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Biodiversity and the vision of two worlds: cassava in the West and for indigenous Amazonians

La biodiversidad y la visión de dos mundos: la yuca en occidente y para los indígenas Amazónicos

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Abstract

Biodiversity in the current context of deforestation and climate change is at risk. One of the main actors involved in biodiversity protection are indigenous peoples. Understanding and comparing their vision of diversity and the mechanisms that generate it with that of academia represents one of the most important challenges. In this reflection paper we present some ideas on the academic perception of diversity by contrasting it with that presented by some indigenous peoples of the Amazon. The reflection takes advantage of the cultivation of cassava, an ancestral crop that is a pillar of global food security and has a special symbolic meaning for the indigenous peoples of the Amazon for this comparison. It is established that for the Amazonian indigenous peoples, biological diversity is associated with cultural diversity and that the concept of diversity, from their cosmogony, encompasses natural biological, cultural and even spiritual aspects that define their identity, their territory and therefore everything that exists there. And although for the Amazonian indigenous people, diversity has existed since creation, it only materialises at different moments in space and time. The importance of the chagra and the chagrera woman as the unconscious driving force behind the diversity of cassava and their leading role in the conservation of this diversity is also presented. Finally, a reflection is made on the importance of keeping indigenous practices alive for the protection and conservation of biological and cultural diversity in the Amazon rainforests.

Resumen

La biodiversidad en el contexto actual de deforestación y cambio climático está en riesgo. Dentro de los principales actores implicados en la protección de la biodiversidad son los pueblos indígenas. Comprender y comparar la visión que ellos tienen de la diversidad y de los mecanismos que la generan con la de la academia representa uno de los retos más importantes. En este artículo de reflexión presentamos algunas ideas sobre la percepción académica de la diversidad haciendo contrastándola con la que presentan algunos pueblos indígenas del Amazonas. La reflexión aprovecha el cultivo de yuca, un cultivo ancestral pilar de la seguridad alimentaria mundial y con un significado simbólico especial para los pueblos indígenas del Amazonas para esta comparación. Se establece que para los indígenas amazónicos la diversidad biológica está asociada con la cultural y que el concepto de diversidad, desde su cosmogonía, abarca aspectos biológicos naturales, culturales e incluso espirituales que definen su identidad, su territorio y por ende todo lo que allí existe. Y aunque para los indígenas amazónicos la diversidad existe desde la creación, ésta solo se materializa a diferentes momentos en el espacio y tiempo. También se presenta la importancia que tiene la chagra y la mujer chagrera como motor inconsciente de la diversidad de yuca y su papel protagónico en la conservación de esta diversidad. Finalmente se hace una reflexión sobre la importancia de mantener las prácticas indígenas vivas en pro de la protección y conservación de la diversidad biológica y cultural en las selvas amazónicas.

Introduction

From antiquity to current times, biological diversity has been a concept that attracted the attention of thinkers, philosophers, naturalists and scientists[1]. From different approaches and visions, efforts have been made to understand the mechanisms that generate it, as well as strategies that allow its classification and study. In the current world, with strong pressure from climate change and habitat deterioration, a growing concern for the study of biodiversity and the different plans and programs for its conservation has manifested[2]. From a functional and evolutionary perspective, diversity represents the raw material for evolutionary change to occur, since natural selection acts upon it. The most diverse populations of a particular species have the greatest probabilities that some variant of them allows them to survive facing a changing environment or facing a particular stress condition. In contrast, populations with little diversity, genetically and morphologically homogeneous, have a low probability that any of the individuals carries a character that offers them the possibility of surviving facing a change in the environment. But biodiversity not only gains special interest as a source upon which natural selection acts. In biodiversity are also the sources of genes that can be responsible for characteristics that improve particular aspects of species on which human beings depend for their survival. The greater the sources of biodiversity, the wider the range of possibilities opens to improve traits such as production, response to biotic and/or abiotic stress, etc., both in domestic animals and in cultivated plants[3], as well as the possibility of observing genetic variants responsible for metabolic products with pharmacological, cosmetological, artisanal interest, etc[3]. It could be concluded that without biodiversity there is no future on a planet that changes at an accelerated pace.

