Sinus-hairs of the Sei-Whale (Balaenoptera borealis)

by

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Sinus-hairs of a whale possess sensitive tactility like the whiskers of a cat. The root of this hair is surrounded by blood sinus in the connective-tissue layer of the hair follicle. It is a venous sinus with numerous nerves coming into the sinus and twining themselves around the root of the hair.

The whale-bone whales have these characteristic sinus-hairs on their upper and lower beaks, but in dolphins they occur only in their foetus-stage and degenerate after birth.

The lack of sinus-hairs in dolphins is believed, generally, to be due to the food of them, being so large as to be easily visible that tactile hairs become unnecessary, but, the food of the baleen whales is tiny Mysidae and is so difficult to see that they search for the food with these hairs.

In the summer of 1946 and 1947, at Ayukawa, Miyagi Prefecture, we had a chance to study sinus-hairs of Sei-Whales, Balaenoptera borealis, which were caught off the coast of Kinkazan and studies were made both at the whaling station and in the laboratory later. The distribution and number of sinus-hairs macroscopically and some facts on histological preparations have been studied.

D. G. Lillie (1910) merely studied the distribution and number, while A. Japha (1910) devoted himself to the microscopic study of histological preparations.

We observed, at the whaling station, some white, weak hairs of 1 to 2 cm in length occurring on the giant body, generally symmetrically in specific arrangement. The observation at the whaling station was not easy; because of the giant body and of the speedy disposition of it. It was almost impossible to count and examine the hairs of both upper and lower beaks of an individual.

The arrangement and number of these hairs are shown in Table 1 and in Figs. 1 and 2. There are four rows of them on the dorsal surface of the upper beak, from the anterior extremity to the blow-hole, almost 30 hairs at each distance of 20—30 cm. At the anterior end of the lower jaw, there are two rows which occur closely together along the median line at

Individual	upper beak				lower beak			
	right		left		right		left	
	outer row	inner row	outer row	inner row	on the lateral side	at the anterior end	on the lateral side	at the anterior end
No. 1	10	5			9	11		
No. 2			8	4		14		16
No. 3						14		14

Table 1. Number of sinus-hairs of Sei-Whale.

Fig. 1. Arrangement of sinus-hairs on the head of Sei-Whale.

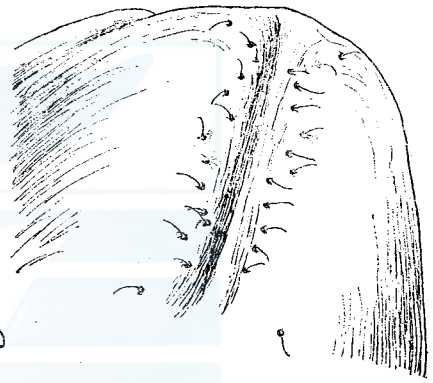

Fig. 2. Sinus-hairs at the anterior end of lower beak.

a distance 1 to 2 cm and contain almost 30 hairs. On each lateral side of lower jaw, there is a row of from 5 to 10 hairs. There are a total of nearly 80 hairs in all which does not greatly differ from reports of the former investigators.

We especially made a study of the hairs at the anterior end of lower beak. We made observations at first by naked eye or with a magnifying-glass inflicting small cuts in the sinus and its neighbouring parts. By this means, we were able to unearth some new facts which seemed to have escaped notice of earlier workers.

When a large blood sinus, surrounding the hair root, was carefully

observed, the skin above it was indented in a funnel shape and became very thin at the point where the hair came out of the sinus, and the sinus extended itself to just beneath the epidermis.

At the bottom of the funnel shaped dent, the thickness of epidermis is only 0.3 mm, but it becomes thicker outward, being 1.3 mm thick at the periphery of the funnel. The corium layer between the epidermis and the blood sinus is only 0.1 mm in thickness.

The sinus-hair is supported in the sinus by many threads from surrounding walls so that the hairwill move freely in all directions when pressure is applied from outside. It is significant that this part of the epidermis where the hair comes out is very thin in order to make this motion easily.

Observations of the cross section of the hair follicle show that this hair is situated not equally distant from inner walls of the sinus, but is eccentric. Furthermore, the inner walls of the sinus are different in shape, such that the side to which the hair shaft is inclined is almost vertical, but the wall on the opposite side forms a curve, of which the central part swells out remarkably (Fig. 3).

The longitudinal diameter of the sinus is almost 12 mm, maximum transverse diameter almost 2 mm. The wall of the sinus is made of dense connective tissue fibers, looking somewhat like the tendon, and is about 1 mm in thickness at the central swollen part. These fibers give off branches radially into surrounding parts of the corium so that the swollen part seems to be strongly pulled outwards.

In the skin of the whale, there is only a thin compact layer of connective tissue between the epidermis and the adipose tissue of the subcutaneous layer. Coarse fiber bundles run in complicated directions through the adipose tissues, but, as no remarkable connective tissue fibers are seen in the neighbourhood of the hair follicle except the above-mentioned radial fibers, the hair follicle lies nearly surrounded by soft adipose tissues.

