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REVIEW: ORAL DISEASES OF REPTILES

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The oral cavity of reptiles shows a number of specialised features, some of which are relevant to the investigation and understanding of disease in these species. Oral diseases of reptiles may be infectious or non-infectious in origin. They can also be primary or secondary. Infectious agents associated with disease comprise bacteria, viruses, fungi and metazoan parasites. Non-infectious factors include trauma and burns, nutritional deficiencies and/or imbalances, neoplasms and developmental/genetic abnormalities. The investigation of oral diseases of reptiles requires an understanding of the normal morphology and function and a systematic approach to diagnosis.

INTRODUCTION

Oral disease is well recognised in reptiles and necrotic stomatitis ("mouth-rot" or "canker") is possibly the most prevalent disease of these species in captivity (Cooper & Jackson, 1981; Frye, 1991; Gabrisch & Zwart, 1985; Ippen, Schröder & Elze, 1985). Lesions of the oral cavity can lead to anorexia, ill-health and may prove fatal. Clinically affected reptiles frequently show evidence of pain or discomfort. There is often a need for rapid diagnosis and prompt treatment.

Data on oral disease in reptiles are scattered in the literature amongst herpetological and veterinary journals and various textbooks. Often descriptions are restricted to diagnosis and treatment and scant attention is paid to normal anatomy and function, despite the importance of this in terms of understanding pathogenesis and formulating preventive measures. Substantial data are available, however, on the normal features of the oral cavity of reptiles, largely because certain species play an important part as "models" in studying the evolution and development of dentition (Cooper, 1963, 1965; Westergaard & Ferguson, 1986, 1987). Recently there has been interest amongst medical researchers in the oral flora of venomous snakes because of an awareness that secondary bacterial infection can be a complication of snakebite (Cooper, 1991).

In this paper we describe the normal dentition and the other features of the oral cavity of reptiles and review the various diseases of this area which have been reported.

THE NORMAL ORAL CAVITY

GENERAL

In reptiles very little digestive or mechanical breakdown occurs in the mouth prior to swallowing (Davies, 1981). Methods of feeding vary widely. Examples include the chameleons (Chamaeleonidae) which catch their prey using their tongue, some snakes and lizards which immobilise their target species with venom, and carnivorous turtles which use gape and suck feeding in which the floor of the pharynx is lowered drawing water into the mouth, including their prey (Winokur, 1988). The teeth, if present, are generally used for grasping and tearing food items. Often they point caudally, preventing the escape of live prey. They are usually present in larger numbers than in mammals. For example, Owen (1866) identified 47-49 teeth in both upper and lower jaws of a lizard of the genus *Iguana*. The number of teeth is not usually fixed for a given species. Chelonians (tortoises, terrapins and turtles) do not have teeth (see later). As in mammals, the hard palate separates the oral and nasal cavities but in many species the hard palate is reduced in size and only in crocodilians is it complete. There are no definite lips in reptiles as there are in mammals. The glottis lies well forward in the oral cavity and, in snakes, is dorsal to the lingual sheath. When a snake consumes large food items, the glottis is extended to one side and the mandible is lowered to permit respiration. The glottis is circumscribed by two longitudinal and two transverse folds (Guibé, 1970). In some lizards and snakes (agamids, pythons) the ventral

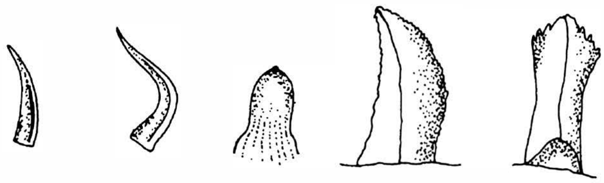

FIG. 1. The structural diversity of lizard and snake teeth. A, Gekkonidae (geckos); B, A tooth typical of snakes; C & D, Varanidae (monitor lizards); and E, Iguanidae (iguanas).

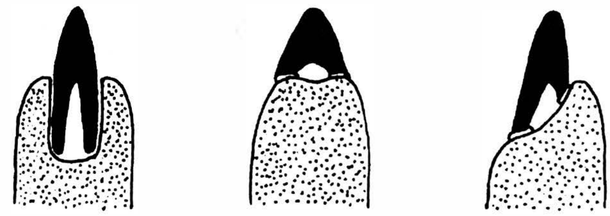

FIG. 3. The three basic types of tooth implantation in modern reptiles. A, Thecodont; B, Acrodont; C, Pleurodont; black = tooth; clear = bone of attachment; and stipples = jaw bone (redrawn from Parker (1977).

transverse fold is enlarged, continuous with a cranial projection of the cricoid cartilage, forming a lobe similar to the mammalian epiglottis (Guibé, 1970). In chelonians the glottis lies in a notch or cavity on the caudal margin of the tongue (Winokur, 1988).