Biological thought, supported by the advancement of knowledge, has revealed the molecular bases that explain the emergence of differential traits, forms, functions, and therefore biodiversity[4]. Physical changes that occur on the DNA molecule, chromosomal rearrangements or macromutations, point mutations, inversions, deletions, among others, as well as genetic recombination that takes place during gamete production in sexual crosses are key factors in the generation of biodiversity[5]. The interaction between these molecular mechanisms and environmental selection pressures constitutes the fundamental motor of biological diversification[6].

However, this scientific academic vision contrasts with the vision of ancestral or indigenous peoples in the Amazon for whom, according to cosmogonic narrations, biodiversity is related to cultural diversity as both have a shared origin, since they emerge as legacies delivered by the Creators. That is, for Amazonian indigenous peoples, in the management of biodiversity, the conservation of certain species and varieties that form part of the particular ethnic identity of each people prevails, which were inherited and maintained since immemorial times[7-9]. The appearance of new variants in space and time is explained by exchanges between human groups and by people's interest in maintaining and selecting incorporated species[10].

In this reflection, we intend to make a comparative analysis of the two visions or ways of conceiving biodiversity, emphasizing the consequences that both visions have for conservation. For this, we focus on the particular case of cassava, an ancestral plant that represents an element associated with practical and symbolic meaning for Amazonian indigenous com-

munities and at the same time is a crop of economic importance for sovereignty and food security around the world[11].

Development

The concept of biodiversity in Amazonian indigenous communities and in academic biological thought. Academic perspective on biodiversity. Academic biological thought defines biological diversity or biodiversity as the quantity, variety and variability of organisms that inhabit the earth and that are the product of millions of years of evolution. Biodiversity does not refer to the number of different species, as species richness does. Biodiversity is a much more complex and broader concept, which among other components includes species richness from bacteria to more complex organisms such as plants and animals[1]. Biodiversity can be considered at different levels, whether between major taxonomic groups or even at intraspecific levels. Likewise, biodiversity can include more general concepts, and include diversity between and intra-ecosystems, and even encompass spatiotemporal concepts, given that diversity is changing from one place to another, and after the passage of time[12]. Recent developments and knowledge achieved in the areas of genetics and molecular biology allowed considering that sexual reproduction is the motor of evolution, since the recombination that occurs during meiosis to generate sexual gametes (haploid, with half the genetic information), allows the mixing of genetic material that comes from the parents[5], and has also revealed that the high diversity of forms (microorganisms, plants and animals) contrasts with a relatively low diversity at the molecular level. For example, evo-devo (evolutionary developmental biology) has indicated that many of the morphological traits that allow the multitude of life forms obey patterns of gene expression regulation during development rather than the appearance of new genes[13,14].

Amazonian indigenous cosmovision about biodiversity. However, biodiversity is not a concept that pertains solely to academic scientific thought, studies on the vision that Amazonian indigenous cultures have about biodiversity are abundant[15,16]. Some works reported the coincidence in the classification of plants and animals by Amazonian indigenous cultures with the Western Linnaean taxonomic system[17]. Also, several works have indicated the importance of indigenous cultures as custodians of diversity[18,19]. However, the literature that describes the way in which diversity originates for Amazonian indigenous communities is relatively scarce. For many of them the concept of change or evolution over time does not exist, biodiversity in the Amazonian indigenous context is static, exists since the origins and was given to them by the Creator in an association that involves both the natural and the cultural where the human being is in charge of preserving and protecting it.

In general, Amazonian indigenous peoples follow a series of principles imparted by the Creator to "live well" or live in harmony with nature. The violation of any of these principles can lead to diseases and even death[20,21]. One of these principles refers to cultivated diversity. The Creator being assigns a set of cultivable plants to each Ethnicity and Clan to live well which demands the care and perpetuation of these among generations, which traditionally has woven a close relationship between Ethnicities and some crops[22]. This principle referred to the management, care and above all the conservation of crops received by spiritual beings and the culture around them, contrasts with the hundreds of species that can be found in a single hectare of the Amazon and with

the very high diversity and poly-variety in their crops, in the chagras[22-25].