We thought that there might be a rule between the eccentric location of the hair root in the sinus, shape of the sinus walls, and the inclination of the hair shaft. By a closer observation, it was found that the hair shaft was always inclined towards the side to which the hair root was located nearer. Further observations revealed that the epidermis forming the funnel at the exit of the hair has a gentler slope on the side the hair shaft is inclined

and the other side constitutes an almost perpendicular wall (Fig. 3).

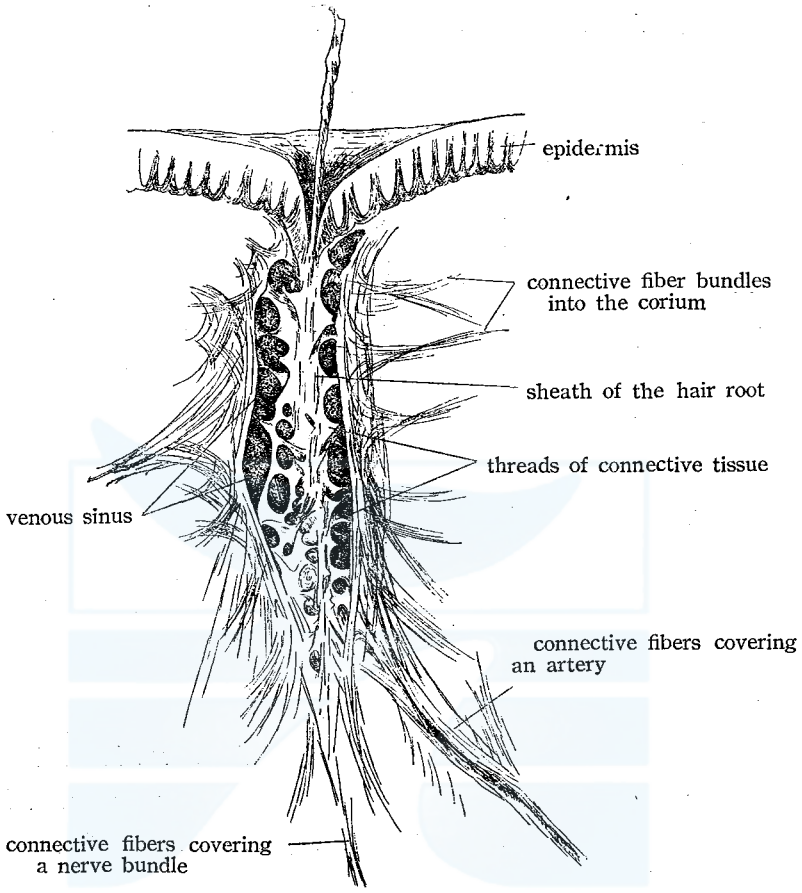

Fig. 3 Root of a sinus-hair and its surroundings

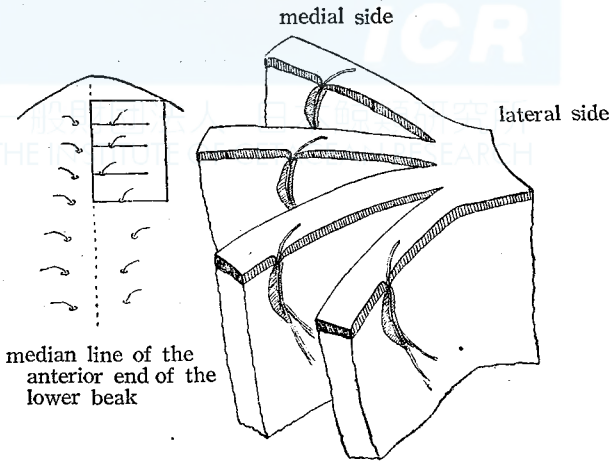

Fig. 4. To show the inclination of sinus-hairs

Therefore, the direction of inclination of the hair shaft seemed to have some intimate correlation to the structure of the sinus. But since we could not make any further generalization on a small piece cut out from the lower jaw, we proceeded then to the examination of the entire tipe of the lower jaw, where each direction in relation to the whole body is easily determinable. It was made clear that the hair was always inclined to the lateral direction (Fig. 4). Therefore, the swollen part of the sinus wall is on the medial side, namely, on the side directed to the median line.

The shaft of the sinus-hair shows no pigmentation and is 0.1—0.15 mm in diameter, being the thinnest at the exit. Its surface is relatively smooth only at the part, where it just comes out of epidermis and its tip has many protrudings and looks like a slender tree trunk with many knots (Fig. 5). While treating the hair under a microscope, it was found that dust adheres easily to the hair shaft. The hair has no marrow; bulbus and papilla of the hair are divided in complex form.

