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Analysis of the Bioecology, and Composition of Venom of Mammals (Chordata: Mammalia): Therapeutics and Treatment

Marco Vinícios de Oliveira Santana[1], Carlos Henrique Marchiori[1*], Klebert de Paula Malheiros[1], Èrico Meirelles de Melo[1]
[1]Researchers of Instituto Marco Santana, Goiânia, Goiás, Brazil

Abstract: In the classification of vertebrate animals, mammals are the most important. Females of this species have mammary glands that secrete milk, an essential food for mammals at an early age. Mammals are a class of vertebrate animals whose main characteristic is the presence of mammary glands. Most mammals have hair, some have their bodies partially covered, while others have hair all over their bodies. The blood of mammals always remains warm at a body temperature that is independent of the temperature of the external environment. Study of the bioecology, and composition of venom of mammals (Chordata: Mammalia): Therapeutics and treatment. A comprehensive search was carried out in the available literature, with a focus on venomous mammals. The research covered several databases, including UpToDate, MEDLINE, Scielo, Google Scholar, and PubMed, covering the period from 1992 to early 2025. The search strategy used a series of keywords, both individually and in combination, such as biotechnology, drugs, therapy, toxins, and venoms. The aim was to identify studies relevant to the objectives of this review. Peer-reviewed publications in English, Portuguese, and Spanish were included. Due to the nature of the findings, a narrative synthesis of the results of the selected articles was chosen.

Keywords: Allergen, Anaphylactic, Draculin, Fel-D1, Poison.

Research Paper

***Corresponding Author:**
Carlos Henrique Marchiori
Researcher of Instituto Marco Santana, Goiânia, Goiás, Brazil

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1.0. INTRODUCTION

Mammals are vertebrates and warm-blooded animals belonging to the class Mammalia. Their essential characteristic is that females have mammary glands that produce milk to feed their young. There are about 5,486 known current species of mammals, including humans, and most are viviparous, except for monotremes.

1.1. Monotremes. The few species of mammals whose females lay eggs after being fertilized. This is the oldest evolutionary group of the group.

1.2. Marsupials. The young climb over their mother's skin until they enter a skin sac known as a ‘marsupium, inside which they will be protected and have access to the breasts.

1.3. Placental. Characterized by carrying their young for several months and giving birth when they are ready to lead an independent life (Sotero-Caio *et al.*, 2010; Ito *et al.*, 2016; Australia Museum, 2019; Marcos, 2020; Santos, 2025).

1.4. Some characteristics are exclusive: The presence of fur, mammary glands, diaphragm, and differentiated teeth.

1.4.1. Presence of mammary glands: Located in the body of the female of the species, with which they secrete milk and nurse their young.

1.4.2. The jaw is composed of a dental bone: Instead of several bones or mobile parts. In addition, the jaw is articulated with the skull between the dental and the squamosal bones.

1.4.3. They have an ear with three small bones: Known as the anvil, hammer, and stirrup, except monotremes which have reptilian hearing (Figure 1).

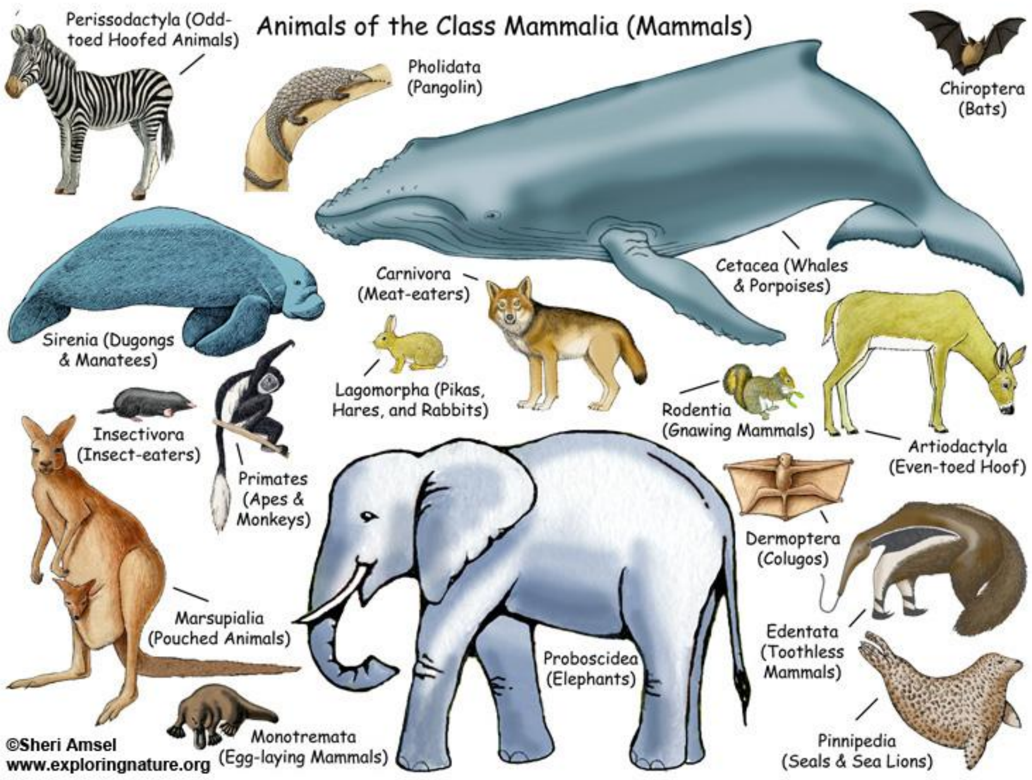

Figure 1: Mammalian Orders
Source: https://www.exploringnature.org/db/view/ABOUT-MAMMALS-Traits-and-Classification

1.4.4. The cardiovascular system of mammals: Has a heart with four cavities, two atria, and two ventricles. The circulation is closed and doubled. Mammals are endothermic animals.

1.4.5. They have hair at almost all stages of their life: And all species have it to some extent.

1.4.6. They can regulate body heat: These animals are endothermic, and the presence of thermal insulation is important for maintaining temperature. Heat retention is also guaranteed due to the presence of a layer of fat located just below the skin, and the presence of sweat glands.

1.4.7. The digestive system of mammals is complete: In platypuses and echidnas, it begins in the beak and ends in the cloaca, unlike other species, in which it begins in the mouth and ends in the anus. Mammals have a complete digestive system.

1.4.8. Excretion: Occurs thanks to the presence of two kidneys, which ensure blood filtration and urine formation.

1.4.9. Mammals have: Pulmonary respiration.

1.4.10. According to the type of diet: Mammals are classified as: herbivores, that is, those that feed on plants, such as horses, sheep, or elephants; carnivores, which eat animal flesh, such as lions, wolves, and bears; and omnivores, which eat both animal flesh and plants, such as humans and some primates.

1.4.11. Mammals have a well-developed nervous system: Which can be divided into the central nervous system and the peripheral nervous system.

