

DIATOM FILMS ON WHALES IN SOUTH AFRICAN WATERS

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ABSTRACT

Diatoms found on the skin of minke whales and 4 species of toothed whales in the waters off South Africa were examined. Typical *Cocconeis ceticola* was common on minke whales and was also found on a southern bottlenose whale. *C. ceticola* f. *constricta* was, on the other hand, found only on a southern bottlenose whale and *C. ceticola* f. *berardiusii* was found on a Cuvier's beaked whale. *Stauroneis olympica* was found on a Cuvier's beaked whale, a killer whale and a strap-toothed whale. *Gomphonema aestuarii* and *Synedra* sp. were also found on a strap-toothed whale, while an unidentified *Navicula* sp. was also found on a minke whale and a strap-toothed whale.

On the assumption that typical *C. ceticola* is only contracted in high latitudes, its occurrence on whales in the waters off South Africa shows that these animals may recently have migrated from colder waters.

INTRODUCTION

Many diatom species on whales have been described in the North Pacific and in the Antarctic (Hart, 1935; Hustedt, 1952; Nemoto, 1956, 1958). Diatom films on the skin of whales have been mostly found in the waters of high latitudes, and they have generally been considered common in the colder waters of both hemispheres. There are few observations of diatoms on whales caught in the waters off South Africa (Mackintosh and Wheeler, 1929; Best, 1969). It is generally accepted that diatoms (mainly *Cocconeis ceticola* and its related forms) propagate and form films on the skin of cetaceans in colder waters and are not so common in temperate waters, although Gambell (1972) has speculated that the lack of ectoparasites on whales at Durban may have been due to the greater rate of epidermal decomposition in the higher sea temperatures prevailing there.

In recent studies of whales caught or stranded on the coast of South Africa, 22 specimens of diatom films from skin or teeth have been collected. These specimens are examined taxonomically and the occurrence of diatoms as skin films of whales is discussed in relation to hydrographic conditions.

MATERIALS AND METHODS

Diatom samples were collected between 1969 and 1973 by one of us (Best) from whales caught or stranded around South Africa. Host species included both baleen and toothed whales (Table 1).

Diatom specimens were mostly collected from the skin but one diatom film was collected from the teeth of a strap-toothed whale. The samples from minke and bottlenose whales were collected immediately after death while they were alongside or on the deck of the catcher. Those from the other species were collected from stranded animals some unknown time after death. All samples were preserved in 10% formalin/sea water with the skin of the whales. The diatom samples were then scratched from the skin and washed with distilled water and rinsed three or four times. After preservation in potassium permanganate for 24 hours, hydrochloric acid was added and the samples kept for a further 24 hours. After boiling for 5 minutes, the samples were washed and rinsed several times, and frustules of diatoms were kept on plates. Double coating of carbon and gold was used for electron

TABLE 1. DIATOM SAMPLES* FROM WHALES FROM SOUTH AFRICA

| Specimen no. | Date collected | Species | Length (m) | Sex | Locality† |
|--------------|----------------|---|------------|-----|-----------------------------|
| 69/10 | July 5 '69 | Killer whale (<i>O. orca</i>) | 6.10 | M | Bordjies Drif Cape Point |
| 73/10 | Oct. 25 '73 | Cuvier's beaked whale (<i>Ζ. cavirostris</i>) | 5.77 | F | Still Bay |
| 75/1 | Jan. 19 '75 | Southern bottlenose whale (<i>H. planifrons</i>) | 6.43 | M | 33°36' S 28°04' E |
| 78/15 | Apr. 6 '78 | Strap-toothed whale (<i>M. layardii</i>) | 5.46 | M | Milnerton |
| U71/2200 | Aug. 28 '71 | Minke whale (<i>B. acutorostrata</i>) | 8.53 | M | 29°30' S 32°51' E |
| U71/2201 | Aug. 28 '71 | " | 7.62 | M | " " |
| U71/2202 | Aug. 29 '71 | " | 9.14 | F | 29°57' S 31°19' E |
| U71/2203 | Aug. 29 '71 | " | 7.62 | F | 30°46' S 31°19' E |
| U71/2211 | Aug. 30 '71 | " | 7.92 | F | 30°48' S 31°58' E |
| U71/2232 | Aug. 31 '71 | " | 8.23 | M | 31°10' S 30°55' E |
| U71/2243 | Sept. 5 '71 | " | 8.23 | M | 31°06' S 31°01' E |
| U71/2245 | Sept. 5 '71 | " | 8.23 | F | 31°11' S 30°46' E |
| U71/2313 | Sept. 16 '71 | " | 8.23 | F | 31°05' S 31°47' E |
| U71/2315 | Sept. 18 '71 | " | 8.84 | M | 30°04' S 31°35' E |
| U73/1255 | June 24 '73 | " | 9.14 | M | 30°42' S 33°25' E |
| U73/1256 | June 24 '73 | " | 8.64 | F | " " |
| U73/1299 | June 26 '73 | " | 8.28 | M | 31°10' S 31°01' E |
| U73/1304 | June 27 '73 | " | 8.15 | M | 30°32' S 31°49' E |
| U73/1306 | June 27 '73 | " | 8.28 | M | 30°22' S 32°04' E |
| U73/1446 | July 17 '73 | " | 8.86 | M | 31°15' S 31°25' E |
| U73/1559 | July 29 '73 | " | 8.43 | M | 30°27' S 31°17' E |
| U73/1839 | Sept. 28 '73 | " | 8.61 | F | 29°45' S 32°12' E |

