Chapter 3
Evolution of Humans and by Humans

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3.1 Introduction

Humans are the result of evolutionary processes operating through principles similar to those that originated all species populating the Earth. This is an extraordinary conclusion derived from scientific research during the last one and a half century, and that has had one of the greatest influences on human thinking (Bowler 1986; Jacob 1993). *Homo sapiens* is a unique species, as all species are, but it arose through mechanisms that operate on all species; these features confer to humans their uniqueness and at the same time, their generality, resulted from material processes occurring in all living things. But the interactions of humans with other living beings of their surrounding world have also determined evolutionary processes in both humans and the interacting species. Some of the evolutionary processes influenced by humans are incidental, derived unintentionally from cultural actions (for instance, evolution of weeds, arising of new varieties of pests and pathogens

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resistant to herbicides, insecticides or antibiotics; see Baker 1974; Rindos 1984; Ridley 2003; Futuyma 2013). Nevertheless, consciousness, symbolism, and intentionality of their actions (Ehrlich 2000) are crucial aspects of human natures, and humans have also guided intentional evolutionary processes through deliberate management and transformation of ecosystems and organisms these ecosystems contain. These are the processes of evolution associated to domestication of ecosystems and landscapes, as well as plants and animals used by humans from ancient times with a wide variety of purposes (Schwanitz 1966; Harlan 1975; Hawkes 1983; Casas et al. 1997). But the processes have also included fungi and microorganisms that have been less frequently analysed, however their high biological and economic importance. These are also evolutionary processes occurring at landscape level, resulting from modelling the physiognomy, the components and functions of ecosystems according to human needs and values. And all these processes are the main study matter of evolutionary ethnobotany, when directed to study plant evolution, evolutionary ethnobiology when including plants and animals, fungi and microorganisms, and evolutionary ethnoecology when including also deliberate modelling of landscapes including biotic and abiotic elements.

3.2 Evolution of Humans

The modelling of the modern scientific idea about human origins and evolution has among its earliest formal expressions in the "Systema Naturae" published by Carolus Linnaeus in 1758 (Linnaeus 1758). In that work, Linnaeus names humans as *Homo sapiens*, considering them animals, which are classified into the group of Primates together with monkeys and apes. Such crucial idea was published in an epoch in which, according with the Judeo-Christian and several religions, humans should be considered apart from the rest of "creatures" since them resemble the image of god and vice versa (Smith 2009).

Nearly one century later, in "The Origins of Species", Charles Darwin (Darwin 1859) concluded that his theory about the origin, diversification and evolution of living beings might help to clarify the origins and history of humans themselves. With this reasoning, Darwin confirmed the consideration of the non-exclusivity of humans as living things and went beyond Linnaeus, looking for an explanation about their origins and transformations throughout time. Later on, in "The Descent of Man", Darwin (1871) published a more explicit and greater treatment of his conception about human evolution, which was the basis of the present scientific theory for explaining the origins of humans from other ancestral organisms, in the context of natural history.

A series of discoveries progressively supported with material evidence the fact that the present humans evolved from previous relatives, all of them grouped together within the Primates. One of the first meaningful discoveries was that of 1856, during the time Darwin wrote "The Origins of Species", and that was carried out by Johann Carl Fuhlrot and Hermann Schaaffhausen, who found the remains of an interesting ancient human-like organism in the Neander Valley, Germany. Those remains belonged to organisms that are currently named *Homo neanderthalensis*. Later on, fossils similar to those from Neander were discovered in La Chapelle aux Saints, France, by Bardon et al. (1908), and during the twentieth century numerous remains of these humans were uncovered in Europe, Middle East, China and Siberia (Hublin; 2009; Tattersall and Schwartz 2006).

By the end of the nineteenth Century, Eugene Dubois (Dubois 1894) reported the finding of a human-like fossil apparently older than the Neanderthal Man. The discovery occurred in Trinil, Java, and the remains were named *Pithecanthropus erectus*. Later on, during the 1930s G. H. von Koenigswald in Java and Davidson Black in Beijing found fossils similar to those found by Dubois and the latter was considered by Black (1931) to belong to *Zynjanthropus pekinensis* (Black 1931; Antón 2003). During the 1950s Louis and Mary Leakey and their research team found the oldest remains of relatives of this human-like fossil in Tanzania, concluding that both *P. erectus* and *Z. pekinensis* were related and similar to the fossils they found in Africa, naming all of them *Homo erectus* (Leakey et al. 1964; Leakey 1996) a binomial that is currently used.

