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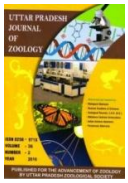

SHORT REVIEW OF DIFFERENT MICROFLORA FROM THE ORAL CAVITY OF SNAKES

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ABSTRACT

Snakebites are an enormous public health concern in tropical and subtropical countries. Along with poisoning it also yields some secondary infections in victims. There are many pathogenic microflora in snake's oral cavity. Snakes typically live in the rhizosphere where various bacterial strains exist and they can lead to opportunistic human diseases. A short review has been done to record different types of microflora isolated from the oral cavity and surface of various snakes. The obtained findings demonstrated significant bacterial pathogens in oral cavity of venomous and non-venomous snakes. Therefore, not only anti-venom treatment but also, due the probability of infections, the diagnosis and treatment should be considered in victims.

Keywords: Microflora; oral cavity; snakes; snakebites; snake venom; anti-venom treatment.

1. INTRODUCTION

Snakes are the members of reptile species [1,2]. Venomous snakes inject venom into the deep body of their prey [2,3]. But non-venomous snakes have simple teeth without a route to poison glands. Semi-venomous snakes are similar to non-venomous ones having the prominent distinctive characteristic of fangs or posterior grooved canine teeth [4,2]. More than 3500 species have been found worldwide which less than 10% are venomous [5,6,3,2]. Snakebite prevalence rate, irrespective of involved species, is different from country to country and even region to region within one country [7,2]. It is a major public health challenge in rural areas. Although 10–20 % of the total reported snakebite cases occur at home or surrounding areas, most occurred events represent the hazard for agriculture-related professions in rural areas. Approximately, 85–90% snakebites happen in rural and agricultural section because mice are the main food for snakes and also the vermin for agricultural products [8,7,9,10,3,11,2]. Annually, 1.22 to 5.5 million cases, out of which 125,000 cases lead to death or disability, has been reported. With antivenom therapy, the mortality rate has decreased from 6.6% to 1.5% since 1904 [12]. Most mortality happens in the southeast part of Asia [13,14,15,2]. Only in Asia, it is estimated that 4 million cases

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happen annually. Fifty percent are venomous snake attacks killing 100,000 persons every year [16]. In India, 200,000 snakebite cases have been reported annually. Out of them, 35,000–50,000 cases are the victims of venomous snakes [17,2]. From 2001–2009, there were 5000–7000 documented cases in Iran where seven to eight cases killed once a year [3]. Only in Central America, approximately 4000 snakebites have been registered per year, being the agricultural workers and/or rural residents the most affected [18]. On the other hand farmers, cattle breeders and also veterans believe that snakebites are the common cause of mortality among pets, yielding a predominant economical loss [19]. Snakebites are associated with pain and infection which may be localized or systematic. Consequently, it may cause shock, acute renal failure, coagulopathy, and heart muscle damage [3,2]. Most complications caused by snakebite are due to poisoning effects such as hemorrhagic or neurotoxicogen effects which may be associated with secondary bacterial infections which are also being presented by non-venomous snakebites [20,21,22,23,2]. The commonest manifestation of a snakebite infection is abscess. Some bacterial infections are expected as the main cause of mortality [8,22]. The species of bacteria in snakes' oral cavity are the key elements for the kind of infection [23]. Like other creatures, snakes' oral cavity is a suitable place for bacterial growth some of which are as the normal oral flora. Using obtained samples from venom and the oral cavity and culturing them, some pathogenic bacteria have been identified, but some infections have secondary etiology due to snakebite. Non-venomous snakes may also harbor a wide range of bacteria in their oral cavity able to complicate the bite wounds [24] so the information on their microflora should not be neglected. Secondary bacterial infections, such as subcutaneous abscess or tetanus, are possible complications of snake bites, either venomous or non-venomous snakes [25]. Some snake bites, especially caused by Viperidae and Cobras, can cause necrosis at the site of bite which increases the likelihood of a secondary infection [26,2]. The oral flora of various snake species and also different geographical ones varies [27]. Some authors believe that seasonal changes have an influence on the flora [28]. Various bacteria have been recognized from the snakes' cavity. The most significant ones are Pseudomonas and Aeromonas [29], Morganella morganii [8], Staphylococcus aureus, Escherichia coli, Proteus, Colestridia, Enterococcus, coagulase-negative Staphylococcus [10], Stenotrophomonas maltophilia [21], Acinetobacter, Klebsiella, and Shigella [26,22,2]. Knowledge of the bacterial flora acquired from snakebites constitutes important information pertinent to management [27]. Snakes from different regions of the world present a variety of oral microbiota. Among the factors suggested to explain such differences are the particularities of the specimens evaluated, such as the species of snake, its origin, whether it is captive or free-living, its health status, whether or not it has fed recently, and the condition of the prey it feeds on [30]. Therefore, in this paper a review has been done to record different types of microflora isolated from the oral cavity and surface of various snakes.

2. *Enterobacter* spp.

The prevalence of enterobacteria in *Bothrops jararaca* in the state of São Paulo, based on a microbiological survey of adult snakes was evaluated. Several genera of the family Enterobacteriaceae were obtained (*Citrobacter, Enterobacter, Escherichia, Klebsiella, Kluyvera, Morganella, Proteus, Providencia* and *Salmonella*) and a morphologically similar genus of Gram-negative bacterium (*Aeromonas*). *Salmonella, Citrobacter* and *Escherichia* were the most frequent isolates [31]. A study of the microbiota in the fangs, fangs heath and venom of *Bothrops jararaca*, reported that the bacterial species most frequently found were: group D streptococci, *Enterobacter* sp., *Providencia rettgeri*, *Providencia* spp., *Escherichia coli*, *Morganella morganii* and *Clostridium* sp., but less frequently *Pseudomonas* spp., *Proteus mirabilis*, *Staphylococcus aureus*, *Salmonella typhimurium*, and *Citrobacter* spp. [30]. Gram-negative bacteria are predominant in the oral cavities of snakes. This is due to their eating habits, where the prey head is ingested first, leaving a colonization of fecal flora on the oral cavity. This also could explain the higher amount of enterobacterial isolates found in the mouth of the individuals sampled snakes [32].

