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# Analysis of the Biology, Ecology, and Composition of Toxic Bird Venom (Chordata: Tetrapoda: Aves)

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**Abstract:** Birds are vertebrate animals that stand out mainly due to the presence of feathers on their bodies. In addition, they have forelimbs modified into wings, a toothless beak, and light bones. They are endothermic, bipedal, and oviparous animals. Although they are known for their ability to fly, it is important to make it clear that not all birds have this ability. Penguins and ostriches, for example, are birds that are unable to fly. Birds participate in the food chain, in addition to helping in the pollination and dispersion of seeds of plant species. Poultry farming represents an important economic activity, generating income for thousands of people. The objective of this article is to analyze the biology, ecology, and composition of toxic bird venom (Chordata: Tetrapoda: Aves). The methodology used an integrative literature review and a synthesis process to develop the study to expand the understanding of knowledge and achieve the expected results. Regarding the inclusion criteria, national and international articles were used in full in Portuguese, English, and Spanish.

**Keywords:** Beetle, Birds, Homobatrachotoxin, Poisonous, Toxin.

**Research Paper**

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## 1. INTRODUCTION

Birds include living beings whose main characteristic is the presence of feathers. These structures are extremely important as they function as thermal insulation and are also essential for flying representatives as they provide greater aerodynamics. In addition, they can be used by some species as an attraction for mating (Randall *et al.*, 2002; Gill and Donsker, 2021; Ferreira, 2023).

The skin of these animals is thin, elastic, and relatively dry. In some species, the uropygial gland is found capable of producing a secretion formed by lipid substances. This secretion allows the animal to keep its feathers waterproof after diving (Figure 1) (Randall *et al.*, 2002; Gill and Rasmussen, 2021).

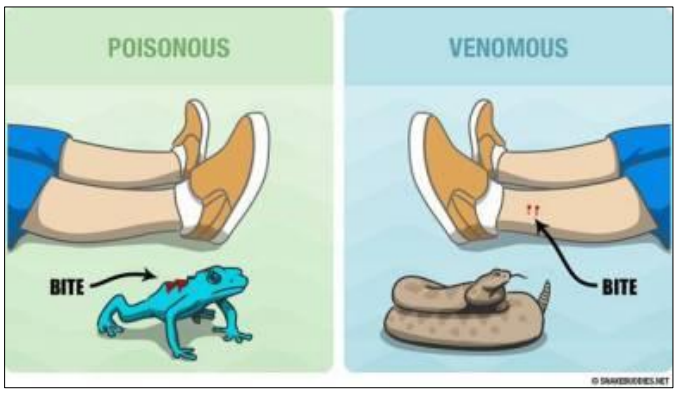


**Figure 1: The drawing above accurately represents a saying I read a few months ago: "If you bite it and you die, it's poisonous. If it bites you and you die, it's venomous"**
**Source**: Snakebuddies.net

**1.1. Main characteristics of birds:**

1. They are vertebrate animals with segmented spines.
2. They are bipeds and move in a vertical position, using their lower limbs to rest on the ground.
3. They are oviparous; the embryo develops inside an egg, in an external environment and without contact with the mother.
4. They are homeothermic; their body temperature is kept constant, even with variations in the temperature of the environment.
5. Their bodies are covered in feathers.
6. They have wings; most birds can fly with these wings.
7. They have beaks used to catch food, break it, pierce it, and even transport it.
8. They have pneumatic bones with air inside; they are hollow.
9. When they consume liquids, mainly water, these go to the intestine, where they are absorbed. The impurities are transformed into urate, which is excreted with the feces (Figure 2).

