reports, Vol. XVII, pp. 7–92.

Matthews, L. H., 1938: The Sei Whale (*Balaenoptera borealis*). Discovery Reports, Vol. XVII, pp. 183–290.

Nozawa, Y., Takayama, I., and Nemoto, T., 1954: Biological Investigation of the Northern Pacific Baleen Whales caught by the Japanese Whaling Fleet in 1953. Fisheries Agency of Japanese Government.

Okada, Y., and Matsubara, K., 1938: Keys to the Fishes and Fish-like Animals of Japan.

Omura, H., 1950: Whales in the Adjacent Waters of Japan. Scientific Reports of the Whales Research Institute, No. 4, pp. 27–114.

Omura, H., Nishimoto, S., and Fujino, K., 1952. Sei Whales (*Balaenoptera borealis*) in the Adjacent Waters of Japan. Fisheries Agency of Japanese Government.

Pike, G. C., 1951: Lamprey Marks on Whales. Journal of Fisheries Research Board of Canada, Vol. VIII, No. 4, pp. 275–280.

Pike, G. C., 1953: Progress Reports of Pacific Coast Stations, No. 97, pp. 3–5.

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Sei Whales in the Adjacent Waters of Japan

III. Relation between Movement and Water Temperature of the Sea

By

HIDEO OMURA, TAKAHISA NEMOTO

In our former reports (1952, 1954) we reached to a conclusion that there are two kinds of species in the so-called sei whales in the waters adjacent to Japan, one being *Balaenoptera borealis* and others *B. brydei*. The latter, *brydei*, has been taken mostly in the waters around Bonin Island, but it moves northward from there up to the ground off Sanriku, where the warm current from the south meet the cold current from the north. It is assumed, however, also in the former report (1954) that it does not go far north beyond the polar front. In this report, the movements of both species are studied in relation to the water temperature of the sea, based on the data collected in 1953.

In 1953, 584 sei whales were caught in the coastal waters of Japan, in which the baleen plates for 343 whales were forwarded to us from the various landstations for the identification of both species. In table 1, the catch of both species in every ten days of the season are shown, separately in two regions of Sanriku and Hokkaido, classified according to the location of the landstations, in which the whales were processed. Among examined 343 whales, 296 were *borealis* and 47 were *brydei*. Only one *brydei* was taken from the landstation in Hokkaido, and the rest in Sanriku, in the period from the 3rd decade of June to the 1st decade of October, mostly in July and August.

In Figs. 1–18 the positions of the catches of both species are shown with isotherms of surface water temperature of the sea, which were supplied by the Oceanographic Section of the Tokai Regional Fisheries Research Laboratory, Tokyo. One may get general idea on the relation between movements and water temperature from these charts, though the actual water temperature at the position of the catch may differ slightly from the temperature shown in these charts.

It is clearly shown in these charts that *brydei* moves in this region of the sea with the warm current and retreats from this ground with the prevalence of the cold current. In May, the water temperature is still low and the isotherm of 20°C is lying further south from this ground. No *brydei* is taken in May, and it is only in the 3rd decade of June that the first *brydei* was caught in this ground, in the waters

Table 1. Catch of *Balaenoptera borealis* and *B. brydei* in Japan, 1953.

Regions	Species	Sex	May			June			July			August			September			October			Total catch
			1st decade	2nd 〃	3rd 〃	1st 〃	2nd 〃	3rd 〃	1st 〃	2nd 〃	3rd 〃	1st 〃	2nd 〃	3rd 〃	1st 〃	2nd 〃	3rd 〃	1st 〃	2nd 〃	3rd 〃	
Sanriku	*B. borealis*	♂	1	5	7	1	1	2	1	4	5	1	1	2	9	8	6	6	4	3	67
		♀	2	4	2	1	1	1	1	1	2	2	5	1	8	8	5	7	2	1	54
	B. brydei	♂	—	—	—	—	—	—	4	4	1	2	6	—	—	1	1	2	—	—	21
		♀	—	—	—	—	—	1	5	5	2	1	7	1	1	2	—	—	—	—	25
	Not examined	♂	4	7	2	1	—	—	1	—	—	1	3	—	3	1	1	—	1	2	27
		♀	4	3	2	4	1	—	1	—	1	—	—	1	—	—	—	4	2	1	24
	Total		11	19	13	7	3	4	13	14	11	7	22	5	21	20	13	19	9	7	218
Hokkaido	*B. borealis*	♂	—	—	—	—	2	2	7	7	—	3	7	10	14	28	12	4	4	1	101
		♀	—	—	—	—	1	1	8	6	1	—	5	3	8	20	14	5	2	—	74
	B. brydei	♂	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		♀	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	1
	Not examined	♂	—	—	3	—	2	1	6	4	—	—	3	6	8	10	6	26	16	8	99
		♀	—	—	2	—	1	2	5	2	—	—	2	1	6	5	13	28	11	13	91
	Total		—	—	5	—	6	6	26	19	1	3	18	20	36	63	45	63	33	22	366
Grand total			11	19	18	7	9	10	39	33	12	10	40	25	57	83	58	82	42	29	584

of about 21°C. We have two records of *brydei* in May. They were taken on 31 May 1952 and 4 May 1954 in the waters off Oshima, south-most part of Japan proper. The water temperature there is over 20°C even in May. As in July and August the water temperature in the ground off Sanriku is high enough to afford a room to the immigration of *brydei*, most of them are taken in this period. Some *brydei* are caught also in September and October, however, they were taken in the waters of about 20°C. From the 2nd decade of October the cold current regains its force and no single *brydei* was taken in this ground, suggesting that they had already retreated from this ground and went further south.

Andrews (1916) describes that his own study of the genus *Balaenoptera* has led him to conclude that the temperature of the water is of comparatively little importance in determing their movements, but we think that the temperature of the water is a very important factor which affects the movement of the whale, at least for *Balaenoptera brydei*. Uda (1954) states that there is a close connection between the prosperous whaling ground and the oceanographic conditions of the sea, chiefly from the viewpoint of the structure of water masses. To our regret, *brydei* is not specified from *borealis* in his paper. We may add more knowledge to this field of science if the staffs of whaling land-stations could cooperate to us also in future, as they did in 1953.

Contrary to *brydei*, most of *borealis* are taken in the cold waters below 20°C, though some are taken also in the more warmer waters than 20°C. Nozawa, Takayama and Nemoto (1954) report that 98 sei whales which were taken by the whaling factory ship "Baikal Maru" in the northwestern part of the North Pacific in 1953 were all *borealis*. The water temperature at the position of these catches were about 11°C. Although it is likely to happen that *borealis* may be taken in the more colder waters than this, however, it seems to us that *borealis* in the North Pacific do not migrate to the seas of so high latitude, as that in the Antarctic.

In our former report (1954), it is assumed that *borealis* comes near to Bonin Island in the period from December to the middle of April, and after it moved up to the north *brydei* approaches to that island from the middle or end of April. The water temperature in these waters in the former period is up to about 20°C and in May about 24°C or more, though it varies according to the oceanographic conditions in that year.

Kawakami and others (1953) sighted 74 sei whales in these waters on the whale marking trip, carried on from the end of June to the beginning of July 1952, in the waters of 28–29°C. These sei whales are thought to be *brydei*.

It will be generally concluded from the above, that *Balaenoptera brydei* is living in the warm waters of about 20°C or more, and *B. borealis* in the colder waters below this temperature, though the two species intermingle each other in the waters around 20°C in some cases.

Literature Cited

Andrews, R. C. 1916 : Monographs of the Pacific Cetacea. II. The Sei Whale (*Balaenoptera borealis* Lesson). Mem. Amer. Mus. Nat. Hist.

Kawakami, T., Otsuru, K., Watase, S., and Iguchi, K. 1953: Report on Whale Marking in Japan, No. IV. Japanese Fisheries Agency.

Nozawa, Y., Takayama, I., and Nemoto, T. 1954: Biological Investigation of the Northern Pacific Baleen Whales Caught by the Japanese Whaling Fleet in 1953. Fisheries Agency of Japanese Government.

Omura, H., Nishimoto. S., and Fujino, K. 1952: Sei Whales (*Balaenoptera borealis*) in the Adjacent Waters of Japan. Fisheries Agency of Japanese Government.

Omura, H., and Fujino, K. 1954: Sei whales in the Adjacent Waters of Japan. II. Further Studies on the External Characters. Scientific Reports of the Whales Research Institute, No. 9.

Uda, M. 1954: Studies of the Relation between the Whaling Grounds and the Hydrographical Conditions (1). Scientific Reports of the Whales Research Institute, No. 9.

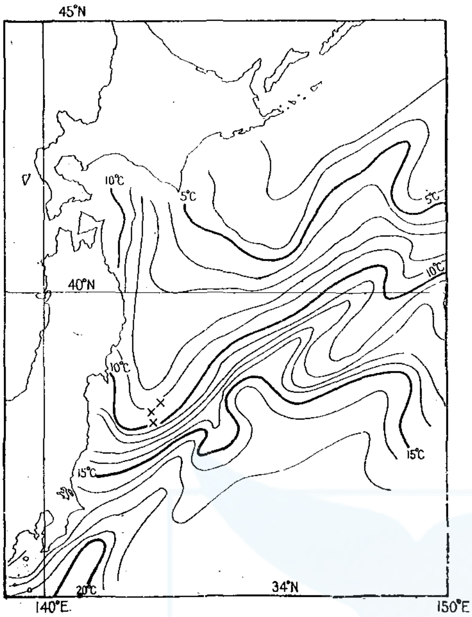

Fig. 1. 1st Decade, May, 1953
× *B. borealis*

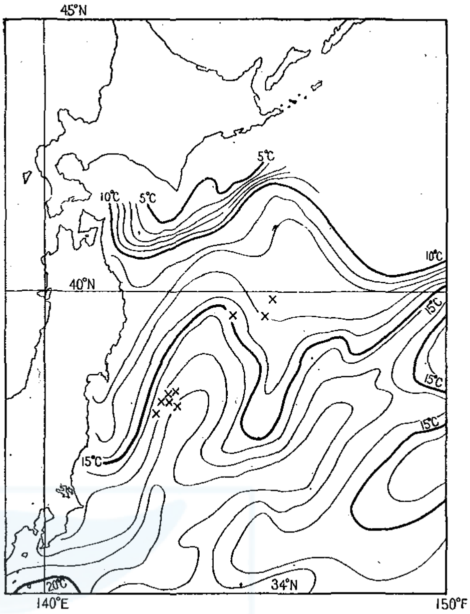

Fig. 2. 2nd Decade, May, 1953
× *B. borealis*.

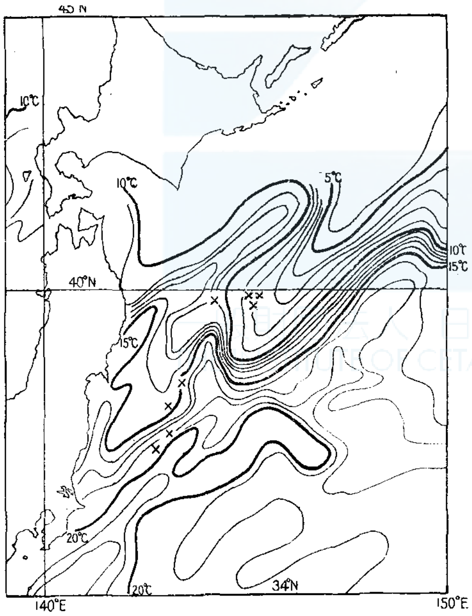

Fig. 3. 3rd Decade, May, 1953
× *B. borealis*

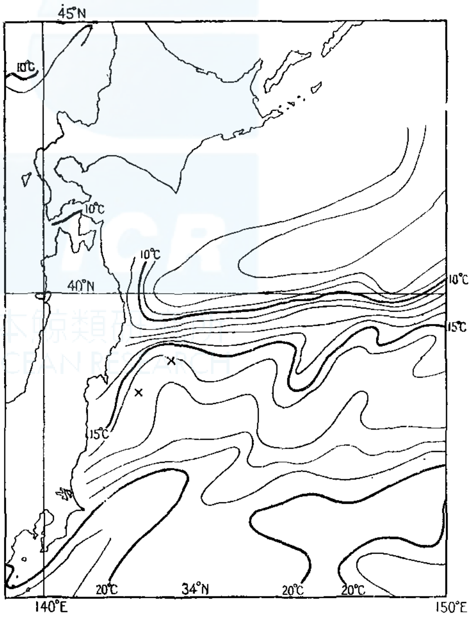

Fig. 4. 1st Decade, June, 1953
× *B. borealis*

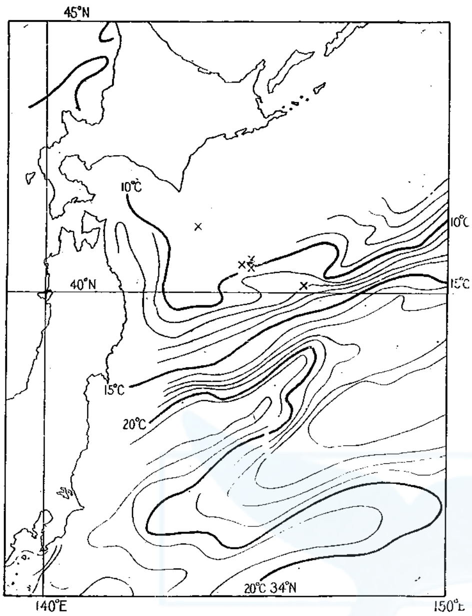

Fig. 5. 2nd Decade, June, 1953
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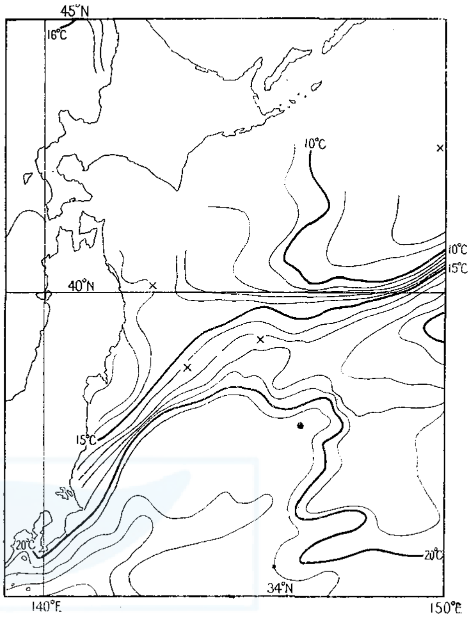

Fig. 6. 3rd Decade, June, 1953
× *B. borealis* ● *B. brydei*

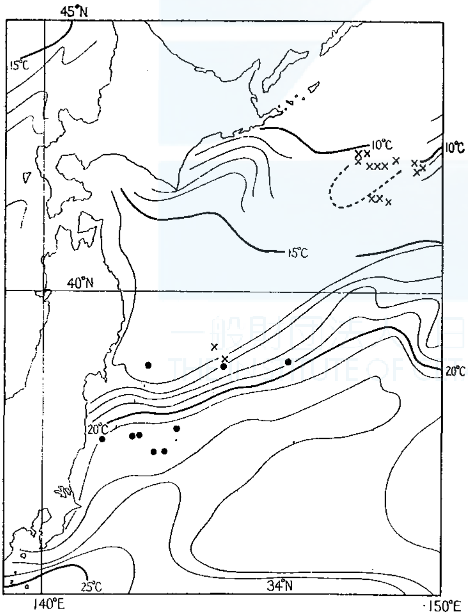

Fig. 7. 1st Decade, July, 1953
× *B. borealis* ● *B. brydei*

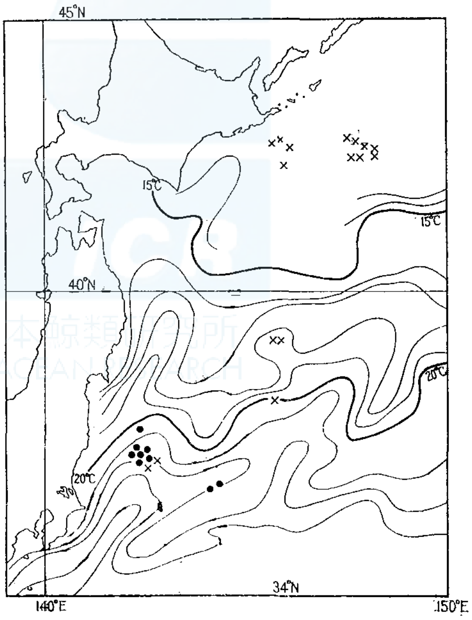

Fig. 8. 2nd Decade, July, 1953
× *B. borealis* ● *B. brydei*

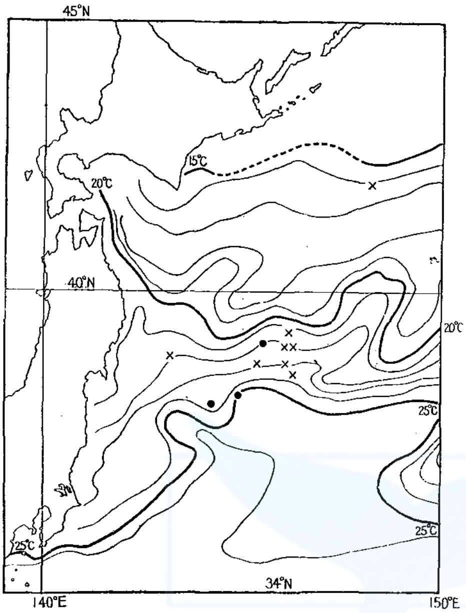

Fig. 9. 3rd Decade, July, 1953
× *B. borealis* ● *B. brydei*

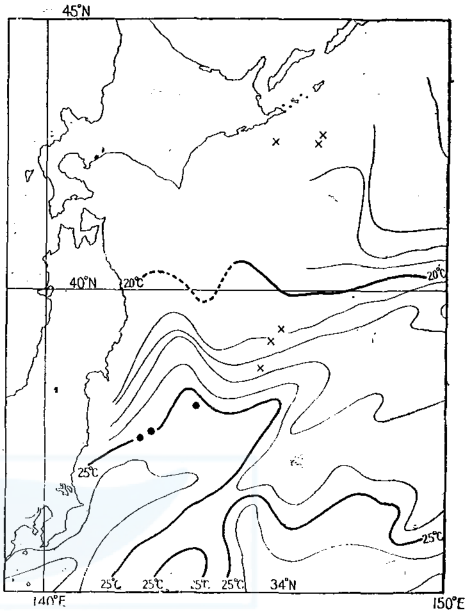

Fig. 10. 1st Decade, August, 1953
× *B. borealis* ● *B. brydei*

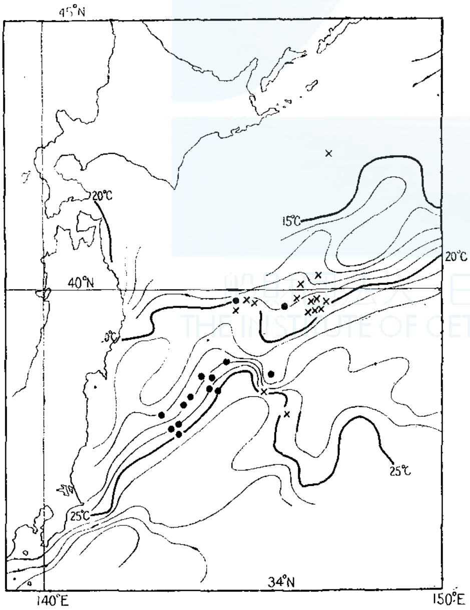

Fig. 11. 2nd Decade, August, 1953
× *B. borealis* ● *B. brydei*

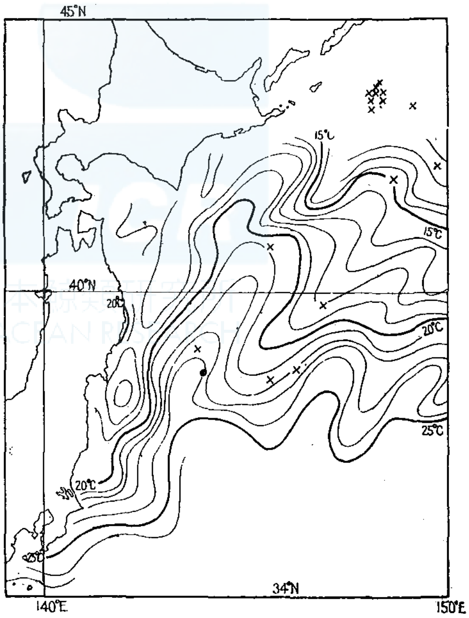

Fig. 12. 3rd Decade, August, 1953
× *B. borealis* ● *B. brydei*

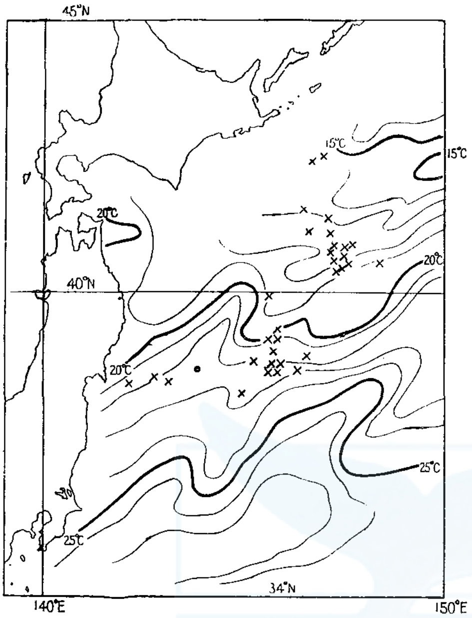

Fig. 13. 1st Decade, September, 1953
× *B. borealis* ● *B. brydei*

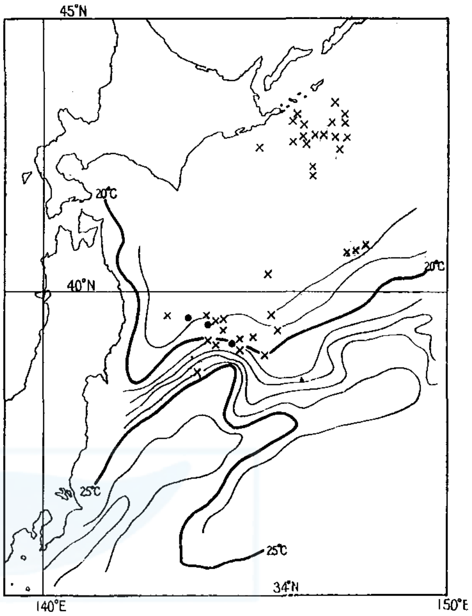

Fig. 14. 2nd Decade, September, 1953
× *B. borealis* ● *B. brydei*

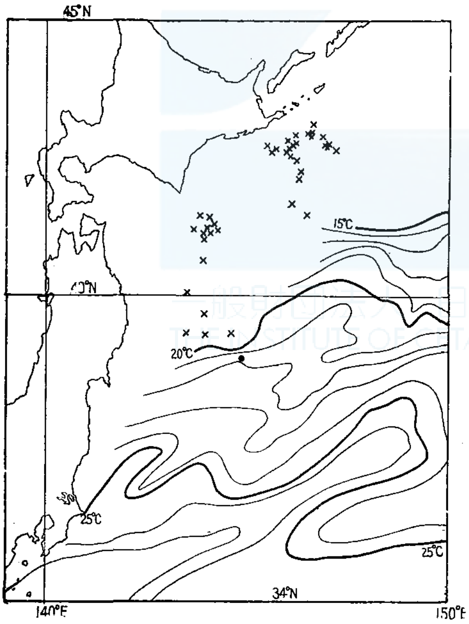

Fig. 15. 3rd Decade, September, 1953
× *B. borealis* ● *B. brydei*

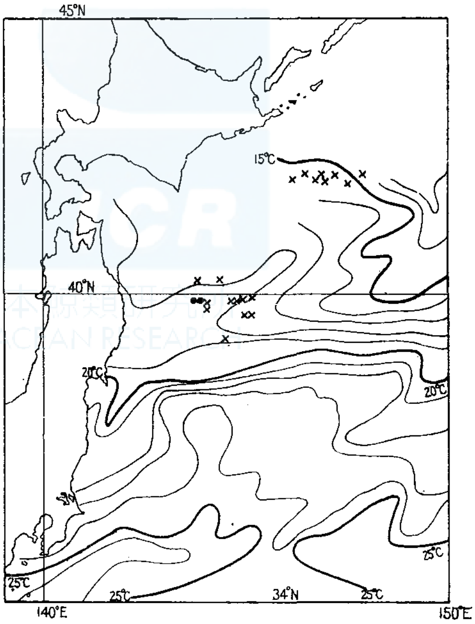

Fig. 16. 1st Decade, October, 1953
× *B. borealis* ● *B. brydei*

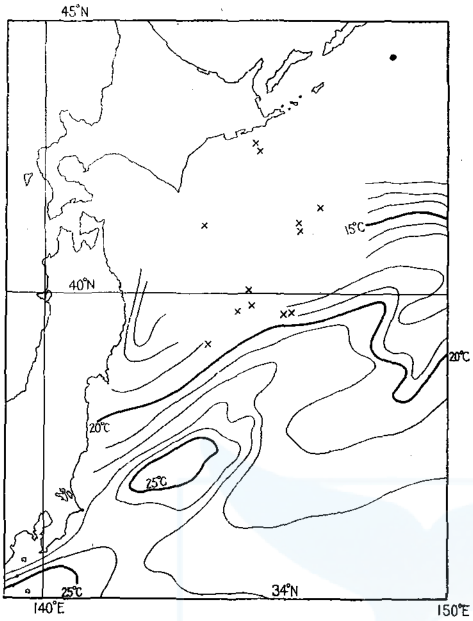

Fig. 17. 2nd Decade, October, 1953
× *B. borealis*

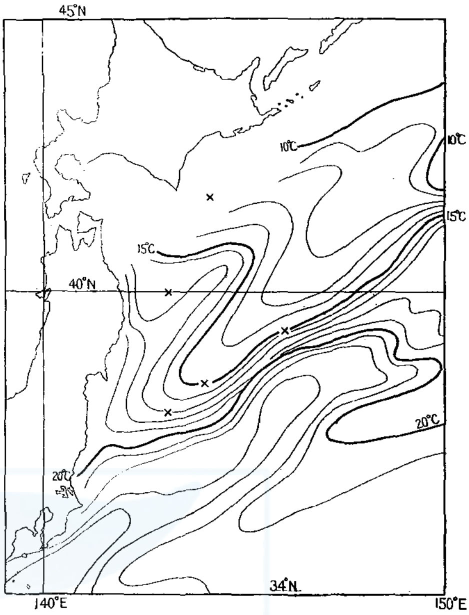

Fig. 18. 3rd Decade, October, 1953
× *B. borealis*


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Beaked Whale *Berardius bairdi* of Japan, with Notes on *Ziphius cavirostris*.

