Anatomy and Disorders of the Oral Cavity of Ornamental Fish

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KEYWORDS

• Fish • Infectious disease • Oral anatomy • Feeding behavior • Neoplasia

KEY POINTS

- Oral anatomy in fish varies greatly by taxonomic family, feeding behavior, life stage, and natural habitat; failure to provide the appropriate husbandry and diet type can result in fish disease and deaths.
- An oral examination should always be included as part of the minimum database when examining fish.
- The oral cavity is subject to infectious diseases, trauma, and neoplasia.
- In-house exfoliative cytology is a quick, easy tool to use as an aid in the diagnosis of oral cavity diseases.
- Differentiation of lesions that seem similar helps determine effective treatments rather than using a polypharmacy approach.

INTRODUCTION

Pet (or ornamental) fish represent the largest and most diverse group of exotic animals kept as pets. It is estimated there are more than 4500 species of freshwater fish and 1450 species of marine ornamentals traded[1] to be kept in captivity privately, or displayed, worldwide. There is an immense variety of anatomic adaptations in fish.

ANATOMY AND PHYSIOLOGY OF THE ORAL CAVITY IN FISH

The oral anatomy of each family or a single species has evolved to best suit the local natural habitat or environment, feeding behaviors, food or prey type, location of the food or prey in the water column, and as an aid in reducing interspecific competition for food within a habitat. The function of the oral cavity is not only for the prehension and ingestion of food but can also include raising offspring (mouthbrooding) and as an

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aid in the detection of environmental chemical changes. The anatomy can change or be fixed over the life of the animal, from fry to adult.

Skeletal Structure of the Oral Cavity

The skeletal components of fish vary according to the phylogenetic changes from less advanced fish, the cartilaginous fishes, including elasmobranches (*Chondrichthyes*), to the bony fish (*Actinopterygia*). In general, the fish oral cavity is composed of the lower jaw, the upper jaw, the palate (dorsally), and the hyoid apparatus ventrally (**Fig. 1**).

In contrast to terrestrial animals, the upper jaw consists of the premaxilla and the maxilla (caudal to the premaxilla) in most fish.[2] The caudal portion of the maxilla is often more mobile in comparison with other vertebrates, contributing to the complex series of muscle and skeletal movements required to produce an effective gape (open mouth) for food prehension. During feeding, the premaxilla protrudes rostrally to provide the dorsolateral aspect of the gape. In most fish, this movement enhances the suction required for feeding. Ventral and posterior movement of the mandible passively enables premaxillary protrusion by the presence of a ligament connecting the caudal aspect of the premaxilla to the caudal end of the dentary bone of the mandible.[3]

One study found a specialized adaptation of the *adductor mandibulae* muscle in some cyprinodontiform fish (*Fundus, Gambusia,* and *Poecilia* sp).[3] This adaptation enables the premaxilla to actively retract producing a forceps like control of the upper and lower jaws giving more dexterity to the mouth.[3] Instead of using suction feeding methods, these fish pick the prey from the water column or graze on substrate. In some species of loricariid and synodontid (*Siluriformes*) catfish, this adaptation works very well for algal scraping from substrates, the preferred feeding mode of these fish.[3]

The lower jaw, the mandible, consists of 3 bones: the more anteriorly placed dentary bone, the central angular bone, and the articular bone. Some fish have an intramandibular joint (IMJ) between the dentary and fused angular-articular bones.[2,4,5] Interestingly, fish species that have an IMJ have better dexterity in feeding; these fish commonly feed by removing food attached to a substrate or by biting pieces off sessile structures.[2,3] A common freshwater aquarium fish, *Helostoma temminckii*

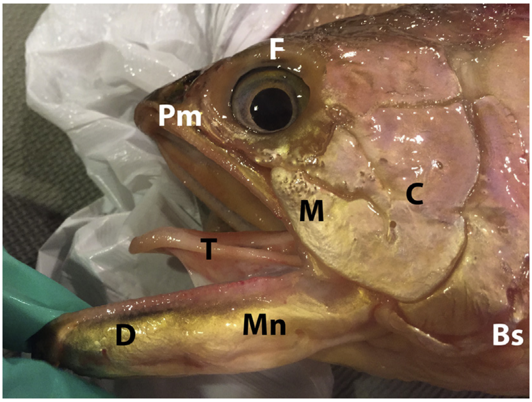

Fig. 1. Skeletal structure of the head. Bs, branchiostegal membrane; C, cheek; D, dentary bone; F, frontal bone; M, maxilla; Mn, mandible; Pm, premaxillary bone; T, tongue. (*Courtesy of* Helen Roberts-Sweeney, DVM, Williamsville, NY; with permission.)