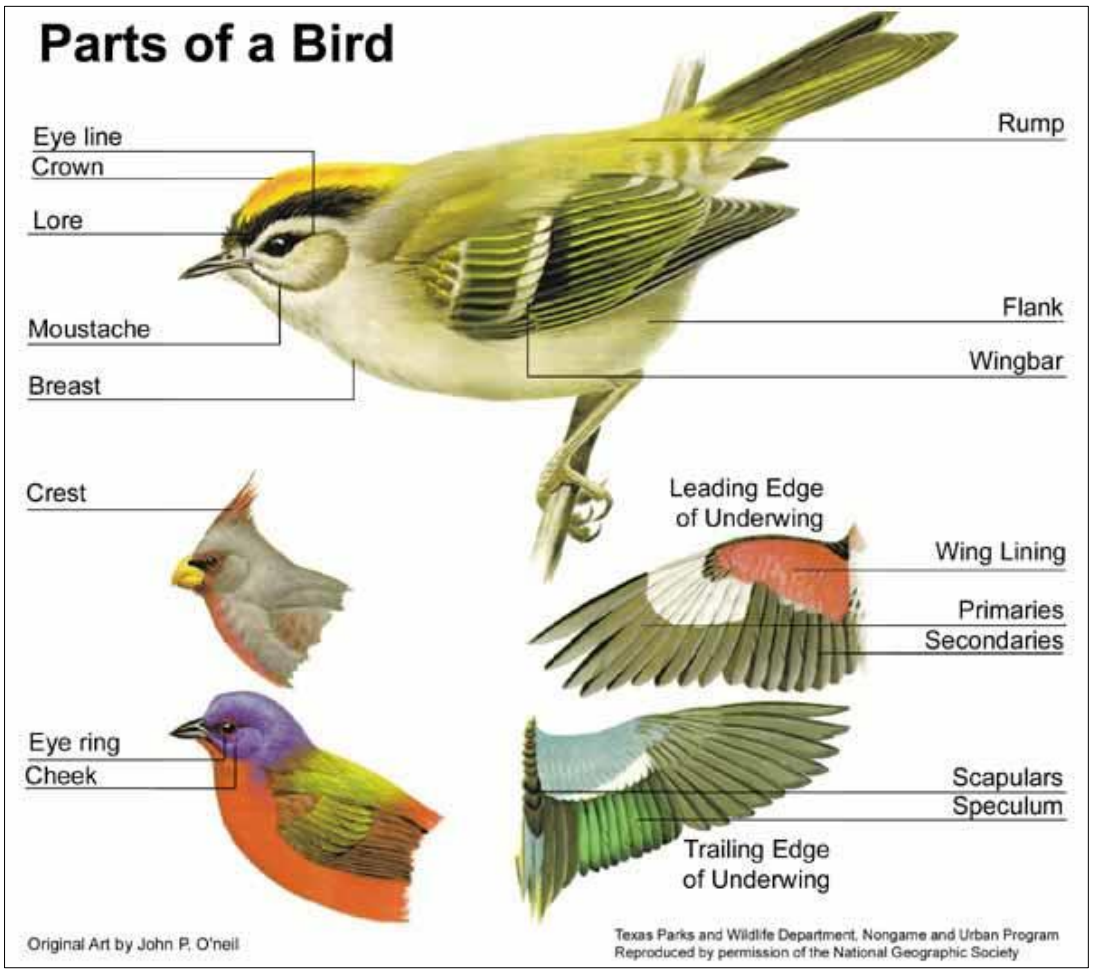


**Figure 2: Bird external anatomy**
**Source:** https://ornithology.com/bird-external-anatomy/

10. Singing is one of the most important forms of communication between these animals. Sound is produced by a structure in the trachea called the syrinx. Birds have a complex nervous system, and the presence of brains and nerves can be observed. In addition, vision and hearing are two well-developed senses.
11. Birds have an excretory system formed by kidneys and are known for excreting uric acid. These animals do not have a urinary bladder, and their excreta is eliminated through the cloaca, along with feces. Seabirds also have so-called salt glands, which act to eliminate excess salt from the body.
12. The circulatory system of birds is closed, and they have a heart divided into two atria and two ventricles, just like the heart of mammals. Circulation is double, with blood passing through the heart twice, and complete since there is no mixing of oxygen-rich blood with oxygen-poor blood (Figure 3).

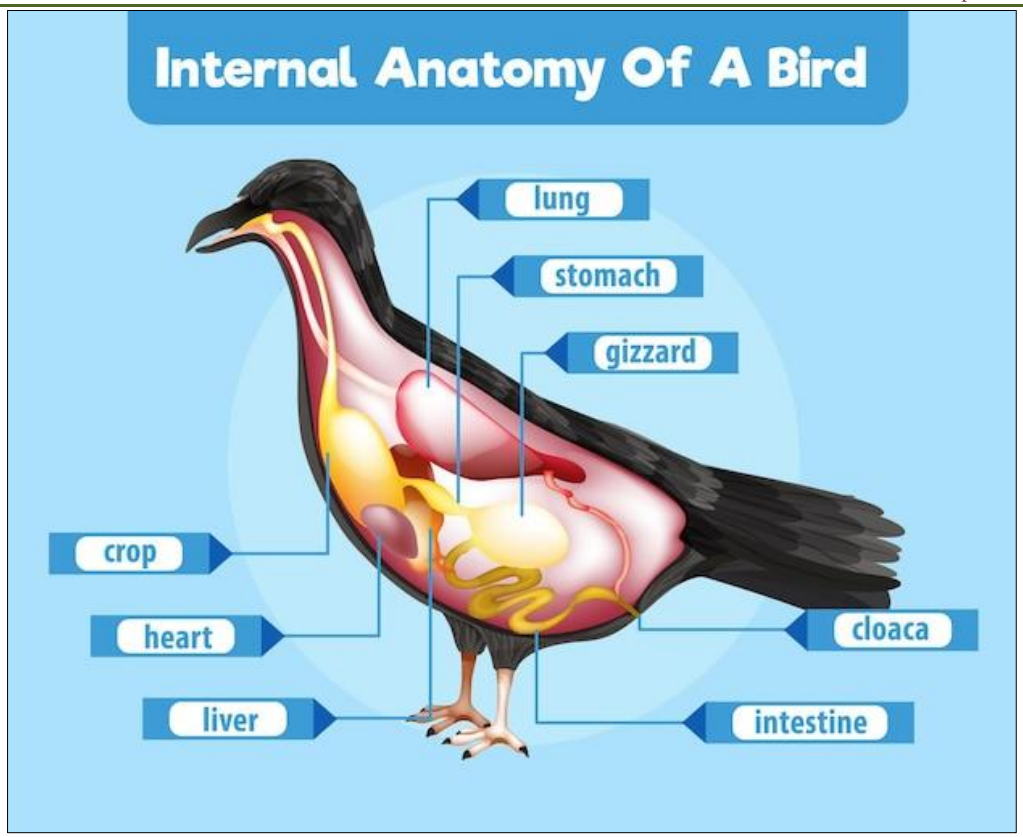


**Figure 3: Internal anatomy of a bird**
**Source:** https://www.freepik.com/free-vector/internal-anatomy-bird_283953430.htm

13. Birds that fly, however, have some characteristics that are considered adaptations to flight. These are the presence of feathers; forelimbs modified into wings; a streamlined body; a large number of pneumatic bones in their skeleton; a sternum with a keel, where the pectoral muscles that help the wings to beat are attached; absence of teeth; compact lungs and air sacs; absence of a urinary bladder; oviparity.
14. Birds are found in a wide variety of habitats and can be observed, for example, in: forest regions, deserts, polar regions, coastal environments, oceanic islands, and open sea, among other regions. Birds can also be found living in anthropized environments.
15. Birds' diet: Birds have a very diverse diet, eating, for example, other animals, dead animal carcasses, grains, fruits, nectar, pen seeds, and others
16. Birds reproduce sexually and have separate sexes, that is, male and female individuals (Randall *et al.*, 2002; Kardong, 2006; Moen and Morlon, 2014; Gill and Rasmussen, 2021; Ferreira, 2023).

It is not uncommon to find accentuated sexual dimorphism in birds when males and females present large differences. Perhaps the most emblematic example is the peacock, as the male is larger and has a long, very exuberant tail, while the female does not have the tail of the male. They are oviparous animals. In many cases, nests are prepared so that the eggs can develop. These eggs are very similar to those of reptiles; however, birds take care of the eggs, and reptiles, with some exceptions, do not take care of their eggs (Kardong, 2006; Moen and Morlon, 2014; Randall *et al.*, 2018; Gill and Rasmussen, 2021; Ferreira, 2023).