* All samples taken from skin except 78/15 where sample taken from teeth.

† All animals collected at sea apart from 69/10, 73/10 and 78/15, which were all stranded animals.

microscopy. The specimens were examined with both scanning and ordinary electron microscopes.

The scanning electron microscope JSM-35 was mainly used for the identification of species. Some species are still under examination, but their preliminary identification is described in this paper.

DESCRIPTION OF SPECIES

The species of diatoms identified and the host species of whales involved are shown in Table 2.

TABLE 2. DIATOMS OCCURRING ON THE SKIN AND TEETH OF WHALES IN THE WATERS OFF SOUTH AFRICA

| | Minke whale | Southern bottlenose whale | Cuvier's beaked whale | Killer whale | Strap-toothed whale |
|--|-------------|---------------------------|-----------------------|--------------|---------------------|
| <i>Cocconeis ceticola</i> (typical form) | 18 | 1 | — | — | — |
| <i>C. ceticola</i> f. <i>constricta</i> | — | 1 | — | — | — |
| <i>C. ceticola</i> f. <i>berardiusii</i> | — | — | 1 | — | — |
| <i>Stauroneis olympica</i> | — | — | 1 | 1 | 1 |
| <i>Navicula</i> sp. | 1 | — | — | — | 1 |
| <i>Gomphonema aestuarii</i> | — | — | — | — | 1 |
| <i>Synedra</i> sp. | — | — | — | — | 1 |

Only pennate diatoms were found in the diatom films examined. There were clear differences between the diatom species on different host whales. The typical form of *Cocconeis ceticola* Nelson was found on every minke whale but only a very few individuals on one of the toothed whales examined (southern bottlenose whale). On the skin of the southern bottlenose whale, some specimens of *C. ceticola* were somewhat deformed and a clear constriction was observed. The edge of the valves was sometimes absent as shown in Fig. F in Plate I. Small numbers of a slender form of *C. ceticola* were also found on this whale. On the Cuvier's beaked whale the more slender form of *C. ceticola* was found, but with no constriction at the edge where the stauros of the lower raphe reaches the edge. This type of *C. ceticola* has been found previously on the skin of Baird's beaked whale *Berardius bairdii* (Kriashorin, 1962), and is named as the form *berardiusii*.

The constricted form of *Cocconeis ceticola* has often been observed in toothed whales. As indicated in Plate I F, the constricted parts sometimes lack the outer edge of the valve, and the hole on the inside is deformed as indicated in Plate I H. The hole in the edge of typical *Cocconeis ceticola* is rather similar to other holes along the edge (shown in Plate I B, C) or a little deformation is observed as shown in Plate I E.

