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(REVIEW ARTICLE)

Biology and feeding behavior of ceratopogonid adult (Diptera: Ceratopogonidae)

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Abstract

The purpose of this paper is to understand the biology and feeding behavior of ceratopogonid adult (Diptera: Ceratopogonidae). The research was carried out in studies related to quantitative aspects taxonomic and conceptual aspects such as habitat, geographical distribution, traps for collecting, their parasitoids and predator, life cycle, damage, economic importance, medicinal importance, biological aspects, and reproduction. A literature search was carried out containing articles published from 1993 to 2021. The mini review was prepared in Goiânia, Goiás, from September to October 2021, through the. The mini-review was prepared in Goiânia, Goiás, from September to October 2021, through the Online Scientific Library (Scielo), internet, ResearchGate, Academia.edu, Frontiers, Publons, Qeios, Portal of Scientific Journals in Health Sciences, Pubmed, Online Scientific Library (Scielo), internet, ResearchGate, Academia.edu, Frontiers, Biological Abstract, Publons, Qeios, Portal of Scientific Journals in Health Sciences, and Pubmed, Dialnet, World, Wide Science, Springer, RefSeek, Microsoft Academic, Science, ERIC, Science Research.com, SEEK education, Periódicos CAPES, Google Academic, Bioline International, VADLO, Scopus, and Web of Science.

Keywords: Biology; Ecology; Habitat; Parasitoids; Predator

1. Introduction

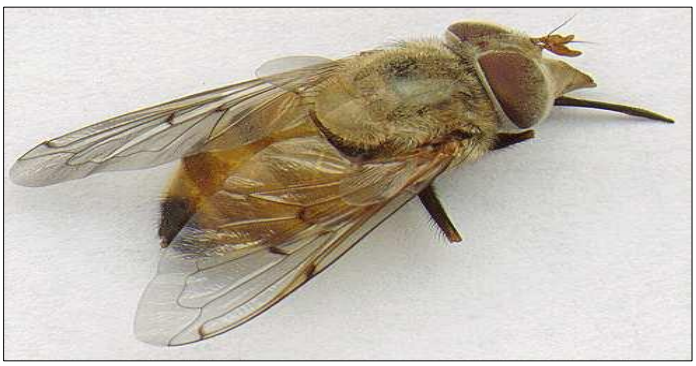

Figure 1 Horsefly is the most widely used English common name for members of the family Tabanidae. Apart from the common name "horseflies", broad categories of biting, bloodsucking Tabanidae are variously known as breeze flies, clegs, deer flies, gadflies, or zimbs. In some areas of Canada, they also are known as Bull Dog Flies. In Australia some species are known as "March flies", a name that in other English-speaking countries refers to a very different Dipteran family, the non-bloodsucking Bibionidae. The Tabanidae are true flies' members of the insect order Diptera.; (Source: http://insects-morphology.blogspot.com/2012/09/horsefly.html)

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Tabanidae is a family of Diptera in the suborder Brachycera. The flies of this family are popularly known as horsefly and gadfly. Females are hematophagous. The Tabanidae family has more than 4,400 described species, distributed in three subfamilies, of which 1,205 are present in the Neotropical region, as well as 9 of the 11 tribes and 64 of the 137 genera are represented (Figures 1 and 2) [1,2,3].

Figure 2 Tabanidae family: Source: http://insects-morphology.blogspot.com/2012/09/horsefly.html

The wings have the R2+3 unbranched rib and show five hind cells. They are the largest blood sucking Diptera, reaching 2.5 cm, robust body, and some with a well-developed proboscis, which imposes fear. Repeatedly, they attack humans, domestic and wild animals, including primates, horses, cattle, rodents, alligators, snakes, turtles, and birds, especially during the driest seasons (Figures 3 and 4) [4,5,6].

Figure 3 female, male, body length 10mm This March Fly is uniform brown in color. Antenna and all legs are brown. The abdomen is golden brown. Eyes are hairy, ocelli are fully developed. Biter-sucking buval apparatus; (Source: https://www.brisbaneinsects.com/brisbane_Tabanoidea/Tabanidae.htm)

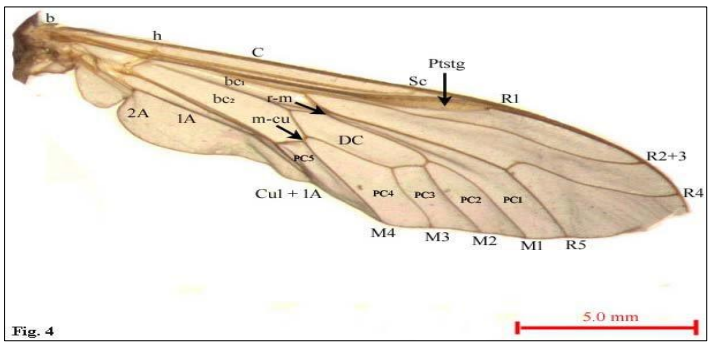

Figure 4 A generalized view of right wing of Tabanid flies of genus *Tabanus* showing different parts such as basicosta (b) at the base of costa (C), below costa lies sub-costa (Sc), costa and subcostal are joined by humeral cross vein (h), light brownish pterostigma (Ptstg), R1-anterior branch of radius, R2+3 (R2 and R3 fused in Tabanidae), R4, R5-posterior branches of radius, medial veins M1, M2, M3 originating from discal cell (DC), M4 originating from medial-cubital vein

(m-cu), 5 posterior cells PC1, PC2, PC3, PC4 and PC5 are present, 1A and 2A are branches of anal veins, first cubital (Cu1) and 1st anal cell (1A) fused apically to form Cu1+1A, first basal cell (bc1) and second basal cell (bc2) are present just above discal cell, radial medial vein (r-m) present behind first basal cell.; (Source: https://www.researchgate.net/figure/A-generalised-view-of-right-wing-of-Tabanid-flies-of-genus-Tabanus-showing-different_fig5_304435297)

1.1. Tabanidae

1.1.1 Adults

Tabanidae flies are large flies, up to 2.5cm long with bodies that are usually dark in color. The dark bodies may have stripes or patches of color down them or be entirely colored in some cases. Adults emerge from the puparia through a "T" slit; they have a semicircular head that is wider than the thorax and abdomen; the short antennas are formed by three articles, the third being subdivided into similar annealing's (Figure 5).