1.4.12. Mammals: Are dioecious and have internal fertilization and direct development.

1.4.13. Mammals: Can be divided into three groups: marsupials, monotremes, and placentals.

1.4.14. Peripheral nervous system: Formed by nerves and ganglia.

1.4.15. Mammals: Have a complex sensory system.

1.4.16. Habitat: Marine, water, and terrestrial mammals (Sotero-Caio *et al.*, 2010; Ito *et al.,* 2016; Australia Museum, 2019; Marcos, 2020: Santos, 2025).

1.5. OBJECTIVE

Study of the bioecology, and composition of venom of mammals (Chordata: Mammalia): Therapeutics and treatment.

2.0. METHOD

A comprehensive search of the available literature was conducted, with a focus on venomous mammals. The investigation covered several databases, including UpToDate, MEDLINE, Scielo, Google Scholar, and PubMed, covering the period from 1992 to early 2025. The search strategy used a series of keywords, both individually and in combination, such as biotechnology, drugs, therapy, toxins, and venoms. The aim was to identify studies relevant to the objectives of this review. Peer-reviewed publications in English, Portuguese, and Spanish were included. Due to the nature of the findings, a narrative synthesis of the results of the selected articles was chosen.

3.0. VENOMOUS MAMMALS

These mechanisms vary greatly among animal groups; some are more effective and dangerous than others. Among them, we find the presence of venom, which is very common in animals such as snakes, lizards, arachnids, certain insects, amphibians, and some fish. However, venom is not restricted to these types of animals, but is also found, albeit less frequently, in mammals (Woods and Ottenwalder, 1992; Sergile and Woods, 1996; Marcos, 2020; Fernandes, 2021).

Venomous animals are poisonous snakes, threatening insects, and venomous mammals. Although there are few of them, these species use this characteristic as a defense mechanism. In this way, they can paralyze their prey in some situations. However, some mammals use venom with their claws to hold their victims more quickly. However, some species have developed this attack capacity, so that venom is not necessary. Therefore, the vast majority of mammals are not venomous (Woods and Ottenwalder, 1992; Sergile and Woods, 1996; Casewell *et al.*, 2019; Marcos, 2020; Fernandes, 2021; Romero, 2021).

Over the past few decades, scientists have tried to understand the characteristics of their toxin, which is rare among mammals and is mostly harmless to humans. However, few studies have focused on them. The challenges include understanding the functions of the venom and its evolutionary and physiological implications. In total, there are only four orders that include venomous species: Chiroptera, Eulipotyphla, Monotremata, and Primates (Woods and Ottenwalder, 1992; Sergile and Woods, 1996; Marcos, 2020; Fernandes, 2021; Romero, 2021).

However, since each of them has a different strategy for using and administering their toxins, researchers rule out the possibility of a single evolutionary origin. The systems for storing and inoculating venom are key adaptations that have evolved and that generally facilitate predation or defense, but also competition between individuals. These are some of the mammals that, despite their harmless appearance, are toxic (Eisenberg and Redford, 1999; Isaac *et al.*, 2007; IUCN, 2007; Marcos, 2020; Fernandes, 2021; Romero, 2021).

3.1. Chiroptera Blumenbach, 1779 (Mammalia: Placentalia)

The last group of venomous mammals includes vampire bats, of which there are three species: *Desmodus rotundu* (Geoffroy, 1810) (Mammalia: Chiroptera: Phyllostomidae), *Diphylla ecaudata* Spix, 1823 (Mammalia: Chiroptera: Phyllostomidae), and *Diaemus young* (Jentink, 1893) (Mammalia: Chiroptera: Phyllostomidae), which feed exclusively on blood. After their pointed fangs or molars pierce the skin of their prey to lick the blood, the venom is injected through saliva, which contains a glycoprotein called draculin (Figures 2-3) (Mayen, 2003; Simmons, 2005; Sotero-Caio *et al.*, 2010; Ivo *et al.*, 2013; Ito *et al.*, 2016; Marcos, 2020).

Figure 2: A vampire bat in Costa Rica
Source: Credit Michael & Patricia Fogden/minden pictures, via getty images

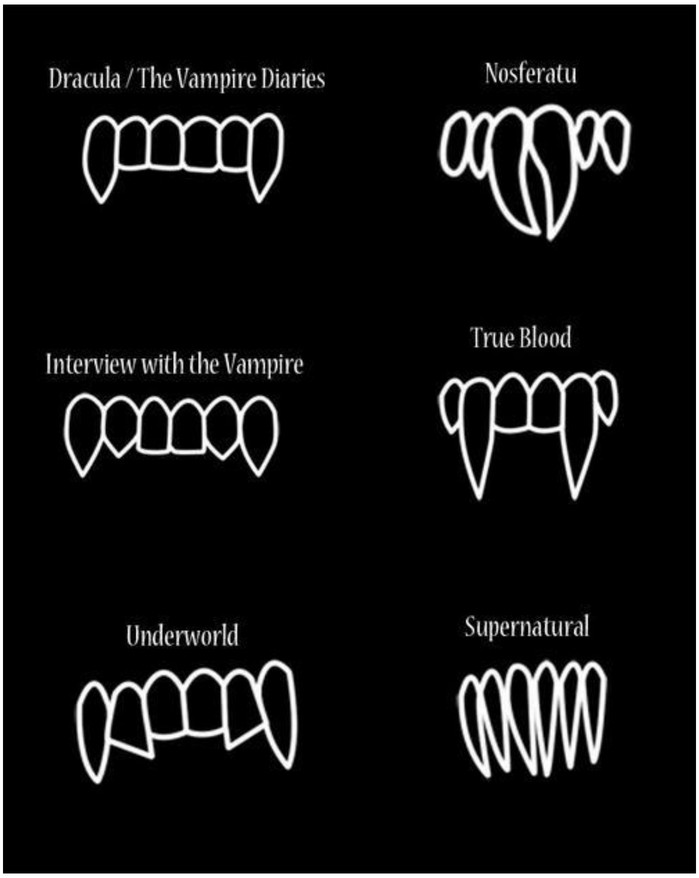

Figure 3: Fangs are usually depicted taking the place of human canines in the upper or top row of teeth. There is usually only one set of fangs, although this also varies by depiction. In some depictions, they are retractable and are only visible just before biting the victim
Source: https://vampires.fandom.com/wiki/Fangs

"These animals use their venom to prevent blood from clotting in their prey and also dilate blood vessels to allow blood to flow faster [Bryan G. Fry, University of Queensland in Australia]. In this way, these bats prevent blood from clotting in their victims, allowing for continuous feeding. In this procedure, their saliva is key, once a cut of about 5 mm in diameter and depth has been made in the prey, which are usually mainly cattle. Its compounds allow for prolonging bleeding, acting as anticoagulants (Figures 4-5) (Mayen, 2003; Simmons, 2005; Ruddock and Molinari, 2006; Sotero-Caio *et al.,* 2010; Ivo *et al.,* 2013; Ito *et al.,* 2016; Marcos, 2020).

