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EPIZOIC BARNACLES REMOVED FROM THE SKIN OF A HUMPBACK WHALE AFTER A PERIOD OF INTENSE SURFACE ACTIVITY

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Humpback whales (*Megaptera novaeangliae*) as well as other slow-moving Mysticetes such as gray (*Eschrichtius robustus*) and right whales (*Eubalaena* spp) are commonly infested with various epizoonts and ectoparasites (Fertl 2002). Humpbacks are particularly prone to infestation by two species of sessile crustaceans (Cirripedia), the acorn barnacles *Coronula diadema* and *Coronula reginae*. These acorn barnacles are used as settlement substrate by the stalked barnacles *Conchoderma auritum* and *Conchoderma virgatum* (Clarke 1966, Dawbin 1988, Fertl 2002). Although none of these barnacles are true ectoparasites as they do not feed on whale skin or body fluids, they could become abundant enough to increase drag and affect hydrodynamics. According to Slijper (1979), older whales carry more barnacles than younger animals. In addition, animals with reduced movement due to sickness become more heavily infested with ectoparasites and epizoots (Fertl 2002). One account reported a humpback whale with more than 1,000 lb (454 kg) of barnacles attached to its body (Slijper 1979).

Acorn barnacles attach to humpback whales as cyprid larvae by means of their cement glands (Schmitt 1965). The more abundant *C. diadema* does not embed in the skin and offers a greater surface for stalked barnacles than does *C. reginae*, which commences its growth beneath the skin forcing it back as the barnacles becomes larger (Schmitt 1965, Clarke 1966). On humpback whales these barnacles occur most commonly in clusters on the tip of the lower jaw, the middle line of the ventral grooves region, the knobs on the front forward edge of the flippers, and around the genital slit (Clarke 1966, Slijper 1979, Fertl 2002).

There is still uncertainty as to whether barnacles attach to the whales in cold or warm waters. Clarke (1966) and Slijper (1979) believed that the low incidence of *Coronula* spp on rorquals hunted in antarctic waters indicated that the barnacles attached to the whales in tropical waters and dropped off in polar waters. However, Kaufman and Forestell (1986) noted that barnacles flourished in polar waters and dropped off in the tropical waters of Hawaii. Furthermore, Dawbin (1988) suggested that the loss of barnacles was a natural phenomenon produced by changes in water temperature during migration, with a high mortality of large barnacles and a spontaneous drop off in warm waters, where they are replaced by rapidly growing juveniles. According to Schmitt (1965), *Coronula* is well adapted to the less-oxygenated warm waters because it possesses the largest and most highly developed gills of any Cirripedia species.

Humpback whales are also known for their intense and varied surface behaviors such as breaching, flipper slapping, and fluke slapping. One function of such displays is the production of percussion sounds, which may travel several kilometers through air and underwater, that are used as a form of communication or to maintain acoustic contact (Herman and Tavolga 1980, Tyack and Whitehead 1983). Scientists have long speculated that breaches also help to dislodge barnacles from humpback whales, but so far no studies have been conducted to determine whether this really occurs.

On 13 August 2004, while aboard a whale watching yacht near Salinas, Ecuador (2°10′S, 81°00′W), a highly active solitary humpback whale was approached and followed for a continuous 65-min period. The photograph records provided an opportunity to document the short-term loss of barnacles from four areas on the body of the whale: the right side of the head, left side of the head, inner side of the right flipper tip, and external side of the left flipper tip. Photographs of these locations were taken at different times with a Canon Digital Rebel at maximum resolution (6.3 megapixels) equipped with a 70–300-mm zoom lens, then photographs were analyzed to look for differences in the number of barnacles attached. Microsoft Photo Editor was used to improve the contrast and clarity of the photographs for comparison. The exact time of each photograph was taken from the camera's digital readout data. Other sites on the whale where barnacles were abundant such as the tip of the lower jaw, the forward edge of the fluke, and the ventral region, could not be photographed or the photographs taken were not of sufficient quality to be used in the comparison.