Figure 5 March Flies have stout body, and they are from small to large. They are usually grey to brown in colors, a few are colorful. They have large eyes with reflective iridescent color. The antenna is segmented flagellum. Their mouth is the strong straight proboscis for piercing and sucking. Their wings always have the 'Y' shaped veins at the tip. Usually there are the dense short hairs on their body. ; (Source: Source: https://www.brisbaneinsects.com/brisbane_Tabanoidea/Tabanidae.htm)

The biter-sucker type mouthparts are short, wide, and robust, and have jaws in the form of sharp blades and lacinia with teeth on the extremity, which, when piercing the host's skin, with scissors movements, cause severe pain. The lip lobes are large, endowed with sclerotized channels that serve to distribute saliva, but which can store and maintain for some time, a blood collection in which the etiological agents are found; are considered powerful flying flies. Adult males feed on nectar and females of most species needs animal protein present in the blood for the maturation of embryonic follicles and oviposition [7,8,9,10].

1.1.2 Larvae

Figure 6 It has a head, which is retracted inside thoracal segments. 3 thoracal and 8 abdominal segments. Distinct creeping welts around segments. Last body segment with a slit inside which spiracles are situated. Looks like *Tabanus* for me but I am not sure. It is large - about 10 mm.; (Source: https://diptera.info/forum/viewthread.php?thread_id=38363)

Tabanid larvae are predators and may even be cannibals; they are generally aquatic or semi-aquatic, and can be found in whorls of bromeliads, water in holes in tree trunks, ecotone between the ground and standing or running water, or in decomposing fallen plant trunks. The larval period varies from a few months to more than a year and the pupal period from a few days to a few weeks (Figure 6).

Tabanidae larvae are large, 1.5 - 3cm in length with large biting mandibles. They are off white in color with longitudinal striations on the cuticle. There are paired unsegmented appendages, pseudopods, along the body to assist in movement. The posterior of the larvae usually has a respiratory siphon present.

1.1.3 Eggs

Eggs are an off-white color and cigar shaped. They can be between 1 - 3 mm long (Figures 7, 8 and 9) [11,12].

Figure 7 Don't believe you can distinguish *Tabanus* masses from *Hybomitra* masses. Don't know how long they take to hatch; don't know time of day they hatch. This batch of eggs has either hatched or has been parasitized and the parasitoids have emerged. What you are seeing are the empty egg cases. Tabanid larvae, except perhaps *Chrysops* are difficult to rear, they are carnivores and require living food and are also cannibalistic.; (Source: https://www.diptera.info/forum/viewthread.php?thread_id=7240)

Figure 8 Egg Tabanidae Family; (Source: https://www.flickr.com/photos/dragonflyhunter/9808309413)

Figure 9 Egg horse fly *Tabanus imitans* Walker, 1848 Tabanidae Family Description: Egg mass, 1 day old, female collected 22 May 1990, near Statesboro, Bulloch, Co., Georgia; human blood meal on May 22, this photo taken 1 June 1990.; (Source: Photographer: Sturgis McKeever)

1.2. Life Cycle

Tabanidae flies lay their eggs on the underside of leaves overhanging areas of water. When the eggs hatch the larvae fall from the leaves into the water where they remain anywhere between 3 months and 3 years if overwintering occurs. Once the larvae have developed, they move onto dry land to pupate. The pupa hatches after about 3 weeks and live flies emerge. In total this life cycle takes over one year to complete (Figure 10 and 11) [13,14].

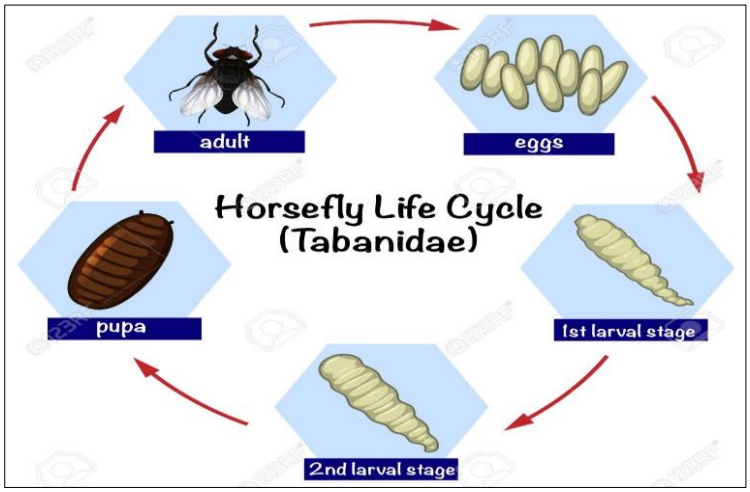

Figure 10 Vector — Science horsefly life cycle; (Source: https://www.123rf.com/photo_110577680_stock-vector-science-horsefly-life-cycle-illustration.html)

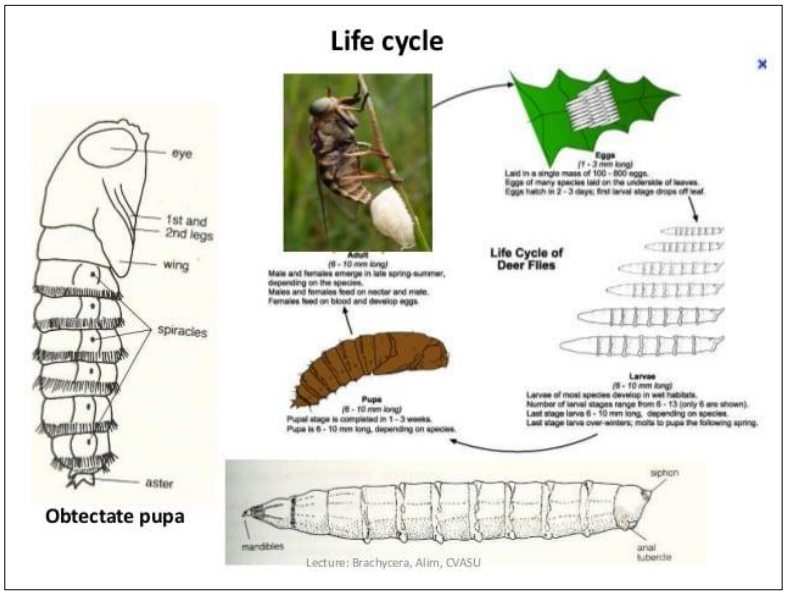

Figure 11 Brachycera (*Tabanus*); (Source: Md Abdul Alim, CVASU, Bangladesh)

1.3. Habitat

Most tabanids seem to prefer defined habitats but are found in almost every possible habitat from ocean beaches to mangroves. Most tabanids seem to prefer defined habitats but are found in almost every possible habitat from ocean beaches to mangroves, deserts, meadows, salt marshes, savannas, savannas, and tropical forests, to the snow line of the highest mountains. Adults can live up to two months [15,16].

1.4. Geographic distribution

Tabanids are insects widely distributed in nature both geographically and in relation to different types of environments. The different habitats they use vary greatly according to the evolutionary stage and the species to which they belong. In

these different environments and niches, they participate in various holarchic systems, where they are influenced by various abiotic factors and biotic factors [17,18].