(kissing gourami), is an example of one species with an IMJ.[2,3] The IMJ allows full 360° contact of the mouth on a substrate during a scraping or biting motion to obtain diatoms and microalgae, components of *Helostoma*'s diet in the wild.[2,3] The cost of this anatomic feature is a reduced ability to produce an effective suction, the method most fish use for feeding.[4]

Syngnathidae (seahorses, sea dragons, pipefishes, sea moths, and shrimpfishes) possess a tubular-shaped mouth whereby only the lower jaw is protractile.[6–8] The cranium is connected mechanically to the hyoid apparatus. Prey is captured by simultaneously elevating the head, rapidly depressing the hyoid apparatus, and opening the mouth.[7] Suction is created in the oral cavity by this movement, allowing water (and prey) to enter the small mouth.[7,8]

The parasphenoid bone, located ventrally to the cranium, represents the dorsal aspect of the oral cavity. This bone functions as the hard palate in most fish. Posterior to this bone is the basioccipital bone. Koi (*Cyprinus carpio*) and goldfish (*Carassius auratus*) have lower pharyngeal teeth that grind food against a hard, cartilaginous pad, known as the carp stone, located ventral to the basioccipital bone.[8,9] In koi, molarlike upper pharyngeal teeth are embedded in the pharyngeal pad and shed periodically.[8] To the joy of their owners, these teeth are often seen on the floor of a lined pond, white against the black color of the pond liner, or found in skimmer boxes.

The hyoid apparatus, located on the ventral midline, provides support to the tongue, connects to the mandible, and generates suction in the buccal cavity when depressed ventrally during feeding.[10] In one study, it was found that in addition to the cranial muscles providing some muscle power, it was estimated that the hypaxial and epaxial muscles contributed more significant muscle power for maximum hyoid depression to create the high suction power required for feeding in largemouth bass (*Micropterus salmoides*).[11,12] One study demonstrated the axial musculature may actually contribute 95% of the power for suction feeding in the largemouth bass.[12]

One skeletal structure of importance in the hyoid apparatus is the branchiostegal rays, flat bars that support the branchiostegal membrane.[8] This membrane stretches from the ventral aspect of the opercular flap (a hard bony flap that covers and protects the gills) to the midline of the pharynx and functions as a gasket to help close the operculum when the pharynx is expanded by water intake during suction feeding.

Dentition in Fish

Dentition in fish varies tremendously. Possible combinations include no teeth, small teeth, multiple rows of teeth, pharyngeal teeth (upper only or both upper and lower), platelike teeth, and teeth on gill rakers.

Members of the Osteoglossidae (bonytongues) family have a toothlike bony structure on the floor of the mouth. This structure has teeth and can be used to bite prey when pressed against the dorsal aspect of the mouth (**Fig. 2**).

Soft Tissue of the Oral Cavity

The oral cavity of most fish is lined by stratified epithelium containing numerous mucous cells.[13] Mucus serves to lubricate the surface of the mouth and may provide protection from abrasions.[14] Numerous taste buds are distributed throughout the oral cavity and also appear on barbells.[8,13] Taste bud density can be as much as $1600/cm^2$ in some fish.[8] Taste buds in the oral cavity are innervated by the vagus nerve. Fish that ingest and spit out undesirable objects, such as goldfish that possess a high density of taste buds in the oral cavity, have enlarged vagal lobes of the brain.[8]

Many, but not all, fish have a ventrally placed tongue, also populated with taste buds.

Fig. 2. Open mouth view of Asian Arowana (*Scleropages formosus*) showing bony tongue. (*Courtesy of* Helen Roberts-Sweeney, DVM, Williamsville, NY; with permission.)

Feeding Behaviors

Suction feeding is the most common type of feeding behavior in fish.[2–5,14,15] Suction is created by opening the mouth when the food is close, expanding the mouth laterally, and, simultaneously, lowering the floor of the mouth (primarily by hyoid depression). This movement creates negative pressure and allows water and food to be sucked into the oral cavity (**Fig. 3**).

Fig. 3. *Leuciscus idus* (golden orfe) showing gape (open mouth) and food entering mouth via suction created. (*Courtesy of* Helen Roberts-Sweeney, DVM, Williamsville, NY; with permission.)

Once the jaws are closed, oral valves help to prevent food from escaping out of the mouth via the gills with the exiting flow of water.[13] The hyoid apparatus is raised and the sides of the mouth contract, forcing trapped water out of the mouth through the gills. Gill rakers, found on the medial aspect of the gill arch, help strain any food from the outflowing water, keeping it in the oral cavity until it is swallowed.[8]

Other types of feeding behaviors include ram or lunge feeding (forward swimming over prey), suction of tiny crustaceans (syngnathids), biting encrusted algae, ambush attacks, rotational feeding (the fish clamp down on the prey, tearing large chunks off while spinning the its body), suspension feeding (or filter feeding), and scraping/substrate grazing of algae.[3,14] Most of these can be grouped into suction feeding or biting behaviors. Ram feeders actively chase their prey. Fish that use the biting technique swim towards their prey, often opening their mouths while still distant from the food. Grazing or substrate feeders use biting type methods in feeding. In most fish, there is a combination of feeding methods used, with suction feeding predominating.

