

On the Presence and Disappearance of the Hind Limb in the Cetacean Embryos

By

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I. A Historical Sketch

G. Guldberg of Norway reported for the first time the unquestionable existence of the hind limb protrusion in the fetal Cetacea. That is, he spoke on May 14, 1894, at the 8th meeting of the Anatomical Association of Germany opened at Strassburg upon a 7 mm long embryo of the harbor porpoise, *Phocaena communis*, which showed comparatively well developed hind limbs. At the same occasion *Guldberg* introduced two other embryos, 17 mm and 18 mm long of the same species, in which he could observe lateral to the genital tubercle very low eminences, representing to his mind the rest of the hind limbs.

Soon afterwards a large monograph (1894) on the development of the dolphin was published from Bergen Museum under the joint names of *Guldberg* and *Fridtjof Nansen*, the famous explorer of the North Pole, and *Guldberg* reported then his findings in details on the hind limbs of the three *Phocaena*-embryos, together with a number of clear drawings. The 7 mm and 17 mm embryos were said to have been obtained from Greenland.

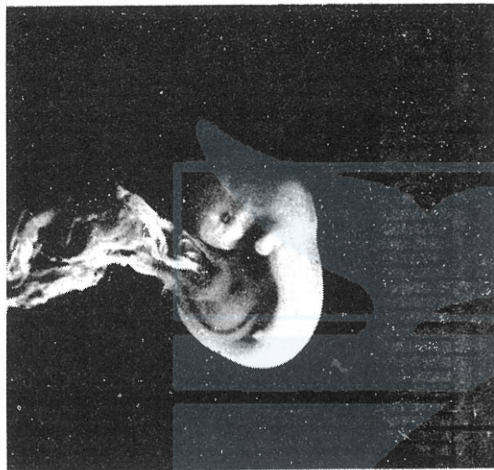
Shortly later (1895) *W. Kükenenthal* of Germany, assuming that the low eminences seen by *Guldberg* in 17 mm and 18 mm embryos might be the anlage of the mammary glands, opposed partly to *Guldberg's* opinion. He added that he had written already in 1893 on the rudimentary hind limb in a 25 mm long embryo of *Phocaena*. The originality requested by *Kükenenthal* was not fully accepted by *Guldberg*, chiefly because the former mentioned the eminence in a height between the navel and the genital organ, namely, its position was different from the latter's finding.

Later *Guldberg* wrote again in 1899 another paper dealing with the same research materials as before, in which he laid stress on the microscopical proofs to indicate that the low eminences in 17 mm and 18 mm long embryos can never be the anlage of mammary glands, but nothing than the rest of the hind limbs. It is also to be noted in this paper, that *Guldberg* revised his earlier drawing on the external appearance of the 7 mm long *Phocaena*-embryo. Compare his pictures of 1894, Taf. IV,

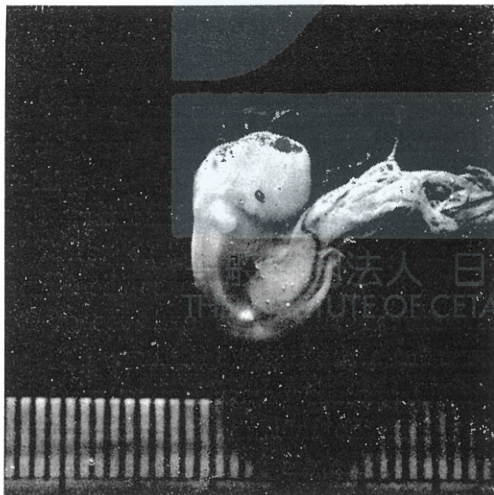
Fig. 12 and of 1899, Taf. XX, Fig. 1.

The present author deems, the very interesting discussions between these two European authorities came to the end in 1899 with the victory of the Norwegian cetologist. Afterwards *Kükenthal* himself made in 1914 a great contribution to this problem, as he found in three embryos (32 mm, 28 mm, 30 mm "direkte Körperlänge") of Megaptera the existence of rudimentary hind limbs, that is, for the first time as to the

baleen whales. The 32 mm embryo, which with relatively less marked curvature of the body-axis was estimated as the youngest of the three, showed on both sides of the genital tubercle the hind limb elevation, 1.2 mm in height and 0.9 mm wide at the base. It was conical but rounded at the tip, papilla-like, and flat laterally, and caudally directed. Also in two other embryos, 28 mm and 30 mm, the rest of the hind limb was recognized, though less remarkably. In the same paper *Kükenthal* added his observation on the hind limb of a 11 mm long embryo of *Phocaenoides dalli* (*True*).