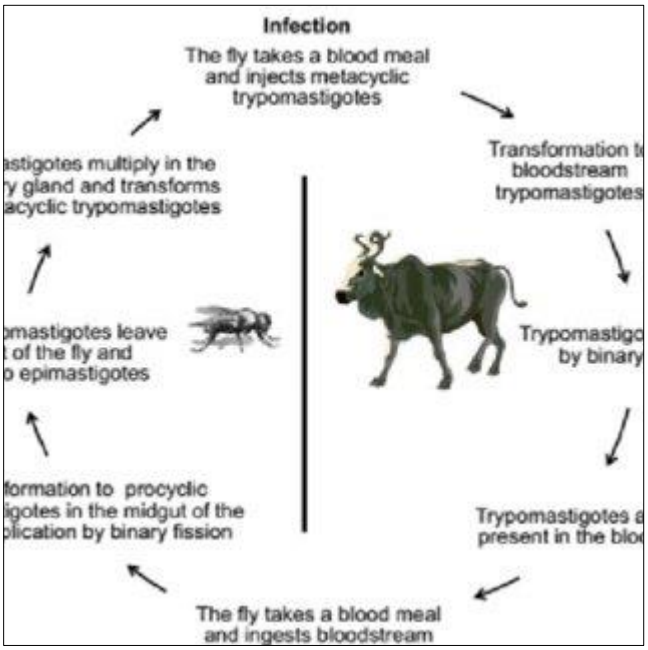

Figure 12 The main phases in the life cycle of the *trypanosome vivax; (*Source: file:///C:/Users/Sti/Downloads/ReviewonTrypanosomavivax.pdf)

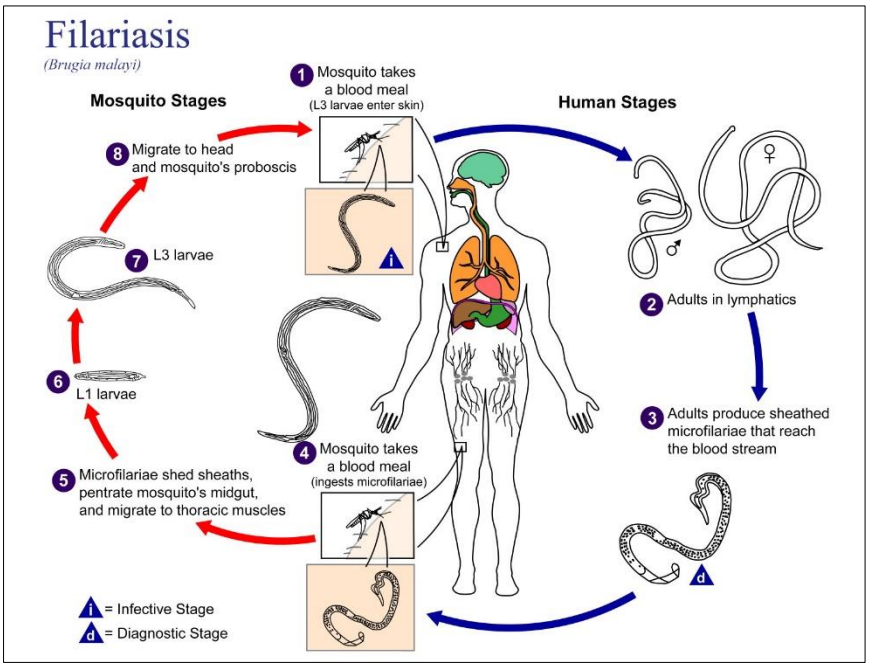

Figure 13 Filariasis; (Source: https://www.grepmed.com/images/11618/wuchereria-lifecycle-pathophysiology-bancrofti-cdc-23)

The Tabanidae Family are cosmopolitan flies, commonly known in Brazil as horseflies. Due to the hematophagous behavior of females, these insects constitute a group of great importance in the mechanical transmission of pathogens to wild and domestic animals, which can also affect humans. Bacteria, viruses, rickettsia, protozoa and helminths can be transmitted by horseflies, causing diseases such as anthrax, tularemia, anaplasmosis, Q fever, various forms of

trypanosomiasis and filariasis. In cattle, it can cause anemia, loss of weight and resistance and a drop in milk production, bringing economic losses [17,18].

Tabanids can also cause allergic reactions through their bite. As is usually the case with hematophagous arthropods, tabanids have developed mechanisms to obtain a blood meal and overcome the immune responses of their hosts (Figures 12 and 13) [17,18].

1.5. Taxonomic

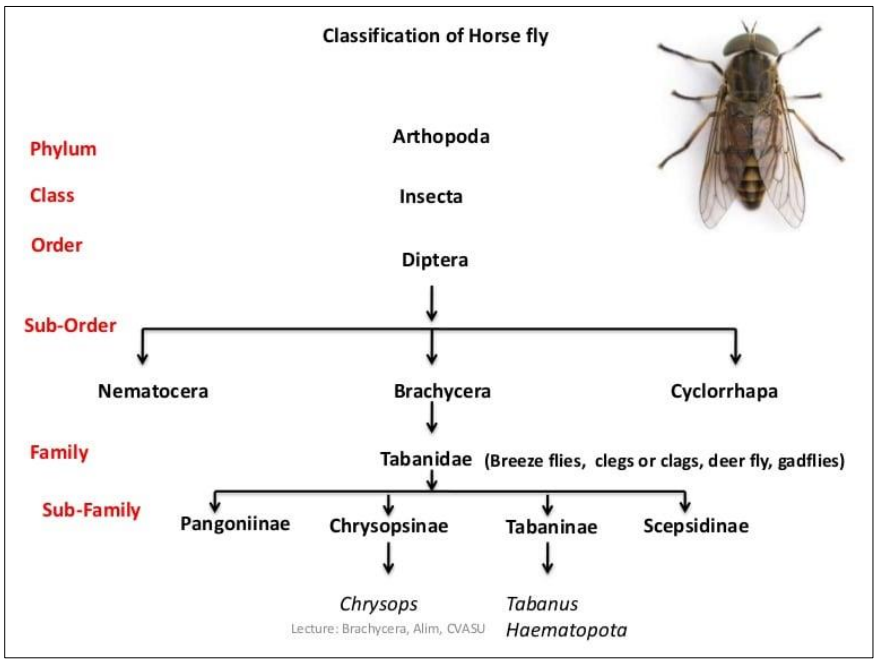

Figure 14 Classification Tabanidae Family; (Source: https://pt.slideshare.net/abdulalim12979/brachycera-tabanus-md-abdul-alim-cvasu-bangladesh)

1.5.1 March Flies, Horse Flies - Family Tabanidae (Figure 15, 16, 17 and 18 A, B)

Subfamily Chrysopsinae

- Ocelli fully developed,
- Antennal flagellum usually with a basal plate and 4-annulate.
- -We did not find any species in this group yet.