Failure to provide appropriate substrate or proper food sources for captive fish species may lead to numerous problems, including chronic stress, nutritional deficiencies, starvation, and general debilitation, leading to secondary infections and immune suppression. Environmental enrichment feeding goals should address the natural feeding behaviors of fish.[16]

Mouthbrooding

At least 8 families of fishes practice mouthbrooding (also known as oral or buccal incubation) of the eggs and fry (recently hatched fish).[17–19] The most well-known ornamental fish are members of the Cichlidae family (freshwater tropical cichlids) and Apogonidae (marine cardinal fish).[19] Strategies vary and include biparental, female-only, and male-only mouthbrooding.[18] It is hypothesized that mouthbrooding evolved from biparental substrate guarding.[18,19] Mouthbrooding fish can experience difficulty in hypoxic conditions.[18] Hypoxic conditions increased the need for increased ventilation. Increasing ventilation can be difficult with a large brood of eggs occupying a large volume of the oral cavity. Filial cannibalism or eggs being spit out can occur when hypoxic conditions require increased ventilation because of the large volume the egg mass occupies in the oral cavity.[18] One study demonstrated one species of cardinal fish, *Apogon fragilis*, spat out eggs more readily in response to hypoxia than another cardinal fish, *Apogon leptacanthus*.[18] The primary reason seems to be because *A fragilis* males tend to hold a larger egg mass in their mouths, up to 26% of their body weight compared with *A leptacanthus*, whose egg mass was only 14% of body weight.[19] In cases of continued loss of egg masses by mouthbrooding fish, checking water-quality parameters, particularly dissolved oxygen, would be a crucial part of the case workup.

It is also worth noting that temperature has been shown to affect sex of the offspring in one species of farmed mouthbrooding cichlids, *Oreochromis niloticus*, (Nile tilapia).[20] Male fish are preferred because they grow faster, reaching marketable size sooner. This fact may have future commercial applications but is not the current practice today; the current method includes exposure to 17,α methyltestosterone, as fry causes females to become phenotypically male.[21]

In a fish version of size matters, the female Banggai cardinal fish, (*Pteragon kauderni*), produced heavier, larger eggs when paired with large males compared with small clutches when paired with small males.[22] Banggai cardinal fish are obligate paternal mouthbrooders, so choosing a larger male for commercial or home spawning may yield higher numbers of viable offspring.

Studies indicate fry from mouthbrooding parents may receive passive immunity to aid in the prevention of some disease outbreaks. Fry of the maternal mouthbrooding *Oreochromis aureus*, blue tilapia, were protected by passive transfer of protective immunity from mothers vaccinated against *Ichthyophthirius multifiliis*.[23]

Many hobbyists keep species that originate from the same natural environment or geographic area. The colorful, engaging African cichlids are a very common group that is kept in a multi species tank. Freshwater species of the African Great Lakes (Lake Malawi, Lake Victoria, and Lake Tanganyika) are commonly kept in community or cichlid tanks by hobbyists with other species. One popular addition to these African Rift lake tanks is the *Synodontis* sp catfish, also native to Africa. One species in this group, *Synodontis multipunctatus*, is a known brood parasitic catfish.[24] *S multipunctatus* is attracted by spawning cichlids (presumably by smell) and spawns at the same time and in the same location as the spawning cichlid pairs. The cichlids will take up the eggs of this catfish and buccal incubate them with their own eggs. The catfish fry typically hatch earlier than the cichlid fry and will eat the cichlid fry as they hatch inside the female's mouth. The female cichlid will care for and protect them while they are vulnerable. A great video example of this behavior can be found online.[25]

CLINICAL DISORDERS OF THE ORAL CAVITY

Both a good history and physical examination are of paramount importance for effective diagnosis of disease in all animals, and fish are no different. There are several textbooks that discuss how to perform a thorough history[26–28] and complete physical examination in fish.[29–33] Sedation will help facilitate an examination and should always be used if the fish is fractious or has the potential to cause injury to itself and the practitioner. A standard otoscope or small rigid endoscope can be used to illuminate the oral cavity for examination in small fish (**Fig. 4**A).

Oral examinations on larger fish can be accomplished with a direct illumination into the open mouth (see **Fig. 4**B) using a flashlight or an endoscope. A thorough understanding of the normal anatomy of the species is necessary to diagnose or differentiate an actual lesion from a normal anatomic structure. In most cases, bilaterally symmetric structures are normal, such as the rough oral pads seen in the tiger shovel-nosed catfish (*Pseudoplatystoma* sp) shown in **Fig. 4**B. Examination of a noninfected cohort of the same species can also help identify normal anatomic structures.

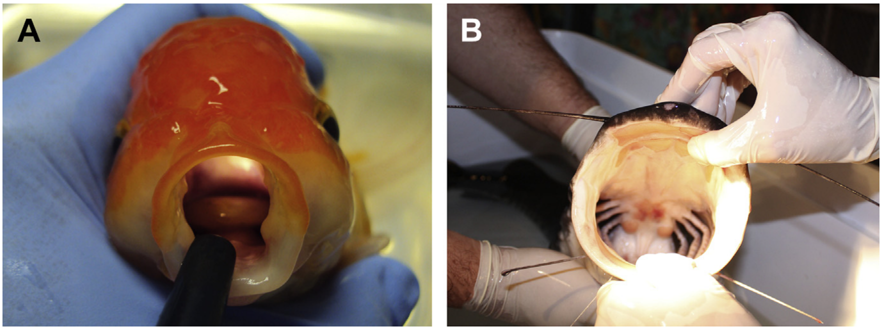

Fig. 4. (*A*) Illumination of the mouth of a goldfish (*Carassius auratus*) with an otoscope. (*B*) Open mouth of tiger shovel-nosed catfish (*Pseudoplatystoma sp*) illuminated by flashlight. (*Courtesy of* Helen Roberts-Sweeney, DVM, Williamsville, NY; with permission.)