### 1.1 Poisonous Birds

Poisonous birds are very rare, but they do exist on our planet. Songbirds that live in the tropical forests of New Guinea are considered the only poisonous birds in the world. They belong to the genus *Pitohui* Lesson, 1831 (Aves: Passeriformes: Oriolidae) and have six different species. This genus was discovered recently, so little is known about their habits. *Pitohui* birds are diurnal and feed on insects, mainly beetles of the Melirydae family (Figures 4-5) (Dumbacher *et al.*, 200’4; Dumbacher *et al.*, 2008; Bruce, 2011).

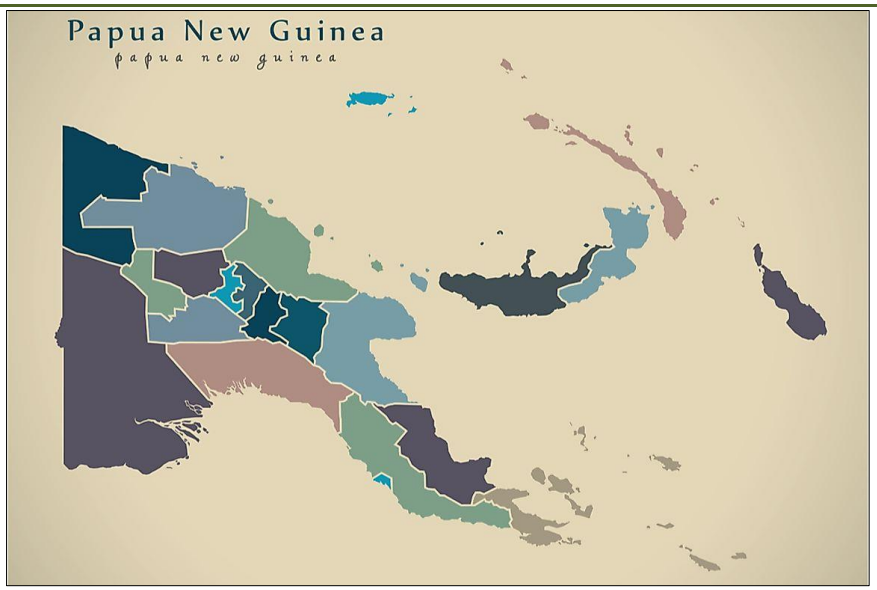


**Figure 4: Papua New Guinea has 21 provinces and one autonomous province**
**Source:** https://www.worldatlas.com/articles/the-provinces-of-papua-new-guinea.html

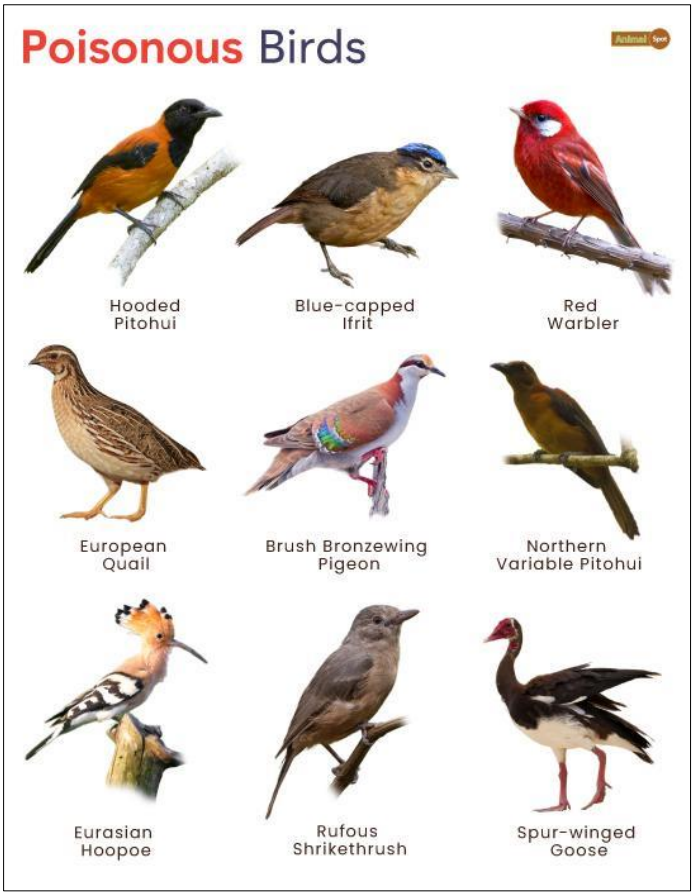


**Figure 5: Poisonous birds**
**Source:** https://www.animalspot.net/poisonous-birds

Most Melyridae are soft-bodied beetles with an elongated oval shape. Many are colored brown, red, and black. Most adults and larvae are predators, but many are commonly on flowers. *Choresine* Pascoe, 1860 is a genus of beetles in the family Melyridae. These insects contain low doses of batrachotoxin and may be the source of the venom found in certain venomous birds of the genus *Pitohui* Lesson, 1831) but also in Kowald's *Ifrita* Rothschild, 1898 (Figure 6) (Dumbacher *et al.*, 2004).

**Figure 6: *Choresine* Pascoe, 1860 (Coleoptera: Melyridae)**
**Sources**: José Sánchez and https://www.facebook.com/photo.php?fbid=2736825729874071&id=1630532720503383&set=a.1648589742031014&locale=ko_KR

Scientists believe that this beetle is where the birds' venom comes from. When feeding, the bird somehow manages to absorb the insect's venom and store it in its own body. Thus, it is deposited in the skin and feathers and used by the bird to defend itself from predators or when hunting. It is a neurotoxic alkaloid, capable of causing paralysis in the bodies of other animals, including in the heart muscles, and can cause death. Poisoning occurs when the toxin comes into contact with the skin, mouth, eyes, and nasal mucosa, causing numbness and paralysis in the affected area (Figure 7) (Paynter, 1986; Jobling, 2010; Gill and Rasmussen, 2021).