By

Hideo Omura, Kazuo Fujino,
and
Seiji Kimura

I. Introduction

Beaked whales have been taken from the very old days in Japan. We can find the names Tsuchi-kujira and Akabo-kujira often in old documents. Especially in Chiba prefecture the Tsuchi-kujira (*Berardius bairdi*) were taken commercially from old times and according to Fukuyama (1943) a ducument, which describes that whales were taken in the 17th year of Keicho (1612), is kept at the Daigo family. The Daigo family had been operating with small boats using hand harpoon from a base at Katsuyama, Chiba prefecture, until the beginning of the Meiji era. Tsuchi-kujira (*Berardius bairdi*) was the main object of such whaling, but also Akabo-kujira (*Ziphius cavirostris*) was caught sometimes. Average catch per year in these days was only four or five whales.

Of course, such old type of whaling went out of existence in the early days of Meiji, and later the Norwegian method was introduced. Mutsuura (1943) states that a harpoon gun was imported from Norway and the Tsuchi-kujira-whaling was resumed in Chiba prefecture in 1908, using that harpoun gun with wooden small boat. In no place other than Chiba prefecture, the whaling on Tsuchi-kujira had been carried out before the World War II, however, Omura, Maeda and Miyazaki (1953) note that in the post-war period the situation of being pressed for increase of food stuff gave impetus to this type of whaling, resulting in a sudden increase of catchers of operating. According to the Fisheries Agency (1952) the license for such small type whaling amounted to 76 in 1952. Tsuchi-kujira is also taken beside minke whales or other small toothed whales by such whalers not only in Chiba prefecture, but also in other ground now.

Four genera of *Mesoplodon*, *Berardius*, *Ziphius* and *Hyperoodon* belong to the family *Ziphiidae*, in which, however, two are taken commercially in Japan. One is Tsuchi-kujira (*Berardius bairdi* Stejneger) and the other Akabo-kujira (*Ziphius cavirostris* Cuvier). Ogawa (1936) reports a sample of *Mesoplodon densirostris* (Blainville) from Japan, but it seems to us that this whale is only taken in very rare occasion. The fourth, *Hyperoodon* (Bottlenose or Bottlenosed whale) has never been reported from Japan in scientific paper. Though there are some publications in Japan which describe that the bottlenose whale is taken in Japanese waters, but this is a mistake. Tanaka and others (1933) note the scientific name of Tsuchi-kujira as *Hyperoodon rostratus* Müller, however this is clearly a mistake of *Berardius bairdi* Stejneger. Tsuchi in Tsuchi-kujira means wooden hammer used in the old days in Japan, of which shape is very resemble to a bottle. Kujira means a whale. Accordingly most people thought that the bottlenose whale is the English name of Tsuchi-kujira, without any evidence of identification.

Also in USSR, Arseniyev and others (1937) and Tomilin (1935) describe that bottlenose whale, *Hyperoodon rostratus*, migrate to the coast of Kamchatka and there are also some records of bottlenose in the catch of Kuril Islands and Kamchatka in the past issues of the International Whaling Statistics. These bottlenose are probably *Berardius*, as already pointed out by Slipp and Wilke (1953). Also in USA, the name of bottlenose was used by whalers in the past, but Scheffer and Slipp (1948) describe that it reasonably certain that the bottlenose whale captured were, indeed, *Berardius* after investigating the amount of oil yielded. As Tomilin (1935) states that the bottlenose attains the body length of 11 meters and produces about 2 tons of oil in average, it is thought that the same can be applied to the Russian bottlenose.

Berardius bairdi is one of little known whale, inhabiting in the waters of the North Pacific. As regard those in the eastern side of the North Pacific, True (1910), Scheffer (1949), Pike (1953), and Slipp and Wilke (1953) contributed considerably, and in particular, very valuable informations were presented recently by the above mentioned latter two papers. However in the western side, to our regret, no scientific report in detail on this whale has been published before, as far as we know. In the light of the above, we collected the data as possible as we could in these years, which are now presented in this report.

Our sincere thanks are due to Dr. R. Kellogg of the U.S. National Museum for his kind advise, and to Dr. T. Ogawa of the Tokyo University, who is so kindly permitted us to read some literatures. We are also indebted to Dr. K. Okada of the National Science Museum, who allowed us to investigate the specimens under his care.

Catch Records and its Analysis

Berardius bairdi is called generally Tsuchi-kujira in Japan, however, Tsuchimbo is more popular in Chiba prefecture. Rather a few number of *Berardius* taken in the pre-war days. According to the Japan Association of Whaling (1943), only 24 whales were caught in 1943 and total number of three years 1941–43, both years inclusive, amounted to 45. In the post-war days, however, the numbers of small type whaling vessels have increased considerably, and moreover the grounds expanded to the northeast part of Japan proper or to Hokkaido, resulting the increased catch of *Berardius*. In 1947 the Fisheries Agency of the Japanese Government promulgated whaling regulations for such small type vessels and placed them under it's control. Table 1 shows the number of *Berardius* taken in each area during the years 1948–1952. Each area is as follows (see also Fig. 1).

Table 1. Catch of *Berardius bairdi* in Japan during the years 1948-1952.

Years	Sex	Areas							Sex ratio
		I	II	III	IV	V	VI	Total	
1948	Male	28	0	1	15	3	0	47	64.38
	Female	15	0	1	9	1	0	26	35.62
	Total	43	0	2	24	4	0	73	100.00
1949	Male	26	0	0	21	9	0	56	60.87
	Female	22	0	0	9	5	0	36	39.13
	Total	48	0	0	30	14	0	92	100.00
1950	Male	93	15	0	9	7	3	127	68.28
	Famale	29	3	1	10	13	3	59	31.72
	Total	122	18	1	19	20	6	186	100.00
1951	Male	73	77	10	7	4	5	176	69.84
	Female	35	25	1	11	2	2	76	30.16
	Total	108	102	11	18	6	7	252	100.00
1952	Male	45	149	19	6	3	3	225	70.09
	Female	27	53	7	5	4	0	96	29.91
	Total	72	202	26	11	7	3	321	100.00
Total	Male	265	241	30	58	26	11	631	
	Female	128	81	10	44	25	5	293	
	Total	393	322	40	102	51	16	924	
	Sex ratio								
	Male	67.43	74.84	75.00	56.86	50.98	68.75	68.29	
	Female	32.57	25.16	25.00	43.14	49.12	31.25	31.71	

Area I. Coast of Chiba prefecture. One landstation operated before the war. Two landstations are operating from 1949 season.

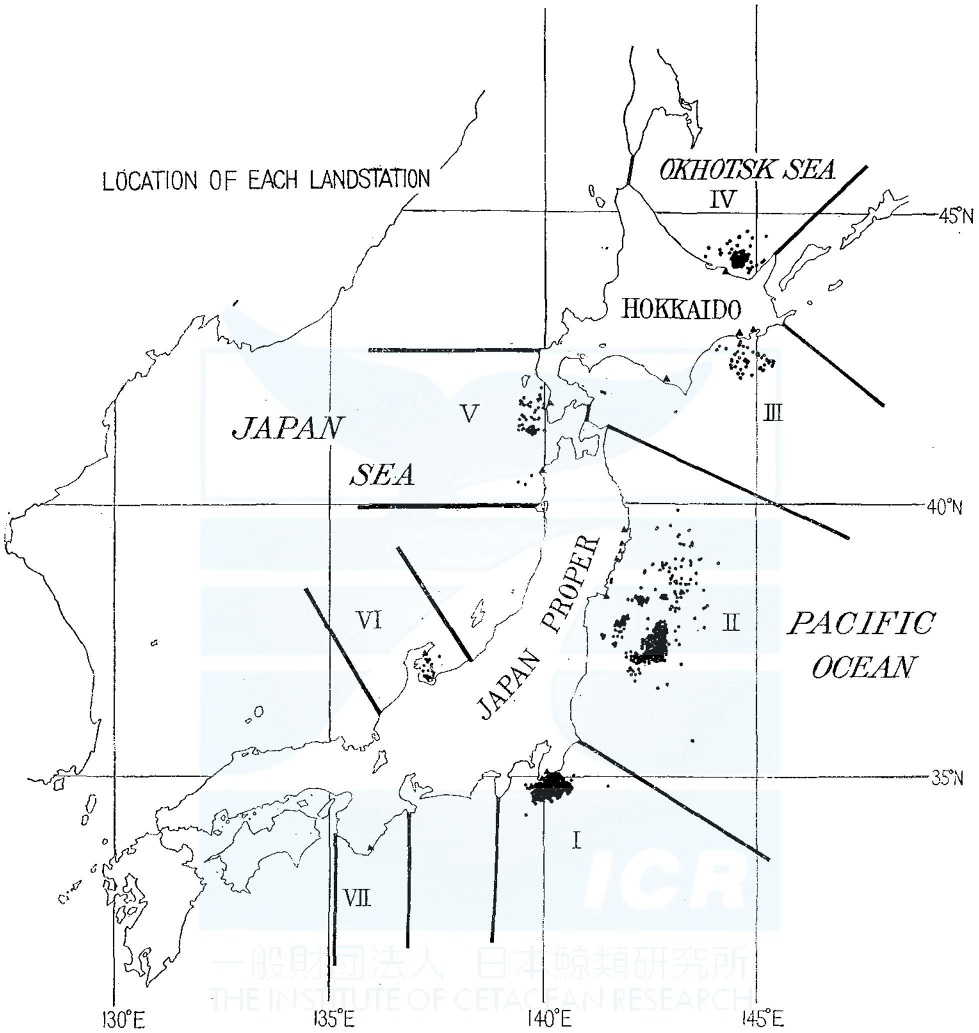

Fig. 1. Position of catch of *Berardius* in Japan, 1948–52.
Roman numerals show each area number.

Area II. North-eastern coast of Japan proper. *Berardius* are taken from and inclusive 1950. Fourteen landstations operated in 1952.

Area III. South coast of Hokkaido. Four landstations operated in 1952.

Area IV. East coast of Hokkaido (Okhotsk Sea.). Three landstations are operating.

Area V. West coast of Hokkaido and Aomori prefecture (Japan Sea). Two landstations operated in 1952.

Area VI. Toyama bay. Two landstations operated in 1952.

Area VII. Coast of Wakayama prefecture. No Beaked whale has been taken in this area, except *Ziphius*.

As shown in table 1, the catch of *Berardius* is increasing year by year, reaching over 300 whales in 1952. Jonsgård and Øynes (1952) report that the yearly catch of the bottlenose in Norway is generally below 100 whales in the recent years and even in 1949, in which the catch reached maximum after 1938, 221 bottlenoses were taken. Therefore there might be no other ground in which so many beaked whales are taken than the waters around Japan.

Most *Berardius* are taken in the Areas I and II. In other areas the catch is very small, compared with the former. Sex ratio in the catch is very striking, showing the preponderant number of males. In the total of these five years, about 68 per cent is occupied by males. Female is about 32 per cent of the total, namely only one half of the male. Similar fact can be seen also in each year and in each area, except Area V. We have very scantly records of foetuses. Only 25 foetuses were reported in these five years, in which one is sex unknown. Remainder 24 is 15 males (62.5%) and 9 females (37.5%). In 1953 10 foetuses, 5 males and 5 females, were reported as of end of October. We can not conclude definitely from the above data, however, we could not suppose that there is a difference in ratio of males and females in the North Pacific. There might be, however, some differences in movement between males and females.

Whaling season for *Berardius* commences usually from April and closes in November, having its flourishing period in summer. Fig. 2 shows the monthly catch of *Berardius* in each area in the past five years, separately according to sex. As shown in this figure the peak of catch lies in July in Area I, whereas the peak lying in August in Area II. There is one month difference between both peaks. As whalers say that *Berardius* approach the coast of Chiba prefecture from the south and pass to the north, the main schools in Area I are deemed to reach the ground in Area II one month later. Main season in Area III is in October and November, though only few *Berardius* are caught in this area. Whether the population in this area is a part of that in Areas I and II or a different one, we have no data at present. In Area IV (Okhotsk Sea) there are two peaks, i.e. one in spring and another in autumn. We can not conclude that *Berardius* in the Okhotsk Sea came from Areas I, II or III, because whaling commences in Area IV in April, earlier than in any other areas. Consequently, it is supposed that there is a different population or community in the Okhotsk Sea from others, which approaches to the coast of east Hokkaido in spring and in autumn and moves north to the northern part of Okhotsk Sea during summer. Areas IV and V are in the Japan sea. *Berardius* in these areas are taken during three months from the beginning of June to the end of August. Comparatively small sized whales migrate into these areas, as stated in the latter part of this report.

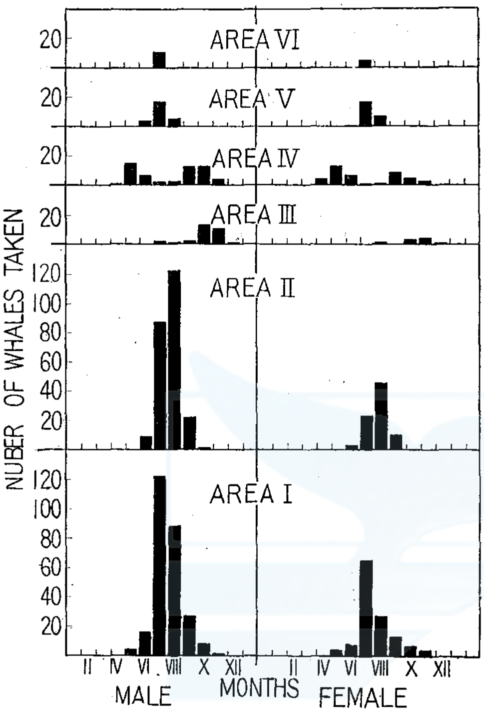

Fig. 2. Monthly catch of *Berardius* in each area. Total of 5 years 1948–52, inclusive.

Size distribution of *Berardius* taken during the five years 1948–1952 are shown in Table 2 and Fig. 3. The biggest male is 38 feet and the biggest female is 40 feet. Further, the peak lies at 35 feet in males, but at 36 feet in females, making a difference of one foot. In *Berardius*, therefore, it is likely that female is bigger than male as such is the case in baleen whale. Also in *Ziphius cavirostris* female is bigger than male by about one foot (see Table 12 and Fig. 30).

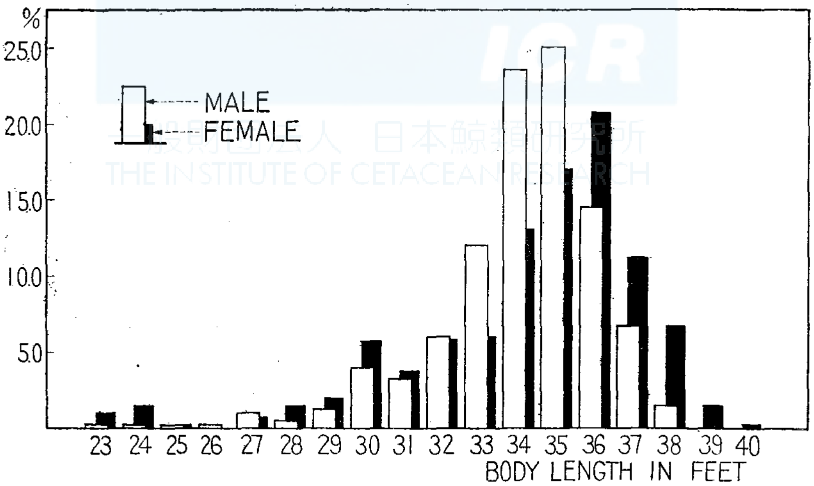

Fig. 3. Size distribution of *Berardius* expressed as Percentages. Total of 5 years 1948–1952, inclusive.

According to Jonsgård and Øynes (1952), male reaches up to 11 meters long and the biggest female is about 9 meters in length in bottlenose. Size distribution of bottlenoses shows also male is bigger than female as in the other species of toothed whales. We have no such data of *Mesoplodon*. We can safely conclude, therefore, that in the Beaked whales at least in the two species, *Berardius bairdi* and *Ziphius cavirostris*, female is bigger than male as in baleen whales. Scheffer and Slipp (1948) state that length of male to about 42 feet, female smaller in *Berardius bairdi*, however, this is not supported by our data. True (1910) reports about the skeletons of *Berardius bairdi*

Table 2. Size Distribution of *Berardius*. Total of 5 years 1948–1952.

Body length in feet	Actual number			Per cent		
	Male	Female	Total	Male	Female	Total
18	—	1	1	—	0.3	0.1
19	—	1	1	—	0.3	0.1
20	—	1	1	—	0.3	0.1
21	—	—	—	—	—	—
22	—	—	—	—	—	—
23	2	3	5	0.3	1.0	0.5
24	1	4	5	0.2	1.4	0.5
25	1	1	2	0.2	0.3	0.2
26	1	—	1	0.2	—	0.1
27	6	2	8	0.9	0.7	0.9
28	4	4	8	0.6	1.4	0.9
29	8	6	14	1.3	2.1	1.5
30	25	17	42	3.9	5.8	4.5
31	19	11	30	3.2	3.8	3.2
32	38	17	55	6.0	5.8	6.0
33	76	18	94	12.0	6.1	10.3
34	149	38	187	23.6	13.0	20.3
35	158	50	208	25.0	17.1	22.6
36	91	61	152	14.4	20.8	16.4
37	43	33	76	6.8	11.3	8.2
38	9	20	29	1.4	6.8	3.1
39	—	4	4	—	1.4	0.4
40	—	1	1	—	0.3	0.1
Total	631	293	924	100.0	100.0	100.0
Average length	34.06	34.10	34.08			

kept in the United States National Museum, in which the biggest one is 41 feet (Cat. No. 49725). Its sex is noted as male (?). As regards this specimen he cites a letter from Mr. J. H. Ring, of Ferndale, California, dated October 24, 1904. In this letter nothing is wrote about its sex, so it is very doubtful that this whale is certainly a male. Next to that is the Cat. No. 49726, a female of 40 feet 2 inches long. Female may reach up to 40 or 41 feet, judged from the data now available. The biggest male is 38 feet long in our data, however, as there are 9 whales of this body length, the male is supposed to attain a little more, e.g. 39 feet.

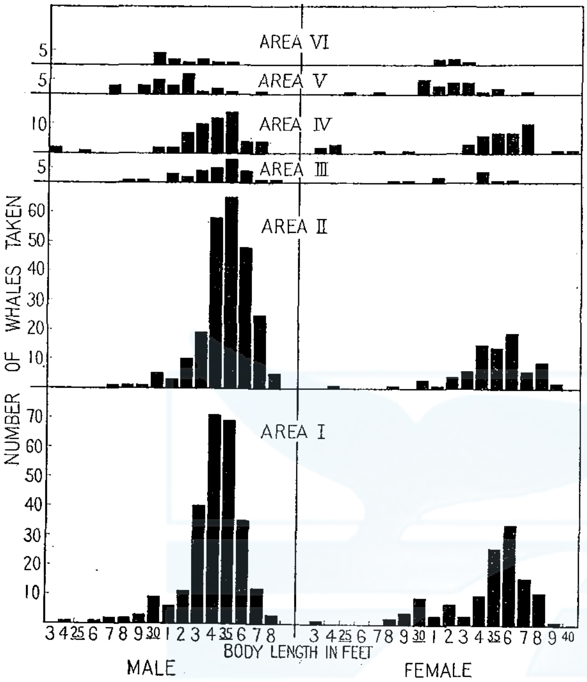

Fig. 4. Size distribution of *Berardius* in each area. Total of 5 years 1948–1952, inclusive.

Size distribution of *Berardius* in each area is histogramed in Fig. 4. Most remarkable point in this figure is the size composition in the Areas V and VI, smaller whales are taken compared with those in the other areas. Though the whales in these areas were not identified yet, but it is not probable that these whales belong to the other species of *Ziphiidae* (e.g. *Hyperoodon*), because most of them are 30 feet or over and too large to be ascribed to other species except *Berardius*. The reason for this may be there that only younger whales approach to the coast of these areas.

External Characters

Color of *Berardius* is described by Pike (1953) as "the body is black on the head, back, flukes and flippers. The undersurface is of a slightly lighter shade, with white and gray markings." According to our observations, however, color of whole body is pure black or somewhat lighter, even on the undersurface of the body. It is not certain, but most whalers say that there are two groups of *Berardius*, one being black and another slatish. As there are many white scratch marks (Plate I. 1) on the skin of *Berardius*, especially in the old bull, the color looks more lighter than it is in such whale. There are white patches in three regions on the ventral side of the body, i.e. on the throat, between the flippers, and at the umbilicus (Plate I. 2, 3, Plate II. 2). Every *Berardius* seems to have the white patch at the umbilicus, but as for those on the throat or between the flippers, there are considerably individual differences. The whale shown in Plate I. 2 has only a patch on the throat, except that at umbilicus, but in the whale shown in Plate I. 3 this patch extends posteriorly into the region between the flippers.

In most animals the white scratch marks are seen, more numerous on the dorsal side than the ventral. These scratch marks have been attributed to the teeth of rival males as in sperm whales. Pike (1953) notes, however, this explanation seems unlikely to be applicable to this species whose teeth are either buried in the gum or are blunt and protrude only slightly. Pike's opinion seems to us not correct, because teeth are buried in the gum only in the immature whale. After the sexual maturity is reached the teeth protrude above the gum and sharp enough to be attributed to the cause of the scratch marks (Plate III. 1, 3). There are some whales whose teeth were abrade considerably, or in extreme cases, both anterior teeth are removed from the alveori and completely lacking (Plate III. 2). As such cases are observed mostly in old whales, they might be ascribed to the struggle with rivals.

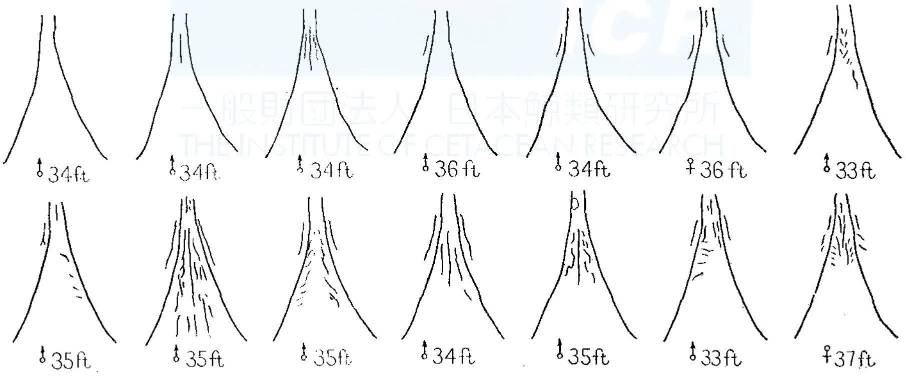

Fig. 5. Examples of the V-shaped grooves in *Berardius bairdi*

The V-shaped grooves extend posteriorly about 70 cm. from nearly the middle part of the lower jaw, with its apex pointing forward.

Two grooves come very near, but never meet at the apex, apart from each other about 4 cm. Besides these two grooves, in some individuals there are short median or very irregular shaped grooves. Fig. 5 shows such example. As shown in this figure, there are many varieties of these grooves, but never lacking the original two. Also in foetus these grooves are well defined (Plate IV. 3).

Notch of flukes is not remarkable, but concaved slightly in middle of hinder margin (Plate II. 3). The flippers are not pointed, as already stated by Pike (1953) (Plate I. 2). However in foetus the flippers are rather pointing, unlike to its parents (Plate IV. 1).

The body proportinons were measured in Chiba prefecture in 4 males and one female, a total of 5 whales in 1952, and at Ayukawa, Miyagi prefecture, in 20 males and 5 females, a total of 25 whales in 1953, making a grand total of 30 whales (24 males and 6 females). Besides above, five foetuses (3 males and 2 females) were measured their proportions.

The measurements were carried on to the following parts.

(1) Total length from tip of snout to notch of flukes.
(2) Projection of lower jaw beyond tip of snout.
(3) Tip of snout to blow-hole.
(4) Tip of snout to angle of gape.
(5) Tip of snout to centre of eye.
(6) Tip of snout to axilla of flipper.
(7) Centre of eye to centre of ear.
(8) Notch of flukes to posterior emargination of dorsal fin.
(9) Width of flukes at insertion.
(10) Notch of fluckes to centre of anus.
(11) Notch of fluckes to umbilicus.
(12) Centre of anus to centre of reproductive aperture.
(13) Vertical height of dorsal fin.
(14) Length of base of dorsal fin.
(15) Tip to anterior end of lower border of flipper.
(16) Axilla to tip of flipper.
(17) Greatest width of flipper.
(18) Length of severed head from condyle to tip.
(19) Length of snout.
(20) Tail flukes, tip to notch.

All these measurements recorded in centimeters and percentages against body length are tabulated in the appended table. Mean values and their standard deviations are shown in Table 3.

Table 3. Body proportions of *Berardius bairedi* from Japan.
(Percent of total length)

Measurements	Male			Female		
	n	$\bar{x}$	σ	*n*	$\bar{x}$	σ
2. Projection of lower jaw beyond tip of snout	16	0.87	0.18	4	0.80	0.10
3. Tip of snout to blow hole	22	10.89	0.45	6	11.30	0.65
4. Tip of snout to angle of gape	24	6.41	0.54	6	6.46	0.56
5. Tip of snout to centre of eye	24	9.64	0.88	5	9.90	0.97
6. Tip of snout to axilla of flipper	20	21.05	0.87	5	21.20	0.75
7. Centre of eye to centre of ear	8	1.89	0.21	2	1.95	0.15
8. Notch of flukes to posterior emagination of dosal fin	24	26.67	1.52	6	28.00	1.42
9. Width of flukes at insertion	3	7.50	0.24	0	—	—
10. Notch of flukes to centre of anus	20	28.60	1.04	5	29.20	1.94
11. Notch of flukes to umbilicus	24	57.08	1.89	6	58.00	1.29
12. Centre of anus to centre of reproductive aperture	24	7.23	1.15	6	4.05	1.41
13. Vertical height of dorsal fin	21	2.51	0.32	6	2.77	0.22
14. Length of base of dorsal fin	23	6.75	1.15	6	6.30	1.23
15. Tip of anterior end of lower border of flipper	23	12.21	0.61	6	12.05	0.86
16. Axilla to tip of flipper	19	7.96	0.40	5	8.00	0.25
17. Greatest width of flipper	20	4.16	0.16	5	4.18	0.20
18. Length of severed head from condyle to tip	1	12.6	—	0	—	—
19. Length of snout	24	6.17	0.32	6	6.28	0.37
20. Tail flukes, tip to notch	7	13.73	1.05	1	14.00	—

n....Number of measurements
$\bar{x}$....Mean value
σ....Standard deviation.