During the 1920s and 1930s palaeoanthropologists were particularly prolific in discoveries, reporting a great variety of fossils of several species of African human relatives that were grouped into the genus *Australopithecus* and later on, some of them into the genus *Kenyanthropus*. Particularly relevant were the discoveries of the "Taung boy" by Raymond Dart in 1924 (Dart 1925), which was named *Australopithecus africanus*, as well as the larger crested skull of *Australopithecus robustus* reported by Robert Broom (originally with the name *Paranthropus robustus*; Broom 1938, 1950; Broom and Robinson 1949).

During the 1960s the most outstanding discovery was the finding of *Homo habilis* by Louis and Mary Leakey team in 1964 (Leakey et al. 1964). At this point of the history of palaeoanthropology, the analysis of trends of skull volume, the degree of perfection of the erect position and the use of tools became the most relevant signs for identifying the evolutionary trends or organisms towards current humans. For this reason, the discoveries of *Homo habilis* and tools fabricated by this humans' relative are particularly important. *Homo habilis* had more perfect erect posture than any species of *Australopithecus*, and the manufacture of stone tools evidences complex processes involving designing of actions. Use of tools is not a feature exclusive of humans, but manufacturing tools it is. The design of actions according to a purpose is what philosophers have defined as *praxis* (Sánchez-Vázquez 2003), which is widely considered a feature dramatically more dimensioned in humans than in any other animal species. Following this thinking, the concept of "human" goes beyond the species *Homo sapiens*. Organisms defined as "humans" are properly those designing actions (Harari 2014). The most ancient evidence of such process is hitherto associated to manufacturing of tools. It is generally accepted that *Homo habilis* definitely fabricated tools (the Oldowan tools) nearly 1.7 millions of years ago, but in addition it has been discussed evidence of bones apparently scratched by tools associated to *Australopithecus grahi* at Bouri, Ethiopia some 2.5

millions of years ago (de Heinzelin et al. 1999). The latter would be the oldest evidence of human way of making and using tools.

Homo erectus was discovered previously to *Homo habilis*, and although both species coexisted at some time, *Homo erectus* continued on Earth for much longer time than *Homo habilis*. Two aspects are relevant characteristics of *Homo erectus*. One of them is their more perfect erect posture compared with *Homo habilis*, the perfection of processes for manufacturing tools, the deliberate use and management of fire, and the larger volume of their skull size relative to their whole body size. The second relevant aspects is their great migratory activity, apparently favoured by the use of tools and fire, which allowed what is known as the first colonisation of Eurasia by *Homo*, or the First Out of Africa. According to Leakey (1996) and Fleagle et al. (2010), the ancient *Homo erectus* originated in Africa, and the fossil records found in Java and Beijing are signs of such extraordinary migration capacity.

The most spectacular finding of palaeoanthropology and possibly one of the most important discoveries of the twentieth century was "Lucy" the fossils of *Australopithecus affarensis* reported by Donald Johanson (Johanson and Maitland 1981). Lucy was not the oldest nor the closest relative of modern humans, but the most relevant aspect of this finding was that nearly 40 % of the skeleton of Lucy was recovered. This fact allowed corroborating and developing hypothetical allometric relations deduced from previous studies, which were of great value during the later decades for more precise interpretation and reconstruction of palaeoanthropological remains.

During the 1990s and the beginning of the twenty-first century the palaeoanthropology increased the finding of a great amount of fossils and information about the high diversification of human relatives such as *Kenyanthropus*. The discovery of *Orrorin tugenesis* by Brigitte Senut and Martin Pickford in the year 2000 (Senut et al. 2001), is also significant, since this fossil appears to be the oldest relative of humans (6 millions of years old approximately) hitherto.

The discovery of fossils and the development of dating techniques based on radioactivity and molecular clocks have significantly influenced our knowledge about human evolution and its relation to Primates (Fig. 3.1). Radioactive dating generally allowed identifying the oldest relatives of humans documented until the present (*Orrorin tugenensis*), lived on Earth approximately 6 millions of years ago. In addition, that several species of the genus *Australopithecus* diversified in Africa within a broad period, from approximately 4.2 to nearly 1.4 millions of years ago. *Homo habilis* populated the current territory of Tanzania from 2.3–1.6 millions of years ago, coexisting with several species of *Australopithecus*. Then, *Homo erectus* arose in Africa from 1.8 millions of years to 300,000 years ago having coexisted with several species of *Australopithecus* and *Homo habilis*. The First Out of Africa started very early after *Homo erectus* appeared on Earth. *Homo erectus* has been recognised at the basis of divergent lineages of the genus *Homo*, including *Homo neanderthalensis*, which lived in Asia and Europe from approximately 250,000 to 30,000 years ago. And *Homo sapiens*, our species, originated in Africa nearly 200,000 years ago and populated practically all corners on the Earth (the Second Out of Africa by *Homo*) throughout this relatively short period.

