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Olfactory Organs of Two Pelagic Teleost Fish—Opah (*Lampris guttatus*) and Dolphin fish (*Coryphaena hippurus*)

Ralph R. MANA, and Gunzo KAWAMURA

Abstract

Olfactory organs of two pelagic teleost species—opah (*Lampris guttatus*) and dolphin fish (*Coryphaena hippurus*) were investigated with scanning electron microscope. Gross morphological observation showed that in both fish the paired olfactory organ is situated on the snout. Anterior and posterior openings are present in both fish. Numerous number of lamellae radiate around a short raphe. Olfactory ventilation sac is present in both fish but is more developed in opah. Olfactory sensory epithelium is found intermingled as islets or patches within the nonsensory epithelium. Ciliated olfactory receptor neuron and microvillous olfactory receptor neuron are observed in both fish with the former being more abundant. The population of receptor neurons is estimated to be ~3.0 and ~7.7 million in opah and dolphin fish respectively. Ciliated nonsensory cell is rare or absent in all lamellae examined while goblet cells are observed in both sensory and nonsensory epithelia. Epidermal cells forming microridge of finger-print like patterns are the primary cells forming the nonsensory epithelium.

Keywords: *Coryphaena hippurus*, *Lampris guttatus*, olfactory organ, pelagic fish

Introduction

Vision and chemoreception are probably the most important sensory systems used in oceanic fish in search of food in vast pelagic environment. Olfaction in particular has shown to induce prey-searching behaviors and feeding responses in little tuna (*Euthynnus affinis*) and yellowfin tuna (*Thunnus albacares*) (VAN WEEL, 1952). ATEMA *et al.* (1980) demonstrated that the yellowfin tuna can form chemical (olfactory) search image in procurement of food as a convenient system that enables the fish to switch to a major food source while ignoring less abundant food source. As a means to delay dilution of potent cues in open ocean, prey odors and other chemical cues are being entrained in lipid components of liposomes so as to provide persistent arousal and search cues for tunas (WILLIAMS *et al.*, 1992) and other pelagic critters. Recently, similar chemosensory information carriers are found in land animals (LAZAR *et al.*, 2001).

Olfactory cues are detected by the olfactory organ and relevant behaviors are released in any given organism. Literature showed that structures of olfactory organ of Genus *Thunnus* were studied especially its relevance to Scombridae taxonomy (IWAI and NAKAMURA, 1964). GOODING (1963) revealed that the skipjack (*Katsuwonus pelamis*) has a well-developed olfactory organ and showed that the olfactory ventilation sac may function

Laboratory of Fish Ethology, Kagoshima University, 4-50-20 Shimoarata, Kagoshima 890-0056, Japan.

as a pumping device to draw in water into the olfactory chamber during swimming. By scanning electron microscopy YAMAMOTO and UEDA (1979) first studied the olfactory organs of bluefin tuna (*Thunnus thynnus*) and other small pelagic fish. MANA *et al.* (1998) also revealed that the olfactory organs of some large pelagic species possess two types of olfactory receptor neurons—ciliated and microvillous olfactory receptor neurons on the lamellar surface, both of which are comparable to the receptor neurons found in red sea bream (*Pagrus major*) (MANA, 2001). Further the olfactory system in bigeye tuna (*Thunnus obesus*) and striped marlin (*Tetrapturus audax*) not only possess an olfactory ventilation sac but the density of olfactory neurons ranged from 40 000–68 000/mm^2 (MANA, 2000).

To reveal the diversity of olfactory systems in pelagic fish, the olfactory organs of opah (*Lampris guttatus*) and dolphin fish (*Coryphaena hippurus*) were investigated with scanning electron microscopy. Results indicated that opah has a well-developed olfactory ventilation sac with ~3.0 million olfactory receptor neurons in one rosette while dolphin fish has ~7.7 million olfactory receptor neurons per rosette. Adaptive morphological features of the olfactory systems of pelagic fish are discussed in relation to pelagic mode of life.

Materials and methods

Source of Materials

Specimens used in this study were caught by tuna longline on board Kagoshima University training vessel, Keiten Maru during ocean cruise at Northern Pacific and South of Okinawa in 1996–1997. Table 1 showed the localities where fish were sampled, standard body length and number of lamellae per olfactory organ.