Slender March Flies - Subfamily Pangoniinae, Pangoniini

- Ocelli fully developed,
- Antennal flagellum usually 8-annulate,
- eyes usually bare,
- R4 with appendix,

Figure 15 *Ectenopsis (Ectenopsis)* sp., body length 12mm. Ectenopsis is slender fly. Its eyes are bare and there are eight annulate 3rd antennal segment. The separation between eyes is wide and ocellus are well developed. Proboscis is stout and long, about the same length as head height. On wings vein R4 has strong appendix. Please check this page for more information; (Source: https://www.brisbaneinsects.com/brisbane_Tabanoidea/Tabanidae.htm)

Subfamily Pangoniinae, Scionini

- Ocelli fully developed,
- Antennal flagellum usually 8-annulate,
- eyes usually hairy,
- R4 usually without appendix

Figure 16 *Scaptia (Scaptia) auriflua* (Donovan, 1805), female, male, body length 10mm

Source: https://www.brisbaneinsects.com/brisbane_Tabanoidea/Tabanidae.htm

Most other female March Flies are blood sucker, but this fly is flower feeder. Both male and female feed on nectars. The fly covered with dense hair mimicking bee. They will buzz like a bee to try to scare you away. Picture taken in Yugarapul Park during early summer. They are common along Bulimba Creek in Wishart area. Note the piercing mouthparts in front of the eyes. For more information and pictures, please visit this.

Robust March Fly - Subfamily Tabaninae, Tabanini

- Ocelli rudimentary or absent,
- Frons with a callus,
- Antennal flagellum usually with a basal plate and 4-annulate,
- On wings R5 and M3 cells always open,
- On wings, basicosta with dense setulate, as setulate on sc,

Figure 17 *Tabanus australicus* Taylor, 1919, body length 15mm This March Fly is common in Brisbane bushes. March Flies are sometimes known as Green Heads. This March Fly landed on our body a few times. Some species of female feed on blood and targeting human. This fly might not do any good to us; (Source: https://www.brisbaneinsects.com/brisbane_Tabanoidea/Tabanidae.htm)

Subfamily Tabaninae, Diachlorini

- Ocelli rudimentary or absent,
- Antennal flagellum usually with a basal plate and 4-annulate,
- On wings R5 and M3 cells always open,
- On wings, basicosta without setulate,
- Proboscis relatively stout with large labella

Figure 18 A *Cydistomyia avida* Bigot, 1892, body length 15mm this is a medium-sized March Fly with greyish brown scutum and yellowish-brown abdomen. Eyes are reddish brown in color with green reflection. This is a common species in Brisbane; (Source: https://www.brisbaneinsects.com/brisbane_Tabanoidea/Tabanidae.htm)

1.5.2 Genus

Merycomyia, Chrysops, *Neochrysops, Silvius, Apatolestes, Asaphomyia, Brennania, Esenbeckia, Pangonia, Pegasomyia, Stonemyia, Goniops, Anacimas, Bolbodimyia, Catachlorops, Chlorotabanus, Diachlorus, Dichelacera, Holcopsis, Lepiselaga, Leucotabanus, Microtabanus, Stenotabanus, Haematopota, Agkistrocerus, Atylotus, Hamatabanus, Hybomitra, Poeciloderas, Tabanus, Whitneyomyia, Zophina* and *Phorcotaban* [18].

1.5.3 Species

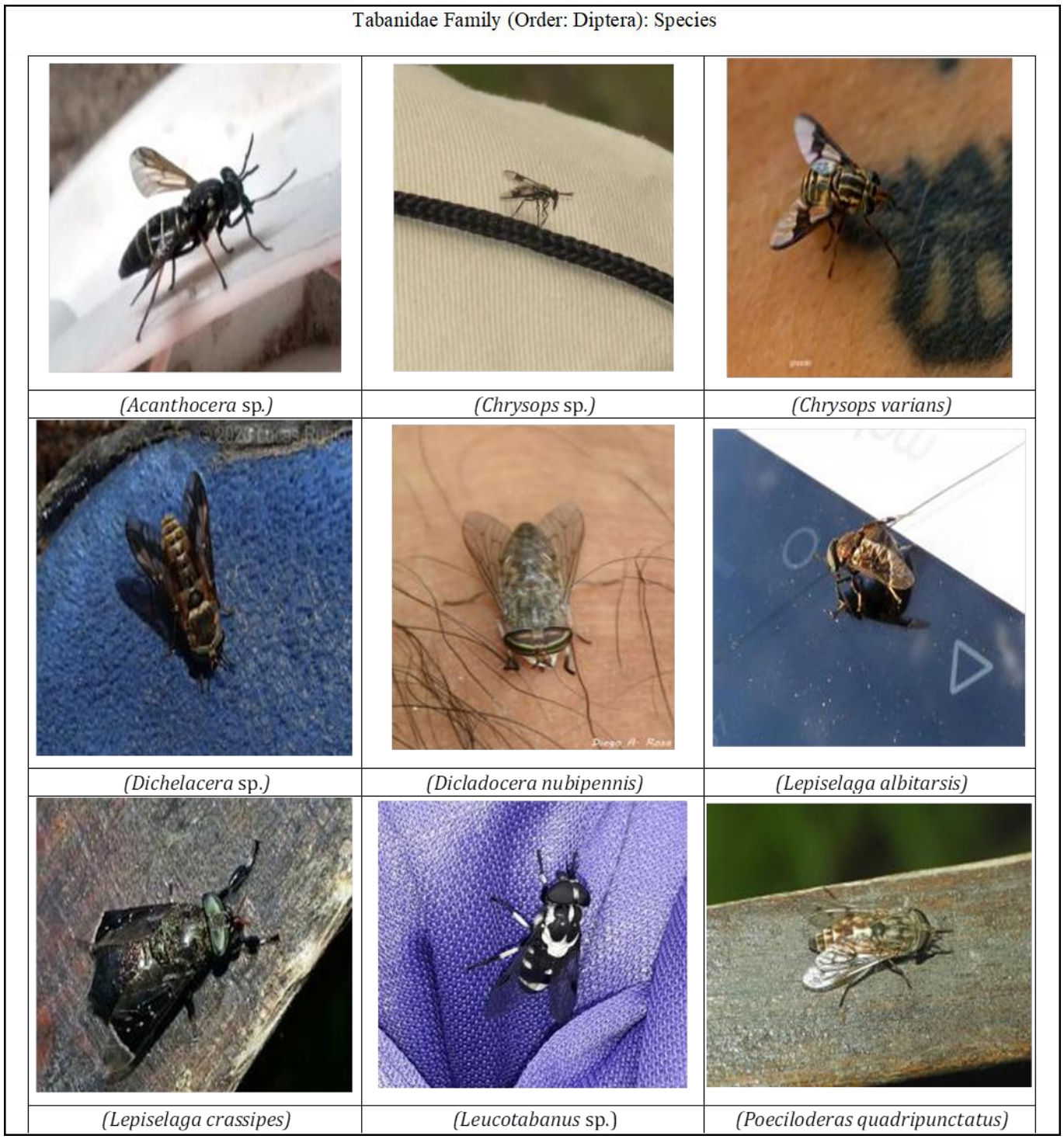

Figure 18 B Especies of Tabanidae; (Source: https://naturdata.com/especies-portugal/taxon/0@1-animalia:arthropoda:insecta:diptera/)

Objective

The aim of this study is to report the diversity of the Family Tabanidae.

