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Biodiversity – the hidden risks

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Abstract: Biodiversity is much more than what we see. Biodiversity also includes a number of microorganisms, such as bacteria, fungi and viruses, many of which cause disease in animals, plants and man. In the Amazon, many of these organisms live in the body of repository animals that are in the forest and can jump to humans, with the potential to cause new epidemics and pandemics. In the region, we cannot discard plants as repositories for these microorganisms too. It is necessary to reduce deforestation, mining, cattle ranching at the heart of the forest and strive for "One Health" approach, improving social organization, including policies, legislation and science.

Key words: biodiversity, Amazon, virus jumping, plants, animals, anthropogenic pressures.

INTRODUCTION

Biological diversity or biodiversity is a concept coined in 1968 by Raymon Dasmann, but it integrated our vocabulary after a preface written by Tom Lovejoy (Soulé and Wilcox 1980). Part of this story was reviewed by Franco (2013), by Val (2019) and in the interview we did with Lovejoy himself (Val and Marcovitch 2019). There are several concepts of biodiversity, which integrate not only the richness of species, but the structural and functional variety they represent (Sandlund et al. 1993). Adaptation, which occurs at all levels of biological organization, allowed and allows organisms to occupy the most different environments on the planet. The enormous plasticity that is inserted in their genome allows them to face challenges that we are far from understanding. Therefore, we know only a small fraction of the living organisms on our planet, despite all the efforts made by science until this year, 2020. As a result, there are many projects under development in the world that use cutting-edge molecular technologies that, coupled with various means of collection, seek to list part of this unknown (Sunagawa et al. 2015). In describing the biodiversity of any of the world's great biomes, immeasurability remains the predicate. This biodiversity includes many organisms that have been used by man since ancient times, an upside of biodiversity. However, there is a wide range of problems arising from man's interaction with biodiversity, the downside of biodiversity.

Here we will make an analysis only of the Amazon, a biome that extends to all the countries of the north of South America. It is an amphibious and dynamic environment, with pulses of flood and ebb that requires diverse adaptive strategies from the organisms (Junk et al. 1989, Val and Almeida-Val 1995). The biological diversity existing in the Amazon biome includes organisms from all major biological groups that, in the face of different human pressures, including climate change, result in the reshaping of flora and fauna associated with animals and plants, often resulting in microorganisms jumping from one to another organism, including man (Uhart et al. 2013). We have selected here

four main groups of organisms to show these aspects: plants, insects, fish and mammals.

CONTEXT

The seed plants in the lowlands of the Amazon totaled over 14,000 species, including over 6,700 trees (Cardoso et al. 2017, Hopkins 2019). Currently, these numbers are possibly higher, since new species are constantly described in the region. Among these plants there are many that produce fruits that are consumed by man, directly or indirectly, or are used in traditional medicine. Little is known about the viral flora causing disease in humans, but in 2010 a plant virus possibly causing disease in humans was described (Colson et al. 2010). This turned on a yellow light. In view of this discovery, it is vital to know whether the hundreds of species of plants in the Amazon represent a risk for the appearance of any new disease. In addition, we must know whether plant viruses can be transmitted to other animals, including insects.

Zoonoses are infectious diseases caused by pathogens (bacteria, viruses, parasites, prions, etc.) that jump from animals to humans. Zoonoses are among the major problems in the modern world. More than three quarters of all emerging diseases are zoonotic (UNEP 2016) and this proportion tends to increase due to the continuous impact that man has been causing on pristine environments. Every four months a new and dangerous zoonosis appears in the world (McDermott and Grace 2020).

