



International Erasmus Mundus Master in
QUATERNARY AND PREHISTORY



**Tools for the feast: Protocols for the study of
chimpanzee perishable tools from Dindefelo Community
Nature Reserve (Senegal)**

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¡Va por ti, Kira!

Abstract

Chimpanzees (*Pan troglodytes*) possess one of the most complex and varied material cultures observed in non-human animals. We studied the technology of western chimpanzees (*P. t. verus*) living in a savanna habitat in the Dindefelo Community Natural Reserve in Senegal. The objective of our study was to create a protocol for the technological study of chimpanzee tools, with the aim of systematizing future data collection and analysis of technological behaviors within the reserve as well as in other chimpanzee study sites. To achieve this, we conducted macro and microscopic analyses of 21 instruments used by chimpanzees from Dindefelo, corresponding to three activities: ant-dipping, termite fishing, and algae fishing. In addition, 40 instruments from an experiment we conducted were also examined. Our findings reveal differences in the tools from distinct activity types, characterized by scars at the proximal, medial, and distal ends, resulting from various processes such as extraction, manufacture, and subsequent use/reuse.

Resumen

Los chimpancés (*Pan troglodytes*) poseen una de las culturas materiales más complejas y variadas observadas en animales no humanos. Estudiamos la tecnología de los chimpancés occidentales (*P. t. verus*) que viven en un hábitat de sabana en la Reserva Natural Comunitaria Dindefelo en Senegal. El objetivo de este trabajo es generar un protocolo para el análisis de herramientas perecederas de chimpancés, desde un punto de vista tecnológico, y que en el futuro pueda ser usado en la propia reserva u otras diferentes, y de este modo permitir sistematizar los datos recogidos. Para ello, hemos analizado 21 instrumentos usados por chimpancés, procedentes de Dindefelo, que corresponden a tres actividades: *ant-dipping*, *termite fishing* y *algae fishing*, junto con 40 instrumentos procedentes de un programa experimental. Los resultados nos muestran que las herramientas tienen diferencias en las encontradas en los extremos proximales, mediales y distales, frutos de procesos diferentes como lo son: la extracción, la manufactura y su posterior uso/reutilización.

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1. INTRODUCTION

1.1.Culture.

When we approach the study of human evolution, some questions come to our mind, such as: what are our links with the rest of animal species? what differentiates us from the rest of primates? Depending on the explanation given, it usually ends in a "why?"

The driving force that leads us to ask these questions is our curiosity to know ourselves. To address some of these questions, we find that there are several disciplines interested in trying to assess what makes us human, such as Archeology, Psychology, and Biology, among many others. But to do that, we must define the common biological and cultural traits that differentiate us from the rest of the species. If we look at what has already been written, some authors consider culture a unique trait of our species. This very broad concept has been approached from different fields including human and social sciences.

Since the XVIII century, culture has been defined by different authors, and we will see how over time they will be quite distant from each other, and even today it is still in discussion, which we could define as constant. What is certain is that this concept began with a differentiation linked to the separation of species. This gave rise to anthropocentric visions, as in the case of Carl Linnaeus (1735), in which he distanced the genus *Homo* from the rest of primate species, showing us a definition such as: '*Nosce te ipsum*', or what is translated as: "know thyself". The irony would be that thanks to this, we could see that such culture is not a vital and defining element as we were discovering ourselves.

In the XIX century, Darwin (1859) define culture as an extra-somatic element of adaptation to the environment, i.e., cultural traits are explained in terms of their specific contribution to adapting human beings to their particular ecological redoubt (Johnson, 2000). Ten years later, Taylor says that culture encompasses the knowledge, beliefs, arts, morals, laws, customs and other faculties and habits acquired by man in society (Tylor, 1871). Here we see that Taylor does not differentiate between culture and civilization. Furthermore, he makes no reference to teaching and learning, the bridge that perpetuates culture. In these cases, culture was considered an exclusive and defining quality of the human being. It was highly criticized because it did not show the importance of each society showing cultural diversity.

Into the 20th century, in *The Mind of Primitive Man* Franz Boas (1938) proposed that culture encompassed the entirety of mental and physical reactions and activities that characterize the behavior of individuals within a social group, collectively and individually, in relation to the environment of other groups or members of the same group. Continuing along this same line, Kroeber and Kluckhohn (1952) suggest that culture consisted of explicit and implicit patterns of behavior, acquired, and

transmitted through symbols, which would constitute the distinctive achievements of human groups, including their expression in tools. This unilinear evolutionism was also challenged by the functionalist school of thought. One of its proponents was B. Malinowski, who argued that culture would take on the role of satisfying individuals' biological, psychological, and social needs (social functions). He defended it as a complex system of behavior, tools, knowledge, and beliefs that are socially transmitted.

In this sense, he argued that *"the problems posed by the nutritional, reproductive, and hygienic needs of man must be resolved, and they are, through the construction of a new artificial or secondary environment. This environment is culture (...) all these problems are solved by individuals with tools and through organization into cooperative groups (...) also through the development and transmission of knowledge..."* (Malinowski, 1981: 43-44).

Later, Kummer (1971) would emphasize the importance of environmental pressure and contact between groups. He defined adaptation as occurring in reaction to ecological factors, such as climate changes, geological shifts, predation, or human pressure. Similarly, changes in the behavior of a social group were attributed to the diffusion of behavior through contact with other groups.

The 1960s and 1970s (Kortlandt, 1962; Goodall, 1964; Reynolds and Reynolds, 1965; Jones and Sabater Pi, 1969) were significant for diversifying the concept beyond the anthropocentric perspective that had been prevalent, shifting focus to other animal species, not exclusively human. In this context, we can mention Sabater Pi (1974a) and their work on cultural behavior and the elements involved in it, indicating that the *"modification and the use of simple natural objects as tools, an activity known to some primates and especially to chimpanzees, is one of the most significant elements of the material culture of any cultural complex; chimpanzees, in this and many other aspects, are animals that are closest to humans."* (Sabater Pi, 1974a: 10).

In the same line, researchers such as Vèa and Clemente (1988) argue that the elements involved in human and primate culture are the same:

- There would be processes of behavioral innovation, involving a change in one or more individuals. In this way, these innovations could be classified as learned behaviors.
- Diffusion would occur through the imitation of new patterns by individuals close to the innovators.
- These patterns are transmitted across generations, resulting in the stabilization of the innovation.
- Subsequently, intergroup differences would emerge due to the lack of contact between different groups. This leads to establishing relationships between different repertoires and the geographical areas in which they are found.

However, some researchers continued to explore the concept from a more anthropocentric perspective, introducing new concepts. For example, Tomasello and Call (1994) spoke about how the concept of culture was specifically formulated to describe group differences in human behavior. He argued that human traditions provide the prototypical case of cultural transmission but not the only one. Due to the complexity of defining the concept and its possible implicit elements, some authors preferred to separate the concept of "tradition" (Llorente, 2019). Thus, tradition would be defined as "distinctive behavioral patterns shared by two or more members of a social unit, persist over time, and are acquired by new practitioners through social learning" (Fragaszy, 2003: 61). From a more scientific perspective, other authors like Mosterin (2012) suggested that culture could encompass procedures, values, and ideas inherited through genetic inheritance. He introduced new concepts that were a result of advances in the field of genetics. Authors who had previously worked on the concept, such as Leroi-Gourhan in his book *Le Geste et la Parole* (1971), made references and introduced the concept of technology within culture as a vital element for our adaptive survival. He argued that its development was linked to cognitive evolution as well as language and that it simultaneously served as a cultural transmitter between populations and generations.

1.2. Technology.

Another trait that has been traditionally considered unique to our species is technology, which is defined as the set of theories and techniques that allow for the practical utilization of scientific knowledge, as well as the treatment of technical terms¹. Meanwhile, "technique" refers to the set of procedures or resources employed in a specific activity, particularly when acquired through practice and requiring skill.

The definition found in Wikipedia² is more comprehensive and pertains to technology as the application of science to address concrete problems. Technology is a set of scientifically organized knowledge that enables the design and creation of goods and services that facilitate adaptation to the environment, as well as meeting individual and collective needs. Beyond these complex and current definitions, they emphasize the importance of technological development that is intertwined with other disciplines. In summary, technology would be knowledge aimed at satisfying the needs of a group. They can be generated by individuals within the same society, that is, spontaneously, or introduced by one or more members of another group, and in this case, there is an assimilation of that technology until it comes into use. Whether it continues to persist depends on the descendants of the

¹ <https://dle.rae.es/tecnolog%C3%ADa> (Consulted: 24/04/2023)

² <https://es.wikipedia.org/wiki/Tecnolog%C3%ADa> (Consulted: 24/04/2023).

group that assimilated it. However, we can find more factors that intervene in this assimilation, such as the environmental need or experimentation.

In the archaeological record, we find that the oldest lithic industry has a chronology of 3.3 million years and was found at the site of Lomekwi 3 (West Turkana, Kenya). This industry predates the Oldowan techno-complex, the oldest evidence of which has recently been dated to 2.9 million years (Plummer *et al.*, 2023). At Lomekwi 3, rocks with fracture marks and core reduction tasks were found, as well as different sharpened tools with highly complex preparation (Harmand *et al.*, 2015).

With a similar chronology to the Lomekwi site, we have the case of Dikika (Ethiopia). At this site, dating to around 3.4 million years, fossil bones were found with cut marks that could have been caused by some tool (McPherron *et al.*, 2010), although there is no evidence of lithic industry in the vicinity of the site, which has generated a significant debate due to the lack of sufficient evidence to confirm whether they are anthropogenic (Dominguez-Rodrigo *et al.*, 2010; 2011).

Knowing about these early examples of tool use and tool manufacture, one question arises: Who were their creators? Based on the paleoanthropological record there are several candidates who could have been responsible for the manufacture and use of the first tools. It's important to remember that there is a great diversification of species, such as *Paranthropus aethiopicus* (2.7-2.3 Ma), *Paranthropus boisei* (2.4-1.6 Ma), *Homo habilis* (2.8-1.5 Ma), as well as *Australopithecus* species like *Australopithecus afarensis* (3.7-3 Ma) or *A. garhi* (2.9-2.5 Ma).

Hence, the selection of raw materials for making tools has a long history throughout our evolution and dates to the early phases of lithic technology (Harmand *et al.*, 2015; Plummer *et al.*, 2023; Braun *et al.*, 2019). Here, we also find provisioning strategies that are flexible, involving local or long distances raw material sources (Kimura, 1999). Although this behavior has been considered characteristic of hominins, the truth is that we can observe this type of instrumental behavior extant primate species like chimpanzees (*Pan troglodytes*) in different parts of the African continent (Kühl *et al.*, 2019).

1.3. Instrumental behavior.

If we go back and attempt to find a somewhat less complex definition than the characterization of technology, while keeping in mind the previous arguments about the cultural aspects of technology provided by B. Malinowski (1981), we have an intermediate concept that predates technology, the instrumental behavior. The intriguing aspect of this concept is that it is not limited solely to humans but, as with culture, can also be found in other animal species.

According to Vèa and Clemente (1988), the instrumental behavior involves the use of an object to achieve a specific goal, and thus, using the object (tool) is more efficient in achieving that goal. For Vèa and Clemente (1988), the following components come into play:

- Type of object used as a tool.
- Instrumental behavior.
- Analysis of function.

Following this concept, in the animal world the chimpanzees use several types of objects including sticks, stones, branches, barks, reeds, vines, grasses, leaves, shrubs, logs, and roots. These meet two indispensable conditions (Parker and Gibson, 1977): they are not part of the individual's body, and they are not attached to the substrate. However, when describing the objects, we must consider that they have been modified for a specific activity or, if not, they possess specific physical characteristics (Teleki, 1974). But the use of an object, imply that can be considered a tool? To answer this question, we need to define what a tool is. According to Beck (1980), it could be any simple modification of an object that might be used in such a way that it would function more efficiently. While other authors like Shumaker *et al.* (2011) define it as a non-corporeal, unattached object that an animal creates and/or uses to modify itself, another individual, or even its immediate environment. If we delve deeper into the complexity and the middle ground between technology and instrumental behavior, we come across the concept of "meta tool-use" (Matsuzawa, 1994), which implies using a tool for crafting or reaching another tool and thereby achieving a specific purpose. The use of tools is common among chimpanzees, who are skillful manufacturers. The simplest form of manufacturing involves cutting a tree branch. The fabrication of more complex tools, especially for extractive foraging, generally requires greater modification of the primary materials before use.

Although concerning instrumental behavior, we encounter a diverse repertoire: crushing, hammering, exploring, investigating, probing, poking, digging, absorbing, collecting, scraping, throwing, shaking, covering, hitting, lifting, or dragging. Finally, the function (Beck, 1975) of instrumental behaviors would be to expand or extend an individual's behavior. These functions fall within behavioral patterns related to social contact (e.g., social grooming), subsistence (ant-dipping, termite fishing, algae fishing, etc.), agonistic behavior (warning, intimidating, or attacking), exploration, play, sheltering (covering for rain). However, it's true that certain functions hold more significance than others – we are referring to subsistence tasks (feeding and/or drinking), which constitute most instruments made in comparison to other categories like agonistic behavior (Teleki, 1974; Sabater Pi, 1978). This is a pivotal point that will define this study – the examination of tools used by savanna chimpanzees at Dindefelo for obtaining food.

The earliest documented observation of a tool use behavior by a wild chimpanzee was made by Savage and Wyman (1844). But it was between the 1960s and 1970s, when the most significant discoveries were made in various parts of Africa such as the Democratic Republic of Congo (Kortlandt, 1962), the Tanganyika National Park, Gombe (Goodall, 1964), in Budongo Forest, Uganda (Reynolds and Reynolds, 1965), Tanzania (Suzuki, 1966), the Muni River (Jones and Sabater Pi, 1969). Thanks to the introduction of a systematic approach to study chimpanzee tool use, comparative studies were conducted (Sabater Pi, 1974b; 1974c; 1975; 1978; Teleki, 1974; and McGrew *et al*, 1979a). As research progressed, it was advisable to initiate discussions about the hominization process and the reformulation of the concept of culture (Beck, 1975), as well as to discuss cultural behaviors.

One of the criteria for defining the presence of cultural behaviors is the differences between different groups' behavioral patterns. As the research advanced, comparisons were made, leading to the following conclusions (Vèa and Clemente, 1988):

- Common cultural elements among studied populations include the use of tools (sticks, branches, etc.).
- Systematic differences in the use of tools in subsistence contexts.
- Such differences are primarily attributable to social determinants (group culture) rather than ecological factors, as they can be found in different parts of Africa.

In this regard, many primatologists began conducting studies and documenting variations among chimpanzee communities as a cultural species (van Lawick, 1974; Sabater, 1974; McGrew, 1978; Boesch and Boesch, 1990). As decades passed, more studies emerged, raising awareness about the importance of primates and the potential fields of study that could shed light on various aspects of human evolution, and the necessity of multidisciplinary research to achieve this endeavor.

2. THEORETICAL FRAMEWORK.

We have records of the introduction of archaeology in primate studies during the 1960s (Napier, 1962), and later for technology in the 1980s (Wynn and McGrew, 1989). However, the explosion that marked the convergence of these disciplines came with the formulation of the manifesto that gave birth to *Primate Archaeology* (Haslam *et al.*, 2009). Primate archaeology provides a reference framework from a comparative and evolutionary standpoint, and in the long term, aims to understand the biological, social, and environmental contexts of primate behavior through the analysis of tool manufacture, instrument use, and patterns of accumulation. This framework allows for:

1. The use of current methods from both archaeology and primatology to record and study the instrumental behavior of non-human primate species, to learn about the evolutionary trajectories of behavior in these species from both an anthropocentric and "primacentric" viewpoint.
2. The use of comparative methods to study humans and primates across all taxa, investigating the use of tools in social, physiological, biomechanical, and environmental contexts.
3. Identifying how convergent evolution has shaped the use of tools to understand technology.
4. Enabling the incorporation of new approaches and documentation techniques.

Several species have been studied to further understand the use of tools in the primate world. For example, there have been studies on *Cebus*, identifying using anvils and stone (Fragaszy *et al.*, 2005) or use of tools for open shells (Visalberghi and Vitole, 1990); *Sapajus*, such as the use of stones by *Sapajus libidinosus* in Serra da Capivara (Ottoni and Izar, 2008; Aguiar *et al.*, 2014); Japanese macaques (*Macaca fuscata*), using stones to obtain fruit (Weinberg and Candland, 1981). Breuer and others (2005) managed to film and photograph a gorilla (*Gorilla gorilla gorilla*) using a branch as a probe to check the depth of the swampy terrain it was moving on. Other primates, like the bonobo (*Pan paniscus*), cover their bodies with leaves during rainy seasons (Kano, 1982) and use sticks for ant-dipping activities (Koops *et al.*, 2015). There is also the case of Kanzi, trained to knap flakes (Schick *et al.*, 1999; Toth *et al.*, 1993; Savage-Rumbaugh and Lewin, 1994), but it is worth mentioning that this training was done in captivity.

However, if we must choose a species where instrumental behavior is significantly represented, it is the chimpanzee. About them, McGrew (1992, 1993) stated that chimpanzees are the species whose instrumental behavior is intelligent and possesses genuine material culture. This is why chimpanzees are the primate species most similar to us in terms of complex cultural traditions, spanning from ecological domains to social ones (Llorente, 2019). Out of 41 cultural behaviors, 31 are related to the use of tools (Table 1) (Whiten *et al.*, 2001), many of which are shared between

groups while others are present during specific times of the year. Sabater Pi (1978) classified chimpanzees based on their geographical location and the tools they used, though this classification is now outdated. It was a first glimpse into the diversity, categorized as:

a) Stone area corresponding to western communities.

b) Stick area for central populations (*P. t. troglodytes*).

c) Stem area corresponding to eastern populations with *P. t. schweinfurthii*. Although this distinction is no longer accurate, it begins to reveal the cultural diversity of chimpanzees.

As time passed, more behaviors were documented, such as ant dipping or termite fishing observed in different regions of East Africa (Newton-Fisher, 1999; Goodall, 1964), Central Africa (Deblauwe *et al.*, 2006; Sanz *et al.*, 2004), and West Africa (McBeath and McGrew, 1982). What is common across all these behaviors is the diversity in the manufacturing and use of tools, which may be due to ecological and habitat differentiation, although most could be attributed to sociocultural traditions.

PATTERN	Western Africa (<i>Pan troglodytes verus</i>)				Central Africa (<i>Pan t. troglodytes</i>)		Eastern Africa (<i>Pan t. schweinfurthii</i>)			
Behavior	Bosnou	Fongoli	Taï N	Taï S	Luongo	Goualougo	Gombe	Mahale	Ngogo	Budongo
Driver ant Dip	P	P	P	P		P	P	A	A	A
Wood ant-Fish	p	E	E	E		A	A	P	A	A
Termite Fish	A	E	E	P	E	P	P	P	P	E
Grab extraction	A	p	P	P	P	A			p	A
Honey dip	A	P	P	P	P	P	P	A	P	P
Bee probe	A	P	P	P	P	A	P	A	P	P
Nut Crack	P	P	P	P	A	A	A	A	E	E
Nut extract	A	P	P	P	A	A	A	A	E	E
Anvil prog	P	A	A	A			A	A	P	E
Inspect stick		P	P	P	P	P	A	A	P	A
Leaf sponge	P	P	P	P	P	P	P	P	p	P
Leaf wedge	p	P	P	P	P	P	P	P	P	P
Leaf wipe	A	P	P	P		p	P	P	P	P
Leaf napkin	A	A	A	A	P	P	A	A	A	A
Leaf dab	A	A	A	A			A	A		A
Wound Inspect	A	P	P	P			P	A	P	P
Marrow Pick	E	P	P	P		P	P	A	A	A
Brain eat	E	P	P	P		A	A	A	P	A
Eye eat	E	P	P	P		A	A	A	A	A
Missile throw	P	P	P	P		P	P	P	P	p
Stick club	P	P	P	P		A	P	P	P	A
Flail twig	P	P	P	P		P	P	P	P	P
Fly whisk	P	P	P	P		P	P	P	E	
Branch drag	P	P	P	P	P	P	P	P	P	P
Lever	A	A	A	A	P	P	P	A	P	A
Pestle pound	P	A	A	A		E	A	A	E	E
Algae Scoop	P	E	E	E			A	A	A	A
Hook stick	P	A	A	A		A	A	A	A	A
Self Tickle	A	A	A	A			P	A	A	A
Leafrain cover	A	A	A	A		P	A	A	A	A

Table 1: Cultural patterns observed in chimpanzees, P: present; A: absent; E: absent for ecological reasons. (Extracted from Llorente (2019) and modify from Riba (2016).

3. PAN TROGLODYTES SUBSPECIES.

To understand why chimpanzees exhibit such consistent tool use behavior, we must look at the specific contexts in which they live, as well as their characteristics. Historically, the taxonomic structure of chimpanzees has been divided into significant parts of Africa (Figure 1): the chimpanzee of East Africa (*P. t. schweinfurthii*), the one of Central Africa (*P. t. troglodytes*), the chimpanzees from Nigeria-Cameroon (*P. t. ellioti*) and the ones from West Africa (*P. t. verus*). The differences are marked by habitats and spatial distribution zones (Fontsere *et al.*, 2022), behavior (Llorente, 2019), diet – which, despite being predominantly frugivorous, includes a significant consumption of animal protein (Llorente, 2019). There are slight variations based on the environmental pressures they encounter, as well as genetic differences. These latter aspects have been the subject of study in recent years, revealing minor group differences (Kambale *et al.*, 2022; Bowden *et al.*, 2012) among these species that may have resulted from isolation and lack of contact between groups. Through such studies, it was discovered that there was a divergence between *P. t. troglodytes*, resulting in *P. t. ellioti* (Mitchell *et al.*, 2015).

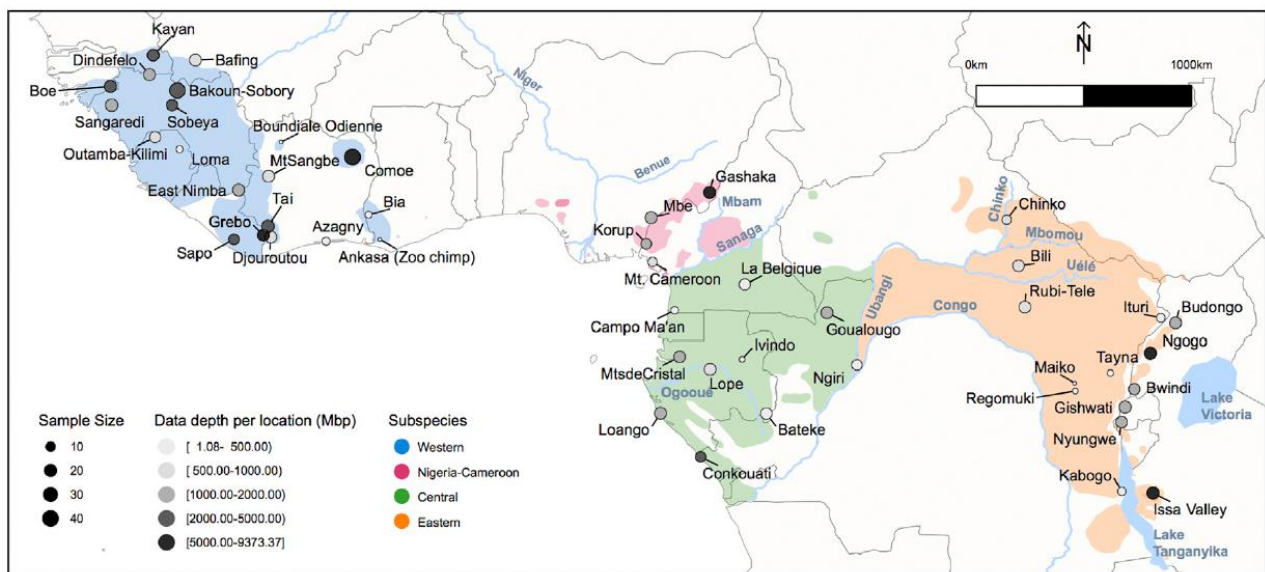


Figure 1: Current distribution of the subspecies of chimpanzees (extracted from Kambale *et al.*, 2022).

The *P. t. troglodytes*. This chimpanzee inhabits various parts of West Central Africa, including Gabon, Cameroon, Republic of Congo, Equatorial Guinea, Angola, and the southeast of Nigeria. Its activity range extends from the Ubangi River to the northern part of Cameroon, marked by the boundary with the Sanaga River (Starr, 2019). Their habitats encompass humid tropical forests, wet savanna forests, as well as certain forest-savanna landscapes. The average distribution area is around

12.5 km², though it can vary (Tutin *et al.*, 2008). They exhibit pronounced sexual dimorphism, with males reaching up to 96 cm in height and weighing up to 60 kilograms, while females reach about 80 cm in height and weight around 42-44 kg (Starr, 2019; Llorente, 2019). Central chimpanzees have less hair compared to other subspecies, particularly notable in the distinction between males and females (Starr, 2019). Groups consist of an average of 66 individuals and can cover distances of up to 18 km (Starr, 2019). Their diet may vary, but it is predominantly composed of fruits, followed by leaves, wood marrow, flowers, seeds, and bark (Morgan and Sanz, 2006; Tutin *et al.*, 1991; 1997). In some cases, higher consumption of animal protein has been observed, such as in the Ndoki chimpanzees of the Republic of Congo (Kuroda *et al.*, 1996).

The *P. t. schweinfurthii*. These chimpanzees are found in the forests of the Republic of Congo, Rwanda, Tanzania, Uganda, and a small population in Burundi. The chimpanzees of Gombe and Mahale in Tanzania are well-known and extensively studied (Goodall 1963, Hladik, 1977, Nishida 1968, Nishida and Kawanaka 1972, Wrangham 1977). This subspecies is the smallest among chimpanzees and displays minimal sexual dimorphism, with both males and females having similar heights ranging from 70 to 90 centimeters and an average weight of 40 kg for males and 33 kg for females (Starr, 2019; Llorente, 2019). Morphologically, this subspecies tends to have darker skin than others. Groups comprise approximately 50 to 100 individuals, spending about 25% of their time socializing, 20% resting, and 15% traveling. Gombe chimpanzees are known to consume around 141 plant species in their diet, consisting of fruits, leaves, and animals, with the latter accounting for 4% (Hladik, 1977). Wrangham (1977) later expanded and refined this, identifying 201 components in the Gombe chimpanzee diet, excluding animals, and introducing flowers, seeds, wood marrow, and bark. In Mahale, their diet is more diversified, with leaves, fruits, wood marrow, flowers, and bark being primary, in addition to consuming 12 mammal species, 15 insect species, and 5 bird species (Nishida and Uehara, 1983).

P. t. ellioti. These chimpanzees inhabit tropical rainforests and are also present in forest-savanna mosaic environments, as well as mountain forests at elevations reaching up to 2,750 meters (Downey, 2022). Another significant difference in the Nigeria-Cameroon chimpanzee groups is the variation in family group sizes, ranging from 4 to 12 individuals. They also exhibit pronounced sexual dimorphism, with males weighing up to 70 kg and standing at 1.7 meters tall, while females weigh between 26 and 50 kg. Their diet still fluctuates based on seasonal variations, with a preference for ripe fruits, as well as leaves, stems, buds, bark, resin, and occasional protein sources such as insects, small vertebrates, and eggs (Downey, 2022).

P. t. verus. Physical characteristics of the West African chimpanzee include dark skin around the eyes, a light muzzle that darkens with age, baldness, and a white beard seen in both males and

females. Savannah chimpanzees are not taxonomically distinct from their forest-dwelling counterparts. However, they are the only great apes inhabiting a hot, dry, and open savanna habitat. These unique conditions, including scarcity of food and water, subject them to particular pressures, resulting in relatively low population density. Researchers term this combination of factors and features as the "*savanna landscape effect*" (Moore, 1992).

For the purpose of this study, we will focus on the instruments generated by the *P. t. verus* species, specifically those living in savanna habitats, to develop an analysis protocol that enables us to document their technology.

4. SAVANNA CHIMPANZEES AS MODELS FOR HUMAN EVOLUTION STUDIES

As we discussed earlier, the accumulation of information discovered so far has led to seeking answers from other disciplines. Research has increasingly reinforced the use of chimpanzee models to understand human origins (McGrew 1992; 2004; 2010). Before delving in, we must grasp that chimpanzees are distributed along a continuum from savanna to forest, as mentioned by Domínguez-Rodrigo (2014), but these landscapes vary from great homogeneity to significant heterogeneity (Lindshield *et al.*, 2021). Due to this adaptive diversity of chimpanzees, researchers have had to establish a systematic approach to classify savanna chimpanzees, for instance, where tree cover must be below 12.5% and annual rainfall percentage is less than 1360 mm (van Leeuwen *et al.*, 2020). The western subspecies of chimpanzees is not the only primate species found in savannas; the African great apes utilize open vegetation. However, the significance lies in chimpanzees' remarkable flexibility, unlike bonobos and gorillas, as they can inhabit warmer, drier, and more open environments (Hernández-Aguilar, 2009). Studying savanna chimpanzees sheds light on the adaptations undergone by great apes in highly seasonal, arid, hot, and open landscapes. Simultaneously, it serves as a testing ground to explore how hominids adapted to the shrinking African forests (Lindshield *et al.*, 2021).

Moreover, and no less importantly, they are our closest relatives from an evolutionary standpoint. This does not imply that chimpanzees and early hominins are equivalent, as there are limitations. However, sharing various characteristics with primates (Fleagle, 1998; Martin, 1990), different research topics are better addressed through a comparative approach, using relevant species as models (Carvalho and McGrew, 2012). To achieve this, comprehending the selection pressures that shaped evolution, starting with examining hominin fossils, is necessary. We know little about the behavioral adaptations of early hominins as they transitioned from a more arboreal and humid lifestyle to terrestrial and arid conditions (Foley, 1987; 1993). This is why savanna-dwelling chimpanzees are used to study that transition. Understanding the landscape, they inhabit as a driving force for adaptation hasn't been the sole field of exploration; gradually, the scope of study has expanded further, making chimpanzees an intriguing model to comprehend evolution. This encompasses inquiries into bipedalism, diet, climate, or technology usage. It is in the latter that we will focus our study: the documentation of technology among savanna chimpanzees.

4.1. Use of tools.

To understand why meat plays a more seasonal role and why the use of tools is an adaptive response to environmental pressure out of necessity or opportunity (Lindshield *et al.*, 2021), we need

to know about the conditions at this environment and the evolution of the diet, and his relations with the use of tools. Open and dry landscapes drive innovations for food extraction in some primate populations, as seen in the case of chimpanzees, which use wooden sticks to extract ants, termites, or algae in Dindefelo Community Natural Reserve (hereafter Dindefelo). Another example is found in Fongoli (Pruetz *et al.*, 2020), where the rainy season leads to a decrease in plant-based foods. Additionally, during times of fires, some foods are trapped inside trees, prompting the use of tools. This is why some authors argue that tool use is linked to seasonality among savanna chimpanzees (Bogart and Pruetz, 2011). Although tool-assisted hunting and termite fishing have seasonal peaks during transitional and/or wet seasons in Fongoli, it cannot be directly linked to fruit scarcity (Pruetz *et al.*, 2020). According to Lindshield (2021), the relationship could be due to a multifactorial cause. The chimpanzee is the only non-human species that habitually uses and creates a wide variety of tools, displaying a diverse repertoire of sequential toolmaking (Boesch *et al.*, 2009; Sanz and Morgan, 2009; Sanz *et al.*, 2010). Recent publications have direct implications for understanding the evolution of technological behavior, primarily focusing on the behavioral research of wild chimpanzees in relation to tools. Some examples include spear hunting (Pruetz and Bertolini, 2007), tools to dig for underground storage organs (Hernández-Aguilar *et al.*, 2007), tool reuse (Carvalho *et al.*, 2009), revisiting activity areas (Carvalho *et al.*, 2009), sleeping sites (Hernández-Aguilar, 2009), and percussion technology (Goren-Inbar *et al.*, 2002; de la Torre and Mora, 2009; Arroyo *et al.*, 2016; Harmand and Arroyo, 2023).

Currently, we do not know when, who, or how stone production and use emerged. The first set of stone tools that can be related to particular uses are pounding tools (Leakey, 1971). In recent years, with the expansion of primatological studies, it has become evident that early hominins and non-human primates share at least one category of lithics, pounding tools, and this overlap could be an important link to understanding the origins of technology. Hammerstones and anvils are nearly universal in the archaeological record (de Beaune, 2004) and even found in the toolkits of some modern human populations like Manon and Guerzé in Guinea-Conakry (Biro *et al.*, 2010). From these materials, various researchers (Goren-Inbar, 2002; de Beaune, 2004; de la Torre, 2004; Mora and de la Torre, 2005) have opened a line of study with hominin artifacts, yielding the following conclusions:

- Hominins performed a wider variety of activities that involved pounding to consume, for example, nuts or to break bones.
- Flake scars resulting from hammer-and-anvil percussion can be confused with intentional knapping.
- Such accidental knapping might have led to the production of stone tools from other objects.

Beyond the savanna environments, chimpanzees inhabiting forested areas have also been used as models to understand the origins of stone tool use, particularly those communities in which it has been documented the use of stones for nut cracking. It has allowed us to understand tool use in wild chimpanzees, particularly in behavior ontogeny, social learning processes, and transmission of tradition (Biro *et al.*, 2003; 2006; 2010), ultimately shedding light on technological evolution (Mercader *et al.*, 2002; Carvalho and McGrew, 2012). Based on materials from Taï Forest in Ivory Coast (Mercader *et al.*, 2002; 2007) and compared with a study in Bossou (Carvalho *et al.*, 2007; 2008; 2009), insights were quite interesting. Among them, the nature and quality of materials affected the identification of percussion types; the tools at Bossou were quite similar to hominin hammers.

However, we should not only consider the lithic tool industry. There are authors (Panger *et al.*, 2002; Wynn *et al.*, 2011; Carvalho *et al.*, 2013) who argue that during the Early Pleistocene, hominin populations living in East and South Africa would not have solely used non-organic support tools, i.e., perishable elements. This perspective was already outlined by Isaac (1981), emphasizing that lithic objects must be understood within their context and that they represent a part of hominin activity. Studies like those of Pascual-Garrido and Almeida-Warren (2021) also underscore how factors in chimpanzees identify similarities with inferred raw material selection processes for Oldowan tool users. The *archaeology of perishable* (Pascual-Garrido and Almeida-Warren, 2021) provides a new framework to reconstruct archaeologically invisible aspects of early human behavior and our own culture.

Furthermore, we must consider that the physical properties of objects would also limit technological innovation. Perhaps instead of solely focusing our research on comparing final products or by-products, thinking they are better indicators of differential cognitive complexity among primates and their motor skills, it could be intriguing to comprehend how and why different contexts can lead to typological and technological variability (Carvalho *et al.*, 2013).

Here lies the significance of the flexibility displayed by the savanna chimpanzee in response to changes. Through these transitions, we can gain better insight into the adaptive changes of early hominins in response to the shifts that occurred in Africa.

4.2. Evolution of diet.

Diet is an important variable as it influences differences with other primates, including hominins (Fleagle, 1999), and the study of savanna chimpanzees can shed light on the study of the evolution of the diet.

In general, hominins would have an omnivorous diet. However, studies indicate that *Australopithecus* primarily consumed fruit and leaves, while *Paranthropus* consumed tougher foods like nuts, and *Homo* consumed a higher amount of meat (Sponheimer *et al.*, 2007; Peters, 2007). Species of *Paranthropus*, characterized by strong jaws adapted for consuming harder foods (Peters and Vogel, 2005; Robinson and Wilson, 1998), might have been generalists.

The consumption of termites using bone tools associated with *Paranthropus robustus* has been suggested as tools for termite mound excavation (Backwell and d'Errico, 2001; 2008). Insects could have been an important food resource for hominin evolution, especially in open environments with scarce other resources.

In the case of *Homo*, they were characterized by stone tool use, yet they were also generalists capable of processing challenging foods (Peters, 2007). Isotope studies (Sponheimer *et al.*, 2005) concluded that early South African hominins were omnivores, consuming various types of invertebrates, birds, and small to medium-sized mammals. *Australopithecus* and *Paranthropus* had diets mainly composed of C3 foods (40% and 35%, respectively). The consumption of reeds, grasses, and non-C4-consuming animals constituted dietary sources for hominins (Sponheimer and Lee-Thorp, 2003). These authors discovered that most termite species living in South African savanna environments consumed over half C4. However, termites alone did not account for the indicated C4 diet in hominins, although they might have contributed (Sponheimer and Lee-Thorp, 2003; Sponheimer *et al.*, 2005). Chimpanzees living in forested environments consume fewer C4 resources (Schoeninger *et al.*, 1999). In the savanna, it has been shown that they differ from *Australopithecus* in their C4 consumption (Sponheimer *et al.*, 2006), but they haven't been compared to early primitive *Homo* species. Isotopic analyses don't measure C4 foods consumed by chimpanzees when they don't chew and swallow, but rather, they engage in leaf-swallowing (Pruetz, 2006).

If we look at present-day chimpanzees in Senegal, such as those in Mount Assirik or Fongoli, their diets are less rich in plant species compared to forest chimpanzees. This is explained by a lower rate of woody species in the savanna and the fact that in most cases they consume woody vegetation (Piel *et al.*, 2017). Chimpanzees also depend on insects, but the percentage varies across groups. Ingestion frequencies of savanna chimpanzees fall within the values of forest chimpanzees, ranging from 37.5% to 60% for savanna chimpanzees and 0% to 88% for forest chimpanzees (Webster *et al.*, 2014). In the case of consumed proportions in Assirik and Fongoli, termites (*Macrotermes subhyalinus*) are essential food and are consumed year-round in Fongoli (Bogart and Pruetz, 2011), in significant quantities. In Assirik, termites are consumed seasonally (Marchant and McGrew, 2005), and in the savanna, they're also consumed in large proportion. The explanation for the latter is due to the relatively low availability of prey in the savanna, at least for preferred prey like red colobus

monkeys (*Galago sp*), rodents, or lagomorphs (Moore *et al.*, 2017). Here, a high diversity of behaviors is observed to cope with environmental pressures, finding the necessary tools to survive in such a dry environment. At the same time, other cases result from food scarcity, like individuals in Comoé, Ivory Coast, which consume bark or cambium (inner bark) as an alternative food source during periods of food shortage (Lapiente *et al.*, 2020).

5. DINDEFELO COMMUNITY NATURE RESERVE, SENEGAL.

To get a deeper knowledge about the creation of Dindefelo Community Nature Reserve (Dindefelo), first, we will refer briefly to the Jane Goodall Institute. The Jane Goodall Institute is a global non-profit organization, founded in 1977 by Dr. Jane Goodall *"to understand and protect chimpanzees, as well as other great apes and their habitats, and to inspire and empower people to make the world a better place for animals and humans, in a healthy environment"*.³

Nowadays, it is known that wild chimpanzee populations have been reduced from 600,000 to 200,000 individuals in recent years. And in the case of the West African subspecies, it is the second most endangered by the IUCN (2010), having disappeared in four countries (Butynski, 2002). For this reason, new offices of the Jane Goodall Institute have been emerging across several worldwide countries to fight against this and try to prevent the disappearance of chimpanzees.

The Jane Goodall Institute Spain (JGIS) was born in 2006 (as a non-profit association in 2007⁴) with the intention of conducting field surveys, from which they detected the need to intervene to prevent the extinction of the western subspecies of the chimpanzee (*P. t. verus*). Although the chimpanzee has a high capacity to adapt to different environments, their main threat is habitat destruction and fragmentation caused by humans (Hicks *et al.*, 2009). The first great success of the JGIS was the creation of the reserve in Senegal with the objective of preserving and protecting biodiversity, especially for chimpanzees, JGI presented a proposal to USAID and the Biodiversity Foundation with the objectives of:

- Research.
- Conservation.
- Education.
- Creation of wealth through ecotourism.
- Valuation of natural resources.

Dindefelo was the most suitable territory for its development. Once in agreement, the Rural Community of Dindefelo, initiated the procedures for the generation of characteristic studies and the first RNCD Management Plan, would see the light in 2012. The JGIS signed an agreement with the Dindefelo Rural Community to become a co-manager of the Reserve.