TEETH

The teeth of reptiles are usually peg-like, showing little differentiation according to their position in the mouth (referred to as homodont), although the teeth of lizards show more diversity than those of snakes (Marcus, 1981) (see Fig. 1). They are generally longer than mammalian teeth. A few species show differentiation associated with feeding specialisations e.g. the venom-conducting fangs in many snakes and one genus of lizard (Edmund, 1969) (see Fig. 2) and the long teeth of bird-eating snakes which can penetrate feathers.

Teeth are present on the maxilla and mandible and, in many snakes, on the palatine and pterygoid bones. The premaxilla has teeth in lizards. Reptilian teeth are composed of enamel, cementum and dentine though the composition of these substances differs from that in mammals (Edmund, 1969).

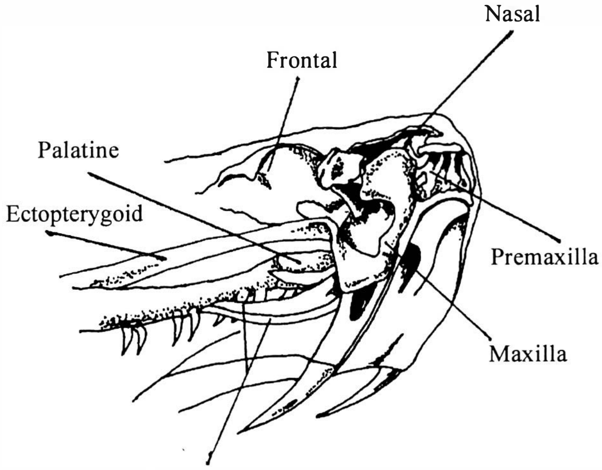

FIG. 2. The upper jaws and fangs of a rattlesnake (redrawn from Evans (1986)).

There are three main types of tooth attachment in reptiles: pleurodont, acrodont and thecodont (see Fig. 3). In the pleurodont species (the majority of lizards and snakes) the tooth is attached to the lingual side of the jaw, while in acrodonts (chameleons) it is bound to the summit of the bone. Some lizards, such as the Agamidae, have teeth attached by both pleurodont and acrodont means (Edmund, 1969). The teeth of thecodonts (crocodilians) are set in alveolar sockets (gomphosis). Chelonians (tortoises, terrapins and turtles) do not have teeth (see later). In pleurodont reptiles replacement teeth develop lingually to their predecessors. In pleurodont and acrodont types of attachment the tooth is ankylosed by a substance similar to cementum. Therefore, healthy reptilian teeth are more difficult to remove surgically than similarly sized mammalian teeth. In thecodont reptiles there is no true periodontal membrane but soft tissue separates the cementum lining the alveolus and that on the tooth (Edmund, 1969).

Most reptiles shed and replace their teeth throughout life (polyphyodont) (Edmund, 1969; Bellairs & Attridge, 1975) and this allows the jaw to grow (teeth are present before hatching when the jaw is small). Consequently, the age of an animal cannot be determined by its dentition. Since there is no maternal feeding in reptiles, teeth must be present prior to hatching so that the young animals can immediately feed themselves. Replacement occurs in a definite but complicated sequence (Osborn, 1973) which ensures that there are as many functional teeth as possible. In lizards and all non-venomous snakes the sequence of replacement is disto-mesial but in most other elapids and all viperids this is reversed (Parker, 1977). However, replacement does not occur throughout life in acrodont reptiles (Edmund, 1969).

In oviparous reptiles a structure on the mesial end of the upper jaw serves to rupture the embryonic membranes and shells. In chelonians and crocodiles this structure is called the egg caruncle ("egg tooth") and is a horny epidermal point which is not a part of the true dentition. However, the egg tooth of lizards and snakes is a highly modified tooth belonging to the regular teeth on the premaxilla (Edmund, 1969). Many of the geckos are remarkable in having paired egg teeth.

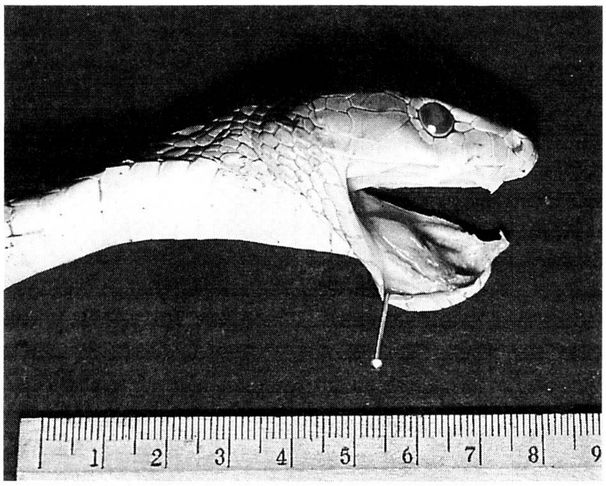

FIG. 4. Jameson's mamba (*Dendroaspis jamesoni*), showing short erect fangs.