Insects are responsible for arboviruses (Arbovirus = Arthropod-borne virus), the most important routes of infection of man with some type of virus existing in animals, in this case including man himself. Insects are the largest and the most diverse animal group in the Amazon biome, with an estimated 250,000 species, less than a third of which have been described (Rafael et al. 2012). About 150 species of arboviruses, out of the 545 known, cause human diseases (Lopes et al. 2014). The most common viruses in the Amazon are transmitted by blood-sucking mosquitoes, especially *Aedes aegypti*. The most common diseases caused by them are dengue, with four known serotypes, yellow fever, chikungunya, zyka, oropouche and mayaro. Only the Evandro Chagas Institute (IEC, Belém, Para state) isolated 220 different types of viruses from various viral families, 37 of which are pathogenic to humans, 15 of which have the potential to cause epidemics (Vasconcelos, Pedro, IEC, interview and personal communication). The arboviruses with epidemic potential, as they have already caused epidemics in other countries are: Western Equine Encephalitis, Eastern Equine Encephalitis, Venezuelan Equine Encephalitis, Saint Louis Encephalitis, West Nile and Rocio, which causes encephalitis in the state of São Paulo. The IEC has already isolated about 20,000 viral strains from these arboviruses (Vasconcelos, Pedro, IEC, interview and personal communication). In Brazil, arboviruses cause disease in both urban and rural areas. In 2019, more than one million cases were registered, but in the Amazon, they have always been considered endemic. The causes of the rise of arboviruses are mainly associated with the lack of urban planning, disorderly growth of cities, poor basic sanitation, climate change, pollution, deforestation and intense population displacement. As there is a limited investment in S&T to describe Amazonian insects and understand their ways of life, in order to expand the description of associated arboviruses, as well as to analyze their pathogenic potential, it is possible to anticipate that there is a tendency for spilling of new arboviruses with the potential to cause epidemic and possibly pandemic challenges. We do not know the size

of this challenge, as there are many unknown parameters in the equation. However, we know that the greater the species displacing and the contact between humans and arthropod species, particularly in urban areas, the greater the possibility of outbreak of new diseases.

Another contact between man and biological diversity in all corners of the world is the use of animals for food, ornamentation and pets, such as fish, amphibians, reptiles, birds and mammals. All of these groups have iconic animals that are repositories of pathogens, including viruses. For example, we know about 2400 species of fish from the Amazon and, possibly, we are unaware of another group of the same size (Oberdorff et al. 2019). However, no more than 20 species are frequently used as food, but a large and significant group is used as ornamental fish. In addition to the already widely known parasites, fish are also repositories of many species of viruses (Pavanelli et al. 2008). Among these fish viruses, some are highly pathogenic and cause extensive economic losses, including among others, hemorrhagic septicemia virus (VHSV), infectious hematopoietic necrosis virus (IHNV) and spring viremia carpvirus (SVCV) (Xu et al. 2017). We know that fish and their associated fauna are vulnerable to environmental changes, including climate change (Campos et al. 2018, Costa and Val 2020), for example, and that associated fauna, including viruses, can seek new hosts.

Finally, the group of mammals, although much smaller in number of species, is worrying because it includes species known to be repositories of viruses that have already caused epidemics in the world. Wild rodents from the Amazon can cause diseases in humans, such as the Laguna Negra Virus, Anajatuba Virus, Castelo dos Sonhos Virus, Rio Mamoré Virus, which are species of hantavirus associated with isolated cases and small outbreaks of cardio-pulmonary syndrome (Oliveira et al. 2014), and the arenavirus that has the potential to cause severe hemorrhagic fevers, such as Flexal, Amapari and Cupixi. Although none of these fevers caused an outbreak, Flexal has already caused infection in humans (Coimbra et al. 1994). Note that there are more than 90 species of wild rodents in the Amazon, many of which are hunted and used for human consumption. Monkeys also represent an important repository in the tropics and, in particular in the Amazon that in recent years had a new species of monkey described (Gusmão et al. 2019), that is, if we do not know all the repository species, we know even less their associated faunas. In several parts of the world, including the Amazon, there is human consumption of monkey meat that is prepared and sold in wet markets without the least hygienic care. Several species of virus jump from non-human-primates to humans (Locatelli and Peeters 2012), as is the case of the titi monkey adenovirus, that causes pneumonia (Chen et al. 2011). Much remains to be known about this virus repository group that can cause new virus outbreak worldwide. However, it is the group of bats that has occupied a prominent position in the transmission of viruses to humans. In the Amazon, 146 species of bats are described, 46 of which are endemic (Bernard et al. 2015). One of these species, *Desmodus rotundus*, a blood-sucking bat, is an important transmitter of rabies in municipalities in the Amazon (Pereira et al. 2017). However, in the last decade in other parts of the world bats are known as an important source of new viruses, among them the well-known coronaviruses such as SARS, MERS and Ebola. As far as we know, direct infection of bats to humans and the dynamics of the transmission of bat viruses have not been described, as it involves a complex process including wild organisms and domesticated animals (Alfet et