Thanks to funds from various organizations, Dindefelo management committee will be set up to implement the plan and ensure its fulfilment: preserving conservation elements such as chimpanzees or landscapes, reducing threats such as fire or logging, and implementing reforestation

³ <https://janegoodall.es/es/misionehistoria.html> (Consulted: 10/08/2023).

⁴ <https://janegoodall.es/es/ijge.html> (Consulted: 10/08/2023).

programs, education, awareness raising, economic valorization of agroforestry resources or infrastructure improvement.

The chimpanzee tools from which we have based ourselves for the generation of this technological analysis protocol come from Dindefelo and were collected by the JGIS. The geographical limits of the reserve are as follows (Figure 2, and 3):

- Latitude: 12° 18' 25.67" North, and 12° 25' 54.90" North.
- Longitude: 12° 11' 11.78" West, and 12° 23' 20.45" West.

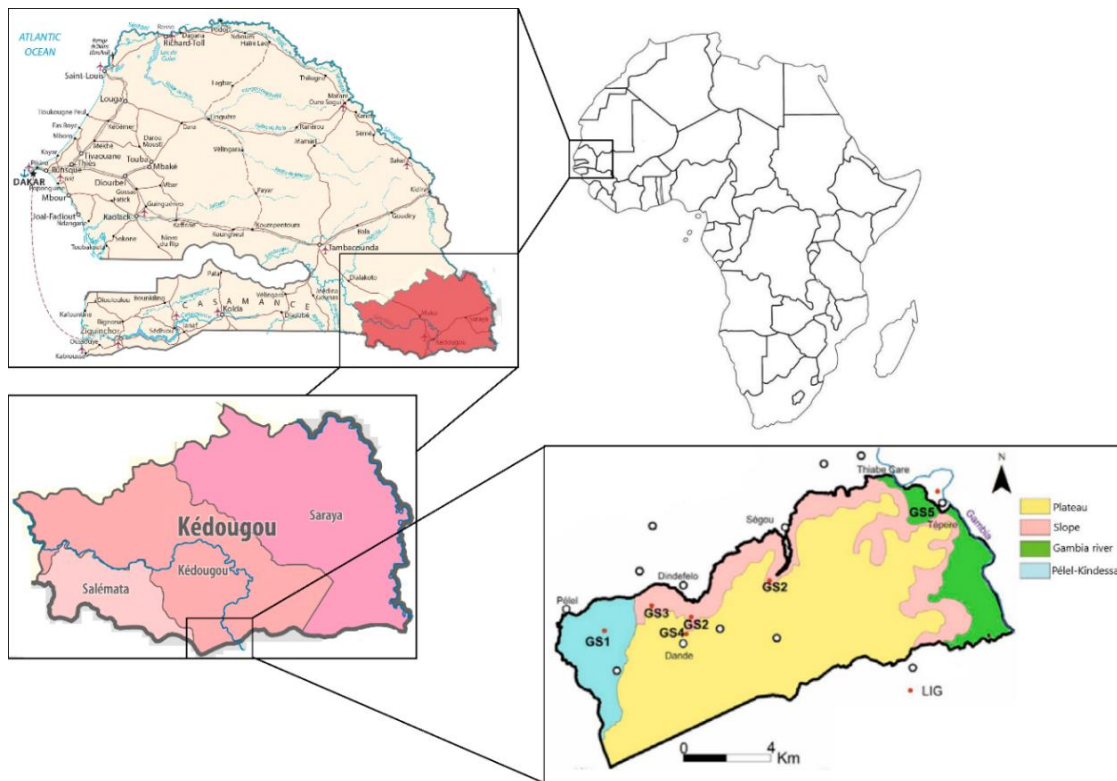


Figure 2: Location of the Dindefelo Community Nature Reserve. Source: Africa continent, Senegal, and Kédougou part from Wikipedia; last one, Dindefelo limits adapted from García-Villalba (2023).

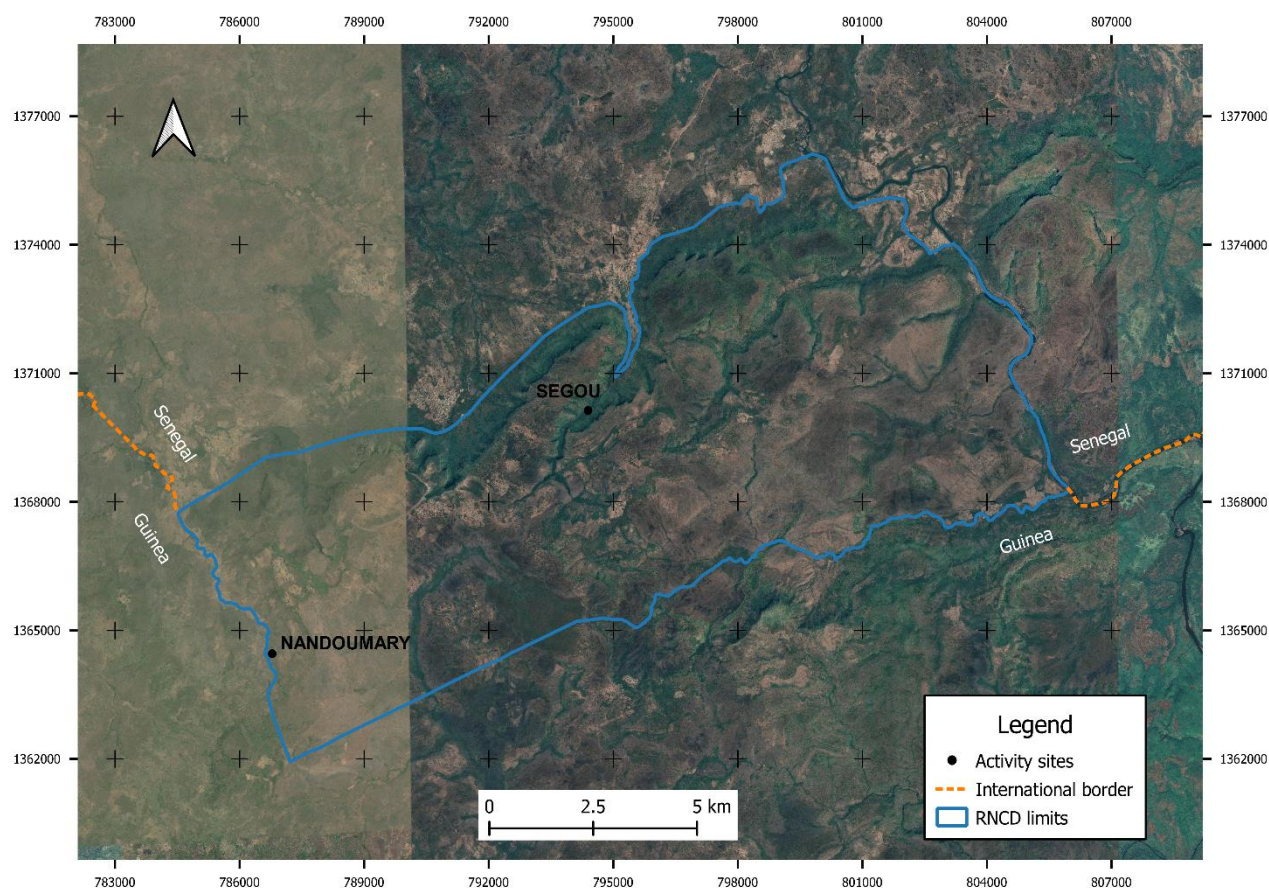


Figure 3: Map with the limits of Dindefelo and the location of the activity areas where the tools analysed were recovered. Source: Adrián Arroyo.

The reserve is in the southwest of the country, in the Kedougou region, one of the largest in the country. This region has about 130,000 people, 83% of whom live in rural areas and 17% in the three main urban centers: Kedougou, Saraya and Salemata⁵. However, the reserve is in Dindefelo Commune, covering 55% of the commune's total surface area. Formed by 12 villages, which would vary between 10-101 hectares in area (Pancorbo de Oñate, 2017); and where the main source of resources would come from the primary sector: river crops, maize, fognio, rice, and peanuts.

Dindefelo is located between two important natural areas: to the north and west are the Niokolo-Koba National Park and the Badiar Park, and to the south are the great mountains of Fouta-Djallon (Guinea-Conakry). And it is here where the importance of this park lies, which due to its geomorphological characteristics would serve as a connection between the two areas, as well as providing food, water, shadow, and shelter. It would be included within a large, elongated sedimentary basin that would run east-west, and it would be in the latter that it would open (Deynoux *et al.*, 1993). This basin would be around 30,000 km², and would be present between the countries of Senegal, Mali, Guinea-Bissau, and Guinea-Conakry (Sarr, 2014).

⁵ <https://www.janegoodallsenegal.org/donde-estamos> (Consulted: 17/08/2023).

From a recent study by the García-Villalba and colleagues (2023), four territorial units have been proposed, based on geomorphological and relief elements (Figure 2):

- The **Plateau** would occupy about 8,612 m², with a total of 61.5% of the reserve, NE-SW direction. It would form the natural border with Guinea-Conakry. It would be located 400 meters above sea level, and would allow the generation of waterfalls, such as the famous Dindefelo waterfall. Tonian substratum (Dindefelo Formation), which has been cut by two faults.

- The **Slope**, with 2,700 m², joins the high zone of the plateau with the low zones, being very steep its route. It would also be within Dindefelo Formation, there are large colluvial deposits at the foot of the escarpments, with fractured rock blocks. It would be in these fractures, the channel of the water, and where the forest of Gallery that would allow the refuge of the fauna is developed (Figure 4).

- The **Gambia River valley**, a linear zone located in the east part of the reserve. This is where the water reservoirs that supply the neighboring populations are located. It does not have a relief as marked as the previous two zones.

- **Pélel-Kindessa** zone is located within the village of Pélel-Kindessa, in the east of the reserve, within the Walidiala and Nandumary valleys. From a geological point of view, it is one of the most interesting areas since the materials that compose it are more diverse and provide information on the origin of the reserve. They would be within the Pélel formation, and Walidiala (Figure 5 and 6)

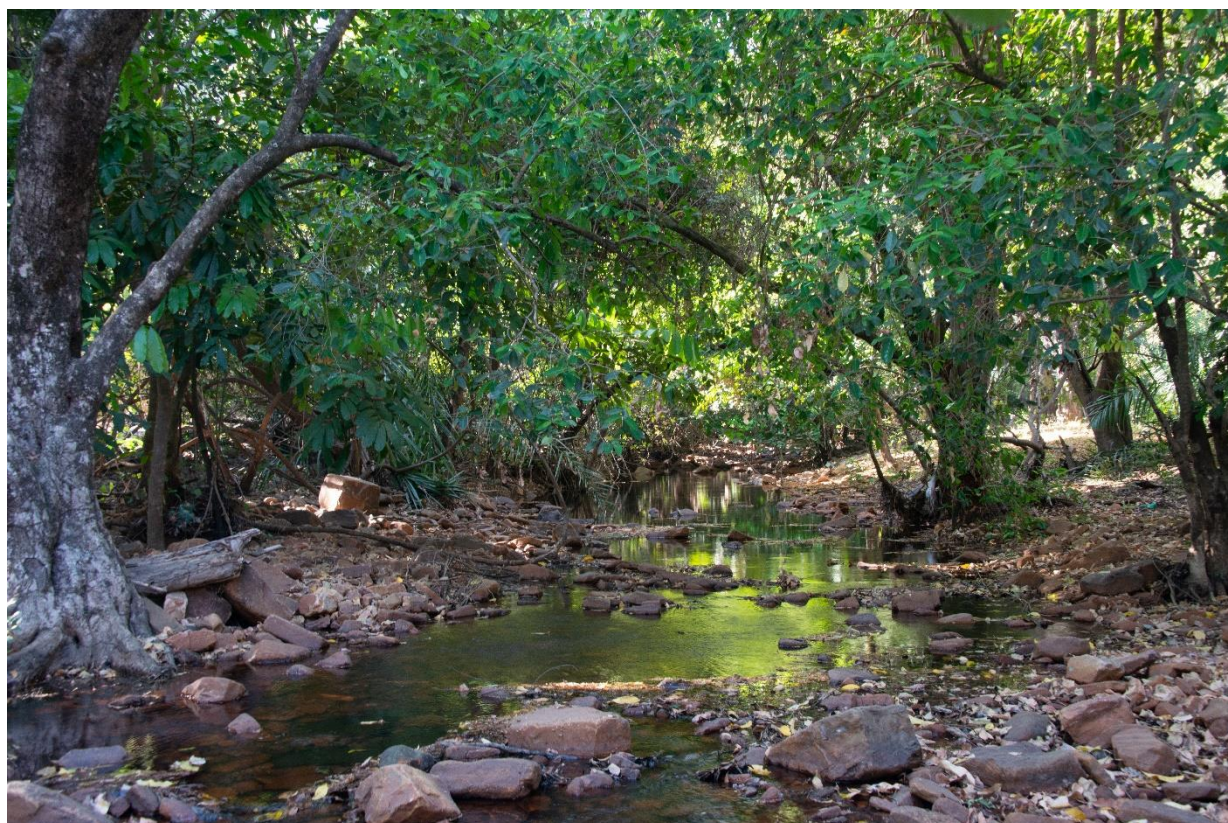


Figure 4: General view of the gallery forest in Segou during the dry season (Dindefelo). Source: Adrián Arroyo.



Figure 5: General view of the area of Nandoumary (Dindefelo). Source: Adrián Arroyo.



Figure 6: Overview of a chimpanzee activity site at Nandoumary (Dindefelo). Source: Adrián Arroyo.

From these areas, several points of geological interest have been proposed García-Villalba and colleagues (2023) within the reserve to promote sustainable tourism, and respectful with the habitat of a great biodiversity. These areas are restricted to areas where animals such as chimpanzees would not be found. The geological sites are as follows: (Figure, reserve map).

- GS1- Pélel-Kindessa area. As we have already mentioned for its uniqueness and geological diversity (Figure 7A-C).

- GS2- Waterfall of Dindefelo formation. It has its origin in the plateau of Dande, with an outcrop of groundwater that falls down the waterfall (Figure 7D).

- GS3- Dande Teeth, northwest of the plateau, within Dindefelo formation. Here, there are prism-shaped pillars with a rectangular base, generated through surface water erosion on the red quartzarenites (Figure 7E).

- GS4- Dande Cave. The plateau is covered by a compact laterite horizon that does not allow the development of large plants. Therefore, the biome is savanna-like, with poor tree cover and little root penetration. In some cases, the horizon can reach several meters thick. But in some areas, where it has been completely eroded, it emerges generating a soil rich in organic matter, where we find the "mushroom" type termite mounds. North of Dande, there is a cut accompanied by a change of vegetation, which would become a gallery forest. In addition to this, here we would find a cave generated in a natural way, and later enlarged by sulfur extraction (Figure 7F-G).

- GS5- Gambia River Valley, is a point of great hydrogeological, ecological, and touristic value. Since it is the main water reservoir and would present the refuge of different species of fauna and flora (Figure 7H).



Figures 7: Different Geological sites from Dindefelo; A-C: Pélel-Kindessa; D: Dindefelo's falls; E: Dande's teeth; F-G: Dande's cave; and H: Gambia river. Source: (adapted from García-Villalba, 2023).

From the climatic point of view, Kedougou is in the Sahelo-Sudanian zone (Walter, 1985), between two ecological zones: the savannah to the north, and the tropical rainforest to the south. It is a contrasting zone where annual rainfall is low, but high at certain seasons of the year. The dry season is from November to May, and the rainy season from May to October, with an annual average of 1,200 mm in the latter (Bogart, 2009). The average annual temperature is between 28°C, with extreme temperatures reaching 40°C between April and May, and a minimum temperature of 17°C between December and January (Bogart, 2009). It also fits that the temperature variation is important between forest and meadow (Pancorbo de Oñate, 2017).

The vegetation in the northern zone there is a predominance by the western Sudanese savannah, composed of large trees, and very tall herbaceous. The Guinean Forest mosaic is the majority base of the reserve. It would constitute the change between the Guinean forest and the Sudanese savannah (Burgess *et al.*, 2004; Oates, 2011). Here, forests, grasslands, and savannahs are mixed.

As of 2017, 225 tree species have been identified at Dindefelo, of which 136 are catalogued, 63 unidentified, and 26 incompletely identified due to the difficulty caused by the different names given to the same species, since each ethnic group gives it a traditional name (Pancorbo de Oñate, 2017). Across Dindefelo we can differentiate these zones: savanna, deciduous forest, and gallery forest:

- In the savanna, we find different species depending on where they are found a) in tree stratum, we have *Terminalia macroptera*, *Pterocarpus erinaceus*, *Bombax costatum*; b) in shrub stratum: *Combretum glutinosum*, *Piliostigma thonningii* and *Strophantus bispidus*; c) herbaceous cover: composed of annual and perennial grasses (Pancorbo de Oñate, 2017).

- In mixed semi-deciduous forest, it would be in the areas of slopes and cliffs, we have a) arboreal layer: *Pterocarpus erinaceus*, *Vitellaria paradoxa*, *Cassia siberiana*; b) in shrub stratum: *Oxytenanthera abyssinica* (Pancorbo de Oñate, 2017).

- In the gallery forests: a) tree layer: *Pseudospondias microcarpa*, *Carapa procera*, *Ceiba pentandra*, *Cola cordifolia*; b) in the shrub layer: *Landolphia sp.* or *Strophantus bispidus*; c) lianas: *Saba senegalensis*, which stand out to a great extent. (Pancorbo de Oñate, 2017).

In terms of fauna had been documented 318 taxa, about 16 species of reptiles (Monasterio *et al.*, 2016), 221 birds (Fernández-García *et al.*, 2013) or 10 amphibians (Monasterio *et al.*, 2016). This is thanks to the connection between Senegal and Guinea-Conakry, as mentioned above. In the line of cliffs that form caves, gorges, and waterfalls, allows the refuge of rare species such as rock hyrax (*Heterohyrax brucei*), snakes, owls, carnivores. The gallery forests are an ideal area due to the abundance of trophic resources, water, as well as various species of fish and crayfish. And finally,

the area of the deciduous forest is a mixed habitat where you can find hares, rats, squirrels, monkeys, porcupines (Pancorbo de Oñate, 2017).

- Mammals include antelopes, hyenas, leopards, and primates. In addition to other species that have not been recorded in these latitudes, such as Johnston's civet catfish. (Pacheco *et al.*, 2013), or the African brush-tailed porcupine (Mirghani *et al.*, 2023). The primates in the reserve are the patas monkey (*Erythrocebus patas*), green monkey (*Chlorocebus sabaeus*), Guinean papio (*Papio papio*) and Senegal galago (*Galago senegalensis*) (Pancorbo de Oñate, 2017), as well as the western chimpanzee (Pruetz *et al.*, 2002).

- Among the birds, we find green turaco (*Tauraco persa buffoni*), Narina trogon (*Apolederma narina*), the red-billed toco (*Tockus erythrorhynchus*), as well as large birds of prey (Fernández-García *et al.*, 2013)

- Reptiles: viper (*Vipera ammodytes*), black mamba (*Dendroaspis polylepis*), rock python (*Python sebae*), Senegal chameleon (*Chamaeleo senegalensis*), or African dwarf (*Osteolaemus tetraspis*) (Monasterio *et al.*, 2016).

At the same time, JGIS develops its own research and conservation work in the region of Kédougou, Senegal, as well as in northern Guinea. This is a unique environment of biodiversity. Chimpanzees, of which there are about 500 left in Senegal, have certain characteristics from the point of view of ethology as well as their culture. They are considered the closest to the behavior of early humans. The main threat to their survival in the area is related to deforestation, fires, and other unsustainable practices by local communities.

All in all, recently the JGI has participated in the elaboration of Senegal's first National Chimpanzee Conservation Plan, approved in 2021. As well as providing technical assistance in conservation of the reserve, or as a collaborator in increasing the ecotourism value of Dindefelo, improving the quality of its offer, and looking for promotion channels. It would be in the latter, where another great organization, the University of Huelva, has been specializing in the training and promotion of Dindefelo, contributing to the preservation and sustainable promotion of Dindefelo.

6. OBJECTIVES AND HYPOTHESIS.

Our work falls within the studies that have been conducted on chimpanzee technology, specifically focusing on the perishable technology. We find a significant amount of literature discussing the behaviors that involve the use of perishable tools (Goodall, 1964; Jones and Sabater Pi, 1969; McGrew *et al.*, 1979b; Boesch *et al.*, 2017; McGrew, 1983; Sugiyama, 1985; Tutin *et al.*, 1995; Hunt and McGrew, 2002; Sanz *et al.*, 2004; McGrew *et al.*, 2005; Hernández-Aguilar *et al.*, 2007; Pruetz and Bertolani, 2007; Bogart and Pruetz, 2008; Hernández-Aguilar *et al.*, 2013; Badjil *et al.*, 2017; Pascual-Garrido and Almeida-Warren, 2021). Moreover, even within a single behavior, regional differences are known, as seen in termite fishing (Boesch *et al.*, 2020). However, we have limited data on the technological characteristics that define the tools themselves. This work aims to redress this imbalance and to provide a systematic protocol to analyse primate tools made from plant materials.

6.1. Objectives.

From here, our study focuses on a selection of tools used by chimpanzees in Dindefelo and involved in three types of activities: termite fishing, ant fishing, and algae gathering. Overall, our objectives are:

1. Develop a protocol to study the tools from both a macroscopic and microscopic perspective.
2. Determine whether there are technological differences based on the activity being performed.
3. Establish an experimental program that allows us to compare original tools with recreated ones. This aims to study the various factors involved in use-wear formation processes.
4. Compare the technology of Dindefelo chimpanzees with the technology of neighboring chimpanzee communities.

6.2. Hypothesis.

6.2.1. Main hypothesis.

Due to the behavioral complexity exhibited by primates, the spectrum of the paradigm had to be expanded to explain the origin of our species. Our main hypothesis was that chimpanzee tools will exhibit identifiable patterns that correspond to the specific activity type they were used for, and that it will be possible to identify distinct patterns of use-wear marks on perishable tools used in the different activities.

6.2.2. Additional aims.

To understand the limitations that microscopic analysis (typically oriented towards the study of lithic tool materials) can present when dealing with a different type of raw material. Thus, proposing efficient and effective cases in situations where a specific type of microscope needs to be used to detect a particular type of mark.

We also aimed to verify the feasibility of generating an experimental program where the protagonist is a species with different cognitive abilities. Additionally, we wanted to explore the extent to which differences arise when using raw materials of different origins (since we do not have access to the same wood types as the chimpanzees).

Furthermore, we seek to investigate the differentiation in the operational sequence of Dindefelo chimpanzees compared to other *Pan troglodytes* communities found across the African continent.

7. MATERIALS AND METHODS.

7.1. Materials.

Given the relative lack of detailed descriptions of the perishable tools of western chimpanzees, first, we made a literature review related to the study of primate technology and behaviors involved in tool making. At the same time, to have a detailed theoretical framework, we reviewed the different hypotheses that justify the study of chimpanzees as models to interpret key evolutionary processes (such as the origins of technology) and to better understand behavioral aspects of the chimpanzees. For such aim, we used both published literature and open-access videos (e.g., Jane Goodall Institute Spain web page).

Previous studies have shown that the manufacture of these tools by chimpanzees whose main objective is to facilitate food consumption (Rolian and Carvalho, 2017). In this sense, our work focus on the study of the tools associated with three behaviors: Ant dipping, algae fishing, and termite fishing.

The tools studied were collected at Dindefelo (Senegal). At Dindefelo the chimpanzees are semi-habituated and not provisioned. The JGIS staff does not carry out habituation processes of the chimpanzees. Instead, the entire monitoring study is conducted through camera traps. To have a minimum impact on their environment, and given the fragility of the tools, it was decided to carry out this study with a limited sample of tools ($n = 21$). Nine were collected by the research staff of the JGIS between 2020 and 2022. On the other hand, 12 tools were collected in 2023 as part of a specific primate archaeology project developed by the IJGE Research Area, IPHES-CERCA and the University of Barcelona (UB). All tools were collected at six activity sites: “Thiangol Garage” ($n=6$), “Punto Animal” ($n=4$) “Punto de agua” ($n=3$), “Thiangol Ndian” ($n=3$), “Segou” ($n=3$), and “Thiangol Sanké” ($n=2$). All the tools were temporarily deposited at IPHES-CERCA (Spain) and were exported with the permission of the *Departement des Eaux et Forêts* of Senegal and the JGIS, as none of them belonged to protected plant species.

7.2. Methods.

After the tools were deposited at IPHES-CERCA, a preliminary study of them was conducted to get an idea of the needs that should be considered when developing a systematic record in the study of the perishable technology of *P. t. verus*. To this end, a study sheet (Figure 1) was designed. including a group of variables that can be replicated and used both by other research projects. In this

way, a systematic collection of data that can be comparable in the future can be guaranteed and facilitating future works cross-referencing of data for more complex analyses.

7.2.1. Description of the file.

The file is divided into different parts (Figure 8):

File number:	Tool identification:	Field site: Dindéfelo Country: Senegal	Area:
Locality:	Day of collection:		Activity: ☐ Termite fishing ☐ Ant dipping ☐ Algae fishing ☐ Baobab pounding ☐ Indeterminate
Site code:	Month of collection:	Site UTM X: -	
Season:	Year:	Site UTM Y: -	
Species consumed:	Tool type 1:	Tool type 2: ☐ Fixed ☐ Portable	Distance to raw material source: -
Plant raw material:	Stone raw material: -	Blank:	Weight (gr):
Digital length (mm):		Proximal width (mm):	
End-to-end length (mm):		Medial width (mm):	
Max thickness (for stone tools; mm):		Distal width (mm):	
Kind of morphology:		Numbers used areas:	
Proximal end (stick): ☐ Stripped bark ☐ Cut ☐ Bended ☐ Frayed ☐ Unmodified	Proximal end modification (mm):	Distal end (stick): ☐ Stripped bark ☐ Cut ☐ Bended ☐ Frayed ☐ Unmodified	Distal end modification (mm):
Residue presence: ☐ Yes ☐ No	Type of residue: ☐ Shells ☐ Fruit residues ☐ Insect fragments ☐ Soil ☐ Algae ☐ N/A	Residue species: Residue location: ☐ Proximal ☐ Mesial ☐ Distal	Analysis: ☐ Macroscopic ☐ Hirox ☐ Confocal ☐ Zeiss ☐ ESEM
Broken tool: ☐ Yes ☐ No	Manufacture peeling: ☐ Yes ☐ No	Presence leaves: ☐ Yes ☐ No	Presence of sub-branches: ☐ Yes ☐ No
Number adhered fractures:	Location of fractures: ☐ Proximal ☐ Mesial ☐ Distal	Research conducting the analysis: Daniel Vivar Ríos (IPHES-CERCA)	

Figure 8: Registration form used for the study of the samples from Dindéfelo and the experimental program.

1st General part of the data sheet is devoted to general data that will correspond to the most basic and at the same time most important information, including:

- **File number:** corresponds to the file number in numerical order (e.g., 0001, 0002, 0003).
- **Tool identification:** this field will include the label of each piece. In our case, we have followed the formula established by the JGIS to label the tools: location, date, activity, site number, and tool number (e.g., NA_10dec21_TF_S1_T03, NA_10dec21_TF_S1_T10).
- **Field site.** Refers to the name of the site (e.g., Dindefelo)
- **Country** of the field site.
- **Area:** it corresponds to the specific area where the tools were collected. In our case, the studied tools were collected in the areas of Nandoumary and Segou.
- **Locality:** refers to the specific activity sites within each area. For example, at Dindefelo, in Segou we have the localities of Thiangol Shanké, Thiangol Ndian, Thiangol Garage.
- **Year of the collection.**
- **Day of collection.**
- **Site code:** specific code given to the site where the tools were found, in our case NA or SE.
- **Month of collection.**
- **Coordinates.** This field will include the coordinates of each activity site. It is recommended to use UTM coordinates.
- **Season** in which the tools were collected (e.g., dry season).

The **2nd part** of the sheet includes the more specific data of the tool in question, such as:

- **Activity:** this field refers to the type of activity in which the tools were used, for example termite fishing, ant dipping, etc.
- **Species consumed:** here we refer to the insects or any other type of food obtained with the tool by the chimpanzees (termites, ants, etc.)
- **Tool type:** We would have two elements that would correspond to tool type:
 - o **Tool type 1:** Anvil, hammer, passive hammer, stick, bark, and leaf.
 - o **Tool type 2:** Fixed or portable.
- **Distance to raw material source:** we will fill this record if during the tool collection is possible to identify, and measure, the distance to the place from which the tool was sourced.
- **Plant raw material:** this refers to the type of raw material of the perishable tool. For example, at Dindefelo it was possible to identify the use of *Desmodium salicifolium*, *Alchornea cordifolia* among many other plants.

- **Stone raw material** refers to the type of raw materials of the tools made on stones (e.g., sandstone, basalt, quartzite, quartz, limestone)
- **Blank**: would be the type of object found specifically among which can be identified cobble, chunk, fragment, block, etc.

The 3rd Part of the data sheet refers to technical data, and corresponds to different quantitative measurements:

- **Weight** (in grams).
- **Digital length (in mm)**: this refers to the length of the tool following the line marked by their natural curvature (image x).
- **End-to-end length (in mm)**: from one edge to another, without considering the tool curvature (Figure 9).



Figure 9: Example of termite fishing tool and the lines drawn to measure it. Upper line (A-B) corresponds to the digital length (mm); bottom line (C-D) to End-to-end length (mm).

- **Proximal width (mm)**. Maximum width of the proximal end of the tool.
- **Medial width (mm)**. Maximum width of the medial part of the tool.
- **Distal width (mm)**. Maximum width of the distal end of the tool.
- **Max thickness (mm)**: in this case, this measurement will only be taken when analysing stone tools.

The 4th Part includes data about tool morphology, scars and residues.

- **Morphology**: curved or straight.
- **Numbers used areas** refers to the number of active areas identified on each tool.

Then, it will be noted the type of modification present at each end (proximal and distal) of the perishable tool. For the type of modifications, we have use common terminology previously used (stripped bark, frayed etc.) (McGrew *et al.*, 1979b; McGrew and Collins, 1985; Sugiyama, 1985; Suzuki *et al.*, 1995; Sanz *et al.*, 2004; Deblauwe *et al.*, 2006; Sanz and Morgan, 2007; Musgrave *et al.*, 2020).

- **Residue presence**: yes or no.
- **Type of residue**: indicate the type of residues (i.e., shells, fruit, insect fragments, soil algae).
- **Residue species**: if identifiable, this record will collect the species of residue.
- **Residue location**: proximal, mesial, and distal, multiple options can be marked.

- **Analysis:** type of analysis the specimen has undergone, could be macroscopic, HIROX KH-8700, Confocal, Zeiss, ESEM, multiple options can be checked. During the analysis, it will be also noted additional information about the tools:

- **Broken tool:** yes, or not.

- **Manufacture peeling:** yes, or not.

- **Presence leaves:** yes, or not.

- **Presence of sub-branches:** yes, or not.

- **Number adhered fractures:** numeric.

- **Location of fractures:** three options according to location, proximal, mesial, and distal (again multiple options can be checked).

- **Research conducting the analysis:** name and contact email.

5th Part Tool description.

Here, it will be possible to describe the tools from a macroscopic and microscopic levels. In this descriptive section, it will be important to be as systematical as possible. For such aim, we will have to consider the orientation of the piece. In the case of the perishable tools, the proximal part would correspond to the area of the tool that connect with the trunk of the tree, where the first fracture occurs, while the distal part will be the opposite end.

6th Part Additional observations.

Here, it will be possible to add data about the technical information of the images taken with the microscope and the camera as well as additional information not included in the previous sections.

7th Part Photograph.

In this section, we must graphically show the elements that we have mentioned in the description of the tool, scaling it and making clear the location of these marks, as well as fractures, residues, manufacture peeling. The purpose of this section is to provide the reader with a good graphical record of the tool (Figure 10).

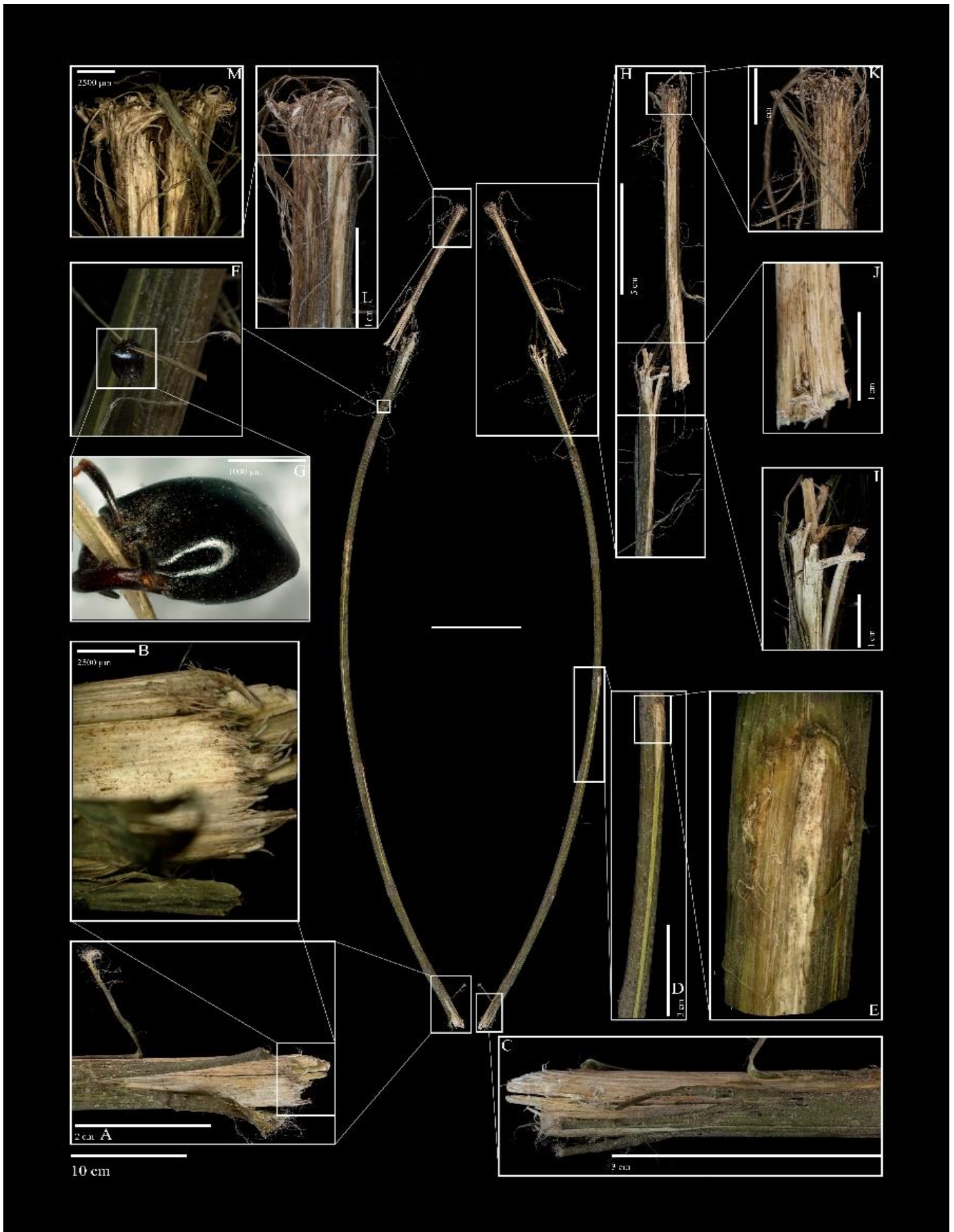


Figure 10: Example of an Ant-dipping tool and several close-up images taken with the Hirox microscope during its analysis (SE_AD_6feb23_S1_T03).

7.2.2. Microscopic study and graphical documentation of the tools.

For the microscopic analysis, we took advantage of the equipment available at the Microscopy lab in IPHES-CERCA. The main microscope used for the study is the HIROX KH-8700 3D Digital Microscope. The microscope is equipped with MXG-5000REZ which has a triple lens with magnifications ranging from 35x to 5000x. In addition, it allows a field of view ranging from 8 mm to 0.06 mm. The illumination systems (coaxial, mixed, and lateral) allow obtaining a range of images from "magnifying glass" type observation scales to those of high magnification microscopes without the need to move the sample (Fernández-Marchena *et al.*, 2018; Martín-Viveros and Ollé, 2020).

Along with these features, the HIROX KH-8700 is accompanied by its powerful software program that enables obtaining sharp photographs, as well as allowing complex tasks such as can be the generation of 3D reconstructed models using the combination of fast autofocus and depth synthesis functions or the generation of automated mosaics.

In this work, we have mainly used the Low-Range, Middle-Range and occasionally High Range lenses. For their use, we must consider that they can be superimposed to have a higher resolution. In addition to this, the HIROX's own mosaic functions, provide us with a much more efficient way to capture larger surface areas, unlike microscopes such as SEM (Vergès and Morales, 2014) or even photogrammetry (Maté-González *et al.*, 2016), which would rely on longer steps to completely reconstruct the study area.

Another microscope used in this study is the Sensofar S neox, a confocal microscope. This microscope uses the same illumination for obtaining confocal images and a bright field image. This would allow us to observe the surface of the object with brightfield illumination to correctly position the objective and identify the desired region. For image acquisition, a light source is placed and directed towards a reflective micro display. The individual pixels would light up individually, illuminating a single point on the surface at the same time. Each pixel of the micro display would be imaged on the surface, and that would be recorded by a camera (Matilla *et al.*, 2016). The specificities for the Sensofar S Neox, depend on the equipped objective, and with the largest numerical aperture (NA) have a resolution of 1.0 nm (using 150x lens) and a tilt of up to 71° (Stemps *et al.*, 2019). In our case, the objectives that the microscope would have equipped would be various lenses ranging from 5x to 150x magnification. As well as different types of light sources to perform the scanning, between 460 nm and 630 nm.

The use of one or both microscopes during this study depended on the data we wanted to obtain and the possibilities for. In our case, the HIROX KH-8700 microscope was more used given the type of documentation performed for our goals and the complex shapes of the tools analysed. In

addition to its efficiency, we also value its use because of the possibilities offered by HIROX in terms of speed in image acquisition, as well as in the generation of 3D color models. Nonetheless, for some of the documentation tasks, we relied on Sensofar X Neox microscope, due to the resolution and quality shown in the generated 3D models.

Additional graphical documentation of the tool was done at the Photography lab at IPHES-CERCA using a Nikon D780, DSLR camera of FX format, Full Frame equipped with a Micro Nikkor 40 mm 1:2.8G lens. The camera was operated from a desktop computer to facilitate the work of focusing and previewing using DigiCam Control software and the Adobe Bridge package.

To obtain photos with a higher degree of detail, we used the stitching method to make the displayed photographs appear completely in focus. For this task, we have used Photoshop's own stitching option.

Overall, to analyse the chimpanzee tools, we followed this workflow (Figure 11):

Analysis Macroscopic – A. Microscopic - Taking photos - Images Processing – Data Analysis.