3. *Pseudomonas* spp.

Pseudomonas spp were the most commonly isolated bacterial species, being found in 50% of the snakes sampled, and was followed by *Staphylococcus sciuri*. Jho et al. [33] also found *Pseudomonas* spp. to be the most-commonly isolated organisms (33% of cultures) from oral cultures of captive Burmese pythons. Interestingly, the oral swabs from Burmese pythons did not yield any strains of *Staphylococcus sciuri*. Iqbal et al. [34] studied Culturable Aerobic and Facultative Anaerobic Bacterial Flora of Black Cobra. The findings revealed that these snakes inhabit potentially pathogenic bacteria including *Serratia arcescens*, *Pseudomonas aeruginosa*, *Shewanella putrefaciens*, *Aeromonas hydrophila*, *Salmonella* sp., *Moraxella* sp., *Bacillus* sp., *Ochrobactrum anthropi*, and *Providencia rettgeri*. These findings are of concern, as injury from snake bite can result in wound infections and tissue necrosis. Draper et al. [35],

studying the microbiota from oral cavities of healthy and sick snakes, found gram-positive bacteria in healthy animals, whereas the sick ones presented, most frequently, *Pseudomanas, Providencia* and gram-negative bacilli. The secondary infection is one of snakebite complications. The isolated pathogens from abscess site encompassed *Pseudomonas* sp., *Proteus* sp., *Escherichia coli*, Providencia, and M. morganii [26].

4. *Staphylococcus* species

Dipineto et al. [36] cultured the oral cavities of 60 pet *Python regius*, and in that study they found *Staphylococcus* spp. to be the most-common organisms isolated (100% of snakes); however, *Pseudomonas* spp. were the second most-common species (85%). The pythons in their study were kept as pets in urban areas in Italy. Gram-positive agents are also sometimes isolated, particularly *Streptococcus* spp. and *Staphylococcus* spp. [37]. *Staphylococcus* spp. has been identified frequently in Bothrops atrox, appearing in 26% of samples. Shek et al. [27] studied Oral bacterial flora of the Chinese cobra (*Naja atra*) and bamboo pit viper (*Trimeresurus albolabris*). They found more than 50 bacteria species in the oral flora of Chinese Cobra including Aeromonas, Proteus, Colestridium sp., and also Staphylococcus aureus, Enterococcus, and coagulasenegative Staphylococcus. Fonseca et al. [22] aimed to determine the oral microbiotic composition of snakes from São José do Rio Preto city, São Paulo State, Brazil. Ten snake species, comprising the families Boidae, Colubridae, Elapidae and Viperidae, were submitted to microbiological examination of their oral cavity. Among isolated bacterium species, the occurrence of coagulase-negative staphylococci in the buccal cavity of *Crotalus durissus* (Viperiade), *Eunectes murinus* (Boidae), *Mastigodryas bifossatus* (Colubridae) and *Bacillus subtilis*, common to oral cavity of *Bothrops alternatus* (Viperidae) and *Phalotris mertensi* (Colubridae), was detected. In a study carried out in Hong Kong, the researchers found 72 bacteria in venomous and non-venomous snakes including gram-positive and gram-negative and also anaerobic bacteria [38].

5. *Escherichia* coli

Castro et al. [39] conducted study to identify the aerobic bacteria in the oral cavity of Bothrops atrox with stomatitis. Samples for microbiological examination were collected from 12 snakes. The following Gram-negative bacteria were isolated: *Escherichia coli* (26.31%), *Citrobacter* spp. (21.05%), *Proteus* spp. (15.78%) and *Salmonella* spp. (10.52%). The only Gram-positive bacterium that was isolated was *Staphylococcus* spp., which was present in 26.31% of the analyzed samples. Goldstein et al. [40] studied Aerobic Bacterial Oral Flora of Garter Snakes. Coagulase-negative Staphylococcus species were the most common species isolated. Acinetobacter calcoaceticus var. anitratus, Hafnia alvei, Arizona hinshawii, Salmonella species, Shigella species, Klebsiella oxytoca, and Pseudomonas aeruginosa were among the potential pathogens isolated.

6. *Salmonella* Spp.

Studies of *Salmonella* spp. in serpents suggest that the entry of infectious organisms in a snake collection is related not only to the addition of new reptiles but possibly also to the food that reptiles in captivity are fed, such as rodents [41]. On a study carried out by Ferreira Junior et al. [42], they indicate the presence of *Salmonella enteric* and *M. morganii* in the oral cavity of rattlesnakes. Goldstein et al. [43], however, found 32.6% of the oral bacterial flora to be anaerobic comprising several *Clostridium* spp., *Bacteroides* tragilis and *Propionibacterium* acnes in rattle snakes.

7. CONCLUSIONS

Knowledge of the bacterial flora acquired from snakebites constitutes important information pertinent to management. Snakes from different regions of the world present a variety of oral microbiota. Among the factors suggested to explain such differences are the particularities of the specimens evaluated, such as the species of snake, its origin, whether it is captive or free-living, its health status, whether or not it has fed recently, and the condition of the prey it feeds on. Therefore, not only anti-venom treatment but also, due the probability of infections, the diagnosis and treatment should be considered in victims.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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