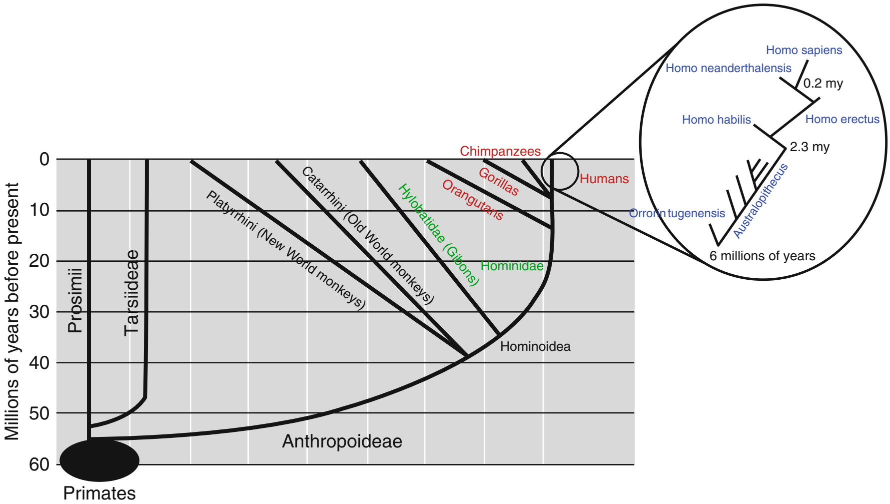

Fig. 3.1 Panorama of human evolution within the context of the general phylogeny of Primates. At the basis of the Figure, the *black ellipse* represents the ancestral organisms preceding Primates, which are out of the analysis of this study. Within the Anthropoideae, the Hominidae diverged from the Hylobatidae some 35 millions of years (my) ago. Within the lineage of Hominidae, Orangutans diverged some 12 my ago, Gorillas some 9 my ago, and Chimpanzees nearly 8 my ago. Humans lineage includes the most ancient fossil of *Orrorin tungenensis* (6 my old), several species of Australopithecus, and several species of Homo, a genus originated 2.3 my before the present. *Homo sapiens*, the species of current humans, appeared on the planet approximately 200,000 years ago somewhere in central Africa, and all human races and variants recognised at present have common ancestors in the earliest African populations of *Homo sapiens*

Homo sapiens and *Homo neanderthalensis* coexisted and apparently interbred from 200,000 and 30,000 years ago (Harvati and Harrison 2006). Actually, for long time both taxa were motive of discussion about their belonging to one single or two species. However, after a series of studies starting by Svante Pääbo of the Max Planck Institute and then other numerous scholars reconstructing mtDNA from remains of Neanderthal bones, it is now clearer that the two species hypothesis is the correct (Caramelli et al. 2003).

It is also clear that all humans that currently populate the planet derived from the earliest *Homo sapiens* populations originated in Africa. Several research groups, but outstandingly that of Luigi Luca Cavalli-Sforza (Cavalli-Sforza et al. 1994; Li et al. 2008; Creanza et al. 2015), have investigated through different biochemical and molecular markers the relation of genetic similarity, cultures and spatial distribution of humans. These scholars have documented with an increasing precision the fascinating relation of genes, populations and languages (phonems, see Creanza et al. 2015), and this approach has been particularly powerful for answering the question about time of genetic and cultural differentiation and occupation of different areas of the planet. Together with archaeological records, molecular biology has allowed a more precise panorama about the Second "Out of Africa".