Furthermore, each measurement is plotted in Figs. 6–25, expressed as percentages against total length, together with the data presented by Pike (1953) for comparison. The latter consisted of two *Berardius*, one being 33 feet 3 inches (10.13 meters) male and the other 29 feet 3 inches (8.92 meters) female, taken in the northwest coast of Vancouber Island, British Columbia. Though in these figures male and female are not classified for the British Columbia sample for the purpose of simplification of the graphs, it is easily identified according to their

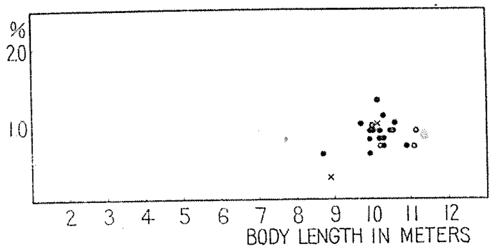

Fig. 6. Projection of lower jaw beyond tip of snout.
● Male ○ Female × British Columbia

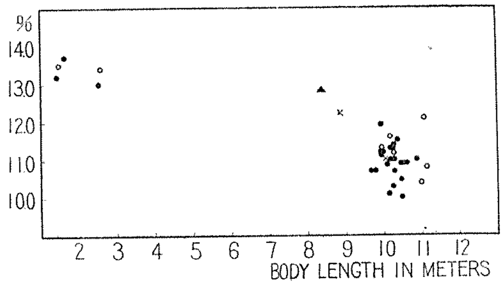

Fig. 7. Tip of snout to blow-hole.
● Male ○ Female × British Columbia
△ *Berardius arnuxi*

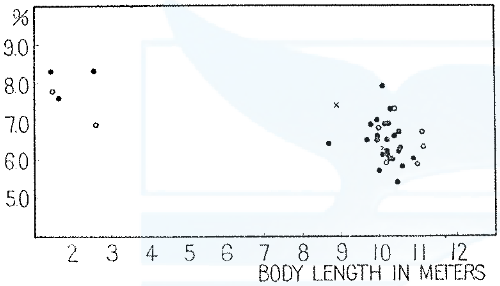

Fig. 8. Tip of snout to angle of gape.
● Male ○ Female × British Columbia

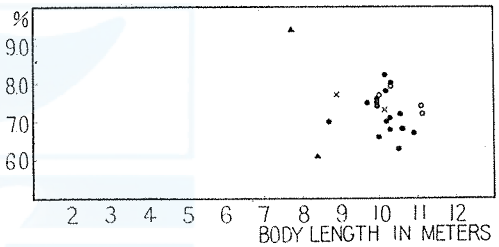

Fig. 9. Tip of mandible to corner of mouth.
● Male ○ Female × British Columbia
△ *Berardius arnuxi*

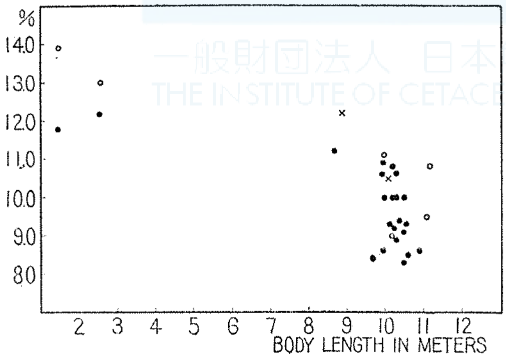

Fig. 10. Tip of snout to centre of eye.
● Male ○ Female × British Columbia

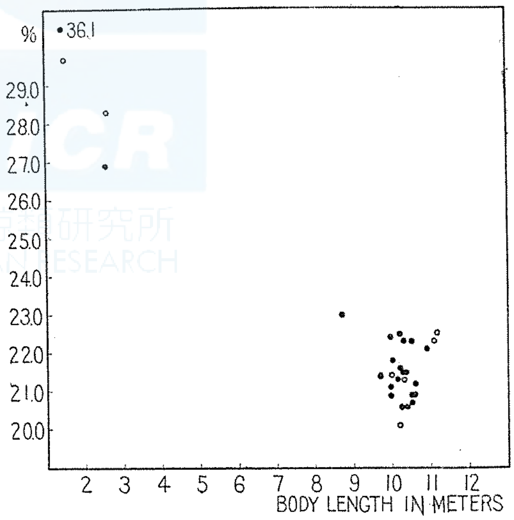

Fig. 11 Tip of snout to axilla of flipper.
● Male ○ Female

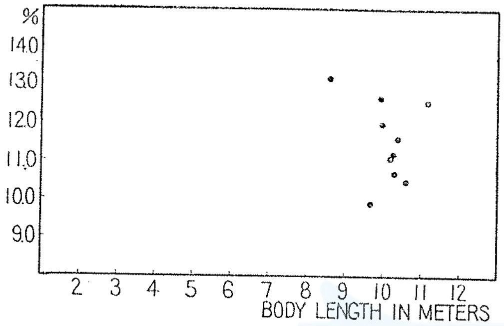

Fig. 12. Tip of snout to centre of ear.
● Male
○ Female

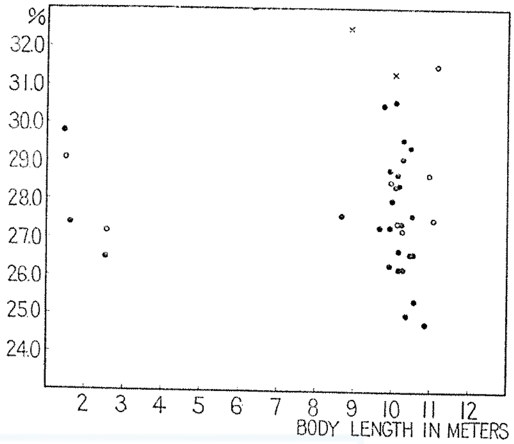

Fig. 13. Notch of flukes to posterior emargination of dorsal fin.
● Male
○ Female
× British Columbia

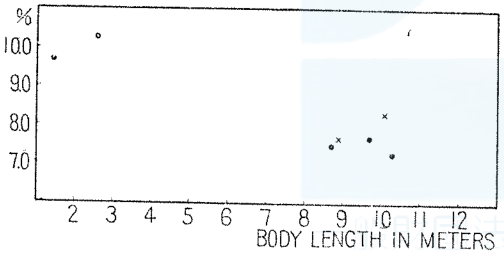

Fig. 14. Width of flukes at insertion.
● Male
○ Female
× British Columbia

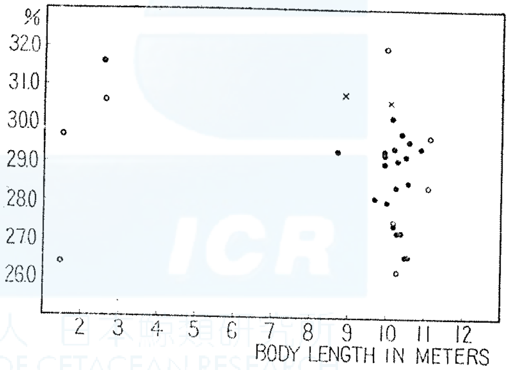

Fig. 15. Notch of flukes to centre of anus.
● Male
○ Female
× British Columbia

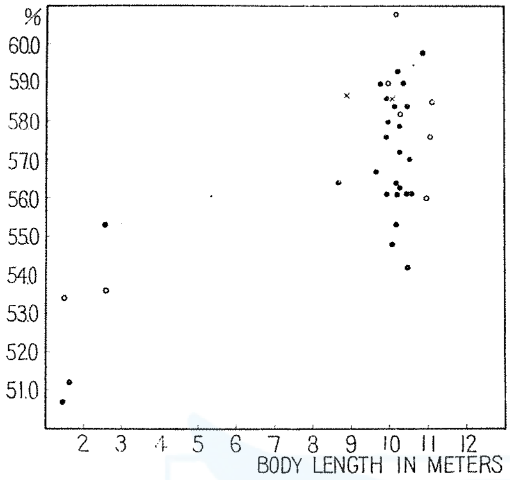

Fig. 16. Notch of flukes to umbilicus.
○ Male
○ Female
× British Columbia

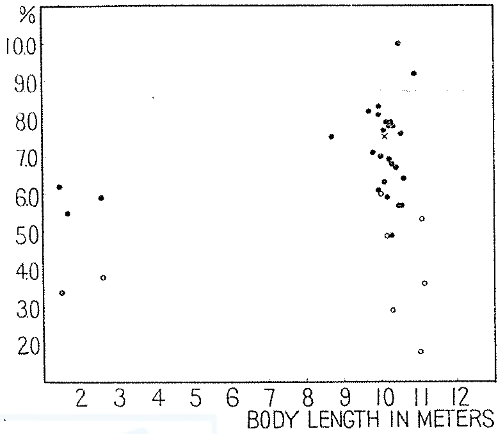

Fig. 17. Centre of anus to centre of reproductive aperture.
● Male
○ Female
× British Columbia.

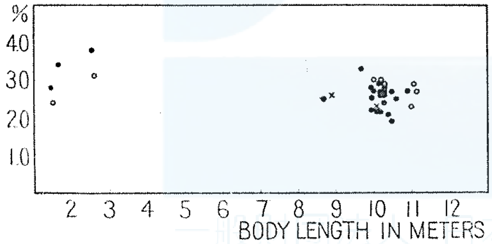

Fig. 18. Vertical height of dorsal fin.
● Male
○ Female
× British Columbia

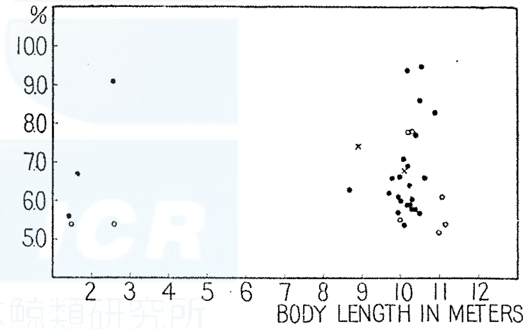

Fig. 19. Length of base of dorsal fin.
● Male
○ Female
× British Columbia

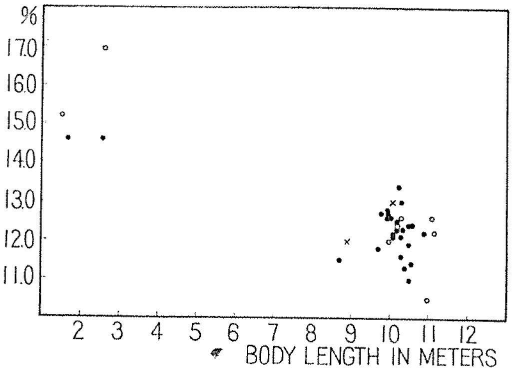

Fig. 20. Tip to anterior end of lower border of flipper.

- ● Male
- ○ Female
- × British Columbia

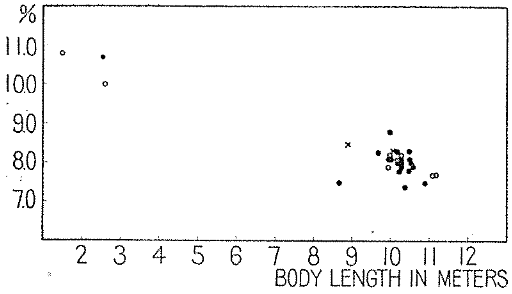

Fig. 21. Axilla to tip of flipper.

- ● Male
- ○ Female
- × British Columbia

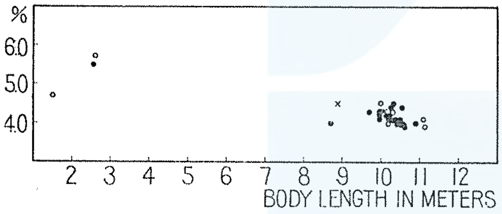

Fig. 22. Greatest width of flipper.

- ● Male
- ○ Female
- × British Columbia

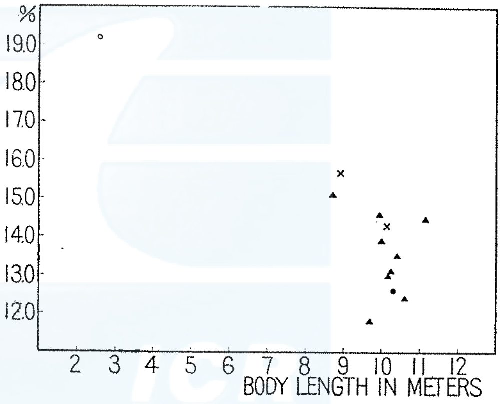

Fig. 23. Length of severed head from condyle to tip.

- ● male
- ○ Female
- × British Columbia
- △ Estimated.

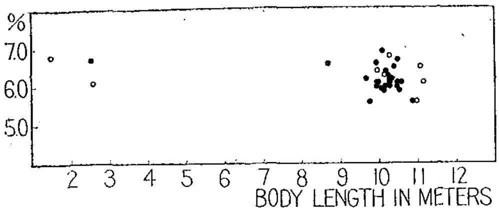

Fig. 24. Length of snout.
● Male
○ Female

body length, i.e. the bigger is male and smaller female. Whales smaller than 3 meters in these graphs are foetuses. Measurement No. 7 (Centre of eye to centre of ear) is expressed as tip of snout to centre of ear in Fig. 12, for the convenience of comparison in head region. Unfortunately we have only one measurement, except one in foetus, for the measurement No. 18 (Length of severed head from condyle to tip) in spite of this measurement is very important for the comparison with *B. arnuxi*, so we estimated this proportion by adding 1.9 per cent to the value from tip of snout to centre of each whale. This 1.9 per cent is the difference between the proportions of the length of the severed head and the length from tip of snout to centre of ear in the whale we measured. These estimated values are shown by another marks from others in Fig. 23.

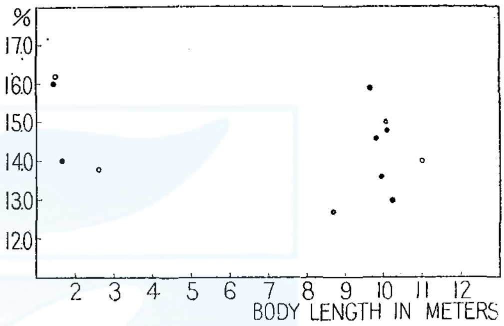

Fig. 25. Tail flukes, tip to notch.
● Male
○ Female

Difference of proportion between male and female is only noticed in measurement No. 12, i.e. centre of anus to centre of reproductive aperture, as is the case in other whales. No remarkable differences are also seen between *Berardius* from Japan and from British Columbia, except following two points.

1. In measurement No. 8 (Notch of flukes to posterior emargination of dorsal fin) a somewhat greater value is seen for the whales from British Columbia than those from Japan (Fig. 13).

2. British Columbia's female has a greater head region than others (Figs. 7, 10, 23).

However, among above stated, point one is probably result of the poorly defined point "posterior emargination of dorsal fin." Point two is perhaps to be ascribed to the fact that body proportions differ in the course of growth, as suggested by those in foetuses. We can safely conclude, therefore, that there is no difference of proportion between *Berardius* from Japan and from British Columbia.

In foetuses body proportions are different from the adult in the following points.

1. Head proportion is bigger for the foetuses (Figs. 7, 8, 10, 11 and 23).
2. Flippers situated more posteriorly in foetuses (Fig. 11).
3. Larger flippers in foetuses (Figs. 20, 21, and 22).
4. More posteriorly situated umbilicus for the foetuses, though the position of anus is deemed similar (Figs. 15 and 16).
5. A somewhat higher dorsal fin for the foetuses, though no difference is seen in the length of its base (Figs. 18 and 19).
6. More broader flukes at insertion for the foetuses (Figs. 14 and 25.)

Besides above, there are some differences in the external form between the both. A most striking point is the length of the lower jaw. As shown in Plate IV. 1 and 2 the length of lower jaw is nearly the same length of the upper, i.e. no projection of lower jaw beyond tip of snout. In the adult the forehead rises abruptly, making a shape similar to a bottle (Plate II-1), however in foetus, the bulge on the forehead is less prominent (Plate IV-1, and 2). As already stated, the flippers are rather pointing as seen in Plate IV-1. In this foetus, the coloration of the body is pinkish in general and with some gray patches on it.

Though we have no data at present as regards when these differences in proportion or in shape will be reduced to a normal one, however, it is likely that there might occur some changes in proportion with the growth of the body after parturition.

As regards the differences of the external dimensions between *B. bairdi* and *B. arnuxi*, True (1910) notes that the specimen of *arnuxi* appears to have had narrower flukes, shorter pectoral fin, and a rather higher dorsal fin, situated further forward than in *bairdi*. Pike (1953) reports, after comparing two *Berardius* taken from British Columbia to the specimen presented by True, that the comparison bears out True's observation that the flukes are wider and the flippers longer in *bairdi* than in *arnuxi*. However, Slipp and Wilke (1953) describe that the two species may be less well marked than previously supposed, after investigating a *Berardius* stranded at Ocean City, Washington. The body dimensions of *B. arnuxi* (body length 27 ft. 6 in. (8.38 meters)) presented by True for the comparison with *B. bairdi* are the following seven points.

Distance from tip of snout to blow hole	12.8%
Distance from tip of mandible to corner of mouth	6.1
Breadth of flukes from tip to tip	19.1
Length of pectoral fin along outer edge	9.4

Distance from anus to "end of body"	(34.0)%
Height of dorsal fin	3.0
Distance from anterior base of dorsal fin to "end of body"	(34.6)

Among above listed seven measurements, distance from tip of snout to blow hole shows greater value for *B. arnuxi* than ours (Fig. 7). It is likely, however, this may be ascribed to the change of body proportion during the course of the growth, as is deemed for the British Columbia female. As regards head proportion, the similar can be said as shown in Fig. 23. Fig. 9 is made by calculating the length from tip of mandible to corner of mouth from the measurements No. 2 (projection of lower jaw beyond tip of snout) and No. 4 (Tip of snout to angle of gape) for the comparison with *B. arnuxi*. Similar calculation are made for the whales from British Columbia too. Though the smallest value is presented by *arnuxi*, we can not conclude that there is a significant difference between the two species. Unfortunately we does not mesured the breadth of flukes from tip to tip, in which a remarkable difference is seen between *arnuxi* and Pike's measurement for *bairdi*. But, judged from our measurement No. 20 (Tail flukes, tip to notch), it is supposed hardly to occur that our *bairdi* show as small value as 19.1 per cent against the total length, as is the case in *arnuxi*. As regards the length of pectoral fin, *arnuxi* shows very smaller value than ours, when compared with Fig. 20. Anus is seemed to situate more posteriorly in *bairdi* than *arnuxi*, because notch of flukes to centre of anus is below 32 per cent of the total length in *bairdi* and distance from anus to "end of body" is 34 per cent in *arnuxi* (Fig. 15). However, it should not be deemed as established, because we don't know what it meant by "end of body." No differences are seen concerning the height of dorsal fin or its position, judged from the Figs. 18, 13 and 14.

In conclusion above, the Pike's opinion is supported by our data, i.e. the flukes are wider and the flippers longer in *bairdi* than in *arnuxi*.

Teeth

The teeth are concealed beneath the gum before whale reach its sexual maturity, but exposed from the gum in matured whale. (Plate II-1, III-1, 3). *Conchoderma* are attached sometimes on the anterior teeth, like in sperm whale (Plate III-3). Caprellid amphipods are seen often in the region of the teeth. In some whales, especially in older one, teeth are abraded in their apices considerably and in the extreme case both anterior teeth are lacking (Plate III–2). As already stated, these causes are thought to be ascribed to the struggle with rivals.

The shape of teeth are roughly triangular in side view, anterior teeth being larger, posterior smaller (Plate V, VI). Its shape and size, however, are dependent on individuals or on their age. In foetus of 9 feet long, teeth is consisted only of dentine and thin layer of enamel, convering the outside of the former, inside being hollow. Their apices are acute and with no root rugosities and their shape are rather conical. After paturition, however, the inside cavity is gradually filled with osteo-dentine and finally the root is closed, making a rugose base. Their shape are slightly depressed laterally. Sometimes a narrow canal is left amidst the mass of bony pulp. On the other hand, outside the teeth a layer of cement is formed yearly, making a coating of cement, from which we think, it is possible to determine the age of *Berardius*. The longitudinal section of an anterior tooth is shown in Fig. 26.

Our data of teeth dimensions are presented in Table 4, together with percentages of greatest height and greatest width at apex against the greatest width of the tooth. Number of corpora lutea in the ovaries are also noted, when observed. The greatest width at apex denotes the degree of abrasion, which is seen mostly in the anterior teeth of the sexually matured whale. It is clear from this table that the lengths of the anterior teeth are not parallel to the body length, while their width increase with age. That is because of comparatively early stop of longitudinal growth and abrasion at apex. Accordingly the greatest height reduced to percentages of the greatest width decreases with age after the sexual maturity is attained. It is noted from this table that the abrasion of anterior tooth occurs also in female. If the cause of such abrasion and scratch marks on the skin are really the struggle with rival, then it should be concluded that also female join such struggle, unlikely to sperm whale. *Berardius* swim in the sea usually consisting a school of about 10 or more individuals. But it is very unlikely that this school is a so-called harem, consisted of leader male and others all females, because male is very preponderant in the catch records, as already stated in former part of this report. The habit of *Berardius*,

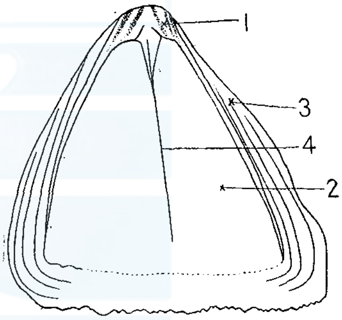

Fig. 26. Longitudinal section of anterior tooth.
1. dentine. 2. Osteo-dentine.
3. Coating of cement. 4. canal

Table 4. Dimensions of teeth of *Beradius bairdi* of Japan.

Body length in feet	Sex and side	Anterior teeth				Posterior teeth			Number of corpora lutea
		Greatest height	Greatest width	Greatest width at apex	Root	Greatest height	Greatest width	Greatest width at apex	
			(Length in millimeters)						
9	♀ L	22	18	0	open	12	15	0	foetus
	R	22	18	0	open	12	16	0	
29	♂ R	84	57	0	recently closed	48	33	0	immature
30	♀ L	81	60	0	recently closed	48	35	0	none (immature)
	R	82	54	0	recently closed	47	34	0	
33	♀ L	71	65	20	closed	55	33	0	11
35	♀ L	86	73	11	closed	Ca. 55	45	0	unknown
35	♂ L	Ca. 81	74	16	closed				mature
	R	Ca. 82	76	15	closed				
35	♀ L	83	65	14	closed	53	26	0	7
	R	84	62	17	closed	53	22	0	
36	♀ L	Ca. 75	70	18	closed	Ca. 54	48	0	14
	R	Ca. 73	68	15	closed	Ca. 52	43	0	
36	♀ L	78	89	20	closed				4 in one ovary, another ovary missed
	R	80	87	19	closed				
			(Per cent of width)						
9	♀ L	124	100	0		80	100	0	
	R	124	100	0		75	100	0	
29	♂ R	147	100	0		145	100	0	
30	♀ L	135	100	0		137	100	0	
	R	152	100	0		138	100	0	
33	♀ L	109	100	31		167	100	0	
35	♀ L	118	100	15		122	100	0	
35	♂ L	109	100	22					
	R	108	100	20					
35	♀ L	128	100	22		204	100	0	
	R	135	100	27		241	100	0	
36	♀ L	107	100	26		112	100	0	
	R	107	100	22		121	100	0	
36	♀ L	88	100	22					
	R	92	100	22					

therefore, may be very different from that of sperm whale, though the final explanation should be left in future investigations.

Skeleton

A skull of *Berardius* kept in the National Science Museum was measured and each measurement is presented in Table 5. This *Berardius* is a female of 36 feet in length and is deemed as physically matured, because the epiphyses of the vertebrae are fused to their centra. In Table 5, also percentages of the total skull length and of the postorbital width are shown for the convenience of comparison with other specimens.

Table 5. Skull measurements of *Berardius bairdi* from Japan. (36 ft. ♀)

Measurements	Length in mm.	Per cent of total length	Per cent of breadth
Total (Condylobasal) length	1,421	100.0	196.8
Height from vertex to inferior border of pterygoids	571	40.2	79.1
Breadth across postorbital processes	722	50.8	100.0
Breadth across middle of orbits	686	48.3	95.0
Length of rostrum	921	64.8	127.6
Breadth of rostrum at base	437	30.8	60.5
Breadth of rostrum at middle	201	14.1	27.8
Length of premaxilla	1,330	97.1	191.1
Breadth of premaxilla at middle	113	8.0	15.7
Greatest breadth of premaxillae in front of nares	230	16.2	31.9
Greatest breadth of premaxillae behind nares	194	13.7	26.6
Distance from anterior end of premaxillae to anterior end of pterygoids	1,170	82.3	162.0
Length of nasals (greatest, median)	141	9.9	19.5
Breadth of nasals (greatest)	115	8.1	15.9
Breadth of anterior nares	98	6.9	13.6
Breadth across occipital condyles	238	16.7	33.0
Breadth of right condyle	109	7.7	15.1
Height of right condyle	163	11.5	22.6
Length of mandible (right)	1,300	91.5	180.1
Length of synphysis	276	19.4	38.2
Height at coronoid	234	16.5	32.4
Distance from tip of jaw to centre of 1st tooth	48	3.4	6.6
Distance from tip of jaw to centre ot 2nd tooth	168	11.8	23.3

It is very interesting to compare these measurements to those from British Columbia presented by Pike (1953). Most of our measurements fall between the male and female from British Columbia. When compared with the measurements by Slipp and Pike (1953), some differences are noted, although in some measurements the both agree fairly well.

Table 6. Selected skull dimensions of *Berardius*.