2. Methods

A literature search was carried out containing articles published from 1993 to 2021. The mini review was prepared in Goiânia, Goiás, from September to October 2021, through the. The mini-review was prepared in Goiânia, Goiás, from September to October 2021, through the Online Scientific Library (Scielo), internet, ResearchGate, Academia.edu, Frontiers, Publons, Qeios, Portal of Scientific Journals in Health Sciences, Pubmed, Online Scientific Library (Scielo), internet, ResearchGate, Academia.edu, Frontiers, Biological Abstract, Publons, Qeios, Portal of Scientific Journals in Health Sciences, and Pubmed, Dialnet, World, Wide Science, Springer, RefSeek, Microsoft Academic, Science, ERIC, Science Research.com, SEEK education, Periódicos CAPES, Google Academic, Bioline International, VADLO, Scopus, and Web of Science.

3. Studies performed and used

3.1. Study 1

Objective in this study was to investigate Senegalese tabanids and their diversity by using molecular and proteomics approaches, as well as their associated pathogens. Methods: A total of 171 female tabanids were collected, including 143 from Casamance and 28 from NiokoloKoba.

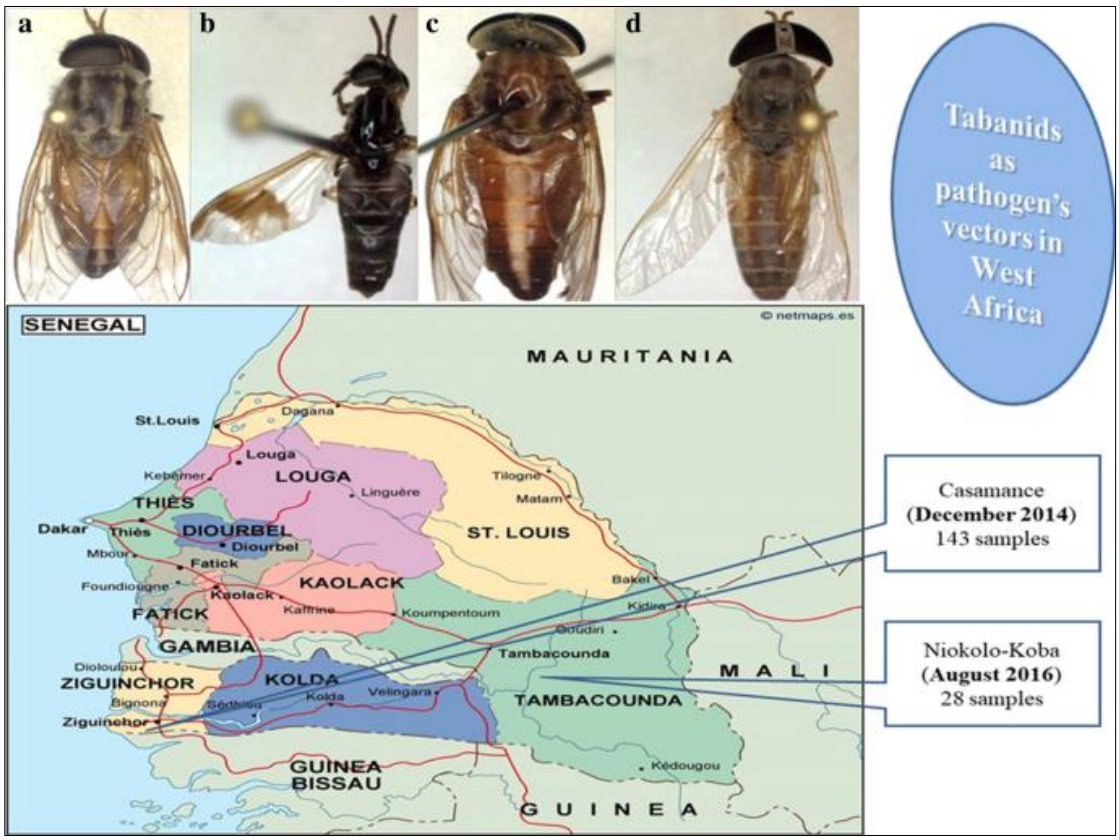

Figure 19 Morphotypes of the collected tabanid species. a *Tabanus taeniola* Palisot de Beauvois, 1806. b *Chrysops, distinctipennis* Austen, 1906. c *Tabanus guineensis* Wiedemann, 1824. d *Atylotus fuscipes* Ricardo, 1908. The samples were identified morphologically by PCR sequencing and by MALDI-TOF MS, and PCR analysis was employed for pathogen detection and blood-meal characterization; (Source: Keita ML, Medkour H, Sambou M, Dahmana H, Mediannikov O. Tabanids as possible pathogen vectors in Senegal (West Africa). Parasites & Vectors. 2020;13(500): 1-15)

The morphological identification revealed four species concordantly with the molecular identification: *Atylotus fuscipes* Ricardo, 1908 (79.5%), *Tabanus guineensis* Wiedemann, 1824 (16.4%), *Chrysops distinctipennis* Austen, 1906 (3.5%) and Palisot de Beauvois, 1806 (0.6%) (not identified by PCR). The molecular investigation of pathogens revealed the presence of *Trypanosoma theileri* (6.6%), *Leishmania donovani* (6.6%), *Setaria digitata* Viborg, 1795 (1.5%), *Rickettsia*

spp. (5.1%) and Anaplasmataceae bacteria (0.7%) in A. fuscipes. *Tabanus guineensis* was positive for *L. donovani* (35.7%), *S. digitata* (3.6%) and Anaplasmataceae (17.8%).