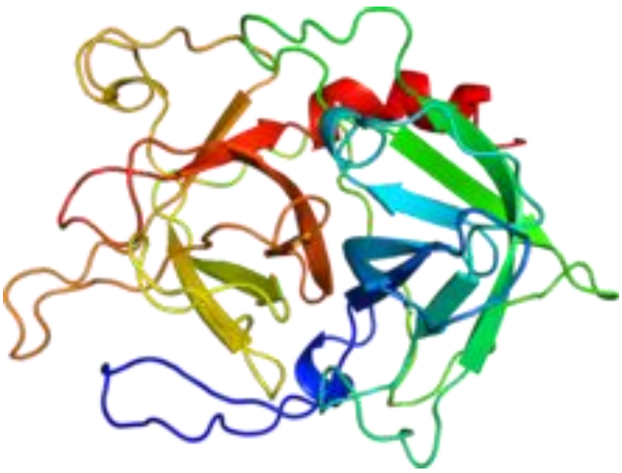

Figure 4: The venom is injected through saliva, which contains a glycoprotein draculin
Source: Doi: 10.1242/jcs.03225

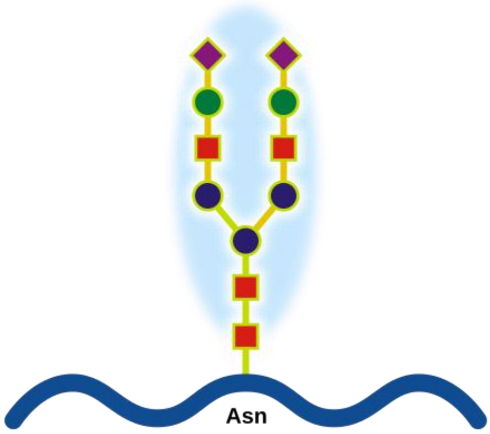

Figure 5: *N*-linked protein glycosylation (*N*-glycosylation of *N*-glycans) at Asn residues (Asn-x-Ser/Thr motifs) in glycoproteins
Source: Doi: 10.1242/jcs.03225

Although millions of years ago more species of mammals could use venom, today only these four groups used it. According to a study, the costs of producing venom, teeth specialized for feeding, and the possible lack of benefit of this toxin prevented it from being generated in larger mammals and thus justify the rarity of this substance in these animals. Bat saliva emerges as a new source of vascular biology modulator (Figures 6-9) (Mayen, 2003; Simmons, 2005; Sotero-Caio *et al.*, 2010; Stoner-Duncan *et al.*, 2014; Ito *et al.*, 2016; Marcos, 2020).

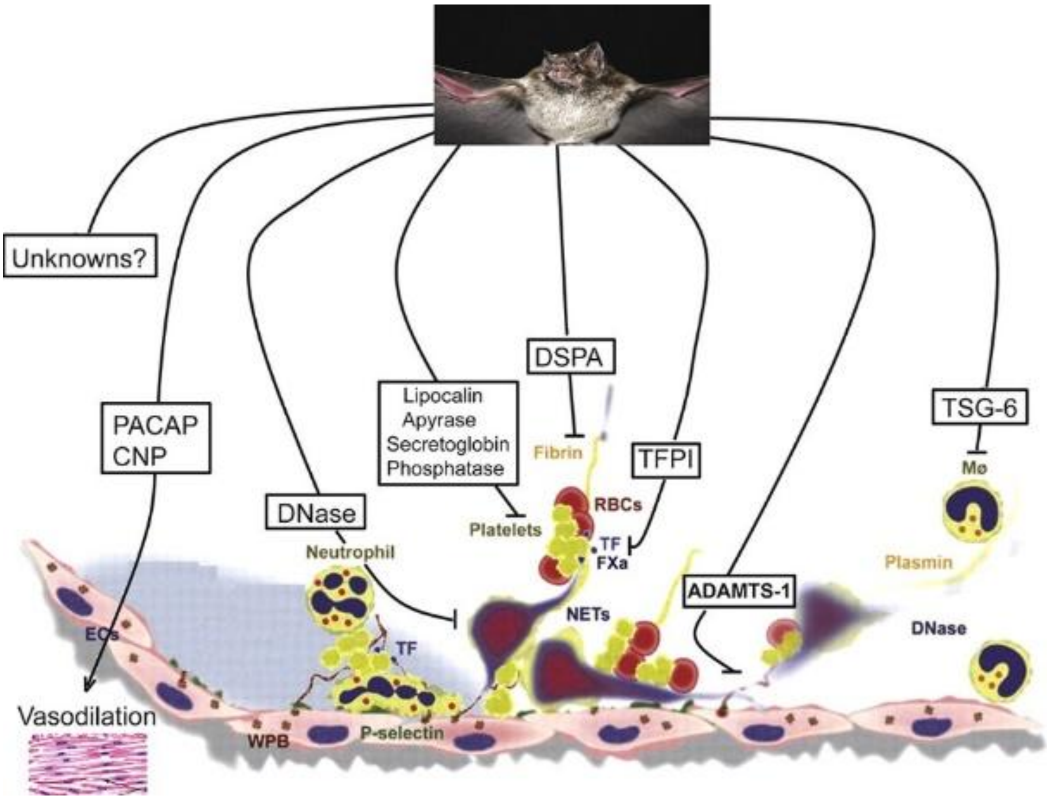

Figure 6: Only one antihemostatic plasminogen activator, desmoteplase, has been molecularly characterized. 200 million reads from the salivary glands of *Desmodus rotundu* (Geoffroy, 1810), were sequenced by Illumina. Several new protein families that affect hemostasis and the immune system were identified
Source: https://doi.org/10.1016/j.jprot.2013.01.009.IvoM.B

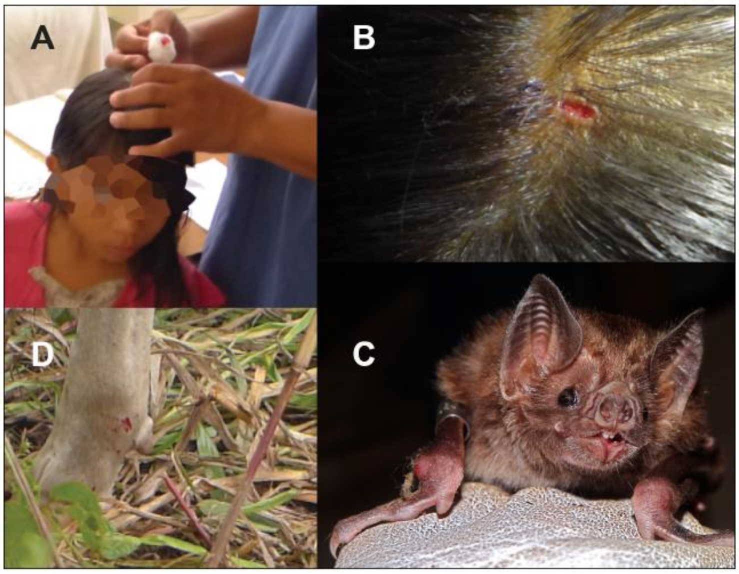

Figure 7: (A) Young woman was bitten by a bat while sleeping. (B) Close-up of the typical concave bite lesion. (C) *Desmodus rotundu* (Geoffroy, 1810). The central incisors remove a small piece of skin from the prey, and the anticoagulants in the saliva prevent clotting - allowing rabies to be transmitted to the prey via saliva. (D) Typical ankle bite of a cow