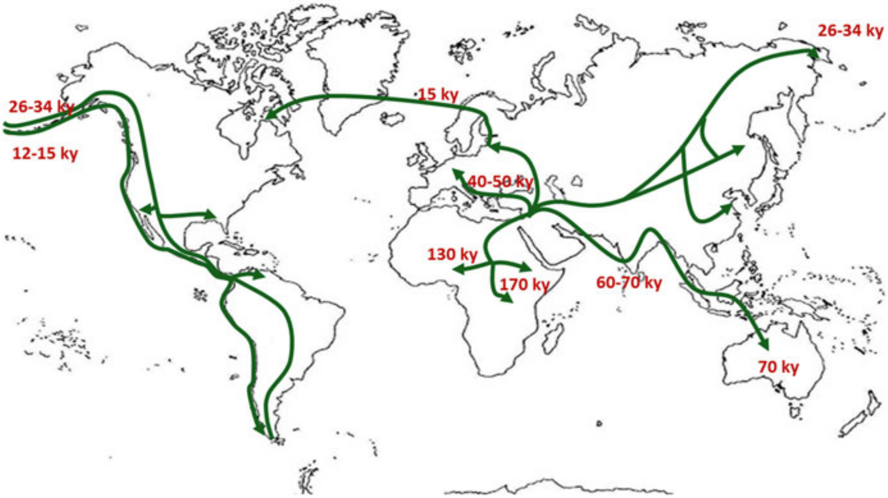

Fig. 3.2 Several routes of dispersal of *Homo sapiens* throughout the World, and their antiquity in thousands of years (ky) before present, according to archaeological radioactive and mtDNA dating (based on Endicott et al. 2009; Pringle 2011). It can be appreciated the relatively rapid diffusion of current humans throughout Africa and tropical Asia, whereas colonisation of Europe and notoriously Beringia took longer time, most probably due to technology needed to survive in such extreme climate conditions. The colonisation of the Americas was the most recent process of colonisation, and the study of this process helps understanding the rapidness of developing of human culture diversification

Based on mtDNA and archaeological remains Endicott et al. (2009), estimate that the earliest populations of *Homo sapiens* started to diverge in Africa 170,000 years ago (Fig. 3.2). Lineages populating southern Asia and Australia diverged from humans at the Middle East some 60,000–70,000 years ago, whereas the lineages that populated Europe diverged from humans that populated the Middle East between 40,000 and 50,000 years ago. Two lineages diverged from human populations of Central Asia, one of them occurred 26,000–34,000 years ago and leaded humans to Beringia and then to populate the Americas. McEvoy et al. (2011), Pickrell and Pritchard (2012), and other authors, using single nuclear polymorphism (SNPs), published finer UPGMA and Bayesian classifications of human genetic groups. This are great pieces of work confirming and making more precise the relation between cultural and linguistic groups of the World.

Recent information (Pringle 2011) confirms that the New World was populated from at least two main waves of human migrants from Beringia. One of them some 18,000 years ago and the others later on. This information also provides evidence that the occupation and diversification of cultures and languages of the Americas occurred in a relatively short time. According to Ethnologue (http://www.ethnologue.com/), at present, nearly 1250 languages are spoken in the Americas (207 in the US and Canada, 547 in Mexico and Central America, and about 400 in South America). This is a still amazing number of languages, but it was even higher some Centuries ago. It has been estimated that after the European Conquest, the indigenous populations dramatically decreased and the native cultures of the Americas felt down at least to one-half of those originally existing when Europeans arrived. These figures suggest that in about 20,000 years, in this area of the World became developed nearly 2500 languages, which in some way are representative of a similar number of cultures. Migration, isolation and eventual reencounters are all processes considered for explaining such a profuse linguistic and cultural diversification.

Such context of human diffusion throughout the New World, the historical waves of entrance from Beringia and later migrations from other regions of Asia and Europe configured a complex setting of cultural effervescence. This human cultural diversification included progressive innovation of management techniques to domesticate ecosystems and biotic resources contained on them. Evolutionary ethnobotany and ethnobiology deals with understanding such important processes.

3.3 Evolution of Management and Control of Ecosystems and Natural Resources

Homo sapiens and other human species were hunter and gatherers, or foraging organisms during most of their time on Earth (Leakey 1996). They designed and used tools maybe nearly 2.5 millions of years ago, apparently for cutting and scratching carrion of animals consumed as food. Humans used and managed fire nearly 1.8 millions of years ago. These technological features meant revolutionary forms of interacting with nature, significantly controlling the high uncertainty of ecosystems and resources of environments where humans lived. Such technologies changed notoriously throughout time, every step presumably improving the human abilities for controlling that uncertainty.

It has been recognised, that after fabricating tools and domestication of fire, one of the most significant technological changes developed by humans was agriculture (Diamond 1997, 2002). Agriculture should be defined as the combination of two main forms of control of the surrounding world by humans: that involving ecosystems and that involving biotic resources (Casas et al. 1997). On one hand, agriculture involves management of ecosystems, for instance through clearing forests, tilling land, providing irrigation, and protection to the organisms of the managed system that are interesting to human purposes. On the other hand, agriculture involves the management of variation of the organisms they consider good resources. At one level, humans select species desirable and undesirable within the system and act in consequence let standing or removing them, respectively (Casas et al. 1996, 2007; Blancas et al. 2010, 2013). At a more specific level, humans have identified intra-specific variation and have decided to promote or remove the beneficial and the undesirable variants (Darwin 1859). This are the general principles of artificial selection as we discuss below, and the evolutionary process resulting from this and other evolutionary forces guided by humans has been called domestication.