Measurements	Length in mm.				Per cent of Postorbital width			
	J. 36 Ft. ♀	B.C. 33. Ft. ♂	B.C. 29 Ft. ♀	W. 34 Ft. ♀?	J. 36 Ft. ♀	B.C. 33 Ft. ♂	B.C. 29 Ft. ♀	W. 34 Ft. ♀?
Total length	1,421	1,440	1,343	1,438	196.8	187.0	203.8	181.8
Breadth across postorbital processes	722	770	659	791	100.0	100.0	100.0	100.0
Breadth across middle of orbits	686	693	657	757	95.0	90.0	99.7	83.2
Breadth of rostrum at base	437	447	397	445	60.5	58.1	60.2	56.3
Breadth of rostrum at middle	201	208	194	206	27.8	27.0	29.4	26.0
Length of premaxilla	1,380	1,220	1,192	1,286	191.1	158.4	180.9	162.6
Distance from anterior end of premaxillae to anterior end of pterygoids	1,170	1,146	865	1,122	162.0	148.8	131.3	141.8
Length of nasals	141	120	110	135	19.5	15.6	16.7	17.1
Height of right condyle	163	180	173	171	22.6	23.4	26.3	21.6
Distance from tip of jaw to centre of 1st tooth	48	38	30	—	6.6	4.9	4.6	—
Distance from tip of jaw to centre of 2nd tooth	168	189	170	—	23.3	24.5	25.8	—

J....Japan
B.C.....British Columbia (Pike)
W.....Washington (Slipp and Wilke)

The measurements, in which differences are observed among *Berardius* from these three regions, are shown in Table 6, both in millimeters and in percentages of postorbital width. As seen in this table, *Berardius* from Japan has longer premaxillae, longer distance from anterior end of premaxillae to anterior end of pterygoids and a longer nasal. Besides above, anterior teeth located more posteriorly, but posterior teeth are, on the contrary situated more anteriorly, resulting more narrower distance between the both teeth than those from British Columbia. *Berardius* from Washington has shorter breadth across middle of orbits, narrower rostrum, and lower condyle compared with others. We can not conclude for the time being, however, whether there are any significant differences among these four specimens from three different localities.

Table 7. Dimensions of one skeleton of *Berardius bairdi* from Japan
36 Ft. ♀

Measurements	Length in millimeteres
Length of centra of seven cervicals	309
Atlas:	
Breadth	326
Height	304
Fourth cervical:	
Greatest height	232
Greatest width	200
Length of centrum	38
Seventh cervical:	
Greatest height	240
Greatest width	188
Lengtn of centrum	41
First thoracic:	
Greatest height	330
Greatest width	284
Length of centrum	63
Nineth thoracic:	
Greatest height	462
Greatest width	262
Length of centrum	169
First lumber:	
Greatest height	546
Greatest width	546
Length of centrum	205
Sixth lumber:	
Greatest height	661
Greatest width	546
Length of centrum	242
First caudal:	
Greatest height	727
Greatest width	515
Length of centrum	298
Nineth caudal:	
Greatest height	383
Greatest width	226
Length of centrum	218
Eleventh caudal, length of centrum	152
Length of scapula	Left 635 Right 637
Height of scapula	〃 478 〃 487
Length of humerus	〃 321 〃 322

Mesaurements	Length in millimeters			
Breadth of humerus at distal end	Left	160	Right	158
Length of radius	〃	368	〃	367
Breadth of radius at distal end	〃	128	〃	124
Length of ulna	〃	382	〃	382
Breadth of ulna at distal end	〃	101	〃	99
Length of sternum		1,415		
Breadth of first segment of sternum		308		
Length of first rib (straight)	Left	490	Right	470
Length of fifth rib (straight)	〃	1,133	〃	1,104
Length of tenth rib (straight)	〃	931	〃	934

Other skeletal dimensions are presented in millimeters in Table 7. When compared these measurements with those of *Berardius bairdi* reported by True (1910), no remarkable differences are recognized. However, there are marked differences in the size of caudal vertebrae, if compared with those of *Berardius arnuxi* and of *Berardius* stranded to Ocean City, Washington, as reported by Slipp and Wilke (1953). The latter two have more smaller nineth and eleventh caudal vertebrae, though no significant difference is noticed in the first caudal vertebra.

Table 8. Centrum lengths as percentages of condylo basal length in *Berardius*

	B. bairdi Japan ♀ Ad.	*Berardius* Ocean City ♀? Ad.	*B. arnuxi* New Zealand (Flower)	*B. bairdi* Pribirof I. ♀ Ad.	*B. bairdi* California ♂? Ad.	*B.bairdi* Pribirof I. ♂ Juv.
1st caudal vertebra	21.0	20.0	19.7	22.2	—	18.8
2nd caudal vertebra	—	—	—	—	19.7	—
9th caudal vertebra	15.3	12.1	12.2	15.8	13.6	15.1
11th caudal vertebra	10.7	7.5	7.6	11.8	11.0	13.4

In Table 8 selected centrum length of caudal vertebrae are shown as percentages of condylobasal length for the various specimens of *Berardius*. In this table, the Japanese specimen shows very similar value to other *bairdi*. And it is suggested from this table that the difference in skeleton between *bairdi* and *arnuxi* lies in smaller caudal vertebrae in posterior region for *arnuxi*. It is suggested also, from this fact, that these smaller caudal vertebrae might be connected with smaller tail flukes of *arnuxi*. It should be left in future, however, that the problem of whether the *Berardius* from Ocean City belongs really to *arnuxi* or to *bairdi*, because it seems also to us that the two species are less well-marked as pointed out by

Slipp and Wilke (1953).

Sexual Maturity and Growth

Testes for 66 males were measured their weight, and in which for 10 whales the testes were examined histologically of their maturity. These measurements were dotted in Fig. 27.

As seen in Fig. 27, the testes of less than 1 kg. are separated clearly from those of above 2 kg. and it is quite certain that the former are immature, and the latter mature. Two males of which testes were examined histologically and weighed less than 1 kg. were immature and others which weighed more than 2 kg. were all proved as mature. Thus in *Berardius* the weight of testis increase abruptly when the sexal maturity is reached. The biggest immature male was 36 feet in length and the smallest matured male was 31 feet long. Judged from this figure, we can safely conclude that the average body length at which sexual maturity is attained is 32 or 33 feet.

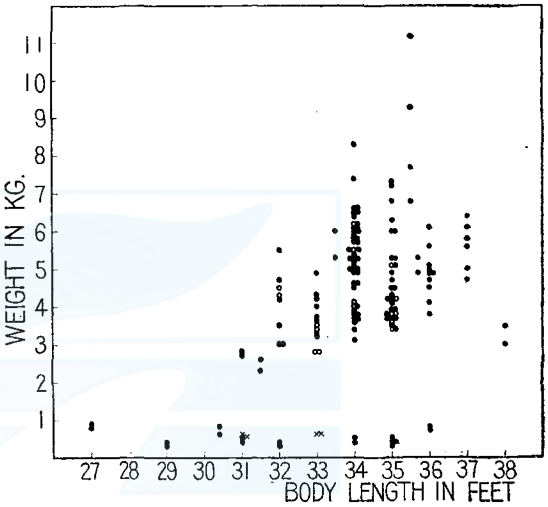

Fig. 27. Weight of testis in *Berardius bairdi* of Japan.

○ Mature ● Not examined histologically

× Immature

Table 9. Number of corpora lutea in *Berardius bairdi* from Japan.

Body length in feet	Imm-ature	Number of corpora lutea														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	Average
30																
31	1															
32																
33												1				11.0
34	1			1		1		1								5.0
35		1			1			1								4.0
36									1					1	1	11.7
37					1	2		1								5.3
38				1												3.0

In females the ovaries for 17 whales were examined of the presence of corpora lutea and their numbers were counted, results of which are presented in Table 9.

As shown in this table, one *Berardius* of 30 feet long is immature. 33 feet one is mature and among four whales of 34 feet only one is immature. All of 35 feet long and above this body length are mature. No data of 31 and 32 feet. Thus we have only scanty data for females at present. So we investigated the record of foetus in the catch record and obtained the following.

Body length of pregnant female	*Occurence*	
	Number	*Per cent*
32 feet	1	2.9
33	0	0
34	8	23.5
35	8	23.5
36	9	26.5
37	4	11.8
38	4	11.8
Total	34	100.0

Judged from the above figures and Table 9, it is likely that the average body length at which sexual maturity is attained is 33 feet or 34 feet for females, being bigger than males by about one foot.

According to our observations, the simple way to know about the maturity of *Berardius* is to examine the teeth, because teeth are all exposed from the gum in sexually matured whales, while in immature whales the teeth are usually concealed beneath the gum. This may be served at least in rough estimation.

Fig. 28 was made by dotting the record of foetuses and *Berardius* of less than 33 feet, according to their body length and also to the date of catch. Estimated growth curve is also drawn very roughly. As seen in this figure, the pairing of *Berardius* takes place in February and the parturition in December in most individuals, length of gestation being about 10 months. The biggest foetus in our record is 14 feet long and according to True (1910), the *Berardius* observed by Dr. Stejneger, which was conjectured it had died immediately after having been born, was 4.81 meters (15 feet 9 inches) long. However, this body length was not measured by straight line, but the length from tip of upper jaw to notch of caudal fin, along the middle of the back, without, however, following the angle between beak and forehead. So we estimated the body length at birth as 15 feet.

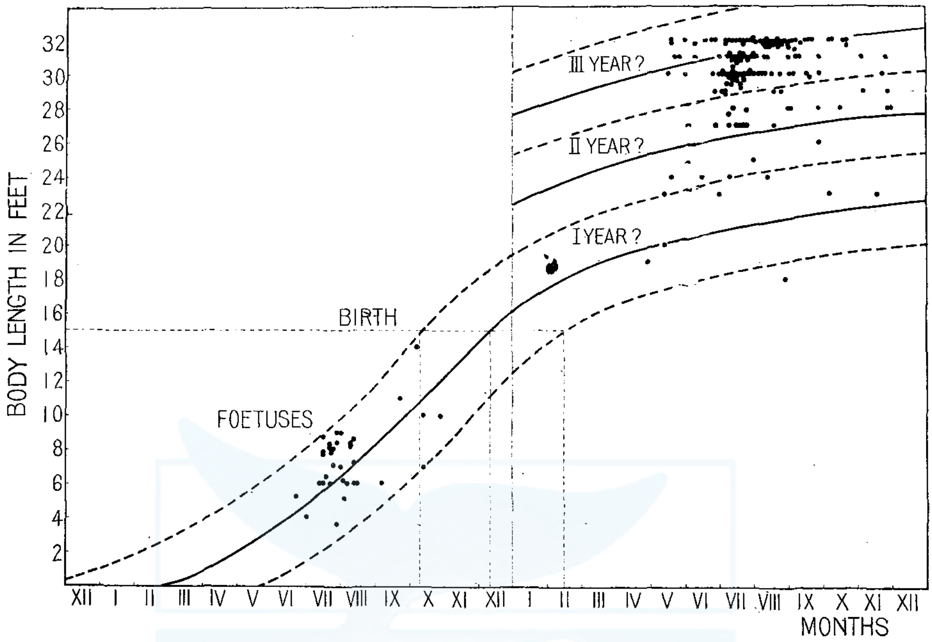

Fig. 28. Growth of *Berardius bairdi*.

The growth curve after birth is very difficult to draw with data available at present. However, it is most unlikely to suppose that *Berardius* reach sexual maturity after one year from birth. It seems also very difficult to us to suppose that they attain their sexual maturity after an interval of two years, judged from the data in hand. Although we drew the growth curve of after the birth very roughly, supposing *Berardius* get matured after three years from birth, we have very little confidence to this growth curve. It may take three or more years in order to be attained the sexual maturity in *Berardius*.

Notes on Ziphius cavirostris

Ziphius cavirostris Cuvier is generally called as Akabo-kujira in Japan, and in Chiba prefecture its local name is Kajippo. Akabo-kujira is also taken by small-typed whaling boats as *Berardius*, however, smaller in number. Yearly catch of *Ziphius* during the five years from 1948 to 1952 is shown in Table 10.

In these five years only 85 *Ziphius* are taken, however, there is also a tendency of increasing number of the catch. The sex ratio of the catch is 60 per cent male and 40 per cent female.

As shown in Table 11, main grounds for *Ziphius* are Area I and Area II, and then Area VII. We have no catch record of *Berardius* in Area VII (coast of Wakayama prefecture), as stated already, but *Ziphius*

Table 10. Catch of *Ziphius cavirostris* in Japan during the years 1948–52, inclusive.

Years	Male	Female	Total
1948	2	1	3
1949	6	4	10
1950	4	6	10
1951	17	10	27
1952	22	13	35
Total	51	34	85
Sex ratio	60.0	40.0	100.0

Table 11. Catch of *Ziphius cavirostris* in each area of Japan. Total of five years 1948–1952.

Areas	Male	Female	Total
I (Chiba pre.)	22	17	39
II (NE-Japan-Proper)	20	9	29
III (S-Hokkaido)	1	0	1
VI (Toyama bay)	0	1	1
VII (Wakayama pre.)	8	7	15
Total	51	34	85

is taken in this area from very old days. Taiji town, Wakayama prefecture, is very famous as a whaling base and many whaling vessels of small type have been operating from old days. The catch is consisted of mainly Gondo-kujira (*Globicephalus melas*), together with other kind of small toothed whales. *Ziphius* is also found in the catch sometimes.

Monthly catch of *Ziphius* is shown in Fig. 29. As seen in this figure, *Ziphius* is caught in all year round, most of catch being from May to October and its peak in August.

Size distribution of the catch is shown in Table 12 and in Fig. 30 in histograms. As shown in these table or figure, the biggest male is 22 feet in length and that of female is 23 feet long, female being

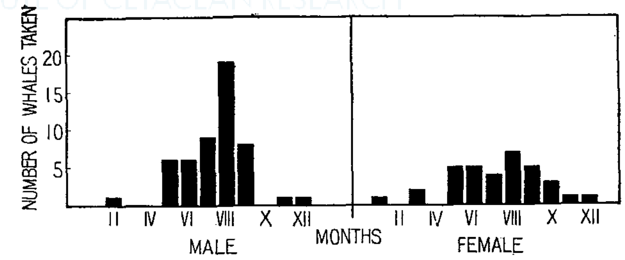

Fig. 29. Monthly catch of *Ziphius cavirostris*. Total of 5 years 1948–52, inclusive.

bigger than male by one foot. The peaks of catch of male and female are lying at 18 and 19 feet respectively, suggesting alse in *Ziphius* female is bigger than male by one foot, as is the case in *Berardius.*

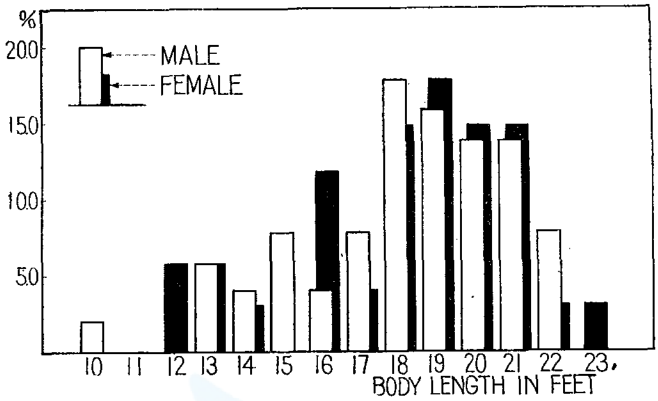

Fig. 30. Size distribution of *Ziphius cavirostris*, reduced in percentages. Total of 5 years 1948–52, inclusive.

As regards to the sexual maturity in *Ziphius*, we have very few data at present. Two *Ziphius* were measured of their testes weight, which were the following.

Table 12. Size distribution of *Ziphius cavirostris* from Japan.

Body length in feet	Actual number			Per cent		
	Male	Female	Total	Male	Female	Total
10	1	—	1	2.0	—	1.2
11	—	—	—	—	—	—
12	—	2	2	—	5.9	2.4
13	3	2	5	5.9	5.9	5.9
14	2	1	3	3.9	2.9	3.5
15	4	—	4	7.9	—	4.7
16	2	4	6	3.9	11.8	7.0
17	4	2	6	7.9	5.9	7.0
18	9	5	14	17.6	14.7	16.5
19	8	6	14	15.7	17.7	16.5
20	7	5	12	13.7	14.7	14.1
21	7	5	12	13.7	14.7	14.1
22	4	1	5	7.8	2.9	5.9
23	—	1	1	—	2.9	1.2
Total	51	34	85	100.0	100.0	100.0

Body length in feet		*Weight of testis*		
18	one	4,100 gr.	another	4,200 gr.
19.2	,,	3,500 ,,	,,	4,000 ,,

Judged from the data of *Berardius*, it is likely that these males are matured. A *Ziphius* of 590 cm (19 ft. 4 in.) in length, reported by Ogawa (1936) is a matured male. Therefore, it is probable that male *Ziphius* reach their sexual maturity at a body length of 18 feet or smaller. For female we have following five records of foetuses in hand.

Date	*Body length of pregnant female*	*Foetus*	
12 Aug. 1951	20 feet	male	1 feet
12 Aug. 1952	18 ,,	,,	7 ,,
7 Sept. 1952	21.3 ,,	female	5.6 ,,
15 Oct. 1952	22.5 ,,	,,	1.4 ,,
28 Aug. 1953	20 ,,	,,	3.2 ,,

There is one pregnant female of 18 feet, but others are all 20 feet or above that length. Further, we have one example of immature female of 18 feet. This *Ziphius* was taken at the position of 171° East longitude and 37° North latitude by tuna long line and brought to the Tokyo Fish Market on 27 November 1949 (Plate X). Saury Pikes were used as bait of the long line, and according to the crew of the fishing boat that *Ziphius* was still alive when they hauled up the line, and was taken up to the deck of the boat by hooks of many hands. This whale was a female of 18 feet long and neither corpus luteum nor maturing follicles were present in the ovaries.

In conclusion above, also in this repect, female is deemed bigger than male.

Summary

A. *Berardius bairdi* from Japan were studied and the following conclusions were reached:

1. The pairing takes place mostly in February and calves are born in December, length of gestation being about 10 months. Body length at birth is estimated as 15 feet.
2. The average body length at which sexual maturity is attained for females and males are 33–34 feet and 32–33 feet, respectively. They reach these body length after an interval of three or more years from birth. The female attain its body length up to about 40 feet and the biggest male is about 39 feet, female is bigger than male like in baleen whales.
3. No difference is noted between *Berardius bairdi* from British

Columbia and those from Japan.

4. The differences between *Berardius bairdi* and *B. arnuxi* in the external proportions are bigger flippers and broader total spread of tail flukes in the former than the latter. In skeletal measurements, the latter have more smaller sized caudal vertebrae in the posterior region than the former.

5. The males are preponderant over the females in the catch, occupying about two thirds of the total catch in the waters around Japan. It is thought, however, this may be attributed to the difference in movements between both sexes.

6. There is no scientific evidence on occurrence of *Hyperoodon* in the western side of the North Pacific.

B. Also in *Ziphius cavirostris* female is bigger than male.

Literature Cited

Arseniyev, V. A. and others, 1937: On the Hunting and Utilization of Sea Animals and Sharks in the Far East. Bull. Pac. Sci. Inst. Fish. Oceanogr. Vol. 10. (in Russion with English Summaries).

Fisheries Agency of Japanese Government., 1952: Some Materials Showing the Status of Whaling of Japan.

Fukuyama, J., 1943: A Story of Shimbei DAIGO. (in Japanese).

Japan Association of Whaling, 1943: Handbook of Whaling. Vol. 3. (in Japanese).

Jonsgård, A. and Øynes, P., 1952: Om bottlenosen og spekkhoggeren. Fauna. Nr. 1. (in Norwegian with English summary).

Matsuura, Y., 1943: Kaiju (Marine Mammals). (in Japanese).

Ogawa, T., 1936: Studien über die Zahnwale in Japan.

Omura, H., Maeda, K. and Miyazaki, J., 1953: Whaling in the Adjacent Waters of Japan. Norsk Hvalfangst-Tidende. Nr. 4.

Pike, G. C., 1953: Two Records of *Berardius bairdi* from the Coast of British Columbia. Journ. Mamm. Vol. 34, No. 1.

Scheffer, V. B. and Slipp, J. W., 1948: The Whales and Dolpins of Washington State with a Key to the Cetaceans of the West Coast of North America. Amer. Midl. Nat. Vol. 39, No. 2.

Scheffer, V. B., 1949: Notes on Three Beaked Whales from the Aleutian Islands. Pacific Science. Vol. 3, No. 4.

Slipp, J. W. and Wilke, F., 1953: The Beaked Whale *Beraridus* on the Washington Coast. Journ. Mamm. Vol. 34, No. 1.

Tanaka, S. and others, 1933: Suisan-Doshokubutsu-Zusetsu (Handbook of Marine Animals and Plants). (in Japanese).

Tomilin, A., 1935: Whaling Industry in USSR. Sci. Fish. No. 10. (in Russian).

True, F. N., 1910: An Account of the Beaked Whales of the Family *Ziphiidae*. Bul. U.S. Nat. Mus. 73.

Appendix

Measurements of Body Proportions of *Berardius bairdi* from Japan.
Upper figures: actual measurement in centimeters.
Lower figures: percentages against total length.

Measurement	No. 1	Total length from tip of snout to notch of flukes.
〃	No. 2	Projection of lower jaw beyond tip of snout.
〃	No. 3	Tip of snout to blow-hole.
〃	No. 4	Tip of snout to angle of gape.
〃	No. 5	Tip of snout to centre of eye.
〃	No. 6	Tip of snout to axilla of flipper.
〃	No. 7	Centre of eye to centere of ear.
〃	No. 8	Notch of flukes to posterior emargination of dorsal fin.
〃	No. 9	Width of flukes at insertion.
〃	No. 10	Notch of flukes to centre of anus.
〃	No. 11	Notch of flukes to umbilicus.
〃	No. 12	Centre of anus to reproductive aperture.
〃	No. 13	Vertical height of dorsal fin
〃	No. 14	Length of base of dorsal fin.
〃	No. 15	Tip to anterior end of lower border of flipper.
〃	No. 16	Axilla to tip of flipper.
〃	No. 17	Greatest width of flipper.
〃	No. 18	Length of severed head from condyle to tip.
〃	No. 19	Length of snout.
〃	No. 20	Tail flukes, tip to notch.

Date, Catch	Body length in Feet	Sex	Land-station	Measurement Number																			
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
5 Jul. 1953	4′ 9″ (foetus)	♂	Ayukawa	144	— —	19 13.2	12 8.3	17 11.8	52 36.1	— —	43 29.8	14 9.7	38 26.4	73 50.7	9 6.2	4 2.8	8 5.6	— —	— —	— —	— —	— —	23 16.0
15 Jul. 1953	8′ 4″ (foetus)	♂	〃	253	— —	33 13.0	21 8.3	31 12.2	68 26.9	— —	67 26.5	— —	80 31.6	140 55.3	15 5.9	9.5 3.8	23 9.1	37 14.6	27 10.7	14 5.5	— —	17 6.7	—
8 Aug. 1953	28′ 7″	♂	〃	870	5 0.6	— —	56 6.4	97 11.2	200 23.0	17 2.0	240 27.6	65 7.5	255 29.3	490 56.4	65 7.5	22 2.5	55 6.3	100 11.5	65 7.5	35 4.0	— —	57 6.6	110 12.7
6 Aug. 1953	31′ 10″	♂	〃	970	10 1.0	104 10.7	63 6.5	82 8.4	208 21.4	15 1.5	265 27.3	75 7.7	273 28.1	550 56.7	80 8.2	32 3.3	60 6.2	115 11.8	81 8.3	42 4.3	— —	60 6.2	154 15.9
13 Jul. 1953	32′ 8″	♂	〃	995	6 0.6	110 11.1	69 7.0	85 8.6	210 21.1	— —	270 27.3	— —	290 29.3	555 56.1	60 6.1	22 2.2	65 6.6	126 12.7	80 8.1	42 4.2	— —	59 6.0	— —
24 Jul. 1953	32′ 8″	♂	〃	995	9 0.9	118 11.9	64 6.5	108 10.9	207 20.9	— —	285 28.8	— —	287 29.0	580 58.6	82 8.3	25 2.5	56 5.7	127 12.8	80 8.1	41 4.1	— —	65 6.6	— —
5 Aug. 1953	32′ 8″	♂	〃	995	8 0.8	111 11.2	65 6.6	105 10.6	222 22.4	21 2.1	260 26.3	— —	290 29.3	570 57.6	80 8.1	28 2.8	60 6.1	125 12.6	78 7.9	43 4.3	— —	60 6.1	135 13.6
4 Aug. 1953	32′ 10″	♂	〃	1000	9 0.9	112 11.2	57 5.7	100 10.0	218 21.8	20 2.0	280 28.0	— —	280 28.0	580 58.0	70 7.0	27 2.7	60 6.0	126 12.6	88 8.8	43 4.3	— —	61 6.1	— —
24 Jul. 1953	33′ 4″	♂	〃	1015	13 1.3	102 10.1	70 6.9	94 9.3	215 21.3	— —	290 28.7	— —	305 30.2	590 58.4	60 5.9	29 2.9	60 5.9	— —	— —	42 4.2	— —	60 5.9	— —
24 Jul. 1953	33′ 6″	♂	〃	1020	8 0.8	112 11.0	63 6.2	110 10.8	230 22.5	— —	272 26.7	— —	280 27.4	564 55.3	81 7.9	27 2.6	96 9.4	126 12.3	82 8.0	42 4.1	— —	61 6.0	— —
16 Jul. 1953	33′ 6″	♂	〃	1021	9 0.9	115 11.3	70 6.9	102 10.0	220 21.6	— —	290 28.4	— —	300 29.4	575 56.4	70 6.9	27 2.6	70 6.9	128 12.5	85 8.3	43 4.2	— —	65 6.4	— —
25 Jul. 1953	33′ 8″	♂	〃	1025	— —	115 11.3	62 6.1	94 9.2	210 20.6	20 2.0	280 27.4	— —	290 28.4	605 59.3	80 7.8	27 2.6	60 5.9	126 12.3	80 7.8	45 4.4	— —	64 6.3	— —
15 Jul. 1953	33′ 10″	♂	〃	1030	7 0.7	110 10.7	75 7.3	103 10.0	230 22.3	— —	270 26.2	— —	280 27.2	580 56.3	80 7.8	29 2.8	60 5.8	120 11.6	84 8.1	42 4.1	— —	64 6.2	— —
23 Jul. 1953	33′ 10″	♂	〃	1030	11 1.1	118 11.4	62 6.0	109 10.6	222 21.5	— —	305 29.6	— —	280 27.2	590 57.2	50 4.9	25 2.4	60 5.8	125 12.1	81 7.9	42 4.1	— —	63 6.1	— —
26 Jul. 1953	33′ 10″	♂	〃	1032	8 0.8	113 11.0	62 6.0	92 8.9	222 21.5	19 1.8	300 29.1	75 7.3	300 29.1	597 57.9	70 6.8	28 2.7	63 6.1	134 13.0	82 8.0	46 4.5	130 12.6	64 6.2	— —
14 Jul. 1953	34′ 1″	♂	〃	1040	— —	120 11.5	69 6.6	98 9.4	215 20.6	23 2.2	260 25.0	— —	310 29.8	615 59.0	70 6.7	22 2.1	80 7.7	118 11.3	77 7.4	42 4.0	— —	68 6.5	— —
24 Jul. 1953	34′ 5″	♂	〃	1049	9 0.9	105 10.0	57 5.4	87 8.3	235 22.3	— —	309 29.4	— —	307 29.2	615 58.4	101 10.0	— —	— —	130 12.4	82 7.8	42 4.0	— —	64 6.1	— —

