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Feeding of sea lampreys *Petromyzon marinus* on minke whales *Balaenoptera acutorostrata* in the St Lawrence Estuary, Canada

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Sea lampreys *Petromyzon marinus* were observed on 109 occasions on 47 individual minke whales *Balaenoptera acutorostrata*. Bloody lesions could be identified as previous attachment sites, indicating *P. marinus* feeding on *B. acutorostrata* blood.

Key words: anadromous; blood; cetaceans; host; marine; parasite. [Correction added after online publication 15 December 2010]

Little information exists on the hosts of anadromous lampreys during their marine phase. Observations of scars on freshly killed cetaceans and comparison with lamprey dentition have provided some evidence that lampreys occur on fin whales *Balaenoptera physalus*, sei whales *Balaenoptera borealis* and harbour porpoise *Phocoena phocoena* (Japha, 1910; Pike, 1951; Nemoto, 1955; van Utrecht, 1959). Recent photographic documentation indicated that sea lampreys *Petromyzon marinus* L. occur on the North Atlantic right whales *Eubalaena glacialis* (Nichols & Hamilton, 2004) and Pacific humpback whales *Megaptera novaeangliae* (P. Nilsson, pers. comm.). Sergeant (1963) speculated that freshly healing scars on a western North Atlantic minke whale *Balaenoptera acutorostrata* were caused by lampreys based on comparisons with Pike's (1951) observations. While many of the above authors hypothesized that these attachments indicated feeding, field observations supporting this hypothesis are scarce. During this study, *P. marinus* occurrence and apparent feeding on *B. acutorostrata* in the St Lawrence Estuary (48° 00′ N; 69° 20′ W) were photographically documented.

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Research cruises were conducted on a daily basis (weather permitting) aboard one to three small (5–7 m) rigid-hull inflatable vessels. Photographs were taken using single lens reflex cameras equipped with 300 mm fixed focal length lenses on ISO 200 slide film to allow identification of individual *B. acutorostrata* based on dorsal fin markings and body scars (Dorsey, 1983; Tscherter & Morris, 2005). Attachments of *P. marinus* were recorded and photographed when possible. Following an observed *P. marinus* attachment, special focus was put on the re-documentation of the attachment on the individual *B. acutorostrata* during subsequent observations. Detachments were recorded when the attachment site on an individual *B. acutorostrata* was observed free of *P. marinus*.

Petromyzon marinus were observed on 109 occasions on 47 individually identified *B. acutorostrata* during the years 1999–2004. The earliest date *P. marinus* were observed in a year was 24 June and the latest date was 20 October. The majority (83%) of the observations occurred in July and August. Of these observations, 84 were documented photographically (Fig. 1). The lamprey shown in Fig. 1 can be identified as *P. marinus* based on body shape and size (total length *c.* >0·5 m), two distinct dorsal fins and colouration (bluish-brown with blackish mottled patches). Although photographs were rarely of sufficient quality to allow confident species identification, it was assumed that the species observed in all cases was *P. marinus*, because it is the only lamprey known to occur in Canadian Atlantic Ocean waters and the St Lawrence Estuary (Scott & Scott, 1988; Scott & Crossman, 1998; Nozères & Bérubé, 2003). The number of *P. marinus* observed attached to a single *B. acutorostrata* ranged from one to four. In 18 cases, the same *B. acutorostrata* was observed multiple times with one or more *P. marinus* attached at the same body

Fig. 1. *Petromyzon marinus* attached to *Balaenoptera acutorostrata* in the St Lawrence Estuary, Canada.

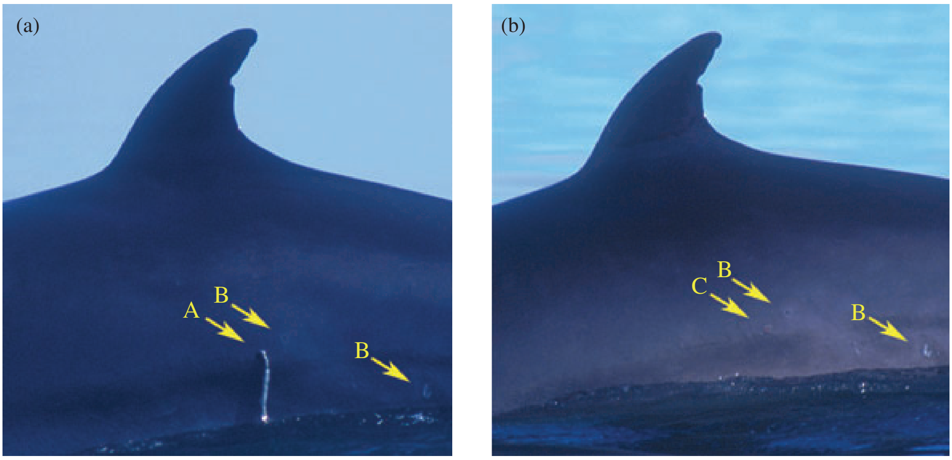

FIG. 2. (a) *Petromyzon marinus* attached to *Balaenoptera acutorostrata* (A). Note scars (B) used to pinpoint attachment site. (b) Bloody lesion (C) at attachment site on the same individual whale *c*. 180 min later.

location over a period of days to months (2–87 days, mean = 15 days, median = 6 days). In these cases, the same *P. marinus* were probably attached for the duration of the observation, but this could not be confirmed. On two occasions, individual *B. acutorostrata* were observed immediately (maximum of 20 and 180 min) following *P. marinus* detachment, and bloody lesions on the body could be precisely identified as the area of previous *P. marinus* attachment based on orientation relative to body markings (Fig. 2).