This article placees emphasis on infectious, neoplastic, traumatic, and toxic disorders of the oral cavity in fish.

The oral cavity of fish has direct access to the external environment resulting exposure to environmental pollutants and pathogens. In addition, captive fish are subject to issues relating to poor husbandry techniques and management practices.

Infectious Diseases

In captive fish populations, most infectious disease is related to a failure to quarantine new animals. Rapid transmission can occur in closed, recirculating systems, especially if husbandry and water quality are marginal. Viral diseases in fish usually have a specific viral permissive temperature range. It is important to quarantine susceptible species within this temperature range for an adequate length of time. For example, quarantining koi (*C carpio*) at 16°C to 28°C is recommended to allow for clinical signs of koi herpesvirus (cyprinid herpesvirus 3).[34] Quarantine is one example of the necessary, but often ignored, biosecurity practices necessary to keep infectious disease to a minimum in a stable population.

Viral diseases of concern affecting the oral cavity

1. Cyprinid herpesvirus 1 (carp pox) causes hyperplastic, papillomatous, smooth, candle wax–appearing cutaneous lesions, primarily in cooler water (<20°C/68°F). These lesions can regress in warmer water. Oral lesions typically involve the lips (**Fig. 5**) but the lesions can appear anywhere on the skin. Koi hobbyists are primarily concerned over the cosmetic appearance if they are involved in showing their fish. The virus has been shown to be lethal in koi fry but is not typically a problem in adult fish.[35]
2. Lymphocystis is the most common viral disease seen in pet fish.[35,36] The causative agent is an iridovirus, and the disease affects marine and freshwater species with varying susceptibility. The virus causes dermal fibroblasts to hypertrophy, up to 10,000 times their normal size.[35] A typical clinical sign is the appearance of multiple focal gray or white masses. Wet mounts of skin scrapings will demonstrate the hypertrophied cells. Lesions often regress over time, especially with stress-reduction techniques and careful handling practices.[35,36] If the lesions are located in, on, or

Fig. 5. The lips of a koi (*Cyprinus carpio*) affected by carp pox. (*Courtesy of* Helen Roberts-Sweeney, DVM, Williamsville, NY; with permission.)

around the mouth, they may interfere with eating. These lesions can be surgically reduced but may reappear at a later time.

3. Angelfish lip fibromas may be associated with a viral cause. Multiple clinically affected fish can be found in one tank; retroviral-like particles have been found on electron microscopy, but attempts to reproduce the disease have not been successful.[35,36] Depending on the reference, lip fibromas may be classified as a viral disease, neoplasia, or retroviral-associated neoplasia.[35,37–39] The masses can interfere with feeding and can be surgically excised.
4. Less common viruses[39,40] causing oral disease in fish are listed in **Table 1**.

Bacterial diseases of concern affecting the oral cavity

1. *Flavobacterium columnare*, previously known as *Flexibacter columnaris*, is a gram-negative, orange-to-yellow pigmented, colony-forming bacteria and the etiologic agent of columnaris disease (fin rot, cotton-wool mouth).[36,41] Columnaris disease affects many species of fish, both wild and captive.[41,42] A common presentation in tropical fish is the development of oral ulcerations that may develop secondary fungal infections giving rise to the terms *cotton wool disease*, *mouth rot*, and mouth fungus.

   Clinical signs are not pathognomonic and include fluffy cutaneous patches or cutaneous ulceration on the fins/tail, mouth (necrotic stomatitis), periocular region, and the dorsal aspect (saddleback disease).[41–43] Infections involving the gills will cause respiratory signs (dyspnea, piping, gasping, and so forth).[43] The disease is often secondary to poor water quality, overcrowding, poor husbandry, and other stressors in the environment.[43,44]

   Diagnosis can be made in the clinic by evaluating wet mount preparations from the lesions. The wet mount prep examination reveals long, thin rods that may glide or flex or are arranged in a haystack appearance.[36,41,43]

   Experimentally induced infection in koi (*C carpio*) was shown to significantly reduce packed cell volume, cause marked hyponatremia, hypochloridemia (due to loss of osmoregulatory capacity), and hyglycemia.[41] Significant increases in alkaline phosphatase, aspartate aminotransferase, lactate dehydrogenase, and creatine kinase were also reported.[41]

   In addition to correcting any underlying contributing factors, bath treatments can be used to treat columnaris disease (**Table 2**). For severe infections, systemic antimicrobials may be necessary.
2. *Flavobacterium psychrophilum* (bacterial cold-water disease, peduncle disease, saddleback disease) has been shown to cause pyogranulomatous and necrotic

Table 1
Less common viruses affecting the oral cavity in fish

Virus	Species Affected	Lesions Seen
Oncorhyncus masu virus (Salmonid herpesvirus 2)	Masu, coho, chum and kokanee salmon, rainbow trout	Epithelial tumors (cutaneous carcinomas) on the mouth and jaw
White sturgeon herpesvirus	White sturgeon	Oral, epidermal hyperplasia
Tiger puffer virus (white mouth disease, kuchihiro-sho)	Tiger puffer, grass puffer, fine-patterned puffer, panther puffer, pagrus sea bream, Schlegel black rockfish	Oral and snout ulcerations