al. 2018). Establishing transmission dynamics for bats can protect humanity from new pandemics.

CONCLUSION

In the Amazon, the deforestation of unknown areas for logging, mining, road building, cattle ranches and urbanization has put men in close contact with wild species, an interaction that was rare or nonexistent or nonexistent up to now. The diseases that can emerge from these dangerous contacts have a cost to humanity, including a stupendous economic cost. It is clear that environmental degradation and loss of biodiversity are connected with the increase in spillover events from animals to humans (Johnson et al. 2020). Thus, efforts must be made at all levels of the social organization, including policies, legislation and science, as foreseen in the "One Health" approach (Uhart et al. 2013, Who 2017), to reduce the frequent epidemic episodes to which humanity has been exposed.

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REFERENCES

ALFET A, DEVAUX C & SERRA-COBO JRF. 2018. Bats, Bat-Borne Viruses, and Environmental Changes. In: Mikkola H (Ed), Bats. IntechOpen, London, p. 113-132.

BERNARD E, TAVARES VC & SAMPAIO E. 2015. Updated compilation of bat species (Chiroptera) for the Brazilian Amazonia. Biota Neotropica 11: 35-46.

CAMPOS DF, VAL AL & ALMEIDA-VAL VMF. 2018. The influence of lifestyle and swimming behavior on metabolic rate and thermal tolerance of twelve Amazon forest stream fish species. J Therm Biol 72: 148-154.

CARDOSO D ET AL. 2017. Amazon plant diversity revealed by a taxonomically verified species list. Proc Natl Acad Sci U S A 114: 10695-10700.

CHEN EC ET AL. 2011. Cross-Species Transmission of a Novel Adenovirus Associated with a Fulminant Pneumonia Outbreak in a New World Monkey Colony. Plos Pathogens 7: e1002155.

COIMBRA T ET AL. 1994. A new Arenavirus isolated from a fatal case of hemorrhagic fever in Brazil. The Lancet 343: 391-392.

COLSON P ET AL. 2010. Pepper mild mottle virus, a plant virus associated with specific immune responses, Fever, abdominal pains, and pruritus in humans. Plos One 6: e10041. doi: 10010.11371/journal.pone.0010041.

COSTA JC & VAL AL. 2020. Extreme climate scenario and parasitism affect the Amazonian fish Colossoma macropomum. Sci Total Environ 726: 138628.

DASMANN RF. 1968. A Different Kind of Country. MacMillan Company, New York.

FRANCO JLA. 2013. The concept of biodiversity and the history of conservation biology: from wilderness preservation to biodiversity conservation. História (Sao Paulo) 32: 21-48.

GUSMÃO AC ET AL. 2019. A New Species of Titi Monkey, Plecturocebus Byrne et al., 2016 (Primates, Pitheciidae), from Southwestern Amazonia, Brazil. Primate Conserv 33: 1-15.

HOPKINS MJG. 2019. Are we close to knowing the plant diversity of the Amazon? An Acad Bras Cienc 91: e20190396. DOI: https://doi.org/10.1590/0001-3765201920190396.