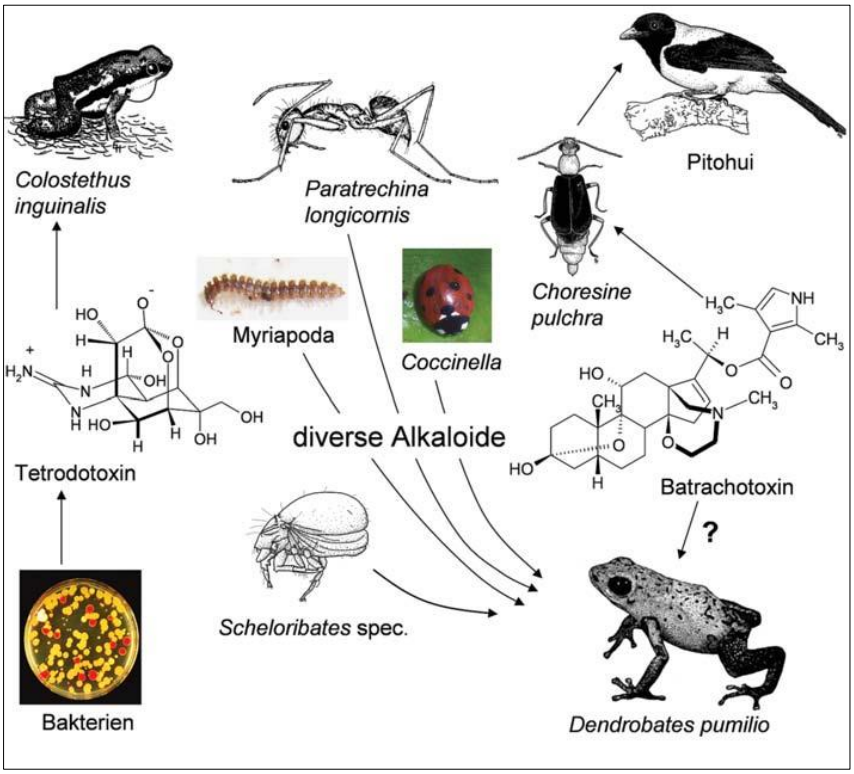


**Figure 7: Transfer of Tetrodotoxin (TTX), batrachotoxin, and other alkaloids from bacteria (TTX) and arthropods. Batrachotoxin: It is well known in birds of the genus *Pitohui* Lesson, 1831). Transfer of tetrodotoxin (TTX), batrachotoxin, and other alkaloids from bacteria (TTX)**

**Source:** modified and completed after MEBS 2004

They do not have a mechanism for producing venom like snakes, but they become venomous when they feed on a type of beetle. An interesting development is that it has already been investigated how amphibians manage to ingest toxic insects to synthesize venom and not become poisoned in the process. In the studies, they discovered that there are specific mutations in genes that prevent the action of venom (Figure 8) (Poulsen, 1993; Jonsson *et al.,* 2008).

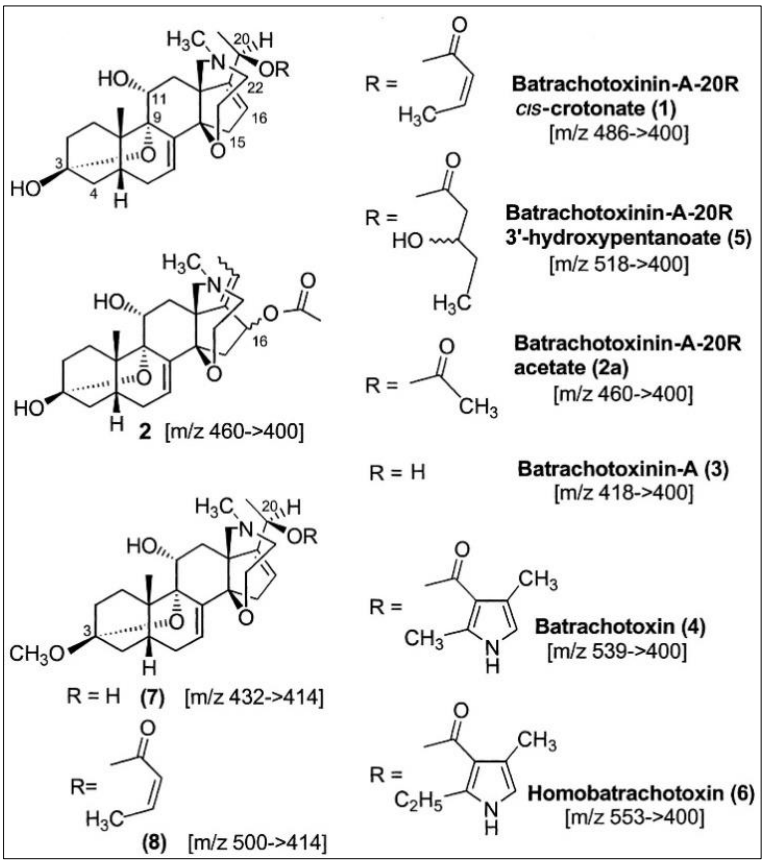


**Figure 8: Batrachotoxins found in feathers and/or skins of New Guinean passerine birds. The protonated parent ion and major fragment ion in chemical ionization mass spectrometry are indicated in brackets for each structure**
**Source:** https://doi.org/10.1073/pnas.200346897

The venom present in pitohui can cause paralysis in the body of living beings, including in the heart muscles, and can cause the death of animals that come into contact with it. "Their venom is used for defense against predators. When it comes into contact with the mouth, eyes, and nasal mucosa or skin wounds, they begin to feel numbness and paralysis at the site [Ornithologist Guilherme Brito] (Poulsen, 1993; Jonsson *et al.,* 2008).

### 1.2 Objective

The objective of this article is to analyze the biology, ecology, and composition of toxic bird venom (Chordata: Tetrapoda: Aves).