Snakes. Most snakes have six rows of teeth attached to the maxillary, palatine and mandibular bones. The mandible is incomplete in the majority of snakes. All teeth are cemented to the rims of shallow crater-like depressions on the lingual surface of the bone (pleurodont), which are formed when a tooth has been shed. As teeth mature, dentine is deposited within and they become thicker. Prior to replacement, the tooth is resorbed from the base. The replacement tooth develops lingual or palatal to its predecessor, lying horizontally with its coronal tip pointing distally. When the old tooth has been completely resorbed the new tooth moves laterally into the tooth row. There is regular dental replacement; teeth that either fall or are torn out are replaced. The teeth are not used for chewing food but are simple, sharp, conical and curved, with the tips pointing distally to help retain prey items (Edmund, 1969). A few species of snake have no teeth. In *Dasypeltis*, an egg-eating snake, the eggshell is broken in the pharynx by ventral extensions of the cervical vertebrae (hypophyses) (Gans, 1974).

In venomous snakes the venom is delivered via specialised teeth or fangs. In some species these are grooved (rear-fanged or opisthoglyphous snakes e.g. the boomslang, *Dispholidus typus*), while in the proteroglyphous (cobras, mambas) and solenoglyphous (vipers), meaning tubular, snakes, the teeth are hollow. Members of the family Elapidae (cobras, kraits, mambas) have a pair of short, erect, rigid fangs in the mesial end of the upper jaw (Fig. 4), while the Viperidae (vipers and pit vipers) have long, curved, hinged fangs enclosed in a sheath at the distal end of the maxilla (Spence, 1986). These fangs can fold back when the mouth is closed and are erect when the snake strikes. The vipers can control their fangs individually (Marcus, 1981). In venomous species, those teeth which do not deliver venom are simple, as in other snakes.

Lizards. The mandible of lizards is complete and bears teeth that appear as a palisade. New tooth development can take place similarly to snakes (e.g. in monitors) or within the old teeth (e.g. in iguanas) (Guibé, 1970). In most lizards there is regular wave-like replacement which can take place up to four times a year. In those lizards with acrodont dentitions this replacement is suppressed after a certain age and no further teeth are produced (Edmund, 1969). Therefore the teeth of older individuals can be severely worn. In iguanas and geckos the replacement teeth lie in cavities on the lingual surface of the predecessor while in other lizards the replacement teeth lie lingually and slightly distally to the precursor (Parker, 1977).

Some lizards initially process their invertebrate prey by chewing prior to swallowing them. In herbivorous lizards, such as the iguana, the cheek teeth are distinguishable from the rostral, pointed, conical ones. The former have expanded crowns which are crenated (Owen, 1866). Thus, the incisors crop vegetation, while the cheek teeth crush and grind. Some monitors feed on molluscs and have broad, blunt teeth (Edmund, 1969). In all Varanidae, the teeth increase in size toward the pharynx. Geckos have large numbers of conical teeth. *Dracaena guianensis*, the Caiman lizard, has remarkable flat-cusped molar dentition well suited for crushing hard-shelled molluscs.

Two species of lizard (the Gila monster, *Heloderma suspectum* and the Mexican beaded lizard, *H. horridum*) have specialized teeth in the lower jaw for delivering venom (all fangs in snakes are in the upper jaw). The venom runs into the space between gums and teeth and rises by capillary action in grooves in the teeth. It is inoculated as the lizard chews on its victim (Marcus, 1981).

Chelonians. These do not have teeth but the heavily keratinized edges of the mandible and maxilla form a "beak" which can effectively cut food and grows throughout life (Evans, 1986). Many specialisations of the beak exist, for example, the herbivorous green turtle's (*Chelonia mydas*) upper beak has vertical ridges and a serrated lower beak for grazing while the desert tortoise (*Gopherus agasizi*) has serrated jaws for plant-shredding (Mahmoud & Klicka, 1979). The carnivorous soft-shelled turtles have very sharp jaws for cutting prey and *Dermochelys coriacea*, the leather-back turtle, has a hooked beak to aid in capturing prey (Mahmoud & Klicka, 1979). In snapping turtles, the mandible itself has a sharp tip and cutting edges (Evans, 1986). In the red-bellied turtle, *Pseudemys rubiventris*, the median ridges on the crushing surfaces are tuberculate, an adaptation for feeding on aquatic plants (Mahmoud & Klicka, 1979).