Source: Doi: 10.1371/journal.pntd.0002867.g003

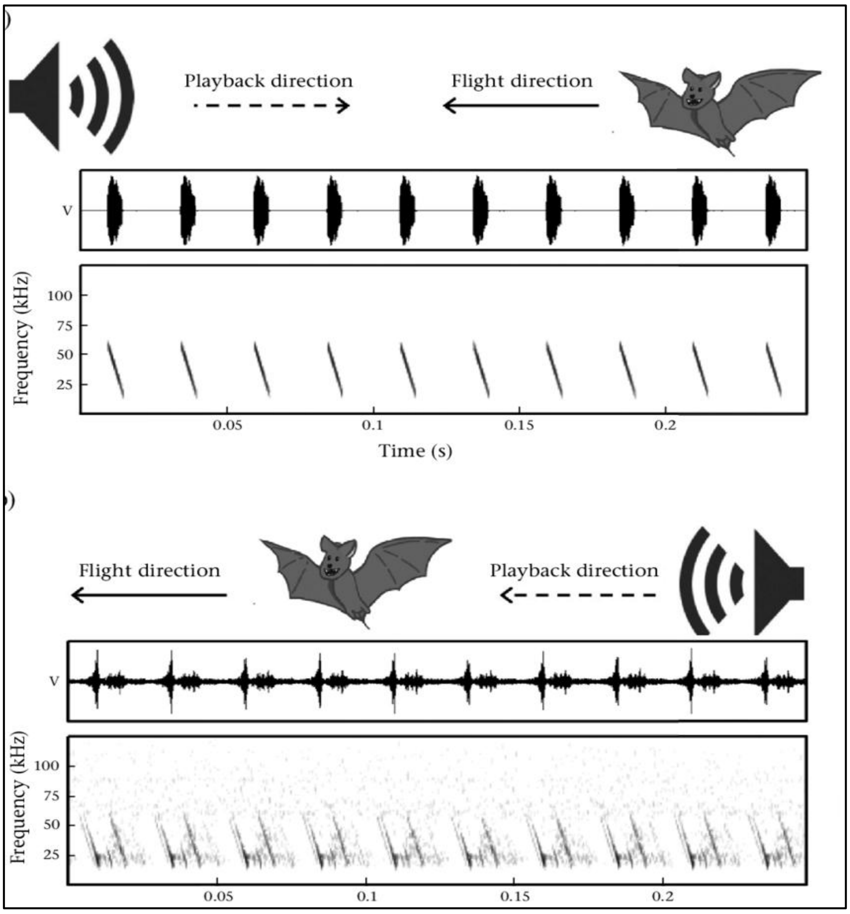

Figure 8: Playback is experienced by bats flying toward or (b) away from the playback source. Each panel includes the upper oscillogram and lower spectrogram. (a) The bat is exposed to a repetitive voltage of individual pulses. (b) It hears the pulses at a low sound pressure level followed by a series of prominent echoes in the room

Source: https://doi.org/10.1016/j.cub.2024.05.062

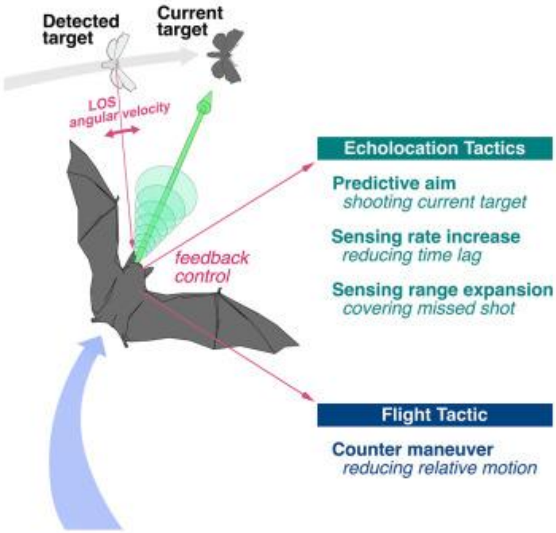

Figure 9: Bats integrate multiple echolocation and flight tactics to track prey (Predation)
Source: https://doi.org/10.1016/j.cub.2024.05.062

3.2. *Nycticebus* Geoffroy, 1812 (Mammalia: Primates: Lorisidae)

In the case of slow lorises such as *Nycticebus bengalensis* (Lacépède, 1800) (Mammalia: Primates: Lorisidae) and *Nycticebus coucang* (Boddaert, 1785) (Mammalia: Primates: Lorisidae), these small, candid-looking primates from Southeast Asia use venom to defend themselves, but in a peculiar way. These mammals lick a gland located on their elbow, loading their comb with needle-sharp teeth with a venom that has an anaphylactic effect (Figure 10) (Pliosungnoen *et al.*, 2010; Nekaris, 2020; Blair *et al.*, 2021; Fuller *et al.*, 2024).

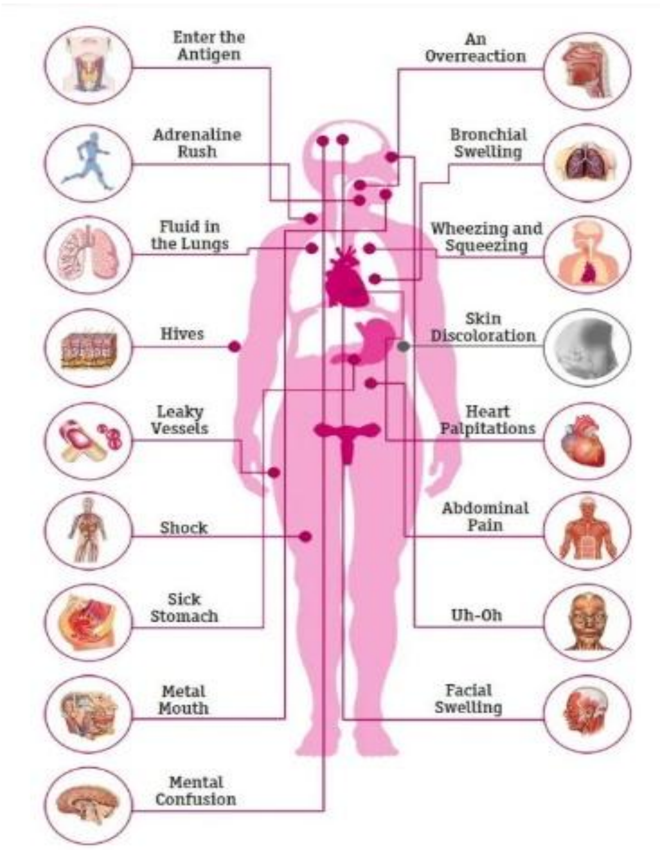

Figure 10: The effects of anaphylaxis on the body
Source: https://danieljmarsh.wordpress.com/17-effects-of-anaphylaxis-on-the-body/

In a study, that analyzed the defensive purpose of this substance, the researchers pointed out that both in the Bengal and Sunda lorises, as well as in the pygmy lorises *Nycticebus pygmaeus* (Bonhote, 1907) (Mammalia: Primates: Lorisidae), a small swelling can be seen on their elbow free of fur but barely visible, called brachial gland (Figure 11) (Blair *et al.,* 2021; Fuller *et al.,* 2024).