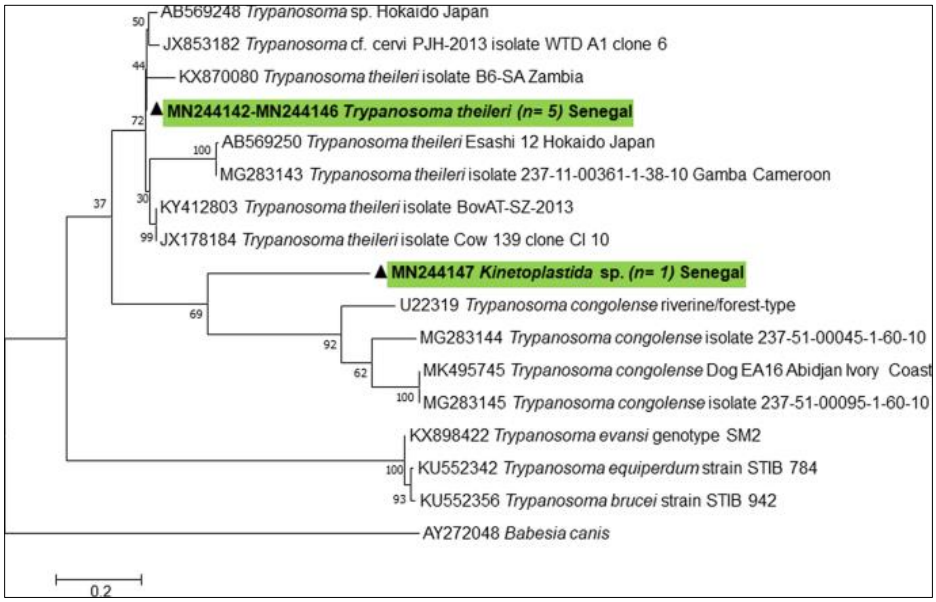

Figure 20 Maximum likelihood phylogeny of *Trypanosoma theileri* and Kinetoplastida sp. detected on tabanids in the present study. The evolutionary history, based on the ITS1 region, was inferred by using the maximum likelihood method based on the Tamura 3-parameter model. The tree is drawn to scale, with branch lengths measured in the number of substitutions per site. The analysis involved 17 nucleotide sequences. The samples were identified morphologically by PCR sequencing and by MALDI-TOF MS, and PCR analysis was employed for pathogen detection and blood-meal characterization; (Source: Keita ML, Medkour H, Sambou M, Dahmana H, Mediannikov O. Tabanids as possible pathogen vectors in Senegal (West Africa). Parasites & Vectors. 2020;13(500): 1-15)

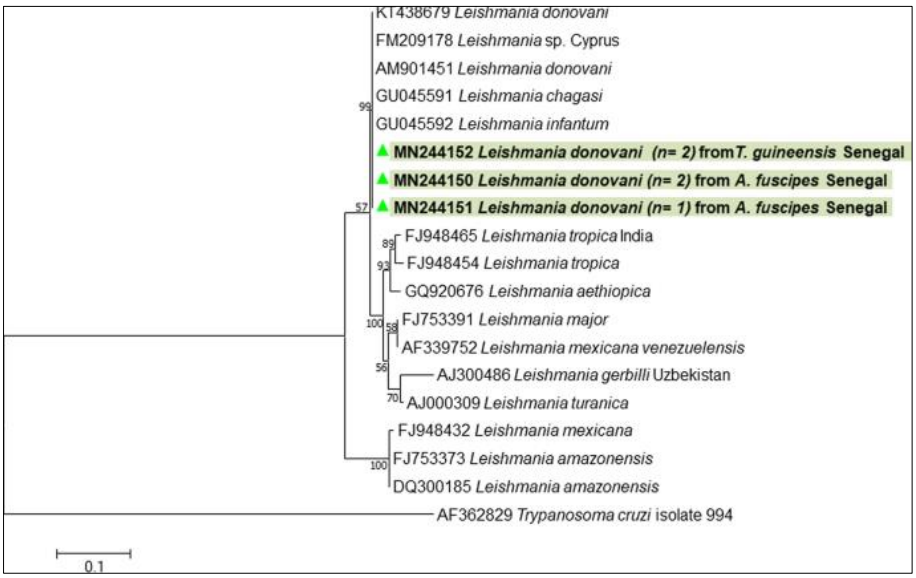

Figure 21 Molecular phylogenetic tree showing the position of the *Leishmania donovani* complex identified in the present study according to sequences from GenBank. The evolutionary history, based on the ITS1 region, was inferred by using the maximum likelihood method based on the Tamura 3-parameter model. The tree is drawn to scale, with branch lengths measured in the number of substitutions per site. The analysis involved 19 nucleotide sequences; (Source: Keita ML, Medkour H, Sambou M, Dahmana H, Mediannikov O. Tabanids as possible pathogen vectors in Senegal (West Africa). Parasites & Vectors. 2020;13(500): 1-15)

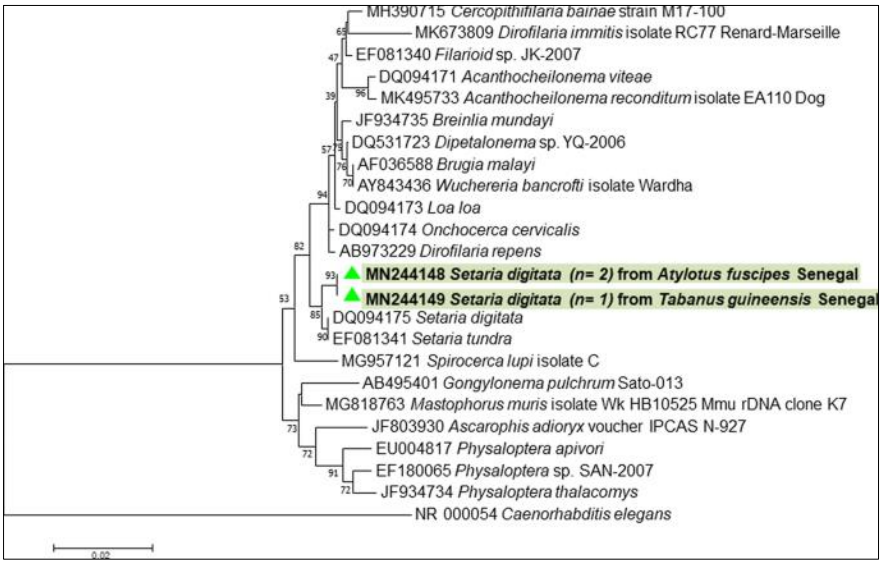

Figure 22 Phylogenetic analysis showing the position of *Setaria digitata* detected in the present study. The evolutionary history based on *18S* rRNA gene was inferred using the neighbour-joining method. The evolutionary distances were computed using the Tamura-Nei method and are in units of the number of base substitutions per site. The differences in the composition bias among sequences were considered in evolutionary comparisons. The analysis involved 24 nucleotide sequences. All positions containing gaps and missing data were eliminated. The samples were identified morphologically by PCR sequencing and by MALDI-TOF MS, and PCR analysis was employed for pathogen detection and blood-meal characterization; (Source: Keita ML, Medkour H, Sambou M, Dahmana H, Mediannikov O. Tabanids as possible pathogen vectors in Senegal (West Africa). Parasites & Vectors. 2020;13(500): 1-15)