Understanding the factors that generate high diversity in cultivated plants in a context of strong principles of tradition and conservation of what was received by the Creator requires involving the indigenous cosmogony within the equation that explains this high observed diversity.

Biodiversity for indigenous cultures is the source of their food, medicine and materials, but it is also their spirituality, their cosmogonies and their cultures. Biodiversity is the source of life itself. This is why indigenous cultures maintain a strong dynamic of responsibility and care with it; they use the forest without destroying it and conserve the land and biodiversity as a central axis for the continuity of their peoples. Even recent research proposes that Amazonian biodiversity is largely the result of cultural diversity and its resource management practices[26,27].

This implies that for these people's biodiversity can be understood from two perspectives. The first is general and the result of cultural diversity seen as a whole, each people contribute the species and varieties that are "their own" or constitutive of their ethnic identity. The second is particular, it is evident in each field of cultivation, called "chagras" in the Colombian Amazon, there a farmer combines the species and varieties that are proper to his people with others that he incorporates throughout life and that come from other peoples and therefore are from "other people". Both types "must always be" in a chagra, but in a different sense. The first ones being the fundamental nucleus, invariant or static of the chagras for being associated with ethnic identity. And the second ones must also be present as they are a type of "practical complement" to the first ones, which are conserved for reasons such as flavor, texture or quantity, among other qualities. These species or specific variants can be incorporated, "conserved" or lost. The important thing is to maintain a biodiversity in each chagra that is composed of both "own" species and variants (invariant) as well as those from "other people" (dynamic and that can change over time). This approach, articulates in general, biological diversity with cultural diversity, allows better understanding of why the protection of indigenous territories is at the same time the protection of a biodiversity[28-32] that is at the same time dynamic and "static and without changes".

The academic and indigenous vision: facts that are reconciled around cassava diversity.

Cassava as an element of biocultural diversity. Cassava, Manihot esculenta, belongs to the taxonomic family Euphorbiaceae, includes around 7200 species characterized by presenting laticifers cells that produce milky secretions[33]. Botanically, cassava is an allogamous species, perennial shrub, whose origin is the Amazon basin[34]. It reproduces vegetatively by cuttings in commercial crops, however, it retains the capacity to generate flowers and reproduce sexually, although with low seed viability[35]. Cassava roots are rich in carbohydrates, their energy yield per hectare is very high and potentially much higher than that presented by cereals. The source of cassava starch has been considered the most economical that exists[35]. For this and other physical properties, cassava starch is used in more than 300 industrial products[36].

There are classically two types of cassava, bitter and sweet, classification given by cyanide content, a toxic compound for human consumption. Bitter cassava contains high amounts of cyanide in its roots and gives cassava a bitter taste. The use of this type of cassava is mainly industrial, however, indigenous peoples have developed various techniques to eliminate this cyanide and be able to use it for human consumption. Sweet cassava, on the contrary, due to its

low cyanide content, has no bitter taste and is widely used in culinary preparations[37].

Molecular studies revealed a relatively high diversity of cassava[34,38,39]. In the germplasm bank of CIAT (International Center for Tropical Agriculture) there are 6155 accessions from 28 countries[35]. The greatest diversity of cassava has been reported in its center of origin, in the Amazon basin, where it was domesticated by indigenous communities[40-42]. Likewise, in non-commercial crops managed by small farmers in some countries of Africa[43], Thailand[44] and Vanuatu (Oceania)[45] have also reported high diversity values, after their introduction and migration since the (16th century) [44,45].

Despite the existing diversity, comparative genomics studies revealed that commercial varieties are not diverse, since they were derived from breeding programs that used few varieties as parents observed through a genetic bottleneck that in turn imposes a challenge and a risk in the conservation of cassava cultivation on the planet[46,47].