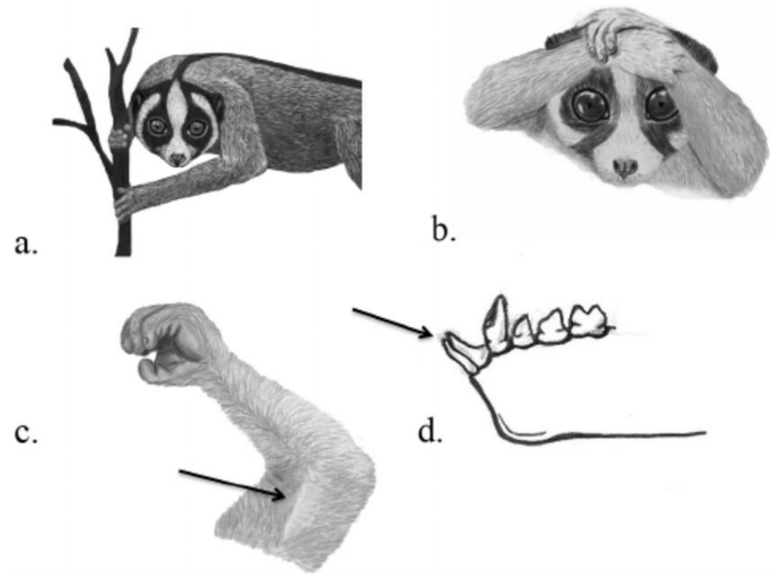

Figure 11: Venom system of slow lorises. Javan slow loris *Nycticebus javanicus*, Geoffroy, 1812 (Primates: Lorisidae), showing warning coloration of the face (a); Javan slow loris displaying defense position (b); brachial gland as indicated by the arrow (c); tooth comb as indicated by the arrow (d)
Source: Illustrations: Kathleen Reinhardt

When the animal feels in danger, the gland, which is activated six weeks after birth, secretes a clear liquid with a strong smell in the form of apocrine sweat. Both males and females adopt defensive positions at that time with their heads bowed and their front legs raised, after sucking the area of the glands and rubbing against them (Figure 12) (Pliosungnoen *et al.,* 2010; Nekaris, 2020; Blair *et al.,* 2021; Fuller *et al.,* 2024).

Figure 12: Clockwise from top: brachial gland secretions on a wild Javan slow loris *Nycticebus javanicus*, Geoffroy, 1812 (Primates: Lorisidae); brachial gland secretions and more bald fur on a captive pygmy loris *Xanthonycticebus* spp.; the position of the brachial gland and the "venom pose" *N. javanicus*
Source: Photo courtesy of Christine M. Drea and slow lorises courtesy of Little Fireface Project and captive *Xanthonycticebus* spp.

This oily toxin, the venom of the slow loris *Nycticebus* spp. is made up of oil from the brachial gland and saliva. The venom contains a variety of compounds, including a protein similar to the cat allergen Fel-D1 which is dragged by their sharp teeth, which are used as a resource to inject it into the attacker. Their bites are painful and cause slow-healing wounds. Being a chemically complex substance, scientists believe that it also allows these primates to transmit information through smell about their health, age, or nutritional status (Figure 13) (Pliosungnoen *et al.*, 2010; Ligabue-Braun *et al.*, 2015; Nekaris, 2020; Blair *et al.*, 2021; Fuller *et al.*, 2024).

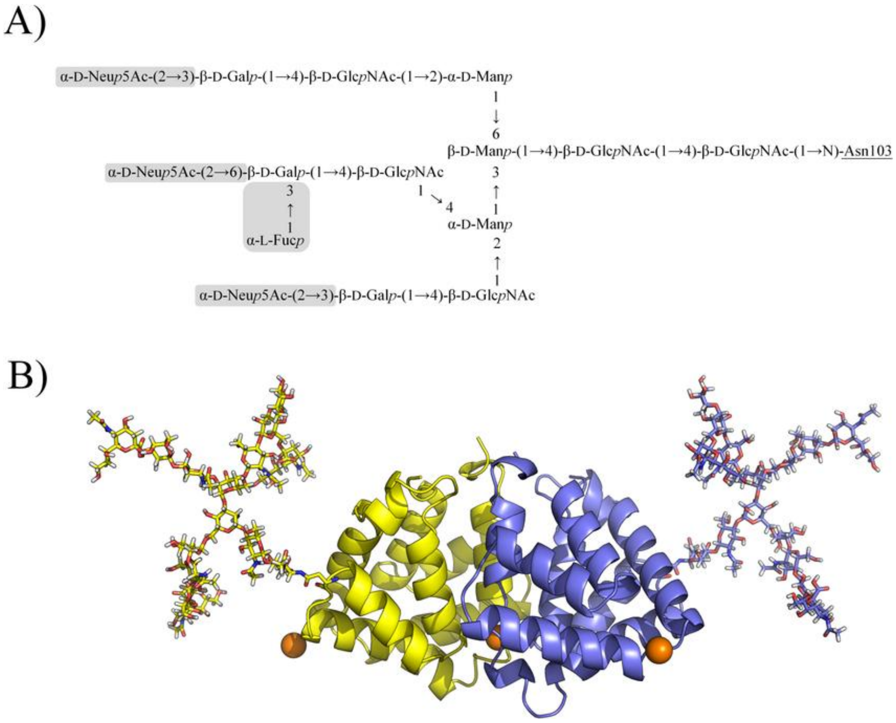

Figure 13: Fel d 1 glycosylation structures. (A) Full (largest) glycosylation structure of Fel d 1, shaded boxes indicate saccharides that are absent in the minimal (smallest) glycosylation structure. (B) Fel d 1 structure with full glycan chains attached. Calcium ions are shown as orange spheres, Chain A is shown in yellow, Chain B is shown in blue

3.3. *Suncus etruscus* (Savi, 1822) (Mammalia: Eulipotyphla: Soricidae)

Shrews are small mammals that, in general, have a high metabolic rate and therefore need to be eaten all the time. Some species can die for more than six hours without eating. Among them, the *S. etruscus* stands out as the smallest mammal in the world, which is approximately 52 mm long. They live alone, have nocturnal habits, and live on the surface of the ground. Some species, however, can make galleries; others live on top of trees and even in flooded areas. They feed mainly on small insects and are included in the order Insectivora (Figure 14) (MacDonald and Barrett, 1993; Cabral *et al.*, 2005; Aulagnier *et al.*, 2017; Santos, 2025; *Suncus etruscus*, 2025).

Figure 14: *Suncus etruscus* (Savi, 1822) - Pygmy shrew
Source: https://pt.wikipedia.org/wiki/Musaranho-pigmeu

The back is greyish-brown and the belly is light grey. It has long hair scattered throughout the coat, especially on the tail and snout, giving it a slightly frosty appearance. It has white teeth, 4 of which are single-cusped. The ears are large and protruding. It has two molts per year, the first in autumn when the individuals become darker and have thicker fur, and the second in spring (Figures 15-16) (MacDonald and Barrett, 1993; Cabral *et al.*, 2005; Aulagnier *et al.*, 2017; Santos, 2025; *Suncus etruscus*, 2025).