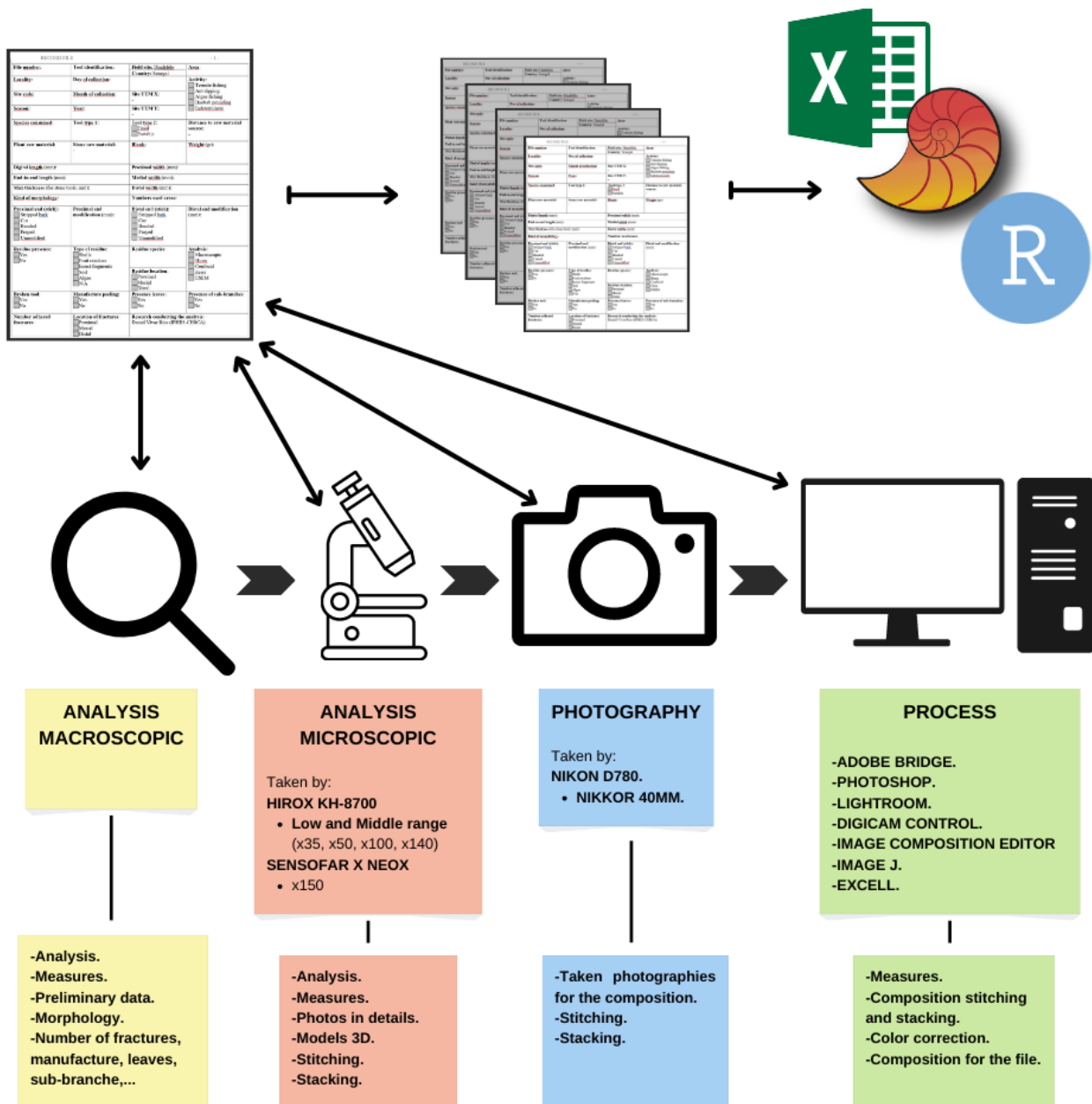


Figure 11: Workflow to complete the analysis of the tools (from macroscopic analysis, microscopic analysis, taking photographs, processing, and data analysis work).

7.2.3. Experimental program.

The analysis of the chimpanzee tools was complemented with a dedicated experimental program that aims to have a deeper understanding about the develop of marks found on the primate perishable tools, ranging from the extraction marks, manufacturing marks, use marks, and subsequent abandonment. To develop and analyse the experimental tools, we followed common procedures used in archaeology, analyzing the changes suffered on the surfaces of the tools and documenting the evolution of the modifications (Ollé and Vergès, 2014).

Nonetheless, the plant raw materials used in the experimental program had a similar reaction when using them imitating the actions that are performed by the chimpanzees.

Knowing these limitations, during the process, we have carried out the experiment by selecting different types of species. To develop this experimental program, we relied on some studies done on perishable tools so far. Additionally, we used video support to replicate the gestures employed by savannah chimpanzees to replicate the activity as closely as possible. These videos can be found on the official pages of the Jane Goodall Foundation Spain (JGIS)⁶, as well as from people outside this institution.

The experiments consisted of two distinct phases, in which field work and laboratory analysis (again at IPHES-CERCA) were interspersed (Figure 12).

⁶ <https://www.youtube.com/@institutojanegoodall5452/videos> (Consulted: 16/08/2023).

Experimental program

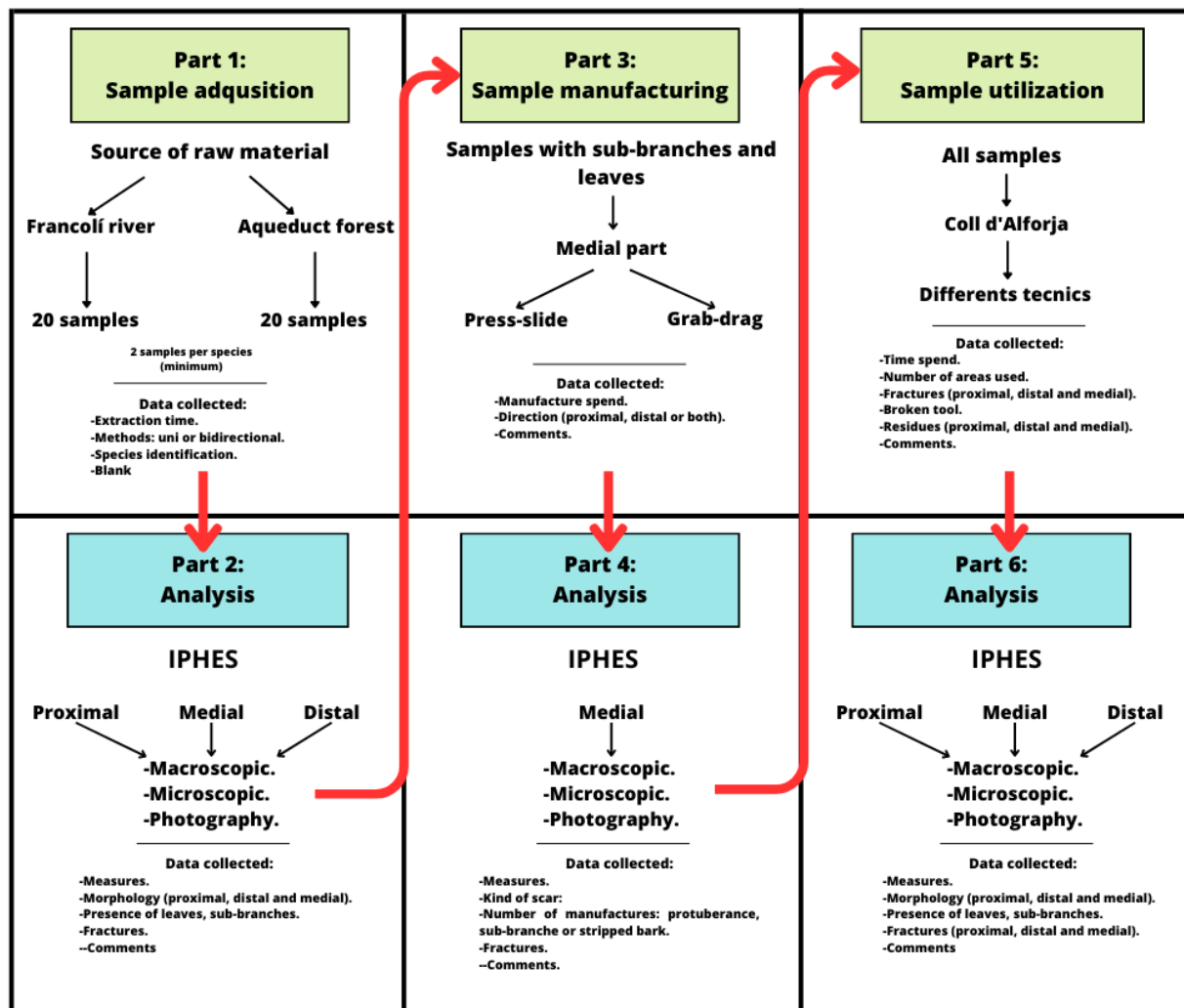


Figure 12: Schema of the experimental program, with the different phases. Colors corresponding to field work (green) and laboratory work (blue).

1st Phase: raw material extraction.

The raw material collection was carried out in two different locations: Francolí river (Figure 13, C) and Aqueduct Forest (Figure 13, A-B) on June 15, 2023. Both locations are in Tarragona, close to IPHES-CERCA. From we will extract the same number of samples ($n = 20$) at each location. Likewise, at least two samples will be taken per species.



Figure 13: View of the places where the first part of the experimental program took place. A-B: Aqueduct forest. C side: Francolí river. Tarragona, Spain.



Figure 14: Map of Tarragona, where we can see the places of the first part of experimental program. Red polygon, situated in the upper part, correspond to Aqueduct Forest; yellow polygon, corresponding to Francolí River. Foto obtained from Google Earth.

The choice of these two locations for the collection of raw materials, responds to the desire to take a greater number of different species with which to compare our sample. The difference between the two locations would be about 2800 meters (Figure 14). Together with the help of Andrés Domínguez Vázquez, this first part of the documentation process was carried out noting the following details:

- Tool **Identification**.
- **Location** (FR or AF), area, X and Y coordinates.
- Plant **species** identification. For this task, we used the PlantNet app.
- **Blank** (twig or liana).
- **Extraction time** (usually in seconds)
- **Type of movement**.
- **State of the branch** (dry or wet).
- **Presence of sub-branches, leaves or fractures** caused by the extraction.

We used two gestures to extract the twigs. We started with a unidirectional movement, followed by a bidirectional movement used if the first one does not have any effect. These gestures will be associated with the proximal ends of the samples that will be classified in the next stage of the experimental program, laboratory analysis.

In addition to this data, during the experiments we recorded each action using an iPhone 11Pro cell phone. After finalizing each experiment, we put an identification label on each tool, and they were stored in a box.

2nd Phase: samples study after extraction.

After the extraction of the potential tools, we studied the experimental twigs at IPHES-CERCA. We are in an intermediate phase between the extraction (1st part) and the manufacture of the branches, use and abandonment. In this stage, we followed the procedures proposed for Dindefelo tools that we have seen in the scheme (table of phases through which the samples pass), collecting the following data:

- They will **check** the materials that were well catalogued.
- **Thickness measurements** of the ends and medial zone.
- Taking of **lengths** end to end (mm) and digital length (mm) using ImageJ⁷.
- **Classification** by **morphology** in both distal and proximal zones.
- **Measurement** of these morphologies on the surface of the sample.

⁷ <https://imagej.nih.gov/ij/download.html> (Consulted: 16/08/2023).

- **Classification of fractures, leaves, or sub-branches.**

3rd Phase: tool manufacture.

This process was done on those samples that have associated sub-branches or leaves on their surfaces. We know that the chimpanzees would do it very quickly and systematically, and that this action is not done on every tool they use.

Data was taken while the experiment took place, while it was also documented through video. In this phase, the data collected was:

- Annotation of the presence or absence of the manufacture stage.
- **Technique used.** In this case, we have proposed two names for the techniques involved: press-slide and grab-drag. Both techniques can be complementary when performing this action:
 - **Press-slide:** this technique consists of pressure on the stem with both fingers from one end (usually distal), and without detaching them from it, move towards the opposite end. This is the best-known technique produced by chimpanzees. These, by doing it in a way contrary to the direction of growth of the sub-branches, produce an easy detachment of both leaves and sub-branches.
 - **Grab-drag:** this technique was proposed due to the difficulty of manufacturing under the press-slide technique. It is a consequence of the thickness of the growing branches of the same main branch, which will be used. The technique consists of grabbing (grab) and pulling (drag) of these sub-branches (in a bidirectional way). Although it is perhaps again more efficient to perform them from a distal to the proximal end.
- Execution **time** in seconds.
- **Direction** in which it was performed: distal to proximal; proximal to distal; or vice versa.
- **Comments:** when it was changed in the case that it has been produced, or generation of protrusions, etc...

4th Phase: samples study after manufacturing process.

In this stage, we documented again the tools using the HIROX KH-8700 and general photographs of a selection of tools that allowed us to illustrate the tools before and after the experiments (Ollé and Vergès, 2014). In this part, we focused on the study of the scars left on the surface, acquiring the following data:

- **Check** the data collected of the tools and the field information taken.
- **Taking thickness measurements.**
- Counting **number of manufactures** performed.

- Generation of scar types.

- Protuberances.
- Sub-branches or leaves not eliminated.
- Surface stripping.
- Stripped bark.

A recorded documentation of the same activities was made to illustrate and be saved in case it was necessary to review data that may have happened.

5th Phase: use of tools.

This is one of the most crucial parts of the experiment. For this final part of field experimentation, we relocated to another site, Coll d'Alforja (Figure 15), located near the Prades Mountains in Tarragona. The reason behind this choice is the presence of vertical walls with semi-dry sediments, providing the perfect conditions for conducting the experiment (Figure 16). This part of the experiment took place on June 21, 2023. The preceding day had rain, which made the task easier due to the softer terrain.



Figure 15. Map of Coll d'Alforja, Prades's mountains, Tarragona. Blue polygon shows the place where we made the 5th part of the experimental program. Made by Google Earth.



Figure 16. Overview of the wall with semi dry sediments in Coll d'Alforja, Prades's mountains, Tarragona.

For this stage, we had the assistance of Andrés Domínguez Vázquez and Constanza Arecheta Baratelli. We conducted the utilization phase on a type of hole we found in the vertical wall (Figure 16).

Using the videos and documents available to us, which are widely recognized, we aimed to imitate the gestures employed by the chimpanzees as closely as possible which includes (Lesnik *et al.*, 2015):

- Gripping the object between the thumb and index finger on the thenar part of the hand.
- Using the phalanx of the four fingers (excluding the thumb).
- Assisting themselves by inserting the object between the fingers to increase precision.
- Holding the object between the thumb and the lateral part of the tip of the index finger's phalanx.

By replicating these gestures as accurately as we could, we aimed to gain insights into the chimpanzees' behaviors and their approach to utilizing objects in their environment. In the next illustrations we can see some of the grips for termite fishing (Figure 17 and 18).

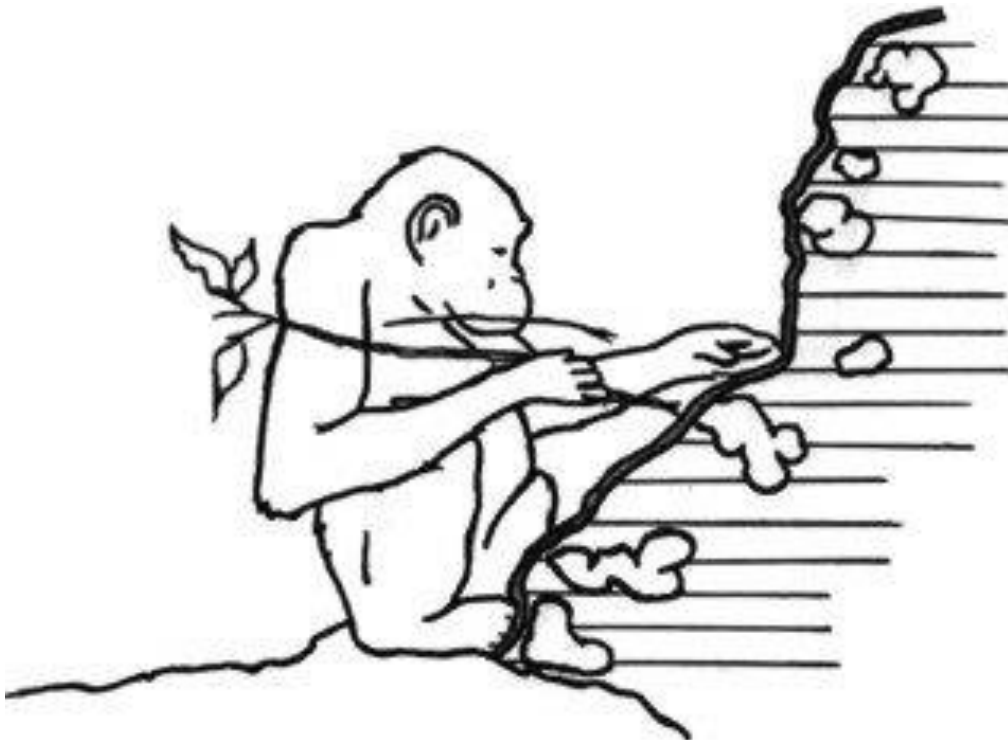


Figure 17: Illustrations corresponding a chimpanzee during the activity of termite fishing in Goulougo Triangle, Republic of Congo (extracted from Sanz *et al.*, 2004).

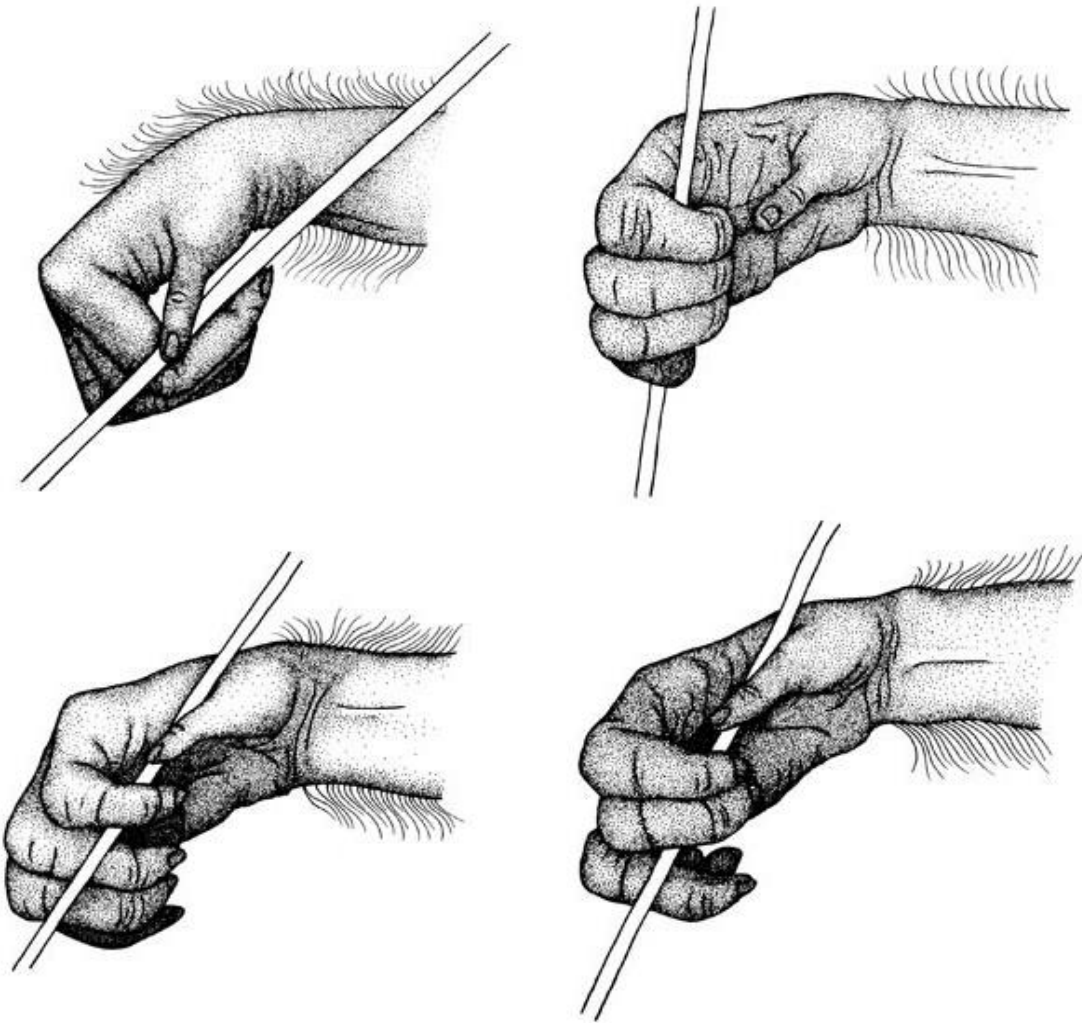


Figure 18: Illustrations corresponding to the grip of chimpanzees in the Goulougo Triangle, Republic of Congo (extracted from: Sanz et al., 2004).

The experimenters will take an active role in simulating the ant-dipping activity, emulating the techniques used by the chimpanzees shown in figure 18. There was no predetermined technical method for performing the actions; they will only be introduced, and each participant will interpret and choose the most comfortable approach. As for the time spent on each tool, it will depend on the experimenters, with a minimum of thirty seconds and a maximum of four minutes. This way, we aim to categorize the data into different time spectrums: less than one minute; between 1:01 and 2:00; 2:01 to 3:00; and finally, 3:01 to 4:00 minutes. Based on this, during this stage of the experiments, we collected the following data:

- **Location**, area code, and X and Y coordinates.
- Number of **areas used**.
- **Location** of the area used (proximal or distal end).
- **Number of fractures** produced during utilization.

- **Location** of these fractures (proximal end, distal end, or medial area).
- **Tool broken** or not.
 - **Location** of the fracture.
- **Time** dedicated to each action.
- **Comments:** We will note any changes observed and when fractures occur.
- Adhered **residues**.
 - **Location** of residues (proximal, medial, or distal).

7.2.3.6. 6th Phase: samples study after use.

In this part, we followed the same methodology used during the 1st stage (source extraction). Here, we conducted a meticulous study of the sample from the proximal to the distal end. The following data was collected:

- Verification of the data gathered in the field.
- Thickness measurements in the medial area, proximal end, and distal end.
- **Tool lengths:** digital length and end to end (mm).
- **Type of morphologies** at the proximal and distal ends.
 - **Measurements** of how far these morphologies extend into the sample's surface.
- **Fractures**, if not detected during field work.
- **Residues**, if we detected.
 - **Location** (proximal, medial, or distal).
- **Comments.** Different types of marks associated with other parts, etc.

By examining all these variables, we aimed to gain a comprehensive understanding of the tool's conditions after use and any changes that occurred during the experimentation process. This provides valuable insights into the tool's durability, functionality, and potential modifications made by the participants during their usage.

8. RESULTS.

8.1. Results from the analysis of Dindefelo tools.

A total of 21 tools from different behaviors of Dindefelo chimpanzees were studied. Eleven belonged to ant dipping behavior, seven to termite fishing, and three to algae fishing.

8.1.1. Ant-dipping tools.

The ant dipping tools (n=11) (Figure 19) analysed here were collected between the dry months of January-February 2022 and 2023. They were found at Segou, specifically at three locations: "Thiangol Ndian", "Thiangol Sanké" and "Thiangol Garage". These tools were used for the extraction and consumption of *Dorylus nigricans* (JGIS unpublished data).

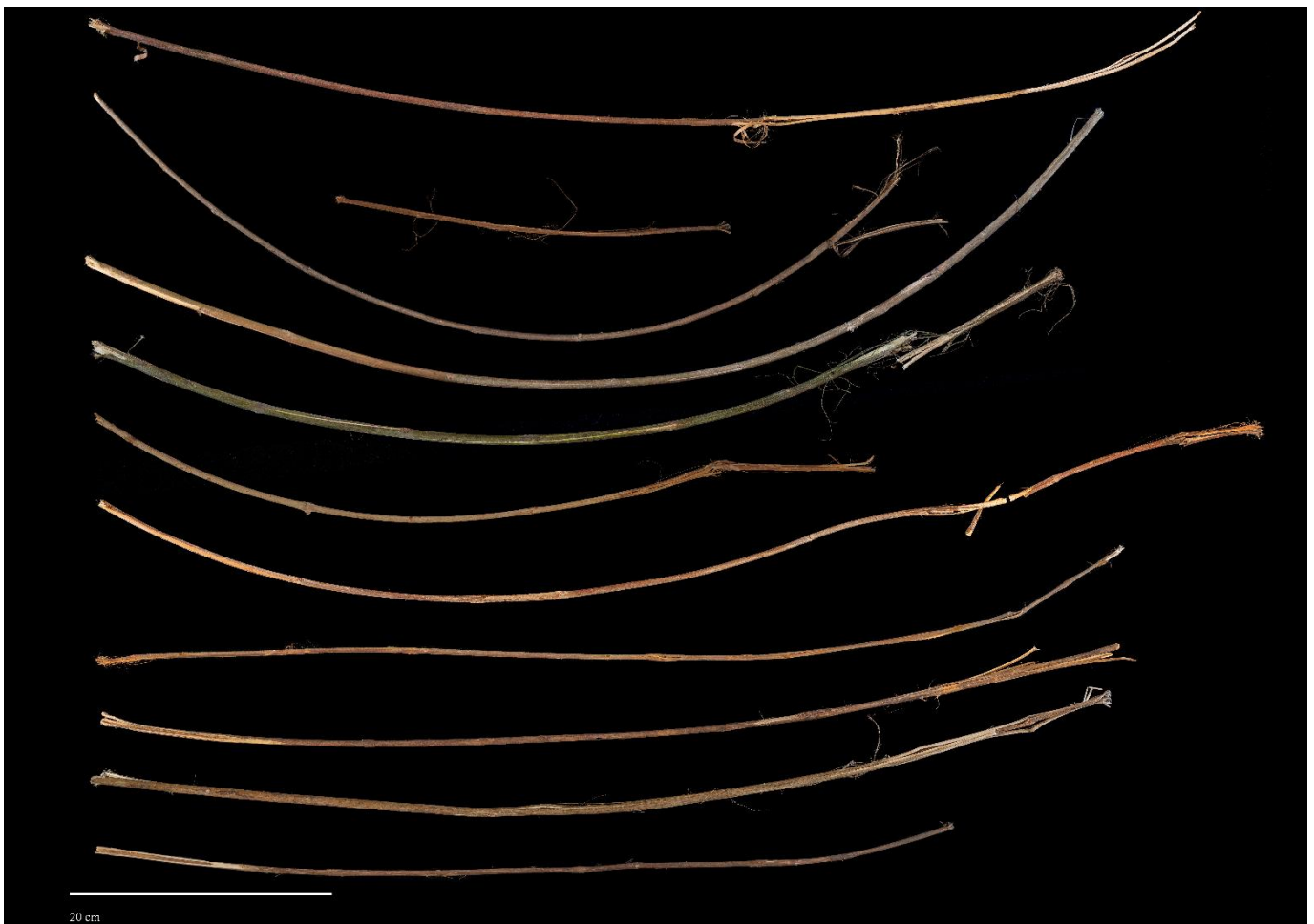


Figure 19: General view of the of ant-dipping tools assemblage analysed in this work (scale = 20 cm)

General measurements of the tools (Figure 20 and Table 2) were taken in different ways: one following the surface of the tool (named here as ‘digital length’); and the second from end to end drawing a straight line (named as end-to-end length). The tools have an average digital length of 713,37 mm ($\pm 48,47$ mm) and an average weight of 5,8 grams ($\pm 0,91$ g). In general, the morphology of the pieces is curved ($n=7$) and slightly curved ($n=4$). In these cases, we find a very small differentiation between these measurements as the analysed tools do not present very accentuated curvatures. Although it was not possible to identify the plant species used as raw materials, thanks to the assistance of the research personnel of the JGIS it was possible to determine that the chimpanzees used *Alchornea cordifolia* ($n=4$) and *Sorindeia juglandifolia* ($n=1$), while on the rest of the tools ($n=6$) it was not possible to identify the plant species without further botanical analysis. Regarding blank, we have a similar representation of twigs ($n=7$) and lianas ($n=4$).

Digital length (mm)	Min: 288,02
	Max: 861,09
	Mean: 713,37
	SD: 160,77
End-to-end length (mm)	Min: 280,00
	Max: 858,97
	Mean: 686,44
	SD: 154,72

Table 2: measures digital length (mm) and end-to-end length (mm). Accompanied by the minimum (MIN), maximum (MAX), mean (MEAN) and standard deviation (SD).

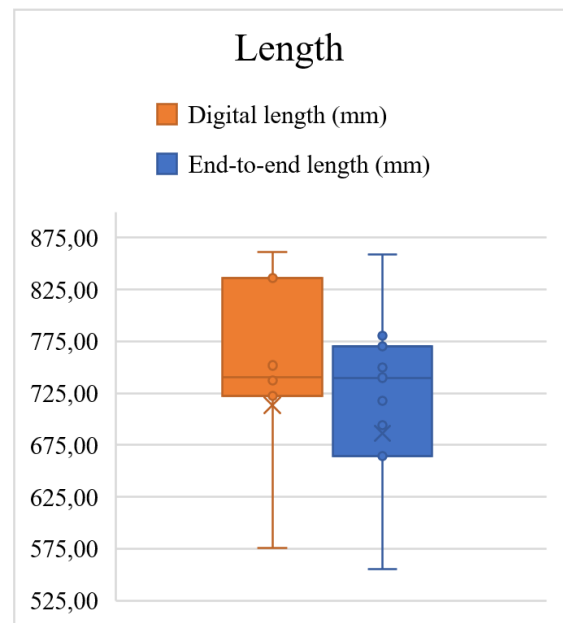


Figure 20: Box and whisker plot diagram digital length (mm) and end to end length (mm).

Regarding the thickness of the tools, the proximal ends have an average of 5,45 mm ($\pm 0,463$ mm), the medial area 4,86 mm ($\pm 0,414$ mm) and finally the distal ends have an average of 4,4 mm ($\pm 0,357$ mm).

In Figure 21, we can observe that the greatest thickness corresponds mostly to the proximal part and that it can be the result of the growth that occurs from the trunk part. Although we also find some cases in which the medial part is greater, and it is due to the natural morphology of the twigs.

Proximal width (mm)	Min: 3,7
	Max: 8,9
	Mean: 5,45
	SD: 1,53
Medial width (mm)	Min: 2,6
	Max: 6,9
	Mean: 4,86
	SD: 1,37
Distal width (mm)	Min: 2,9
	Max: 6,00
	Mean: 4,4
	SD: 1,18
Weight (gr)	Min: 1,52
	Max: 10,62
	Mean: 64,01
	SD: 3,02

Table 3: Thickness measurements of the proximal, distal, and medial ends accompanied by the minimum (MIN), maximum (MAX), mean (MEAN) and standard deviation (SD).

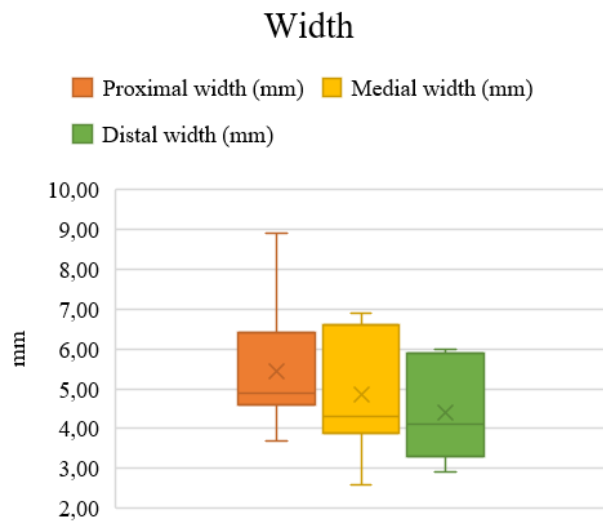


Figure 21: Box and whisker plot diagram of the proximal, medial, and distal thicknesses (mm).

Proximal end modifications.

The most represented modification on the proximal end of the ant dipping tools was stripped bark (n=5) as well as the combination of cut end and stripped bark (n=3), followed by cut ends (n=2) and the combination of frayed and stripped bark (n=1) (Figure 22/table 4).

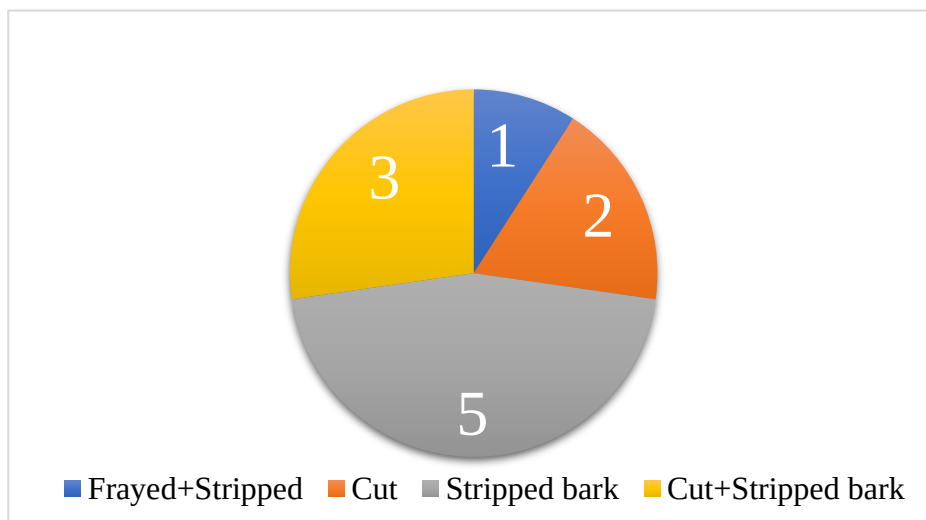


Figure 22: Type of proximal modification that we can find in ant-dipping behaviors.

Tool ID	Type of modification	Modification length (mm)
SE_27jan22_S1_T02	Cut+Stripped	331,00
SE_AD_18Jan23_S2_T13	Cut	0
SE_AD_19Jan23_S01_T05	Stripped bark	131,5
SE_AD_19Jan23_S01_T06	Frayed+Stripped	11,9
SE_AD_25jan22_S1_T01	Cut+Stripped	118,00
SE_AD_25jan22_S1_T02	Stripped bark	38,00
SE_AD_27Jan23_S01_T04	Cut	0
SE_AD_27Jan23_S01_T05	Stripped bark	27,7
SE_AD_27Jan23_S01_T06	Cut+Stripped	157,1
SE_AD_6feb23_S1_T03	Stripped bark	46,4
SE_AD_6Feb23_S1_T04	Stripped bark	49,4

Table 4: samples of the ant dipping tool together with the type of modification at the proximal end and its size (mm).

In the case of the length of these modifications of the proximal ends of the ant dipping tools, we see that most of them are quite invasive, to the point of reaching more than 300.00 mm (for instance on the tool SE_27jan22_S1_T02). Most of the modification types are accompanied by stripped bark reaching a presence in this set of 90.9%. We also identify a significant difference between lengths by type of modification. Again, if we take the case of SE_27jan22_S1_T02, with 331.00 mm, and compare it with the samples that show cut end morphology (SE_AD_18Jan23_S2_T13 and SE_AD_27Jan23_S01_T04), which do not present marks beyond the tip, this differentiation between invasions on the surface of the tool becomes very evident. However, if we compare it with the rest of the tools showing stripped bark, we can see that the mean caused by stripped bark is 82,81 mm ($\pm 29,68$ mm).

Table 5 shows the null effect on the surface of the tool by the cut end modification since it only leaves a trace on the tip as we have discussed above. The second modification with the lowest invasiveness on the tools is the combination of frayed and stripped modifications (although we must bear in mind that this is represented by a single tool). Continuing towards more invasive modifications we find an important jump, represented by the stripped bark and the combination of cut end and stripped bark (Figure 23A).

Modification	MIN	MAX	MEAN	SD	%
Cut (n= 2)	0	0	0	0	18,18%
Stripped bark (n= 6)	27,70	131,50	58,6	41,61	54,54%
Frayed+Stripped (n= 1)	11,9	11,9	11,9	0	9,09%
Cut+Stripped (n=3)	118,00	331,00	202,03	113,38	27,27%

Table 5: Table of the type of modification of the proximal end. Accompanied by the minimum (MIN), maximum (MAX), mean (MEAN) and standard deviation (SD) and percentage of representation in the sample. The units, are mm.



Figure 23: Modifications of the proximal ends of ant-dipping tools A: cut+stripped (SE_AD_25jan22_S1_T01); B: frayed+stripped (SE_AD_19jan23_S01_T06); C: stripped bark (SE_AD_19jan23_S01_T05); and D: cut (SE_AD_27jan23_S01_T04). Photos taken with HIROX KH-8700, 35x lens

Distal end modifications.

At the distal ends, we identified a predominance of two types of modifications: frayed (n=3), stripped bark (n=3), but most tools bear a combination of both (frayed+stripped; n=5) (Figure 24/table 6).

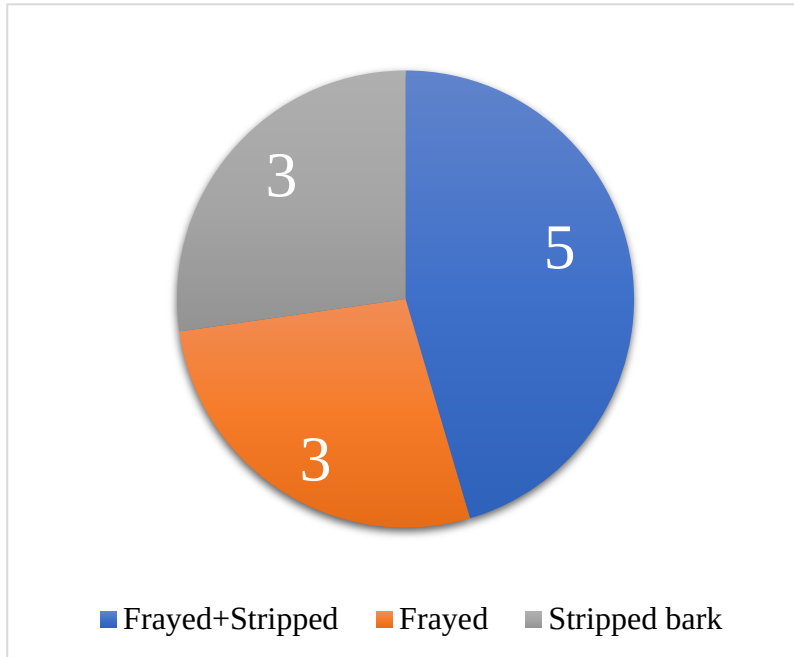


Figure 24: type of proximals modifications that we can found in ant dipping behaviour

Tool ID	Distal end modification	Modification lenght (mm)
SE_27jan22_S1_T02	Frayed+Stripped	6,00
SE_AD_18Jan23_S2_T13	Frayed	9,10
SE_AD_19Jan23_S01_T05	Stripped bark	170,00
SE_AD_19Jan23_S01_T06	Frayed+Stripped	8,60
SE_AD_25jan22_S1_T01	Frayed	6,00
SE_AD_25jan22_S1_T02	Stripped bark	11,00
SE_AD_27Jan23_S01_T04	Frayed	60,20
SE_AD_27Jan23_S01_T05	Stripped bark	32,10
SE_AD_27Jan23_S01_T06	Frayed+Stripped	17,40
SE_AD_6feb23_S1_T03	Frayed+Stripped	210,00
SE_AD_6Feb23_S1_T04	Frayed+Stripped	218,00

Table 6: samples of the ant dipping tool together with the type

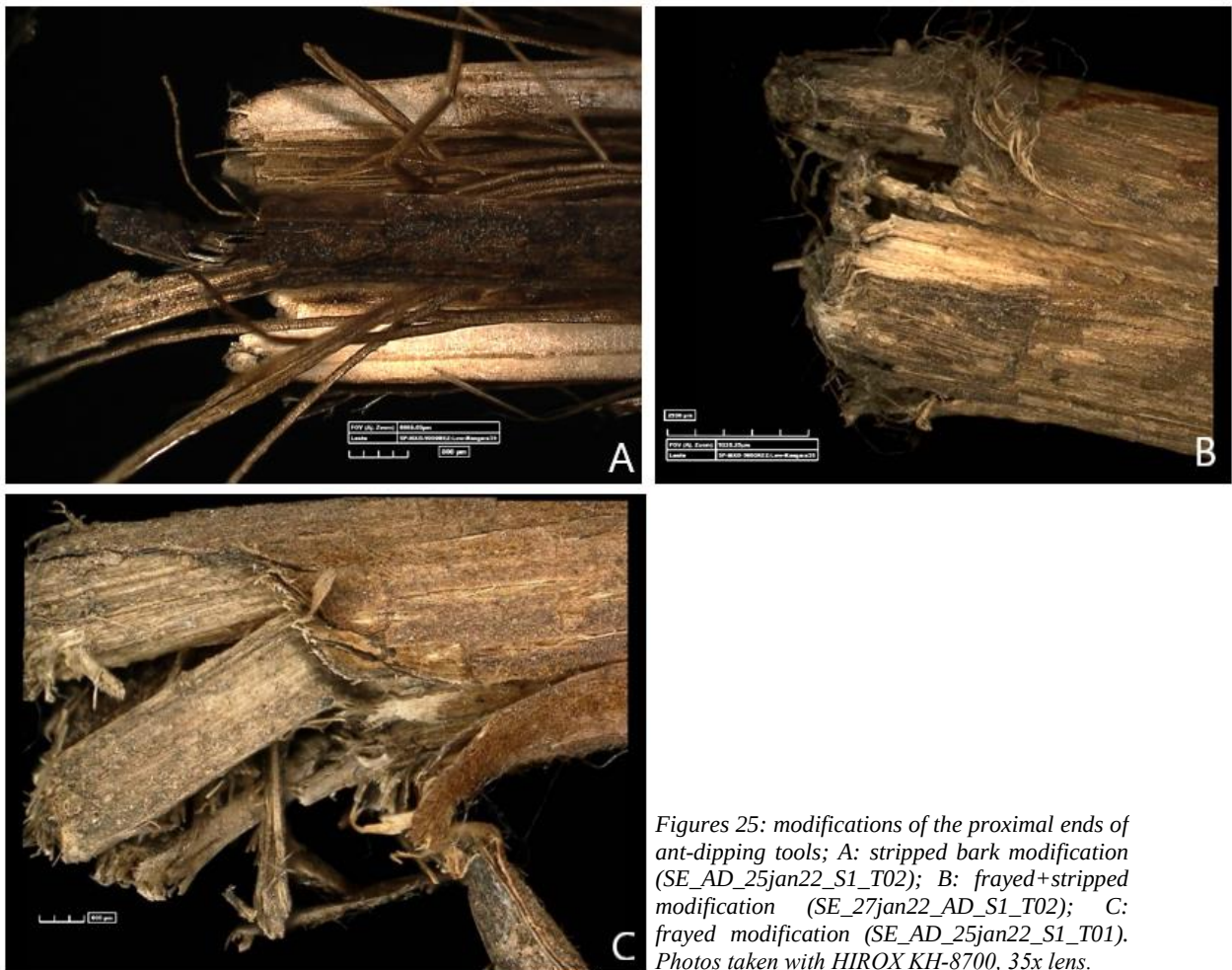
In the distal ends, we do not identify the cut-type modification recognised in the proximal ends. On the contrary, the frayed modification is more represented, with up to eight ant dipping tools

showing it. In addition to this, again we see a great differentiation even in tools that have a similar stripped bark modification or the combination of this, accompanied by frayed.