Four other species of pennate diatoms were found on toothed whales. *Stauroneis olympica* Hustedt was found on the Cuvier's beaked whale, killer whale and strap-toothed whale. This species has clear pseudosepten from the tips of the cell,

which is different from the pseudosepten and the shape of the tip of *S. omurai* Nemoto (Nemoto, 1956) found on sperm whales in the North Pacific. The shape of *S. olympica* as originally described (Hustedt, 1952) is more slender than these specimens and the structure of the stauros may be somewhat different. However, considering the varieties within one diatom species on different species of whales, these specimens may be attributed to the *Stauroneis olympica* complex. The closely related species *S. aleutica* reported by Nemoto (1956) can also be put in this group. *Stauroneis* diatoms were also present on sperm whales off South Africa, Chile and Australia (Best, 1969). The presence of *Navicula* species (possibly *Stauroneis olympica*, as described from the epiphytes on barnacles on a humpback whale from the Antarctic) was described on a sperm whale landed in the Outer Hebrides (Hart, in Clarke, 1956). This species is possibly cosmopolitan or bipolar on sperm whales and toothed whales (Hart, in Best, 1969).

Small naviculoid diatoms were found on the strap-toothed whale, and were also found in the film of *Cocconeis ceticola* on the skin of one minke whale. *Gomphonema aestuarii* Cleve which is also described by Giffen (1966) in South African waters, and *Synedra* sp., which is very close to *S. tabulata* (Ag.) Kupzing (Harrison and Thurley, 1974), were also found on the teeth of this strap toothed whale.

DISCUSSION

Studies of skin films of *Cocconeis ceticola* have suggested that these diatoms are most common on cetaceans in the colder water of high latitudes.

Mackintosh and Wheeler (1929) concluded that such diatom films on whales are undoubtedly contracted in the austral summer in Antarctic or sub-Antarctic waters. Hart (1935) described the general tendency for the rate of diatom film infestation of blue and fin whales to increase as the season progressed at South Georgia. Gambell (1968) also noted the diatom infestations on sei whales caught at South Georgia, and that sei whales newly arrived from the breeding grounds in the middle of the summer season do not bear diatoms. However, Mackintosh and Wheeler (1929) also noted that small spots of *C. ceticola* were seen on a few immature (fin and blue) whales at Saldanha Bay, South Africa. Best (1969) and Bannister (1969) recorded the presence of *C. ceticola* on sperm whales (mostly large or medium-sized males) off Donkergat (South Africa) and Albany (Western Australia) respectively, during the autumn and winter. *Cocconeis* diatoms have also been recorded from whales in the Eastern Pacific off South America (A. Aguayo L., pers. comm.). Clarke (1956) found no clear infestation with diatoms of *Cocconeis* type on the sperm whales caught in the Azores.

Diatoms in the northern part of the North Pacific, where many diatoms are found on the baleen and sperm whales, have been described by Nemoto (1956). Diatom infestation is common in the Bering Sea and its adjacent waters, while in the coastal waters, *Cocconeis* diatoms are often observed on both sides of the Pacific; off British Columbia (Pike, 1953) on the eastern side, and in the Okhotsk Sea and off Hokkaido waters in Japan on the western side (Omura, 1950). *Cocconeis ceti-*

cola Nelson is the most common diatom on baleen whales. The varieties and forms of *C. ceticola* in the North Pacific have been described and discussed by Usachev (1940), Nemoto (1956, 1958), Nemoto *et al.* (1977) and Kriashtorin (1962). According to these authors, the typical *Cocconeis ceticola* form is only described from baleen whales. Kriashtorin (1962) reported some large-sized *C. ceticola* as a new variety, *C. ceticola* var. *arctica*, but this is clearly the same type of *C. ceticola* from its shape and size. The fact that the typical form of *C. ceticola* has now been found on the skin of minke whales caught off South Africa suggests that minke whales are similar to other rorquals as host-types. *C. ceticola* has also been recorded from minke whales in the Antarctic (Ohsumi *et al.*, 1970), but no remark was made concerning the type of *C. ceticola* involved.

Cocconeis ceticola f. *constricta* Nemoto is found on the skin of sperm whales in the North Pacific (Nemoto, 1956). *C. ceticola* has also been recorded from sperm whales off Donkergat, South Africa (Best, 1969) and off Albany, Western Australia (Bannister, 1969): no distinction was made, however, between form *constricta* and typical *ceticola*. *Cocconeis* diatoms found on the *Hyperoodon planifrons* in the waters off East London, South Africa, were of two types. A very few specimens of typical *C. ceticola* forms were found, but the rest were all constricted forms. Constricted forms found in this study show some variation although there was no clear boundary to separate them. One was typical *C. ceticola* f. *constricta* which was previously found on sperm whales (Nemoto, 1956). Kriashtorin (1962) also described the same type from sperm whales in the Far Eastern seas. It was clearly shown that the edge of the raphe-valve where the stauros reaches was absent or deformed. The second type of *constricted* form was similar to *C. ceticola* f. *berardiusii* which was first described by Kriashtorin (1962) from *Berardius bairdii*. This type (Kriashtorin, 1962 in Fig. 1e) is the same as the type M in Fig. 3 in Nemoto (1958), and was common among the diatoms on the *Z. cavirostris* examined in this paper. As no *Cocconeis* specimen was found on the killer whale in this study, it is difficult to assess the position of *Cocconeis orcii* Kriashtorin described by Kriashtorin (1962). From the surface structure shown by him, *C. orcii* is one variety of *C. ceticola* and is not a valid species.