Figure 15: The venom delivery tooth of a *Solenodon paradoxus* Brandt, 1833 (Mammalia: Eulipotyphla: Solenodontidae). Proteins that make up the venom consist of multiple serine proteases kallikrein-1. An analysis of these toxins was shown to be used to cause low blood pressure
Source: Credit: Nicholas Casewell

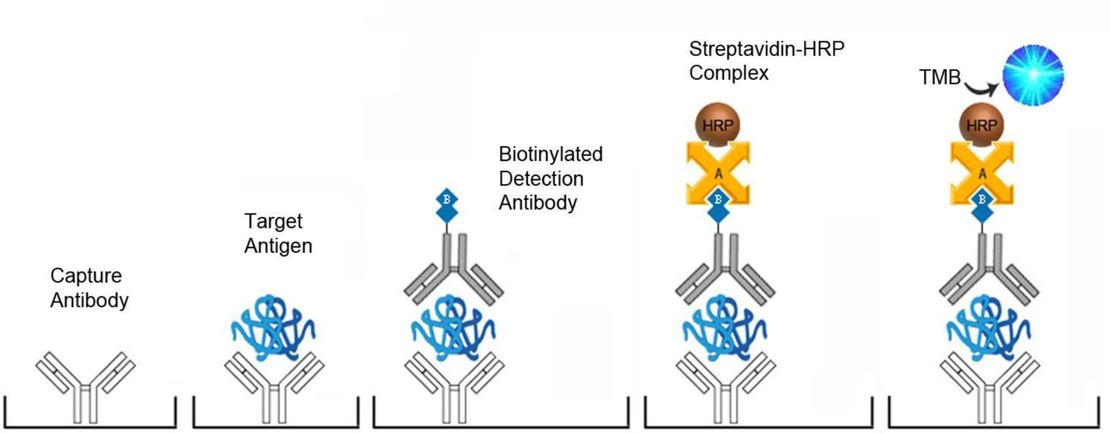

Figure 16: **LS-F52153 is a 96-well enzyme-linked immunosorbent assay (ELISA) for the Quantitative detection of Human KLK1 / Kallikrein 1 in samples of Plasma, Serum, and Tissue Homogenates. It is based upon a Sandwich assay principle and can be used to detect levels of KLK1 / Kallikrein 1 as low as 0.195 nanograms per millilter**
Source: https://www.lsbio.com/elisakits/human-klk1-kallikrein-1-sandwich-elisa-elisa-kit-ls-f52153/52153

Kallikrein-1 (KLK1) is a serine protease that is involved in the regulation of blood pressure and is expressed in the kidney. It is also known as tissue kallikrein and urinary kallikrein. Kallikrein-1 (KLK1) is a protein that is present in humans and is encoded by the KLK1 gene. I am a member of the S1 family of peptidases (Aulagnier *et al.*, 2017; Santos, 2025; *Suncus etruscus*, 2025).

3.3.1. Functions 1:

A. Regulates vasodilation.
B. Reduces blood pressure.
C. Relaxes and contracts the smooth muscle.
D. Induces pain and Induces inflammation.

3.3.2. Characteristics:

A. It is a highly conserved serine protease.
B. Its activity decreases in acute kidney injury (AKI).
C. It is one of the proteases of the kallikrein family, which is a group of 15 secreted serine proteases.
D. Kallikreins are encoded by genes clustered on chromosome 19q13.
E. The expression of kallikreins is associated with the progression of several cancers.

3.3.3. Functions 2:

A. Kallikreins are responsible for the coordination of several physiological functions, including

B. (continued) blood pressure, semen liquefaction, and skin desquamation.

B. KLK1 is one of the kallikreins that cleave kininogen to release vasoactive.

3.3.4. Reproduction

Birth occurs between March-April and September-October, after 27 to 28 days of gestation. Females can have more than one litter per year and normally produce 2 to 5 young per litter. All sub-adults reach sexual maturity after winter. During the breeding season, they form pairs and tolerate the juveniles in the nest for a long time. The maximum longevity is about 18 months (Aulagnier *et al.,* 2017; Santos, 2025).

It is distributed throughout southern Europe, northern Africa, and some Asian countries. In Portugal, it appears to be more abundant in the center and south of the country. In the Algarve, this species has been confirmed in the Ria Formosa Natural Park and the Castro Marim Sapal Natural Reserve (MacDonald and Barrett, 1993; Cabral *et al.,* 2005; Aulagnier *et al.,* 2017).

To defend themselves, these animals release a substance with an unpleasant odor that ends up discouraging predators. In addition, some shrews have venom in their saliva that is capable of killing and immobilizing prey. Due to their type of diet, they are important in insect control. They feed on nectar produced by a palm tree that has a high alcohol content (Figure 17) (Aulagnier *et al.,* 2017; Santos, 2025; *Suncus etruscus,* 2025).

Figure 17: The pen-tailed tree shrews have a taste for "bud". A tiny tree shrew that lives on alcoholic nectar could - pound for pound - drink the average human
Source: http://news.bbc.co.uk/1/hi/7530720.stm

3.5. *Solenodon paradoxus* Brandt, 1833 (Mammalia: Soricomorpha: Solenodontidae)

Among the shrews, the short-tailed ones, along with the *S. paradoxus*, have an oral venom system, meaning that their saliva is poisonous to paralyze and subdue their prey, especially small vertebrates. However, the evolution of this toxin in these insectivores has aroused much interest in the scientific community (Figure 18) (Ottenwalder, 1999; Ottenwalder, 2001; Hutterer, 2005; Turvey *et al.,* 2008; Jonathan *et al.,* 2015).

Figure 18: *Solenodon paradoxus* Brandt, 1833, Natural History Museum Vienna.jpg
Source: https://pt.m.wikipedia.org/wiki/Ficheiro:Solenodon_paradoxus,_Naturhistorisches_Museum_Wien.jpg

The substance evolved by reusing existing salivary proteins, in particular a type of enzyme called kallikrein. Later, other toxins were added to the chemical arsenal that was not of salivary origin, but genes that are normally expressed in other parts of the body, and which ended up being expressed in the venom gland and then evolved for new functions," [SINC Bryan G. Fry, researcher at the Toxin Evolution Laboratory at the University of Queensland, Australia, and one of the authors of the paper] (Figure 19) (Ricketts *et al.,* 2005; Turvey *et al.,* 2008; Jonathan *et al.,* 2015; Alhenc-Gelas *et al.,* 2019).