Table 2
Bath treatments for superficial bacterial diseases such as columnaris

Copper sulfate	1–4-h bath treatment 100 mg/L 0.2 mg/L free copper ion for prolonged immersion	*Always observe fish during treatment.* Measure alkalinity before calculating dose. Reduced alkalinity and low pH increases toxicity of copper. It is immunosuppressive and can cause gill toxicity.
Diquat[1,3]	2–18 mg/L 4-hour baths	Monitor fish during treatment. Repeat daily for 3–4 treatments.
Hydrogen peroxide	3.1 mg/L for 1-h bath treatment	Monitor fish during treatment.
Oxytetracycline	750–3780 mg per 10 gallons for 6–12 h, repeat daily for 10 d (dose will depend on hardness of water)	It is not very effective in hard water or seawater.
Potassium permanganate	2 mg/L prolonged immersion	Levels are reduced by high levels of organic matter in the water. Treatment can be stopped by adding hydrogen peroxide to water.

Adapted from Roberts HE, Palmeiro B, Weber ES. Bacterial and parasitic diseases of pet fish. Vet Clin North Am Exot Anim Pract 2009;12:615; with permission.

lesions in the cartilage and bone of the snout, vertebrae, and surrounding tissues, sometimes referred to as "dissolving head disease."[44,45] Antimicrobials, as for columnaris disease, may be used in addition to correcting husbandry and management deficiencies.[44]

3. *Tenacibaculum maritimum* (formerly known as *Flexibacter maritimus*) is a gram-negative bacteria that causes lesions similar to *F columnare* or columnaris disease in marine species, primarily young fish.[36,42]
4. Enteric redmouth disease is caused by the gram-negative rod, *Yersinia ruckeri.*[36,42,46] The disease is seen in salmonid species, such as rainbow trout (*Oncorhynchus mykiss*), and can cause significant economic losses in the industry.[46] Subcutaneous hemorrhages of the mouth, gums, and tongue are typically seen, giving the disease its name. The disease condition can be anywhere from acute with high mortalities, especially in young fish, to chronic, low-level mortalities in older fish. Diagnosis is made by culture or serologic testing.[46] Treatment involves the use of antimicrobial therapy, adding probiotics, and vaccination, and improved sanitation and biosecurity practices.[36,46] In food fish, antimicrobial options are limited to a few approved drugs, including oxytetracycline and oxolinic acid.
5. Oral lesions are often seen associated with or secondary to systemic bacterial infections. In the author's practice, lip lesions are noted in koi with systemic aeromonad infections (**Fig. 6**). Erosions, ulcerations, and severe osteomyelitis can be seen in the mouth and surrounding tissue. These infections are often secondary to severe parasitism, poor water quality, and other immunosuppressive conditions. More about systemic aeromonad infections and treatment recommendations has been previously reported.[43]
6. Mycobacteriosis is the most common chronic bacterial disease in aquarium fish.[47,48] The most often identified species causing mycobacteriosis in fish include *Mycobacterium marinum*, *M fortuitum*, and *Mycobacterium chelonae.*[43,48]

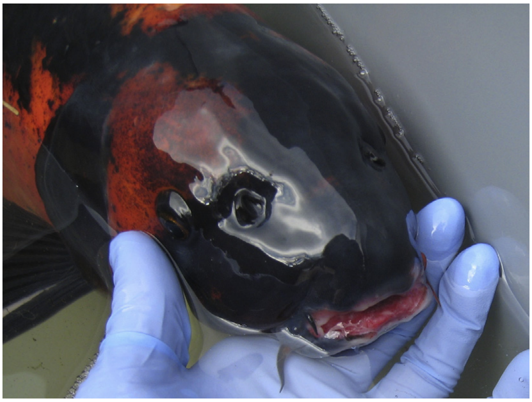

Fig. 6. Linear ulceration on the dorsal lip of a koi (*Cyprinus carpio*). (*Courtesy of* Helen Roberts-Sweeney, DVM, Williamsville, NY; with permission.)

Mycobacteria are slow-growing, acid-fast-staining bacteria and are ubiquitous in the aquatic environment.[43,48] Mycobacteriosis is also a zoonotic disease (fish handler's disease or fish tank granuloma) and causes ulcerative or raised granulomatous nodules.[47] The lesions are typically located on the extremities because of the temperature preferences of *Mycobacterium* spp.[47] The most common clinical signs seen in fish affected with mycobacteriosis are granulomas located in internal organs, although granulomas can also form inside the oral cavity.