The observation started at 1540 and ended at 1645, during which 63 photographs were taken. Data were recorded continuously through two 15-min intervals and one 35-min interval. Three specific displays were used in the assessment: backward breaches, forward breaches, and flipper slaps. The types of displays and their frequency in each interval are shown in Table 1. Backward breaches occurred with similar

Table 1. Frequency of displays executed in each interval and rates (*n*/minute).

	Interval I (1540–1555)		Interval II (1555–1610)		Interval III (1610–1645)	
Display	*n*	Rate	*n*	Rate	*n*	Rate
Backward breach	5	0.33	1	0.07	15	0.43
Forward breach	12	0.8	32	2.13	15	0.43
Flipper slap	3	0.2	2	0.13	73	2.08

Table 2. Initial and final counts of barnacles on four parts of the whale and their removal rates.

	Initial count		Final count		
Body part	*n*	Time	*n*	Time	Removal rate
Left side of the head	10	1547	9	1642	0.10
Right side of the head	2	1552	2	1640	0
Right tip of the flipper	19	1554	19	1640	0
Left tip of the flipper	46	1554	43	1640	0.065
Global rate					0.052

frequency during the first and third intervals, but decreased significantly during the second interval ($\chi^2_2 = 4.25$, $P < 0.05$). Conversely, the frequency of forward breaches was lower in the first and third intervals and significantly higher in the second interval ($\chi^2_2 = 34.04$, $P < 0.01$). Flipper slaps were executed with a low frequency during the first two intervals but increased significantly in the third interval ($\chi^2_2 = 41.96$, $P < 0.01$).

Table 2 shows the number of barnacles recorded at the time of the first and last photographs and their removal rates for each part of the whale. Losses were noticed on the right side of the head ($n = 1$) (Fig. 1) and on the left flipper tip ($n = 3$) (Fig. 2). The barnacle removed from the right side of the head fell off sometime after the second 15-min interval started, when the rate of forward breaching increased,

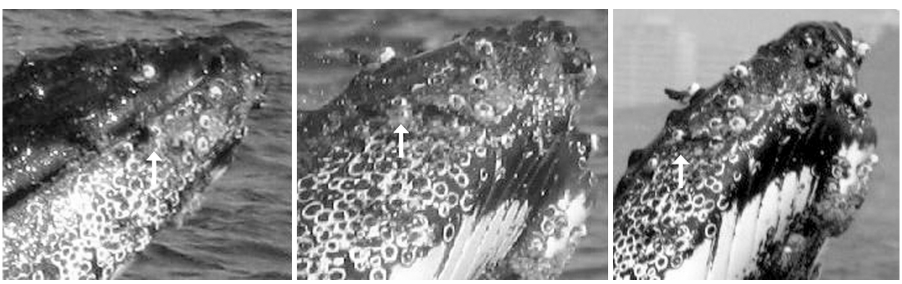

Figure 1. Photos of the right side of the head taken at 1547 (left), 1608 (center), and 1642 (right). White arrows in the left and center photos show the barnacle prior to removal and the white arrow in the right photo indicates the site from where it was removed.