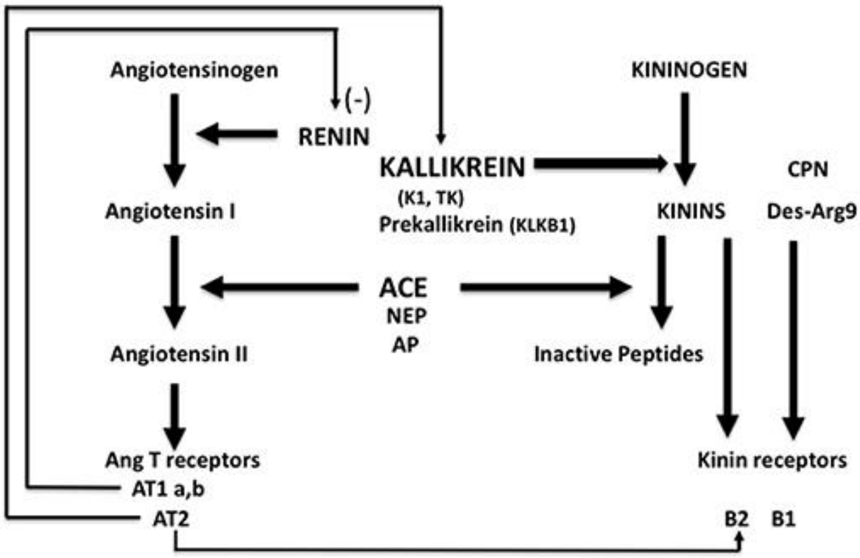

Figure 19: Schematic representation of the renin-angiotensin and kallikrein-kinin systems with physiological interrelation. ACE, Angiotensin-Converting Enzyme/Kininase II; NEP, Neutral-Endopeptidase; AP, Aminopeptidase P; CPN, Carboxypeptidase N
Source: Doi: 10.3389/fmed.2019.00136

The venom, which can be painful if the shrew bites a human, is secreted by the submaxillary glands to the base of the lower incisors where saliva flows. This substance seems to have been generated with a clear objective – predation, and its function has remained intact until now (Figure 20) (Alhenc-Gelas *et al.,* 2019).

Figure 20: The submaxillary glands
Source: https://carnegiemnh.org/mammals-with-venom/

Solenodons, which exist only in the Dominican Republic, Haiti, and Cuba. Platypuses, which exist only in Oceania, belong to a group that has not developed all the typical characteristics of mammals. This suggests why venom is so rare in mammals (Sergile and Woods, 1996; Turvey *et al.,* 2008; Jonathan *et al.,* 2015).

Kallikrein has direct and indirect vasodilator action. Kallikrein acts on bradycinogen, breaking down the molecule and giving rise to plamakinins, mainly bradykinin, and kallidin (Chatzikyriakidou *et al.,* 2018; Lau *et al.,* 2020; Shen *et al.,* 2022).

3.5.1. Bradykinin is a vasoactive peptide that is produced during inflammatory processes. It can cause bronchoconstriction, coughing, redness, heat, and pain.

3.5.2. Kallidin is a peptide that is formed from kininogens in response to injury. It is a vasodilator and smooth muscle stimulator.

3.5.3. Kallikrein: This is an enzyme that acts on proteins, participating in several biological processes, such as blood pressure regulation and inflammation.

3.5.4. Functions:

A. Interacts: With the renin-angiotensin-aldosterone system.
B. Regulates blood pressure.
C. Production is prostaglandin. Releases vasopressins.
D. Balances hydro-electrolytes.
E. Participates in the activation of coagulation.
F. Participate in fibrinolysis.
G. Generates kinins.
H. Participates in the kallikrein-kinin system, which controls the kidney.
I. Participating in inflammation (Figure 21) (Chatzikyriakidou *et al.*, 2018; Lau *et al.*, 2020; Shen *et al.*, 2022).

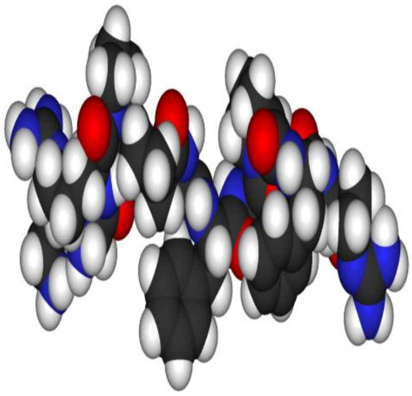

Figure 21: Kalidin is an organic compound, containing 56 carbon atoms and having a molecular mass of 1188.381 Da
Source: https://www.wikiwand.com/sh/articles/Kalidin

3.5.5. Characteristics:

A. It is a decapeptide sequence H-Lys-Arg-Pro-Pro-Gly-Phe-Ser-Pro-Phe-Arg-OH.
B. It is identical to bradykinin, with an additional lysine residue at the N-terminus. It is an agonist of bradykinin B1 and B2 receptors. It is a substrate for carboxypeptidase M and N It can be converted to bradykinin by the enzyme aminopeptidase.

3.5.6. Functions:

A. It is used as a research tool to characterize the bradykinin B-1 receptor It is a vasodilator and hypotensive agent that acts by vasodilation.

3.5.7. Importance:

A. Kallidin is one of several kinin peptides that are part of large proteins (kininogens).
B. Kinins have a variety of beneficial effects, including effects on insulin sensitivity, skeletal muscle function, fluid balance, vascular tone, and cardioprotection (Ruddock and Molinare, 2006; Chatzikyriakidou *et al.*, 2018; Lau *et al.*, 2020; Shen *et al.*, 2022).

3.6. *Ornithorhynchus anatinus* (Shaw, 1799) (Mammalia: Monotremata: Ornithorhynchidae)

The platypus is a species of venomous mammal endemic to Australia, with semi-aquatic habits and currently classified as near-threatened with extinction. It is undoubtedly a rarity in the animal world, because, although it is a mammal, it has a beak similar to that of a duck, a tail similar to that of a beaver, and webbed hind legs (Figure 22) (Grant and Temple-Smith, 1998; Lin and Jones, 2000; Martinez, 2021).

Figure 22: *Ornithorhynchus anatinus* (Shaw, 1799) (Mammalia: Monotremata: Ornithorhynchidae)
Source: https://a-z-animals.com/animals/lists/most-venomous-mammals/

These animals have spurs on their hind legs which, in the case of males, have poisonous glands and produce a toxin composed of proteins. They can cause significant damage to other animals and people, causing extremely intense pain and the formation of edema in the affected area. Their fur is dark brown on the head and body, and blond or gray on the belly. Their paws have membranes that they use to swim, as does their tail, which serves as a rudder. Although their olfactory system is limited, they can smell underwater (Figures 23-24) (Kashuba *et al.*, 2013; Whittington and Belov, 2014; Woinarski-Burbidge, 2016; Australia Museum, 2019; Martinez, 2021).

Figure 23: Photograph of spur of adult male platypus. A wire of 0.1 mm diameter is inserted through the central channel of the spur two of these wires can fit through the central channel at once
Source: https://doi.org/10.1016/j.jprot.2008.12.004

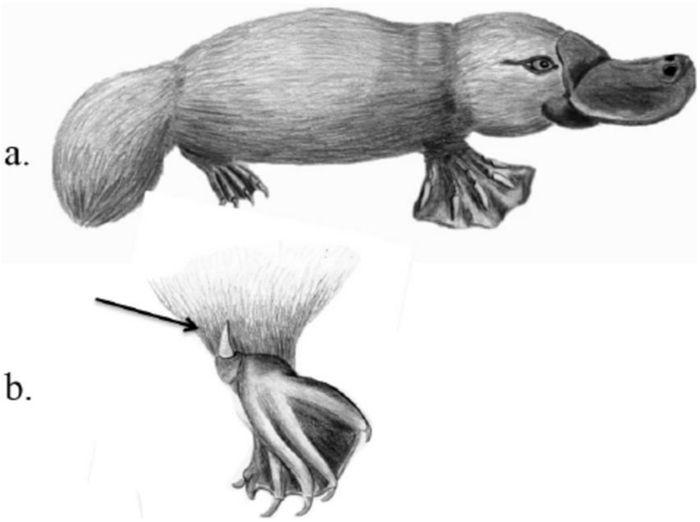

Figure 24: V**enom system of the platypus. Platypus *Ornithorhynchus anatinus* (Shaw, 1799) (a); with crural spur as indicated by the arrow (b)**
Source: Illustrations: Kathleen Reinhardt

These animals are semi-aquatic, meaning they live both in water and on land. Their habitats are usually small rivers and streams spread across various types of ecosystems. These rivers are found throughout the extensive tropical forests of Queensland in the mountains of the Australian Alps or the mountainous and cold-climate region of Tasmania (Woinarski and Burbidge, 2016; Australia Museum, 2019; Martinez, 2021).