Date, Catch	Body length in Feet	Sex	Land-station	Measurement Number 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
13 Jul. 1953	34′ 5″	♂	Ayukawa	1050	—	110	65	96	220	—	280	—	280	590	60	28	90	116	87	43	—	63	—
					—	10.5	6.2	9.1	20.9	—	26.6	—	26.6	56.1	5.7	2.7	8.6	11.0	8.3	4.1	—	6.0	—
16 Jul. 1953	34′ 6″	♂	〃	1052	—	115	70	105	218	—	280	—	280	570	60	20	60	125	85	42	—	70	—
					—	10.9	6.7	10.0	20.7	—	26.6	—	26.6	54.2	5.7	1.9	5.7	11.9	8.1	4.0	—	6.7	—
13 Jul. 1953	34′ 7″	♂	〃	1055	9	115	66	98	220	—	290	—	300	600	80	—	100	120	84	46	—	62	—
					0.9	10.9	6.3	9.3	20.9	—	27.6	—	28.5	57.0	7.6	—	9.5	11.4	8.0	4.4	—	5.9	—
25 Jul. 1953	34′ 9″	♂	〃	1060	11	116	62	90	225	21	270	—	315	597	68	27	70	132	84	42	—	65	—
					1.0	10.9	5.8	8.5	21.2	2.0	25.4	—	29.6	56.1	6.4	2.5	6.6	12.4	7.9	3.9	—	6.1	—
23 Jul. 1953	35′ 9″	♂	〃	1090	8	120	65	93	240	—	270	—	320	650	100	29	90	133	82	44	—	61	—
					0.7	11.0	6.0	8.6	22.1	—	24.8	—	29.4	59.8	9.2	2.7	8.3	12.2	7.5	4.0	—	5.6	—
19 Jul. 1952	5′ 5″ (foetus)	♂	Chiba prefecture	164	—	22.5	12.5	—	—	—	45	—	—	84	9	5.6	11	24	—	—	—	—	23
					—	13.7	7.6	—	—	—	27.4	—	—	51.2	5.5	3.4	6.7	14.6	—	—	—	—	14.0
20 Jul. 1952	32′ 3″	♂	〃	982	—	105	68	100	—	—	300	—	—	580	70	—	65	125	—	—	—	55	143
					—	10.7	6.9	10.2	—	—	30.5	—	—	59.0	7.1	—	6.6	12.7	—	—	—	5.6	14.6
25 Jul. 1952	33′ 2″	♂	〃	1012	—	110	80	108	—	—	287	—	—	644	64	22	72	122	—	—	—	70	150
					—	10.9	7.9	10.7	—	—	28.4	—	—	63.6	6.3	2.2	7.1	12.1	—	—	—	6.9	14.8
27 Jul. 1952	33′ 2″	♂	〃	1012	—	—	62	95	—	—	310	—	—	555	78	22	55	122	—	—	—	59	152
					—	—	6.1	9.4	—	—	30.6	—	—	54.8	7.7	2.2	5.4	12.1	—	—	—	5.8	15.0
27 Jul. 1952	33′ 7″	♂	〃	1024	—	105	67	95	—	—	268	—	—	574	81	28	65	137	—	—	—	62	133
					—	10.3	6.5	9.3	—	—	26.2	—	—	56.1	7.9	2.7	6.4	13.4	—	—	—	6.1	13.0
28 Jul. 1953	4′ 10″ (foetus)	♀	Ayukawa	148	—	20	11.5	20.5	44	—	43	—	44	79	5	3.5	8	22.5	16	7	—	10	24
					—	13.5	7.8	13.9	29.7	—	29.1	—	29.7	53.4	3.4	2.4	5.4	15.2	10.8	4.7	—	6.8	16.2
6 Aug. 1953	8′ 7″ (foetus)	♀	〃	261	—	35	18	34	74	—	71	27	80	140	10	8	14	44	26	15	50	16	36
					—	13.4	6.9	13.0	28.3	—	27.2	10.3	30.6	53.6	3.8	3.1	5.4	16.9	10.0	5.7	19.2	6.1	13.8
17 Aug. 1953	32′ 10″	♀	〃	1000	9	112	68	111	214	—	285	—	320	590	60	30	55	120	82	45	—	64	—
					0.9	11.2	6.8	11.1	21.4	—	28.5	—	32.0	59.0	6.0	3.0	5.5	12.0	8.2	4.5	—	6.4	—
25 Jul. 1953	33′ 6″	♀	〃	1020	—	118	60	92	205	21	280	—	280	620	50	31	80	125	82	42	—	64	—
					—	11.6	5.9	9.0	20.1	2.1	27.4	—	27.4	60.8	4.9	3.0	7.8	12.3	8.0	4.1	—	6.3	—
15 Jul. 1953	33′ 10″	♀	〃	1030	7	115	75	—	220	—	280	—	270	600	30	30	80	130	85	44	—	70	—
					0.7	11.2	7.3	—	21.3	—	27.2	—	26.2	58.2	2.9	2.9	7.8	12.6	8.2	4.3	—	6.8	—
23 Jul. 1953	36′ 5″	♀	〃	1110	8	134	74	105	248	—	305	—	315	640	60	32	68	140	85	45	—	72	—
					0.7	12.1	6.7	9.5	22.3	—	27.5	—	28.4	57.6	5.4	2.9	6.1	12.6	7.7	4.1	—	6.5	—
17 Aug. 1953	36′ 7″	♀	〃	1115	10	120	70	120	250	20	350	—	330	650	40	30	60	135	85	43	—	68	—
					0.9	10.8	6.3	10.8	22.5	1.8	31.5	—	29.7	58.5	3.6	2.7	5.4	12.2	7.7	3.9	—	6.1	—
2 Aug. 1952	36′ 0″	♀	Chiba prefecture	1098	—	114	65	100	—	—	315	—	—	615	20	25	57	115	—	—	—	62	154
					—	10.4	5.9	9.1	—	—	28.7	—	—	56.0	1.8	2.3	5.2	10.5	—	—	—	5.6	14.0

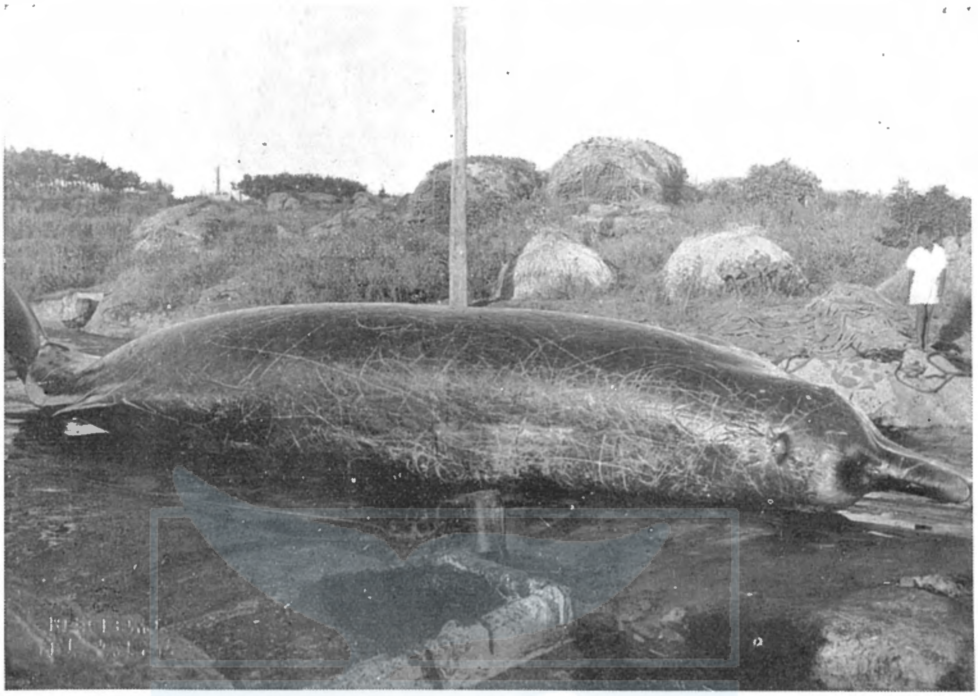

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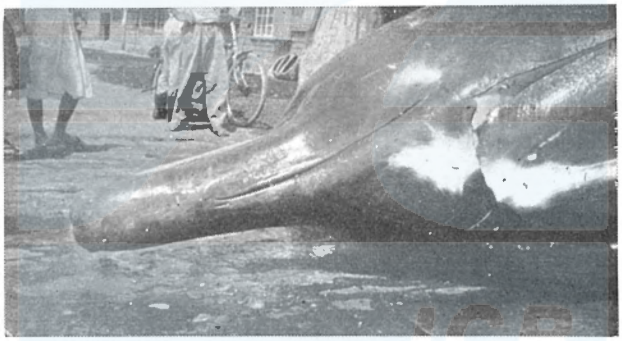
Plate I. *Berardius bairdi* of Japan.

1



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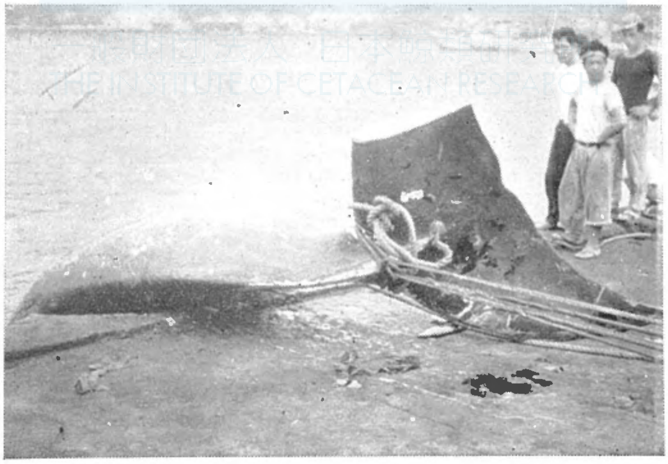

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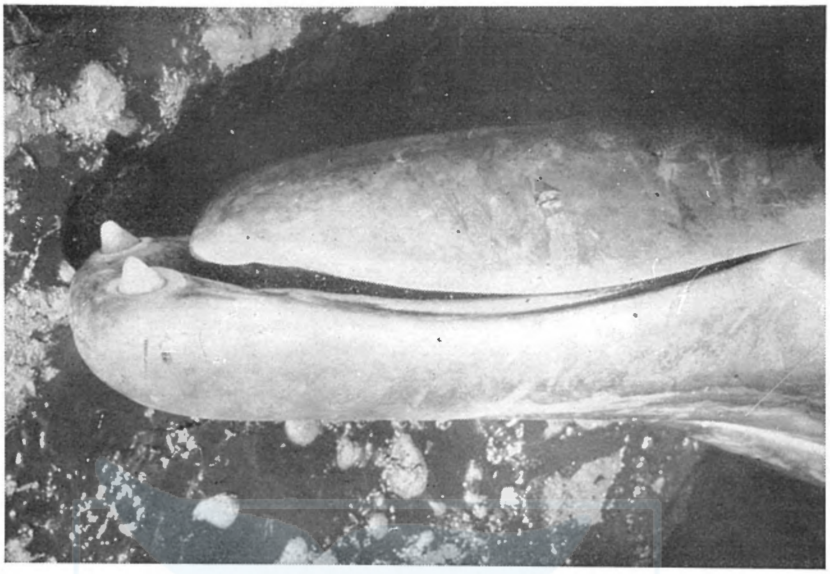
Plate II. *Berardius bairdi* of Japan.



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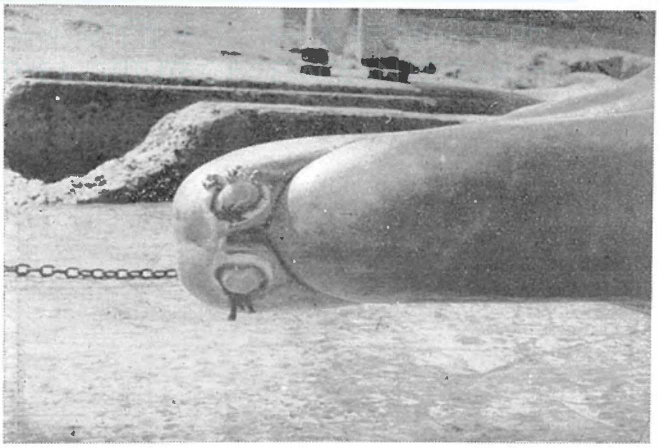

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Plate III. Teeth of *Berardius bairdi* of Japan.

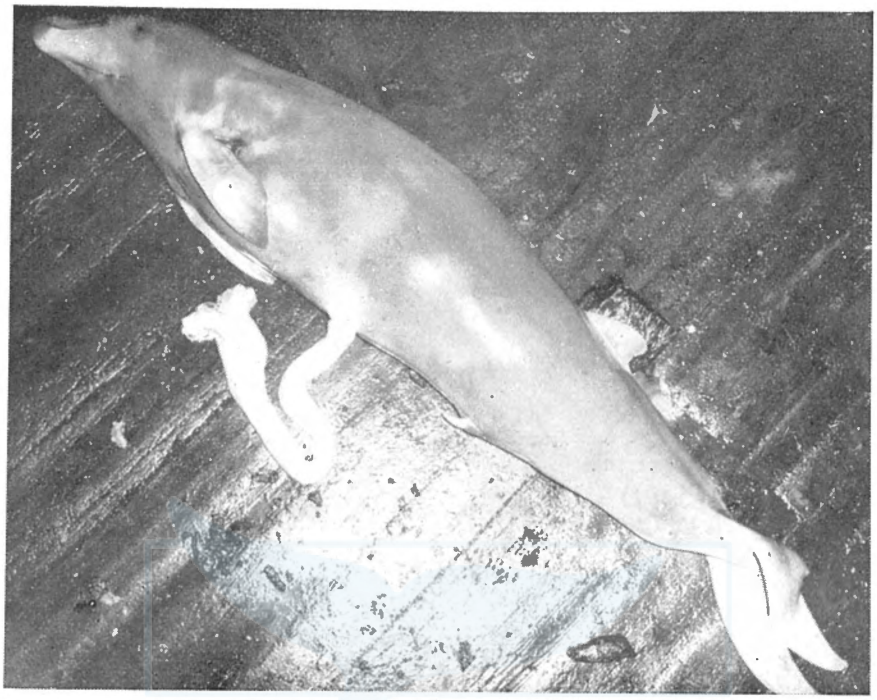

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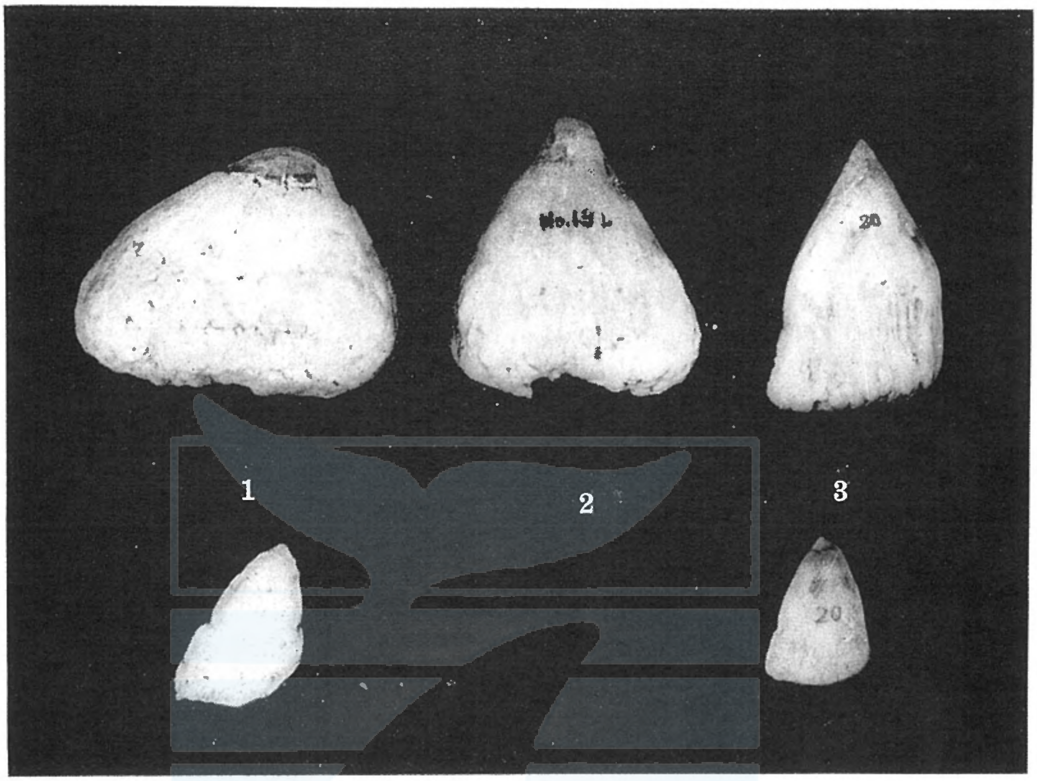
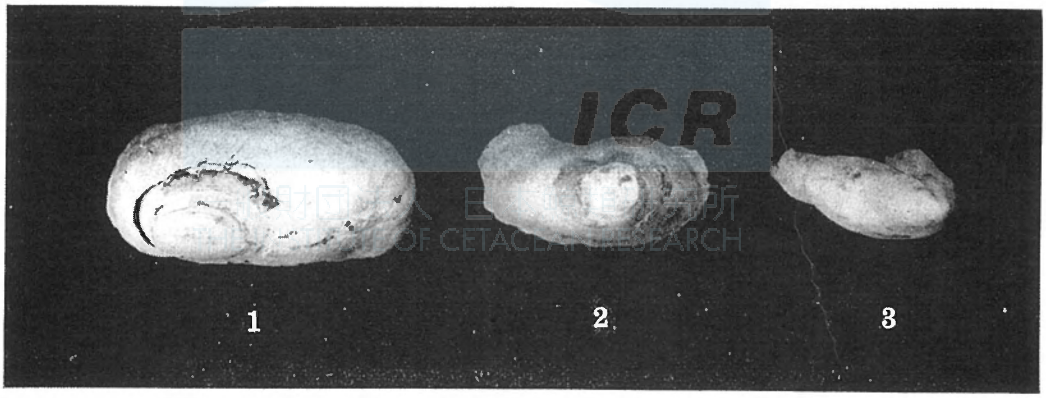
Plate IV. Foetus of a *Berardius bairdi*.



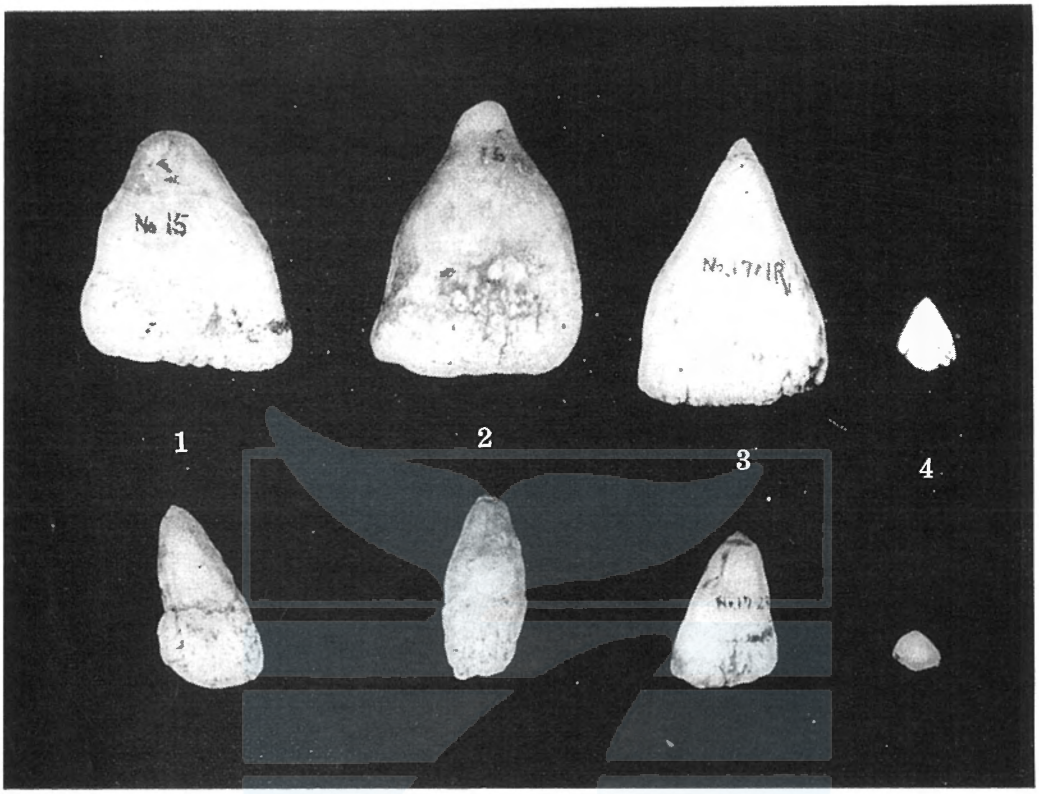
Side View



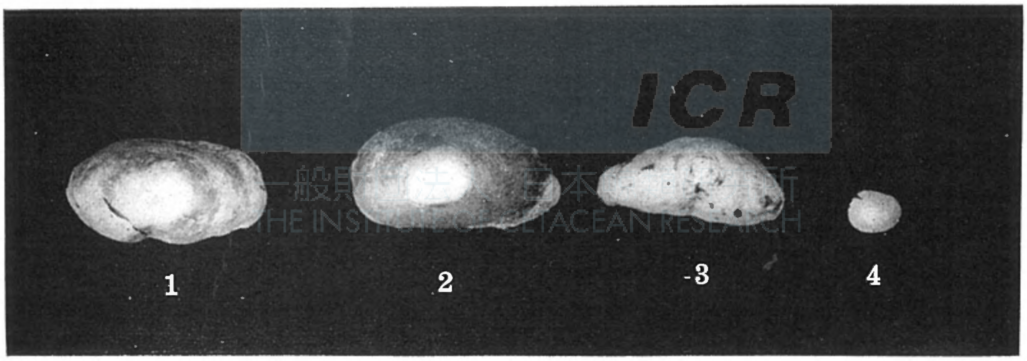
Dorsal View

Plate V. Teeth in Males

1. Right Teeth (Anterior and Porterior)	Mature length unknown
2. Left Teeth (Anterior)	Mature 35 ft.
3. Right Teeth (Anterior and Posterior)	Immature 29 ft.



Side View



Dorsal View

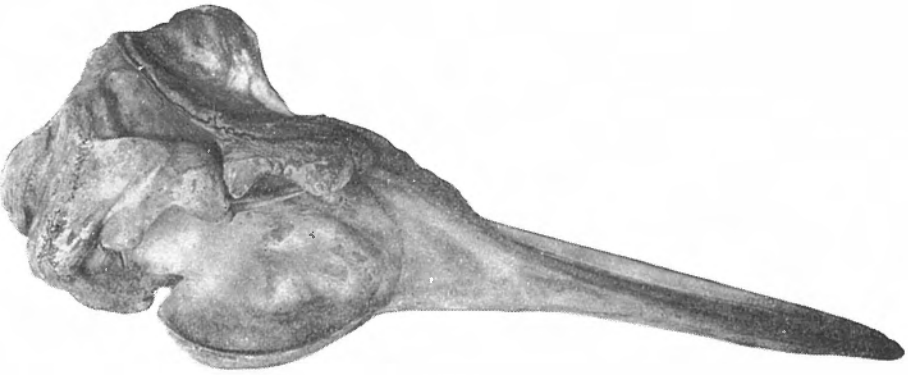
Plate VI. Teeth in Females

1. Left Teeth (Anterior and Posterior) Mature (Number of C.L. 11) 33 ft
2. Right Teeth (Anterior and Posterior) Mature (Nnmber of C.L. 7) 35 ft
3. Right Teeth (Anterior and Posterior) Immature 30 ft
4. Right Teeth (Anterior and Posterior) Foetus 9 ft

1

2

Plate VII. Skull of *Berardius bairdi* from Japan 36 Ft. ♀ adult.
1. Dorsal view 2. Ventral view



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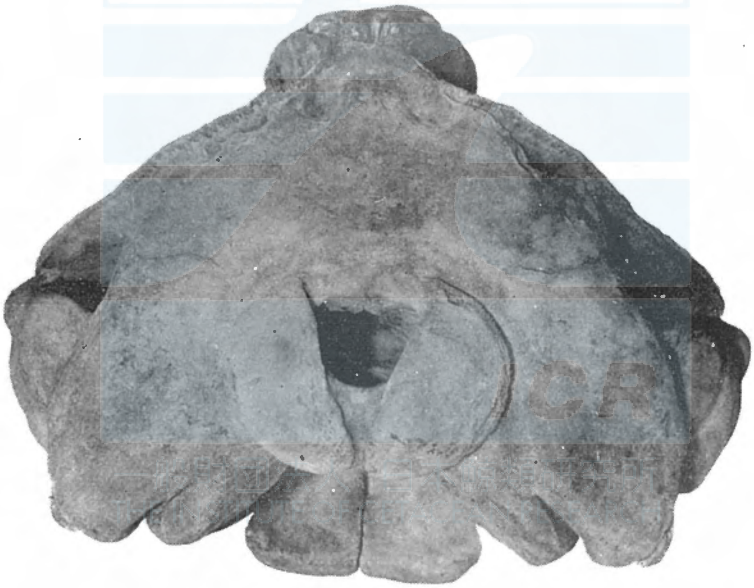

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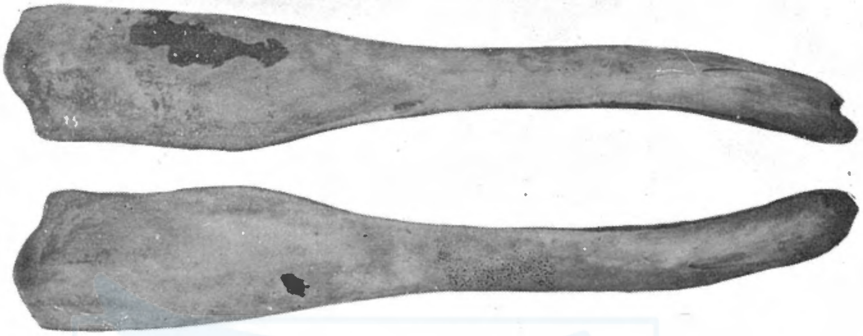
Plate VIII. Skull of *Berardius bairdi* from Japan.
36 Ft. ♀ Adult.
1. Lateral view.
2. Posterior view.