In one publication,[49] *M chelonae* was found associated with tumorlike skin and oral masses in Russian sturgeons, *Acipenser gueldenstaedii. M chelonae* was considered a secondary to trauma and increased stress in the sturgeons.[49] Lesions developed in areas on the fish susceptible to chronic traumatic injury. It was theorized these traumatic lesions developed dystrophic calcification, then subsequent granuloma formation in response to the foreign body, calcium.[49] The lesions were subsequently colonized by the opportunistic, ubiquitous *M chelonae.*[49] None of the typical internal granulomas were seen in the fish, making mycobacteriosis unlikely to be the primary cause of the oral and skin masses.[49]

7. *Vibrio spp*, a marine gram-negative bacteria, causes disease in a wide variety of marine fish species.[43,47,48] Clinical signs are similar to those found in aeromonad infections in freshwater fish species, including cutaneous ulcerations and systemic infections. *Vibrio splendidus* infections have been reported to cause lesions in the jaw and oral cavity of farmed turbot.[42] *Vibrio vulnificus* is the most reported *Vibrio* spp cultured in zoonotic infections in humans.[47]
8. A less commonly seen pathogen, Sekiten-byo (*Pseudomonas anguilliseptica*) causes petechiae around the mouth, operculum, and ventrum of Japanese and European eels.[48] Experimentally induced infections can be seen in common carp, bluegills, goldfish, ayu, and crucian carp.[48]

Parasitic diseases affecting the oral cavity

Many common external parasites can be found in and around the oral cavity in addition to the rest of the external body. A few in particular favor the oral cavity and surrounding tissues.

1. Parasitic isopod infestations often involve the oral cavity of wild, marine fish.[36] These crustacean parasites are grossly visible and are manually removed if present in a few numbers or treated with bath medications, including organophosphates.[36] One of the largest isopod families, Cymothoids, contains members that specifically target the oral and buccal cavity of fish.[36,50,51] One member, *Cymothoa exigua*, the tongue eating isopod, causes degenerative changes in the tongue of the host fish, a common food fish (rose snapper).[52] It then replaces and functions as the tongue by attaching to the remaining stub.[52]
2. Myxosporeans, spore-producing parasites with complex life cycles, have a worldwide distribution and infect a variety of fish species.[43] Not all species are pathogenic. A Myxobolus sp was found to cause an oral deformity in a goldfish, *C auratus.*[53] The goldfish presented respiratory difficulty, flared opercula on one side, unilateral exophthalmia, and anorexia. Exploration of the area revealed a pink, nodular mass partially occluding the mouth and associated ventrally with the gill arch[53] (**Fig. 7**). Tentative diagnosis was made based on an impression smear of the mass.[53] Another myxosporean, *Myxobolus oralis* sp, has been associated with infection of the palate of a gibel carp, *Carassius auratus gibelio.*[54] There is no effective treatment of myxozoan infections. Prevention and management is aimed at preventing the presence of the intermediate hosts, oligochaete worms (red worms, black worms, *Tubifex* worms). Unfortunately these are often fed as a live food source to aquarium fish.[55]
3. *Epistylis*, a ciliated sedentary protozoan, is a common secondary pathogen of skin damage caused by bacteria, other primary parasites, and trauma.[36,43] The oral cavity is a common site of infestation. *Epistylis* infestations can appear as white, cottony, fluffy lesions similar to *Flavobacterium* infections (columnaris disease) and fungal infections.[36,43] Wet mount preparations of the lesion examined under direct microscopy will help differentiate. Formalin and salt as baths or prolonged immersion can be helpful in treating *Epistylis.*[36]
4. The ocean sunfish, Mola mola, is often infested by the trematode parasite *Accacoelium contortum.* This parasite attaches itself inside the pharyngeal and gill chambers, causing an extensive inflammatory response.[56] Interestingly, more parasites were found on the right side than the left.[56] The reason was proposed to be due to ocean sunfish behavior of leaning their bodies on the right as they incline when in lateral recumbency.[56] The parasites on the left side would be more exposed to desiccation, heating, and UV exposure.[56]

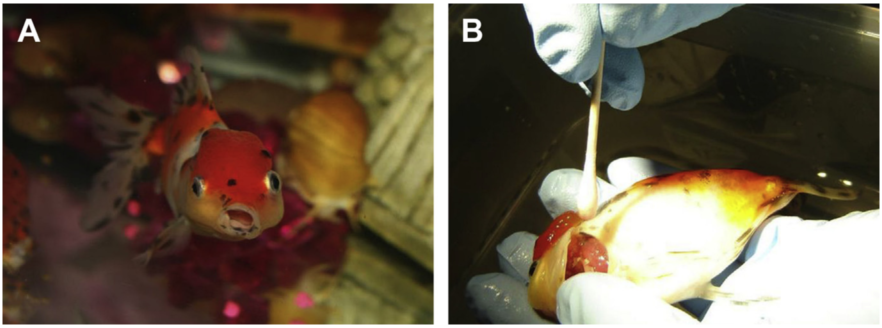

Fig. 7. (*A*) Goldfish (*Carassius auratus*) showing deviation/deformity of the mouth. (*B*) Exploration reveals nodular mass below left operculum. (*Courtesy of* Helen Roberts-Sweeney, DVM, Williamsville, NY; with permission.)