The bloody lesions observed immediately following detachment indicate that *P. marinus* are gaining access to blood during attachment. Blood is thought to be the primary food of adult *P. marinus* (Farmer, 1980), which attach to their host with an oral disc and rasp through tissue with a tongue-like piston tipped with denticles that form cutting edges (Hardisty & Potter, 1971). Cetacean skin contains vascular networks that extend through the dermis along with the dermal papillae that interlace with the epidermis (Parry, 1949; Sokolov, 1960; Giacometti, 1967; Yablokov *et al*., 1974). Published measurements of *B. acutorostrata* epidermal thickness range from 0·8 to 1·7 mm (Sokolov, 1959; Yablokov *et al*., 1974; de Bakker *et al*., 1997). The dermal papillae and associated capillaries in the skin of the ventral pouch of a juvenile *B. acutorostrata* measured by de Bakker *et al*. (1997) extended 0·8 mm into the 1·5 mm thick epidermis (or *c*. 0·7 mm from the surface). The vascular networks extending into the epidermis of *B. acutorostrata* and other cetaceans would allow attached lampreys access to blood following penetration of tissue depths of <1 mm. It is reasonable to assume that such penetration happens regularly during *P. marinus* and other parasitic lamprey attachments on cetaceans.

In several instances, scrape marks along the body of a *B. acutorostrata* indicated that an attached *P. marinus* had moved backwards along the whale's body, similar to the multiple and sliding attack marks observed on fish hosts of landlocked *P. marinus* (King, 1980; Ebener *et al*., 2006). On at least one occasion, abrasions on a *B. acutorostrata* body indicated that the attached *P. marinus* had moved *c*. 1 m forward along the body of the whale from the point of initial attachment and against the flow of water that is generated by the forward swimming of the whale. This is probably an energetically expensive activity and may indicate that the *P. marinus* was actively seeking areas of greater access to blood or decreased water flow. It is unclear if all areas of a whale's body could provide equal access to blood, although Sokolov (1959) measured *B. acutorostrata* epidermal thickness as a percentage of total skin thickness at 4, 6 and 50% at the ventral, dorsal and fluke surfaces, respectively, noting that epidermal thickness was always greatest at 'working places', *e.g.* flippers and flukes. In the estuary, *B. acutorostrata* frequently exposed much of their body, particularly during feeding behaviour (Kuker *et al.*, 2005), however, no *P. marinus* were documented on whales' flukes, flippers or ventral surfaces. Water flow and epidermal thickness may be the reason for the lack of attachments on flippers or flukes, while the expansion of the grooved ventral pouch during feeding may prevent *P. marinus* attachments on much of the ventral surface despite the relatively thin epidermis. As the entire body of a *B. acutorostrata* was never seen during observations, it was impossible to make many firm conclusions regarding *P. marinus* attachment site preference; however, all observed attachments were on the dorsal portion of the whale, mostly on the flanks below or posterior to the dorsal fin. The prevalence of dorsal attachments is likely to be a product of the relatively thin epidermis and reduced water flow in comparison to flippers and flukes, and the continual expansion of the ventral pouch during feeding. In a sub-set of 28 observations chosen for high image quality, 30 (94%) of 32 total *P. marinus* were attached below (8, 25%) or behind (22, 69%) the dorsal fin, while the remaining 2 (6%) were located on the flanks forward of the dorsal fin. The large proportion of posterior flank attachments may be a product of availability to a pursuing *P. marinus* attempting to overtake its prey and reduced water flow in comparison to flukes and anterior regions. One (3%) *P. marinus* was attached on the dorsal midline, 19 (59%) were on the right side and 12 (38%) were on the left. Beamish (1980) noted a higher proportion (64–77%) of lamprey scars on the right side of Atlantic salmon *Salmo salar* L., but the cause of this apparent preference is unclear in both cases.

In the estuary, *B. acutorostrata* regularly swam at speeds >1 m s^{-1} when travelling or resting (U. T. Tscherter, unpubl. data) whereas laboratory and field telemetry studies indicate that *P. marinus* generally swims at speeds <1 m s^{-1} (Stier & Kynard, 1986; Quintella *et al.*, 2009). Applegate (1950) noted that *P. marinus* is capable of bursts of extreme speed ($\leq 3{\cdot}9$ m s^{-1}; Hunn & Youngs, 1980) while ascending dams and falls and speculated that prey was overtaken in the same manner. If such energetically expensive bursts are the means by which *P. marinus* and other lampreys attach to fast-swimming cetaceans, lampreys probably gain energetic benefit from such attachments, further supporting the hypothesis that lampreys attached to cetaceans are feeding. As far as is known, the observations described here provide the first *in situ* evidence that lampreys actively feed on cetacean blood.

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