Tools bearing stripped bark have a pronounced difference in the length of this modification, varying between 11.00 mm (SE_AD_25jan22_S1_T02) and 170.00 mm (SE_AD_19Jan23_S01_T05), with a mean length of 71,03 mm ($\pm 26,09$ mm) (Table 7). Whereas, if we look at the frayed+stripped bark modification (with a mean length of 92 mm), there is a great difference between the length of the longest modification (SE_AD_6Feb23_S1_T04) and the shortest (SE_27jan22_S1_T02) of 212.00 mm.

Modification type	MIN	MAX	MEAN	SD	%
Frayed (n=3)	6	60,2	25,1	30,436	27,27%
Stripped bark (n=3)	11	170,00	71,03	86,354	27,27%
Frayed+Stripped (n=5)	6	218,00	92,00	111,48	45,45%

Table 7: Type of modification of the distal end. Accompanied by the minimum (MIN), maximum (MAX), mean (MEAN) and standard deviation (SD) and percentage of representation in the sample (%). The units are in mm.



Figures 25: modifications of the proximal ends of ant-dipping tools; A: stripped bark modification (SE_AD_25jan22_S1_T02); B: frayed+stripped modification (SE_27jan22_AD_S1_T02); C: frayed modification (SE_AD_25jan22_S1_T01). Photos taken with HIROX KH-8700, 35x lens.

Comparison between proximal and distal end modifications.

Comparing all the types of marks found at both proximal and distal end have stripped bark as the most representative (on 11 tools) and invasive modification (with an average of 202,03 mm) (Table 8).

	MIN	MAX	MEAN	SD	%
Cut (n=2)	0	0	0	0	9,09%
Cut+stripped (n=3)	118,00	331,00	202,03	113,38	13,63%
Frayed (n=3)	6,00	60,20	25,10	30,43	13,63%
Frayed+stripped (n=6)	6,00	218,00	78,65	104,94	27,27%
Stripped bark (n=8)	11,00	11,00	63,26	56,22	36,36%

Table 8: Table of the types of modifications in the ant dipping tools. Accompanied by the minimum (MIN), maximum (MAX), mean (MEAN), standard deviation (SD) and percentage (%). The units, are mm.

In the same way, we must consider other factors that can influence the presence of marks including the blank, the structure of the wood itself, as well as factors such as the degree of humidity/dryness, the number of times it has been reused or the period it has been used. Some elements may superimpose certain modifications that have occurred previously, such as, the case of the manufacture peeling, that can be produced in a phase prior to the use of the tool. But what is certain is that we find a wide representation of stripped bark at both ends while comes combined in some cases such as cut+stripped and frayed+stripped.

In figure 26, we can observe the differentiation between the sizes of the marks between the proximal and distal ends with respect to the digital length size of the sample (Figure 26A). Here we observe that the invasiveness is not so pronounced with respect to the part of the piece that is without modification. But we must also consider the modification of the medial part that normally corresponds to the manufacturing process. In the next figure (Figure 26B), we can observe only the proximal and distal modifications, together with the size occupied. The reading we can make out of this is that the distal part seems slightly more pronounced in distal end the proximal part, this is a consequence of the tools being used for the distal end. In the latter, even in some points it has hardly any representation, due to the cut morphology itself.

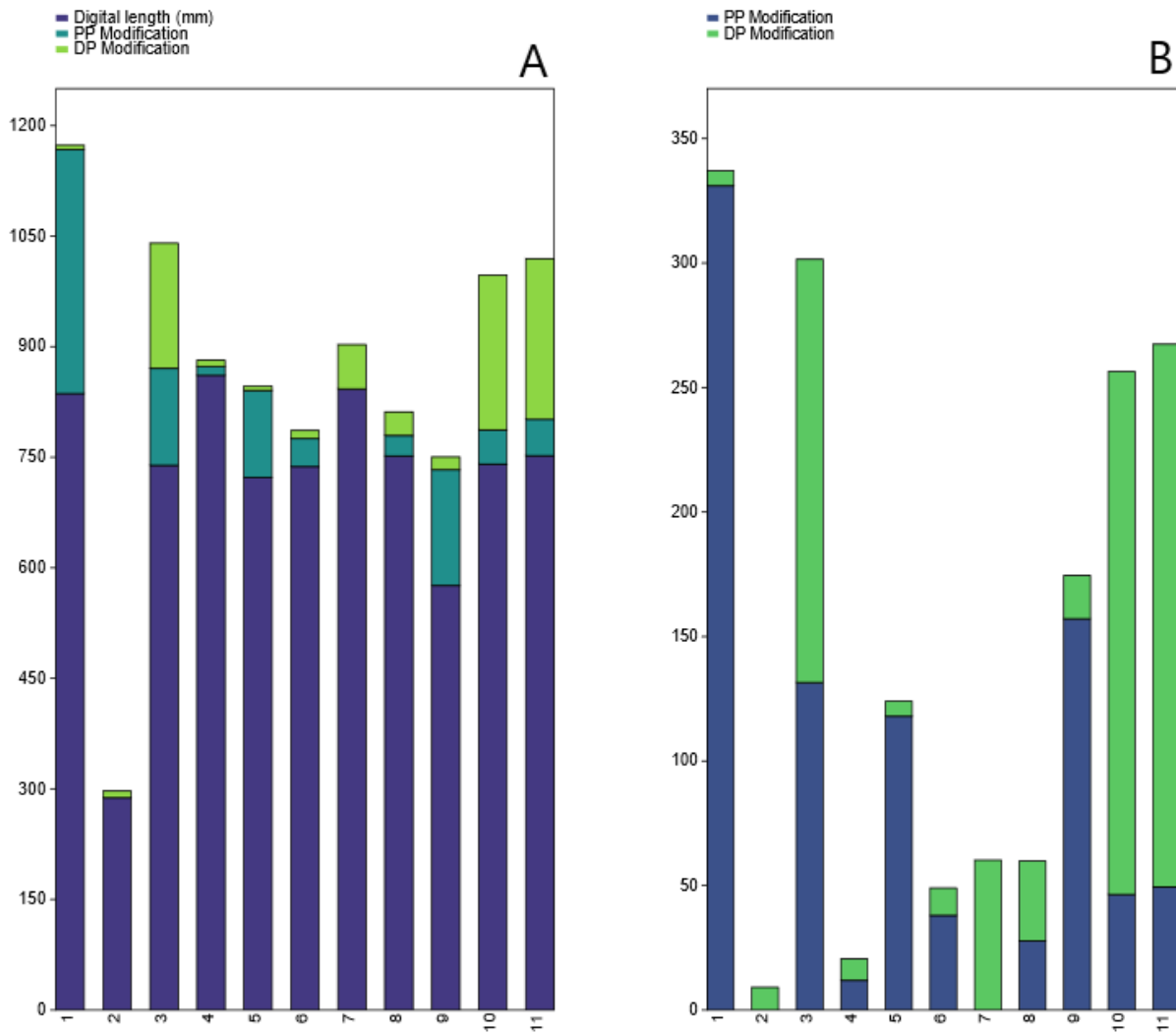


Figure 26: Comparison between the lengths of the modifications of the ant dipping tools. A: modifications of PP, DP, and the digital length; and B: only modifications PP and DP. X-axis: mm; Y-axis: pieces, in order of Table 4.

In sum, it is possible to establish a classification of the average type of morphology that leaves more evidence in the samples, that shows the impact of the modifications on the tools (from the lowest to the highest), from the average of the scars:

CUT > FRAYED > STRIPPED BARK > FRAYED +STRIPPED>CUT+ STRIPPED

Modifications at the medial part.

Manufacture peeling.

These type of marks, tells us about the cleaning processes in which the chimpanzees eliminate the sub-branches or leaves attached to the twigs. Generally, the chimpanzees remove these leaves in the opposite direction to the natural growth of the sub-branches. The morphology of these scars is like the stripped bark modification, as during the process the most superficial plant fibers are torn off, because of the movement in favour of the growth lines.

Accross the analysed ant dipping tools, the representation of manufacture peeling is almost absent, and was identified in only two pieces, corresponding to the tools: SE_AD_6feb23_S1_T03 (3 scars) (Figure 27A) and SE_AD_27jan22_S01_T02 (2 scars) (Figure 27B). All were produced following a distal to proximal direction.

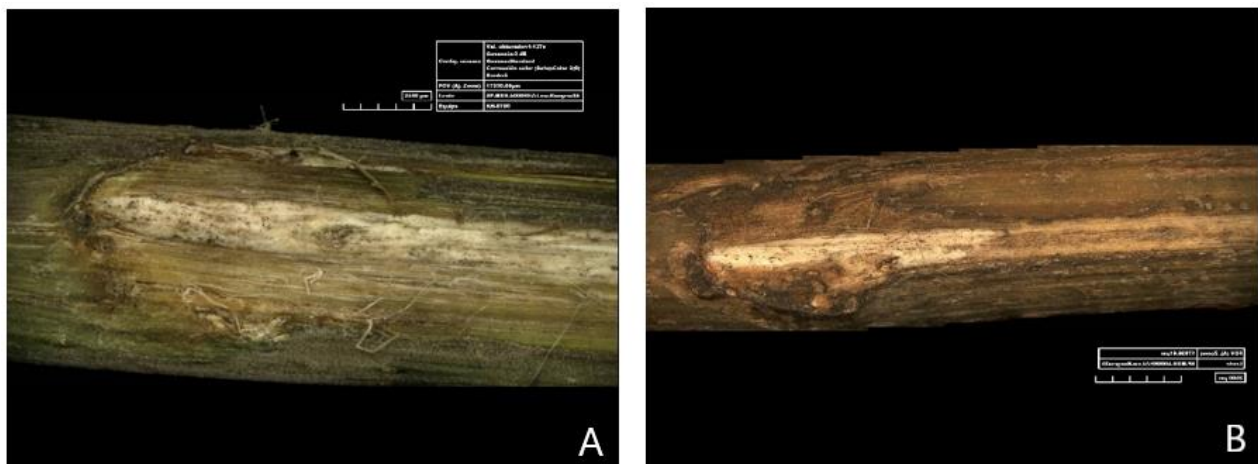


Figure 27: Examples of the manufacture peeling scars on two ant-dipping tools: A: SE_AD_6feb23_S03; and B: SE_AD_27jan22_S01_T02. Magnification at 35x.

Fractures.

In addition to the manufacture scars, we can also find fractures, which we differentiate between complete (Figure 28B) and non-complete fractures (Figure 28A). Fractures are present in almost all the ant dipping tools (bearing up to six fractures), except for one case (Table 9).

Tool id	Fractures	Location	Complete	Non-complete
SE_AD_27jan22_S1_T02	2	Mesial	0	2
SE_AD_18Jan23_S2_T13	1	Mesial	0	1
SE_AD_19Jan23_S01_T05	2	Mesial-distal	1	1
SE_AD_19Jan23_S01_T06	6	Mesial-distal	1	5
SE_AD_25jan22_S1_T01	2	Distal	0	2
SE_AD_25jan22_S1_T02	0	-	-	-
SE_AD_27Jan23_S01_T04	4	Mesial-distal	3	1
SE_AD_27Jan23_S01_T05	3	Mesial-distal	2	0
SE_AD_27Jan23_S01_T06	2	Mesial	1	1
SE_AD_6feb23_S1_T03	1	Mesial	1	0
SE_AD_6Feb23_S1_T04	3	Mesial-distal	2	1

Table 9: Ant-dipping tools with fractures.

As shown in Table 9 the fractures are mostly located in the medial zone (n=14) and in smaller quantities in the distal zone (n=12). We have no representation in the proximal zones. The percentage of fractures in the medial zone is 81.81%, while the percentage of distal fractures is 54,54%.



Figure 28: Details of the fractures found in ant-dipping tools. A: non-complete fracture of SE_AD_27jan22_S1_T02. B: complete fracture of SE_AD_19Jan23_S01_T06 (photos at 35x).

Residues.

During the analysis of the tools, we found various types of residues associated with the use of the tools located at their distal ends. In this case, of the 11 samples, we recognized: no residues (n=5), insect fragments (n=4), and soil remains (n=2) (Figure 29/table 10).

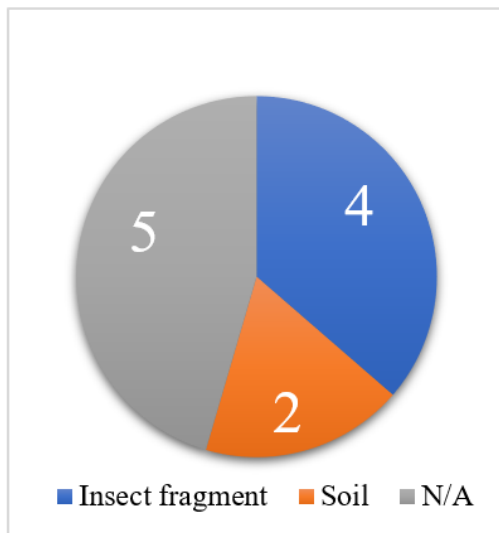


Figure 29: Type of residue found in ant-dipping tools.

Type of residue	Porcentaje
Insect fragment	36,36%
Soil	18,18%
No residues	45,45%

Table 10: Type of residue found in ant-dipping tools with percentage respect to the overall.

Tool ID	Type residue	Species	Location
SE_AD_18Jan23_S2_T13	Soil	Soil	Distal end
SE_AD_19Jan23_S01_T05	Insect fragments	<i>Dorylus nigricans</i>	Distal end
SE_AD_27Jan23_S01_T04	Insect fragments	<i>Dorylus nigricans</i>	Distal end
SE_AD_27Jan23_S01_T06	Soil	Soil	Distal end
SE_AD_6feb23_S1_T03	Insect fragments	<i>Dorylus nigricans</i>	Distal end
SE_AD_6Feb23_S1_T04	Insect fragments	<i>Dorylus nigricans</i>	Distal end

Table 11: Type of residue found in ant-dipping tools, with species, and location.

The insect fragments correspond to the presence of heads the ants consumed (*Dorylus nigricans*) (Figure 30) that are attached to the fibers of the tools.



Figure 30: Examples of ant heads in ant dipping tools. A: SE_AD_27jan23_S1; B: T04SE_AD_19jan23_S1_T05 (140x); C: SE_AD_6feb23_S1_T04 (50x); and D: SE_AD_6feb23_S1_T03 (140x).

8.1.2. Termite fishing tools.

The termite fishing tools (n=7) were collected during the dry months of December-February 2021 and 2023. These tools were found at Nandoumary at the locations called by the JGIS as "Punto animal" and "Punto de agua". These tools were used to consume *Macrotermes sp.* and *Macrotermes subhyalinus*. For some of them (n=4) we have recorded the distance from the termite mound (30,25 cm in average) and the source from which they were extracted, which were relatively close (2,60 cm in average) (Figure 31).

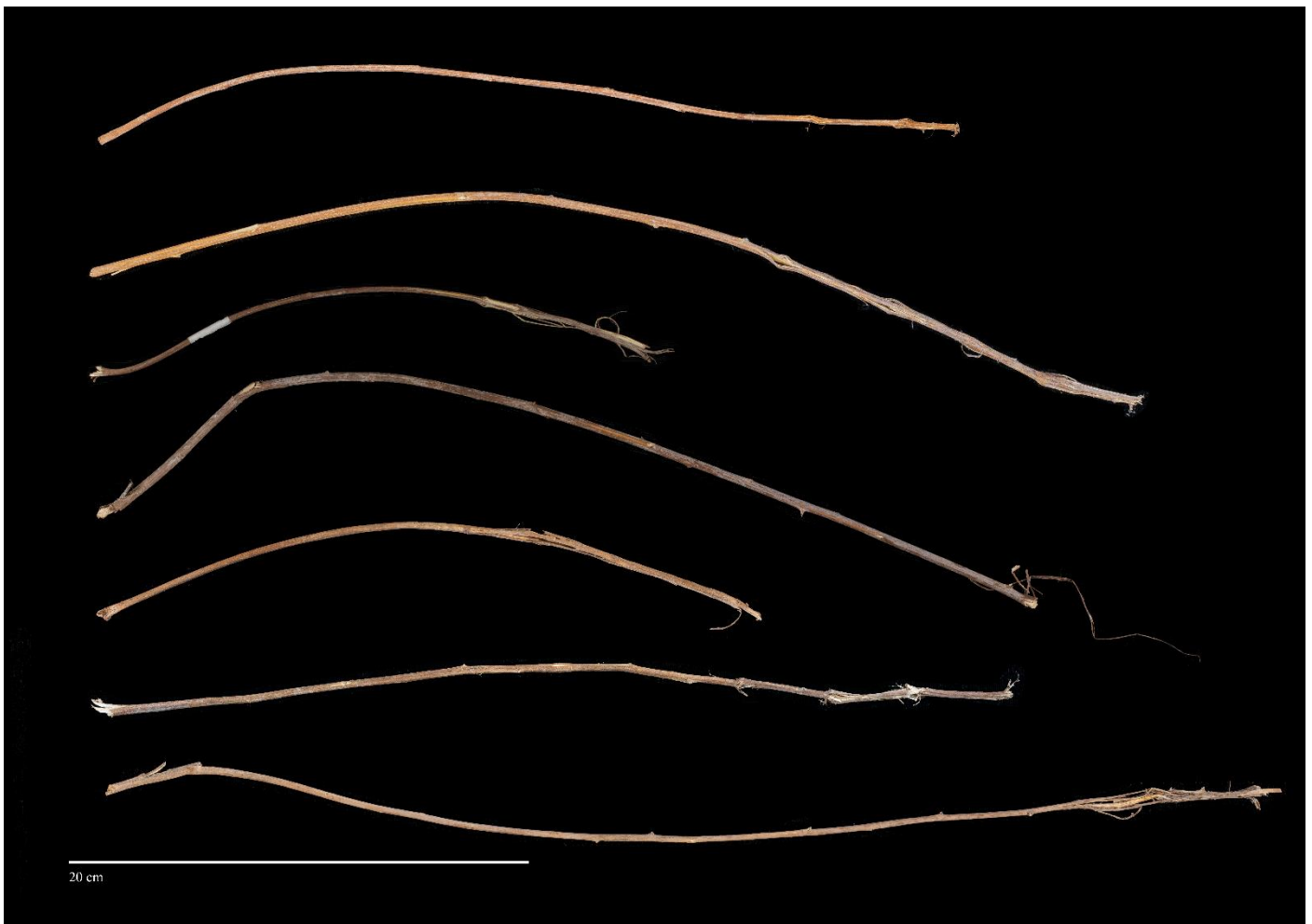


Figure 31: General view of the termite-fishing tool assemblage (scale = 20 cm).

In terms of their general dimensions, we find again that the length of the pieces, taken differently (using the morphology of the artefact and the end-to-end linear measure), presents an almost inappreciable variation that is the result of the natural curvature of the tool. Overall, the termite fishing tools have a mean digital length of 393,68 mm ($\pm 34,00$ mm), and a mean weight of 1,33 grams ($\pm 0,21$ g) (Table 12/figure 32).

Digital length (mm)	Min: 259,12
	Max: 512,35
	Mean: 393,68
	SD: 89,95
End-to-end length (mm)	Min: 248,11
	Max: 495,00
	Mean: 378,21
	SD: 86,68

Table 12: measures digital length (mm) and end-to-end length (mm). Accompanied by the minimum (MIN), maximum (MAX), mean (MEAN) and standard deviation (SD).

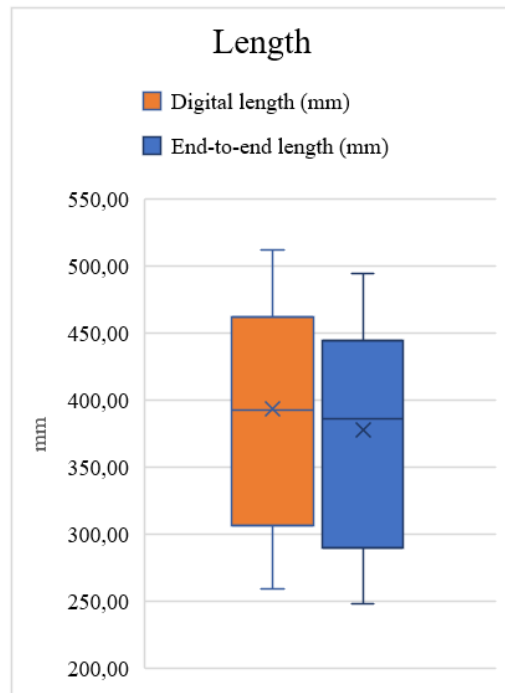


Figure 32: Box and whisker plot diagram digital length (mm) and end to end length (mm).

The general morphology found in the tools is curved (n=5) and slightly curved (n=2). The plant raw materials used were mainly two *Desmodium salicifolium* (n=3) and *Flueggea virosa* (n=4).

As shown in table 13 and figure 33 we find a very noticeable differentiation between the tool thicknesses of the proximal end with respect to the distal end and medial zone of the tools. Again, these differences are explained by the natural morphologies of the twigs, as the proximal end would correspond to the area connected to the rest of the trunk and therefore, it tends to be thicker.

Proximal width (mm)	Min: 3,1
	Max: 5,8
	Mean: 3,942
	SD: 0,92
Medial width (mm)	Min: 2,1
	Max: 3,4
	Mean: 2,8
	SD: 0,47
Distal width (mm)	Min: 1,7
	Max: 3,5
	Mean: 2,571
	SD: 0,66
Weight (gr)	Min: 0,53
	Max: 1,99
	Mean: 1,332
	SD: 0,57

Table 13: thickness measurements of the proximal, distal, and medial ends accompanied by the minimum (MIN), maximum (MAX), mean (MEAN) and standard deviation (SD).

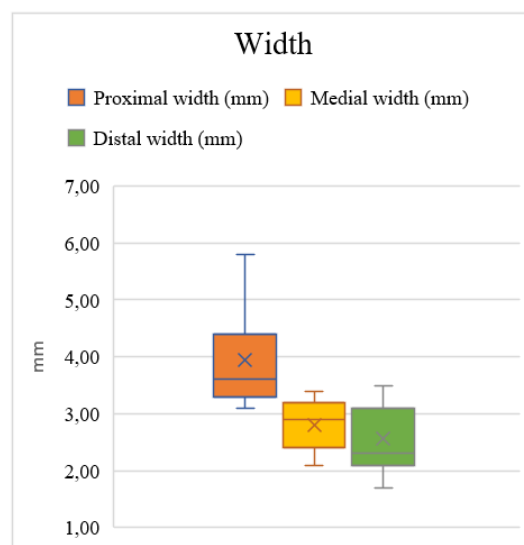


Figure 33: Box and whisker plot diagram of the proximal, medial, and distal thicknesses (mm).

Proximal end modifications.

The modifications in the proximal ends are varied, and again we found that there are samples that exhibit a combination of different types of modifications. Of the seven tools analysed, we found the presence of stripped bark (n=2), bent (n=2), bent+stripped bark (n=2), and cut end (n=1) (Table 14, and Figure 34).

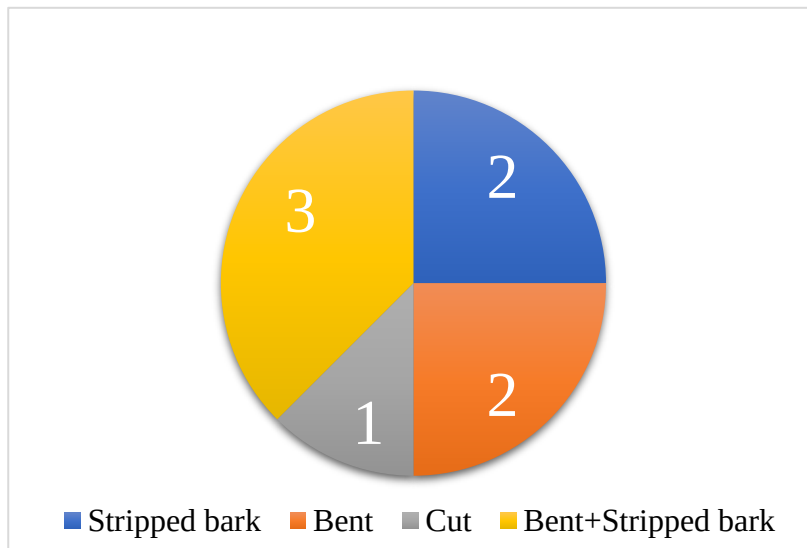


Figure 34: modifications in proximal end of termite fishing.

Tool ID	Proximal end modification	Modification lenght (mm)
NA_10dec21_TF_S1_T03	Stripped bark	18,00
NA_10dec21_TF_S1_T10	Bent+Stripped	13,00
NA_TF_1Feb23_S1_T01	Bent	0
NA_TF_1Feb23_S1_T02	Cut	0
NA_TF_1Feb23_S1_T08	Bent	10,00
NA_TF_1Feb23_S1_T10	Stripped bark	34,3
NA_10dec21_S1_T06	Bent+Stripped	11,00

Table 14: samples of termite fishing tools together with the type of modification at the proximal end and its size (mm).

The maximum length of the modifications is shown by two samples that present a stripped bark morphology, NA_10dec21_TF_S1_T03 and NA_TF_1Feb23_S1_T10 (Figure 35A) and being the most invasive with 34,3 and 18,00 mm respectively. On the contrary, the less invasive modifications were found on two termite fishing tools (NA_10dec21_TF_S1_T10 (Figure 35B) and NA_10dec21_S1_T06) that have a combination of bent+stripped, measuring 13,00 and 11,00 mm respectively. In third place, two tools exhibited a bent proximal end, but only in one have a modified end of 10,00 mm (NA_TF_1Feb23_S1_T08), while in the other case (NA_TF_1Feb23_S1_T01) the modification was not invasive. And, finally, we found a single tool with a cut proximal end, a non-invasive modification.

Modification type	MIN	MAX	MEAN	SD	%
Cut (n= 1)	0	0	0	0	14,28%
Stripped bark (n= 2)	18,00	34,3	26,15	8,15	28,57%
Bent+Stripped (n= 2)	11,00	13,00	12	1,00	28,57%
Bent (n=2)	0	10,00	5,00	5,00	28,57%

Table 15: of the type of modification of the proximal end. Accompanied by the minimum (MIN), maximum (MAX), mean (MEAN) and standard deviation (SD) and percentage of representation in the sample. The units, are mm.

As we have discussed above, we can observe that the representation of the proximal end modifications is very similar among them. The degree of invasiveness of the modification shows a certain pattern, more profuse in the tools that present a morphology of unique stripped bark or accompanied by bent.



Figure 35: Details of the modifications of the proximal end of termite fishing tools. A: Stripped bark (NA_TF_1feb23_S1_T10); B: Bent+Stripped (NA_TF_10dec23_S1_T10); C: Cut (NA_TF_1feb23_S1_T02); D: Bent (NA_TF_1feb23_S1_T02). All photos taken at 35x.

Distal end modifications.

The modifications found at the distal ends of the termite fishing tools are very different from those we find at the proximal end. We also see morphologies that can be unique or in combination with each other. We have peeled (n=1) (Figure 36A), frayed (n=3) (Figure 36B), frayed+stripped (n=2) (Figure 37A), cut+stripped (n=1) (Figure 37B) morphologies. Again, we find a very similar distribution among the tools.

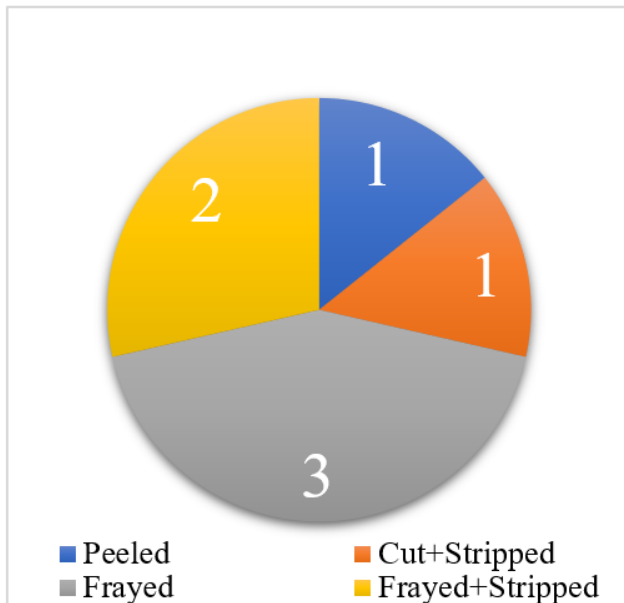


Figure 36: modification types at the distal ends

Tool ID	Proximal end modification	Modification length (mm)
NA_10dec21_TF_S1_T03	Cut+Stripped	32,00
NA_10dec21_TF_S1_T10	Frayed+Stripped	4,00
NA_TF_1Feb23_S1_T01	Peeled	13,6
NA_TF_1Feb23_S1_T02	Frayed	14,8
NA_TF_1Feb23_S1_T08	Frayed	2,8
NA_TF_1Feb23_S1_T10	Frayed	5,2
NA_10dec21_S1_T06	Frayed+Stripped	133,00

Table 16: samples of the termite fishing tool together with the type of modification at the distal end and its size (mm).

The diversity of morphologies is also accompanied by a great disparity in their lengths. As shown in Table 16 and Table 17, the longest modification refers to the frayed+stripped morphology on tool NA_10dec21_S1_T06 with 133.00 mm. The length of this modification in this tool is much higher than the sample with a similar morphological modification, with 4,00 mm (NA_10dec21_TF_S1_T10). The next most accentuated modification in the distal end is cut+stripped with about 32,00 mm, (NA_10dec21_TF_S1_T03). We must bear in mind that this greater length in this last modification is a consequence of the stripped bark, since the cut morphology, as we have seen, hardly leave any trace on the inner surface of the tool, beyond the tip. Then, frayed, and peeled morphologies (14,8 and 13,6 mm, respectively) are very close to each other (1,2 mm).

When averaging the pieces, we found that this disparity is maintained, i.e., they are not close, being the difference in invasion between the first scar (68,5 mm), with respect to the second (32,00 mm), more than half, although with respect to the last two, there is not so much difference (13,6 mm, and 7,60 mm). To a large extent among the pieces, they present a stripped bark morphology combined with an additional modification.

Modification type	MIN	MAX	MEAN	SD	%
Cut+Stripped(n= 1)	32,00	32,00	32,00	0	14,28%
Frayed (n= 3)	2,80	14,80	7,60	6,34	42,85%
Frayed+Stripped (n= 2)	4,00	133,00	68,5	64,50	28,57%
Peeled (n=1)	13,6	13,6	13,6	0	14,28%

Table 17: Table of the type of modification of the distal end. Accompanied by the minimum (MIN), maximum (MAX), mean (MEAN) and standard deviation (SD) and percentage of representation in the sample. The units, are mm.



Figure 36: Modifications of the distal end of termite fishing tools. A: Peeled (NA_TF_1feb23_S1_T01); B: Frayed (NA_TF_1feb23_S1_T02). All photos taken at 35x.



Figure 37: Modifications of the distal end of termite fishing tools. C: Frayed+Stripped (NA_TF_10dec21_S1_T06); D: Cut+Stripped (NA_10dec21_TF_S1_T03). Photos taken: C: 50x, and D:35x.

In addition, to the modifications recorded at the distal ends, we found additional marks that could be associated with the use of the tools. In one of the pieces (NA_TF_10dec21_S1_T06), there are two rectangular grooves located in the matrix of the branch (Figure 38). Similar in size. Since it was used to consume termites, it could be the result of chimpanzee chewing. Nonetheless, this hypothesis will require to analyse a more extensive set of tools to be confirmed.

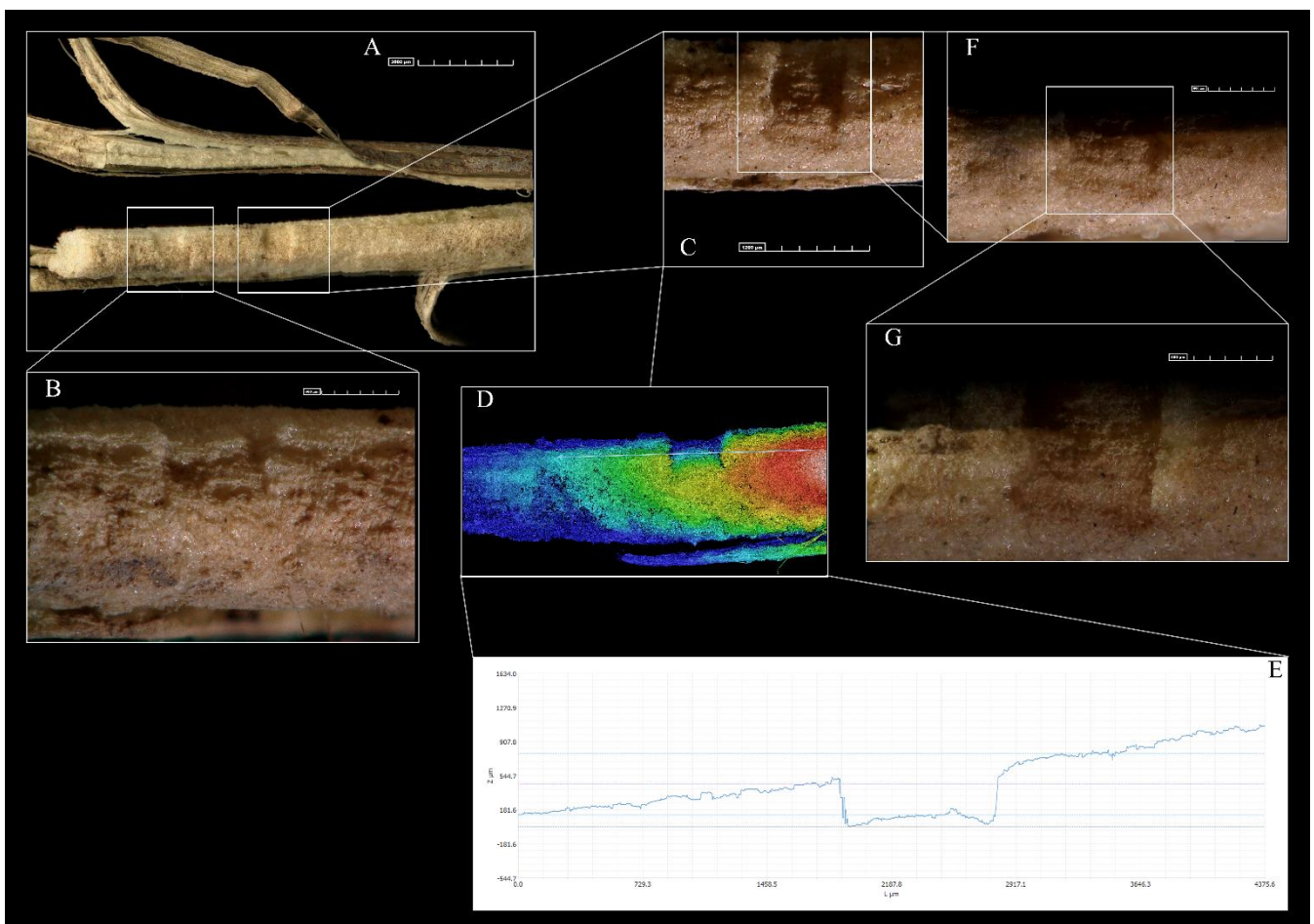


Figure 38: Wear traces in the distal end corresponded to NA_TF_10dec21_S1_T06. Photos taken with the HIROX microscope: A: 50x; B: 100x; C:50x; F: 140x; and G: 140x; and with the confocal microscope: D, and E.

Comparison between proximal and distal end modifications.

If we put all the modifications in common and observe the surface of the tool affected by the extraction and use, it is evident that the higher modifications occur at the distal ends, except for 3 cases: NA_TF_10dec21_TF_S1_T10, NA_TF_1Feb23_S1_T08, and NA_TF_1Feb23_S1_T10.

Modification type	MIN	MAX	MEAN	SD	%
Cut (1)	0	0	0	0	7,14%
Cut+Stripped (1)	32,00	32,00	32,00	0	7,14%
Stripped bark (2)	18,00	34,3	26,15	8,15	14,28%
Bent (2)	0	10,00	5,00	5,00	14,28%
Bent+Stripped (2)	11,00	13,00	12,00	1,00	14,28%
Frayed (3)	2,80	14,80	7,60	6,34	21,42%
Frayed+Stripped (2)	4,00	133,00	68,5	64,50	14,28%
Peeled (1)	13,6	13,6	13,6	0	7,14%

Table 18: Table of the types of modifications in the ant dipping tools. Accompanied by the minimum (MIN), maximum (MAX), mean (MEAN), standard deviation (SD) and percentage. The units, are mm.

As we have seen above, none of the morphologies are present at the same time in both ends. Although we do find the presence of stripped bark, both appear alone and in association with other morphologies, specifically bent (at the proximal end) or frayed (distal end).

If we order the scars based on their degree of impact on the termite fishing tools, we can establish the following classification (from lowest to highest):

CUT
CUT+STRIPPED > STRIPPED BARK
PEELED > BENT\BENT+STRIPPED > FRAYED
FRAYED+STRIPPED

Modifications at the medial part.

Manufacture peeling.

Of the termite fishing samples, we have evidence of manufacture peeling in three of them (tools: NA_10dec21_TF_S1_T10 [Figure 39A]; NA_10dec21_TF_S1_T03 [Figure 39B], and NA_TF_1feb23_S1_T10 [Figure 39C]). Most of them were performed from the distal to the proximal end. They correspond to the cleaning of sub-branches located in most of the medial surface of the samples (Figure 39D).