Crocodilians. The teeth are generally homodont but the rostrally placed teeth are sharper than the distally placed ones and some teeth are enlarged (Edmund, 1969). When the mouth is closed, teeth in the lower jaw may sit in notches, grooves or cavities in the upper jaw. A good example is the fourth mandibular tooth of true crocodiles, which is large and can be seen when the mouth is closed; in alligators, the fourth mandibular teeth fit into pits in the upper jaw and thus, are hidden from view. New teeth develop within the sockets of established ones and eventually displace them.

OTHER COMPONENTS OF THE ORAL CAVITY

The remaining parts of the oral cavity include the tongue, gingiva, and oral glands.

The tongue. The structure and function of the tongue vary enormously (Guibé, 1970). In snakes, the tongue is long, cylindrical and lies within a sheath ventral to the glottis. The tongue is usually lined with partially keratinised squamous epithelium and in species where it is fleshy (e.g. geckos), it contains many glands including mucous glands (Luppa, 1977). The sublingual glands in some lizards produce a swelling at the base of the tongue; these also contain mucous glands. The tongue is usually lined with many papillae on the dorsal surface but the sides and ventrum are smooth. The aquatic Chelonia either have small lingual papillae or lack them entirely, while terrestrial chelonia have many glandular papillae which produce mucus for lubrication (Winokur, 1988). In snakes and many lizards e.g. monitors, the tongue's function is solely for monitoring the chemical composition of the surroundings and is forked at the tip and retractable at its base. In chelonians and crocodiles, it has a mechanical function only but is relatively immobile in comparison with that of some species, especially certain lizards (e.g. chameleons) where it plays an important part in the capture of prey (Schwenk & Throckmorton, 1989). In lizards the shape is variable and this characteristic is used taxonomically (Fig. 5). Taste buds are present on the tongues of some reptiles (Marcus, 1981).

The Jacobson's (vomeronasal) organ on the dorsal aspect of the oral cavity provides olfactory function. The forked tip of the tongue of snakes and some lizards slides into the ducts of this organ, carrying chemical particles with it.

Gingiva. A mucous membrane which largely consists of compound squamous, non-keratinized epithelium lines the oral cavity of most reptiles. In lizards this is replaced by a compound, ciliated, columnar epithelium, containing goblet cells, distally. The squamous epithelium is tougher and allows greater mechanical breakdown of food in the mouth (Luppa, 1977). In large sea turtles, the oropharyngeal and oesophageal epithelium has large numbers of long, conical, keratinized papillae that point distally, helping to retain food (Evans, 1986). Some chelonia have vascular, non-keratinized papillae which perform respiratory gas exchange (e.g. the soft-shelled turtles, Trionychidae (Winokur, 1988)). Taste buds occur within the epithelium of reptiles along with many types of glands, which are also found in the lamina propria (Luppa, 1977). In many snakes the gum forms a thick sheath which surrounds each tooth and conceals a large part of the base of that tooth (Owen, 1866).

Glands. In reptiles salivary gland secretions are mucous, have little digestive function, acting largely as lubricants. Venoms are an exception, being rich in proteolytic enzymes and other substances (Russell & Brodie, 1974).

There are a large number of glands in the oral region of reptiles (Fig. 6). The palatine glands are numerous and line the roof of the oral cavity of all reptiles apart from some turtles and lizards (Kochva, 1978). They may be simple crypts or relatively complex, multibranched tubules, which produce mucous

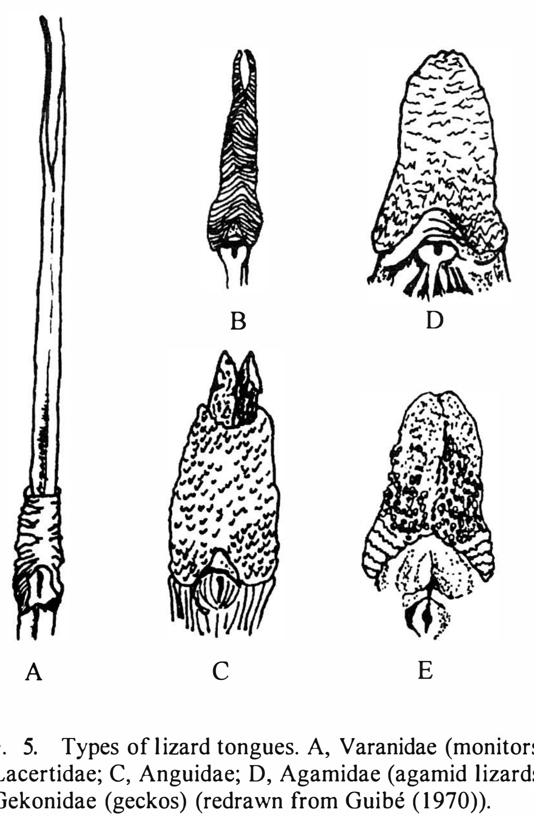

FIG. 5. Types of lizard tongues. A, Varanidae (monitors); B, Lacertidae; C, Anguidae; D, Agamidae (agamid lizards); E, Gekonidae (geckos) (redrawn from Guibé (1970)).