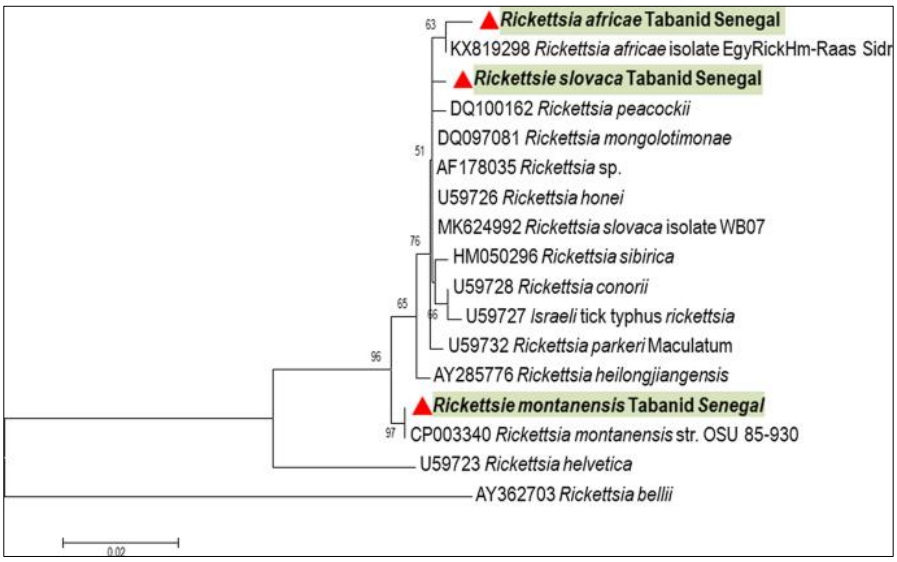

Figure 23 Molecular phylogenetic analysis for *Rickettsia* spp. detected on Senegalese tabanids. The evolutionary history based on the *gltA* gene was inferred by using the maximum likelihood method based on the Tamura 3-parameter model. The tree is drawn to scale, with branch lengths measured in the number of substitutions per site. The analysis involved 17 nucleotide sequences. All positions containing gaps and missing data were eliminated. The samples were identified

morphologically by PCR sequencing and by MALDI-TOF MS, and PCR analysis was employed for pathogen detection and blood-meal characterization; (Source: Keita ML, Medkour H, Sambou M, Dahmana H, Mediannikov O. Tabanids as possible pathogen vectors in Senegal (West Africa). Parasites & Vectors. 2020;13(500): 1-15)

Leishmania donovani has been detected in 50% of *C. distinctipennis* specimens and the only *T. taeniola* specimen. No Piroplasmida, *Mansonella* spp. or *Coxeilla burnetii* (Coxiellaceae) DNA was detected. In addition to humans (96.43%), *Chlorocebus sabeus* (Primata) monkey, a nonhuman primate, has been identified as a host of (3.57%) analyzed tabanids. MALDI-TOF MS enabled us to correctly identify all tabanid species that had good quality spectra and to create a database for future identification (Figures 19, 20, 21, 22, 23 and 24) [19].

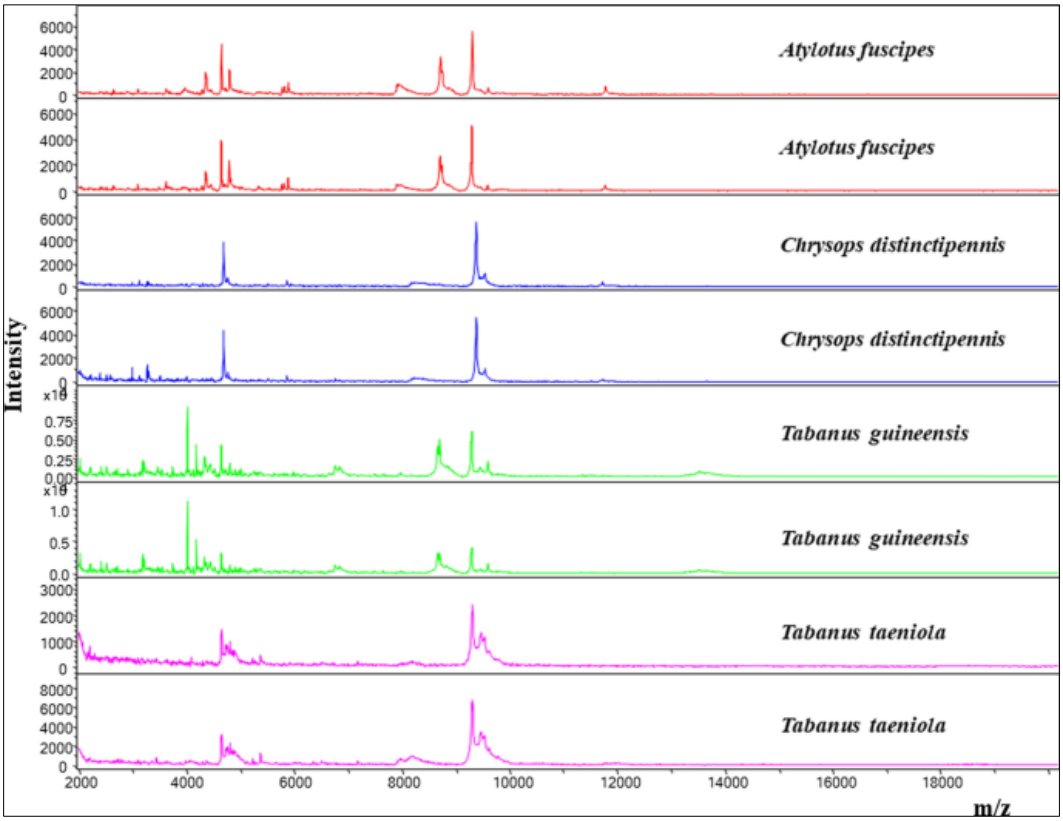

Figure 24 MALDI-TOF specific spectra for four species of Senegalese tabanids. The samples were identified morphologically by PCR sequencing and by MALDI-TOF MS, and PCR analysis was employed for pathogen detection and blood-meal characterization; (Source: Keita ML, Medkour H, Sambou M, Dahmana H, Mediannikov O. Tabanids as possible pathogen vectors in Senegal (West Africa). Parasites & Vectors. 2020;13(500): 1-15)

3.2. Study 2

3.2.1 Natural Enemies: Predator and Parasitoids (Part 1)

Figure 25 *Telenomus dignus* Gahan, 1925 (Hymenoptera: Chalcidoidea); (Source: https://link.springer.com/article/10.1007/s12355-018-0612-4)

The main natural enemy arthropods of tabanids in the egg stage are the parasitoid microhymenoptera *Phanurus emersoni* Girault, 1916 (Hymenoptera: Scelionidae) reported in several studies since the beginning of the last century *Telenomus dignus* Gahan, 1925 and *Lathromeris* sp. (Hymenoptera: Chalcidoidea). Tabanid egg predators are species of *Lepidoptera nola* sorghiella Riley, 1882 (Lepidoptera: Nolidae), larvae and adults of *Sepedon* sp. (Diptera: Sciomyzidae), adults of *Collops bipunctatus* (Say, 1823) (Coleoptera: Melyridae), of *Coleomegilla maculata* De Geer, 1775 (Coleoptera: Coccinellidae) and of *Orchelimum vulgare* Harris, 1841 (Orthoptera: Tetigonidae) (Figure 25) [20].