Agriculture is therefore the expression of management of domesticated organisms in managed ecosystems (Casas et al. 1997). Use of tools and fire allowed managing and controlling in some way ecosystems for long time before practising domestication. Once people started combining ecosystem management for propagating domesticated organisms, agriculture arose.

Ecosystem management is older than domestication of organisms. How old it is? According to Rose-Innes (1972), peoples of Africa fired the savannahs deliberately some 50,000 years ago in order to increase abundance of some grasses particularly valued as cereals. The different responses of grass species to fire were of course result of natural selection. Anyway, this human action, favoured those species preferred by humans and this is the principle explaining the recurrent use of such technique. Similar forms of management exist at present in Africa and in other parts of the world, and these allow understanding the principles moving people to this kind of practices that are not agriculture nor simple gathering. At the end of the day, it is a way of transforming ecosystems to improve the conditions for gathering resources. In several parts of Mexico, people use to fire recurrently forest areas in order to favour the abundance of grasses for livestock. In addition, in the Mixtec region of Oaxaca and Guerrero people fire different types of forest to promote the abundance of the palm *Brahea dulcis*, which is used as an important resource for weaving handcrafts (Casas et al. 1994, 1997). Groube (1989) documented that in Papua, New Guinea there are archaeological remains indicating intensive felling of trees in the rainforest in order to favour abundance of plants that attracted herbivores for hunting, as well as species like yams (*Dioscorea* spp.) and taro (*Colocasia esculenta*), which were (and currently are) important edible resources for humans.

Another management principle for a similar purpose was documented by Julian Steward (Steward 1938) among the Paiute in California. Until the early twentieth century, this people constructed systems of channels, in order to irrigate grasslands areas, artificially increasing the abundance of *Cyperus* sp., a species used for its edible rhizome.

Numerous forms of management that are more than simple gathering but that are not *sensu stricto* agriculture, have been documented in several parts of the world. These management forms are called "incipient management" or "silvicultural management", since these represent form of modifying populations and communities of wild plants. In Mexico, our research team has studied the spectrum of these forms of plant resources management that currently are carried out by indigenous peoples in several regions, but we have conducted deep studies particularly in the Balsar River Basin (Casas et al. 1996), and the Tehuacán Valley (Blancas et al. 2010, 2013). In the Tehuacán Valley we have documented that nearly 300 native plant species are silviculturally managed. And we have distinguished silvicultural management occurring in the forests in situ (in natural forests or in patches of forests associated to agroforestry systems), as well as management involving moving plants from their natural distribution areas to other transformed systems (ex situ management) (Fig. 3.3).

In situ management involves gathering, which may be simple gathering or simple harvesting of products from the wild. However, gathering commonly involves strategies, specialised techniques, social organisation and construction of agreements. All these practices indicate that gathering may be a real complex management strategy. In addition, these practices indicate that different forms of gathering may be identified within a gradient of complexity according to: (1) The energy invested

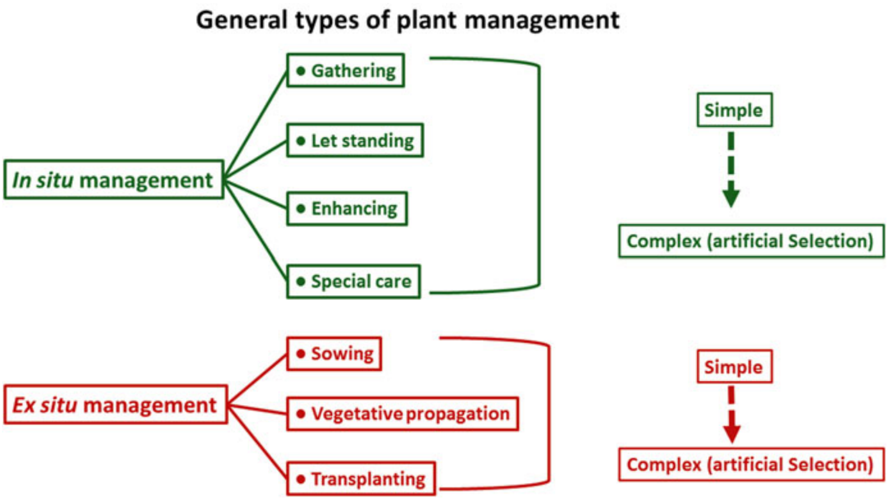

Fig. 3.3 General types of plant management documented in the Tehuacán Valley, Mexico, according to Blancas et al. (2010). The in situ management types occur in natural forests or patches of forest associated to agroforestry systems, whereas ex situ management types occur in artificial environments close to human settlements. Explanation of each management type in the text. All management types have been found to be in gradients from simple to complex forms depending on investment of energy, tool types, amounts of products and productivity (production per area managed). The most complex forms involve artificial selection