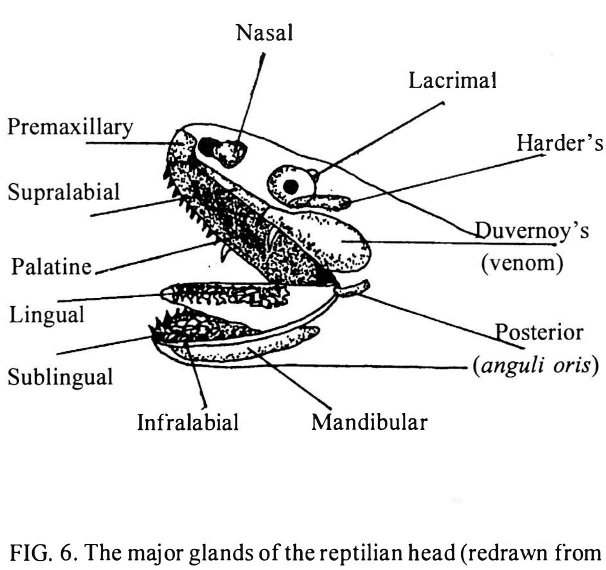

FIG. 6. The major glands of the reptilian head (redrawn from Kochva (1978)).

secretions. The sublingual glands lie in the base of the mouth and may fuse in the midline rostrally. They are similar in structure to the palatine glands. In true sea snakes (family Hydrophiidae) and the file snake (*Acrochordus granulatus*) the caudal sublingual gland is a salt gland (Dunson, 1976). Marine reptiles utilize salt glands for extra-renal excretion of electrolytes and specifically sodium chloride. The caudal sublingual salt gland encloses the lingual sheath. When the tongue is extended, fluid is expelled via multiple ducts into the tongue's sheath (Dunson, 1976). Lingual glands occur in the tongues of some lizards, Chelonia and crocodilians. They produce either mucous or serous secretions. They are absent in species where the tongue has mainly chemoreceptive functions (e.g. lizards, such as the Varanidae, and snakes).

In some crocodilians, the lingual glands are salt glands (Mazzotti & Dunson, 1989). In squamates, labial glands line the mouth edges and produce serous and mucous secretions.

The Gland of Gabe (Kochva, 1978) lies laterally to the mandible and ventrally to the labial glands. It only occurs in some anguimorphan lizards. It has been suggested that this gland produces venom. The venom gland of snakes in the family Colubridae is called the Gland of Duvernoy (Kochva, 1978). It is located in the maxillary region, originating at the angle of the mouth and extending as far dorsally as the level of the eye. The surrounding muscles are believed to assist in emptying the gland but neuronal control may also occur. It is a branched tubular gland divided into two parts and many lobules, each opening into its own duct; these in turn feed a central duct.

Venom glands of Elapidae, Viperidae and *Atractaspis* are not called Duvernoy's glands. They differ considerably in size. The glands of the Elapidae are situated on the lateral side of the head. The gland is divided into an accessory gland and several lobules each containing many tubules. The secretory epithelium is columnar and serous apart from in the accessory gland where it is mucous. Muscular activity empties the gland. The Atractaspidinae have elongated glands which may extend up to one-sixth of the length of the body and do not have an accessory gland. The venom gland of the Viperidae is triangular and has an accessory gland. The capsule is thinner than in elapids. The function of the accessory gland is unknown. Viperidae tubules contain flattened, round and conical cells as well as columnar types.

DISEASES OF THE ORAL CAVITY

Oral diseases of reptiles can be categorised under two headings - (1) those conditions which primarily affect the oral cavity, and (2) diseases in which lesions or clinical signs involving the oral region occur but these are secondary to other changes. Necrotic stomatitis is an example of the former, bacterial septicaemia (with petechiae in the buccal mucosa) an example of the latter. In this review particular attention will be paid to specific (primary) conditions of the oral cavity but mention will also be made of those in the second category where this is appropriate.

Oral diseases can be divided into two main groups: (a) Infectious - bacterial, viral, mycotic, and parasitic; and (b) Non-infectious - physical/traumatic, nutritional, neoplastic, and developmental/genetic.

This distinction is not absolute. Some conditions may be infectious in aetiology but non-infectious factors - for example, physical damage or nutritional deficiencies - can predispose to their development or spread. However, for convenience the two groups will be discussed separately.