## 2.0. METHODS

The exclusion criteria were articles that were presented in duplicate and that did not meet the objectives of the investigation. In this way, the reviewer/researcher can prepare an integrative review with different purposes, which can be directed towards defining concepts, reviewing theories, or methodological analysis of included studies of a particular topic In its construction process, it is necessary to go through six distinct stages, which are: identification of the theme and selection of the hypothesis or research question; establishment of criteria for inclusion and exclusion of studies/sampling or literature search; definition information to be extracted from selected studies/categorization of studies; evaluation of included studies; interpretation of results; and presentation of knowledge review/synthesis. To carry out the study, a search for scientific articles was carried out through the Virtual Health Library, in the SCIELO, LILACS, and Pubmed databases.

## 3.0. SELECTED STUDIES

### 3.1. The Ability to Accumulate Toxins via the Food Chain

#### 3.1.1. Batracotoxina

They carry batrachotoxin, a potent neurotoxin that can lead to human death if found in large quantities. Pre v sent in beetles of the Melyridae family, batrachotoxin is a potent neurotoxic alkaloid that affects sodium channels in nerve cells, resulting in paralysis and, in high doses, can be lethal even to humans. They carry batrachotoxin, a potent neurotoxin that can lead to human death if found in large quantities (Figure 9) (Poulsen, 1993; Cestèle and Catterall, 2000; Weldon, 2000; Wiese *et al.*, 2010).

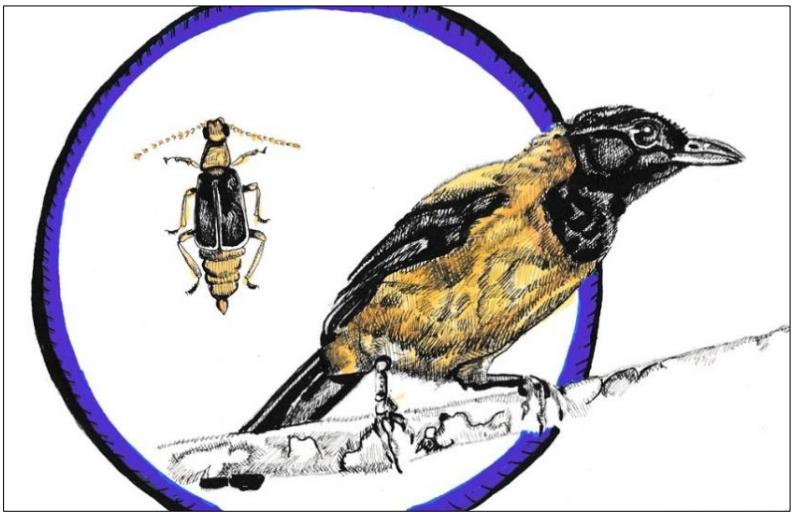

**Figure 9: *Pitohui* (Lesson, 1831) *i*s a poisonous bird - it eats toxic beetles (*Choresine* Pascoe, 1860) and frogs, isolates the poison from its diet, and incorporates it into its body**
**Source:** https://www.flickr.com/photos/studiotau/44335515324/

This toxicity is most likely an adaptation to prevent the action of ectoparasites, the lice that live on the feathers of birds. There have been experiments in which it was observed that this toxin can inhibit the action of lice and some vertebrates [Wesley Rodrigues Silva, professor of the Department of Animal Biology at the Institute of Biology at Unicamp] (Poulsen, 1993; Jonsson *et al.*, 2008; UOL, 2024).

The neurotoxin alters a cell membrane, the sodium channel, which is responsible for mediating muscle contraction. This toxin alters these channels so that they remain permanently open, which can lead to death by muscle paralysis. The birds managed to develop a mutation in the cell protein to which the toxin binds. With this mutation, the toxin is unable to act (Figure 10) (Poulsen, 1993).

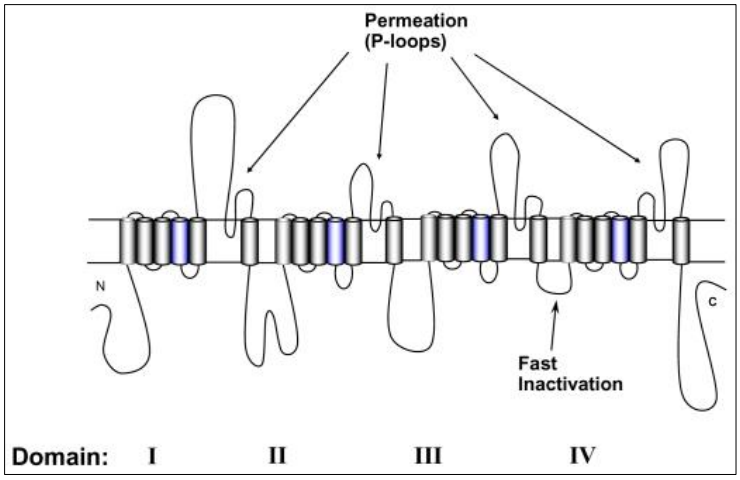


**Figure 10: Transmembrane-folding diagram of the α-subunit of the voltage-gated Na+ channel. Probable α-helical segments and polypeptide chains are represented as cylinders and bold lines, respectively. The bold lines represent polypeptide chains. S4 segments (blue) are the voltage sensors**
**Source:** Doi: 10.3390/md8041373

New Guinea for causing skin irritation, causing sensations of numbness. There are also reports of symptoms such as runny nose and watery eyes. In higher concentrations, it can cause cramps and even cardiac arrest. poisons are transferred through more passive contact, such as touching or eating. poisons are transferred through more passive contact, such as touching or eating (Jonsson *et al.*, 2008; Paixão, 2021; UOL, 2024).

The toxin can be felt when you hold on to one of them. It feels a little unpleasant, and holding on to one for too long is not an attractive option. This could indicate that the poison serves to deter those who would want to eat them to some extent. The reference was simply to the fact that it gave off a foul smell when cooked. They clarified that they ate it only in case there was nothing else available and they were starving (Poulsen, 1993; Jonsson *et al.*, 2008; Ferreira, 2023).