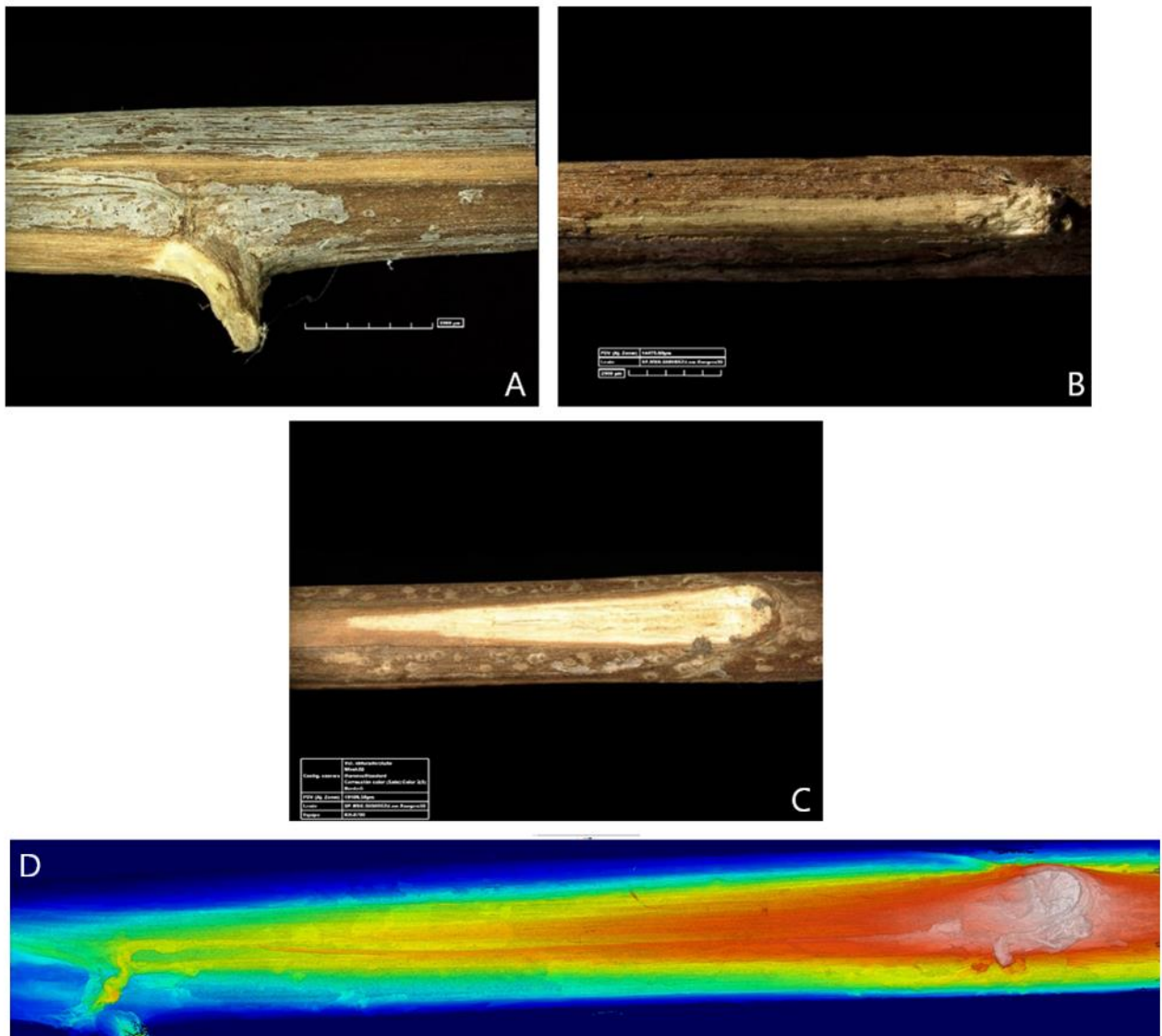


Figure 39: Details of the tools that show the scars related to the manufacture of the tools; A: NA_10dec21_TF_S1_T10; B: NA_10dec21_TF_S1_T03; C: NA_TF_1feb23_S1_T10; D: confocal image with NA_TF_1feb23_S1_T10. All photos at 35x.

Fractures.

In addition to the manufacturing marks, we also found fissures and fractures in the samples. In this case, all the pieces present at least one fracture and some of them have up to four (Table 19).

In Table 19, we can see the pieces with the associated fractures, as well as their location, and if they are not complete (Figure 40A) or complete (Figure 40B). We have representation of fractures in the three parts of the sample. But there are differences between zones, with greater representations of fractures in the distal ends. The latter have a percentage of representation of 85,71%, followed by the mesial zones with 71,42%, and finally the proximal ends with 14,28%. The most frequent presence of articular fractures was 57,14%. And the average number of fractures was 2,71 fractures per sample of termite fishing tools.

Tool ID	Fractures	Location	Complete	Non-complete
NA_10dec21_TF_S1_T03	1	Mesial	0	1
NA_10dec21_TF_S1_T10	4	Mesial-Distal	2	2
NA_TF_1Feb23_S1_T01	2	Mesial-Distal	1	1
NA_TF_1Feb23_S1_T02	4	Proximal-Distal	2	2
NA_TF_1Feb23_S1_T08	3	Mesial-Distal	2	1
NA_TF_1Feb23_S1_T10	4	Mesial-Distal	3	1
NA_10dec21_S1_T06	1	Distal	1	0

Table 19: Breakdown of fractures identified on the termite fishing tools.



Figure 40: Details of fractures in termite fishing tools. A: corresponding to non-complete fracture, NA_10dec21_TF_S1_T03. B: corresponding to complete fracture, NA_10dec21_S1_T06. Photos at 35x, and 50x respectively.

Residues.

Finally, regarding the presence of residues in the samples (Figure 41/table 20), they are minimal and were found only on two termite fishing tools (NA_TF_1Feb23_S1_T02 [Figure 42A] and NA_TF_1Feb23_S1_T10 [Figure 42B]). In both cases, these residues are soil remains located at different points, distal and proximal end respectively, whose presence may be related to soil transfer from the termite mound or from the substrate where the tools were collected.

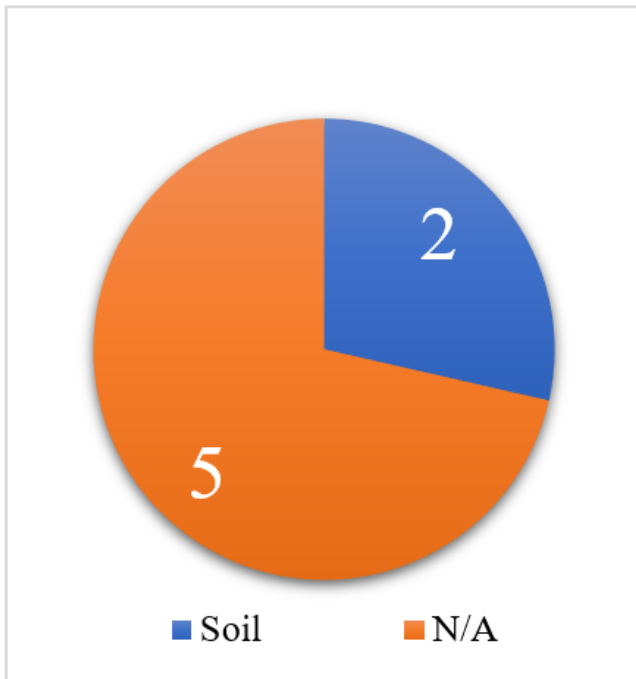


Figure 41: Type of residue found in termite-fishing tools.

Type of residue	%
Soil	28,57
No residues	71,42

Table 20: Type of residue found in termite fishing tools with percentage respect to the overall



Figure 42: Details of soil residues in termite fishing tools. A: NA_TF_1Feb23_S1_T02; and B: NA_TF_1Feb23_S1_T10. Photos at 35x.

8.1.3. Algae fishing.

Samples belonging to the algae fishing activity ($n=3$) were collected in March 2020 (Figure 43), which corresponds to the dry month. The raw material to which they were made could not be determined.



Figure 43: General view of the algae-fishing tools analysed (scale = 20 cm).

In terms of measurements, the samples have a mean digital length of 805,38 mm ($\pm 37,57$ mm) and an average weight of 13,8 grams ($\pm 5,61$ g) (Table 21/Figure 44). The morphology of all the algae fishing tools is slightly curved.

Since the lengths have a rather slightly curved morphology, there is no great difference between the measurements taken end-to-end and following the surface of the samples. Although we must consider that we are dealing with a sample of small tools.

Digital length (mm)	Min: 741,02
	Max: 871,17
	Mean: 805,38
	SD: 65,08
End-to-end length (mm)	Min: 738,77
	Max: 864,34
	Mean: 797,66
	SD: 63,145

Table 21: measures digital length (mm) and end-to-end length (mm). Accompanied by the minimum (MIN), maximum (MAX), mean (MEAN) and standard deviation (SD).

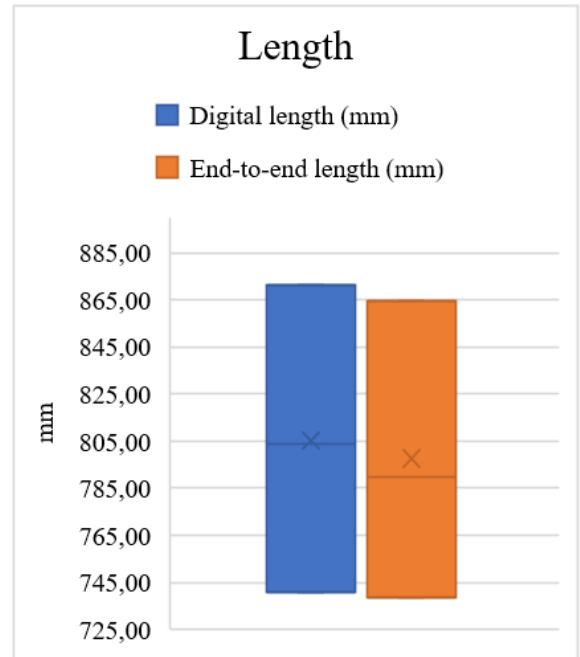


Figure 44: Box and whiskers diagram digital length (mm) and end-to-end length (mm).

As seen in Figure 45 and Table 22, the proximal, medial, and distal width of the tools shows again a great disparity between them, being the width of the medial areas the narrowest.

Proximal width (mm)	Min: 5,70
	Max: 8,90
	Mean: 7,43
	SD: 1,61
Medial width (mm)	Min: 5,50
	Max: 7,60
	Mean: 6,80
	SD: 1,135
Distal width (mm)	Min: 4,30
	Max: 7,80
	Mean: 5,96
	SD: 1,01
Weight (gr)	Min: 6,94
	Max: 24,93
	Mean: 13,8
	SD: 9,72

Table 22: thickness measurements of the proximal, distal, and medial ends accompanied by the minimum (MIN), maximum (MAX), mean (MEAN) and standard deviation (SD).

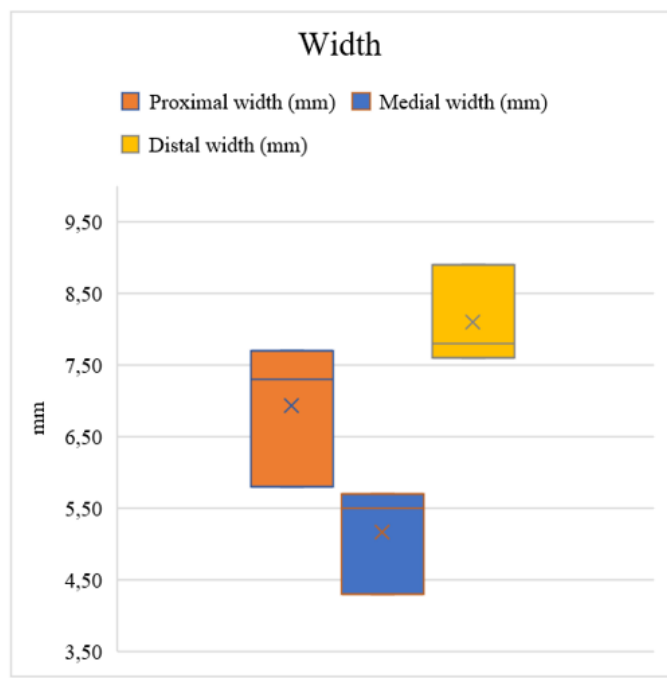


Figure 45: Box and whisker plot of proximal, medial, and distal thicknesses (mm).

Proximal end modifications.

In the proximal end (Figure 46/table 23), cut end modifications on the tools are non-invasive within the surface of the samples as we can see in tools SE_AF_19mar20_S1_T02 (Figure 47A) and SE_AF_19mar20_S2_T12 (Figure 47B). While the tool in which we found a stripped bark morphology, presents an invasive alteration in the sample (SE_AF_19mar20_S1_T05).

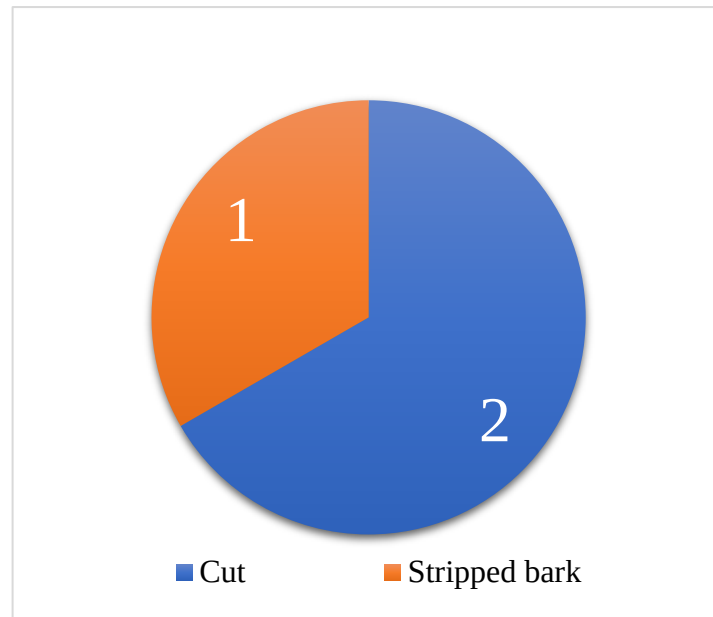


Figure 46: modification types at proximal ends in algae fishing behavior samples.

Tool ID	Proximal end modification	Modification length (mm)
SE_AF_19mar20_S1_T02	Cut	0
SE_AF_19mar20_S1_T05	Stripped bark	81
SE_AF_19mar20_S2_T12	Cut	0

Table 23: samples of algae fishing tool together with the type of modification at the proximal end and its size (mm).



Figure 47: Modifications of the proximal ends of algae fishing tools. A: Cut (SE_AF_19mar20_S1_T02); B: Cut (SE_AF_19mar20_S2_T12); C: stripped bark (SE_AF_19mar20_S1_T05). Photos at 35x.

Distal end modifications.

At the distal ends (Figure 48/table 27) we can find two types of modifications: frayed (n=2) and cut+stripped (n=1).

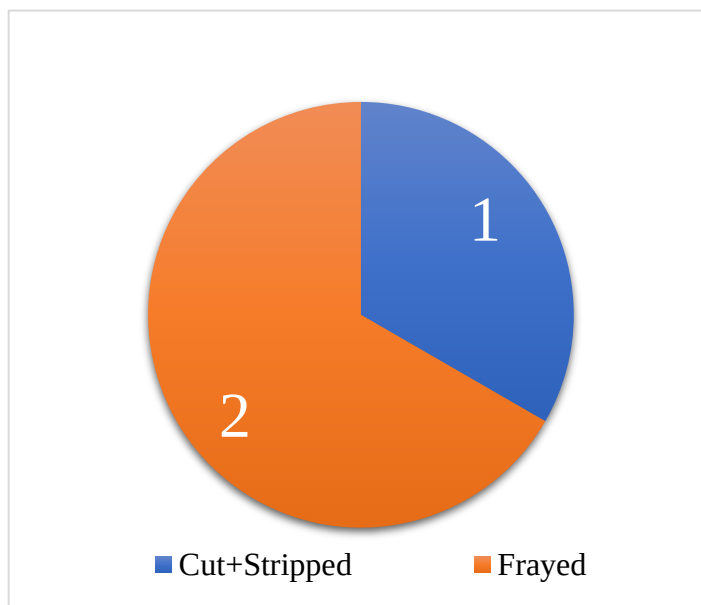


Figure 48: Figure of modification types at distal ends in algae fishing behavior samples.

Overall, the minor common modification, it is represented by the combination of cut+stripped bark with a percentage of 33,3 % (SE_AF_19mar20_S1_T02[Figure 49A]), while the remaining 66,6% of the algae fishing tools is represented by the most common, stripped bark (SE_AF_19mar20_S1_T05 [Figure 49C] and SE_AF_19mar20_S2_T12 [Figure 49B]). The measurements of the modifications (except for the one that barely has invasion in the sample), we see that it is very similar being different morphologies (Table 24).

Tool ID	Distal end modification	Modification length (mm)
SE_AF_19mar20_S1_T02	Cut+Stripped	11,00
SE_AF_19mar20_S1_T05	Frayed	10,00
SE_AF_19mar20_S2_T12	Frayed	0

Table 24: samples of algae fishing tool together with the type of modification at the distal end and its size (mm).

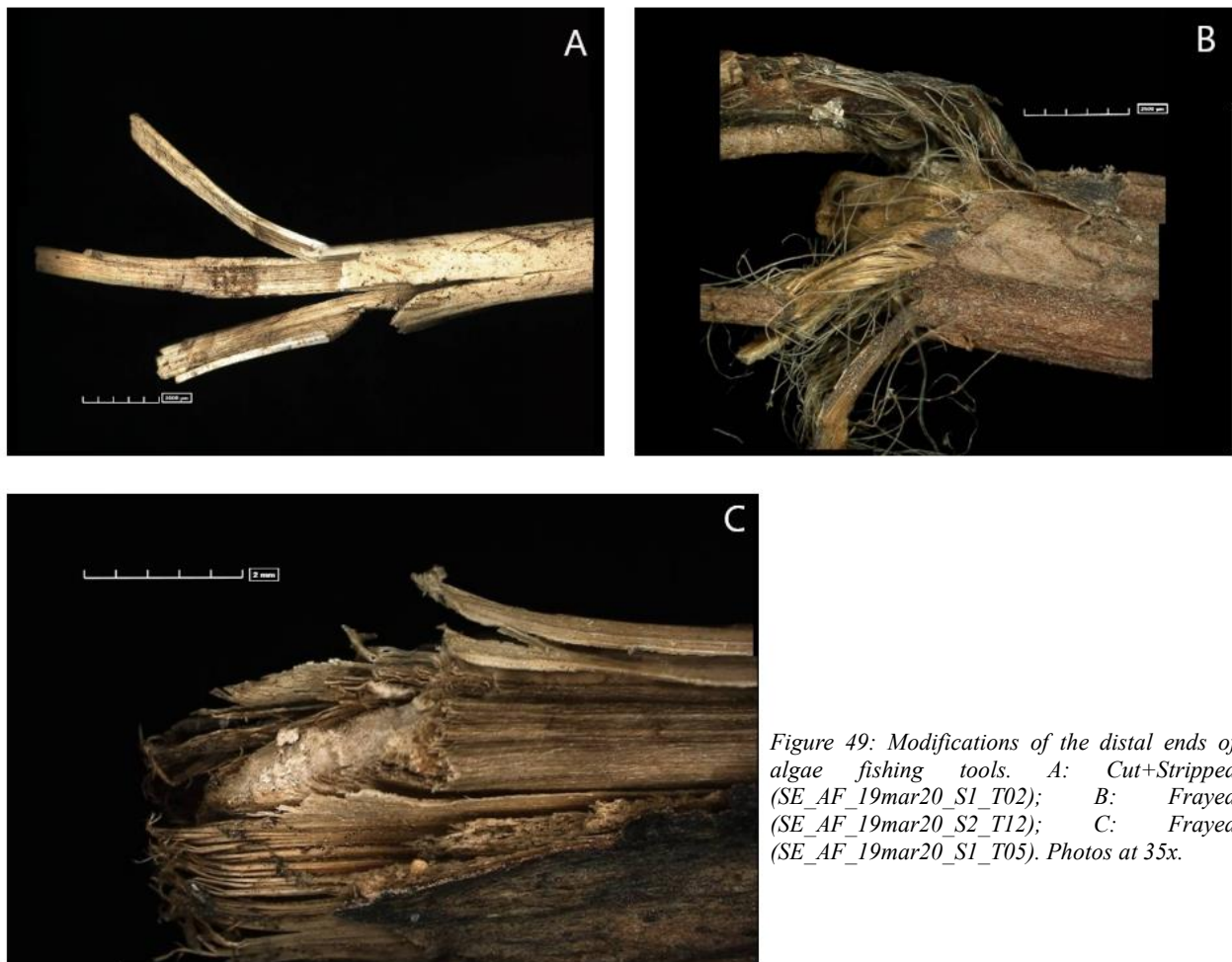


Figure 49: Modifications of the distal ends of algae fishing tools. A: Cut+Stripped (SE_AF_19mar20_S1_T02); B: Frayed (SE_AF_19mar20_S2_T12); C: Frayed (SE_AF_19mar20_S1_T05). Photos at 35x.

Comparison between proximal and distal end modifications.

In Table 25 we can see a certain diversity in which no morphology stands out. Although most of the modifications do not leave a very pronounced trace, we find in one of the cases it does occur (SE_AF_19mar20_S1_T02), reaching 81,00 mm.

	MIN	MAX	MEAN	SD	%
Cut (n=2)	0	0	0	0	33,3%
Cut+stripped (n=1)	11,00	11,00	11,00	0	16,6%
Frayed (n=2)	0	10,00	5,00	7,07	33,3%
Stripped bark (n=1)	81,00	81,00	81,00	0	16,6%

Table 25: Type of modifications recognized in the algae fishing tools. Accompanied by the minimum (MIN), maximum (MAX), mean (MEAN), standard deviation (SD) and percentage.

In Figure 50, we can see that the deepest traces are found in the proximal ends mainly when the tools have stripped bark. But if we compare it among the three tools, the distal ends have a greater representation (n=2), because in the proximal ends we have cut in two of them, and it is not too invasive.

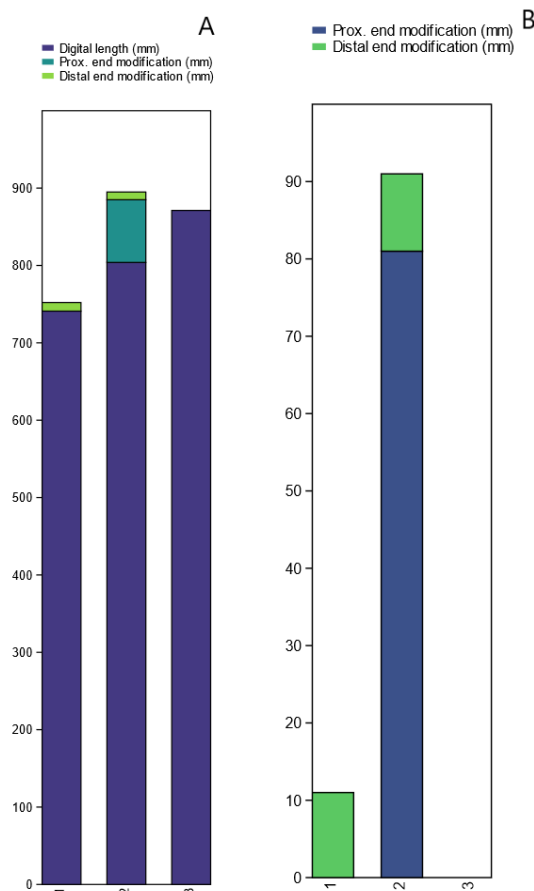


Figure 50: Comparisson between the lengths of the modifications of the algae fishing tools. A: modifications of PP, DP; B: the digital length; and right: only modifications PP and DP. X: mm; Y: pieces, in order of table 25.

Modifications at the medial part.

Manufacture peeling.

It is notable to indicate that we did not find manufacturing scars in the Algae fishing performance samples, most likely related to the fact that the plant chose did not bear any leaves or sub-branches to be removed before the use of the tool.

Fractures.

As for the fractures associated with the algae fishing samples (n=3), we only found evidence in one of them: SE_AF_19mar20_S2_T12 (Figure 51). As shown on Table 26 there is an almost non-existent presence of fractures found in the samples of the algae fishing behavior. The representation of fractures is 33% on average over the entire sample of algae fishing.

Tool ID	Fractures	Location	Complete	Non-complete
SE_AF_19mar20_S1_T02	0	-	0	0
SE_AF_19mar20_S1_T05	0	-	0	0
SE_AF_19mar20_S2_T12	1	Distal	1	0

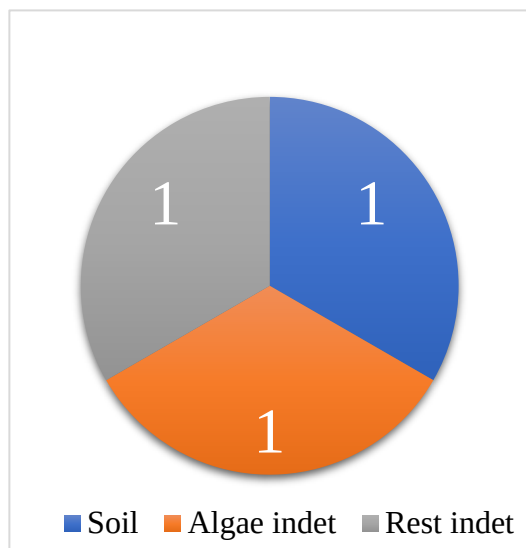
Table 26: algae fishing with the fracture, location, and the status.



Figure 51: Photographs of fractures found in algae fishing tools. Correspond to SE_AF_19mar20_S2_T12. Made by HIROX KH-8700

Residues.

In terms of the residues found in the samples, we see a high representation (Figure 53/table 27) of them despite the small number of tools analysed. Of the three samples, we found representation in two of them (SE_AF_19mar20_S1_T02 [Figure 54] and SE_AF_19mar20_S1_T05 [Figure 55C]). In them, we have evidenced the presence of algae, and the presence of soil respectively.



Type of residue	%
Soil	33,3%
Algae indet	33,3%
Rest indet	33,3%

Table 27: Type of residue found in algae fishing tools with percentage respect to the overall

Figure 53: Type of residue found in algae fishing tools.

In Table 28, we can observe the diversity of residues found in the samples, being the algae and soil, the most outstanding. We have also included the undetermined remains found at the proximal end of SE_AF_19mar20_S2_T12 (Figure 55, A-B). It could not be determined whether it was an exogenous element non-related to the use of the artefact. In any case, we have evidenced its presence in one of the samples, and that could highlight an exceptionality.

Tool ID	Type residue	Species	Location
SE_AF_19mar20_S1_T02	Algae	Algae indeterminate	Distal-Mesial
SE_AF_19mar20_S1_T05	Soil	Soil	Distal-Mesial
SE_AF_19mar20_S2_T12	Rest indet	-	Proximal

Table 28: algae fishing tools with the type of residue, species, and location.



Figure 54: Details of the residues in algae fishing tool, SE_AF_19mar20_S1_T02). Taken at 35x.



Figure 55: photographs of residues in algae fishing tools; A-B: corresponding to rest indeterminate (SE_AF_19mar20_S2_T12); C: rest of soil in distal end (SE_AF_19mar20_S1_T05).

8.1.4. General results.

Considering the whole assemblage of perishable tools analysed from Dindefelo, (n=21) we see that, morphologically, they tend to be curved (n=12) and slightly curved (n=9). Among them, it was possible to determine the use of four plant raw materials (Figure 56).

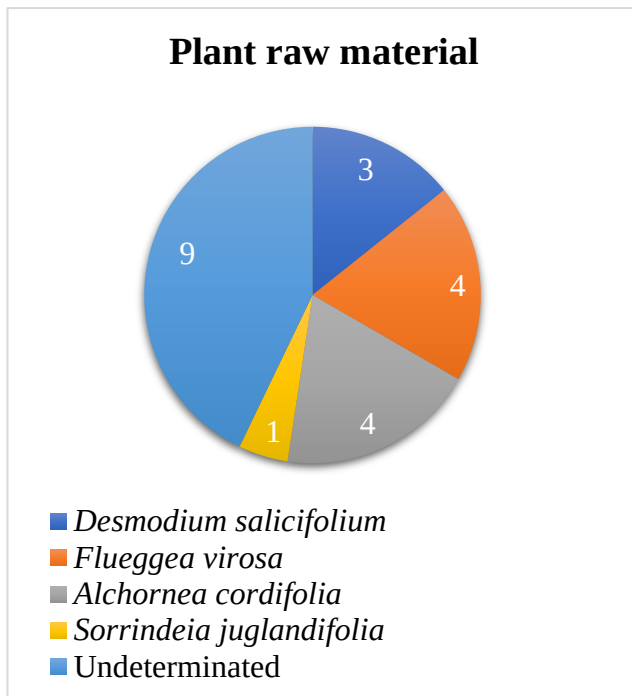


Figure 56: Overall results from Dindefelo materials. Corresponding to plant raw material identified and non-identified.

Regarding their general dimensions, we did not find major differences between digital length and end-to-end length, but it gives a more accurate result the use of the digital length, as it follows the real shape of the samples. As shown in Figure 57 and Table 29, we can observe the average between both techniques, which differs in less than 20 mm (SD = 4 mm). This difference between the two measurements might be considered insignificant but they are illustrative of how the morphology and the curvature of the tools affect the maximum length of the tools. In fact, the curvature of the tools contributes somehow to the activity, acting either as a hook or to introduce it through holes with sinuous channels.

Digital length (mm)	Min: 259,12
	Max: 871,17
	Mean: 619,95
	SD: 208,93
End-to-end length (mm)	Min: 248,11
	Max: 864,34
	Mean: 599,58
	SD: 204,47

Table 29: Digital length (mm) and end-to-end length (mm) Dindefelo materials, accompanied by the minimum (MIN), maximum (MAX), mean (MEAN) and standard deviation (SD).

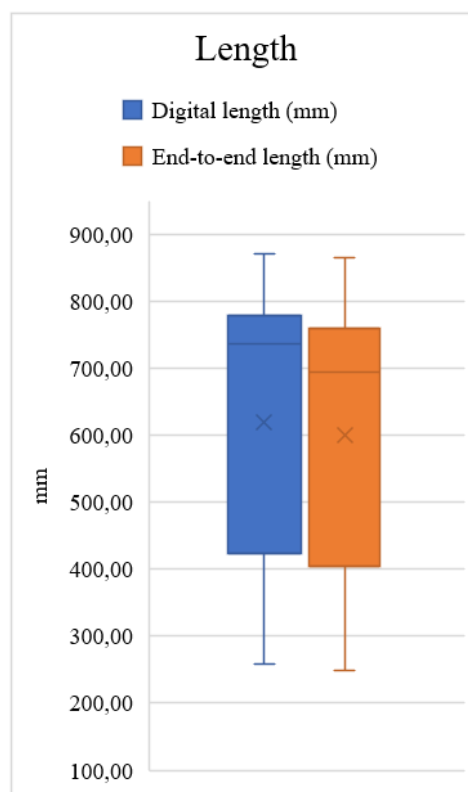


Figure 57: Box and whisker plot of digital length and end-to-end length (mm).

If we compare the measurements (both taken by digital length and end-to-end by activity, we find that there is a not significant difference between activities in relation to the measurements obtained by both type of measurements (Kruskal-Wallis test, $p= 0,003$ for both techniques measuresment). However, there is a statistical significant difference when comparing the measurements of the ant-dipping, and algae-fishing tools (Kruskal-Wallis test, $p= 0,913$). If we look at the average of the tools of both activities, we have that average per digital length (mm) of ant-dipping is 713,37 mm, and that of algae fishing 805,38 mm, and therefore a difference of 92,01 mm. While if we look at the end-to-end measurements (mm): in ant-dipping is 686,38 mm, and in algae fishing is 797,66 mm, and therefore a difference of 111,28 mm. Thus, we found a large difference between the two, which could be due to the small amount of samples to be compared (Annex 1)

As for the width and weight (Table 30, and Figure 57) of the samples, we have seen that the greatest width corresponds to the proximal ends, followed by the medial ends with the distal ends having the thinnest areas. The average width starts at 5,23 mm; in the medial zone, it is 4,45 mm; and finally at the distal end we find 4,01 mm.

Proximal width (mm)	Min: 3,1
	Max: 8,9
	Mean: 5,23
	SD: 1,74
Medial width (mm)	Min: 2,10
	Max: 7,6
	Mean: 4,45
	SD: 1,73
Distal width (mm)	Min: 1,70
	Max: 7,80
	Mean: 4,01
	SD: 1,58
Weight (gr)	Min: 0,53
	Max: 24,93
	Mean: 5,46
	SD: 5,53

Table 30: thickness measurements of the proximal, distal, and medial ends accompanied by the minimum (MIN), maximum (MAX), mean (MEAN) and standard deviation (SD).

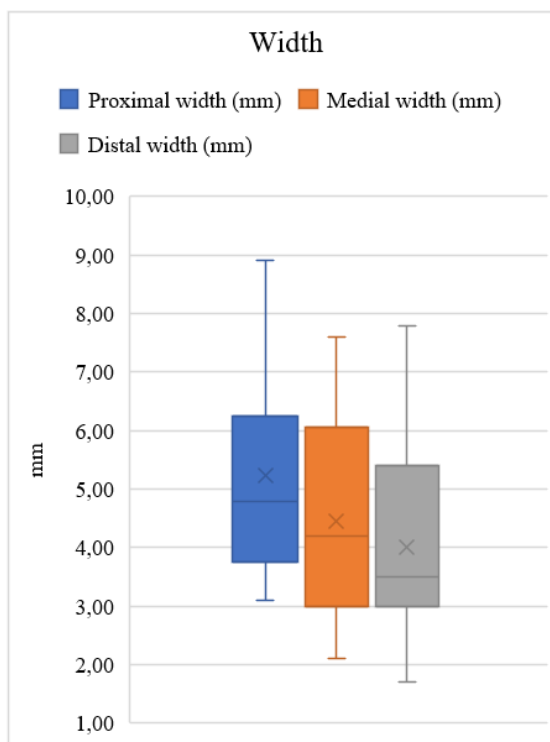


Figure 57: Box and whisker plot diagram of the proximal, medial, and distal thicknesses (mm). From all Dindefelo materials.

Seeing these differences, we wondered if there would be some kind of differentiation by type of activity at the proximal and distal ends. From these data, we obtain (Annex 2):

- At the proximal ends there is no significant difference between the width when comparing the tools of the three activities (Kruskal-Wallis test, $p=0,009$). However, we find statistical differences between the termite-fishing and ant-dipping tools (Kruskal-Wallis test, $p=0,071$), as well as between ant-dipping and algae fishing (Kruskal-Wallis test, $p=0,560$).
- At the distal end, again in general terms, there are not statistically significant difference (Kruskal-Wallis test, $p=0,003$). However, there are differences between ant-dipping and algae fishing (Kruskal-Wallis test, $p=0,912$).

Regarding the tool weight, we see marked differences between the minimum (0,53 g) and the maximum (24,93 g), with a mean weight of 5,46 g. If we make a comparison between the tool weight variable according to the activity for which it was used, we obtain that there is no significant difference on the weight based on the activity (Kruskal-Wallis test, $p=0,001$). Therefore, we cannot affirm that the chimpanzees selected the tools based on their weight. However, there is a significant difference between the tools that were used for ant fishing and algae fishing (Kruskal-Wallis test, $p=0,607$). Therefore, there must be other factors influencing the weight, which could be the species used, and/or the length of the tool. The very limited sample on which we are relying must also be taken into account (Annex 3).

Proximal end modifications.

From the point of view of the modifications (Table 31/figure 58) that we found in the tools of the three activities, we have great diversity, but there are certain morphologies that have a predominance over others. We start with the most common: stripped bark has a representation in the set of 38,09% (n=8), appearing either as a sole modification or in combination with another type (e.g., bent+stripped). It has been found in 66,65% (n=14) combined with other modifications. The next in representation is the cut end modification with 23,8% (n=5), which is also be found in combination with stripped bark, representing a total of 38,08% (n=8). The latter is next in the list is cut+stripped with 14,28% (n=3). Then we move on to the modifications of bent (n=2), as well as its combination with stripped bark (n=2), with equal representation: 14,28% (unique), and combined (28,56%). Finally, and with a single representation, we have frayed end that represent 4,76%.

Modification type	N	%
Stripped bark	8	38,09%
Bent stripped	2	9,52%
Cut	5	23,8%
Frayed+stripped	1	4,76%
Cut+stripped	3	14,28%
Bent	2	9,52%

Table 31: type of modifications in proximal ends, with number, and % in overall.

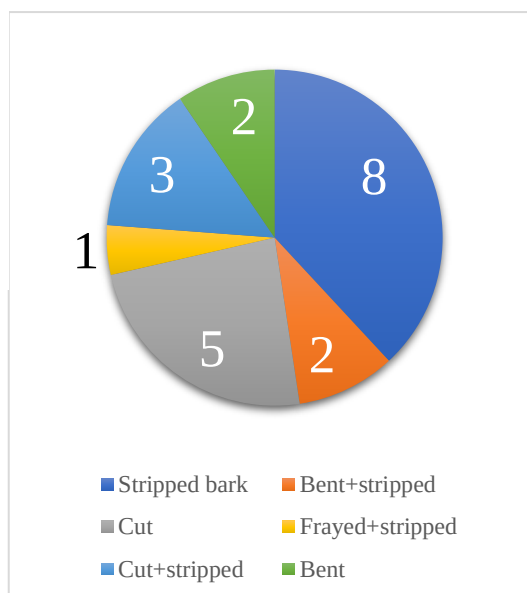


Figure 58: Types of modifications in proximal ends of the Dindefelo's samples

If we now plot the basic statistics of the lengths of these modifications (Table 32), we can observe a big difference in the length of the modifications. Si observamos la media de las modificaciones del extremo proximal, encontramos una gran diferencia entre ellas, en términos de espectros, puesto que observamos una media en Bent de 5,00 mm, mientras que encontramos una media en cut+stripped de hasta 202,03 mm. If we disregard the type of cut modification (0 mm), we have two distinct large poles, with those modifications that have an average less than 15 mm, which are close to each other, namely bent (5,00 mm), frayed+stripped (11,90 mm), and bent+stripped (12,00 mm). In the middle, we would find Stripped bark with an average greater than 50 mm (53,28

mm), which falls between this first group under 15,00 mm and the larger one we have. The latter, with an average of 202,03 mm, is associated with cut+stripped.

If we order from lowest to highest impact of the modification length on the tool surface at the proximal end, we have the following classification (from lowest to highest using the average values of Table 32).

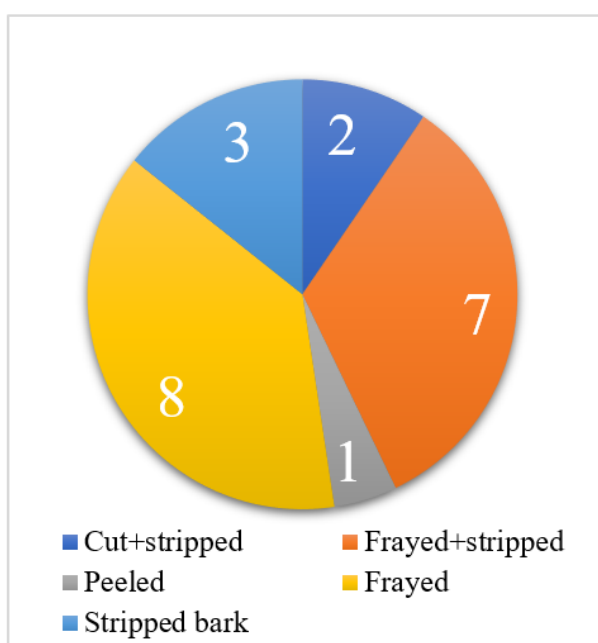
Modification type	MIN (mm)	MAX (mm)	MEAN (mm)	SD (mm)
Stripped bark (n=8)	18,00	131,5	53,28	36,72
Bent stripped (n=2)	11,00	13	12,00	1,141
Cut (n=5)	0	0	0	0
Frayed+stripped (n=1)	11,90	11,90	11,90	0
Cut+stripped (n=3)	118,00	331,00	202,03	113,38
Bent (n=2)	0	10,00	5,00	7,07

Table 32: Modifications in the proximal ends and their impact on the tools.