JOHNSON CK, HITCHENS PL, PANDIT PS, RUSHMORE J, EVANS TS, YOUNG CCW & DOYLE MM. 2020. Global shifts in mammalian population trends reveal key predictors of virus spillover risk. Proc Royal Soc B 287: 20192736. DOI: https://doi.org/10.1098/rspb.2019.2736.

JUNK WJ, BAYLEY PB & SPARKS RE. 1989. The flood pulse concept in River-Floodplain Systems. In: Dodge DP (Ed), Proceedings of the International Large River Symposium, Vol 106. Can. Spec. Publ. Fish. Aquat. Sci., Canada, p. 110-127.

LOCATELLI S & PEETERS M. 2012. Non-Human Primates, Retroviruses, and Zoonotic Infection Risks in the Human Population. Nature Education Knowledge 3: 62.

LOPES N, NOZAWA C & LINHARES REC. 2014. Características gerais e epidemiologia dos arbovírus emergentes no Brasil. Rev Pan-Amaz Saúde 5: 55-64.

MCDERMOTT J & GRACE D. 2020. Agriculture-Associated Diseases: Adapting Agriculture to Improve Human Health. In: Fan S & Pandya-Lorch R (Eds), Reshaping agriculture for nutrition and Health. International Food Policy Research Institute, Washington, US.

OBERDORFF T ET AL. 2019. Unexpected fish diversity gradients in the Amazon basin. Science Advances 5: eaav8681.

OLIVEIRA RC ET AL. 2014. Rio Mamore Virus in fatal hantavirus pulmonary syndrome case in Brazilian Amazon. Emerg Infect Dis 20: 1568-1570.

PAVANELLI GC, EIRAS JC & TAKEMOTO RM. 2008. Doenças de peixes: profilaxia, diagnóstico e tratamento. 3ª ed., Eduem, Maringá.

PEREIRA AS, CASSEB LMN, BARBOSA TFS, BEGOT AL, BRITO RMO, VASCONCELOS PFC & TRAVASSOS DA ROSA ES. 2017. Rabies virus in bats, state of Pará, Brazil, 2005-2011. Vector-Borne Zoonotic Dis 17: 576-581. DOI: 10.1089/vbz-2016.2010.

RAFAEL JA, MELO GAR, CARVALHO CJB, CASARI SA & CONSTANTINO R. 2012. Insetos do Brasil: diversidade e taxonomia. Editora Holos, Ribeirão Preto.

SANDLUND OT, HINDAR K & BROWN AHD. 1993. Conservation of biodiversity for sustainable development. Scandinavian University Press, Oslo, Norway.

SOULÉ ME & WILCOX BA. 1980. Conservation Biology: An Evolutionary-Ecological Perspective. Sinauer Associates.

SUNAGAWA S ET AL. 2015. Structure and function of the global ocean microbiome. Science 348: 1261359. DOI: 1261310.1261126/science.1261359.

UHART M ET AL. 2013. A 'One Health' Approach to Predict Emerging Zoonoses in the Amazon. In: Chame M & Labarthe N (Eds), Wildlife and human health: Experience and perspectives. Fiocruz, Rio de Janeiro, p. 65-73.

UNEP. 2016. UNEP Frontiers 2016 Report: Emerging Issues of Environmental Concern. United Nations Environment Programme. UNEP, Nairobi.

VAL AL. 2019. Conservação da biota aquática da Amazônia. Revista de Estudos Brasileños 6: 79-89. http://doi.org/10.14201/reb20196117989.

VAL AL & ALMEIDA-VAL VMF. 1995. Fishes of the Amazon and their environments. Physiological and biochemical features. Springer Verlag, Heidelberg.

VAL AL & MARCOVITCH J. 2019. Interview with Tom Lovejoy. Revista de Estudos Brasileños 6: 187-201. http://doi.org/10.14201/reb2019611187201.

WHO. 2017. One Health. https://wwwwhoint/news-room/q-a-detail/one-health.

XU J, XU Z & ZHENG W. 2017. A Review of the Antiviral Role of Green Tea Catechins Molecules 22: http://10.3390/molecules22081337.

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