INFECTIOUS

Bacterial. The most prevalent and well recognised oral disease of reptiles is probably necrotic stomatitis (commonly termed "mouth-rot" or "canker"). Its features have been discussed by many authors, amongst them Cooper & Jackson (1981), Frye (1991) and Hoff, Frye & Jacobson (1984). The condition may be acute or chronic. Snakes and chelonians (mainly tortoises) appear to be particularly susceptible (Fig. 7), lizards and crocodilians less so. The causal organisms are usually Gram-negative bacteria, especially *Pseudomonas* and *Aeromonas* spp., but other bacteria have occasionally been reported, amongst them a *Mycobacterium* sp. (Quesenberry, Jacobson, Allen & Cooley, 1986).

There has been considerable interest in the oral bacteria of reptiles (see for example, Cooper, 1981; Draper, Walker & Lawler, 1981; Goldstein, Agyare, Vagvolgy & Halpern, 1981) and the relationship between "normal flora" and infectious lesions such as stomatitis. Many of the organisms involved appear to be opportunists (Cooper, 1991). Factors that predispose to stomatitis probably include suboptimum temperatures and other stressors and a high challenge because of a build-up of bacteria in, for example, water containers. The inhalation of necrotic material and the

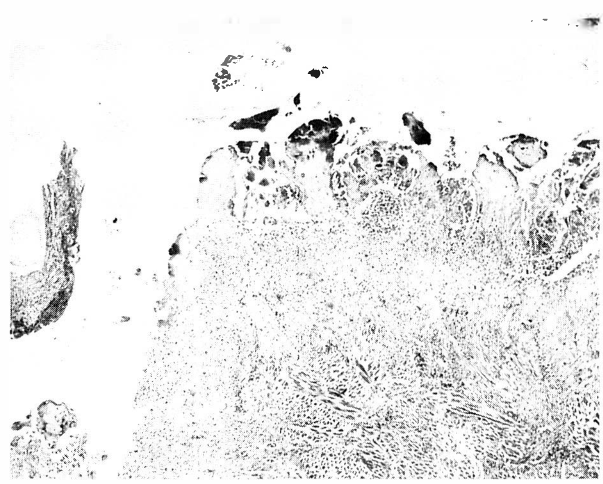

FIG. 7. Histological section of tongue of Mediterranean tortoise (*Testudo* sp.) with a bacterial glossitis. The mucosal surface is ulcerated and many bacteria are present.

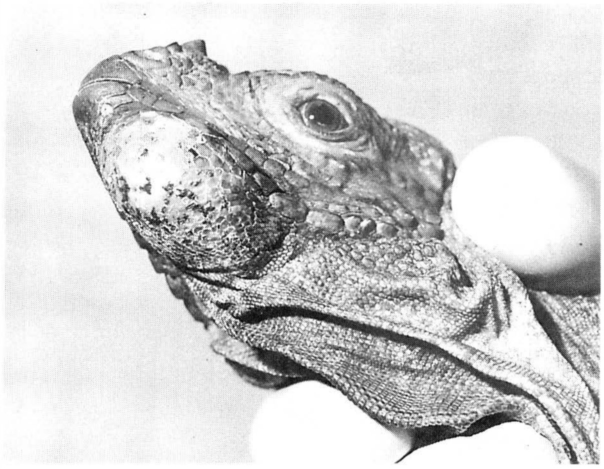

FIG. 8. Rhinoceros iguana, *Cyclura cornuta*, with a pronounced gular swelling. Radiography, histology and microbiology confirmed that this was an abscess.

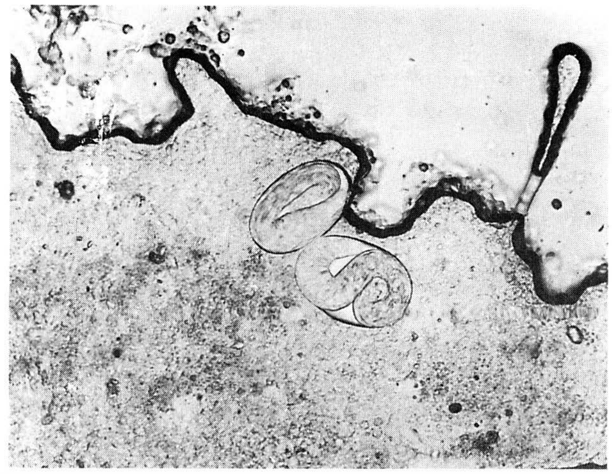

FIG. 9. Eggs of *Kalicephalus* in cellular debris from the upper oesophagus of a sand snake (*Psammophis*).

development of aspiration pneumonia is a common complication of necrotic stomatitis (Frye, 1991), particularly in chronic cases which progress to erosion, ulceration and fibrinous diphtheritic membrane formation.