Their diet is based on the consumption of other animals, mainly crabs, insects, shrimp, and various species of annelids that inhabit their respective habitats. The female lays 1 to 3 platypus eggs, measuring between 10 and 11 millimeters. These eggs are incubated by the mothers for a time that varies between 10 and 15 days, after having been gestated in their womb for approximately 28 days (Grant and Temple-Smith, 1998; Lin and Jones, 2000).

3.6.1. Electrolocation

The system is based on the location of its prey thanks to the electric fields that are generated when its muscles contract. The electroreceptors are located in the beak, distributed in rows, and the mechanoreceptors, which are responsible for touch, are also located there. Several studies have demonstrated the strong neuronal association of both types of receptors (Figure 25) (Woinarski and Burbidge, 2016; Australia Museum, 2019; Martinez, 2021; Nishiumi *et al.*, 2024).

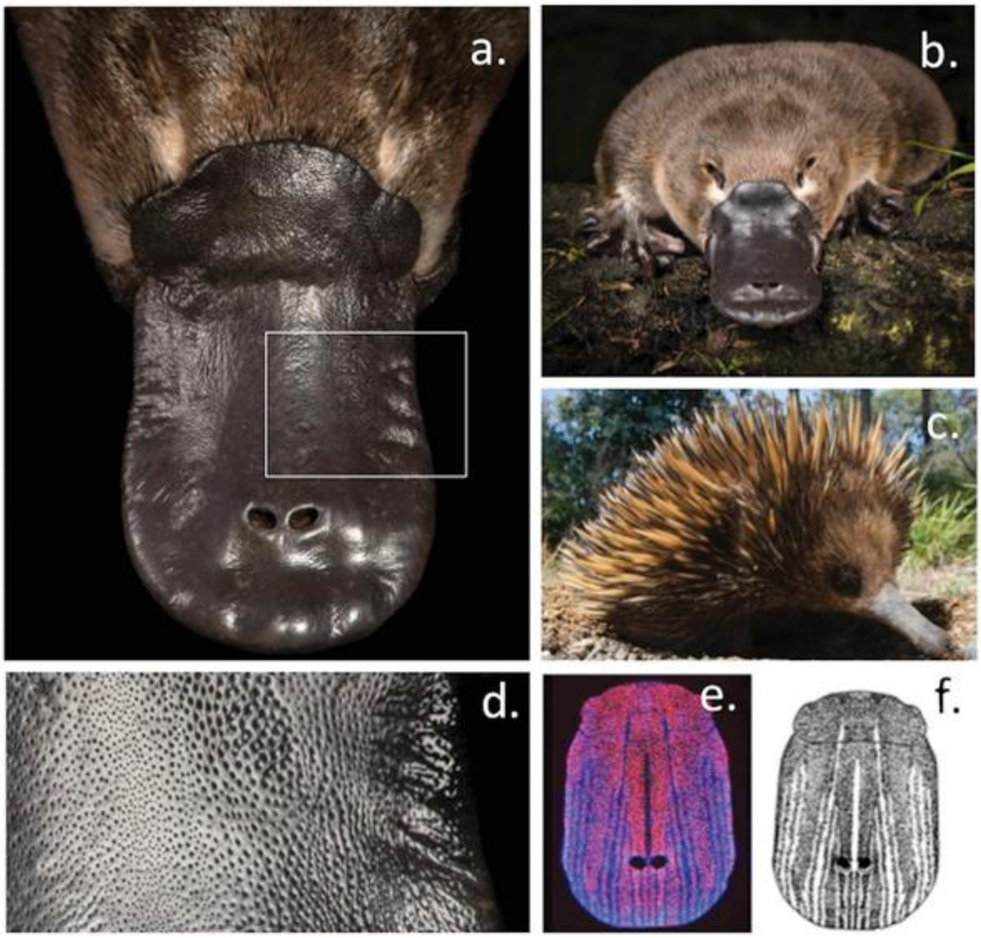

Figure 25: Electrolocation in the duck-billed platypus and short-nosed *Echidna*. (a), (b), (d) are reproduced with permission. (c) is reproduced (d) is an enlargement of panel (a) and depicts the surface pores on the platypus bill. (e) and (f) depict electroreceptors (red) and mechanoreceptors blue distributed in rows along the platypus bill
Sources: Copyright 1998, The Royal Society. f) Adapted with permission.24 Copyright 1999, The Company of Biologists Ltd and Copyright Doug Gimesy

3.7. Overview of venomous and poisonous animals (According to Lima, 2024).

A. **Venom: Venomous**: The toxin or mixture of several toxins of strict animal origin that are produced by glands capable of altering the metabolism of another animal when inoculated through a natural apparatus of the animal such as spines, teeth, and others. The toxin is injected into the victim's body through intact skin.
B. **Poison: Poisonous:** A toxin or mixture of several toxins of animal, plant, viral, bacterial, seaweed, or mineral origin, but it is not produced by a gland and is not inoculated by ingestion or respiration or by absorption through an intact tissue, such as the skin or mucosa. Produce its toxins: It can produce its toxins. This occurs according to its genetic information.
C. **Vehicles:** On the other hand, those animals that have structures that pierce or cut the tissue of others, without actually injecting them, that is, with compact piercing structures without internal channels.

3.7.1. Mammals

A. Venomous animals inoculate or transmit their toxins through the structure in this case teeth - compact piercing apparatus without an internal canal: **Teeth**: Examples: *Suncus* Ehrenberg, 1832 (Mammalia: Eulipotyphla: Soricidae) and *Solenodon* Brandt, 1833 (Mammalia: Soricomorpha: Solenodontidae) (Lima, 2024).
B. Venomous animals that only transmit venoms - compact piercing apparatus without internal canal - **Teeth**. Examples: *Nycticebus* Geoffroy, 1812 (Mammalia: Primates: Lorisidae) (Lima, 2024).

4.0. CONCLUSION

Toxins tend to be metabolically expensive to synthesize. Most mammals have evolved to be fast and/or powerful, but you'll notice that most venomous animals are smaller in size and use keen senses of smell, sight, or touch, rather than brute strength, to carefully ambush their prey. Neither strategy is necessarily better; it's just a matter of the course evolution has taken to direct strategies for survival.

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