CUT > BENT > FRAYED+STRIPPED > BENT STRIPPED > STRIPPED BARK > CUT+STRIPPED.

Distal end modifications.

The diversity (Figure 59, and Table 33) that we find here is somewhat less than what we have seen in the proximal end, the modifications that we find on the distal ends are associated with the phase of use of the tools. We have that the most represented modification is the frayed end with 38,09% (n=8), and it is followed by this same modification in combination with stripped bark represented by 33,33% (n=7). Therefore, we have that the combination of both add up to 15 representations of a total of 21 instruments, being 71,36%. This is followed by the stripped bark modification with 14,28% (n=3), being far from the representation we have at the opposite extreme. Then we find the case of the cut end modification together with stripped bark, 9,52% (n=2). And finally, peeled with up to 4,76% (n=1).



Modification type	N	%
Cut+stripped	2	9,52%
Peeled	1	4,76%
Stripped bark	3	14,28%
Frayed	8	38,09%
Frayed+stripped	7	33,33%

Figure 33: types of modifications in distal ends of the Dindefelo's samples.

Figure 59: Types of modifications in distal ends of the Dindefelo's samples.

If we now look at the invasiveness of the modifications at the distal ends occurred during the use phase (Table 33), we find similarities in the minimum values, the largest being 13,6 mm (peeled), followed by two similar measurements 11,00 mm (cut+stripped, and stripped bark), followed by 4,00 mm (frayed+stripped), and ending in a combined modification with hardly any modification (frayed). Regarding the maximum values, the highest would correspond to frayed+stripped (218,00 mm), followed by stripped bark (170,00 mm), frayed (60,2 mm), cut+stripped (32,00 mm), and finally peeled (13,6 mm). It may seem strange that there is so much difference between modifications with stripped bark, but we must take into account the diversity of species, the behavior of their fibers as well as the total length of the instruments. As for the mean values, we have two well-differentiated groups: 1) the first one formed by those modifications with lengths less than 21,5 mm, and close to each other by only 10,00 mm (cut+stripped, peeled, and frayed); 2) while the other group would be

formed by those modifications that invade more than 70,00 mm (stripped bark, and frayed+stripped). Here we would see a certain relationship between modifications that have stripped bark, directly or indirectly.

Modification type	MIN (mm)	MAX (mm)	MEAN (mm)	SD (mm)
Cut+stripped (n=2)	11,00	32,00	21,5	14,84
Peeled (n=1)	13,6	13,6	13,6	0
Stripped bark (n=3)	11,00	170,00	71,03	86,35
Frayed (n=8)	0	60,2	13,51	19,40
Frayed+Stripped (n=7)	4,00	218,00	85,28	99,01

Table 34: Type of modifications in distal ends and their impact on the tools.

But if we compare the measurements of the modifications that have been produced by the type of activity for which they were used, we find a statistical significant difference the length of the modifications at the proximal ends across activities (Kruskal-Wallis test, $p= 0,102$). These differences are maintained if we compare the terminte fishing and the ant-dipping tools (Kruskal-Wallis test, $p= 0,160$) and, between the algae fishing and termite fishing tools (Kruskal-Wallis test, $p= 1,000$). This may be because we have a large diversity of modifications in a low number of samples (Annex 4). Similarly, at the distal ends we also found significan diffences in the length of the modifications (Kruskal-Wallis test, $p= 0,232$).

When comparing the length of the modifications and their type, we see that at the proximal ends (Annex 4), we find that there is no significant differentiation between the types of modifications and the invasion lengths (Kruskal-Wallis test, $p= 0,003$). On the contrary, on the distal ends, we find a significant difference (Kruskal-Wallis test, $p= 0,323$) between the type and the modification length.

We can visually see by proportions of invasion on the same specimen (Figure 60), at a glance, we can observe that by proportions, some of the samples hardly show any representation, as is the case of the termite fishing tools, or algae fishing, being the ones with the highest representation over the total surface in ant-dipping.

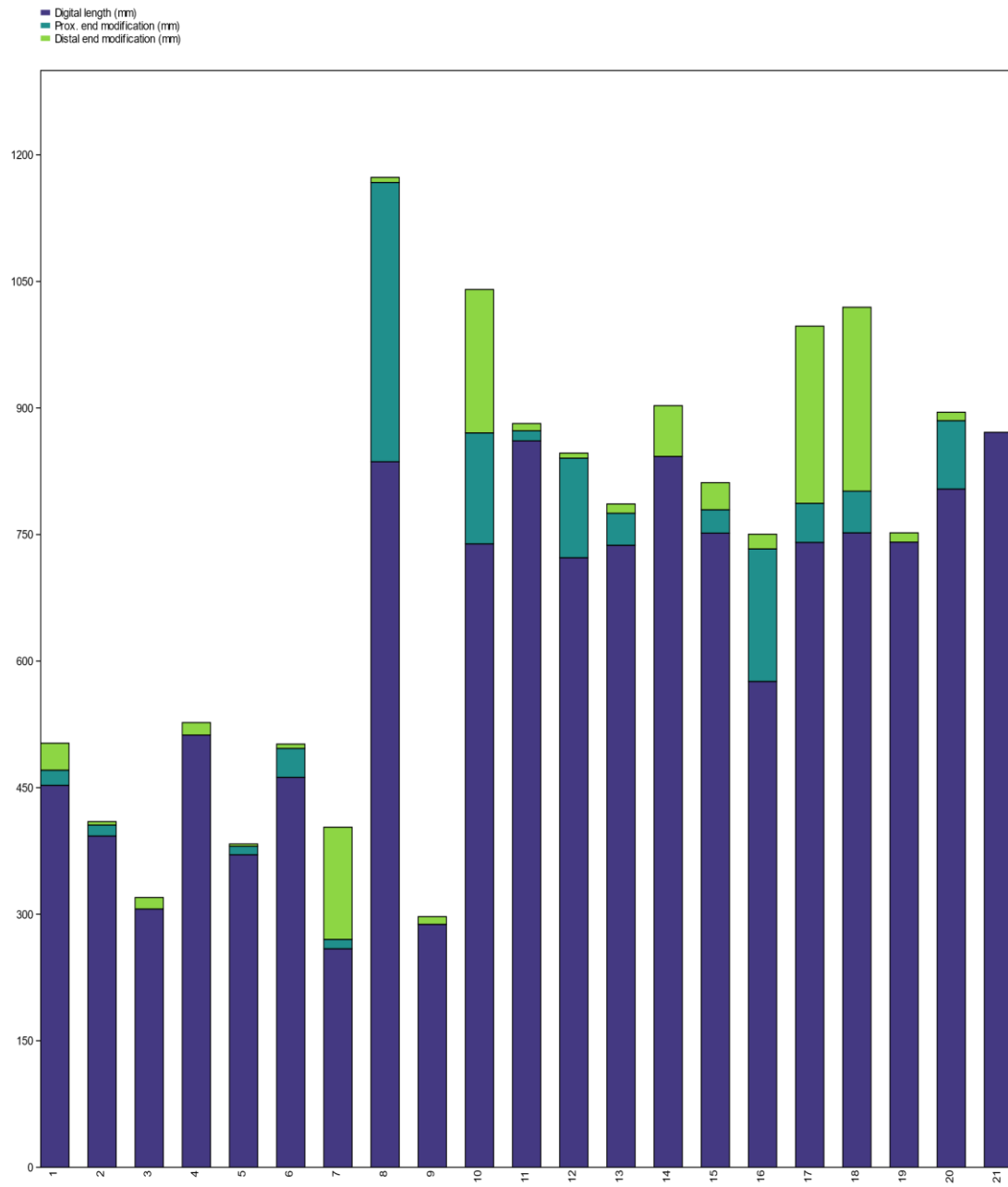


Figure 60: Stacked bar with the length (Digital length, mm) of the sample with the length of the scars in ends, proximal and distal. X-axis: representing by the samples; 1-7: termite fishing; 8-18: ant-dipping; and last three for algae fishing; Y-axis: mm.

Modifications at the medial part.

Manufacture peeling.

Regarding the manufacture scars identified in the samples, they are present in a total of 5 of them. Three of them correspond to the termite fishing samples, and the last two to the ant-fishing samples. All of them have been produced in the direction from distal to proximal end, and would be related to the phase before (manufacture) to the use.

Fractures.

Of the 21 samples, we have evidence of fractures in 18 of them. We identified a total of 46 fractures. The minimum is one fracture, and the maximum of fractures present on a single tool is 6 (with an average of 2,19 fractures, Table 35). We can see that the behavior that presents more representation in fractures is termite fishing, even not having the highest number of samples. And having the best spectro between the number of fractures (0-6 fractures), i.e., we have pieces without any fracture, and the maximum would be 6 in the same sample. After this one, we find the ant-dipping with the major mean in overall. And finally with the algae fishing with only a sample with fracture, constituting 2,17% of all fractures.

Activity	MIN	MAX	MEAN	SD	SUM	PER
Ant-Dipping (n=11)	1	4	2,71	1,38	19	41,30%
Termite Fishing (n=7)	0	6	2,36	1,62	26	56,52%
Algae-Fishing (n=3)	0	1	0,33	0,57	1	2,17%

Table 35: numbers of fractures per behavior, accompanied by minimum (MIN); Maximum (MAX); Mean (MEAN); and Standard deviation (SD).

8.2. Results of the experimental program.

The field experimentation was conducted between June 15th, 2023, and June 21st, 2023. We have divided the presentation of their results into three parts, conducting an analysis of the tools at each stage of the experimental program:

- 1st Part: Tool extraction.
- 2nd Part: Tool manufacture.
- 3rd Part: Tool use.

8.2.1. 1st Part. Tool extraction.

During this stage, we collected 20 samples from each zone (Francolí river and Aqueduct Forest) that include different species of the Mediterranean ecosystem (Figure 61). All twigs were recovered the same day.

The diversity of plant types used for the experimentation allows us to have a solid base to understand the properties of the twigs during their use. of each species we collected two samples, except in the case of *Arundo donax* L., *Hirschfeldia incana*, *Tamarix gallica*, *Schinus molle* L., which were collected up to 4 samples (Figure 61).

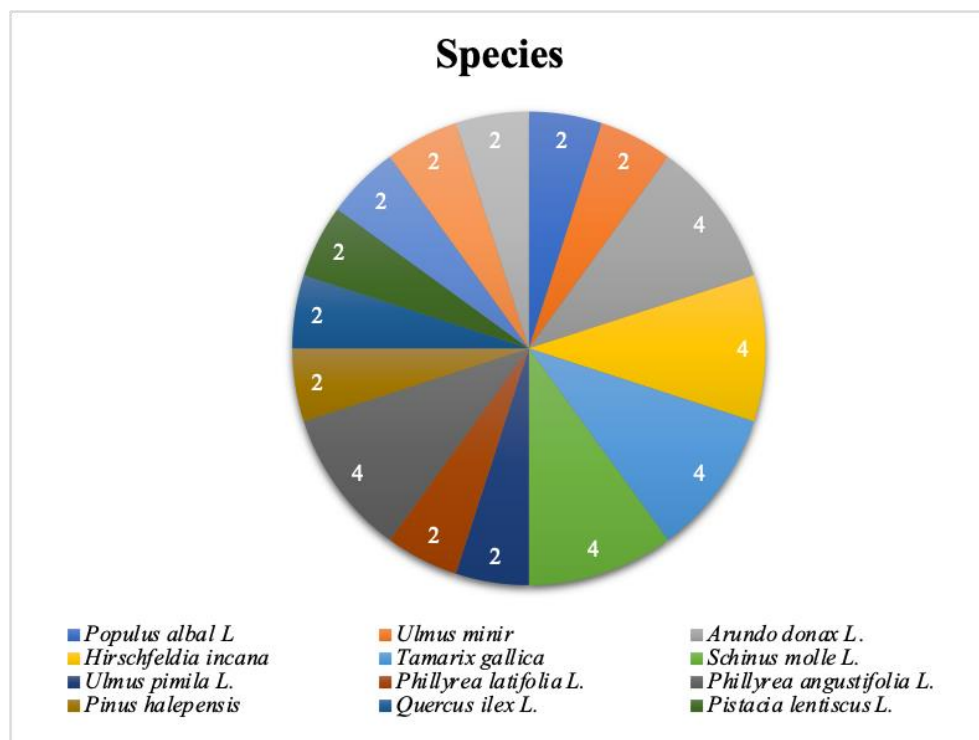


Figure 61. Species recollected during first part of the experimental program, in Francolí's river and Aqueduct Forest.

Techniques and time.

During the experiment, we computed the time and documented the gestures employed to extract the samples from the plant tree.

The extraction time was measured right before initiating the first bidirectional movements, which overlapped with additional motions. The unidirectional movement was applied to extract twigs

that were thin and easy to detach (Figure 62). And therefore, the second one, repetitive movements in both directions, would be the consequence of the resistance of the fibers to be pulled out.



Figure 62: Photos that shows the process of extraction of stick, the gest, and some results, like we can see in the last pictures, with stripped bark caused.

As for the time taken to extract the samples, it ranges from less than one second (0,53 seconds) to 46,33 seconds. Being the average of about 5,4 seconds (SD = 8,79 seconds) (Figure 63)

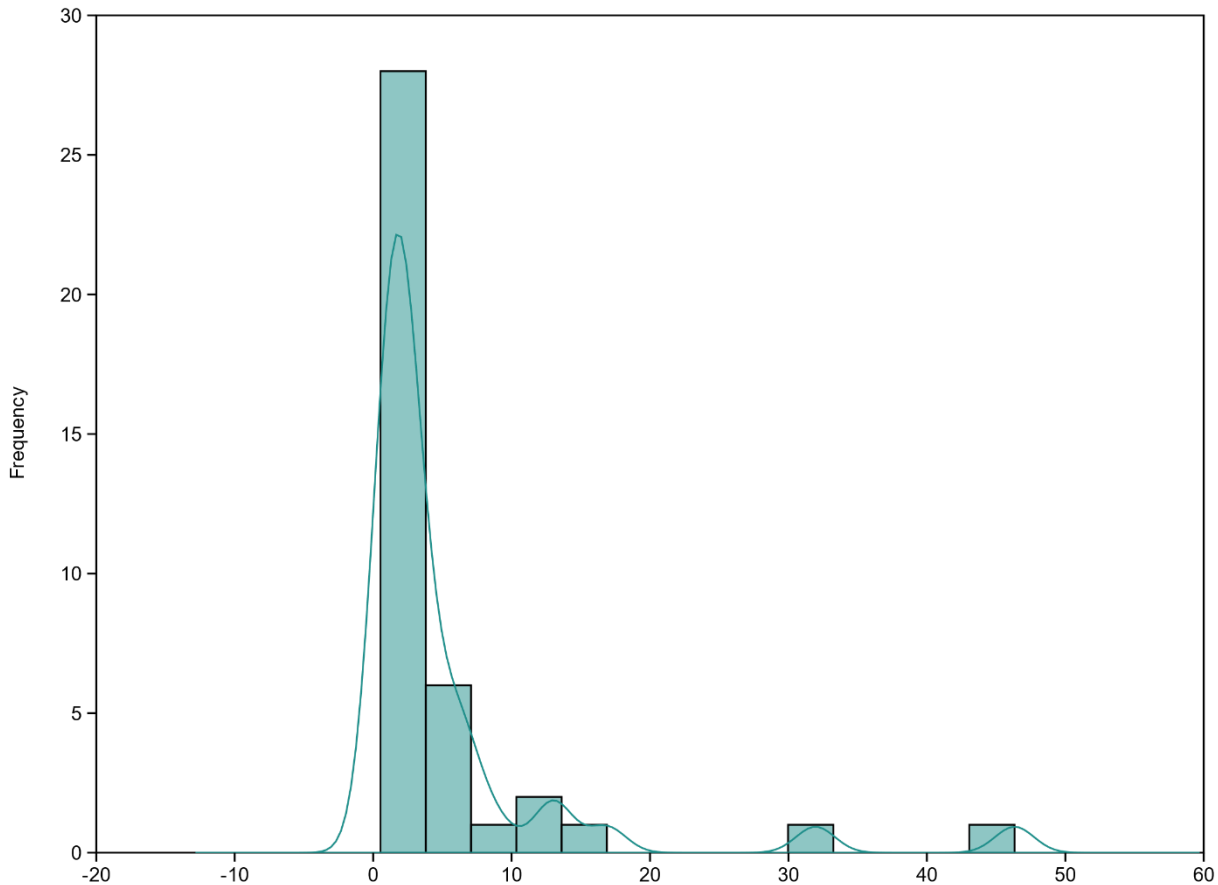


Figure 63: Histogram of the frequency of tool extraction, together with the time of the experimental program samples. X: time in seconds, and Y: number of samples.

Regarding the gestures required to extract the twigs, 29 of them needed a single movement, while 11 required repetitive bidirectional movement until they were extracted.

If we correlate the type of gesture to the width of the proximal end, we can see two different groups, marked by unidirectional and bidirectional gestures (Figure 64).

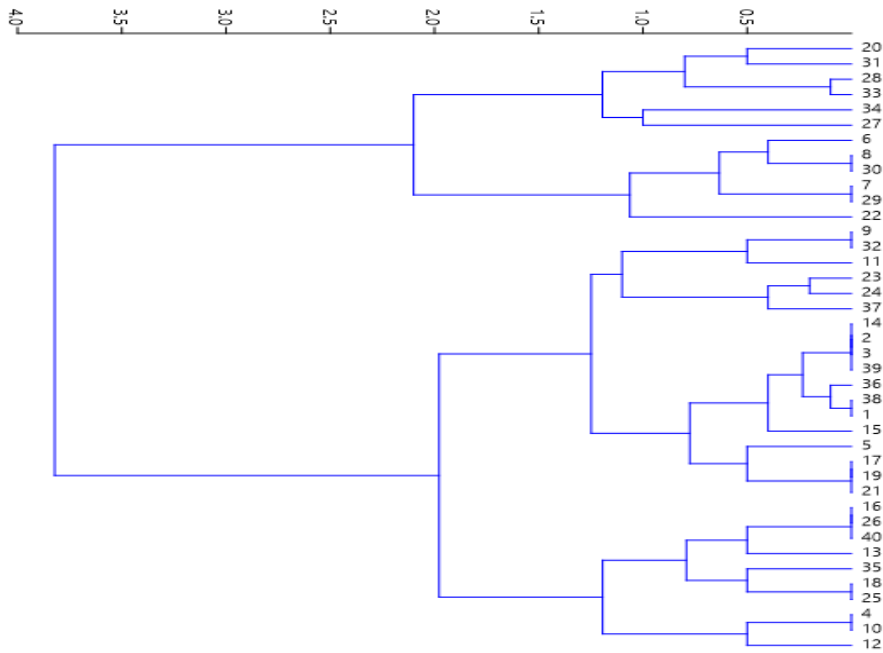
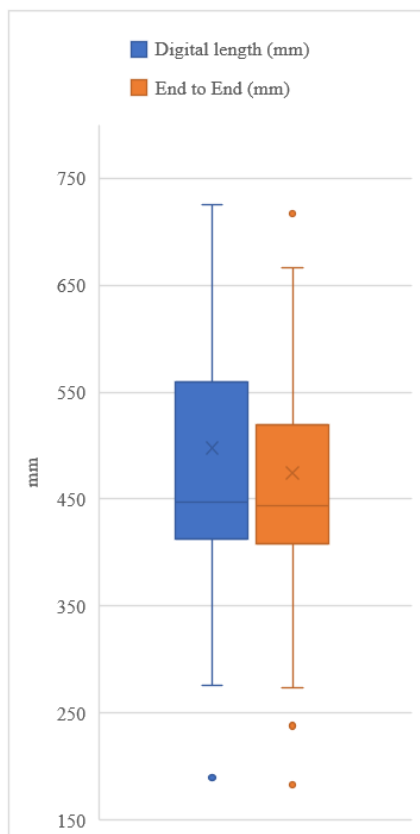


Figure 64: Analysis by cluster between gest unidirectional or bidirectional, and the width in proximal end.

General dimensions.

In Figure 65 and Table 36, we can see that in general the differentiation between the digital and the end-to-end measurements do not differ much on average. We cannot say the same for the total lengths shown by certain pieces, where the differences are mainly caused by their curvature.



Digital length (mm)	Min: 189,73
	Max: 1261,51
	Mean: 497,49
	SD: 189,24
End-to-end length (mm)	Min: 183,08
	Max: 1011,91
	Mean: 474,46
	SD: 161,19

Table 36: measures digital length (mm) and end-to-end length (mm) of experimental samples. Accompanied by the minimum (MIN), maximum (MAX), mean (MEAN) and standard deviation (SD).

Figure 65: Box and whiskers diagram digital length (mm) and end-to-end length (mm).

As for the width of the samples, Table 37 shows the differentiation between the different thicknesses of the experimental tools. Again, the parts with the greatest width are those located at the proximal ends (PW), followed by the medial zones (MW), and finally the distal zones (DW). Since the proximal zones are the parts from which the rest of the branch grows, and connects it to the trunk, it is normal for them to be somewhat thicker. We also see additional differences between the maximum and minimum (Figure 67, there is no proportionality as we would see in the calculation of the mean, i.e., between the PW and MW, we have a 1 mm difference. Whereas between MW and DW, it is less than 1 mm, at the minimum, and more than 1 mm at the maximum).

Proximal width (mm)	Min: 2,00
	Max: 9,10
	Mean: 4,96
	SD: 2,03
Medial width (mm)	Min: 1,00
	Max: 8,10
	Mean: 4,58
	SD: 1,73
Distal width (mm)	Min: 0,50
	Max: 6,50
	Mean: 3,12
	SD: 1,35

Table 37: thickness measurements of the proximal, distal, and medial ends accompanied by the minimum (MIN), maximum (MAX), mean (MEAN) and standard deviation (SD) of experimental program.

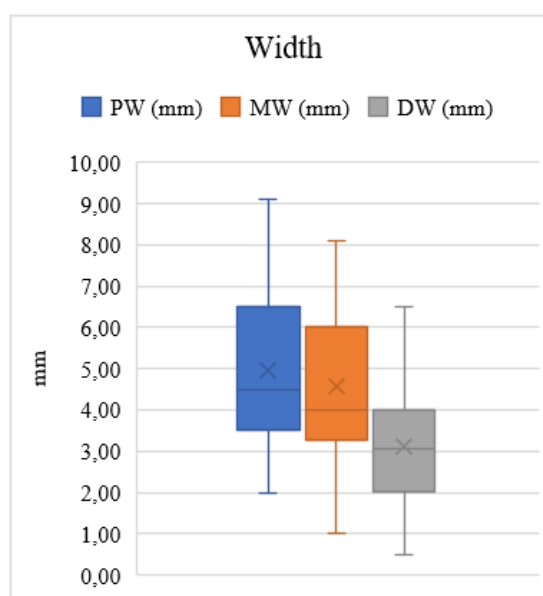


Figure 66: Box and whisker plot diagram of the proximal, medial, and distal thicknesses (mm).

Proximal end modifications.

The modifications caused by the extraction of the tools and found at the proximal ends of the samples are mostly linked to stripped bark modifications (n=20), followed by frayed+stripped (n=9), cut end+stripped (n=4), cut (n=4), and bended+stripped (n=3) (Figure 67 and Table 38).

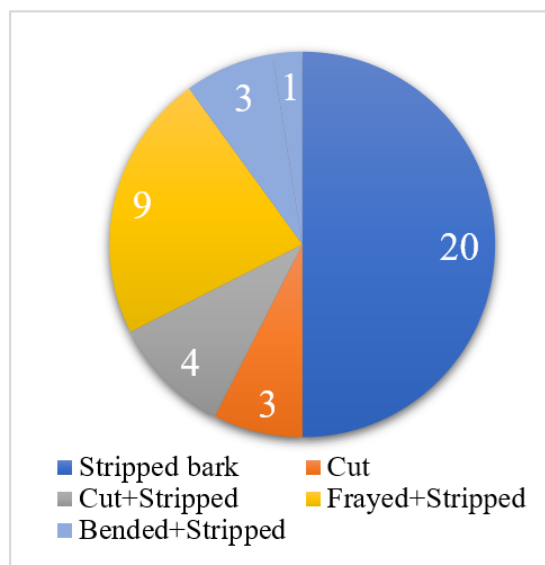


Figure 67: Distribution type of modification in proximal end.

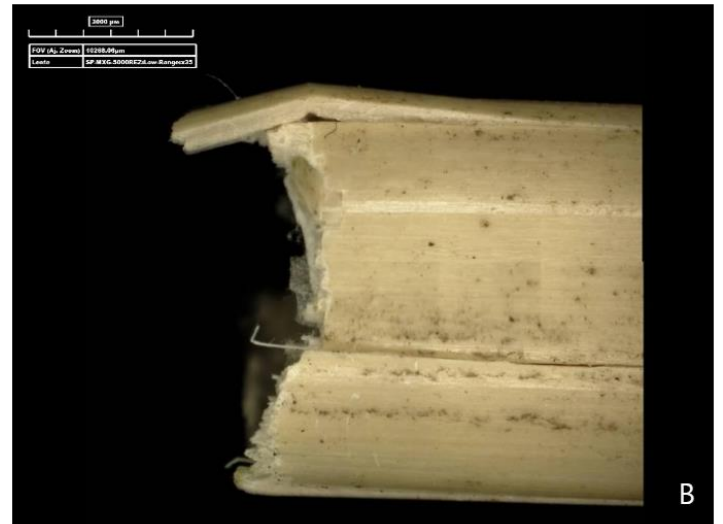
N=40	MIN(mm)	MAX(mm)	MEAN(mm)	SD(mm)	%
Stripped bark (N= 20)	5,00	235,00	45,33	57,87	50%
Cut+Stripped (N= 4)	6,50	19,50	14,50	6,09	10%
Cut (N=4)	0	0	0	0	10%
Frayed+Stripped (N= 9)	9,50	119,00	58,33	12,36	22,5%
Bended+Stripped (N=3)	7,00	22,5	12,36	8,78	7,5%

Table 38: thickness measurements of the proximal, distal, and medial ends accompanied by the minimum (MIN), maximum (MAX), mean (MEAN) and standard deviation (SD) of experimental program.

Overall, we see different type of modifications: bended (7,5%; Figure 68A), cut (10%; Figure 68B), cut end is present only in 10% of the tools (Figure 68C), frayed (22,5%; Figure 68D-F), and stripped bar (Figure 68E) in the proximal ends of the tools is a consequence of their extraction, this latter modification is reaching the 50% of presence in tools. Furthermore, we can observe that in other cases, stripped bark is accompanied by other stigmas. Therefore, we can say that the generation of this type of scar (stripped bark) is very common.

As some of these scars will be modified using the proximal ends during the last phase of the experiment (utilization), we will be able to know the extent of the change that affected the tool.

If we compare the type of modification (Annex 5) produced after the extraction process, together with the length invaded within the inner surface of the piece. The Kruskal-Wallis test shows that there is no significant difference ($p=0,003$) between modifications. However, if we look case by case, we find significant differences between the various types ($p=1,000$). Similar data when comparing cut-stripped ($p=0,15$). But we there it is not significant differences between cut-frayed+stripped ($p=0,003$).

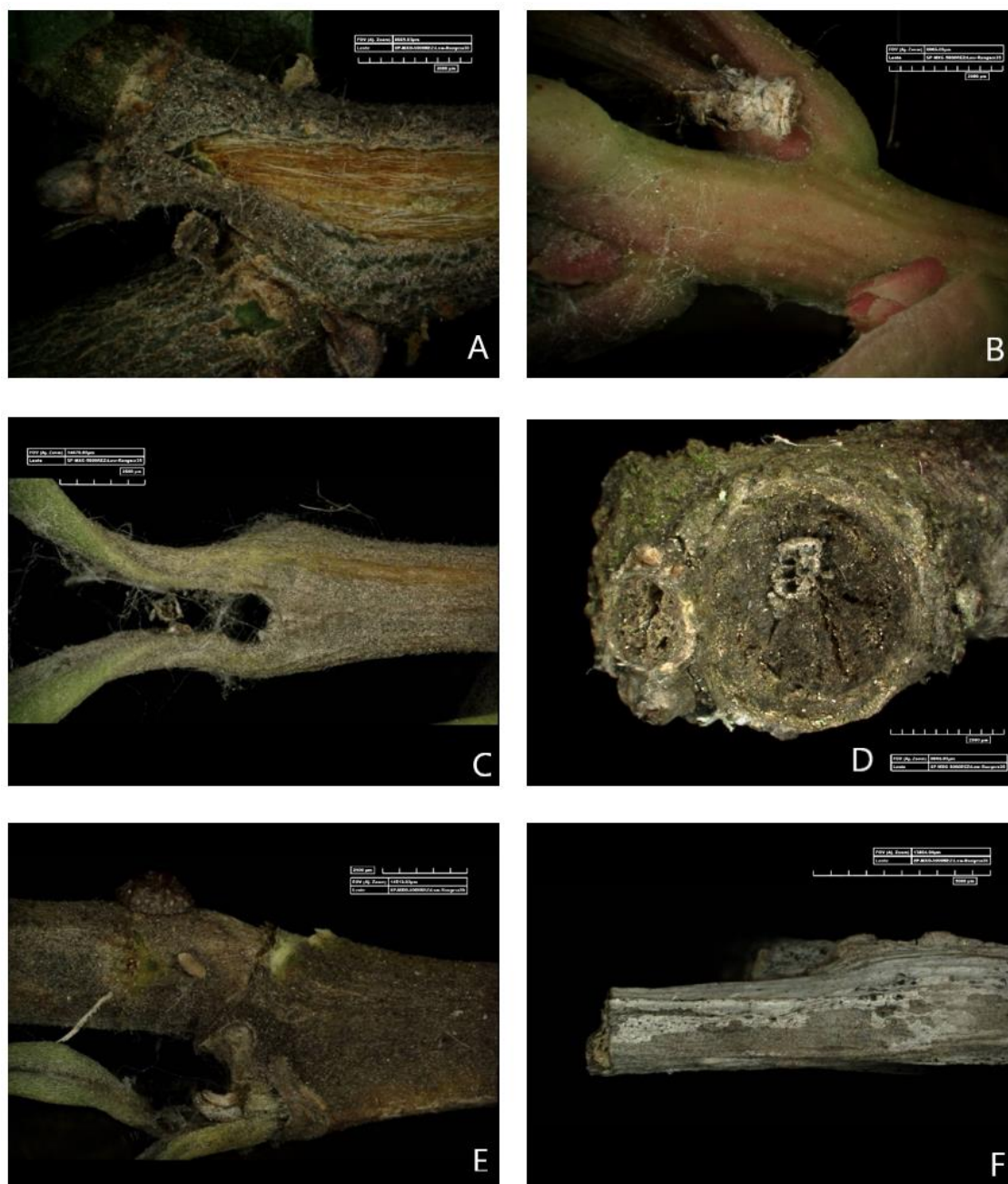


Figures 68: Modifications found in proximal end. A: Banded+Stripped bark (T17); B: Cut (FR_15jun23_S2_T07); C: Cut+Stripped bark (FR_15jun23_S2_T06); D: Frayed+Stripped (AF_15jun23_S5_T34); E: Stripped bark (FR_15jun23_S1_T04); and F: frayed+stripped bark (FR_15jun23_S3_T09). All photographs at 35x.

Distal end modifications.

At this stage, in which the tools have not been used yet, the samples do not present extraction scars. However, we documented the distal ends to then allow a comparison before and after the experimental program to understand how the ends of the tools are modified (Figure 69).

In some of the samples, we see that there are points that are not entirely clear, as they have sub-branches as well as leaves, while in other cases the distal ends before the use of the tool had cut morphologies.



Figures 69: Details of the distal ends of the tools before to used; A: AF_15jan23_S1_T22; B: AF_15jun23_S6_T40; C: AF_15jun23_S6_T38; D: AF_15jun23_S5_T32; E: AF_15jun23_S5_T31; and F: FR_15jun23_S5_T18. All photographs at 35x.

Medial part.

During the stage of twig extraction, we did not perform any leave cleaning of the tools, although we found some protuberances that indicate the growth of sub-branches, as well as leaves.

During the execution of the extraction, fractures occurred in two of the samples (FR_15jun23_S5_T20 [Figure 70A], and AF_15jun23_S3_T27 [Figure 70B]), both near the proximal ends.

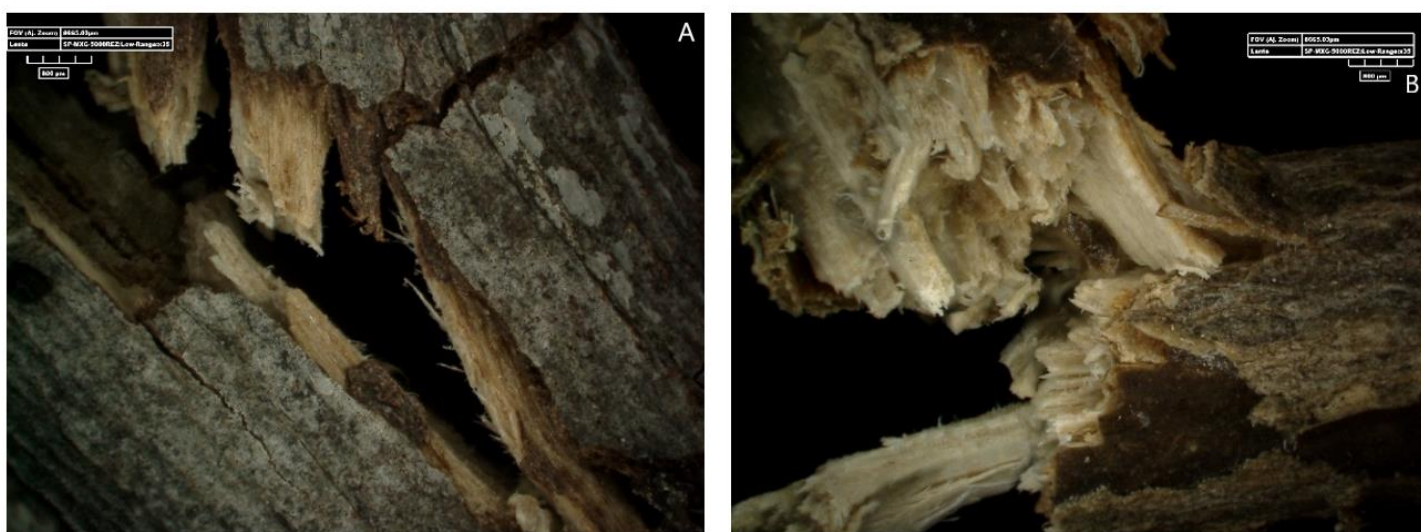


Figure 70: Details of complete fractures, on the proximal end. A: FR_15jun23_S5_T20; B: AF_15jun23_S3_T27. Photos at 35x.

8.2.2. 2nd Part. Manufacture.

Of the whole experimental assemblage (n=40), most of the twigs had sub-branches (n=36) and/or leaves (n=14), very similar to the ones we have seen in Figure 71.



Figure 71: Photos of experimental samples before to manufacture peeling act.

Techniques and time.

For this experimental stage, two techniques were used to clean the surfaces: press-slide (Figure 72A-B) and grab-drag (Figure 72C-D), which occasionally were simultaneously used.

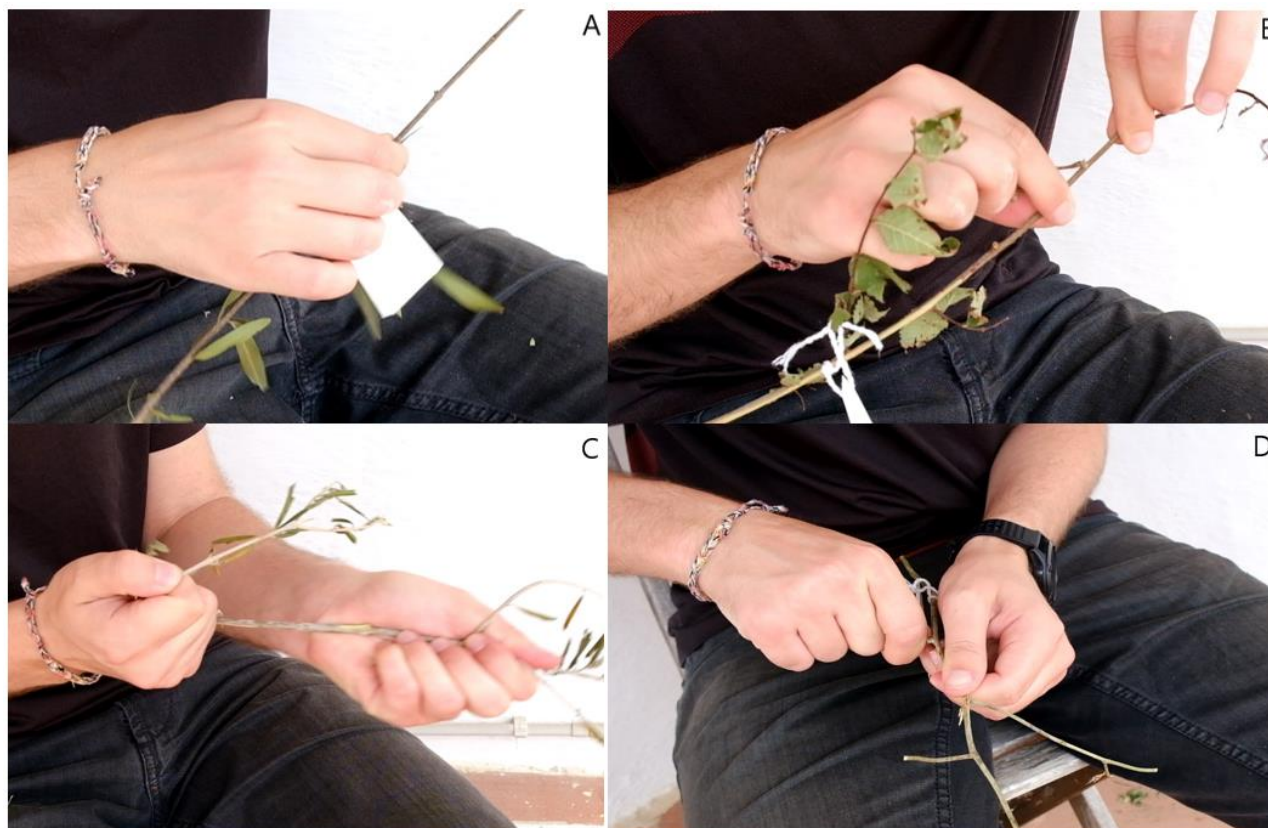


Figure 72: Photos of different techniques made during the manufacturing. A-B, corresponding to press-slide; C-D corresponding to grab-drag.

The minimum time employed in the manufacturing process was 3,56 seconds, and the maximum was 1:06 minutes (mean = 23,42 seconds, SD= 14,95 seconds (Figure 73).

All manufacturing actions used started with the press-slide technique. While the grab-drag technique was used because it was not very efficient to detach the sub-branches that had a great thickness.

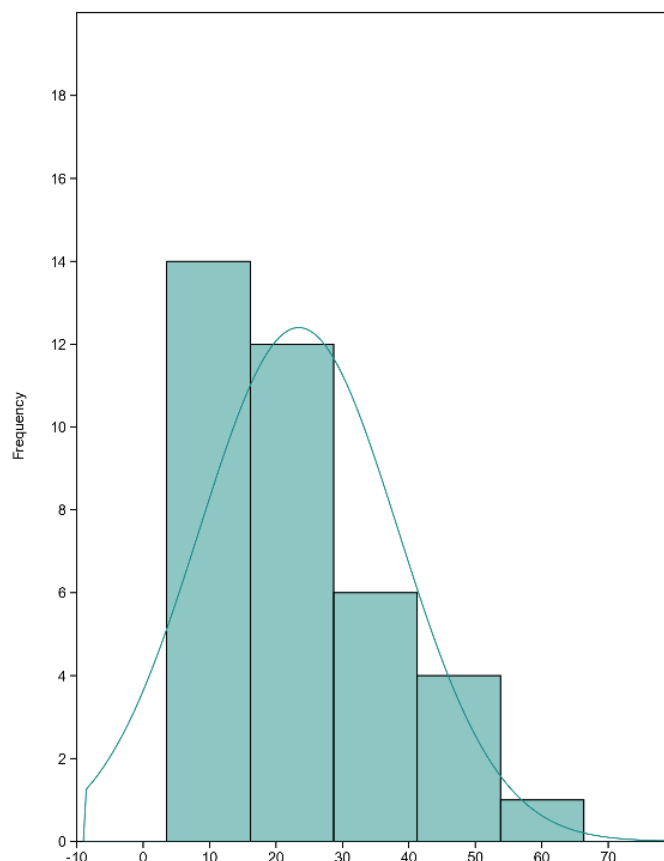


Figure 73: Histogram of the frequency of manufacture, together with the time inverted

During the manufacturing process. Most of the techniques were made against the natural growth of the leaves and sub-branches (i.e., distal-proximal end; $n=29$). However, in some cases, an attempt was made to make the techniques bidirectional ($n=8$).