Other bacterial infections of the oral region which have been reported include gular and parotid abscesses (Fig. 8) and cephalic cellulitis (Frye, 1991).

Reptiles with a bacterial septicaemia may exhibit petechiae of the buccal cavity. Similarly, cases of pneumonia may present with oedema of the mucosa and purulent exudate (from the lung or lungs) may be seen.

Viral. Herpesviruses have been isolated from the venom of elapid snakes and in the case of Siamese cobras (*Naja n. kaouthis*) were associated with venom gland infections (Simpson, Jacobson & Gaskin, 1979).

Herpes virus-like bodies were reported in Argentine tortoises (*Geochelone chilensis*), many of which died following severe stomatitis (Jacobson, Clubb & Gaskin, 1985).

An outbreak of stomatitis in Mediterranean tortoises (*Testudo graeca*) yielded a number of different bacteria including *Pseudomonas* spp., but there was no response to antimicrobial therapy. Transmission electronmicrography revealed virus particles, similar to a *Herpesvirus*, in two tortoises (Cooper, Gschmeissner & Bone, 1988). There have been subsequent reports of a glossitis and oesophagitis involving large numbers of Mediterranean tortoises (Müller, Sachsse & Zangger, 1990) and concern has been expressed recently that there may be a viral 'epidemic' in this genus in Europe (Cooper, Lawton, Jacobson & Zwart, 1991).

Mycotic. Several species of fungus have been reported from oral lesions in reptiles (Austwick & Keymer, 1981), including *Candida*, *Cladosporium*, *Trichosporon* and *Penicillium*. Others have not been fully determined. Fungi have been associated with stomatitis and cephalic granulomata, although whether they are primary pathogens or secondary to (for example) a bacterial infection, nutritional deficiency or the use of antibiotics, remains unclear. Jacobson (1984) reported a case of chromomycosis and fibrosarcoma involving the intermandibular area of a mangrove snake (*Boiga dendrophila*).

Parasites. Ectoparasites are usually of little consequence insofar as the oral cavity is concerned, although ticks of various species occasionally attach to the skin around the mouth and leeches (e.g. *Placobdella* spp.) may be found on the buccal mucous membrane (Sawyer, 1986).

Three genera of nematodes, *Rhabdias*, *Entomelas*, and *Kalicephalus*, are sometimes associated with oral lesions. *Rhabdias* (in snakes) and *Entomelas* (in lizards) may cause oedema and inflammation while ulceration and accumulation of oesophageal debris are more typical of *Kalicephalus* (Cooper, 1971) (Fig. 9). Pentastomes (linguatulids) are primitive arthropod parasites which are usually associated with the lung and respiratory tract. Cellular debris is sometimes passed up the trachea and may be seen in the pharynx or buccal cavity.

Trematodes, usually of the genus *Ochetosoma*, are not uncommonly seen in the buccal cavity of snakes (Cooper, 1974; Pitman, 1974). They do not appear to be associated with oral lesions and can usually be removed with ease (Fig. 10).

NON-INFECTIOUS

Physical/traumatic. Captive reptiles are very prone to damage and this may have a number of different causes. Self-inflicted rostral abrasions are particularly prevalent in snakes and lizards which repeatedly rub themselves against the wall of their enclosure, especially if it is made of glass. The lesions become

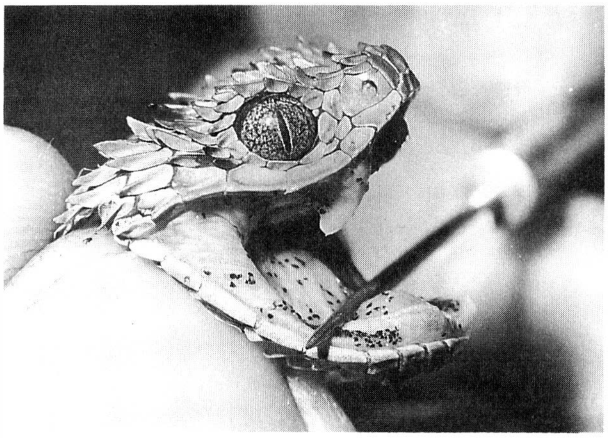

FIG. 10. The buccal cavity of a bush viper (*Atheris* sp.) showing many trematodes. The sheathed fangs are also visible.

ulcerated and ultimately, if not treated or alleviated, chronic and granulomatous. Secondary bacterial infection may occur and osteolysis can be a sequel.

Teeth may break or be lost due to self-inflicted damage - for example, striking at the handler. It must be borne in mind that in most species teeth are shed regularly under natural conditions: the presence of teeth in the alimentary tract or faeces of a reptile does not therefore necessarily imply a physical injury or pathological process.