Cassava for many Amazonian indigenous communities is not only a source of food; it also has a transcendental cultural and symbolic meaning. Around cassava, the family and community structure centered on women is cohesioned, who in many Amazonian cultures is responsible for this plant[28].

For the Amazonian indigenous communities Muinane, Uitoto, Andoke, Bora, Miraña, Cubeo, among others, cassava, as well as other species of edible plants are planted in the chagra[32].

The role of chagra in diversity conservation. The chagra is an agroecological system, a place destined for the cultivation of species of interest to indigenous communities and at the same time is part of a broader system that includes resource management[27,48]. Its importance goes much further than being a planting place where food is obtained for people and animals. On the contrary, the chagra is a social space and is the basis of human organization and at a ritual and symbolic level, it is an almost sacred place[22,32,49]. Each plant of each species and its planting place within the chagra, maintains relationships with the human beings of the community, and the animals that inhabit there and can take advantage of them. The chagra together with the maloca and the "mambeadero" are places that articulate masculine and feminine labors from where tradition is protected and conserved, but at the same time, and as will be mentioned later, protected by men's intentions and driven by women's hands, the chagra is a motor of biological diversity[7,8,50].

For the Coco Clan of the Muinane community of Villa Azul (Department of Amazonas, Colombia), the first woman of each people and Clan was given certain varieties of species such as cassava and chili, and the first man coca and tobacco, since these species and their varieties are associated as representative of each gender[51]. In this sense, the cassavas of origin for this community, are those that the Creator gave them along with the prescriptions to cultivate them and "live well", since as already mentioned, these visions articulate nutritional aspects with others to live adequately in society, with a "sweet, calm" thought, according to what the Creators established in what some groups have called the Law of Origin[52] or the Higher Right. For this same community what exists today has existed forever and thus must continue to exist. Biodiversity for them is having the species that were given to them by the Creator, which are added, and can be exchanged, with those that other peoples also received.

For the Murui, the narration of creation establishes that Moo Buinaima, one of their gods, chose the top of a mountain where there was a hole through which the earth breathed. Moo Buinaima gave the order for

people to come out through that Creator hole. Subsequently each couple of those men chose different kinds of leaves to receive a portion of güio and two kinds of bitter cassava that will ethnically identify each group. In this way the different Clans were formed and with them the different types or varieties of cassava that identify them[53]. Thus, each variety of cassava appears since the origins and establishes a mark of ethnic identity.

Equally, for the Makushi all varieties of cassava are pre-existing, as well as their uses, and their unalterable essence comes from the spirit of Mother Cassava[54]. For the Makushi, ancestrally and in a similar way to the Murui and Muinane, cassava varieties are inherited through maternal line from mother to daughter and/or from mother-in-law to daughter-in-law, when a woman marries she takes the varieties of her Ethnicity to that of her husband and in this way the woman who arrives accumulates the varieties she had inherited from her mother plus those she receives from her mother-in-law[54]. Cassava, in this way, equally becomes for these communities an ethnic reference of kinship.

Traditional practices as genetic preservation strategies. The attachment and identity that these communities have with cassava can also be observed through their preparations, different peoples elaborate products that identify them from specific and different cassavas. Thus, cahuana is a drink made from water and starch of certain varieties of bitter cassava, which can be combined with juices of other fruits. Among the Murui, Muninane, Bora, Ocaina and Andoque peoples it is a drink whose preparation, thicker or more watery, can vary depending on the context. It is used for daily food, to accompany advice and traditional education of children and youth, to offer to visitors of a communal house or maloca and to participants of ritual dances and community work, as well as to perform healings with medicinal and protection purposes[55]. The sweet taste of cahuana is related to the nutrition of the body and soul, transmitting health, tranquility and good living. From a symbolic point of view, cahuana represents the women of the home, who with their power take care of it, the family and relatives[55]. For its part, manicuera is a drink prepared from the juice of certain varieties of cassava, which have a "sweet taste" after being boiled and that serve to "sweeten the thought" of those who consume it, facilitating coexistence, good living, both among humans and between them and the rest of the beings of the territory. Among the Murui, Muninane, Bora, Ocaina and Andoque peoples it is considered a "sweet" drink despite being made from bitter cassava varieties, due to the qualities attributed to "sweeten, heal, gladden and calm" the thought and actions of people who consume them. It is also used as food in daily life, but stands out as a drink to offer at ritual dances, in conversations in the maloca, in collective work and for healing purposes[55]. During festivities or mingas (collective work), the consumption of this drink is related to harmony, avoiding fights or accidents, ensuring that people can be happy performing these activities[55].