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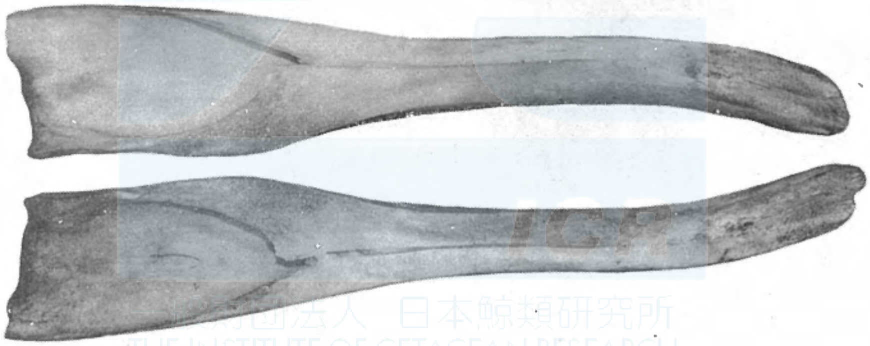

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Plate IX. Mandibles of *Berardius bairdi* from Japan.

36 Ft. ♀ Adult.
1. Outer view.
2. Inner view.

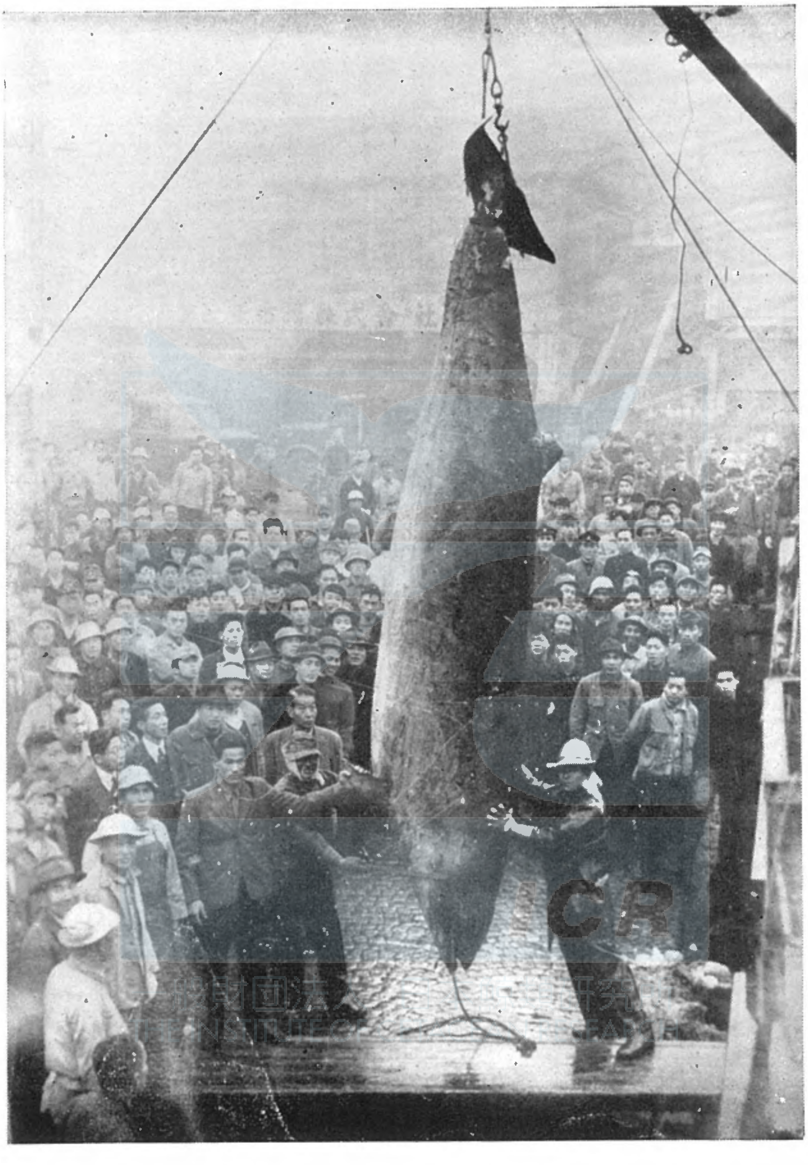

Plate X. *Ziphius cavirostris* taken by tuna long line and was landed at the pier of the Tokyo Fish Market on 27 Nov. 1949. 18 Feet ♀ Immature. (Photograph by kindness of Tokyo Shimbun)

On the Body Weight of the Sei Whales located in the Adjacent Waters of Japan (II)

By

KAZUO FUJINO

After studying the correlation between body length and weight of various parts of the body, i.e. meat, bones, blubber and internal organs, in sei whales located in the adjacent waters of Japan, Omura (1950) notes the differences in weights between sei whales from Bonin Islands and those from Kamaishi, from which a clue for identifying two types of sei whales was drawn. Further study has been carried out consecutively, mainly on the external characters of both types by Omura, Nishimoto and Fujino (1952) and Omura and Fujino (1954), reaching finally to a conclusion that there present two species in the so-called sei whales in the waters adjacent to Japan, i.e. *Balaenoptera borealis* and *B. brydei*, the latter mostly located in the seas around Bonin Island.

As only scanty data were available as regards sei whales from Bonin waters (*brydei*) at the time when Omura reported previously (1950), further weighing of whales were carried out in 1950. In the year 1950, 20 whales (7 males and 13 females) of Bonin Islands were weighed. These materials are studied in the present paper, comparing with those presented by Omura (1950).

I am much indebted to the crew of the whaling factory ship "Baikal Maru" of Kyokuyo Hogei Company who engaged in the actual weighing of the carcass, and to the whaling inspectors of Japanese Government Messrs. Setsuo Nishimoto and Hirosaku Koda who helped me immensely in the field work. My sincere thanks are also due to Dr. Hideo Omura who directed this investigation.

Nearly the same method as reported by Omura (1950) were followed also in 1950, i.e. the various parts of the body were weighed separately according to blubber, meat, bones, and internal organs, etc., cutted into small pieces and using 50 kg. balance. As regards bones and internal organs, each parts of them were weighed in detail in general, however in some occasions, some parts were weighed together, when it was deemed that more reliable data will be obtained by doing so, not separating into so minor parts. Blood was not weighed. Size distribution of sei whales weighed are shown in Table I, together with those from Kamaishi for comparison.

Table I. Size distribution of sei whales weighed in Bonin waters and Kamaishi.

Area	Bonin Islands			Kamaishi		
Sex	Male	Female	Total	Male	Female	Total
*37	–	–	–	–	1	1
38	1	3	4	–	–	–
39	1	1	2	–	–	–
40	–	–	–	1	2	3
41	2	–	2	4	2	6
42	–	1	1	4	5	9
43	–	1	1	–	3	3
44	–	2	2	1	2	3
45	–	1	1	–	2	2
46	–	–	–	–	–	–
47	–	2	2	–	–	–
48	–	1	1	–	–	–
Total No.	4	12	16	10	17	27
Av. length	39.8	42.8	42.0	41.6	42.1	41.9

* Body length in feet.

1. Meat: In the previous report (Omura, 1950) the weight of "Tongue" is included in the category "Meat," but in 1950 those two parts were recorded separately. Weight of meat in each measurements are plotted in Fig. 1. For the sake of comparison to those from Kamaishi, the weight of tongue is added also in those from Bonin Island. It will be seen from this figure that sei whales from Kamaishi are little heavier than those from Bonin Islands in meat, though the difference is small, as already pointed out by Omura (1950). Regression line of weight of meat obtained from the actual values of each whale is given by the formula I.

$$W=0.00015\cdot L^{2.84} \qquad \ldots\ldots\ldots(I)$$

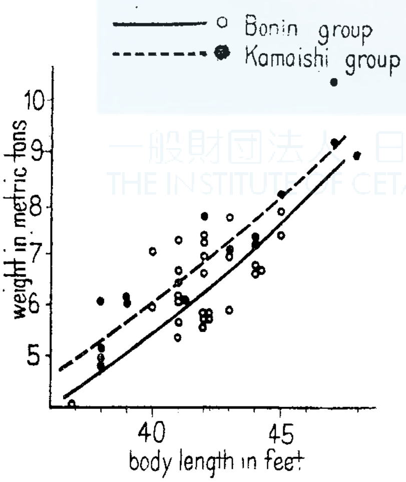

Fig. 1. Weight of meat, sei whales taken from Bonin and Kamaishi areas.

In Table II, the weight of meat from both regions are compared, and from which it will be seen that the whale from Kamaishi is heavier than those from Bonin Island by about 10% in meat. However, this weight of meat includes weight of tongue, therefore, net weight of meat is also shown in this table, calculated by deducting the weight of tongue, which is easily computed from the similar formula for itself.

2. Blubber: In the category "Blubber," the weight of "Ventral grooves" is also included. "Ventral

Table II. Standard weight of meat.

Body length in feet	Weight of meat calculated from formula (I)		Net weight of meat
	Bonin. metric tons	Kamaishi. %against Bonin	Bonin. metric tons
37	4.38	113.9	4.17
40	5.46	111.2	5.23
43	6.71	109.1	6.45
46	8.12	107.0	7.83

grooves" means the ventral part of the body, consisting of furrowed blubber and attached meat to it. As seen in Fig. 2 difference in weight of blubber between sei whales from Bonin Island and Kamaishi is very remarkable, the former having very heavier blubber than the latter. The ratios of "Ventral grooves" against the total weight of Blubber in Bonin and Kamaishi groups are, in average, 42.64 and 30.97 percent, respectively. This fact endorses that the ventral grooves of the southern type sei whale (*brydei*) extend more posteriorly than those of the northern type sei whale (*borealis*). Regression line of the weight of Blubber against body length is given by the formula II, and standard weight is shown in Table III, calculated from this formula.

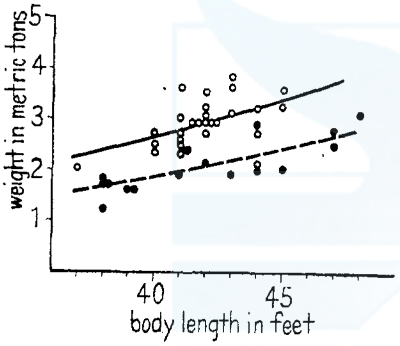

Fig. 2. Weight of blubber, sei whales taken from Bonin and Kamaishi area.

$$W=0.00076\cdot L^{2.21} \quad \text{........(II)}$$

From this table, it is seen that blubber of Kamaishi group weigh only about 72% of those of Bonin Islands group.

Table III. Standard weight of blubber.

Body length in feet	Weight of blubber	
	Bonin. metric tons	Kamaishi. % against Bonin
37	2.21	71.5
40	2.63	71.7
43	3.09	71.9
46	3.58	72.1

3. Bones: As shown in Fig. 3, the bones of Bonin Islands group are heavier than those of Kamaishi group, and this difference increases

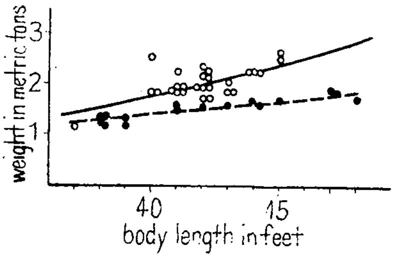

Fig. 3. Weight of bones, sei whales taken from Bonin and Kamaishi areas.

gradually with the growth of body length. Regression line is given by the formula III.

$$W=0.00005\cdot L^{2.81}\ .....(III)$$

Standard weight is shown in Table IV.

Average weight of skull, jaw bones and back bones are shown in Table V. From this table it is shown that Bonin Islands group have heavier bones than those of Kamaishi group.

Table IV. Standard weight of bones.

Body length in feet	Bonin. metric tons	Kamaishi. % against Bonin
37	1.41	87.9
40	1.76	80.1
43	2.16	73.1
46	2.61	67.4

Table V. Average weight of skull, jaw bone and back bone.

unit: kilogrammes

	skull	jaw bone	back bone	bone total	Remarks
Bonin Is.	524.4 (25.83)	209.2 (10.30)	901.3 (44.38)	2030.9 (100.00) %	Average of 27 whales, average body length of which is 41.9 ft.
Kamaishi	467.1 (30.28)	146.1 (9.47)	655.2 (42.47)	1542.4 (100.00) %	Average of 16 whales, average body length of which is 42.0 ft.

4. Internal organs: In the year 1948 the heart, lung, stomach and kidney of Bonin Islands group were not weighed separately. As it is not clear that whether those are added to "Others" in the item of "Internal organ" or to "Others" in the item of "Miscellaneous," such materials were excluded in comparison according to areas (Fig. 4).

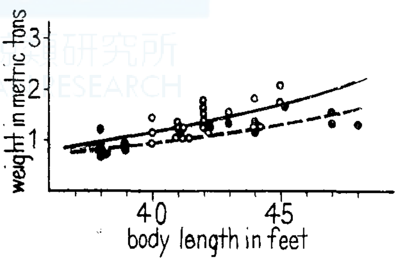

Fig. 4. Weight of internal organs, sei whales taken from Bonin and Kamaishi areas.

From this figure it may be understood that Bonin Islands group have heavier Internal organs than those from Kamaishi. Regression line is given by the formula IV.

$$W=0.000003\cdot L^{3.50} \qquad \ldots\ldots\ldots(IV)$$

Standard weight is shown in Table VI.

Table VI. Standard weight of internal organs.

Body length in feet	Bonin. metric tons	Kamaishi. %against Bonin
37	0.88	86.4
40	1.16	83.6
43	1.49	80.5
46	1.89	77.8

5. Total weight: The category "Total weight" is consisting of the above stated four items and of "Miscellaneous" which includes baleen, tongue, jaw ligament and scraps of various parts of the body. As shown in Fig. 5, the Bonin Islands group is heavier than the Kamaishi group in the "Total weight" also. Regression line is expressed as the formula V.

$$W=0.00047\cdot L^{2.74}\ldots\ldots\ldots(V)$$

Standard weight is shown in Table VII. Table III shows the differences of weight of various parts between both areas. It may be seen from this table that the difference in Blubber weight occupies the greatest ratio in the difference of Total weight between both areas. As already stated, "Ventral grooves" in the item of "Blubber" includes the meat just underneath the furrowed blubber in the ventral region. It is quite natural that the sei whales

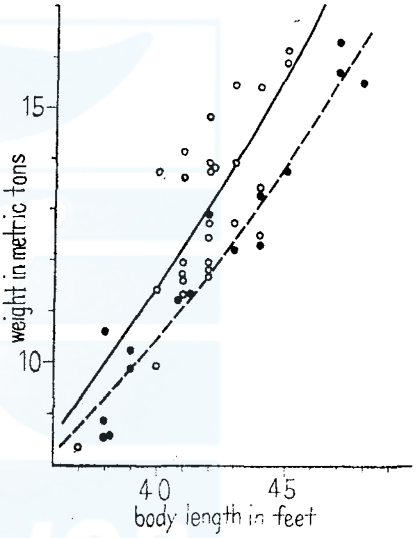

Fig. 5. Total weight, sei whales taken from Bonin and Kamaishi areas.

Table VII. Standard weight of whale body.

Body length in feet	Bonin. metric tons	Kamaishi. % against Bonin
37	9.27	94.2
40	11.47	92.0
43	14.00	89.9
46	16.83	88.1

from Bonin waters have more heavier ventral grooves than those from Kamaishi, because the ventral grooves extend far more posteriorly in the former, this being one of every important character identifying *brydei* from *borealis*.

Table VIII. Differences in weight of various parts of the body between sei whales taken in Bonin area and those from Kamaishi.

	total weight	meat	bone	blubber	internal organs	miscellaneous
	m. tons	m. tons	m. tons	m. tons	m. tons	m. tons
Bonin, average of 27 whales	13.001	6.362	2.031	2.949	1.293	0.366
Kamaishi, average of 16 whales	11.981	6.958	1.542	2.124	1.163	0.194
Difference of the above	1.020	-0.596	0.489	0.825	0.130	0.172
Ditto (%)	100.0	-58.4	47.9	80.9	12.7	16.9

Table IX shows the weight of various parts of the body, expressed as percentages of the total weight, for the sei whales from Bonin waters. As already stated these weights are calculated from the formulae I–V, and it is not certain that these formulae can be applied for whales of which body length does not fall within these limits of length, because these formulae were obtained from the measurements of whales ranging from 37 to 45 feet in length.

Table IX. Standard weight of sei whales captured in Bonin area.

Body length in feet	Total weight in metric tons	meat* %	blubber %	bones %	internal organs %	miscellaneous %
37	9.27	45.0	23.8	15.2	9.5	6.5
40	11.47	45.6	23.0	15.3	10.1	6.0
43	14.00	46.1	22.1	15.4	10.6	5.8
46	16.83	46.5	21.3	15.5	11.2	5.5

* not include the tongue.

Summary

Various parts of the whale body were weighed for 20 sei whales caught in the Bonin waters in 1950, and after comparing with those from Kamaishi the following conclusions have been reached.

(1) Total body weight are heavier in whales from Bonin Island than those from Kamaishi, however,

(2) Those from Bonin Islands is lighter than the latter in Meat.

(3) On the contrary Bones, Blubber and Internal organs are heavier than in Kamaishi group.

(4) Correlations between body length and weight of various parts of body are expressed by the following formulae for the sei whales from Bonin Island, which are in reality belong to *B. brydei*.

Total weight $=0.00047\cdot L^{2\cdot 74}$
Meat $=0.00015\cdot L^{2\cdot 84}$
Bones $=0.00005\cdot L^{2\cdot 84}$
Blubber $=0.00076\cdot L^{2\cdot 21}$
Internal organs $=0.000003\cdot L^{3\cdot 50}$

Literatures

1. Omura, H.: Whales in the adjacent waters of Japan. Sci. Rep. Whales Res. Inst., 4: 27–114, 1950.
2. Omura, H.: On the body weight of Sperm and Sei Whales located in the Adjacent Waters of Japan. Sci. Rep. Whales Res. Inst., 4: 1–13, 1950.
3. Omura, H., Nishimoto, S. and Fujino, K.: The Sei Whales in the Adjacent Waters of Japan, 1952. Fisheries Agency of Japanese Government.
4. Omura, H. and Fujino, K.: Sei Whales in the Adjacent Waters of Japan II. Further Studies on the External Characters. Sci. Rep. Whales Res. Inst., 9: 89–103. 1954.

Appendix

Weight of various parts of sei whales caught in the waters adjacent to Bonin Island, 1948 and 1950

Male (in kilogrammes)

Body length in ft.	Date, caught	Meat	Blubber			Bones								Internal organs									Miscellaneous					Grand total
			ventral grooves	others	total	skull	back	jaw	rib	shoulder	flipper	others	total	heart	lung	stomach	liver	kidney	intestine	diaphragm	others	total	baleen	jaw ligament	tongue	others	total	
40	June 8 1950	5,573	1,069	1,271	2,340	450	750	214	265	74	83	—	1,836	47	94	92	120	38	203	62	331	987	135	105	413	105	758	11,494
41	May 29 ″	5,570	1,085	1,544	2,629	518	774	196	257	53	69	—	1,867	44	140	102	188	59	248	64	474	1,319	115	74	100	78	367	11,752
41	June 8 ″	5,775	1,005	1,335	2,340	533	840	204	159	45	75	—	1,856	38	90	86	161	51	203	56	403	1,088	133	111	259	79	582	11,641
41	June 9 ″	5,907	1,001	1,549	2,550	396	981	185	155	47	71	—	1,835	47	86	101	171	49	200	77	332	1,063	140	83	206	143	572	11,927
41	June 9 ″	6,390	1,361	1,714	3,075	420	1,084	237	296	49	83	56	2,225	64	102	113	180	53	279	86	387	1,264	157	90	258	152	657	13,611
42	June 1 ″	6,345	1,260	1,643	2,903	605	927	248	301	64	99	—	2,244	68	90	117	203	60	324	71	620	1,553	157	139	258	161	715	13,760
*42	April 13 1948	5,820	—	—	3,100	440	760	180	250	—	—	90	1,720	—	—	—	100	—	190	—	570	860	—	—	—	480	480	11,980
*42	April 15 ″	5,770	—	—	2,930	490	750	170	220	—	—	90	1,720	—	—	—	110	—	190	—	610	910	—	—	—	440	440	11,770
*42	April 15 ″	6,970	—	—	3,510	510	820	200	260	—	—	110	1,900	—	—	—	130	—	220	—	550	900	—	—	—	590	590	13,870
44	May 28 1950	6,540	1,037	1,706	2,743	570	1,060	208	265	66	93	—	2,262	48	100	174	148	59	256	59	446	1,290	149	141	252	83	625	13,460

* Cited from Sci. Rep. Whales Res. Inst., 4: 1–13, 1950.

Appendix (cont.)

Female

Body length in ft.	Date, caught	Meat	Blubber			Bones								Internal organs									Miscellaneous					Grand total
			ventral grooves	others	total	skull	back	jaw	rib	shoulder	flipper	others	total	heart	lung	stomach	liver	kidney	intestine	diaph-ragm	others	total	baleen	jaw liga-ment	tongue	others	total	
*37	Apr. 12 1948	4,040	—	—	2,040	290	580	90	140	—	—	40	1,140	—	—	—	100	—	150	—	290	540	—	—	—	630	630	8,390
40	May 15 1950	6,825	1,230	1,549	2,779	544	1,065	161	281	38	52	375	2,516	45	109	94	184	64	307	64	323	1,191	101	109	263	—	473	13,784
40	May 27 〃	3,725	1,148	1,390	2,538	525	870	186	156	42	55	24	1,858	68	120	101	180	64	314	56	503	1,406	94	139	229	—	462	9,989
41	May 26 〃	5,115	1,125	1,598	2,723	422	804	215	254	49	69	19	1,832	59	96	88	210	68	286	—	414	1,221	49	120	255	—	424	11,315
*41	Apr. 16 1948	7,240	—	—	3,620	520	860	170	280	—	—	90	1,920	—	—	—	150	—	220	—	570	940	—	—	—	400	400	14,120
42	May 23 1950	5,760	1,144	1,568	2,712	536	860	213	214	56	80	—	1,959	51	101	155	204	56	316	56	261	1,200	136	81	—	45	262	11,893
42	June 4 〃	5,266	1,275	1,677	2,952	522	940	243	285	63	95	39	2,187	84	101	131	283	77	443	86	513	1,718	137	125	251	139	652	12,775
42	June 2 〃	6,980	1,290	1,950	3,240	598	1,074	271	279	62	83	—	2,367	93	101	119	251	74	352	88	547	1,625	140	113	236	149	638	14.850
42	May 16 〃	7,068	1,207	1,714	2,921	570	898	233	263	67	73	30	2,134	50	113	90	202	56	247	53	427	1,238	131	146	270	—	547	13,908
42	May 22 〃	5,531	1,590	1,377	2,967	545	882	219	199	41	97	—	1,983	68	86	90	210	60	311	50	540	1,415	165	112	285	—	562	12,458
43	May 24 〃	5,648	1,421	1,710	3,131	522	920	200	254	56	68	—	2,020	54	94	165	210	60	383	83	529	1,588	154	—	251	—	405	12,792
*43	Apr. 14 1948	6,940	—	—	3,670	500	800	190	260	—	—	100	1,850	—	—	—	140	—	240	—	870	1,250	—	—	—	200	200	13,910
*43	Apr. 16 1948	7,700	—	—	3,890	490	820	210	240	—	—	90	1,850	—	—	—	130	—	190	—	1,070	1,390	—	—	—	600	600	15,430
44	June 5 1950	7,353	1,283	1,962	3,245	536	1,061	266	283	62	75	—	2,283	35	108	120	300	78	331	95	698	1,805	187	149	304	145	785	15,471
44	May 16 〃	6,356	937	1,256	2,193	652	986	240	176	48	74	38	2,214	83	98	98	210	58	281	75	363	1,266	120	146	255	—	521	12,550
45	May 30 〃	7,073	1,650	1,951	3,601	745	1,090	267	394	66	131	—	2,693	71	143	150	278	79	413	72	892	2,098	143	130	304	109	686	16,151
45	May 31 〃	7,513	1,327	1,961	3,288	712	1,080	232	367	75	101	—	2,567	83	116	154	225	68	334	86	718	1,784	180	135	319	173	807	15,959

* Cited from Sci. Rep. Whales Res. Inst., 4: 1–13, 1950.

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On the Sexual Maturity of the Antarctic Male Sperm Whale (*Physeter catodon* L.)

By

M. NISHIWAKI

(Read at the meeting of the Japanese society of scientific fisheries on Nov. 4, 1953)

Introduction

Since all the sperm whales that have every been caught in the Antarctic whaling ground were males, and many of them were large-sized, it has been generally believed that the sperm whales found in these waters are old lone bulls which were driven away from their harem. As shown in Figure 1, the modal length of the male sperm whales caught in these waters is 50 ft., and is much longer than that of the catch in the adjacent waters of Japan, 36 ft.