The keratinous "beak" of chelonians may become damaged (see later) or overgrown (Frye, 1981). Injuries can be repaired using a variety of techniques. Overgrown beaks can be trimmed and manicured.

Bite wounds are not uncommon in captive reptiles. Sometimes another reptile is responsible - for example, an adult male iguana may attack another - but more often the wound is inflicted by a predator, such as a dog, cat or other carnivore, or a rodent provided as food. The last of these can be avoided if only dead animals are used. The extent and significance of bite wounds vary considerably: sometimes severe damage ensues (e.g. fracture), but it must be remembered that even an apparently minor injury can result in anorexia and certain types of trauma (e.g. the loss of a snake's tongue), may have serious consequences.

Injuries to the oral cavity may also be caused by humans (intentional or accidental) and by accidents in the vivarium - for instance, a stone rolling on to a lizard, or a snake damaging its head because it slips or falls when trying to climb out of its enclosure. Burns may occur as a result of contact with heaters: although the body is most often affected, the head, including the oral cavity, may also be damaged. Chemical burns can occur if reptiles are housed in containers which have previously harboured or been cleaned with acids, alkalis or other irritant substances. Minor wounds affecting the oral cavity usually heal well but there is always a danger of a secondary bacterial infection. Prompt attention to hygiene is important. Wounds can be treated topically: suturing may be necessary. More extensive damage such as fractures, may require specialist attention.

Long-term sequelae to traumatic lesions include granulation and fibrosis. Venom gland/duct damage can occur. Distortion of facial structures may make feeding difficult or predispose to desiccation/infection of oral mucous membranes.

Nutritional. Metabolic bone disease (MBD), or nutritional osteodystrophy due to a calcium:phosphorus imbalance, is a well recognised cause of oral changes (Lawton, 1991). Soft bones are a characteristic feature: in some cases the mandible and maxilla become pliable and easily distorted due to muscular action. Submandibular masses of fibrous tissue are common.

The only other nutritional deficiency which is unequivocally recognised in reptiles and which may have a direct effect on the oral cavity is vitamin A deficiency. The classical lesions in terrapins are swollen eyes associated with a build-up of keratinous debris (Elkan & Zwart, 1967), but some cases also show abrasions of the epithelium around the mouth and a tendency for the keratin to crumble and degenerate.

Vitamin C deficiency has been suggested as a predisposing factor in stomatitis (see earlier) (Wallach, 1969), but there is little evidence to support this claim.

Neoplastic. Papillomata, probably caused by viruses (Cooper, Gschmeissner & Holt, 1982; Raynaud & Adrian, 1976), but occasionally associated with fungi and other organisms, occur in captive green lizards (*Lacerta viridis*) and may involve the animal's head and mucocutaneous junctions, including the "lips".

Carcinomas and sarcomas of various types have been recorded in reptiles (Jacobson, 1981): occasionally the buccal cavity may be affected. Careful differentiation from chronic inflammatory lesions may be necessary.

Developmental/genetic. Various developmental abnormalities have been recognised in reptiles (Bellairs, 1981). Prognathia and epignathia are not uncommon. Cleft lip/palate has been reported and axial bifurcation/conjoined twinning may result in duplication of all or part of the head and associated structures. The cause of these abnormalities is never easy to determine. Genetic factors may be involved, but there is also evidence for the role of an adverse environment - for example, eggs incubated at too high or too low a temperature (Frye, 1991).

DISCUSSION

Oral diseases are important in reptiles. Differential diagnosis requires an understanding of the normal anatomy and how this is related to function.

Full investigation is necessary. The taking of a clinical history is always important and in view of the frequent role of the environment in oral diseases should, if possible, be coupled with inspection of the management. The patient should be carefully observed before handling: subtle clinical signs, such as a tendency to yawn or to rub the side of the head on the substrate, may assist in diagnosis. More apparent signs may include salivation and the appearance of bubbles around the mouth and nares. Clinical examination must be thorough and may be facilitated by the use of an auriscope or rigid endoscope.

The taking of samples - for example, swabs and biopsies - for laboratory examination is advisable at an early stage and may play a key role in diagnosis. Likewise, *post-mortem* examination of reptiles with oral disease should include submission of specimens for bacteriology, histopathology and other investigations. It is most important to preserve material for subsequent examination: the authors recommend that whenever possible one portion is retained in buffered formol-saline and another in a deep freeze (-20°C).

Treatment has not been discussed in this paper: excellent papers are to be found amongst the references. Treatment of oral diseases will often include attention to management as well as (on their own or in combination) chemotherapy, surgery and supportive care.

Oral diseases of captive reptiles are best prevented by good management, the maintenance of hygiene and prompt attention to minor abrasions and other lesions. The veterinary surgeon can do much to promote this approach amongst those who keep and breed these animals.

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