Fungal infections of the oral cavity

Most fungal infections found in the oral cavity of fish are caused by *Saprolegnia*, a common water mold (*Oomycetes*). Water molds are opportunistic and often associated with immunosuppression in fish.[36] Immune suppression can occur with primary infections; poor water quality; rapidly changing water conditions; increased fish density in ponds, tanks, raceways, and aquaria; and other common stressors. Diagnosis of secondary fungal infections should always steer the clinician to search for primary problems on/in the fish or in the environment. Fungal infections appear as white to tan, fluffy, superficial lesions. Diagnosis is made by examination of wet mount preparations taken from the lesions of a live fish. Dead fish will quickly become colonized by saprophytic fungi, so it is critical to evaluate the lesion on live fish. It is important to perform a wet mount preparation to differentiate fungal lesions from columnaris disease and *Epistylis* infections.[36,43] Treatment is aimed at identification and correction of primary stressors. Prolonged immersion in less than 3 parts per thousand noniodized salt can aid in healing. Other treatments, such as malachite green, are not recommended. Malachite green is a known carcinogen and is prohibited from use in food fish.

Neoplasia of the Oral Cavity

Neoplasms in fish reflect the tissue type of the oral cavity. The cause can be genetic mutation, husbandry or environmental stressors, and virally associated or induced. Often the cause is multifactorial involving genetic susceptibility, stress of captivity (overcrowding, poor nutritional status, trauma), and exposure to carcinogenic pollutants in the environment.[37,57] The incidence of virally induced tumors in wild fish often shows a seasonal pattern.[57,58] **Table 3** lists the most common viral-associated tumors in fish.

Spawning, viral permissive temperatures, pollutants, life stage of the fish, water temperature, and weather patterns have all been suggested as contributing factors for the seasonality associated with development of tumors in fish.[37,58,59] In wild fish,

Table 3
Viral-associated neoplasia of the oral cavity in fish

Carp pox/cyprinid herpesvirus 1	*Cyprinus carpio*	Benign papillomas	—
Onchorhyncus masu virus	Salmonids, including Masu, coho, chum and kokanee salmon, rainbow trout	Epithelial tumors (cutaneous carcinomas) on the mouth and jaw	—
Retroviral-like particles (unidentified)	*Pterophyllum scalare* (freshwater angelfish)	Angelfish lip fibroma/ odontoma	Experiments thus far have failed to isolate the virus.
Retroviral-like particles	*Catostomus commersoni* (white sucker)	Epidermal papillomas, predilection for lips and head[7]	Experiments to isolate the virus have been unsuccessful. Pollution may be a contributing factor.
Virus suspected papillomatosis	*Anguilla anguilla* (European eel)	Oral papillomas, commonly around mouth[6]	Lesions regress with cooler water temperatures or higher salinities.

the presence of polynuclear aromatic hydrocarbon and chlorinated chemical contaminated sediments have been associated with squamous cell carcinomas and papillomas.[37,59–61] In particular, bottom-dwelling fish that scavenge the floor of lakes, streams, and rivers have increased prey contamination, incidence of oral trauma, and exposure to pollutants in sediments.[37,59–61]

Squamous cell carcinoma is a frequent diagnosis of cutaneous neoplasms in koi (*C carpio*) in the author's practice. Lesions can appear anywhere on the body, including the mouth (**Fig. 8**). Masses can interfere with feeding and lead to emaciation, poor condition, and death.

Masses of any kind should be removed or biopsied to determine cell type. Treatment success depends on degree of tissue invasion, condition of the fish, and the level of owner commitment.

Miscellaneous Disorders of the Oral Cavity

1. Traumatic injury of the oral cavity is a relatively common occurrence in captive fishes.[62] Mechanical damage to the mouth results in deformities, hemorrhages, hematomas, tissue erosion, and snout deformation.[62] Traumatic injuries can result in an inability to feed and breath normally.[62] Lightning strikes in ponds, predators, and sudden changes in the environment (inappropriate lighting conditions, sudden presence of light, presence of humans) that trigger the startle reflex result in self-inflicted oral injuries as the fish move rapidly and strike objects, such as the sides of a pond or aquaria with their mouth. These injuries are often accompanied by opercular and spinal trauma.[62] Netting fish can cause trauma to delicate mouthparts in addition to the fins and tail.[62] Oral damage is likely to be painful, and the fish should be treated appropriately with analgesics. Wounds and secondary infections should be treated via debridement (if needed) and appropriate antimicrobials.
2. Nutritional diseases affecting the oral cavity are listed in **Table 4**.[63,64] Nutritional diseases are often caused by inadequate knowledge on the natural diet of the captive species, feeding a diet meant for one species to another, unrelated species (commercial catfish food given to salmonids, the use of outdated food, and the feeding of spoiled or rancid food.
3. Traditionally bottom-feeding fish that ingest and spit out inedible items (stones, small twigs, tank décor), such as goldfish (*C auratus*) and koi (*C carpio*), are

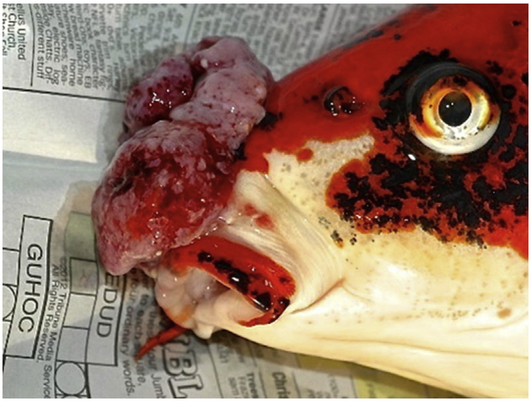

Fig. 8. Squamous cell carcinoma on the rostrum of a koi (*Cyprinus carpio*). (*Courtesy of* Helen Roberts-Sweeney, DVM, Williamsville, NY; with permission.)