But there is also the case of fariña and the different cassavas used for the different forms in which this food can be prepared. According to the Muinane of Villa Azul, several generations ago, their grandparents learned from other people to prepare this food that today is so common in all indigenous communities of the Colombian Amazon and along with these techniques they also received and exchanged cassava varieties suitable for its elaboration and that they did not have before. From this perspective, although for the Muinane fariña and associated variants are foreign, since they did not receive them at the moment of their mythical birth (creation), and therefore do not

form a central part of their ethnic identity, these have been widely appropriated and currently form an important part of the varieties present in any chagra. This contrasts with drinks like cahuana and manicuera and the cassava varieties used in their preparation, which are considered as "their own"[55]. However, and from another perspective, this culinary technique and the associated cassava varieties are not "totally" new, since the same Creators bequeathed them to other peoples as part of their identity. That is, for Amazonian cosmology both cassavas and their own uses or those incorporated from other peoples, leads to the idea that all biodiversity that has existed, that exists and that will exist was already created ("thought" or "named") by the Creators.

Despite the fact that these traditions have been losing ground among repeated processes of colonialism, slavery and the adoption of global economic practices[22,54], what is important to highlight is that these traditions were one of the factors that allowed them, perhaps without understanding it in the same way as it is done from scientific thought, to conserve, propitiate and foster cassava diversity since maintaining high cassava diversity (different cassavas), for indigenous people responds both to following the norms of chagra management given by the Creators and to the need to improve the quality of food products they elaborate (color, texture, flavor, nutrition) and to face changes in the environment (prolonged winters and/or summers, as well as pests and diseases).

In the chagra many varieties of cassava manage to reach flowering and some chagrera women recognize and describe the flowers. They identify that some varieties flower early and others consider that they do not have flowering capacity. However, for them cassava flowers do not represent a form of propagation of cassava plants, since they multiply them vegetatively by cuttings (asexual seed). Although they do recognize that from the flowers of other species fruits and seeds are produced that serve to multiply plants, such as the case of chili. It is very possible that in the chagra self-crossings or spontaneous crossings between varieties occur through pollination and that occasionally some sexual cassava seeds manage to germinate. Some chagrera women recognize in the chagra the appearance of cassava plants that were not planted by them. The People of the Center call them in Spanish cassava of the devil, that is, a cassava that is the product of the initiative of some spiritual being of the territory. For academia these plants arise from the product of cross-pollination that occurs spontaneously in nature. Cassava seeds that originate from this sexual cross fall to the ground and germinate unnoticed by chagrera women. Another denomination for these cassava plants from sexual seed is "volunteer seeds" in the Amazon[40,54]. These plants are characterized by not being very vigorous, some women let them grow to know the characteristics of that cassava that they did not plant. Women learned through practice that the devil's cassava can only be known for its characteristics in the second planting, so they let it grow to then replant and know. If the new cassava satisfies some of the needs or requirements of the chagrera woman, she incorporates it into her collection along with the cassavas of origin[7]. However, chagrera women do not dare to designate new names to these plants despite having different and in some cases new characteristics, since for them all varieties are pre-existing and have a fixed name[54].