Manufacture peeling.

The scars that we have registered during this stage, have the same morphologies as the manufacture peeling documented on the chimpanzee tools. These scars (Figure 74) are produced by the defibration of the most superficial tissues during the extraction of the sub-branches because there is a continuity between the fibers of the main branch with the sub-branches. On the contrary, we do not find these scars in those branches where leaves cleaning has taken place. Also, we reported the presence of a final protuberance that during the manufacturing it was impossible to remove.

Finally, we identify additional stigmas related to the manufacture stage such as stripped bark (peeling, Figure 74), protuberance (T09, Figure 75A), and scar of removing leaves (T15, T02, and T14, Figure 75C-E), and one tool with remains in the medial part (FR_T15, Figure 75D).



Figure 75: manufacture peeling scars associated to sub-branches, and leaves; A: FR_15jun23_S3_T09; B: FR_15jun23_S3_T10; C: FR_15jun23_S4_T14; D: FR_15jun23_S4_T15; E: FR_15jun23_S1_T02; and F: FR_15jun23_S4_T15. All photos at 35x.

8.2.3. 3rd Part. Use of tools.

Techniques and time.

During the experiment, the experimenters used two main techniques:

- Gripping by the index and the thumb (Figure 76, A-B).

- Gripping the tool between the thumb and index finger on the thenar side (Figure 76C-D, F-G).



Figure 75: Techniques of sample utilization in the 3rd part of the experimental program. A-B: experimenters using the grasping technique with the index and big fingers; C-D: experimenters using the grasping technique between the index and big fingers, resting it on the thenar area; E: fracture in the medial part during experimentation; F-G: experimenters using the grasping technique between the index and big fingers, resting it on the thenar area.

The time dedicated to the use, varied between 0:15 seconds and 4:00 minutes. The mean duration for each tool was 1:43 minutes, but the bulk of them were used between one minute, and the minute and a half (Figure 77 and Table 39).

And if we put, everything from the time dedicated to all process, since the extraction with the manufacturing, and for final the used, it is evident that the most dedicated stage of the experimental program, was the last one, the utilization. As shown in Figure 77 we see a predominance in the time of use, followed by the phases of manufacturing phases. Although in some cases, there was no such activity, as in the case of T15, T19, and T20. And, finally, the extraction phase was relatively the fastest except for one case, the one referred to sample T27.

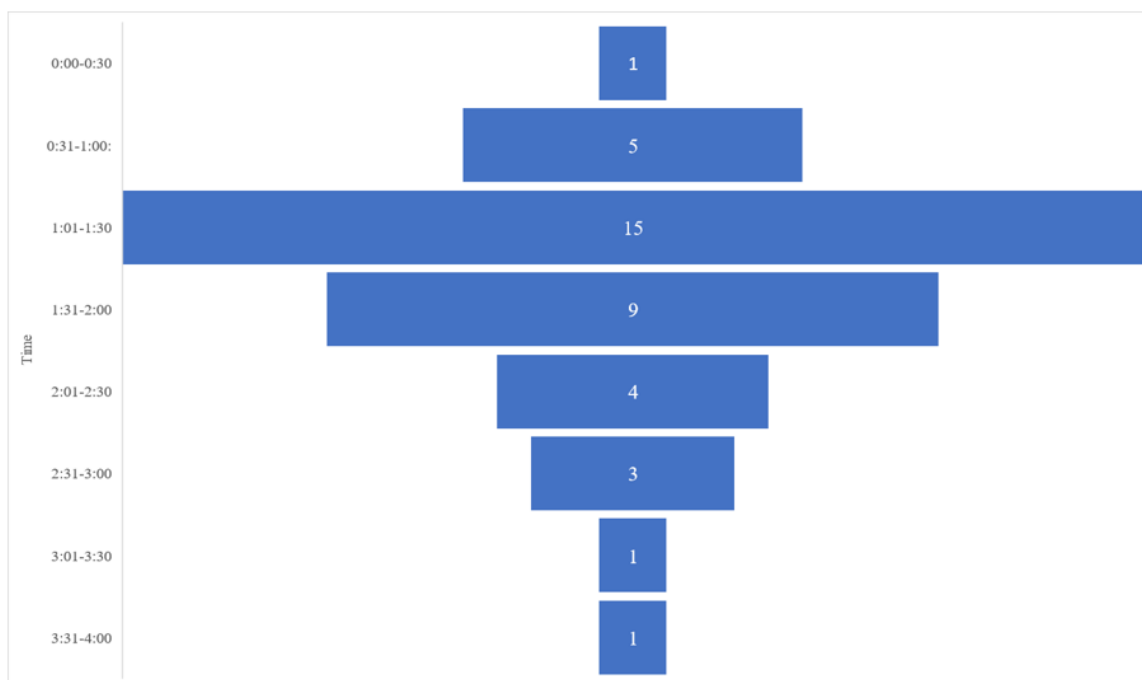


Figure 76: histogram of time by interval from 30 seconds, for tools used. Unit is minute.

Time	N
0:00-0:30	1
0:31-1:00:	5
1:01-1:30	15
1:31-2:00	9
2:01-2:30	4
2:31-3:00	3
3:01-3:30	1
3:31-4:00	1

Table 39: time with the number of samples. Unit is minute.

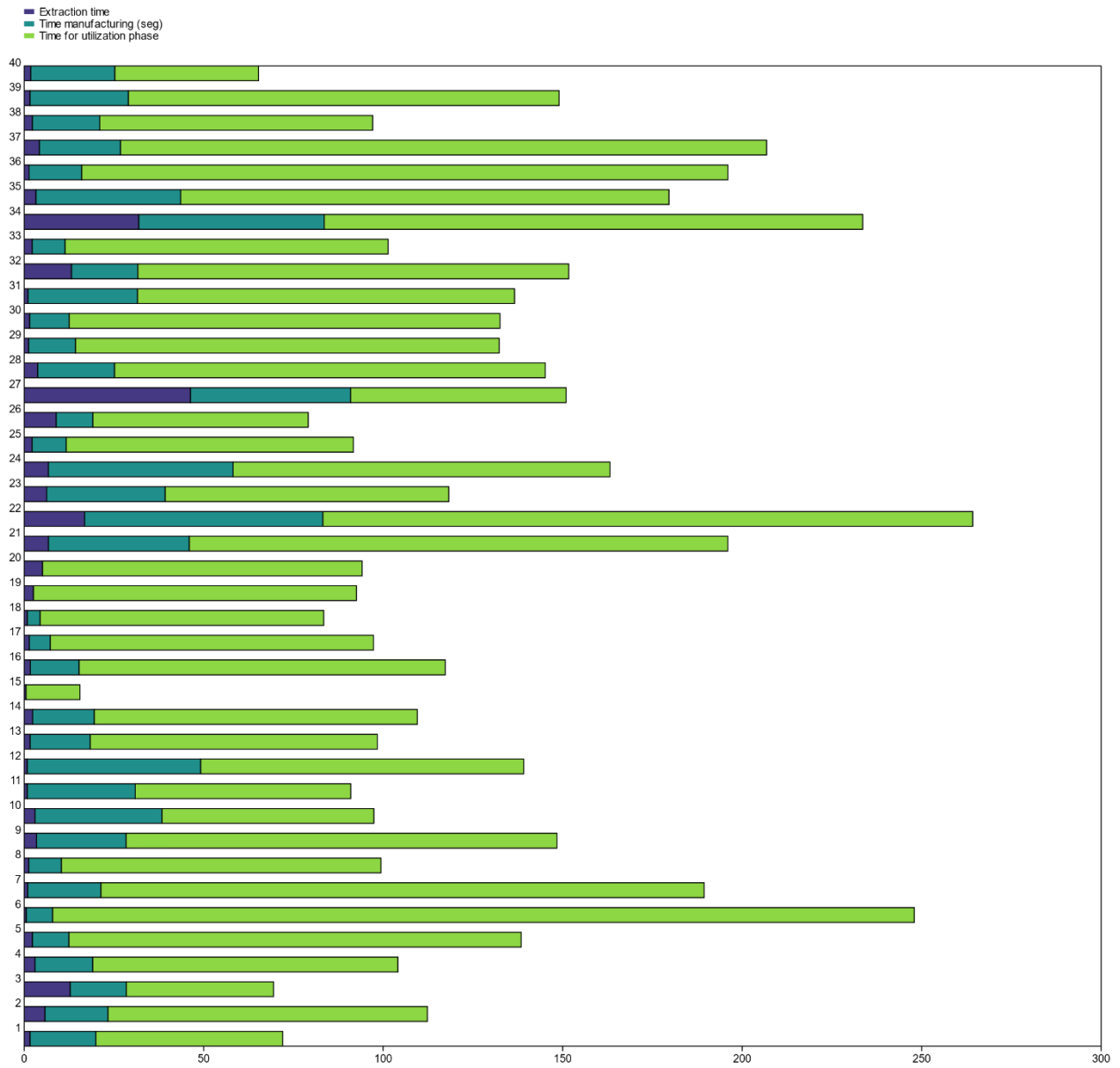
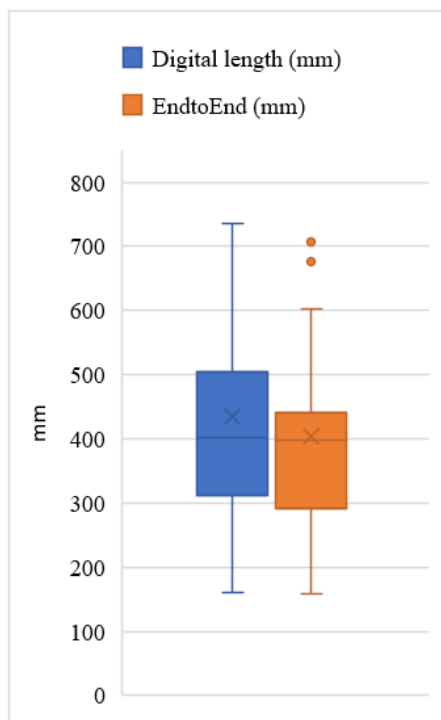


Figure 77: Stacked bar with the time in different phases of experimental program. In X-axis: time in seconds; and Y-axis: the samples.

General dimensions.

To develop this part of the experimental program, all the samples were used. During the experiments, we recorded the time of use, the generation of fractures, as well as the number of areas that were used. Subsequently, lengths and thicknesses were measured, the scars were studied in distal and proximal parts, and the potential residues deposited because of the activity.

Again, we note that the samples appear to be longer calculating the digital length than the end-to-end length (Figure 78 and Table 40). Although it appears to be proportional, we find that the mean is very close. The minimum shown in the set seems to belong to the same sample, as it is very close after being measured both ways, 1,80 mm difference. The same cannot be said for the maximum measurements, which seem to be far from coinciding with 1206,37 mm (DL) and 923,16 mm (ETE).



Digital length (mm)	Min: 159,83
	Max: 1206,37
	Mean: 434,25
	SD: 185,37
End-to-end length (mm)	Min: 158,03
	Max: 923,16
	Mean: 404,82
	SD: 152,61

Table 40: measures digital length (mm) and end-to-end length (mm) of experimental samples used. Accompanied by the minimum (MIN), maximum (MAX), mean (MEAN) and standard deviation (SD).

Figure 78: Box and whiskers diagram digital length (mm) and end-to-end length (mm).

Before and after the used, we clearly have a reduction in their size after used of tools (Figure 79). Clearly, it is a consequence of the repeated movements that were made to simulate the ant-dipping activities. Here we can see the differences between before and after used.

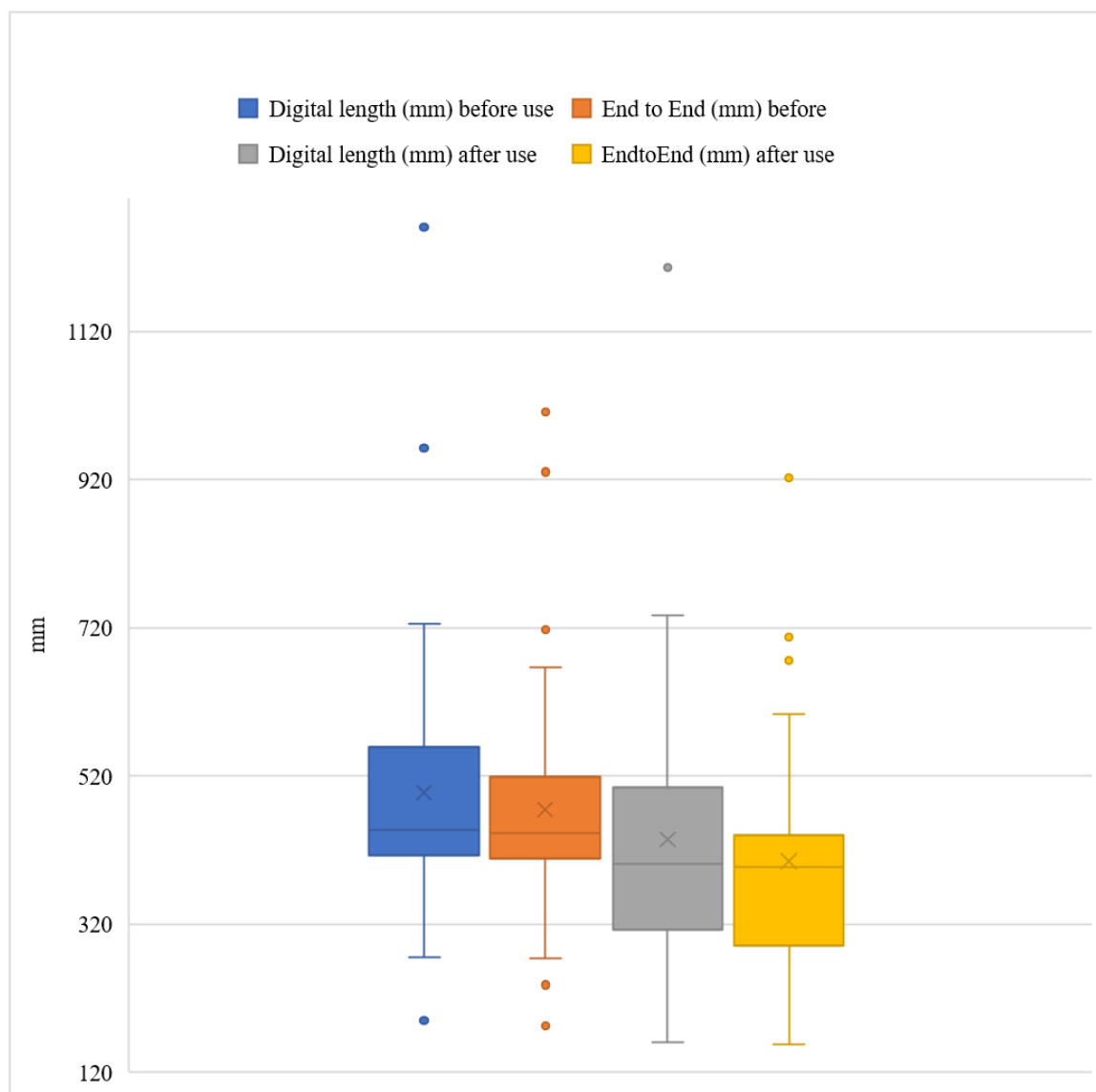


Figure 79: Digital and end-to-end length of the experimental tools before and after the use.

The difference that we can observe is that there has been a reduction in the minimum digital length of up to 30,01 mm, while in the maximum length the difference is up to 55,14 mm, and the average is 63,24 mm (digital length) (Table 41 and Figure 80), when we compare the reduction before and after the use. If we look at it from end-to-end, we would a difference of 25,05 mm in the minimum, in the maximum 88,75 mm in the minimum, and 69,64 mm in the average of the tool length.

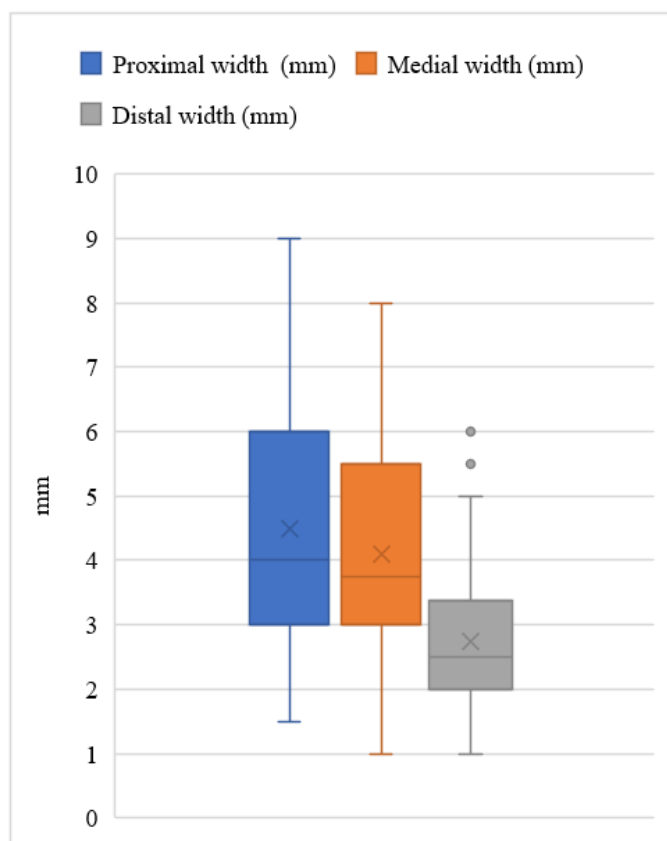


Figure 80: Box and whisker plot diagram of the proximal, medial, and distal thicknesses (mm).

Proximal width (mm)	MIN: 1,5
	MAX: 9,00
	MEAN: 4,50
	SD: 1,97
Medial width (mm)	MIN: 1,00
	MAX: 8,00
	MEAN: 4,10
	SD: 1,59
Distal width (mm)	MIN: 1
	MAX: 6
	MEAN: 2,74
	SD: 1,38

Table 41: thickness measurements of the proximal, distal, and medial ends accompanied by the minimum (MIN), maximum (MAX), mean (MEAN) and standard deviation (SD) of experimental program.

Moving onto the measurements of the proximal, medial, and distal width, the medial areas changed after the manufacturing and use stages, in addition to the fact that there are certain elements that have suffered breakages. The measures after the used are shown in Table 41.

The greatest dimensions are found in the proximal ends, followed by the medial zones, and ending at the distal ends with a similar average width of the proximal end and the medial zones (4,50 and 4,10, respectively); while in distal end, we found 2,74 mm.

If we compare the thickness measurements we have of the samples before and after use, we obtain a change in relation to the original length (immediately after extraction) (Table 42 and Figure 81). We see a clear decrease in thickness at the proximal and distal ends, remaining without much change in the medial areas. In the proximal part, we find that the minimum thickness has decreased by 0,50 mm after use. While the maximum has remained almost intact, this may be due to several factors, including the constitution of the branch itself. The average has decreased by 0,46 mm, compared to what it already had after extraction (4,96 mm). If we move towards the medial area, we find that the minimum and maximum are practically the same (0,10 mm difference only in the maximum thickness). The mean has been reduced by about 0,48 mm, practically the same as what

has been reduced at the proximal end. And finally, we have the case of some elements that have caused the piece to increase in thickness, up to 0,5 mm, this may be due to several factors, including the generation of fractures that cause the increase in volume or the modification itself (Figure 82). However, if we look at the average, we have that it has decreased 0,38 mm, somewhat less than what we found in the previous cases (proximal end, and medial part).

Before use		After use	
Proximal width (mm)	MIN: 2,00	Proximal width (mm)	MIN: 1,5
	MAX: 9,10		MAX: 9,00
	MEAN: 4,96		MEAN: 4,50
	SD: 2,03		SD: 1,97
Medial width (mm)	MIN: 1,00	Medial width (mm)	MIN: 1,00
	MAX: 8,10		MAX: 8,00
	MEAN: 4,58		MEAN: 4,10
	SD: 1,73		SD: 1,59
Distal width (mm)	MIN: 0,5	Distal width (mm)	MIN: 1
	MAX: 6,5		MAX: 6
	MEAN: 3,12		MEAN: 2,74
	SD: 1,35		SD: 1,38

Table 42: differences in width in proximal, medial, and distal end, after the extraction of the source, and after the use. The minimum (MIN), maximum (MAX), mean (MEAN) and standard deviation (SD).

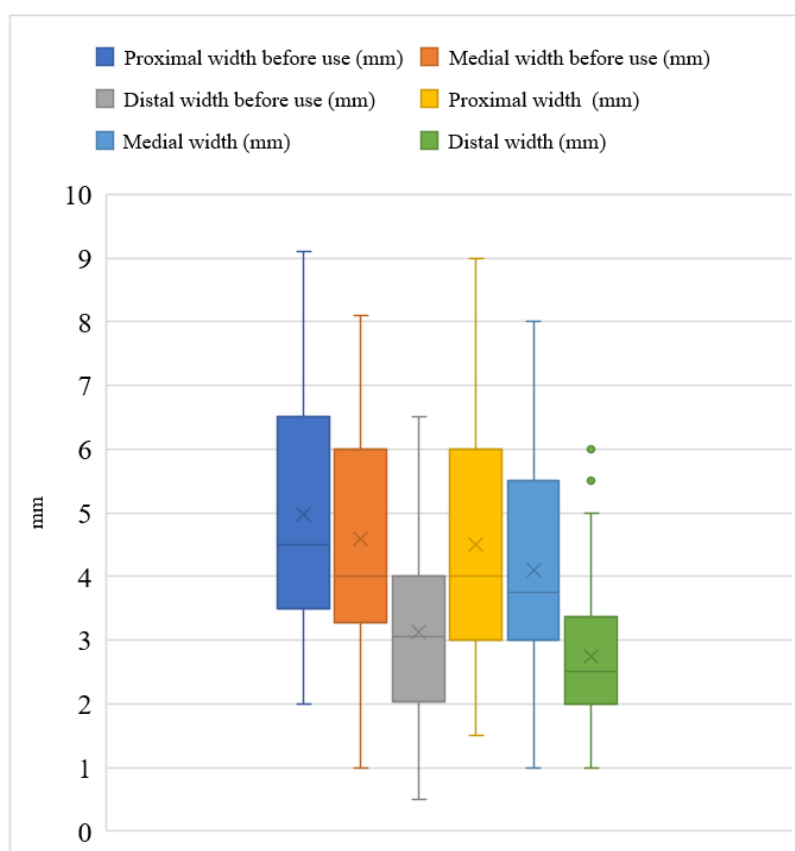


Figure 81: graph with the different width after the extraction and after the use. In proximal, medial, and distal width (mm).



Figure 82: Example of tool use during the experimental program, where we can see an increase in thickness at the end.

Proximal and distal end modifications

Of all the experimental assemblage ($n=40$), 22 tools were used using both ends, while the rest ($n=18$) were used by distal or the proximal end. Participants were allowed to use the tools as much as they wanted and to change the tool that they considered more suitable. The only limit imposed was that they should not exceed 4:00 minutes of activity per piece.

Proximal end modifications.

A total of 32 tools were used by this end, 10 uniquely, and 22 together with the distal end. The modifications identified on the proximal ends (Figure 83) include: Stripped bark ($n=10$), stripped+frayed ($n=12$), cut ($n=3$), peeled+stripped ($n=4$), bended+stripped ($n=3$), cut+stripped ($n=2$), rounded+stripped ($n=2$), rounded ($n=1$), bended ($n=1$), cut+peeled ($n=1$), and frayed ($n=1$). Here we have a greater variety than in the pieces we have from Dindefelo, and we even find new ones that could be the result of other factors that we have not yet considered, or that are not in the repertoire used by chimpanzees (Figure 83)

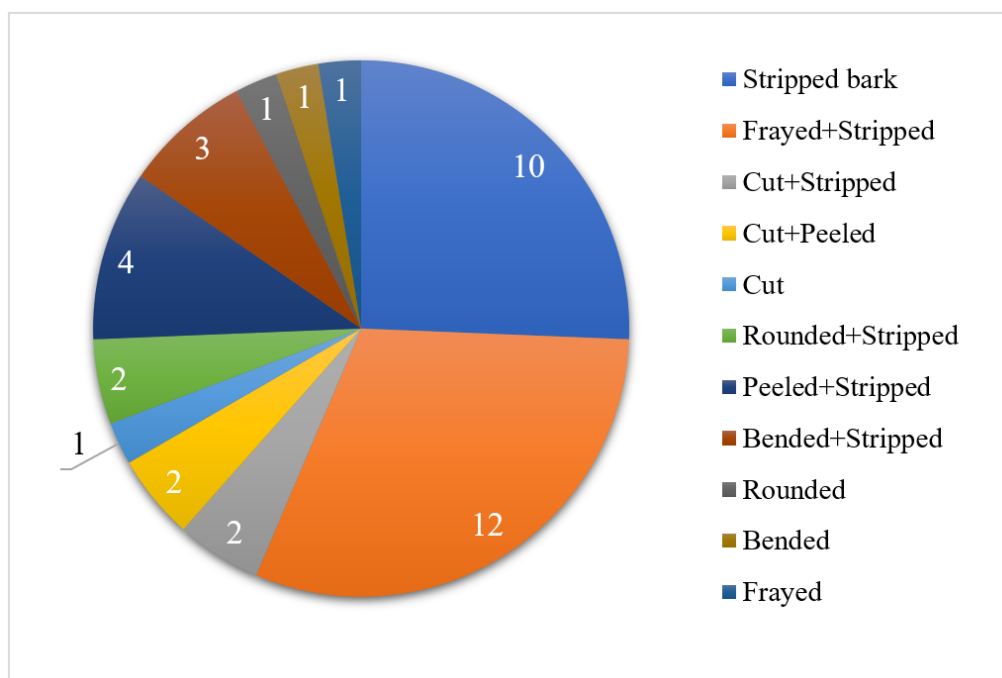


Figure 83: types of proximal ends modifications on the experimental program, after the use.

The morphologies with a higher representation are peeled+stripped (Figure 84A), bended+stripped (Figure 84B), cut (Figure 84C), cut+stripped (Figure 84D) and rounded+stripped (Figure 84E). Again, we find that, in most of them, stripped bark is present (Figure 84F). If we focus only on the results extracted from these samples, we find a great diversity. In the case of bended+stripped, it presents a great difference almost as great as the one we have seen in frayed+stripped (Figure 84G), with only a considerable representation (3 out of 12). In the middle zone, we have peeled+stripped, which, although its representation is one point higher than the previous one, we find more compact data, since it does not present such a large differentiation between samples. In the last positions, we can observe the rounded+stripped group with measurements very similar to those found in cut+stripped, even though some morphologies are accompanied by stripped bark (which are certainly the ones that have caused the most scar in the sample) and are very similar since it would be a scar that would affect little more than the surface of the tip (rounded and cut). And finally, we find cut ends as the sample that leaves the smallest scars on the pieces.

This variety of stigmas have similar measurements. For example, the morphology with the greatest representation, and being the one with the greatest length on the surface of the sample is frayed+stripped (108,00 mm). Similarly, the morphology with the minimum (except cut) is the same modification (2,50 mm). If we look at the average, the minimum is found for the rounded morphology (5,00 mm), and the maximum frayed+stripped (58,10 mm). This last modification, being the one with the highest representation, and with a deviation as high as in other types of scars we found, as there are other modifications that have a larger arc between the maximum and minimum length measurements at the proximal end but have a smaller standard deviation. Even for example, the second type with a higher representation is stripped bark, which with a maximum and minimum (56,00 mm and 6,00 mm, respectively), presents half the mean and a standard deviation that we found in frayed+stripped. Thus, frayed+stripped has more differences within its own group than other groups. And being these last two (stripped bark and frayed+stripped bark) that monopolize more than 50% of the set, and where they present stripped bark in both morphologies, we move on to the rest, which has less than 5 representations. Finally, there is a group of tools showing various morphologies bended (Figure 84H), frayed (Figure 85A-B), cut+peeled (Figure 85C), rounded (Figure 85D). The incidence of these modifications on the tools is disperse but does not measure more than 28,00 mm in length (see details on Table 43). Therefore, we would be left that this group, there are no stripped bark samples which in most cases, are the ones that leave a mark of greater length.

Modification type	MIN	MAX	MEAN	SD	%
Stripped bark (n= 10)	6,00	56,00	24,35	17,12	25%
Cut+Stripped (n= 2)	7,00	9,00	8,00	1,41	5%
Cut+Peeled (n=1)	15,00	15,00	15,00	0	2,5%
Cut (n=3)	0	0	0	0	7,5%
Rounded+Stripped (n=2)	5,00	10,00	7,50	3,53	5%
Frayed+Stripped (n= 12)	2,50	108,00	58,1	42,50	30%
Bended+Stripped (n=3)	7,00	120,00	52,66	59,53	7,5%
Peeled+Stripped (n=4)	19,50	40,00	28,62	10,45	10%
Rounded (n=1)	5,50	5,50	5,50	0	2,5%
Bended (n=1)	28,00	28,00	28,00	0	2,5%
Frayed (n=1)	14,00	14,00	14,00	0	2,5%

Table 43: type of modification in proximal ends after the used in the experimental program. The minimum (MIN), maximum (MAX), mean (MEAN) and standard deviation (SD), and the percentage (%).

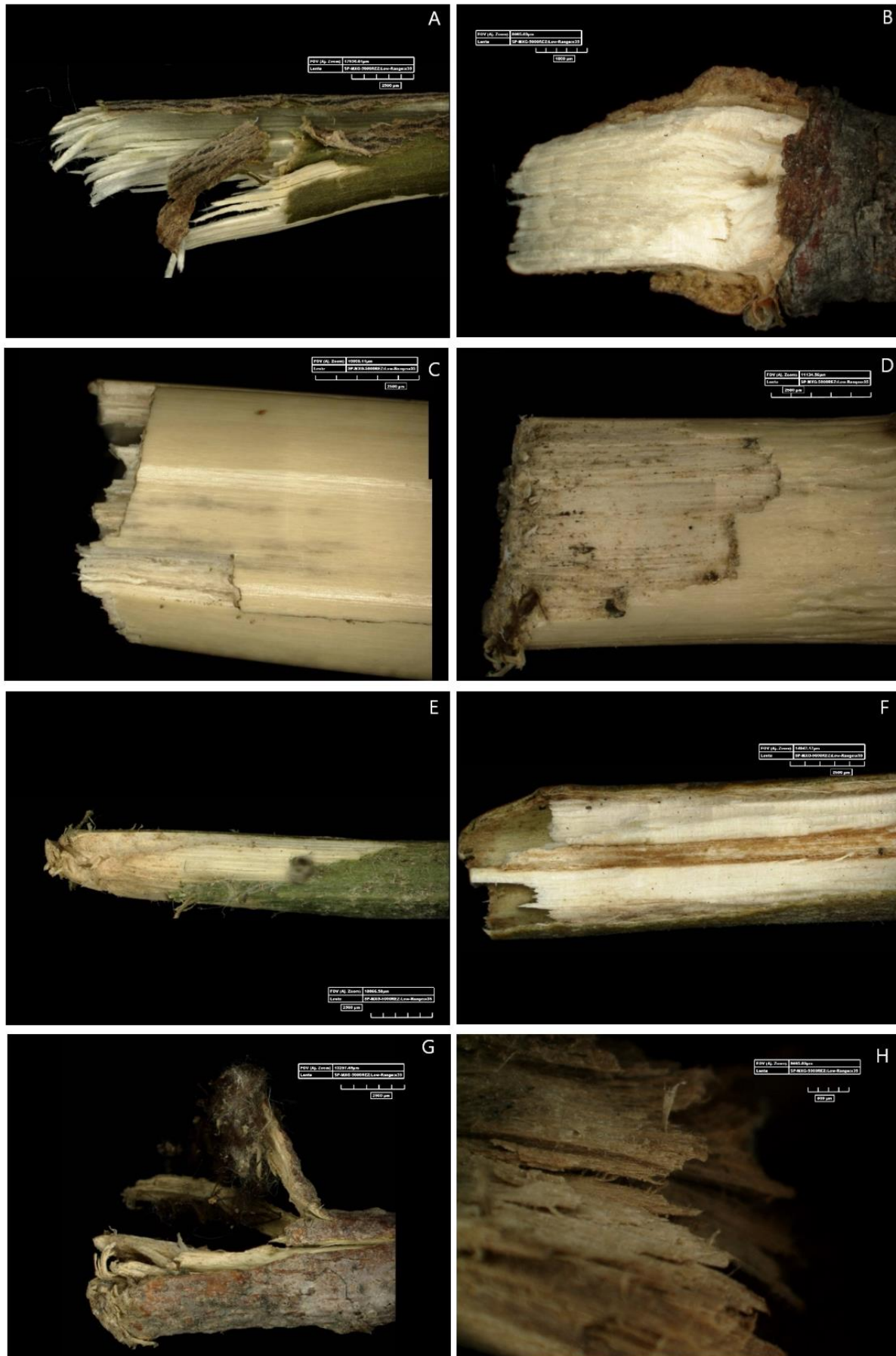


Figure 84: modifications in the proximal end of experimental samples after used. A: peeled+frayed (AF_15jun23_S6_T35); B: bended+stripped (FR_15jun23_S4_T15); C: cut (FR_15jun23_S2_T07); D: cut+stripped (FR_15jun23_S2_T05); E: rounded+stripped (FR_15jun23_S3_T12); F: stripped bark (FR_15jun23_S1_T02); G: frayed+stripped (FR_15jun23_S4_T14); and H: bended (FR_15jun23_S5_T20). All photos at 35x.



Figure 85: modifications in the proximal end of experimental samples after used. A: frayed (AF_15jun23_S5_T34); B: frayed (AF_15jun23_S5_T34) 3D; C: cut+peeled (FR_15jun23_S2_T06); and D: rounded (FR_15jun23_S5_T19). HIROX KH-8700, with 35x.

For the study, it is interesting the change observed on the type of scars in proximal ends, ever since we identified the extraction marks, and subsequently after their use.

As we can see in Figure 86 and Table 44, we found that out of the total samples that were used (n=40), not all of them were used from the proximal end (n=32), and of those, a vast majority have been altered (n=30). Out of these, it can be observed that alterations may have occurred in one aspect or both:

- Alteration in measurements but not in morphology (n=11), out of which mostly decrease (n=8), and the rest increase (n=3).
- Alteration solely in morphology, but not in measurements (n=2).
- Alteration in both measurements and morphology (n=17).

From these results, it can be seen that in most cases, the ends that have been altered in their morphology were done so to introduce a mark, as is the case with stripped bark (n=12). Nevertheless, there are instances where the alterations served to conceal marks, as can be observed in the cases of T06, T08, T19, T28, T29, or T34.

We also find a change in measurements due to these modifications, leading to a clear decrease after use, in the majority of cases, 68,75% (n=22) of the pieces used from the proximal end. The reason for such changes in measurements can be attributed to various factors, such as the force applied during repetitive use, whether breakage of the piece occurred or not, as well as the wear caused by friction that might have resulted in a decrease in the previous modification after extraction.

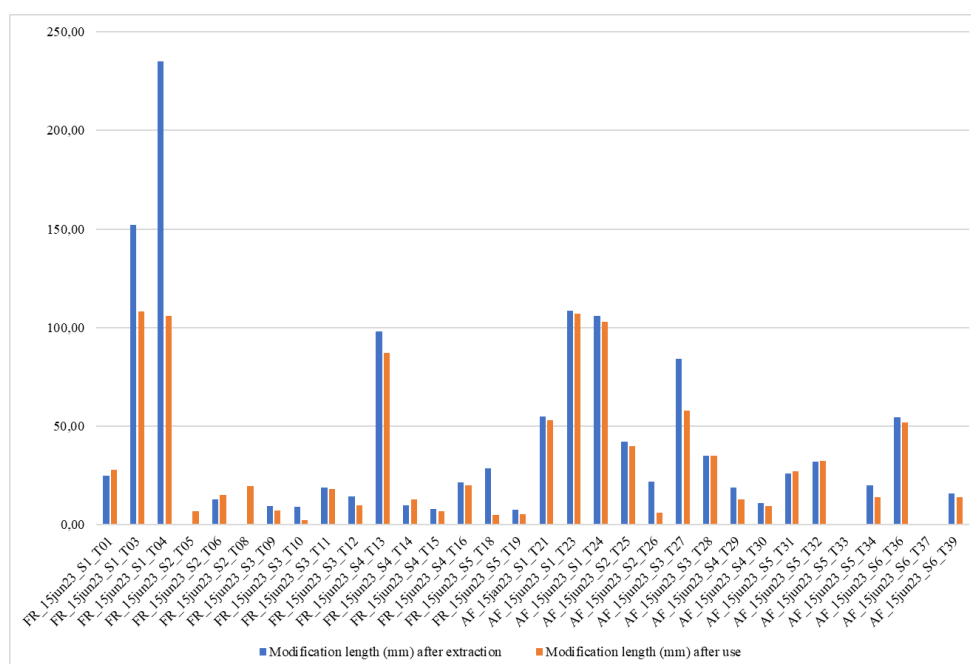


Figure 86: measures of modifications in proximal end after the extraction and after use with the ID Tool.

TOOL ID	Modification type after extraction	Modification length (mm)	Modification type after use	Modification length (mm)
FR_15jun23_S1_T01	Stripped bark	25,00	Stripped bark	28,00
FR_15jun23_S1_T03	Stripped bark	152,00	Stripped+Frayed	108,00
FR_15jun23_S1_T04	Stripped bark	235,00	Stripped+Frayed	106,00
FR_15jun23_S2_T05	Cut	0,00	Cut+Stripped bark	7,00
FR_15jun23_S2_T06	Cut+Stripped	13,00	Cut+Peeled	15,00
FR_15jun23_S2_T08	Cut+Stripped	19,50	Stripped+Peeled	19,50
FR_15jun23_S3_T09	Frayed+Stripped	9,50	Frayed+Stripped	7,20
FR_15jun23_S3_T10	Stripped bark	9,00	Frayed+Stripped	2,50
FR_15jun23_S3_T11	Stripped bark	19,00	Stripped bark	18,00
FR_15jun23_S3_T12	Stripped bark	14,50	Rounded+Stripped	10,00
FR_15jun23_S4_T13	Frayed+Stripped	98,00	Frayed+Stripped	87,00
FR_15jun23_S4_T14	Stripped bark	10,00	Frayed+Stripped	13,00
FR_15jun23_S4_T15	Stripped bark	8,00	Bended+Stripped bark	7,00
FR_15jun23_S4_T16	Frayed+Stripped	21,50	Frayed+Stripped	20,00
FR_15jun23_S5_T18	Stripped bark	28,5	Rounded+Stripped	5,00
FR_15jun23_S5_T19	Bended+Stripped	7,60	Rounded	5,50
AF_15jan23_S1_T21	Stripped bark	55,00	Frayed+Stripped	53,00
AF_15jun23_S1_T23	Stripped bark	108,5	Frayed+Stripped	107,00
AF_15jun23_S1_T24	Frayed+Stripped	106,00	Frayed+Stripped	103,00
AF_15jun23_S2_T25	Stripped bark	42,00	Peeled+Stripped	40,00
AF_15jun23_S2_T26	Stripped bark	22,00	Stripped bark	6,00
AF_15jun23_S3_T27	Frayed+Stripped	84,00	Frayed+Stripped	58,00
AF_15jun23_S3_T28	Frayed+Stripped	35,00	Peeled+Stripped	35,00
AF_15jun23_S4_T29	Cut+Stripped	19,00	Stripped bark	13,00
AF_15jun23_S4_T30	Stripped bark	11,00	Stripped bark	9,50
AF_15jun23_S5_T31	Stripped bark	26,00	Stripped bark	27,00
AF_15jun23_S5_T32	Frayed+Stripped	32,00	Frayed+Stripped	32,5
AF_15jun23_S5_T33	Cut	0,00	Cut	0
AF_15jun23_S5_T34	Frayed+Stripped	20,00	Frayed	14,00
AF_15jun23_S6_T36	Stripped bark	54,50	Stripped bark	52,00
AF_15jun23_S6_T37	Cut	0	Cut	0
AF_15jun23_S6_T39	Stripped bark	16,00	Stripped bark	14,00

Table 44: table with the modification type after the extraction and use, with the length of all of them.