The global distribution and occurrence of parasitic diatoms on whales are interesting. As stated previously, *Cocconeis* diatoms are mainly described from the high latitudes of the North Pacific and Southern Hemisphere, where they can form films over a large part of the body (Bennett, 1920). *Cocconeis* diatom infestation on whales in lower latitudes is usually rarer and much smaller in extent ("small spots"-Mackintosh and Wheeler, 1929), so it might be concluded that such animals are recent migrants from higher latitudes. The only resident cetacean population outside the Antarctic known to carry *Cocconeis* films is the Franciscana dolphin, which lives in water from 13–23°C (Nemoto *et al.*, 1977). Presumably therefore it is possible to contract *Cocconeis* films in water as warm as 13°C, but as little is known about the seasonal incidence of diatoms on or movements of the Franciscana dolphin it is impossible to give an upper limit to the temperature range in which *C. ceticola* can survive. On the assumption that the films of *Cocconeis* on the larger

cetacea are contracted only in high latitudinal waters, the presence of *C. ceticola* on minke whales off Durban from June to September indicates that the animals have recently arrived from colder waters, and that the migration may be more protracted over time than for other baleen whale species. The presence of *Cocconeis* films on *H. planifrons* and *Z. cavirostris* off South Africa is the first indication that these species may also migrate from Antarctic or sub-Antarctic to warmer waters.

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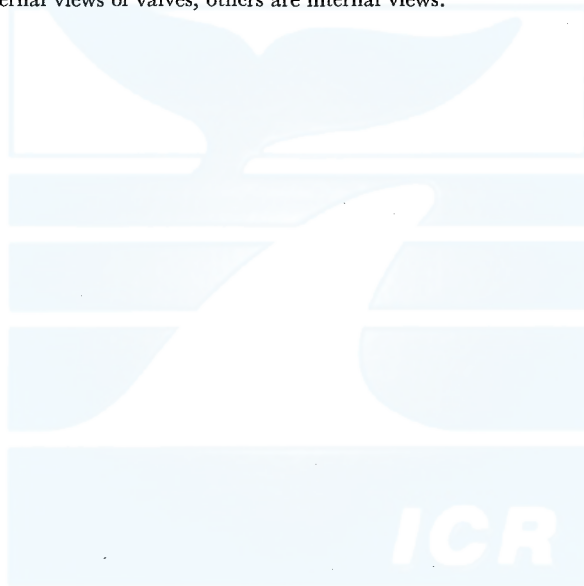
EXPLANATION OF PLATE

PLATE I

Figures A.D.F.G. are taken by light microscope, B.C.E.H.K.L. are taken by scanning electron microscope and I.J. are taken by Electron microscope.

A.*—raphevalve of *Cocconeis ceticola* Nelson typical form found on minke whale (*B. acutorostrata*) U73/1299. B.—raphevalve of *C. ceticola* typical form on minke whale U73/1304. C.—raphevalve of *C. ceticola* typical form on minke whale U71/2200. D.*—raphevalve of *C. ceticola* typical form on minke whale U71/2203. E.—raphevalve of *C. ceticola* typical form on minke whale U71/2245. F.*—raphevalve of *C. ceticola* f. *constricta* Nemoto on southern bottlenose whale 75/1. G.—rapheless valve of *C. ceticola* f. *constricta* on southern bottlenose whale 75/1. H.—raphevalve of *C. ceticola* f. *constricta* on southern bottlenose whale 75/1. I.*—*Gomphonema aestuarii* on strap-toothed whale, 78/15. J.*—*G. aestuarii* on strap-toothed whale. K.—*Stauroneis olympica* Hustedt found on killer whale 69/10. L.—*S. olympica* found on killer whale 69/10.

* External views of valves, others are internal views.



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