(a)



(b)

Fig. 1. Fourteen millimeter embryo of *Prodelphinus caeruleoalbus*. (a) left side, (b) right side.

II. Personal Observations

Recently I could affirm in a 14 mm long embryo of *Prodelphinus caeruleoalbus* (*Meyen*) collected at Arari on the western coast of Izu Peninsula, the presence of the hind limb, as shown in the accompanying photographs (Fig. 1 a, b). The body-axis of the embryo is strongly bent, so the length (14 mm) was measured straight from the nucha to the

caudal flexure. This way of measurement is appropriate so as not to spoil the delicate material after fixation in formalin, and besides to compare with *Guldberg's* figures, as this author measured also the "Nacken-steisslänge".

The form of the hind limb protrusion observed by me in this *Prodelphinus*-embryo is considerably different from *Guldberg's* description. In my case it is more conical and pointed, the apex being directed caudally and laterad. Though the *Guldberg's* pictures of the 7 mm long embryo are different as mentioned above between 1894 and 1899, one should take

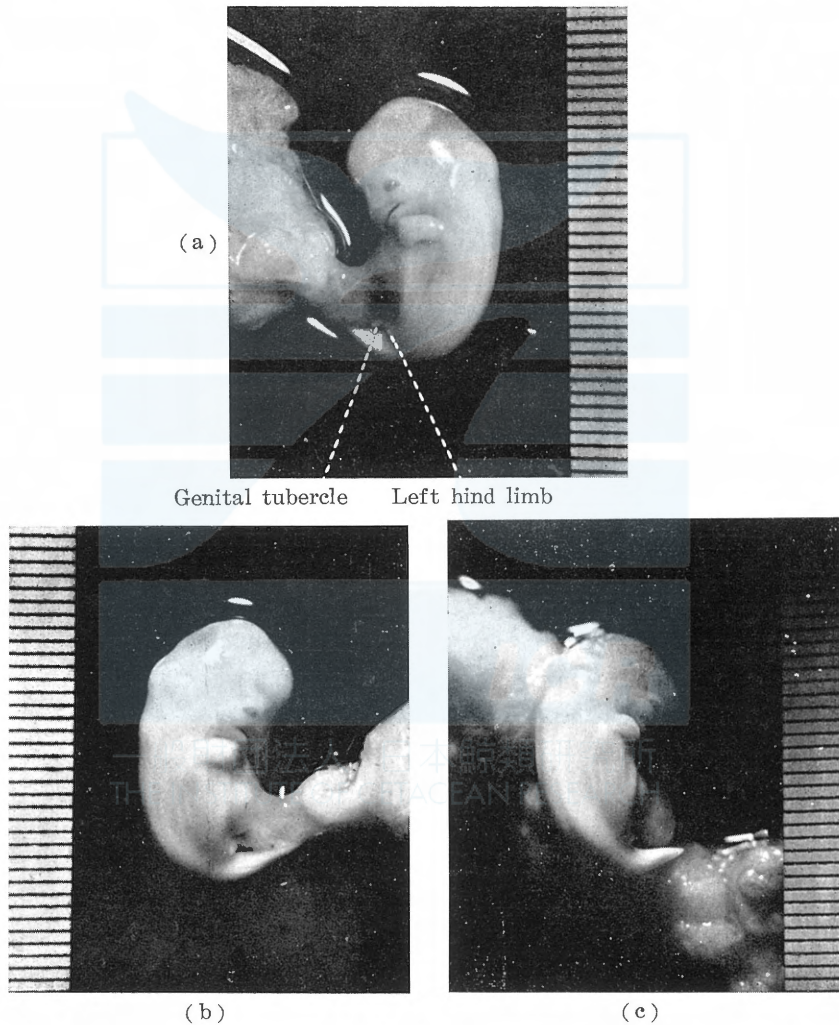


Fig. 2. Twenty millimeter embryo of *Megaptera nodosa*. (a) left side, (b) right side, (c) from right dorsal, the protrusion of the hind limb well noticeable.

naturally the later published picture for more accurate. Anyway, in his specimen the limb in question must have been more rounded and relatively fan-like.

The difference of the form between *Guldberg's* and mine is probably due to the ontogenetic stage of the embryos. It is very conceivable that in my specimen the retrogression of the hind limb has proceeded further. The difference according to the species of animals seems to be less plausible.