in the system (e.g. number of persons involved in the activity, hours of work invested per person, use of fossil energy); (2) the complexity of tools involved (from rocks or sticks to sawing machines or tractors); (3) the strategies followed (organised, planned, landscape ordinated, among others), (4) the areas under gathering, and the amount of products extracted in relation to those areas (Blancas et al. 2010, 2013). Similarly, other in situ managed practices may involve gradients of complexity. These is the case of tolerance, through which people let standing individuals of particular species or particular phenotypes of a given species (Casas et al. 1996, 2007; Parra et al. 2010, 2012). Another management form is the in situ promotion of abundance of those plant resources appreciated by people. The examples of intentional firing and irrigation referred to above are examples of this management form (Casas et al. 1996, 1997). Indigenous people also use to practice special caring actions for protecting species or phenotypes of wild plants interesting to them. They, for instance, protect particular plants against herbivores or pest attacks, frosts, excessive solar radiation or excessive shade (Blancas et al. 2010, 2013). All these forms of in situ management may have consequences on fitness of plants that are favoured or not; in other words, these practices may involve artificial selection and domestication processes occurring in management systems different to agriculture (Casas et al. 2007). We have documented effects of artificial selection in these in situ management systems on morphology, physiology, reproduction and population genetics, in herbaceous, shrubby and arboreal species. More details of these studies will be discussed in the Chap. 4 of this book.

We have documented other forms of managing wild plants: the ex situ management. Through these management forms people propagate in human-made environments, closer to sites of human settlements those plants that find in the forest and that are interesting for them. These are the cases mainly of edible, medicinal, crafting used and ornamental plants (Casas et al. 2007; Blancas et al. 2010, 2013). People move sexual and asexual propagules and cultivate them in the desirable environments, but they also move complete individuals (transplantation), more commonly of young plants, but in some cases also adult plants (Blancas et al. 2010, 2013). These are also forms of silvicultural management, since it is wild plants those that are managed (Casas et al. 1996, 2007).

What is more relevant for the moment to mention is that domestication may operate not only associated to agriculture, but also in other forms of ecosystem management. This fact, tested based on current ongoing processes of management (Casas et al. 2007; Parra et al. 2010, 2012), makes possible suggesting that not only ecosystem management preceded agriculture, but even domestication could have been associated to those pre-agricultural (or silvicultural) forms of management. Agriculture is, therefore, an advanced stage of the convergence of these two forms of managing ecosystems and organisms comprised within those ecosystems (Fig. 3.4). It is an (in reality there is a high diversity) advanced form of controlling environmental variables and organisms particularly adapted to those variables, as well as to human needs and values, as we will review in the following section.