These batracotoxins are neurotoxins that act selectively on the ionic sodium ducts of membranes of excitable cells neurons and muscle cells, causing sustained opening at low resting potentials. This effect results in an irreversible electrical depolarization of cells, which results in cardiac arrhythmia, fibrillation, and cardiac failure (Figure 11) (Poulsen, 1993; Jonsson *et al.*, 2008; Ferreira, 2023).

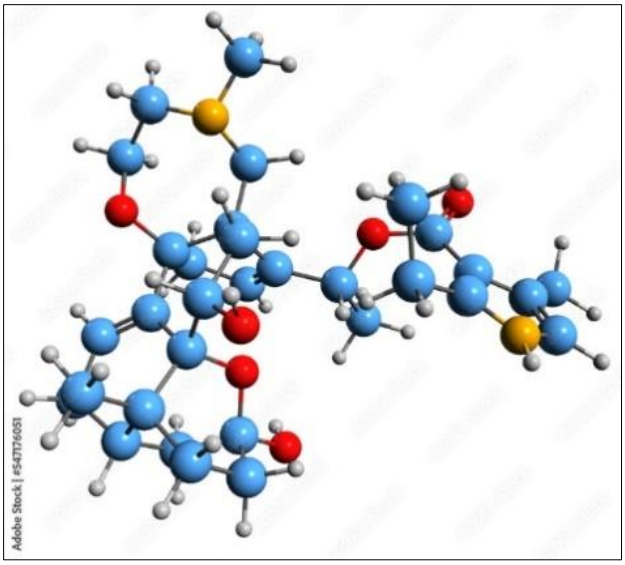

**Figure 11: Homobatrachotoxins, a substance related to batrachotoxin, occurs in the skin, feathers, and muscles of three species of *Pitohui* spp. Homobatrachotoxin prevents the closure of the Na+ channel and thus leads to permanent excitation and, consequently, paralysis of the muscles of poisonous birds**
**Source:** https://stock.adobe.com/br/search?k=homobatrachotoxin&asset_id=547176051

**3.2. Substances Produced by Birds:**

**3.2.1**. **Batrachotoxin, a Potent Neurotoxin**: Has great potential in the treatment of cardiac arrhythmias.

**3.2.2. The Steroid Alkaloid is called**: Homobatrachotoxin.

**3.2.3. The Fluoroacetate Poison**: Acts as an inhibitor of cellular respiration, causing a range of responses from intense stomach pain to death (Figure 12).

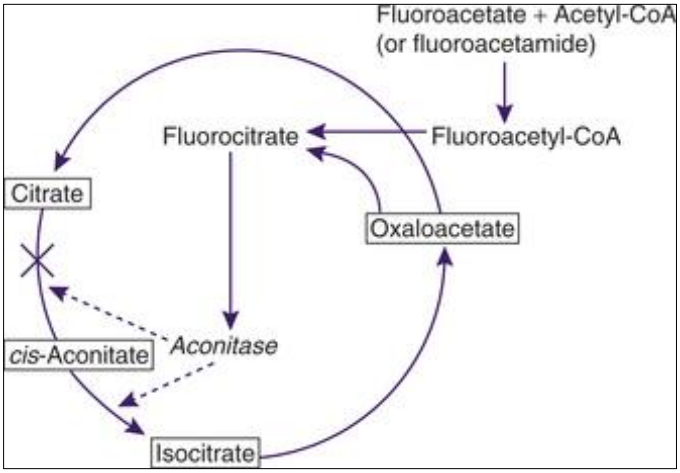

**Figure 12: Mechanism of toxicity: Compounds 1080 and 1081 are readily absorbed from the gastrointestinal and respiratory tracts, abraded skin, and mucous membranes, but not through intact skin. They are not known to accumulate in any one tissue. Classic theory: Fluoroacetate inhibits aconitase in the Krebs TCA cycle**
**Source:** https://veteriankey.com/sodium-monofluoroacetate-1080/

**3.2.4. Cantharidin:** Toxin is the terpenoid compound called (Figure 13).

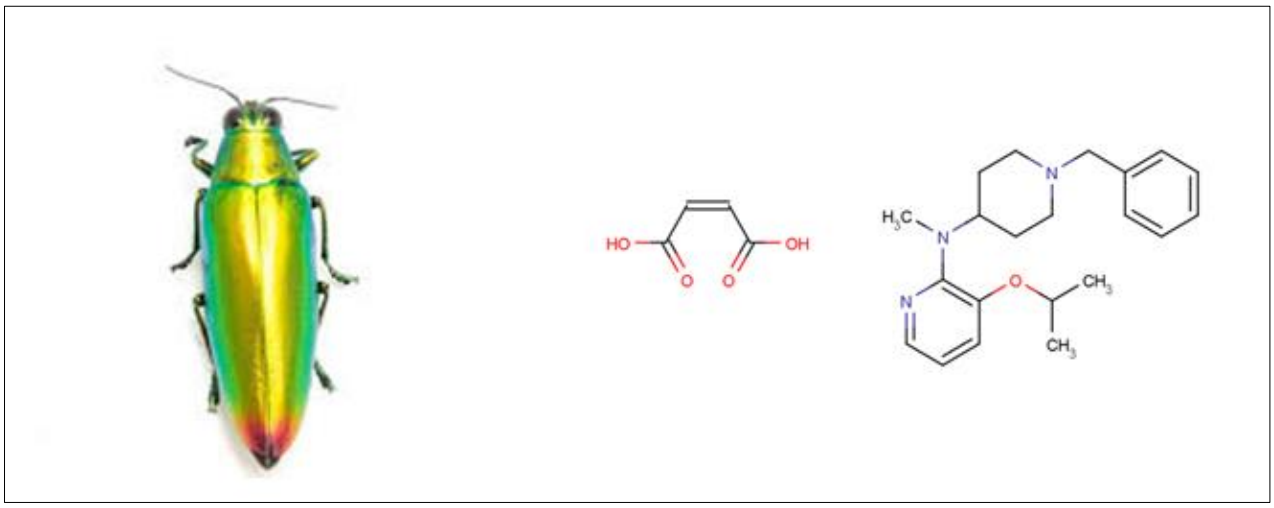


**Figure 13: *Lytta vesicatoria* (Linnaeus, 1758) (Coleoptera: Meloidae) and Cantharidin**
**Sources:** https://smallmolecules.com/product/56-25-7-targetmol-cantharidin-20-mg/ and https://br.freepik.com/fotos-premium/colagem-de-imagens-macro-do-besouro-lytta-vesicatoria-conhecido-por-ter-uma-substancia-venenosa-e-afrodisiaca-nos-elitros-a-cantharidina_26704576.htm

The family is characterized by numerous species that secrete cantharidin, a corrosive and vesicant compost, as a defense mechanism against predators. Many species exhibit conspicuous aposematic coloration as a way of announcing their toxicity to potential predators due to a poisonous and aphrodisiac substance in their elytra, cantharidin (Figure 14) (Bhattacharjee and Robert, 2003).