In two other more developed embryos of *Prodelphinus caeruleoalbus* collected recently by Dr. *M. Nishiwaki* at Arari, which are respectively 20 mm and 24 mm in body-length, I could recognize rudiments of the hind limb as a very low eminence on each side, exactly at the place, where *Guldberg* saw the rudimentary hind limb in the 17 mm and 18 mm embryos of *Phocaena*. But in my cases it appeared to the naked eye as a single eminence, though *Guldberg* found "on each side two small tubercles, which are connected at their origin". The body-length of these fetuses (20 mm and 24 mm) was measured not from the nucha, but from the head to the tail flexure, as the head is more erected and the neck flexure is less marked than in the 14 mm embryo. *Guldberg* also calculated the length of 17 mm and 18 mm from the head to the tail.

As the next, I wish to mention another finding of the hind limbs in a 20 mm long embryo of the Humpback, *Megaptera nodosa*. This embryo has been preserved for several years in formalin in the Whales Research Institute, Tsukishima, Tokyo, and its state of preservation is very good. On opening the fetal membranes the existence of the hind limb elevation is clearly visible (Fig. 2 a, b, c), though not so marked as in the 14 mm long *Prodelphinus*. To compare with *Kükenthal's* description on the fetuses of *Megaptera*, the hind limb elevation in my case is a little lower in height but broader at the base. Fig. 9, Taf. 1 of his paper, showing a 28 mm long embryo, seems to resemble my own observation in a high grade, as to the hind limb.

III. Relation with the Caudal Flukes

My attention was further given to the chronological relation between the disappearance of the hind limb and the formation of the caudal flukes. For this purpose I examined several other fetuses of *Prodelphinus*, a little larger than the above mentioned, and reached the opinion that a certain synchronism exists between these two phenomena. In the 14 mm long embryo, which has the easily observable hind limb, no lateral widening of the flukes can be recognized, the tail tapering quite gradually to the tail-end (Fig. 3 a). Keeping pace with becoming smaller

of the hind limb protrusion in the 24 mm and 25 mm long *Prodelphinus*, the elevation of the flukes makes appearance (Fig. 3 b, c), at first so faintly that one may fail to find it, if not with special care. In larger embryos, in which the flukes can be seen at ease, there remains no trace of the hind limb elevation at all (Fig. 3 d).

The same circumstance applies probably also to *Megaptera*, though I have examined till today only two embryos of this species small enough for this problem. We can recognize scarcely any elevation of the flukes in the 20 mm long embryo (Fig. 3 e), while the other embryo, 51 mm long (from the head to the tip of the tail, as the caudal flexure is here nearly absent), shows pretty well developed flukes, but no trace of the hind limb protrusion (Fig. 3 f).

This relation may be merely a matter of coincidence without any important significance. But if one considers the hind extremities of Pinnipedia, above all of Phocidae, being shifted far caudally and functioning in swimming rather as the main portion of the tail, the chronological agreement between the disappearance of the hind limb and the appearance of the caudal flukes deserves our special notice.

I won't discuss here the validity of *E. Haeckel's* famous thesis, that the ontogenesis recapitulates the phylogenesis, nor any phylogenetic relationship between Pinnipedia and Cetacea. But in my opinion the disappearance of the paired hind limbs in the Cetacea seems to have an intimate causal nexus with the appearance of the paired caudal flukes of them.

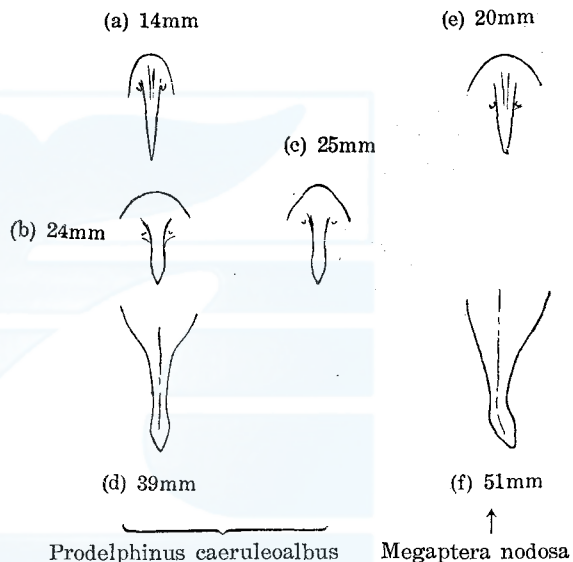


Fig. 3. Schema showing the tail and the hind limb in small embryos of the Cetacea (seen from caudal direction).

IV. Summary

In a 14 mm long embryo of the dolphin, *Prodelphinus caeruleoalbus*, and in a 20 mm long embryo of the Humpback, *Megaptera nodosa*, the

paired elevations of the hind limb are pretty well developed. Photographs of them are shown. Further consideration was given to the simultaneousness of the disappearance of the hind limb elevation with the first appearance of the caudal flukes in the Cetacean embryos.

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