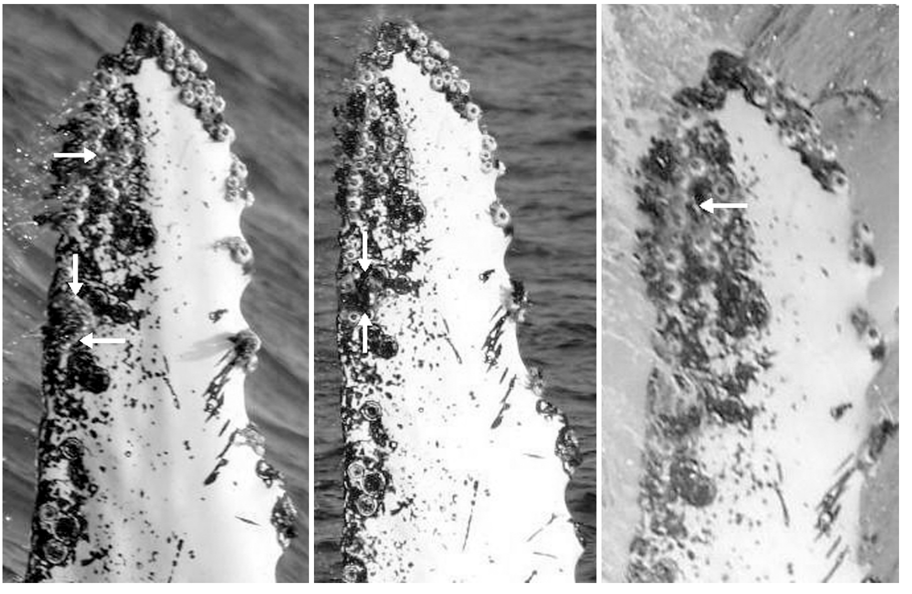

Figure 2. Photos of the outer side of the left flipper taken at 1554 (left), 1631 (center), and 1640 (right). White arrows in the left photo indicate the barnacles prior to removal, white arrows in center show the sites from where two barnacles were removed, and the arrow in the right photo indicates the site from where a third barnacle was removed.

and the three barnacles removed from the left flipper tip occurred during the third interval, when the rate of flipper slaps increased significantly (see Table 1). This suggests a relationship between barnacle detachment and these particular surface displays, but without control groups it is not possible to establish how many barnacles dislodged naturally or due to whale behavior. However, it is unlikely that all removed barnacles detached spontaneously, *i.e.*, without help of the surface activity; otherwise all barnacles would have detached from the assessed parts (and from other parts with similar removal rates) in 1,251 min (20.8 h). If the global rate showed in Table 2 is extrapolated to the whole whale a considerable amount of barnacles could have been detached during the sighting period.

It must be noted that in addition to slaps, barnacles on the flippers receive abrasion during breaching, which would weaken the barnacles' attachment. Rubbing during male competition (see Tyack and Whitehead 1983, Baker and Herman 1983) would also reduce barnacle resistance in breeding animals, especially those located on appendages. Big barnacles and scars on the head of the whale left from previously detached barnacles (see Fig. 1) suggest either that barnacles had stop growing or that they are removed at a similar and particular size. Larger and massive barnacles would be more easily removed as they grow taller and heavier, increasing drag and surpassing the force of adherence of the barnacle to the whale.

The form and size of the barnacles in the photographs on both the head and flippers of this individual indicate that they were *Coronula diadema*, the more common barnacle species present on humpback whales (Clarke 1966), although it is possible that *C. reginae* was also present because this species settles mainly on the lips and edges of the flippers (Cornwall 1927, cited by Clarke 1966).

Recently, we confirmed that barnacles attach to humpback whales in the tropics at a very early stage of life and that their growth rate is fast, as noticed by Dawbin (1988). A 6.4-m humpback whale calf that beached on 30 August 2005 at Salinas was examined by one of us (JF). Its ventral groves area behind the knobs of the lower jaws tip was infested with hundreds of small *C. diadema*, some as large as 1.5 cm in diameter. This part of the whale would be first colonized during lactation by just spawned larvae released from adult barnacles attached to the genital area of the lactating female. Such form of transmission from mother to offspring suggest that the free-swimming cypris larvae of *C. diadema* settle down soon after spawning, which would explain why the humpback whale is a highly specific host of this barnacle.

From this opportunistic sighting it is not possible to establish with certainty that surface activity was the primary cause of barnacle removal or whether it just accelerated the natural detachment process. Nor can it be discarded that dislodging barnacles was the main reason to carry out such vigorous surface activity, despite the low removal rate found. Not much can be added with respect to the behavior of the whale in a social context, because no whales were interacting with this individual nor was any other group of whales around. If any information or signal was sent through the whale behavior it was not evident to us, but the lack of response from conspecifics could have been a reason to continue the activity. Observations made during our long-term humpback whale study in Ecuador suggest that solitary subadults and adult males that are forming competitive groups have the highest level of surface activity (Félix 2004). Such continued activity is rather atypical and has been recorded in only 8 of 136 (6%) solitary animals observed in 15 yr.

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