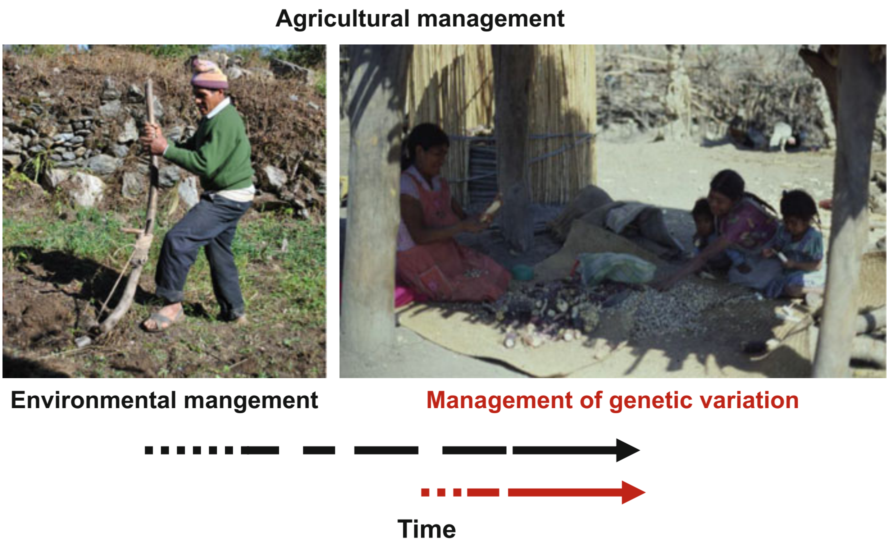

Fig. 3.4 Agricultural management is the convergence of environmental or ecosystem management and management of genetic variation or domestication. Ecosystem management has been documented to be significantly more ancient than domestication. However, the occurrence of artificial selection in non-agricultural management forms suggests that both ecosystem management and domestication may have occurred before agriculture, which became agricultural management when ecosystem management and domestication reached a significant integration

3.4 Evolution by Humans

Domestication is an evolutionary process guided by humans in order to adequate variation of organisms that are domesticated according to human purposes. The first theoretical treatment of domestication was the Chap. 1 of “The Origins of Species” (Darwin 1859), whose main premises were later on developed in the two volumes treatise “The variation of animals and plants under domestication” (Darwin (1868). In these works, Darwin developed four main ideas that were crucial for his thinking on the origins of biological diversity. The first one is the recognition that variations in plants and animals are frequent and measurable, which was an important conclusion based on extensive observations, in a world dominated by fixist ideas. It is widely known the detailed Darwin’s work measuring and analysing numerous morphological and physiological variations among individuals of particular species. This important approach contributed to develop empirical evidence of evolutionary processes.

The second main idea is that artificial selection practised by humans (including Darwin himself) favours some variants and disfavours others, and that such a simple mechanism is a principal cause of differentiation of varieties and races of domestic plants and animals. The third main idea is that the high diversity of varieties and races that have been generated by artificial selection have one or few common ancestors, and that it is possible to reconstruct the history of the divergence and common ancestry of the varieties and races. Based on his own experience as breeder of pigeons Darwin reconstructed the phylogeny of some main European races of these animals, and similarly speculated about the ancestors of some of the most important domestic plants and animals. The fourth main idea is that the three principles enunciated above occur similarly in both human and natural contexts moved by artificial and natural selection, respectively (Darwin 1859, 1868).

This is certainly the route of thinking that made possible arising the concept of natural selection, a crucial idea in the modern evolutionary theories. In addition, this thinking allowed the analysis of artificial processes that may be used as models for explaining what may occur in nature. In other words, the analysis and praxis of domestication allowed Darwin developing a theory about the origin of biological diversity and empirical bases to support his thinking.

The mechanisms of artificial selection described by Darwin were simple. In the case of animals, the breeders commonly select the male and female organisms with desirable attributes (general body or particular parts size, colour, quality of hair or feathers, among others), and the exacerbation of some features determine that the lineages diverge, with time becoming different races. In the case of plants, in Darwin times the breeders were able to drive crosses of particular lineages and practised systematic artificial selection on the descendent phenotypes. These simple processes were what the breeders practised with strong directionality and Darwin called them to practice “conscious selection”. Darwin contrasted this type of artificial selection from that practised progressively and more slowly in peasant rural contexts. Darwin called that kind of artificial selection “unconscious selection”, to distinguish it from the relatively more intensive and systematic artificial selection described before. Nevertheless, it is not exact that this selection is "unconscious", as it has been widely demonstrated during the twentieth and the early twenty-first centuries by ethnobotanical researches studying traditional agriculture (Hernández-Xolocotzi 1959; Zizumbo and Colunga 1982; Casas et al. 1994, 1996).

Whatever the type of artificial selection, its common purpose is favouring those variants of a population of organisms that are desirable to humans, while disfavouring in the extreme case eliminating those variants that are not desirable to humans (Darwin 1859). Nevertheless, what is "desirable" or "undesirable" is a complex issue since human cultures may consider something desirable in a context and undesirable in other context, and both natural and cultural factors may influence in those considerations (Casas et al. 1996). This is one of the reasons why domesticated organisms have as particular characteristic a high morphological and physiological variation compared with the variation that can be recognised among wild populations of a species (Schwanitz 1966; Hawkes 1983; Brush 2004). Nevertheless, humans have in common some physiological and cultural aspects in common which have determined similar artificial selection pressures in different social-ecological contexts. Such similarities have determined numerous evolutionary convergences in features of plants and animals that have been domesticated. Such convergences have been called the domestication syndrome. The domestication syndrome has been polemic, but in fact, it is a hypothetical premise particularly helpful to analyse the result and progress of ongoing processes of domestication through comparative biology, as it will be discussed in Chap. 4.