Diptera species *Villa lateralis* (Say, 1823) (Diptera: Bombyliidae), *Carinosillus novaeangliae* (West, 1924) and *Ormia punctata* Robineau-Desvoidy, 1830 (Diptera; Tachinidae), and wasps *Spilomicrus* sp. and *Trichopria* sp. (Hymenoptera: Diapriidae) and *Diglochis occidentalis* (Ashmead, 1896) (Hymenoptera; Pteromalidae) parasitize tabanid larvae and pupae Arthropods registered as parasites of tabanid adults are *Bactromyiella* sp. (Diptera: Tachinidae), *Perilampsus* sp. (Hymenoptera: Chalcididae); *Rhipicephalus turanicus* Pomerantsev, 1936 (Acari: Ixodidae) was found attached to Tabanidae: female proboscis of *Tabanus leleani* Austen, 1920 and *Rhipicephalus (Boophilus) annulatus* (Say, 1821) (Acari: Ixodidae) was found parasitizing *Tabanus americanus* Forster, 1771[20].

3.3. Study 3

3.3.1 Natural Enemies: Predator (Part 2)

The main predator groups of adult tabanids are the Odonata, the Diptera Asilidae and Tipulidae, the Coleoptera Carabidae, the Hymenoptera Crabronidae, birds, lizards, and fish. The Crabronidae family comprises a group of solitary wasps widely distributed in the world; it has more than 9,000 species, of which more than 1,750 are present in the neotropical region and about 600 species in Brazil. The subfamily Bembicinae has three tribes, Alyssontini Dalla Torre 1897, Nyssonini Latreille, 1804 and Bembicini Latreille, 1802, of which the latter is the most numerous, with more than 1,400 species (Figure 26).

Figure 26 Diptera Asilidae; (Source: http://novataxa.blogspot.com/2020/08/humorolethalis.html)

To feed their larvae, bembicine females are active hunters of other insects, such as those of the orders Diptera, Hemiptera, Lepidoptera and Odonata; among flies, wasps hunt specimens of several families including Tabanidae Latreille, 1802, Stratiomyidae Latreille, 1802, Syrphidae Latreille, 1802, Muscidae Latreille, 1802, Tachinidae Robineau-Desvoidy, 1830, Sarcophagidae Macquart, 1834 and Calliphoridae Brautamer, von Bergens 1889. The 'lone wasps' or 'sand wasps' have quite unique habits. They copulate when on the ground, with the male holding the female from behind, which can be dragged when the female takes off after copulation [21].

3.4. Study 4

3.4.1 Tabanidae collection trap

The Malaise trap captures insects by intercepting the flight. They are constructed using black bands of fabric, which intercept the insects, leading them through two white bands to the top, where there are two plastic bottles (200ml)

linked together by a lid. threaded In the bottle below, there is fixative liquid (Dietrich's solution: 600 ml of 96º alcohol, 300 ml of distilled water, 100 ml of 40% formaldehyde and 20 ml of acetic acid), where the insects fall and stay fixed there. These vials are positioned north to better attract parasitoids. The attracted insects fall into this mixture, being collected using a fine sieve and fixed in 70% alcohol for later identification

The method has the disadvantage of overflow caused by rainfall; daily material removal and liquid evaporation in hot places. To solve these problems, small holes with mesh are recommended just below the top of the plate or tray that allow the liquid to leak, while retaining the insects. To suppress the daily removal of the material, water must be replaced by ethylene glycol (10%), which acts as a low volatile fixative liquid and remains efficient for more than one month.

Today, all tent-type traps that collect insects that tend to rise when they encounter a vertical obstacle are known as Malaise traps. It consists of an open tent with a septum (or more septa in the case of a multidirectional trap) in the middle, preferably dark. They are excellent for catching flying insects, especially Diptera and Hymenoptera. These traps can be set indefinitely, day and night. The disadvantages: they are selective and insects that are poorly flying or that close their wings when encountering an obstacle and fall (for example, Coleoptera) are hardly ever collected (Figure 27) [22].

Figure 27 Malaise trap; (Source: chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/viewer.html?pdfurl=https%)

3.5. Study 4

This work complements the information obtained using different vertebrate hosts in the same area. Through capture with flight interception and attraction traps, contributing to the knowledge of the populations of Tabanidae in the Central Amazon (Figure 28).

Figure 28 Attraction traps: two suspended (Rafael & Gorayeb 1982) Source: SciELO - Brazil - Seasonality and use of environments by species of Tabanidae (Diptera) in Central Amazonia, Brazil; (Source: https://www.scielo.br/j/ne/a/sJvGkwFn7hRTYqLdx9DS4Ly/?lang=pt)

2,643 specimens belonging to 66 species were collected, distributed in 17 genera of Tabanidae. Diachlorini (35 species in 11 genera) was the most representative, followed by Tabanini (19 species in three genera), Chrysopsini (seven species in one genus) and Scionini (four species in two genera). Four species were more frequent (n > 120): *Phorcotabanus cinereus* (Wiedemann) (15.7%), *Thuja occidentalis* L (Pinales: Cupressaceae) (15.47%), *Chrysops laetus* Fabricius (14.9%) and *T. angustifrons* Macquart (7,2%). Five species were collected with intermediate frequency (between 90 and 120): *Tabanus nematocallus* Fairchild (4.5%), *Stypommisa glandicolor* (Lutz) (3.9%), *Tabanus trivittatus* Fabricius (3.5%), *Phaeotabanus cajennensis* (Fabricius) (3.5%) and *Philipotabanus stigmaticalis* (Kröber) (3.4%). The other species were represented with less than 60 individuals, corresponding to less than 1% of the total [23, 24].

4. Conclusion

Haematophagous diptera of the family Ceratopogonidae are commonly known as maruins, sand flies and mangrove mosquitoes. These belong to the genera *Culicoides* Latreille, *Forcipomyia* Meigen subgenus Lasiohelea Kieffer and Leptoconops Skuse. The *Culicoides* genus is the largest of the family and the most distributed. More than 1400 species of *Culicoides* are known worldwide, of which 96% compulsorily attack mammals (including humans) and birds.

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