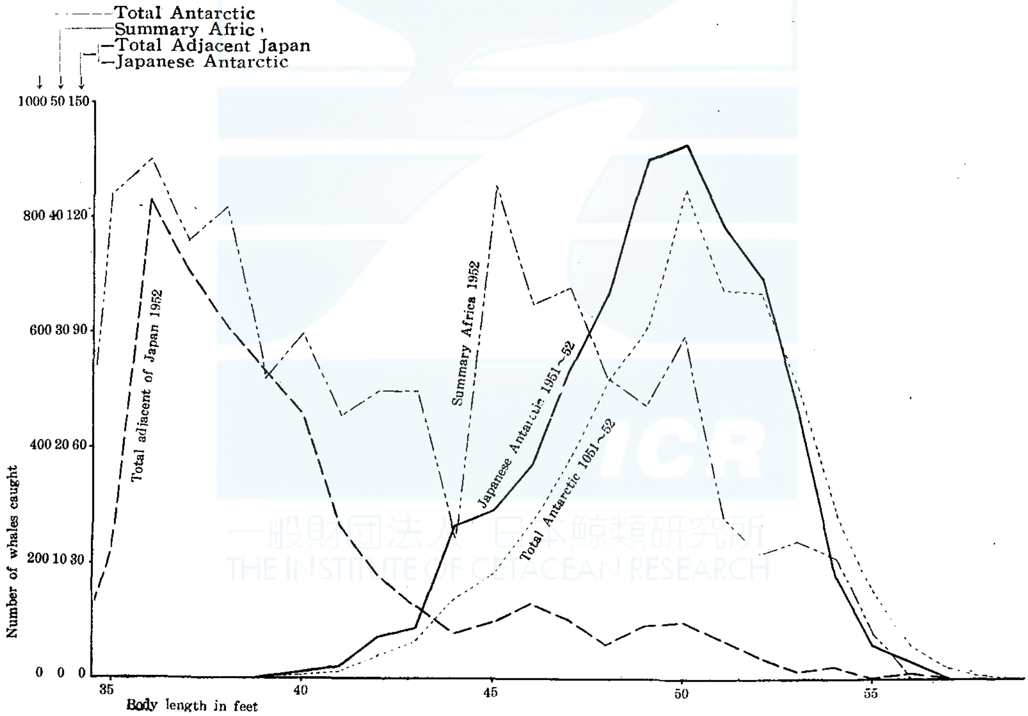

Fig. 1 The Size Distribution of the Male Sperm Whale

In comparison, two modes are recogenized, at 36 and 45 ft., in the length frequency curve for the male sperm whales caught in the African waters (Fig. 1). Probably, these two modes represent respectively the sexually immature and the sexually mature group within the single population of male sperm whales, from which the catch was drawn. Since these two modes coincide considerably with the aforementioned modes for the male sperm whale catches in the Antarctic and the Japanese waters, one may be inclined to postulate that male sperm whales in the latter two regions belong to a single population, the Antarctic catch representing the sexually mature group and the Japanese catch, the immature group.

Recent studies, however, have revealed that sexually mature male sperm whales are found in the adjacent waters of Japan, as well as sexually immature males. In addition, preliminary investigation indicated that some of the male sperm whales caught in the Antarctic whaling ground gave relatively small testis weight, and were probably sexually immature. For the purpose of ascertaining this point, the present study was undertaken, in which were studied 961 sperm whales—all were males—caught by the Tonan Maru Fleet of the Nippon Suisan Co., Ltd., the Nisshin Maru Fleet of the Taiyo Fishing Co., Ltd. and the Baikal Maru Fleet of the Kyokuyo Whaling Co., Ltd. in the Antarctic season 1951–52.

I would like to express my sincere thanks to the above mentioned three whaling companies and to the government inspectors and biologists named below, for their immense cooperation in collecting the material and data for this study.

Government Instructor: Mr. H. Sakiura, Mr. Y. Teraoka, Mr. Y. Nozawa, Mr. R. Ohyama and Mr. H. Kawamura.

Government Biologist: Mr. Z. Kakuwa, Mr. T. Kawakami and Mr. K. Iguchi.

My thanks are also due to Mrs. S. Nogami who rendered much assistance in the preparation of histological preparats.

Material and Method

The material for this study are the aforementioned 961 male sperm whales caught during the Antarctic season 1951–52. Histological examination was made on pairs of testes of those 164 males whose body lengths were under 40 ft. or whose smaller testis weighed less than 4.0 kg. From the depth of about 1 cm. of the middle part of such testes, a small sample piece (about 1 cm. cube) was cut out after the testes were weighed on board. These pieces were immediately fixed in the alcohol-formalin mixture (9 parts of 60% alcohol and 1 part of 10% formalin).

Fixed sample pieces were transported to the laboratory, where they were cut into sections in the paraffin method, double-stained with

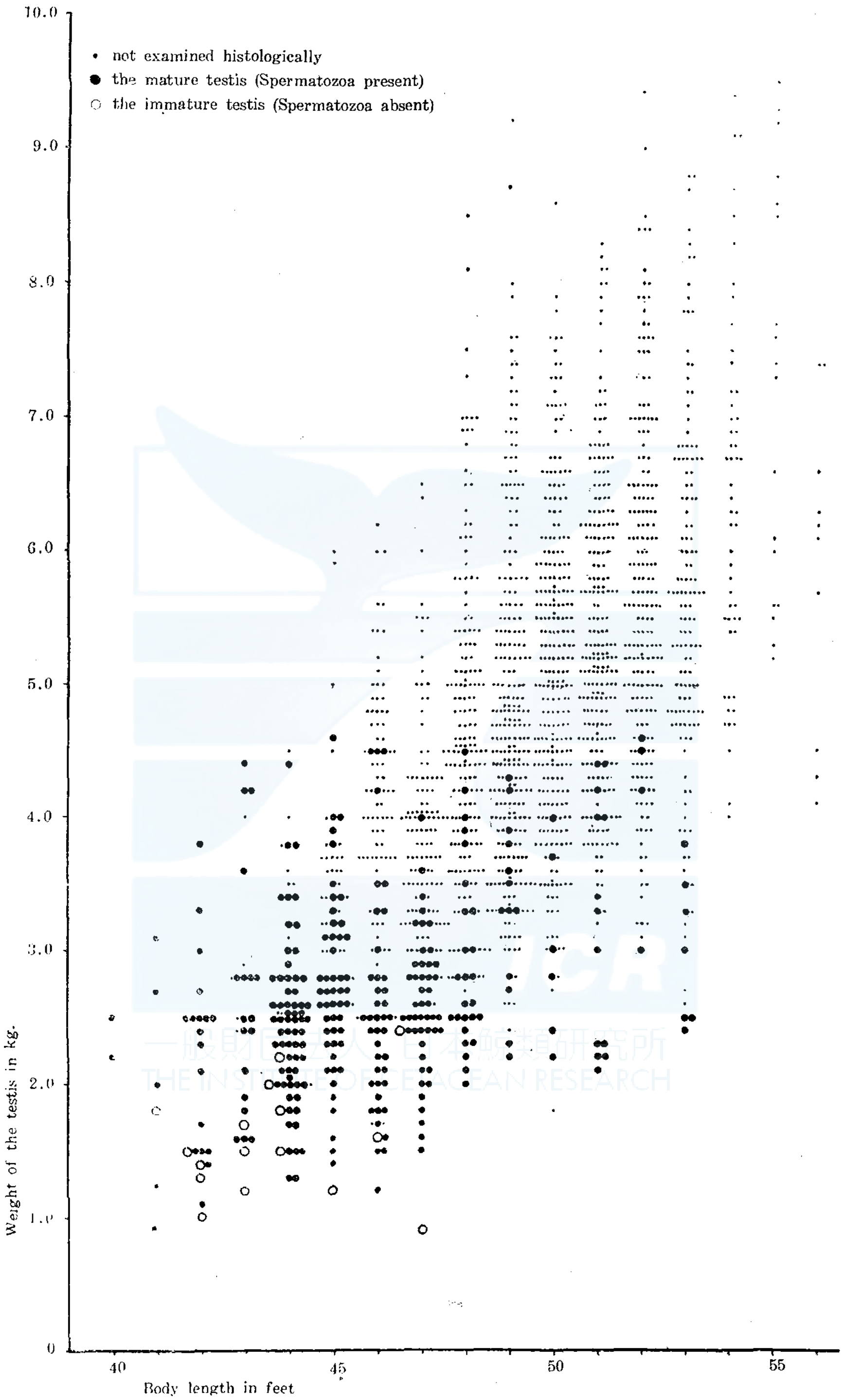

Fig. 2 The Weight of Examined Testes against the Body Length of Whales.

haematoxylin and eosin, and subjected to microscopic examination.

Careful observation was made to determine whether spermatozoa were present or not.

Table I. Number of the whales caught and those whose testes were examined histologically, by fleets.

Fleet	Whales caught (Number)	Whales whose testes were examined	
		(Number)	(Percentage)
Tonan-maru	362	37	
Nisshin-maru	377	73	
Baikal-maru	222	54	
Total	961	164	17.1%

Testis Weight at Spermatozoa Formation

Based on the result of the microscopic examination, those testes in which spermatozoa were found are classified as mature and those in which no spermatozoa were detected are classified as immature, irrespective of the presence of well developed spermatocytes.

In Figure 2 is plotted the weight of histologically examined testes against the length of whales, and discrimination is made between mature and immature testes.

In Figure 3 is shown the percentage that mature testes occurred for each 0.1 kg. testis-weight class. The graph indicates that 75% of the testes were mature at the weight of 1.5 kg. I regard this figure as the average testis weight of the male sperm whale of the Antarctic waters at the attainment of sexual maturity.

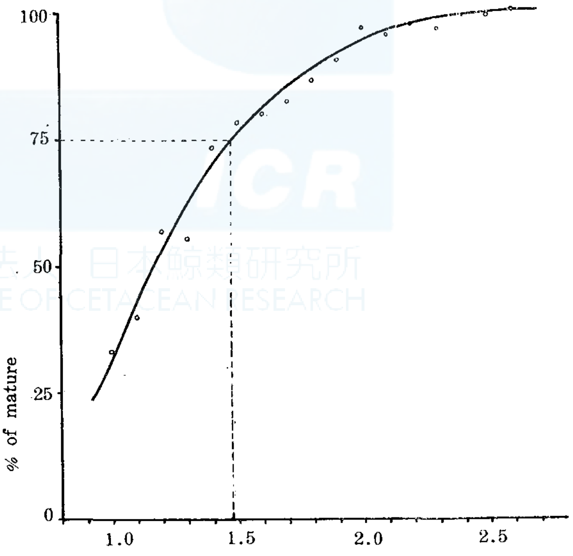

Fig. 3 The Percentage of Mature Testes occurred for each 0.1 kg. Testis-weight Class.

Comparison of the Weights of the Right and the Left Testis

In the whalebone whale species, such tendency is not known that the testis on a definite side of the body is heavier than that on the other side; in other words, the right testis is heavier in as many individuals as the left testis. Accordingly, the testes weight—right and left testis combined at the attainment of sexual maturity is reasonably estimated in these whales as twice of the testis weight at spermatozoa formation, which is determined by the method indicated in Figure 3. From the testes weight at sexual maturity thus estimated and the length-testes weight relationship, the length at sexual maturity can be determined.

In the sperm whale, however, the left testis is heavier than the right one in the majority of the cases, as indicated in Table 2. This tendency, probably related with the bilateral asymmetry which is seen in the blow hole and other organs of this species, preclude us from accepting twice of the testis weight at spermatozoa formation (1.5 kg.) as the testes weight at sexual maturity.

Table 2. Number of the male sperm whale caught in the Antarctic season 1951-52 as classified according to the relative weight of the right and left testis.

Name of fleet	Left testis heavier	Both testes equal in weight	Right testis heavier	Uuknown because single lost	Total
Tonan-maru	212	27	122	1	362
Nissin-maru	220	55	100	2	377
Baikal-maru	110	21	64	27	222
Total	542 56.4%	103 10.7%	286 29.8%	30 3.1%	961 100%

Body Length at Sexual Maturity

For the reason mentioned in the preceding section, the length of the sperm whale at sexual maturity was estimated in the following way.

Based on the abovementioned result, testes weighing 1.5 kg. or more are considered as mature, and the percentage of the testes weighing 1.5 kg. or more is calculated for each length class of the whale. The result is represented by the broken curve in Figure 4.

As another approach, the percentage of the testes containing spermatozoa is calculated similarly, and the result is shown in Figure 4 as the solid curve.

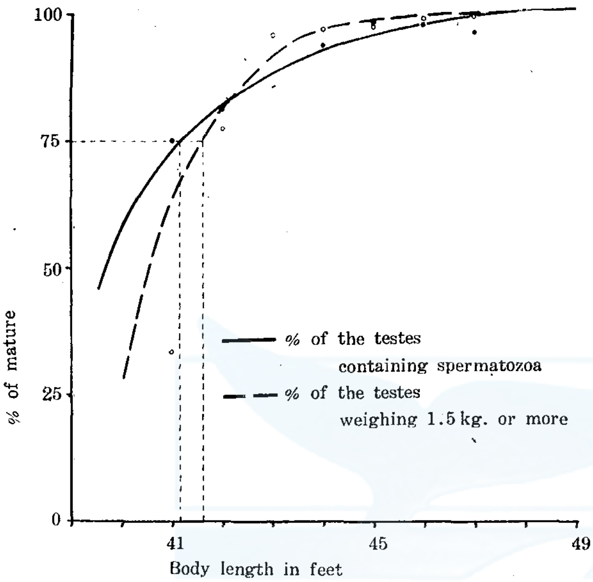

Fig. 4 The Body Length of the Antarctic Male Sperm Whale at Sexual Maturity.

In either curve of Figure 4, the body length at which 75% of the testes are mature is 41–42 ft.

Conclusion

From the foregoing evidences and discussions, it is estimated that, in the male sperm whale of the Antarctic waters, the testis matures, (i.e. spermatozoa are formed) at the average weight of 1.5 kg., and the body length at sexual maturity is 41 ft.

The abovementioned body length is greater than the body length at which the male sperm whale of the adjacent waters of Japan attain sexual maturity, which is certainly below 38 ft. and probably between 35 and 37 ft. It may be then that the body length of the male sperm whale at sexual maturity differs in the northern and the southern hemishpere, as is the case in whalebone whales.

Calculation based on the foregoing results indicates that 0.5% of the male sperm whales caught in the Antarctic waters in the 1951–52 season were sexually immature.

References

Y. Matsuura: On the Sperm Whale found in the Adjacent Waters of Japan (in Japanese with English Summary): Bulletin of the Japanese Society of Scientific Fisheries, Vol. 4, No. 2. (1935).

L.H. Mattews: The Sperm Whale, Physeter catodon: Discovery Reports, Vol. XVII. (1938).

Y. Matuura & K. Maeda: Biological Investigation on the Whales found in the Northern Pacific Ocean. (in Japanese); Hogei Shiryo (Whaling Materials), Vol. 9, No. 1. Nihon Hogeigyo Suisan Kumiai (Japan Whale Fisheries Association), Tokyo, Japan. (1942).

H. Omura: Whales in the Adjacent Waters of Japan: The Scientific Reports of the Whales Research Institute, No. 4, (1950).

M. Nishiwaki & T. Hibiya: On the Sexual Maturity of the Sperm Whale (Physeter catodon) found in the Adjacent Waters of Japan (I): The Scientific Reports of the Whales Research Institute, No. 6. (1951)

M. Nishiwaki & T. Hibiya: On the Sexual Maturity of the Sperm Whale (Physeter catodon) found in the Adjacent Waters of Japan (II): The Scientific Reports of the Whales Research Institute, No. 7. (1952)

G.C. Pike: Whaling on the Coast British Columbia: The Norwegian Whaling Gazette, No. 3, 1954. (1954)


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Composition of Fin Whale Milk

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Introduction

In studying the relation between the rate of growth and the composition of the milk during the nursing stage of various mammals, as shown in Table I, the greater the rate of growth is, the greater is the amount of substances necessary for the organization of the body, as protein, minerals, etc., contained in the milk of the animal.[1]

Table I. Rate of Growth and Composition of Milk of Various Mammals

	Days required for the body weight at birth to double	Protein %	Minerals %
Human	120	1.30	0.30
Horse	60	2.14	0.35
Cow	47	3.50	0.75
Goat	22	3.76	0.85
Sheep	15	5.15	0.93
Hog	14	6.20	1.07
Cat	9½	9.08	0.51
Dog	9	9.72	0.91

From Pfaundler and Schlossmann's Handbuch der Kinderheilkunde

Of the mammals the animal with the largest body is the Cetacea. According to Peters[2] the length of the fin whale at birth averages 6 meters, and 6 months later (at the end of the nursing stage) it becomes 12 meters, at 1 year 15 meters, at 2 years 19 meters and at 6–8 years 21 meters. According to Nishiwaki[3] the male reaches the sexual maturity in 3.5 years, the female in 4 years, and it is said that it lives 25–30 years. In other words, throughout the course of life the rate of growth during the nursing stage is the greatest. In this sense the analysis of the whale milk is an interesting subject but reports on this are very few.

A report will be made in this paper on the results obtained by analyzing the milk from 3 fin whales by comparing it with the human and cow milk.

Materials

The whale milk the authors used in this study was that obtained from 3 fin whales which will be tentatively called fin whale milk A, B and C, respectively.

The fin whale milk A and B was obtained from the 2 fin whales captured by the Tonnan-maru group of ships belonging to the Nihon Suisan Kabushiki Kaisha (Japan Fisheries Co., Ltd.) in the Antarctic Ocean (near the Ross Bay), and the fin whale milk C from the fin whale captured by the Baikaru-maru group of ships organized jointly by the 3 companies, Kyokuyo Hogei (Polar whaling co.), Nihon Suisan (Japan Fisheries co.) and Taiyo Gyogyō Co., in the Arctic Ocean (south of the Aleutian Islands), the milk being obtained at the time the whales were slaughtered after being captured, preserved in an electric refrigerator and sent to the authors through the courtesy of Dr. M. Nishiwaki of the whale Research Institute in Tokyo. The authors express their thanks to those cooperating in the collection and transportation of the fin whale milk.

The general characteristics of the fin whale A, B and C are shown in Table II.

Whale milk A was a part of about 2 liters of milk flowing out from the mammary gland of a 71-foot fin whale during dissection, and from the state of the mammary gland, uterus and corpus luteum. this fin whale was considered to be in the last half of the nursing stage. This milk was collected on Feb. 8, 1952, and 136 grams of it were sent to the authors on March 4, 1953. Whale milk B was a part of about 0.5 litter of milk flowing out from the mammary gland of a 72-foot fin whale during dissection and was considered to be in the weaning stage. This milk was collected on March 12, 1953, and 128 grams of it were sent to the authors on May 14, 1953. Whale milk C was a part of about 2 liters flowing out from the mammary gland of a 65-foot fin whale and was considered to be in the last half of the nursing stage. This milk was collected on August 29, 1953, and 130 grams of it were sent to the authors on Oct. 24, 1953.

Results

Color and external appearance: Fin whale milk A was of a cream color with a brownish yellow tone, fin whale milk B a cream color with a light red tone and fin whale milk C a milk white color, all being of the so-called cream color. According to Dr. Nishiwaki the color of the fin whale milk A and B was said to be darker than that

Table II. General Characteristics of Whales Captured in the Antarctic and Arctic Oceans (Courtesy of Dr. Nishiwaki)

	A	B	C
Name of Whaling ship group	Tonan-maru (Antarctic Ocean)	Tonan-maru (Antarctic Ocean)	Baikaru-maru (Arctic Ocean)
Date of slaughter (Capture)	05 ; 55, Feb. 8, 1952	18 ; 30, March 12, 1953	05 ; 45, Aug. 29, 1953
Date of beginning of treatment	19 ; 15, Feb. 8, 1952	20 ; 40, March 12, 1953	—
Place of slaughter (Capture)	S. lat. 69°23′ ; W. long. 166°47′	S. lat. 69°48′ ; W. long. 163°12′	N. lat. 50°27′ E. long. 162°23′
Kind of Whale	Fin	Fin	Fin
Sex	Female	Female	Female
Length	71 feet	72 feet	65 feet
Thickness of subcutaneus fat	6.0 cm.	6.0 cm.	6.0 cm.
Gastric content	(—)	(—)	—
Embryo	(—)	(—)	(—)
Amount of milk	About 2 lit.	About 0.5 lit.	About 2 lit.
Thickness of mammary gland	22.5 cm.	11.0 cm.	19.0 cm.
Color of mammary gland	White	—	Brownish yellow
Maximum width of uterus cornu	Left 14 cm Right 16 cm	Right and left almost the same	Left 20 cm Right 20 cm
Color of uterus	Grayish yellow	—	Brownish red
Weight of ovary	—	—	Left 1.2 kg. Right 1.0 kg.
Number of corpora lutea	Old: right 7 left 5 New (—)	Old: right 7 left 9 New (—)	Old: right 3 left 4 New (—)
Maximum diameter of corpus luteum	Left 5.5 cm. Right 4.0 cm.	Right 4.5×3.5×4.0 cm.	6.0 cm.
Stage of secretion	Latter half stage	Latter half stage (Weaning state)	Beginning of latter half of lactation stage
Date whale milk was received	March 4, 1953	May 14, 1953	Oct. 24, 1953

of the fresh milk. The external appearance of all 3 showed a very thick creamy state. (Table III)

Table III.

Color Tone

Whale milk A	Whale milk B	Whale milk C	Human milk	Cow milk
Cream color (Light brownish yellowish white color)	Cream color with light red tone	Cream color (Milk white color)	Milk white color with bluish tone	Milk white color with yellowish tone

Taste and flavor

Whale milk A	Whale milk B	Whale milk C	Human milk	Cow milk
Flavor resembles cod liver oil Taste astringent	Same as whale milk A	Somewhat fishy smell Astringent taste light	Fishy smell A little sweet	Aromatic Very slightly sweet

Taste and flavor: Both fin whale milk A ane B had a flavor resembling a cod liver oil and the taste was somewhat astringent but the fin whale milk C had a somewhat fishy smell and compared to the former 2 the astringent taste was light. According to Dr. Nishiwaki the taste and flavor of the fin whale milk C were said to be close to those of the fresh milk but those of the fin whale milk A and B were stronger than those of the fresh milk. (Table III)

Specific gravity: (18°C)

Measuring method[4)]—The specific gravity of the whale milk was determined by the copper sulfate method. In case the specific gravity was lighter than that of water, a drop of the milk was dropped into a measuring cylinder with a certain amount of water, and then alcohol was added little by little, determining the proportion of water to alcohol where this drop of milk neither sank nor rose. The specific gravity of this mixture of water and alcohol was measured and the value obtained was taken as the specific gravity of the whale milk. The specific gravity of the human and cow milk was determined by a hydrometer.

The specific gravity of the whale milk A was 1.012, whale milk B 0.994 and whale milk C 1.003, all being lighter than the specific gravity 1.032 of the human and cow milk (Table IV). This was probably due to the large amount of fat contained in the whale milk.

Surface tension: (20°C)

Measuring method[5)]—From the principle that the ratio of the surface tension between the two kinds of solutions is equal to the ratio between the specific gravity and the number of drops, the number of drops of equal amounts of the whale milk and water was measured by using Traubes stalagmometer, and the surface tension of the whale milk was calculated with the surface tension of water (against air 72.8 dynes/cm) as the basis. As the whale milk was viscid and the surface tension could not be measured in this state, the whale milk was diluted 4-fold with distilled water and the surface tension was measured for general information. The surface tension of the whale milk A was 38.4 dynes/cm and whale milk B 39.8 dynes/cm, being far greater than that of the undiluted human and cow milk (Table IV). By the same method the surface tension of the whale milk C was measured but it could not be measured successively because the liberation of fat was rapid.

Table IV.

Specific gravity (18°C)

Whale milk A	Whale milk B	Whale milk C	Human milk	Cow milk
1.012	0.994	1.003	1.032	1.032

Surface tension (dyne/cm) (20°C)

Whale milk A	Whale milk B	Whale milk C	Human milk	Cow milk
As it was not measurable in the original state, the value is that diluted 4-fold with distilled water				
38.4	39.8	-----	44.4	51.2

Viscosity: (20°C)

Measuring method[6]—The viscosity was measured by Hess' viscosimeter. As the viscosity of the whale milk was high and impossible to measure, the value was that of the whale milk diluted 4-fold with distilled water.

The value of the whale milk A was 2–6 centipoises, the whole milk B 6.4 centipoises and the whale milk C 1.2 centipoises. The viscosity of the whale milk A and B was far higher and that of the whale milk C was lower than that of the undiluted human and cow milk but it still showed that the viscosity of the whale milk A, B and C was quite high (Table V).

Boiling point:

Measuring method[7]—The boiling point was measured roughly with a 200°C thermometer and accurately with Beckmann's apparatus. The boiling point of the whale milk A was 98.5°C and the whale milk B and C 98.2°C, being lower than that of the human and cow milk (Table V).

Table V.

Viscosity (centipoise) (20°C)

Whale milk A	Whale milk B	Whale milk C	Human milk	Cow milk
As it was not measurable in the original state, the value is that diluted 4-fold with distilled water				
2.6	6.4	1.2	2.1	2.3

Boiling point (°C)

Whale milk A	Whale milk B	Whale milk C	Human milk	Cow milk
98.5	98.2	98.2	101.2	100.4

PH and acidity:

Measuring method—The PH was determined with the PH test paper manufactured by the Toyo Filter Paper Company, Ltd., and the acidity was measured by applying Soxhlet-Henkel's method[8]: One to 2 drops of the alcohol solution, to which the indicator, phenolphthalein, was added at the rate of 2%, were added to 10 cc of the whale milk and measured with 1/4N NaOH.

The PH of the whale milk A, B and C was 4.6, 6.2 and 6.4, respectively, all being lower than that of the human and cow milk. Especially the whale milk A and B showed a fairly high acidity, the acidity of the whale milk A being high with a value of 46.7 and that of the whale milk C being comparatively low with a value of 21 (Table VI). The reason for this was considered to be due probably to the whale milk A and B acidifying during the long period from the time of the collection of the milk to the time of analysis. As will be stated later, this fact was confirmed by the comparison of the amount of lactose contained in the 3 whale milk.

Table VI.

PH (Tōyō filter paper)

Whale milk A	Whale milk B	Whale milk C	Human milk	Cow milk
4.6	6.2	6.4	7.0	6.8

Acidity (Soxhlet-Henkel's method)

Whale milk A	Whale milk B	Whale milk C	Human milk	Cow milk
46.7	——	21.0	5.0	7.1

Water content:

Measuring method[9)10)]—The whale milk was mixed with refined white sand and dried by air bath of 98–100°C. The amount of the decrease in weight was made to represent the water content, which was expressed in %.