In plants, among the main features of domestication syndrome (Schwanitz 1966; Hawkes 1983) we can mention: (1) Gigantism, which is the enlargement of parts or increasing of content of fluids (sap, latex, oils) or elements (nutriments, aromatic compounds) that are used or beneficial to humans. Of course, not only the useful parts increase their size, other highly correlated parts and the general architecture of the plant have changed as consequence of selection in favour of gigantic desirable parts. (2) Suppression of natural mechanisms of dispersion, particularly for those species whose fruits or seeds are the useful part. For instance, in plants like cereals that disperse their caryopsides by fracturing their rachis, people have selected those variants with strong rachis; in the case of legumes, commonly dispersing their seeds by explosive dehiscence of their pods, humans have selected those variants with indehiscent pods. Some fruits with natural attractive colours to attract seed dispersers have been selected favouring colours cryptic for the dispersers in order to decrease damage of the useful part. (3) Suppression of mechanisms of protection against herbivores. Plants generally have mechanical (spines, thick peel or cortex, flaxy surface, among others) or chemical (toxic, unpalatable, or repellent compounds) that defend the plant or some of its parts of herbivores. Humans are herbivores and have selected in favour of those variants lacking defence mechanisms. (4) Loss of dormancy mechanisms and increasing synchronic germination of seeds. Natural mechanisms adapting seed germination to the appropriate environmental conditions in order to increase the probability of establishment, are generally undesirable for human management of plant stands. Therefore, this is a character commonly found in domesticated plants.

Comparing features of domesticated plants like those described above, with those showed by wild plants is a common methodological strategy to document when domestication started, how advanced is the domestication process, and how it has operated and it is currently operating (Casas et al. 2007; Parra et al. 2010). Domesticated plants become completely dependent on humans for surviving and reproducing. This is the most advanced stage of domestication. But not all domesticated species have achieved this stage, and some are partially independent of humans in their most advanced stages of domestication. Even more, in the regions where the crops originated, it is possible to observe populations or subpopulations of organisms in a continuum of stages of independence and dependence from humans.

Domestication is an evolutionary process and, therefore, it is continually operating. Even on those species that are completely dependent of humans for their survival and reproduction, artificial selection is continually changing intensity and direction. This is because human culture is highly dynamic, much more than natural factors guiding natural selection; and also because humans move relatively rapidly plants and animals in the space. The diffusion of crops has been extraordinarily rapid throughout human history and it is progressively more and more accelerated. This context confers a highly dynamic change of environmental conditions where the crops grow. In addition, the management technology of agriculture has dramatically changed, particularly during the last Century. These three factors confer to domestication highly dynamic conditions to operate. Therefore, in a time lapse relatively brief, domestication has determined the appearance of a high agrobiodiversity, which constitutes the basic process that has generated the valuable genetic resources for current and future needs.

Artificial selection is the most documented evolutionary process influencing domestication, but it is not the only one. Other general evolutionary processes influence domestication: The random changes generated through genetic drift, which are favoured by the relatively small populations predominantly managed by the human domesticators throughout the world. The gene flow among wild relatives and crops that frequently occur in their centres of origin are main sources of agrobiodiversity. In addition, gene flow occurring between varieties originated in distant geographic areas are progressively more common as human cultures rapidly increase their contact. Some of these processes are incidental, not guided, unintentional, but some others are deliberately managed. These evolutionary processes when guided by humans, like artificial selection, should be considered part of the process of domestication. But even when they are not intentional, as it is natural selection, they also influence the evolution of domesticated organisms. A holistic comprehension of domestication requires understanding these evolutionary processes that have been increasingly studied in natural evolution, but scarcely in evolution determined by humans.

3.5 Conclusions

Evolution by humans has therefore two main expressions: changes in ecosystems that configure evolution of landscapes adapted to human purposes, based on needs, customs, values, technology and other elements of human culture. The other is the transformation of organisms guiding their fitness according with the human cultural contexts. But both processes are connected: what happens at landscape level influences the criteria for selecting and modelling the organisms in process of domestication. In counterpart, the result of domestication of organisms influences the characteristics of the production system and, in turn, on the configuration of the landscape.

Documenting these processes is the general purpose of evolutionary ethnobotany. How human cultures determine changes in landscapes and in organisms composing those landscapes is crucial for understanding the human culture itself and the shaping the configuration of most of the surface of our planet. At the same part, evolutionary ethnobotany and ethnobiology may help to understand how changes in landscapes and in organisms influence the configuration of human cultures throughout the time and space.

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