Ultrastructures

For scanning electron microscopic (SEM) observation, specimen was sacrificed by decapitation. Immediately each nasal sac was flooded with 2.5% glutaraldehyde in 0.1M cacodylate buffer (pH 7.4) through anterior nasal opening for ~10 min as suggested by MORAN *et al.* (1992). Then the rosettes were surgically removed and fixed in the same fixative for 12 hr. The lamellae were post-fixed in 1% OsO_4 for 2 hr. After dehydrated through a gradient series of ethanol, the lamellae were dried in liquid CO_2 critical-point apparatus Hitachi HCP-2, coated with platinum-palladium in a Hitachi E-1030 ion sputter and viewed with a Hitachi S-430 scanning electron microscope.

In density analysis of olfactory receptor neurons (ORNs) we estimated the number of ORNs based on the SEM micrographs that included both nonsensory and sensory regions to minimize the effect of the unique sensory pattern in both fish. Micrographs were taken randomly on lamellar surface at a magnification of 2000 depicting an area of 750 μm^2. The counts were then converted to density/mm^2. Lamellar areas were determined by cutting and weighing of the well-preserved lamellae. A total of 16–24 micrographs from the lamellae of 3–5 rosettes in each fish species were examined.

Results

Gross Morphology of Olfactory Organ

The opah and dolphin fish possess a pair of olfactory organs situated on the dorsolateral side of the head just anterior to the eye (Fig. 1 A, B). The olfactory chambers are not

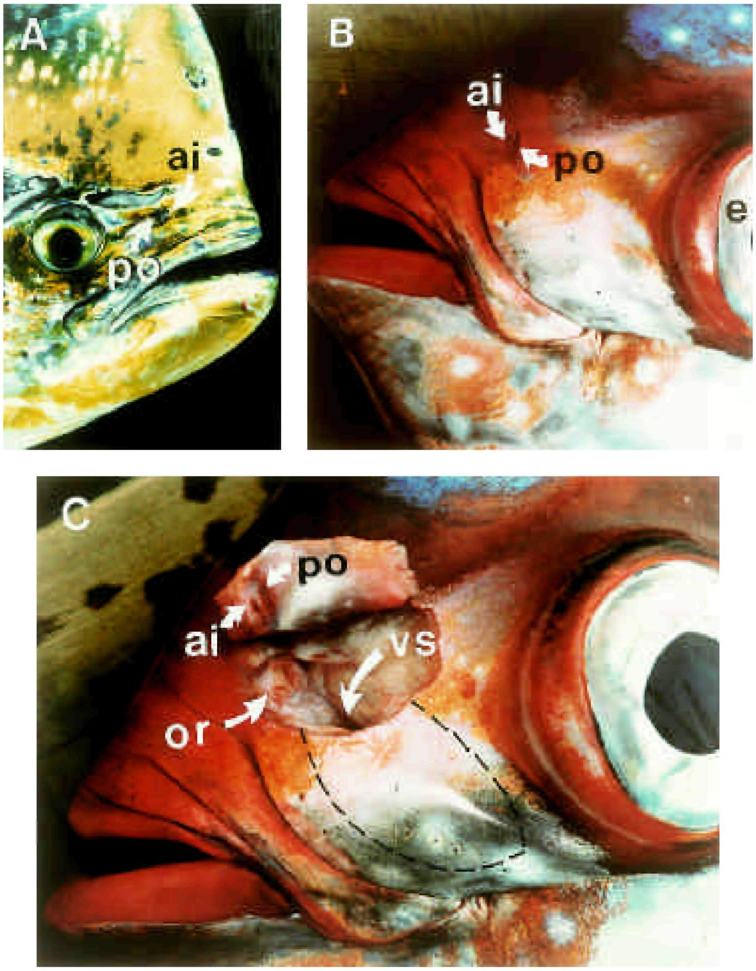

Fig. 1 Head region showing the position of olfactory nostrils and olfactory organ in (A) dolphin fish and (B) opah. (C) Olfactory chamber of opah exposing the olfactory rosette (or) and an opening leading to a ventilation sac (vs) as shown by the hatched lines. (ai) anterior opening, (po) posterior opening, (e) eye.

connected to the respiratory system in both species. When a pelagic fish swims in open seas/oceans the water containing odorants enters into the olfactory chamber via an anterior inlet and exits via a posterior outlet. In both species, the inlet and outlet are separated by a nasal bridge of epidermal tissue which is ~1–2 mm wide in both species and the inlet is smaller (~1 mm diameter) than the outlet (~2 mm diameter). In the dolphin fish an