Table 4
Nutritional disorders of the oral cavity

Hypovitaminosis C	Short snout, lower jaw deformity, including erosion/ulceration	Vitamin C content in food diminishes quickly. Replacing food every 90 d is suggested.[3]	—
Hypervitaminosis A	Overall increase in mouth deformities, pug headedness	There is an increased incidence due to metabolite and retinoic acid.	—
Niacin deficiency	Hemorrhage and erosion around the mouth	—	—
Leucine excess in diet	Deformed opercula	It is noted in rainbow trout (*Onchorhyncus mykiss*).	—
Phosphorus deficiency	Cranial deformities	It is noted in carp/koi (*Cyprinus carpio*).	—
Pantothenic acid deficiency	Deformities of the lower jaw and head	It is noted in channel catfish (*Ictalurus punctatus*).	Protect food from excessive heat.

susceptible to oral and pharyngeal foreign bodies. The most common foreign body is a piece of gravel or rock substrate (Fig. 9). Appropriate-sized substrate should be provided for these fish. Historically, it is not uncommon of the owner to report the fish appear hungry and approach the food but do not ingest it. On examination, these fish may have developed erythema, erosions, or ulceration ventral to the foreign body. Foreign bodies can also be observed in other captive species with a tendency to ingest anything in the search of food. Diagnosis of an oral foreign body is made by direct visualization of the oral cavity. Most items can be removed in the sedated or anesthetized fish via forceps. Occasionally, surgical extraction and repair of the surrounding tissue is necessary. Prophylactic antibiotics, analgesics, and gavage feeding may be necessary in fish with a large degree of trauma to the oral cavity.

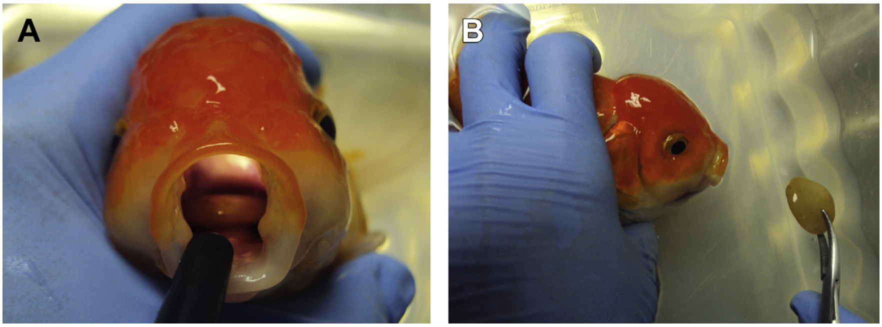

Fig. 9. (*A*) Open mouth examination of goldfish (*Carassius auratus*) with pharyngeal foreign body visible (gravel). (*B*) Gravel removed. Note the size in comparison with the mouth and body size. (*Courtesy of* Helen Roberts-Sweeney, DVM, Williamsville, NY; with permission.)

Fig. 10. Sedated puffer fish, lateral aspect showing dental overgrowth (*inset*); and using a dental handpiece with bur to reduce overgrown beak. (*Courtesy of* Helen Roberts-Sweeney, DVM, Williamsville, NY; with permission.)

4. The most common dental abnormality seen in pet fish is overgrowth of the incisor platelike teeth in Tetraodontidae, puffer fish. The incisor teeth of puffer fish are fused and can resemble a beak. These incisor plates continuously grow throughout life and are usually worn down by their natural feeding habits. Failure to provide a source of species-appropriate corals, mollusks, and crustaceans in captivity can result in severe overgrowth and malocclusion. Clinical signs and symptoms include anorexia, inability to close the mouth, severe malocclusion, and death due to an inability to eat. In addition, traumatic injury can occur because of excessively hard food items, leading to fracture of the plates, malocclusion, jaw fractures, and secondary infections. A good oral examination under sedation allows a complete look at the external and inner aspect of the dental plates.

Trimming of the teeth has been described[65] and can readily be performed in a clinical setting with a minimal investment in equipment. Small-animal high-speed dental handpieces equipped with a bur head (**Fig. 10**) or a low-speed device, such as a Dremel tool (Dremel, Racine, WI), equipped with a grinding disc[65] are effective in reducing the teeth to the proper size and alignment. It is important to include client education and suggest husbandry changes to prevent recurrence in these fish. Regular follow-ups are suggested to monitor the teeth.

SUMMARY

Oral disorders in captive fish are fairly common and usually readily identifiable. Clinical signs and symptoms, such as anorexia, food regurgitation, persistent and frequent opercular movements, coughing, rubbing, and identifiable masses and deformities, should be evaluated and treated promptly when possible. Because the oral cavity is essential to proper feeding and respiration, oral disorders may have fatal consequences if not diagnosed and treated early.

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