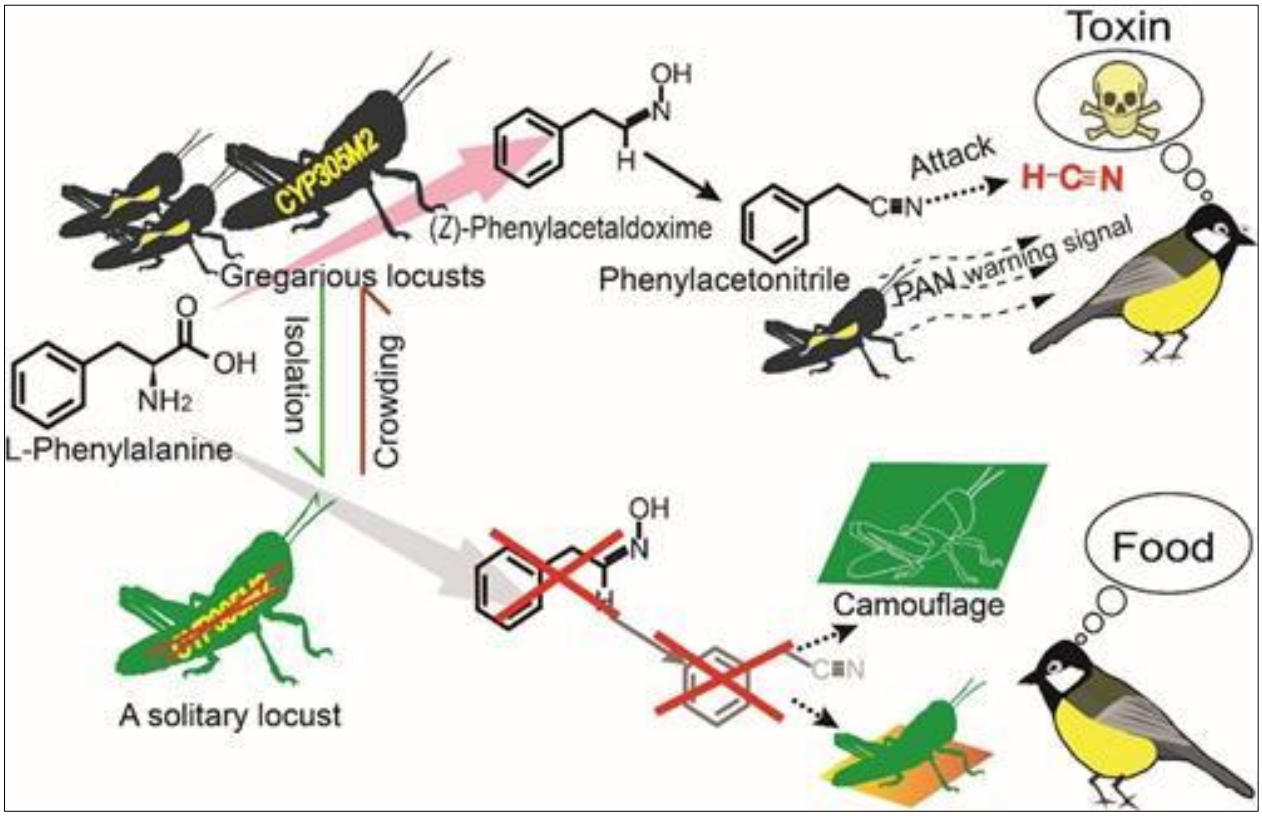

**Figure 14: PAN aposematism may alert and deter consumers from poisoning by PAN-generated HCN. The yellow marker in gregarious locusts denotes the expression of CYP305M2. Against a green background, solitary locusts utilize predators and are easily discovered and preyed upon**
**Sources:** https://www.eurekalert.org/multimedia/678554 and IOZ

**3.2.5. Chemicals:** Andromedotoxin and arbutin (Figures 15-16).

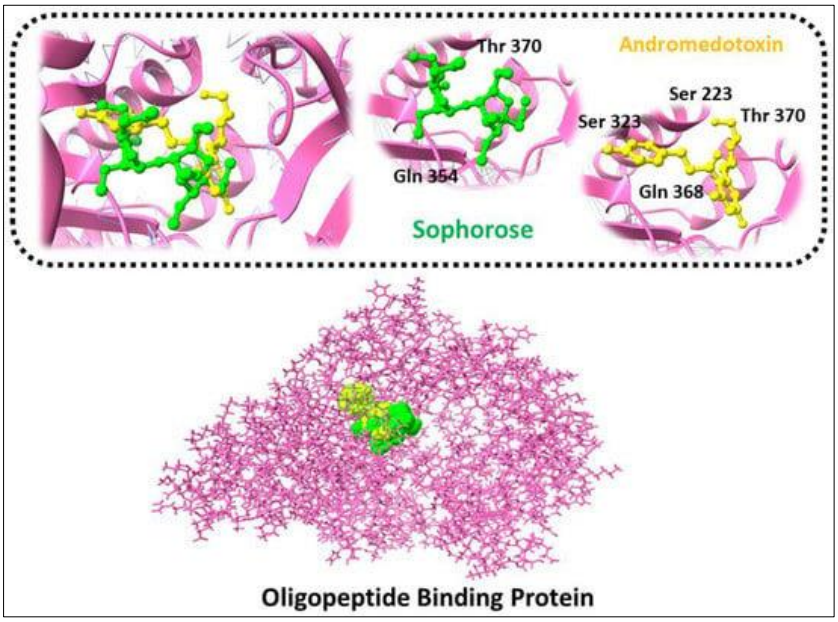


**Figure 15: Three-dimensional representation of molecular docking analysis and the interaction of andromedotoxin and sophorose inhibitors with oligopeptide binding protein**
**Source:** https://doi.org/10.3390/ijerph19127306