The water content was much less than that of the human and cow milk (Table VII) and the solid substances were about 4 times those of the human and cow milk, this naturally accounting for the creamy state of the whale milk.

Table VII.
Chemical composition (%)

	Water	Protein	Fat	Lactose	Minerals
Whale milk A	53.4	13.3	33.0	0.3	1.0
Whale milk B	55.0	12.3	31.8	0.2	0.7
Whale milk C	54.1	10.5	32.5	1.4	1.4
Human milk	87.5	1.7	3.5	7.1	0.2
Cow milk	88.1	3.4	3.1	4.7	0.7

Protein:

Measuring method[11)]—Five grams of the whale milk were quantitatively measured for the total nitrogen by Kjeldahl's method, and the figure obtained by multiplying the amount of the total nitrogen by 6.38 was made to represent the amount of protein. Casein nitrogen was determined by adding 70–80 cc of water to 10 gm. of the whale milk, heating to 40–42°C., adjusting the PH to 4.5 with 1.0 cc of 10% acetic acid solution and 1.0 cc of 1 N sodium acetate solution, cooling, precipitating the casein, drying and filtrating this solution with the No. 6 Tōyō filter paper and measuring the nitrogen in the precipitate together with the filter paper by Kjeldahl's method. Noncasein nitrogen was determined by quantitatively measuring the nitrogen in 20 cc of the filtrate.

The soluble protein fractions of the whey were studied by dialyzing the filtrate of 40 cc (10gm.) of the whale milk, from which casein was removed by the same method stated above (human and cow milk was diluted to about 1:10 and the whale milk to about 1:40), in an ice room with a cellophane paper in a 50% gum arabic solution, concentrating the entire content to about 1/20 till the protein content became about 2–4% and then studying the protein fraction electrophoretically with Tiselius' apparatus.

The amount of protein was very great, being 6–8 times that of the human milk and 3–4 times that of the cow milk (Table VII).

There was less of the casein nitrogen than the noncasein nitrogen, being similar to the amount in the human milk (Table VIII). In studying the protein fractions, electrophoretically, of the whey of the whale milk C after removing the casein, as shown in Fig. I, the results of the analysis showed that the A/G ratio was 1.6, average albumin 61.8% and globulin 38.2%, the albumin, contrary to the human milk, being greater and that the globulin fractions were: α-globulin 2.5%, β-globulin 10.1% and γ-globulin 30.4%, γ-globulin being the greatest.

Table VIII.
Kinds of Proteins (mg%)

	Total N	Casein N	Noncasein N	N.P.N.
Whale milk A	2082	849 (41%)	1233 (59%)	—
Whale milk B	1921	660 (34%)	1266 (66%)	56.0
Whale milk C	1650	770 (46%)	880 (54%)	———
Human milk	266	118 (44%)	148 (56%)	26.3
Cow milk	537	416 (78%)	121 (22%)	71.7

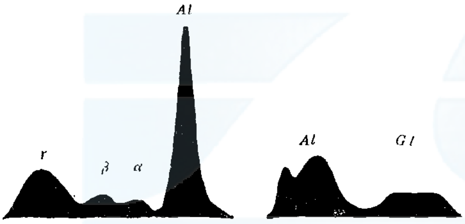


Fig. I.

Next, in order to examine the amino acid in the hydrolyzed substance of the whale milk, an equal amount of 10% hydrochloric acid or 5 N sodium hydroxide was added to the whale milk, decomposed by boiling for 24 hours at 100°C, dried by evaporation, dissolved in distilled water and a certain amount examined by paper chromatography. For filter paper the No. 2 Toyo filter paper was used. For solvent N-butyl alcohol saturated with water, S-collidin saturated with water and phenol liquified with 0.1% ammonia water were used. For color reaction 0.25% ninhydrin-butyl alcohol solution saturated with water was used[12][13].

As in the human and cow milk, in both the whale milk A and B glycine, alanine, valine, leucine, isoleucine, proline, phenylalanine, lysine, arginine, histidine, tryptophan, asparaginic acid, glutamic acid, serine, threonine, tyrosine, cystine and methionine were found.

Fat:

Measuring method—The fat content was measured by Gerber's method.

The size of the fat globule was measured by measuring the diameter of the fat globule with a microscope attached with an ocular net and expressed in per cent. The method of measuring the milk fat is as stated below.

Saponification value (Köttstorfer's method)[14]—Fifty cc of 0.5 N alcoholic KOH were added to 4–5 gm. of the whale milk, heated until Saponification was completed by attaching a refluent refrigerator and titrated with 0.5 N HCl, with phenolphthalein as the indicator.

Acid value[15]—Fifty cc of 95% neutral alcohol were added to 10 gm. of the whale milk, heated to 60–65°C and dissolved, and titrated with 0.1 N potassium hydroxide, with phenolphthalein as the indicator.

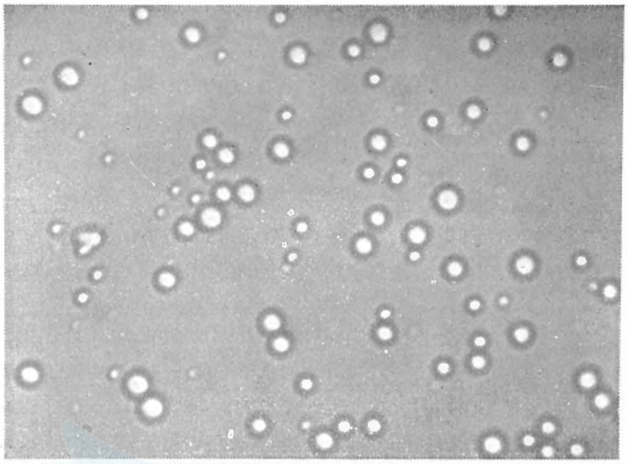
Iodine value (Heubner's method)[16]—Chloroform and iodine solutions were added to 0.5 gm. of the whale milk and titrated after being left standing for 6 hours with sodium thiosulfate, the corresponding iodine value of which had been tested beforehand, with starch solution as the indicator.

The fat content was very large, being about 10 times that in the human and cow milk (Table VII). There was more of the fat globules of far larger size than in the human and cow milk (Table IX, Fig. II).

Table IX.
Size of fat globules (%)

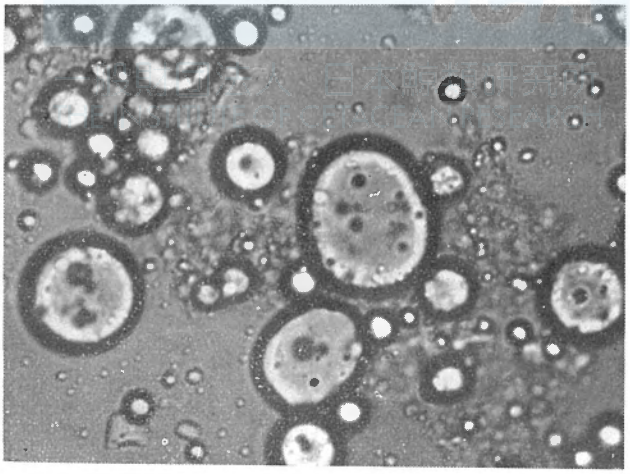
	Less than 1.48μ	1.49–2.85μ	2.86–5.70μ	5.71–7.18μ	7.19–11.40μ	Greater than 11.41μ
Whale milk A	27	41	22	2	6	2
Whale milk B	28	26	34	6	4	2
Whale milk C	20	38	34	5	2	1
Human milk	35	44	21	0	0	0
Cow fresh	24	56	16	2	2	0
Cow homogenized	73	27	0	0	0	0

Fig. II. is a picture of the whale milk B. Besides the fatglobules numerous cells are seen in the picture. According to the authors' study on the human milk large fat globules and various kinds of cells appear in the milk during the weaning stage. The whale milk B was presumed to be the milk of the weaning stage from the state of the mammary gland, corpus luteum, etc. of the whale and this microscopic finding confirmed this fact. Three kinds of characteristic values of the milk fat were measured but the saponification, acid and iodine values were all much higher than those of the human and cow milk (Table X), and in comparing the 3 whale milk they all showed generally similar values with the exception ot the acid value of the whale milk A and B, which was conspicuous in being especially higher than that of the whale milk C.



Cow milk

Human milk



Fin whale milk

Table X.
Characteristic values of Milk fat

	Acid value	Saponification value	Iodine value
Whale milk A	3.7	329.0	188.5
Whale milk B	2.7	298.9	80.0
Whale milk C	0.9	389.0	101.0
Human milk	0.1	196.0	55.0
Cow milk	0.2	236.0	26.0

In comparing these characteristic values with the results obtained by Pedersen17)18), on the milk fat of the sperm whale and humpback whale and those by Alent19) on the milk fat of the white fin whale, both the saponification and iodine values were very much alike but acid value of the whale milk A and B was 6–10 times higher than that of the milk of the whales stated above, only the acid value of the whale milk C showing a slightly higher value. The reason for this was probably due to the fact that the elapse of time between the collection and analysis of the whale milk A and B was long and therefore the fat decomposing and the isolated fatty acid increasing during preservation.

Lactose:

Measuring method20)—About 80 cc of water were added to 5 gm. of the whale milk and to this mixture 1.5 cc of Fehling's copper sulfate solution were added, heated and adjusted to neutral or to a very slight acid with N/4 alkali, after the crystallized sediment had settled, the supernatant fluid was filtered into a 100 cc measuring bottle and 100 cc of water added to this filtrate; 40 cc of the 200 cc were added to 20 cc of boiling Fehling's solution and boiled further for exactly 6 minutes; the crystallized cuprous oxide was collected being carefull not to come in contact with air as much as possible, dissolved in 40 cc of ferric sulfate solution and this solution was colored to a faint red with a potassium permanganate solution; the amount of copper was calculated from the amount of $KMnO_4$ consumed, and the amount of the lactose was calculated from the lactose quantitative determination table.

The amount of lactose was very small, being roughly about 1/20–1/30 of that in the human milk and 1/15–1/25 of the cow milk in the case of the whale milk A and B and about 1/5 of the human milk and about 1/3 of the cow milk in the case of the whale milk C. However, that the amount of lactose in both the whale milk A and B was very small is not the essential property but it is considered that a part of the lactose decomposed during the long period of the preservation of the whale milk, as stated above in regard to the PH and acidity.

Minerals:

Measuring method[21)22)]—The whale milk was evaporated and dried by air bath, heated for 3 hours in the electric muffle furnace keeping the temperature from rising above 550°C, the ash measured and the value expressed in per cent.

Ca.[23)24)]—Of the minerals the amount of calcium was calculated as follows: The carbon, silicic acid and the sand thought to be contained in a minute amount were removed from the ash obtained by the above process, ammonia water and ammonium oxalate added to the filtrate, calcium precipitated as calcium oxalate, filtered, heated for one hour in the electric muffle furnace at 1100°C, the calcium oxalate changed to calcium carbonate and further to calcium oxide and measured.

P[25)].—Of the minerals the phosphorus was measured as phosphoric acid as follows: A mixed solution of hydrochloric acid, ammonium acetate and magnesia was added to the filtrate stated above from which the calcium was removed, ammonia water was added and ammonium magnesium phosphate was precipitated, the precipitate was heated for 1 hour in the electric muffle furnace at 1100°C, the magnesium pyrophosphate was measured and 0.6376 times the value obtained was the amount of the phosphoric acid.

Mg.[26)]—After evaporating and concentrating by the use of the sand bath the filtrate in which the calcium was separated as calcium oxalate, the concentrated substance was transfered on to a porcelain evaporating dish and after evaporating and drying over a water bath it was heated over a Bunsen burner driving out the ammonium salts, oxalic acid, etc.; next, after cooling the residue 6 N HCl was added and the residue moistened; after adding a small amount of boiling water and dissolving the magnesium salt by heating for a while over a water bath it was filtered; then to the filtrate were added ammonium acetate and an excess of ammonium acetate and an excess of ammonium phosphate solution, and the indicator phenolphthalein was added and $MgNH_4PO_4 \cdot 6H_2O$ was precipitated, heated and measured as $Mg_2P_2O_7$; by multiplying this value by 0.3624 the weight of MgO was obtained.

The amount of the minerals was less than what the authors had imagined, being approximately of the same degree as in the cow milk. However, in the whale milk C it was about 2 times that in the cow milk. The amount of Ca and P was near to that of the cow milk in the case of the whale milk A; with the whale milk B it was slighter more than in the human milk; in the whale milk C the amount of Ca and P was large, being about several times that in the human and cow milk; magnesium was also present at the rate of 0.232% (Table XI).

Table XI.
Minerals (%)

	Total	Calcium (CaO)	Phosphorus (P_2O_5)	Magnesium (MgO)
Whale milk A	1.03	0.190	0.125	——
Whale milk B	0.74	0.066	0.040	——
Whale milk C	1.37	0.323	0.409	0.232
Human milk	0.20	0.054	0.038	——
Cow milk	0.74	0.165	0.194	——

Vitamins:

Measuring Method Vitamin A and total carotenoids—First, when the whale milk was examined by Fujita-Aoyama's[27) method for the presence of peroxides, the peroxide number was 0 for 1 gm. of the whale milk.

Next, for the purpose of quantitatively measuring the total carotenoids in the whale milk, 1 gm. of the whale milk was collected and to it 5 cc of 20% alcoholic potassium hydroxide were added, and after saponifying for 10 minutes at 60°C the contents were shaken vigorously three times, each time with 2 cc of petroleum-ether and for 10 minutes at a time, extracting the total carotenoids; for the sake of convenience it was measured with the standard solution of β-carotene and the photoelectric colorimeter, and the value obtained was taken as the value of the total carotenoids.

In regard to vitamin A, after saponifying 1 gm. of the whale milk in the same way as above it was shaken vigorously three times, each time with 2 cc of petroleum benzene and for 10 minutes each time, extracting the vitamin A; the layer of the petroleum benzene was collected and after washing three times with water it was measured on a weakly activated Al_2O_3 chromatograph (length of the column 2.5 cm; the content 0.7 cm) according to Fujita-Aoyama's method of determination of the genuine value of vitamin A, the vitamin A was extracted twice with 2 cc of benzene, each time, the benzene was evaporated and the residue was dissolved in chloroform, Carr-Price's reaction was brought about inside the photoelectric colorimeter apparatus and quantitatively measured colorimeterically. With the human and cow milk 5 cc of the material were taken and measured in the same way.

Thiamine—To 1 gm. of the whale milk distilled water was added to bring the entire content to 50 cc, shaken vigorously for 15 minutes and suspended; 10 cc of this content were taken as the material. In the case of human and cow milk 100 cc of each were used for the study. For the removal of protein 10% meta phosphoric acid solution was used, and the measuring method was the thiochrome flourescent method[29][30][31] with permutit.

Riboflavin—Distilled water was added to 1 gm. of the whale milk to bring the content to 50 cc, shaken vigorously for 15 minutes, heated in water bath for 5 minutes at 80°C and suspended, shaken vigorously further for 15 minutes and 10 cc of it were taken as the material. In the case of human and cow milk 10 cc of each were taken as the material. For suspension the milk was heated in the same way in water bath for 5 minutes at 80°C and suspended. For the removal of protein 10% glacial acetic acid solution was used. The measuring method was the lumiflavin flourescence method[32][33].

Ascorbic acid—The quantitative determination method (Teruuchi's modification) of vitamin C in the blood with 2, 4-dinitro-phenylhydrazine was applied. Eight cc of distilled water were added to 1 gm. of the whale milk (1 cc in the case of human and cow milk), mixed thoroughly and to this 0.2% 2, 6-dichlorophenylindophenol was added and the reduction type of ascorbic acid was changed completely to the oxidation type; then 24% tin chloride was added and the surplus dye was removed and then the protein was removed with 24% sulfosalicylic acid solution. The bis-2, 4-dinitrophenylhydrazone produced by the action of 2% dinitrophenylhydrazine on the centrifuged supernatant was dissolved in concentrated sulfuric acid and the orange-red color appearing at this time was quantitatively determined by a photoelectric colorimeter.

In the case of the whale milk A the easily destroyable vitamin A and ascorbic acid were not found at all but the total carotenoids, thiamine and riboflavin were found to the same extent, or to a greater extent, as in the human and cow milk. In the case of the whale milk C thought to be preserved better than the whale milk A, vitamin A, total carotenoids, thiamine, riboflavin and ascorbic acid were all found to a considerable amonnt, especially vitamin A, thiamine and riboflavin showing values considerably higher than in the human and cow milk (Table XIII).

Table XIII.
Vitamins

	Vitamin A	Total carotenoids (including carotene)	Thiamine	Riboflavin	Ascorbic acid
Whale milk A	0	25 γ %	0.093 mg%	0.084 mg%	0
Whale milk C	650 I.U. %	11 γ %	0.110 mg%	0.220 mg%	0.73 mg%
Human milk	20–138 I.U. %	25–86 γ %	0.020 mg%	0.030 mg%	4.80 mg%
Cow milk	17– 60 I.U. %	9–20 γ %	0.040 mg%	0.150 mg%	1.00 mg%

Enzymes:

Measuring method—The method of measuring diastase was by Wohlgemuth's method36). To a row of test tubes were added the whale milk diluted serially, the content of each test tube being the same (1 cc); to this 0.1 cc of 1% starch solution was added, and after being left standing in an incubator for 24 hours at 38°C 1–2 drops of N/10 KJ solution are added and the number of the test tube showing a yellow color, or in other words whether the digestion was up to achrodextrin, was observed.

The determination of lipase was done by Kayajima's alkali titration method37). 1 gm. of the whale milk, 0.2 cc of tributyrin (substrate), 1 cc of 0.5% gelatin solution and 1.0 cc of N/15 phosphoric acid buffer solution (PH 7.0) were transferred in order into a 50 cc trianglular flask and after shaking vigorously for 2 minutes it was kept warm for 5 hours at 37°C; and then 25 cc of ethyl alcohol were added, shaken vigorously for 2 minutes and filtered; 20 cc of the filtrate were titrated for the amount of acid, decomposed from the tributyrin by the enzymatic action, with N/20 potassium hydroxide solution using a microbiuret and with phenolphthalein as the indicator. If this value was a cc and a′ cc the value of the control, the process of which was performed without adding tributyrin at first but adding it after keeping the filtrate warm for 5 hours the acidity titrated in the same way as stated above, the consumed amount of potassium hydroxide was expressed by a—a′.

The amount of diastase in the whale milk C was $D^{38^\circ C}_{24\,h} = 32$ and the amount of lipase was N/20 KOH titration ualue (37°C) 2.0, observing the presence of these enzymes.

Summary

Physicochemical studies were made on 3 kinds of whale milk collected from the fin whale of the Antarctic and Arctic Oceans and preserved in an electric refrigerator for 2–15 months, and the following results were obtained:

The external appearance was of a viscous creamy state, and the flavor was of the degree of having a slightly fishy smell in the case of a fresh milk but in the case of an old milk it had a cod liver oil-like flavor and the taste was somewhat astringent. The specific gravity and boiling point were both lower than those of the human and cow milk while the surface tension and viscosity were higher than those of the human and cow milk. Due to acidification the milk was acid and the acidity was high. The water content was lower than that of the human and cow milk. The solid substances were about 4 times those in the human and cow milk. Protein was about 8 times that of the human milk and about 4 times of the cow milk. The amount of casein nitrogen and noncasein nitrogen was similar to that in the human milk. The ratio of albumin and globulin in the whey protein studied electrophoretically was opposite to that in the human milk, albumin being greater, and of the globulin fractions there was more of the γ-globulin. Amino acid found also in 18 kinds of human and cow milk was found. Fat was 10 times that in the human and cow milk and there were more of the large fat globules. The saponification, acid and iodine values were far higher than those of the human and cow milk. Two kinds (A, B) of whale milk showed especially a high acid value but this is not the essential property, being due probably to the decomposition of a part of the fat. Lactose was smaller in amount than that in the human milk, or 1/5–1/15–1/30 of that in the human milk. This low lactose content is not the essential property, being considered as being due to the decomposition of a part of the lactose by fermentation because of the milk being old. The minerals were 1–2 times those of the cow milk. In regard to the vitamins, in the whale milk thought to be preserved comparatively well vitamin A, total carotenoids, thiamine, riboflavin and ascorbic acid were all found in considerably large amounts but in the old milk vitamin A and ascorbic acid were not found, the amount of other vitamins being also comparatively small. The presence of the enzymes, diastase and lipase, was demonstrated. Calories per 100 gm. were 330–350, being very much higher than the 65 calories for the human milk and the 60 calories for the cow milk.

References

1) Degkwitz, R.: Chemische Zusammensetzung der Milch, Aus Pfaundler und Schlossman: Handbuch der Kinderheilkunde, 4. Ed., 1:272, 1931.
2) Peters, N.: Die biologische Grundlagen des antarktischen Walfangs, Fett und Seifen, 45:19, 1938.
3) Nishiwaki, M.: On the Age-Determination of Mystacoceti, Chiefly Blue and Fin Whales, The Scientific Report of the Whale Research Institute, 6:87, 1952.
4) Nemoto, R.: Shishitsu (Lipids) (in Japanese) 1. Ed., p. 171, 1934.
5) Ueno, S. and Okamura, J.: Yushi Jikkenhō (Experimental Method on Oils and Fats) (in Japanese) 1. Ed., p. 98, 1935.
6) Fujii, Y.: Seikagaku Jikkonhō, Teiryōhen (Experimental Method in Biochemistry, Sect. On Quantitative Determination) (in Japanese), 4. Ed., p. 110, 1943.
7) Jujii, Y.: ibid., p. 112, 1943.
8) Saitō, M.: Chichi to Nyūseihin no Kagaku (Chemistry of Milk and Milk Preparations) (in Japanese), 6. Ed., p. 349, 1949.

9) Kōseishō-hen (Helfare Ministry): Eisei Kensa Shishin (Guides to Sanitary Examination) (in Japanese), 2. Ed., 3:155, 1950.

10) Tōkyō Daigaku Nōgakubu Nōgeikagaku Kyōshitsu (Department of Agricultural Chemistry, Faculty of Agriculture, Tōkyō University): Jikken Nōgeikagaku (Experimental Agricultural Chemistry) (in Japanese), 1. Ed., 2:599, 1952.

11) Tōkyō Daigaku Nōgakubu Nōgeikagaku Kyōshitsu (Department of Agricultural Chemistry, Faculty of Agriculture, Tōkyō University): ibid., 2:600, 1952.

12) Satake, K.: Paper Chromatography, Kagaku no Ryoiki (Domain of Japanese Chemistry) (in Japanese), 3:264, 1949.

13) Hōjō, S.: Igaku to Seibutsugaku (Medicine and Biology) (in Japanese), 17:85, 1950.

14) Ueno, S. and Nkamura, J.: Yushi Jikkenhō (Experimental Method on Oils and Fats) (in Japanese), 1. Ed., p. 111, 1935.

15) Tōkyō Daigaku Nōgakubu Nōgeikagaku Kyōshitsu (Department of Agricultural Chemistry, Faculty of Agriculture, Tōkyō University): Jikken Nōgeikagaku (Experimental Agricultural Chemistry) (in Japanese), 1. Ed., 2:436, 1952.

16) Saitō, M.: Chichi to Nyūseihin no Kagaku (Chemistry of Milk and Milk Preparations) (in Japanese), 6. Ed., p. 101, 1949.

17) Pedersen, T.: The Milk Fat of Sperm Whale, The Norwegian Whaling Gazette, 6:300, 1952.

18) Pedersen, T.: A Note of Humback Oil and on the Milk and Milk Fat from this Species, ibid., 7:375, 1952.

19) Zenkowich, B. A.: Milk of Large-sized Cetaceans, C. R. Acad. Sc. USSR, 20:203, 1938, cit. in 18) Pedersen.

20) Kōseishō-hen (Helfare Ministry): Eisei Kensa Shishin (Guides to Sanitary Examinations) (in Japanese), 2. Ed., 3:121, 1950.

21) Kōseishô-hen (Helfare Ministry): ibid., 3:168, 1950.

22) Tōkyō Daigaku Nōgakubu Nōgeikagaku Kyōshitsu (Department of Agricultural Chemistry, Faculty of Agriculture, Tōkyō University): Jikken Nōgeikagaku (Experimental Agricultural Chemistry) (in Japanese), 1. Ed., 2:602, 1952.

23) Tōkyō Daigaku Nōgakubu Nōgeikagaku Kyōshitsu (Department of Agricultural Chemistry, Faculty of Agriculture, Tōkyō University): ibid., 1:9, 1952.

24) Tōkyō Daigaku Nōgakubu Nōgeikagaku Kyōshitsu (Department of Agricultural Chemistry, Faculty of Agriculture, Tōkyō University): Nōgeikagaku Bunsekisho (Analysis of Agricultural Chemistry) (in Japanese) 2. Ed., 1:2, 1949.

25) Tōkyō Daigaku Nōgakubu Nōgeikagaku Kyōshitsu (Department of Agricultural Chemistry, Faculty of Agriculture, Tōkyō University): Jikken Nōgeikagaku (Experslmental Agricultural Chemistry) (in Japanese), 1. Ed., 1:19, 1952.

26) Tōkyō Daigaku Nōgakubu Nōgeikagaku Kyōshitsu (Department of Agricultural Chemistry, Faculty of Agriculture, Tōkyō University): ibid., 1:31, 1952.

27) Fujita, A. and Aoyama, M.: Vitamin (in Japanese), 6:139, 1953.

28) Fujita, A. and Aoyama, M.: ibid., 3:189, 1950.

29) Hennessy, D. J. and Cerecedo: J. Am. Chem. Soc., 61:179, 1939.

30) Hennessy, D. J.: Ind. Eng. Chem. Anal. Ed., 13:216, 1941.

31) Fujiwara, G. and Kitamura, S.: Cation Kokan wo riyo suru Vitamin-gun no Teiroynho (Quantitative Determination of Vitamin Group Utilizing the Exchange of Cation) (in Japanese), 1. Ed., p. 44, 1949.

32) Fujita, A.: Vitamin (in Japanese), 3:254, 1950.

33) Yagi, K.: Flavin (in Japanese), 1. Ed., p. 65, 1951.

34) Roe, J. H.: J. Biol. Chem., 147:399, 1943.

35) Fujita, A. and Teruuchi, A.: Vitamin (in Japanese), 4:53, 1951.

36) Wohlgemuth, J.: Bioch. Zschr., 9:10, 1908.

37) Kayajima, S.: Igaku Kenkyū (Medical Research) (in Japanese), 13:96, 1939.

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