Next, the nerves come into consideration. We observed both in macro

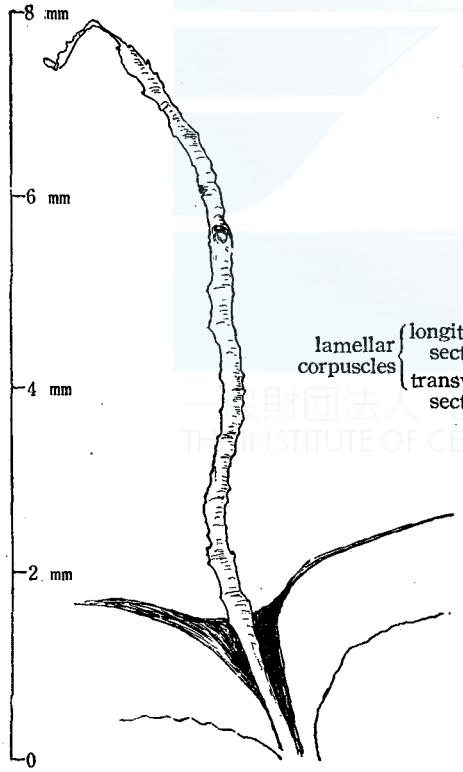

Fig. 5. shaft of a sinus-hair

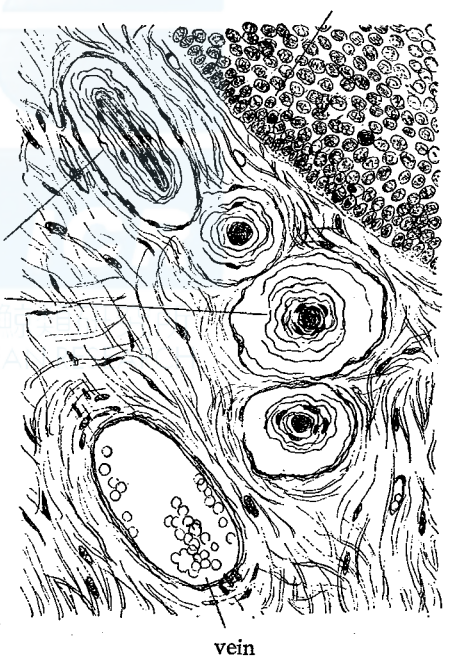

Fig. 6. Lamellar corpuscles in the superficial part of a hair-follicle

and microscopical sections, a relatively thick bundle of nerve fibers ascending almost vertically and it gave off one branch entering the hair follicle from just beneath it and the other branch ascending outside of the follicle.

According to Japha, as several hundreds of myelinated nerve fibers are counted in one sinus-hair, there must be almost 10.000 fibers at the anterior end of the lower jaw, and he quoted in relation to this an interesting story, told by Malm (1866) that when one touched the lips of a Blue whale washed ashore alive near Göteborg in Sweden this giant whale started violently.

We ascertained by microscopic observations that the ascending nerve bundles end in special terminal apparatus, in the outside of the sinus. This apparatus resembles the Pacinian corpuscle, but since the number of lamellae is so few that, it comes nearest to the Herbsti's corpuscle.

They are nearly oval, 60—300 μ in length, 20—150 μ in transverse diameter, and are made of concentric lamellae of connective tissues. The axis of the corpuscle is occupied by a well developed eosinophile core, containing the termination of a nerve fiber (Fig. 6).

The corpuscles are grouped in the following wise: one group about 1 mm immediately beneath the epidermis, on the lateral side of the hair; another group about 1.5 mm in length on the opposite side (median); the third group on the lateral side (same side with the first group) somewhat beneath the second, and also at the height of the hair papilla, where more corpuscles are obviously seen on the median side than on the lateral side.

Further researches are needed as to the distribution of the terminal apparatus and differences in its size according to location. We can, however, assume that this distribution of the corpuscles has a close connection with the functional direction of the hair, when the hair encounters pressure and resistance. Japha also observed that there were especially numerous small terminal corpuscles (about $20 \times 60\ \mu$) in the papillae of corium immediately beneath the epidermis around the hair.

We are endeavouring to throw more light by the method of axis cylinder staining on the distribution of nerve fibers to the corpuscles and to study the characteristic feature of nerve fibers at the point, where the sinus continues into a vein.

The inner surface of the venous sinus, as well as nerves, blood vessels and threads of connective tissues which are all present inside the sinus are

covered by endothelial cells.

According to macroscopic studies, a relatively thick artery, being the size of a thin needle, runs up from the under and lateral direction and enters the sinus through the lower lateral part of the hair follicle, about at the height of a hair papilla. The artery entering the sinus is divided into two, runs upward and becomes more brouched and thinner.

A large amount of blood sent into the sinus from the lower part, runs up and seems to flow out into a vein near the epidermis. The exit is situated on the opposite side to the artery, namely on the median side. The terminal corpuscles are crowded in this side near the exit.

It is especially worthy of notice, in the above-mentioned results, that a rule of direction exists between the sinus-hair and things accompanying it, as a whole. For this reason, the sinus-hair seems to have a greater significance in the life of a baleen whale than it has been assumed as a tool for finding food. We suppose that by use of sinus-hairs the whales might feel the currents of water upon their heads.

Kükenthal was of the opinion that the scanty remaining hairs of whales are merely a reduced organ, as they have no sebaceous glands. But it is the common property of the skin of whales that it lacks not only the sebaceous glands, but also the sweat glands. We are of the opinion, the sinus-hairs of whales seem to be a very important sensory organ for the life of them.

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