The above suggests that the chagrera woman, through the cultural management of the chagra together with the tradition of maternal inheritance (mother-daughter/mother-in-law-daughter-in-law) of plant material, is the main selecting factor and source of biological diversity of cassava, while conserving her varieties of origin through a management

that consists of maintaining diversity in itself, combining some permanent ones (cassavas of origin associated with ethnic identity and cosmovision) with other new ones that can indeed be changing according to characteristics or environmental conditions and consumption or use. This phenomenon can occur in the chagra, but also spontaneously in the forest and would explain, in part, the high diversity of cassava found associated with regions where traditional cultivation management is carried out[41]. In addition, another interesting aspect is that the diversity represented by cassava varieties is dynamic. Just as varieties disappear due to cutting loss due to adverse environmental conditions such as floods, droughts and/or pests, it was also found that new varieties could arrive to the chagras of different families due to factors such as generalized seed exchange and in some cases due to "curiosity", where they tend to conserve the most productive ones[54]. Thus, it is recognized that on occasions plants can appear as a product of sexual seed germination, but also new varieties arrive from neighboring peoples or communities.

This reflection evidences that Western academic paradigms and Amazonian indigenous knowledge offer radically different but complementary perspectives.

Our main contribution is to make visible on one hand, that the genetic diversity of cassava cultivation is shaped by the interaction between cultural, ecological and genetic systems, and on the other hand, to chagras as dynamic ex situ conservation systems where diversity is not understood as an object of study, but as a living system of relationships where the indigenous woman, protagonist of these spaces, is fundamental in the generation and conservation of genetic diversity.

Cassava cultivation is configured, thus as an emblematic case where the scientific and the traditional can meet and allows putting in evidence that the biological diversity of cassava cultivation is intimately linked with the cultural diversity of cultivating communities.

This approach, moreover invites to rethink conservation models, especially crucial in the current context of climate change and biodiversity loss.

Conclusion

It can be established that both for academic culture and for indigenous culture, diversity is a present element and of great force. It is the raw material for evolutionary change and the possibility of perpetuation of species, both human and cultivated plants, as has been seen from the particular case of cassava.

The objective of this reflection article was to comparatively analyze the understanding of biodiversity from two perspectives: Western academic and the cosmogony of Amazonian indigenous peoples. In this sense, we have managed to show that the management and meaning of diversity by indigenous cultures takes on a crucial significance, especially in the current context where a great responsibility to preserve and generate threatened biodiversity falls on them.

For Amazonian indigenous people, biodiversity is associated with cultural diversity. One cannot exist without the other, since indigenous communities conceive diversity as an aspect that appears since the origins of life and that was granted and distributed among different human groups from their beginnings as a divine gift and part of their respective identities and not as an element of change over time.

For the case of the biological diversity of cassava cultivation with indigenous people the great knowers and articulators between plant biology and traditional management that implies the preservation of their ancestral legacies and experimentation and innovation,

which results, perhaps without knowing it, in high genetic diversity of this crop of global importance.
The reflection allows concluding that the understanding of biodiversity requires an intercultural dialogue that transcends disciplinary boundaries, recognizing in traditional knowledge systems a source of scientific understanding as valid as conventional academic methods.

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Conflicts of interest

The authors declare that there is no conflict of interest that could affect objectivity in the presentation of results, analysis and conclusions of the present manuscript.

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Ethical considerations

In the present research, ethical considerations that ensure scientific integrity have been taken into account.

Research limitations

There were no limitations in the present research.

Authors' contribution

Rubén Eduardo Mora Moreno, contributed to the compilation of information and its analysis and collaborated in the writing of the article. *Andrés David Jiménez Maldonado*, contributed to the compilation of information and its analysis and collaborated in the writing of the article. *Carlos Eduardo Franki Calvo*, contributed to the compilation of information and its analysis and collaborated in the writing of the article. *Johana Carolina Soto Sedano*, contributed to the compilation of information and its analysis and collaborated in the writing of the article. *Camilo Ernesto López Carrascal*, contributed to the compilation of information and its analysis and collaborated in the writing of the article.

Acceso a los datos

The information of this research is present in the article.

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