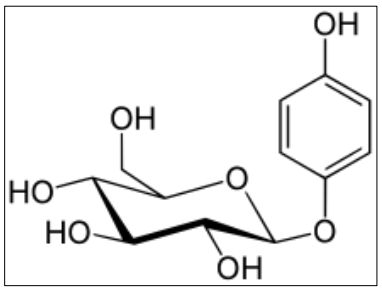


**Figure 16: Arbutin is a glycosylated derivative of hydroquinone. β-Arbutin is naturally present in the leaves and bark of a variety of plants, notably the bearberry plant, *Arctostaphylos uva-ursi* (Ericaceae). Utilized as a biosynthetic active ingredient in topical treatments for skin lightening**
**Source:** https://pt.wikipedia.org/wiki/Arctostaphylos_uva-ursi

**3.2.6. Coturnism:** The disease caused by can result in weakness and muscle pain, even paralysis, as well as vomiting (Figure 17) (Poulsen, 1993; Weldon, 2000).

**Figure 17: Common quail, Male: *Coturnix coturnix* (Linnaeus, 1758) (Aves: Galliformes: Phasianidae)**
**Source:** https://app.birda.org/species-guide/1444/Common_Quail

In *Coturnix coturnix* (Linnaeus, 1758) (Aves: Galliformes: Phasianidae), the origin of the poison, current theories suggest that quail eat the toxic seeds of the mint plant *Stachys annua* (L.) (Lamiales: Lamiaceae) (Jonsson *et al.,* 2008; Ferreira, 2023).

Researchers from the University of Copenhagen have discovered two species of venomous birds in the rainforest of New Guinea. The paper on the discovery was published in the scientific journal Wiley Online Library. The latest species to join the list of venomous birds are the regent whistler and the red-headed whistling bird *Aleadryas rufinucha* Sclater, 1874), (Aves: Passeriformes: Pachycephalinae), *Colluricincla cinerea* Vigors & Horsfield, 1827 (Aves: Passeriformes: Pachycephalidae), *Colluricincla megarhyncha* (Quoy & Gaimard, 1830) (Aves: Passeriformes: Colluricinclidae), *Gambiensis plectropterus* (Linnaeus, 1766) (Aves: Anseriformes: Anatidae), *Pachycephala schlegelii* Schlegel, 1871, (Aves: Passeriformes: Pachycephalidae) and *Pitohui dichrous* (Bonaparte, 1850) (Aves: Passeriformes: Oriolidae) (BirdLife International, 2004a; BirdLife International, 2004b; Oreoicidae, 2021; Paixão, 2021).

The *Pitohui* is a bird native to the wilds of New Guinea. This species is omnivorous, so it feeds on both animals and plants. The skin and feathers of several subvariants of this species contain powerful neurotoxins that can kill large birds, snakes, small parasites, and even humans. *Pitohui dichrous* was the first officially documented poisonous bird in the scientific literature (Figure 18) (Weldon, 2000; Bartram and Boland, 2001; Dumbacher *et al.,* 2014).


**Figure 18: *Pitohui* Lesson, 1831 (Aves: Passeriformes: Oriolidae)**
**Source:** https://www.youtube.com/watch?v=XOoVkj-MO34

The toxic substance secreted by this pigeon-sized bird with a brick-red belly and jet-black head is concentrated in the bird's feathers and skin. Many of these birds live discreet, elusive lives. Some have been dangerous to humans in the past, but thanks to modern science, we know a little more about these feathered creatures (Weldon, 2000; Dumbacher *et al.,* 2004; Ferreira, 2023).

### 3.3. Some Species

#### 3.3.1. *Colluricincla Megarhyncha* (Rufous or Little Shrikethrush)

The rufous or little grebe is another venomous bird that lives in remote territories of South Asia and Oceania and that also obtains its venom through its diet, based on certain insects. To be more precise, we can find this type of venomous bird in territories such as Australia, Indonesia, and New Guinea (Figure 19) (Weldon, 2000; Bartram and Boland, 2001; Ferreira, 2023).

**Figure 19: *Colluricincla megarhyncha* (Quoy & Gaimard, 1830) (Aves: Passeriformes: Colluricinclidae)**
**Source:** http://www.arthurgrosset.com/ozbirds/littleshrike-thrush.html

**3.3.2. *Ifrita Kowaldi* (De Vis, 1890) (Aves: Passeriformes: Ifritidae) (Blue-Capped Shrikethrush)**

The Blue-capped Shrikethrush, like all other types of venomous birds discovered so far, obtains its venom through its diet. However, it is believed to be the most venomous bird species of all, as it consumes only insects. The blue-headed *Ifrita* Rothschild, 1898(Aves: Passeriformes: Ifritidae), can again be found in the humid forests and jungles of New Guinea (Figure 20) (Bartram and Boland, 2001; Dumbacher *et al.*, 2004; Ferreira, 2023).

**Figure 20: *Ifrita kowaldi* (De Vis, 1890) (Aves: Passeriformes: Ifritidae)**
**Source:** https://en.wikipedia.org/wiki/Blue-capped_ifrit

## 4. CONCLUSION

Poisonous birds are very rare, but they do exist on our planet. Songbirds that live in the tropical forests of New Guinea are considered the only poisonous birds in the world. They belong to the *Pitohui* genus, and there are six different species. The genus includes four species of birds, all from Papua New Guinea, in Oceania, and at least three of them are known to be poisonous. The poison present in pitohui can cause paralysis in the body of living beings, including in the heart muscles, and can cause the death of animals that come into contact with it.

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