We have specific cases, such as pieces T03 and T04, where there is a significant jump between the measurements of the modifications at the proximal end. Both correspond to a morphology of stripped bark, which later, after use, shows a scar of frayed. The reason behind this lies in a drastic change in the overall size of the pieces between extraction and use. In sample T03, we go from a digital length of 189,73 mm to around 173,97 mm; whereas in the piece that shows the greatest difference between the two modification measurements, it goes from about 505,86 mm to 399,24 mm.

Consequently, we find that thanks to these results, it's possible to observe a loss of extraction marks, which might combine with use or ultimately not show alteration, making it difficult to distinguish between marks from usage and from extraction.

Distal end modifications.

Of the total set (n=40) of experimental samples, 30 pieces were used at this end only (n=8) and together with the proximal end (n=22), the rest (n=10) were not used by the distal end. Morphologically, we found that some of the samples present similar marks than the ones found in the proximal ends, but with presence of manufacture peeling (Table 45 and Figure 87). The first of these arises because of the different ramifications generated in the main branch and causes a scar like the stripped bark marks but which leaves some resulting protuberances (illustrated in Figure 88A)

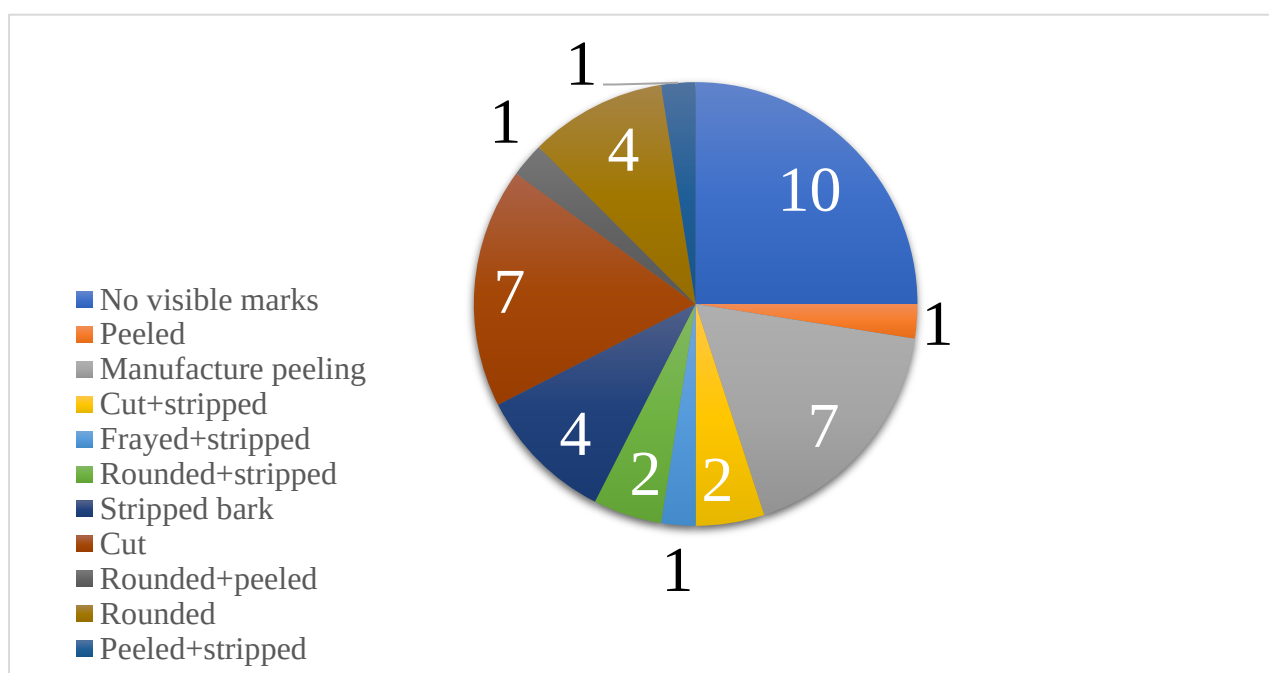


Figure 87: Distribution type of modification in distal end.

Modification type	MIN	MAX	MEAN	SD	%
No visible marks (n=10)	0	0	0	0	25%
Peeled (n=1)	14,50	14,50	14,50	0	2,5%
Manufacture peeling (n=7)	0	6,00	2,42	2,69	17,5%
Cut+stripped (n=2)	3,50	6,50	5,00	2,12	5%
Frayed+stripped (n=1)	60,00	60,00	60,00	0	2,5%
Rounded+stripped (n=2)	4,50	26,00	15,25	15,20	5%
Stripped bark (n=4)	3,00	18,00	10,12	6,30	10%
Cut (n=7)	0	0	0	0	17,5%
Rounded+peeled (n=1)	10,00	10,00	10,00	0	2,5%
Rounded (n=4)	1,10	5,00	3,90	1,88	10%
Peeled+stripped (n=1)	35,00	35,00	35,00	0	2,5%

Table 45: Table of the type of modification of the proximal end. Accompanied by the minimum (MIN), maximum (MAX), mean (MEAN) and standard deviation (SD) and percentage of representation in the sample (%).

Overall, the first notable aspect is that, for the first time, the stripped bark (Figure 88B) morphology is not the most represented modification, directly or indirectly, represent a total of 25%. A quarter of the samples have turned out to lack of identifiable scars or use marks 25% (n=10). Next, we find that the second scar with the highest representation is the one generated by manufacture peeling, representing 17,5% (n=7), of the modifications. This type of scar is like the one found in the stripped bark ends, but it corresponds to the manufacturing process of the samples that were not completely removed. The length generated with an average of 5,00 mm differs quite a lot with the samples that present stripped bark at this same end. The latter, with 4 samples, have a minimum of 3,00 mm, with respect to a maximum of 18,00 mm, and with an average that is three times that of those with peeling manufacture. Cut ends were identified on 7 tools (17,5%) (Figure 89A). Then we would find stripped bark, as we have already mentioned, together with the rounded (Figure 89B) samples with a representation of 10% (n=4). Rounded is similarly represented than cut ends, as far as lengths affecting the piece are concerned, except for those adhered to non-visible marks, there are cut and rounded, as was also the case in the proximal ends. And finally, we find morphologies that would have one or two representations in the set such as rounded+stripped with 5% (n=2) (Figure 89C), cut+stripped (n=2) (Figure 89D) with 5%, frayed+stripped (n=1) (Figure 89E) with 2,5%, rounded+peeled (n=1) (Figure 89F) with 2,5%, and peeled+stripped with 2,5% (n=1) (Figure 89G). All of them with similar measurements, except for the case of two morphologies that are combined with stripped bark, frayed and peeled that within the total set are the ones that cause more invasion in the pieces (60.00 mm and 30.00 mm respectively). For last, we the last modicication type that we can see peeled (n=1) (Figure 89H).



Figures 88: Modifications in distal end of experimental samples after used. A: manufacture peeling (FR_15jun23_S3_T10); B: stripped bark (FR_15jun23_S4_T15) Photos at 35x.



Figures 89: Modifications in distal end of experimental samples after used. A: cut (FR_15jun23_S3_T11); B: rounded (AF_15jun23_S5_T32); C: rounded stripped bark (FR_15jun23_S2_T08); D: stripped bark (FR_15jun23_S4_T15); E: frayed+stripped (FR_15jun23_S2_T05); F: rounded+peeled (FR_15jun23_S2_T06); G: peeled+stripped (AF_15jun23_S3_T28); and H: peeled (FR_15jun23_S1_T02). Photos at 35x.

- Fractures in medial-distal areas due to usage at both ends: 2 were used.
- Fractures in the medial area: due to proximal use (4), distal use (1), or used at both ends (3).
- Fractures in the distal area: due to proximal use (2), distal use (3), or used at both ends (3).
- Proximal fractures: after proximal use.

Also, some of these fractures (Figure 91) caused the breakage of the tool, as it occurred on 11 pieces that were broken during the utilization. Some of them fractured from the proximal end (n=1), for medial part (n=5), and for the distal end (n=5). These breakages caused an alteration of the tool length, and the results scar in this end, most of them were a cut.

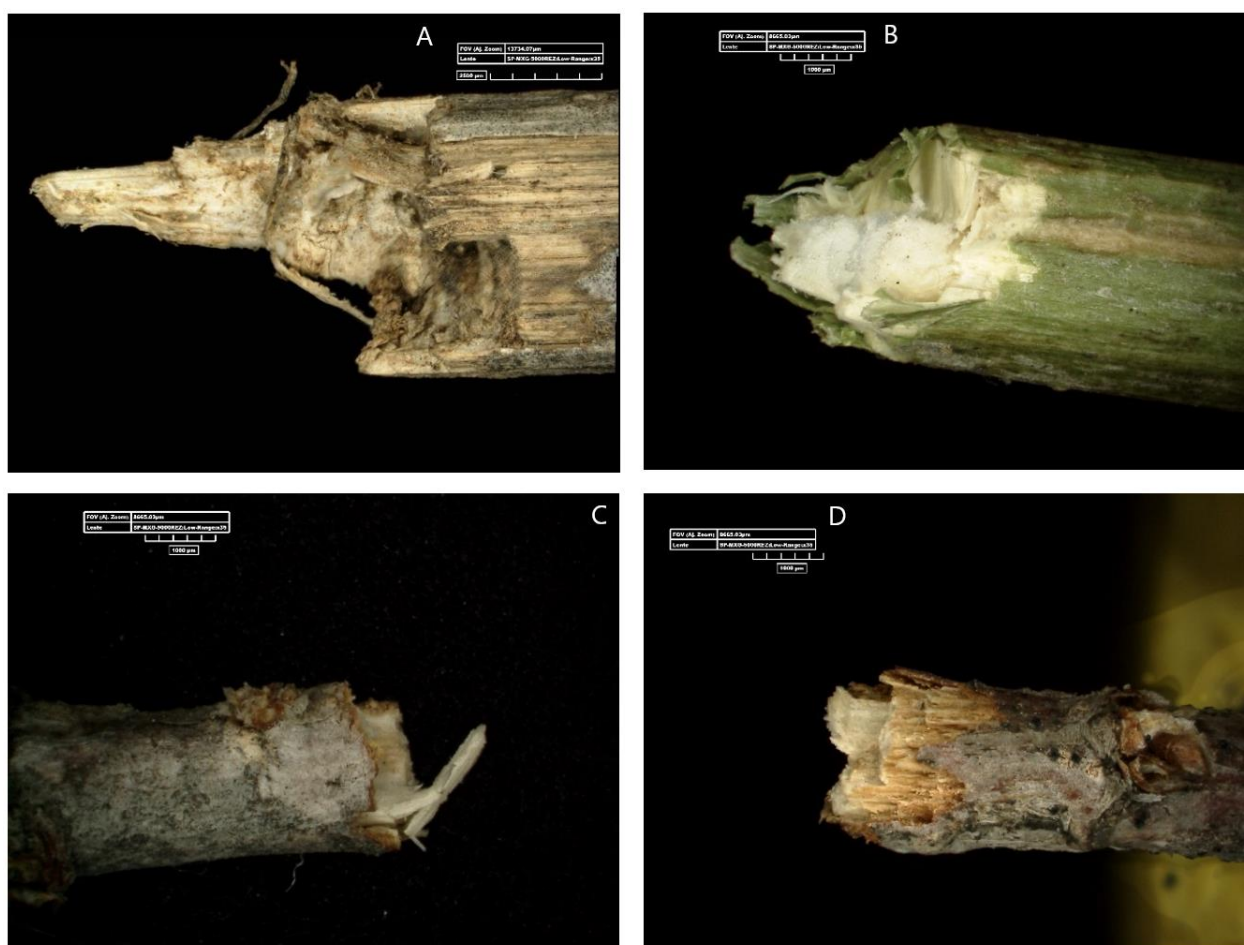


Figure 91: Details of the ends in broken tools: A: FR_15jun23_S2_T08; B: FR_15jun23_S3_T10; C: FR_15jun23_S4_T14; and D: FR_15jun23_S4_T13. Photos at 35x.

Finally, we need to talk about the residues identified on the experimental tools. In this case, 35 of the 40 experimental pieces bear residue remains. The most representative is soil attached to the used ends. But we have a unique sample, that shows insect fragments. The location in most cases is in the proximal end (28), and the distal end (16) (Figure 92).

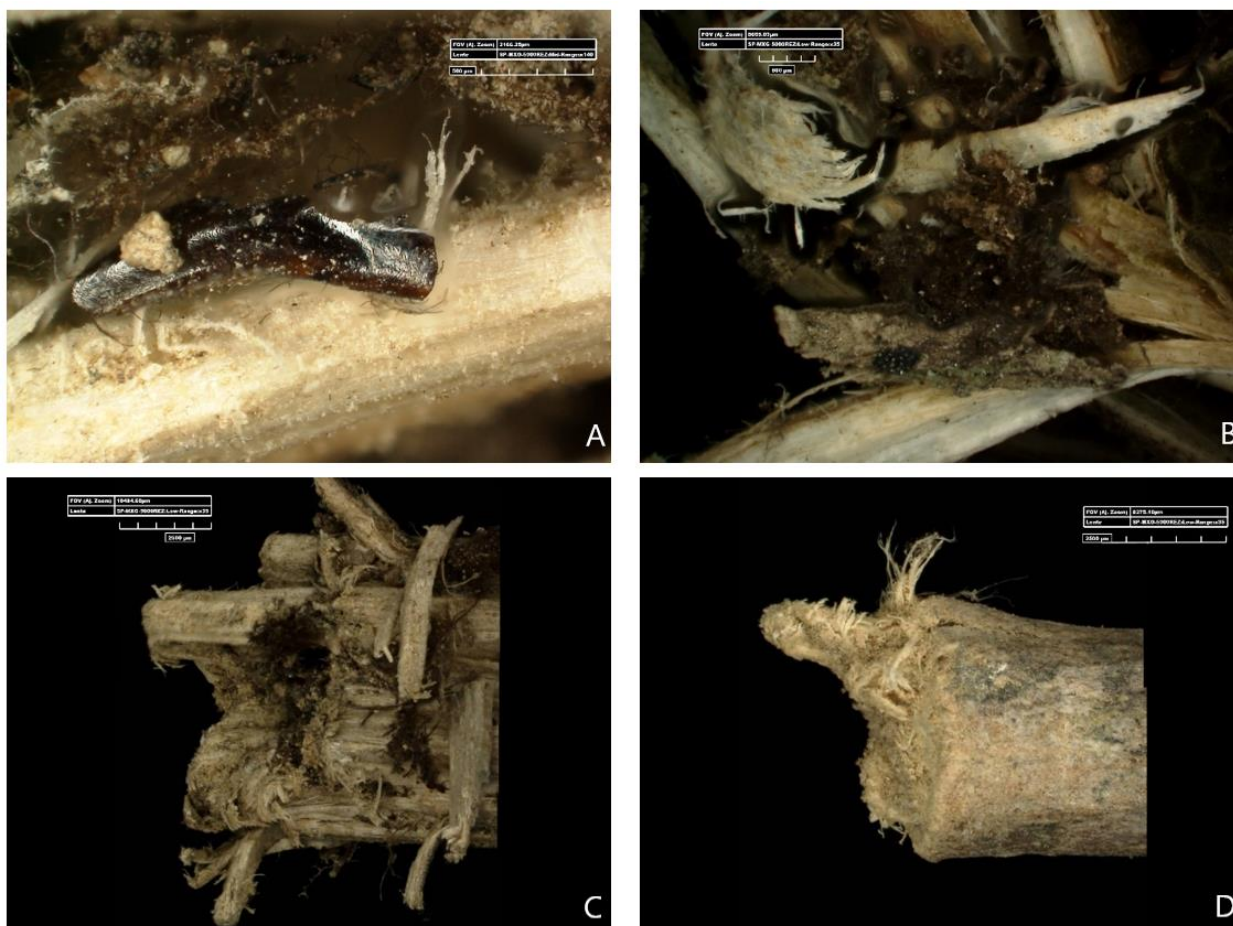


Figure 92: Examples of residues in broken tools: A: insect fragment (AF_15jun23_S5_T32); B: soil residue (AF_15jun23_S3_T27); C: soil residue (AF_15jun23_S3_T28); D: soil residue (AF_15jun23_S6_T37). Photos at 35x, except the first, that was made at 140x.

9. DISCUSSION.

Thanks to the analysis protocol developed for the study of tools in perishable material, we have been able to extract a significant amount of information. This information has been structured into different sections, with the first section covering basic data related to the collection of the tools. We then moved onto a measurement phase, followed by a detailed description of the scars we identified. This description encompasses two perspectives: macroscopic and microscopic. There is limited literature on the microscopic analysis of tools made from perishable materials, beyond macroscopic analyses that primarily involve measurements and morphological classification of the tool ends (Sanz *et al.*, 2009; Bermejo and Illera, 1999; McGrew *et al.*, 1979b; McGrew and Collins, 1985; Sugiyama, 1985; Suzuki *et al.*, 1995; Sanz *et al.*, 2004; Deblauwe *et al.*, 2006; Sanz and Morgan, 2007; Musgrave *et al.*, 2020; Heaton and Pickering, 2005). As a result, we drew from established methodological studies of mark analysis on lithic materials (Ollé *et al.*, 2016; Fernández-Marchena *et al.*, 2016; Fernández-Marchena and Ollé, 2015; Fernández-Marchena, 2021; Martín-Viveros and Ollé, 2020), or cut mark studies on bone materials (Courtenay *et al.*, 2020; 2018).

From the outset, we divided the behavioral process of ant-dipping, termite fishing, and algae fishing into an operational chain, as seen in the existing literature (Musgrave *et al.*, 2020). We identified an initial phase of extraction, an optional second phase of manufacture, followed by the use, and abandonment of the tool. However, this is a simplified version, as the actual process is far from linear. We chose to describe the tool starting from the end that was attached to the branch, which is typically the thicker end and the one presumably not used for insertion into termite or ant holes or water. Subsequently, the description moved towards the medial area, pausing at areas showing evidence of manufacture (manufacture peeling), fractures, or fissures. Finally, we reached the distal end, where we sometimes found types of modifications in common with the proximal end.

9.1. Application of the protocol to the materials from Dindefelo.

The first measurements taken were approached in two different ways: one involved measuring the entire real surface of the branch (digital length), and the other measured from end to end, representing the tool's working distance (end-to-end). The end-to-end distance was always shorter than the digital length because the latter always has a larger surface, even if the branch curves slightly. In this basic measurement, we faced some problems when comparing with pieces measured in other studies where the measurement method was not detailed (McGrew *et al.*, 1979b; Bogart, 2009). Although the difference is not significant in certain activities like algae fishing (Boesch *et al.*, 2017) in Bakoun, Guinea, where they used morphologies resembling hooks to gather algae more efficiently.

This issue did not arise when measuring thicknesses since there was only one way to measure them. We chose to measure thickness in three zones (proximal, medial, and distal), with the proximal end being the thickest (where growth begins) and the distal end being the thinnest.

We identified six proximal modifications, with a clear predominance of tools that had the "stripped bark" modification. Out of the total set of tools ($n=21$), the "stripped bark" modification was directly identified in eight tools, while in combination with other types, the count would exceed half of them (14). This type of modification is very common in proximal ends, resulting from the tool's extraction, which generates the characteristic fibrous appearance when torn during trunk removal (McCarthy *et al.*, 2017; Pascual-Garrido, 2018). This stripped bark on the tools can also be seen as a "negative" on the trunk if it hasn't detached for other reasons. On the other side, the distal end, we found up to five types of scars, with "frayed" being the most common scar ($n=7$) out of the entire set ($n=21$). However, if we consider the presence of stripped bark, either alone or in combination, we find that up to 12 tools displayed it. The generation of these stripped bark marks at the distal end could result from various actions. For instance, friction on the tool's surface could cause the fibrous appearance, particularly in activities like termite fishing or ant-dipping where tools may find with walls. However, for this fibrous appearance to occur, the tools must have a certain tendency to shed fiber. Furthermore, the insertion and extraction processes would likely align with the plant's natural vertical fiber structure. Measurements of these stripped bark modifications seem to indicate a clear, highly pronounced invasion compared to other modifications; hence, it is the most common and invasive. Here we encounter one of the first questions we posed: we have different types of marks originating from different processes, as one is from extraction, and others are from use.

But it would not be the only one; the results have shown us that differentiating marks based on processes is not an easy task. Out of the six types of proximal end marks and the five distal end marks, three of them coincide (stripped bark, frayed+stripped, and cut+stripped). If we focus on the measurements they create at each end, we can't rely on them since, in some cases, it's in the distal end (stripped bark: 71,03 mm; frayed+stripped: 85,28 mm), and in others, it's in the proximal end (cut+stripped: 218,00 mm). We conducted a study where we made a test (Kruskal-Wallis) to know, if there it is differences between the type of modification with size, the results it was not very significant for the proximal end (Kruskal-Wallis test, $p = 0,003$). Thus, we would need to look for another causative factor. Conversely, when the same analysis was performed on the distal end, we found a significant differentiation (Kruskal-Wallis test, $p = 0,323$), indicating a relationship between the type of modification and the invaded length. However, these results should be taken with much caution due to the small sample size. Therefore, our conclusion would be that the generation of certain modifications depends on factors that elude us.

In addition, the process that lead to the generation of the frayed modification, might be explained as the result of a stripped bark that gradually opens, and the repetitive use causes the fibers to bent. Whereas the generation of cut ends would involve the breaking of part of the end. Beyond these modifications, we would find those that haven't been mentioned before, such as bent (only on the proximal end) and peeled (only on the distal end).

When we conducted the analysis of the medial zones of the tools, we identified the presence of manufacturing activity in only a portion of them (n=5), making it an optional phase within the activity. There was a complete absence of this presence in one of the activities: algae fishing. For the identification of the branches, we observed the presence of a mark similar to stripped bark (but associated with another process), protuberances, small sheaths that could indicate this process. Here we must include a factor that could influence its identification, which is the drying process after the tool was abandoned, which could cover and be confused with a branch that was starting the growth process when it was torn off.

In the medial zone, we also found some traces related to use, extraction, or manufacturing since it could occur in various processes. This led to the generation of fractures identified in tools used in all three behaviors, all associated with medial or distal zones. We identified up to 46 fractures, with termite fishing (n=26) having the highest presence, followed by ant-dipping (n=19), and lastly algae fishing (n=1). These fractures were classified as complete or incomplete. The former included fractures where the central matrix broke, being held together only by the superficial fibers, while the latter involved the opposite, the breaking of the outer fibers but not the matrix. The conclusion we reached was that the appearance of fractures depended on how the instrument was held. If it was held firmly, it had a higher probability of breaking from the point of pressure, and the hand would stop the energy from propagating. Therefore, we could say that instruments primarily broke during the usage process at the distal end. Identifying use is an important part, especially when the techniques and acquisition behaviors are not very clear. That's why we rely on marks, such as those found on some pieces, like usage marks, grip marks, as seen in the medial zone of the algae-fishing tool, SE_AF_19mar20_S1_T02 (Figure 52), or possible tooth marks, which we documented on the distal end of the termite-fishing tool, NA_10dec21_TF_S1_T03 (Figure 37), and were already documented (Pascual-Garrido, 2018).

Nevertheless, the presence of these marks or fractures is not the only way to detect the use of the instrument and/or for what it was used for; an important part was the detection of residues and marks related to consumption. We found residues in tools from all three behaviors. In ant-dipping and termite fishing behaviors, it's easy to discern that, given the field of action, which includes soil (ant nest and termite mound), part of it would remain attached during use (Figure 36). This is what

we found in these tools. Additionally, in some cases (n=4) where we had residues of the species that was consumed, *Dorylus nigricans* (Figure 30) during the ant-dipping behavior, and since only the heads remained, we could say that chimpanzees mostly consume the rest of the body during this process because it's more accessible. Regarding algae, we also found traces of soil and algae (n=1) (Figures 54 and 55), which could tell us about the techniques used for algae fishing (which we will address in Section 9.4).

End modifications, as well as fractures, manufacturing scars, and some residues, were quickly identified during macroscopic analysis. However, certain elements, such as nail marks, tooth marks, and some residues, were identified during microscopic analysis, using HIROX KH-8700 and Sensofar S Neo. The former was the most used due to its efficiency in taking photographs to document all modifications, fractures, residues, manufacturing, etc., which we have included in the annex sheets. However, we encountered some problems related to this microscope due to errors during stitching and stacking tasks. Finally, Sensofar S Neo was used relatively infrequently due to the speed demonstrated by HIROX. It was used for detailed photography with heat maps showing the depth of the marks, as can be observed in the details of the tooth mark (Figure 37) or manufacturing (Figure 39).

Lastly, in the sheet, we included a section for spatial studies, providing fields for entering tool-nest distance or source-to-found location. This will allow us to understand the acquisition patterns of chimpanzees and to what extent the selection process is complex. For the study of these specific materials, we have limited information from the ant-dipping and termite fishing behaviors. Among the tools identified in ant-dipping (n=5), it was found that the tool was less than a meter away from the nest, except in one case where it was almost two meters away. In the case of termite fishing tools (n=4), the pieces were relatively close to the source from which they were acquired, less than 5 meters away. They were also very close to the nest, with a maximum distance of 62,5 cm. This aligns with some studies that have been conducted on tool transport (Pascual-Garrido *et al.*, 2012; Pascual-Garrido, 2018; Almeida-Warren *et al.*, 2017).

Based on the results obtained during the study of the materials from Dindefelo, we can make several comparisons regarding certain characteristics and whether they follow a certain pattern that allows us to understand the key factors in branch selection.

9.2. The technological differentiations based on activities in Dindefelo.

Once the data has been standardized and tests of analysis have been conducted, we determined that, in general, pieces from the behaviors of algae fishing, ant-dipping, and termite fishing exhibit some similarities. Non-parametric tests were performed on activities with digital length and end-to-end, and no significant differences were found overall (Kruskal-Wallis, $p = 0,003$). However, differences were observed when comparing two specific behaviors, such as ant-dipping and algae fishing (Kruskal-Wallis, $p = 0,913$). Similar patterns emerged when examining thickness. In general, they are similar (distal end, Kruskal-Wallis, $p = 0,003$; for the proximal end, Kruskal-Wallis, $p = 0,009$). But when comparing tools from ant-dipping and algae fishing, the differences are quite noticeable. Lastly, with regards to empirical parameters, if we look at weight, once again, no significant differentiation was found overall (Kruskal-Wallis, $p = 0,001$), but there were differences between ant-dipping and algae fishing (Kruskal-Wallis, $p = 0,607$) (Annex 1-3).

From these tests conducted on the technical conditions of the tools, we identified certain differentiating patterns when comparing them. The longest tools were found in the activities of algae fishing, although there were relatively few samples ($n=3$), with an average of 805,38 mm ($\pm 65,08$ mm), followed by ant-dipping tools with an average of 713,37 mm ($\pm 160,77$ mm). From this, we can infer that longer tools tend to be thicker and, therefore, heavier. This differentiation can possibly be justified by the distance required for the tool to achieve its intended purpose. It wouldn't be unusual to think that the distance traveled in an ant nest is not as significant since they are situated nearby, whereas for an activity like obtaining algae, a longer pole is needed to reach the deeper areas, as observed in Bakoun (Boesch *et al.*, 2017) to access resource-rich zones.

When comparing tools from ant-dipping with termite fishing, the length and weight measurements showed no significant differences (Length: Kruskal-Wallis, $p = 0,017$; and for weight: Kruskal-Wallis, $p = 0,011$). This is due to the activities being quite similar. However, significant differences were found in the proximal end (Kruskal-Wallis, $p = 0,071$), whereas in the distal end, differences were not significant again (Kruskal-Wallis, $p = 0,016$). This could be justified by the fact that the proximal ends of ant-dipping tools have a higher proportion of "stripped bark" modifications ($n=9$), which reduces thickness by destroying layers, while in termite fishing, there is a "bent" modification ($n=4$), which stretches the fibers, causing them to bend and elongate.

Now, when we make comparisons after classifying the tools by type, thus becoming more descriptive, we conducted tests again to see if there was a relationship between end modifications and activity type. The result was that for proximal end modifications by activity type (Kruskal-Wallis, $p = 0,102$), there was no significant differentiation. We found greater differentiation when comparing

modifications found in algae fishing and termite fishing (Kruskal-Wallis, $p = 1,000$). Similarly, we found a significant differentiation in the measurements of distal end modifications (Kruskal-Wallis, $p = 0,232$) (Annex 4). This can be somewhat explained by the high diversity with a low number of samples.

Finally, we performed a comparison between the measurements of modifications in relation to the type of modification. In the proximal ends, there was no significant differentiation (Kruskal-Wallis, $p = 0,003$). Conversely, we found significant differentiation between the types of modification and their length in the distal ends (Kruskal-Wallis, $p = 0,323$) (Annex 5).

Therefore, the impression we can gather from the materials from Dindefelo is that they exhibit very similar measurements when looked at, but there are differentiations among specific activity types, as seen in algae fishing and ant-dipping. At the same time, we have observed that the tools possess a wealth of evidence that allows us to classify them based on length, thickness, types of modifications, measurements of these modifications, and manufacturing they have undergone. These are activities with a marked diversity, which also share some commonalities. Due to the low number of samples, we cannot extrapolate them as patterns, but we can emphasize the differences.

9.3. Experimental program.

From the experimental program, we were able to identify the marks found on the tools from Dindefelo, which are associated with different processes such as extraction, manufacturing, and use.

During the first phase, 40 branches of plant species with different characteristics, both rigid and flexible, were extracted in order to understand how they would behave when subjected to ant-dipping and termite-fishing activities. We have evidence that both flexible and rigid tools are used in areas near Dindefelo, such as Assirik (Whiten *et al.*, 2001). However, the tools we have for our study are all rigid and quite fragile. The average extraction time depended on the thickness of the branch we wanted to extract, with an average time of 5,4 seconds (ranging from a minimum of 0,53 seconds to a maximum of 46,33 seconds), and the average thickness of the tools after extraction was 4,96 mm ($\pm 2,03$ mm). The most common modification generated at the proximal end, similar to the materials from Dindefelo, was "stripped bark," accounting for 90% of the cases. From these measurements, we conducted a Kruskal-Wallis test comparing the length of the modification with the type of modification generated. The result was the same ($p = 0,003$), but in this case, we did observe differentiation between types of marks such as "cut" and "stripped" ($p = 0,15$). The morphologies found in the tools from the experimental program after extraction were similar to those found in ant-dipping tools (stripped bark, cut+stripped, cut, and frayed+stripped), with the exception of a single type of modification (bended+stripped), which was found in termite fishing tools (e.g.,

NA_10dec21_TF_S1_T10). In the medial area, during extraction, two complete fractures occurred because when the branches were pulled, they were grabbed at the proximal end to exert greater force. Finally, the distal area remained intact, with only elements such as sub-branches requiring manufacturing.

During the second phase of the program, tool manufacturing was carried out using different techniques, which we referred to as "grab and drag" and "press-slide" (Figure 72). The time taken to extract it again depended on the thickness of the sub-branches and leaves. It was determined that "grab and drag" was more efficient for sub-branches, while "press-slide" passes were better for removing leaves. The average time was 23,42 seconds (ranging from a minimum of 3,56 seconds to a maximum of 1 minute and 6 seconds). During the analysis, a significant difference was found based on the type of manufacturing performed. For the extraction of sub-branches: protuberances (Figure 73C-D) that could no longer be extracted, samples of (Figure 73A-B), as well as some small residual branches that were difficult to remove (Figure 74A). On the other hand, for leaf extraction, the elements were much less pronounced, with very small protuberances (Figure 74C, F), and when performing the press and slide, sap bleeding occurred (Figure 74D). Therefore, we can differentiate very specific marks generated by the type of technique used.

In the final phase, the materials from the experimental program were used for an average of 1 minute and 43 seconds (with a minimum of 15 seconds and a maximum of 4 minutes). During this process, two types of techniques were used, similar to those found in the literature (Figure 18) (Lesnik *et al.*, 2015). In this part of the experiment, the tools were used by one or both ends. The reason for using both ends was to understand how the end without marks changed after use, while in the proximal end, we were investigating how the extraction modification was affected by use, whether it was altered, reduced, or ultimately eliminated.

The results of continued use on the proximal end showed an increase in the diversity of modification types, going from 5 modifications to 11 types of modifications. In this regard, the most common modifications were stripped bark, but we went from a presence of 90% to 82,5% (Table 44; and Figure 86) (both unique and accompanied by others). This is reflected in the increase in types of unique morphologies, including some for which we had no records, such as rounded. We also see a clear reduction in the total length of the piece due to use, fractures, and generated breaks (Figure 79). From the study of the proximal end, subjected to extraction and use, there is a clear change where some types of modification are reduced in favor of greater diversity.

On the other end, the distal end, we have the greatest differences in terms of the types of modifications found in the tools for ant-dipping and termite fishing. Among the latter, we have the presence of the following: frayed+stripped, stripped bark, frayed, peeled, and cut+stripped.

Meanwhile, in the distal ends of the experimental program, we have up to 10 types of modifications (except for no visible marks). They match in 4 of them, while the rest are different (Table 45). Among the different types of modifications with respect to the tools from Dindefelo, we find: peeled+stripped, rounded, rounded+peeled, cut, and manufacture peeling. In addition, their measurements differ between them, except in one case (peeled with 13,6 mm in termite fishing, and 14.5 mm in the experimental program).

	Termite fishing			Ant dipping			Experimental program		
	MEAN	SD	N	MEAN	SD	N	MEAN	SD	N
Frayed+stripped	68,60	64,5	2	92,00	111,48	6	60,00	0	1
Stripped bark	-	-	-	71,03	86,35	3	10,12	6,30	4
Peeled	13,60	0	1	-	-	-	14,50	0	1
Cut+stripped	32,00	0	1	-	-	-	5,00	2,12	2

Table 45: Comparison of modifications in the distal ends along with the average measurements of tools from termite fishing, ant dipping, and the experimental program. The unit is mm.

The generation of fractures has been one of the most notable elements during the use process; fractures were generated in almost half of the experimental tool set. The locations of these fractures per piece are the medial zone and distal end (8 each one), medial-distal zones (2), and proximal (1). The generation of these fractures according to use, based on the data presented in Section 8.2.1., shows that the appearance of fractures after using the tools on the proximal end can generate fractures not only in the proximal zone but also in the medial zone. Therefore, we should look for more accurate elements to verify the use of the tool on the proximal end, not limited to fractures but also incorporating other elements such as the presence of residues.

Thanks to this type of technological studies, we can discern some of the possibilities we may encounter in the future. Even though we have such a limited comparison since we have few real samples from Dindefelo, it is interesting to explore the types of marks that can be obscured, overlapped, or disappear, as well as how sample size can be affected, and the presence of fractures after use on certain ends. It goes in the same direction as understanding the processes by which a specific type of mark is formed, and this is the final question we ask in this work: how do they produce a frayed, stripped bark, bent? What are the factors involved? To answer these questions, we need to know the techniques, grip gestures, the characteristics of their environment, the materials they use. Similarly, it is important to know the relationships with other chimpanzee communities that may have similar behaviors, which can help shed light on the uncertainties. Fortunately, we have the presence of this type of behavior (termite fishing and ant dipping) is quite common among chimpanzee groups, and we find two interesting Senegalese cases to compare, Fongoli and Assirik.

9.4. Ant-dipping, termite fishing and algae fishing in others chimpanzee communities.

For the comparison of materials, we should look at other chimpanzee communities in the savannah near Dindefelo in southeastern Senegal, specifically in the Assirik Mountains (located within the Niokolo-Koba National Park), as well as in the Fongoli area, where the "Fongoli Savanna Chimpanzee Project" is being conducted. Ant-dipping and termite fishing behaviors are quite common in chimpanzee groups, as they forage for insects as a significant source of food resources. In the first location, Assirik, the existence of ant-dipping as well as termite fishing has been documented by McGrew *et al.*, (2003). In the second location, the Fongoli area, activities of ant-dipping (Pruetz and Bertolani, 2009), as well as termite fishing (McGrew *et al.*, 2005; Bogart and Pruetz, 2008; 2011) have been recorded.

Termite fishing is well-documented in both areas, Fongoli and Assirik. However, we don't have much information published about this behavior at Dindefelo. In Assirik, termite fishing has been identified in forested and plateau areas, where chimpanzees have a good number of raw materials to manufacture tools. Chimpanzees use flexible probes made from branches, stems, barks, vines, and leaves to extract termites. The probe is inserted into the termite mound, where the termites eventually attack the "intruder," allowing them to be caught as the probe is slowly extracted (White *et al.*, 2001). In the other case, Fongoli, termite fishing would occur in forests, depending on availability. Four termite species have been recognised as consumed by the chimpanzees: *Macrotermes subhyalinus*, *M. bellicosus*, *Trinervitermes togoensis*, and *T. geminatus*. The tools are branches, stems, barks, leaves, or vines, all of which are flexible (Bogart, 2005). The chimpanzees use these sticks, to probe into the termite mound after opening a hole with their fingers, and after their extraction, chimpanzees hold the probe in the opposite wrist and collect the termites with their lips. This technique is very similar to what can be observed in other communities beyond West Africa such as Gombe (Goodall, 1963), Mahale (McGrew and Collins, 1985), and Goualougo (Sanz *et al.*, 2004).

When comparing it with the tools from Dindefelo, we find a difference in the type of tools used for this activity (Boesch *et al.*, 2020), as well as the technique they use. It would be an activity they perform while seated, primarily using rigid wood, although flexible wood is also found. They insert it with one hand, subject it to scraping, biting, shaking, and the instrument would have a brush-like head.

Studies of termite fishing behavior have been conducted in both locations, with measurements taken (Bogart, 2005; 2009; McGrew *et al.*, 1979b), but without knowledge of how these measurements were taken, and as a result, we face certain difficulties in making comparisons.

In Fongoli, in 2005, 401 tools were collected during both wet and dry season (Bogart, 2005). They had an average length of 295,00 mm (minimum 9, maximum 1060,00 mm). Of these, it was found that at the distal end, 61% of the set had frayed tips, while at the proximal end, stripped bark was identified (Bogart, 2005). In another later study by Bogart (2009), the measurements remained very similar, and some plant species were identified, including *Saba senegalensis* (51%), *Grewia lasiodiscus* (16%), *Daniellia Oliveira* (9%), and *Hexalobus monopetalus* (9%).

In Assirik, a study by McGrew and colleagues (1979b) collected 173 tools, with tool lengths ranging from 130,00 mm to 710,00 mm, and an average length of 300,00 mm.

The measurements are quite similar when comparing both areas, based on the reflected average, although the minimum and maximum ranges are quite far apart. From here, we can conduct careful comparisons, considering the limits of our sample and the type of measurement used. The results of our study of termite fishing tools (n=7) show an average of 393,68 mm (digital length) and 378,21 mm (end-to-end length). This does not differ significantly from the tools in these areas, as the sample size from Dindefelo is so small that it may conceal the true size of the tools. There are also differences in the types of termites consumed (at least in the case of Fongoli) and the type of plant species used as tools (Boesch *et al.*, 2020). We do not know the extent to which we can attribute importance to these differential factors between different populations when it comes to generating a type of modification.

However, we also have another set of data that highlights the relationship regarding the pattern of branch acquisition. In Fongoli, the distances varied concerning the source from which the branches were obtained, with an average of 1,3 meters (range 0 to 10 meters). The distance between the termite mound and the tool had an average of 36,5 cm (range 0-224 cm) (Bogart, 2005). In Dindefelo, the distance from the tool to the source averaged about 2,6 meters (range 1,66 to 4,63 meters), while the distance between the branch collection and the nest had an average of 30,25 cm (range 0 to 62,5 cm). These data show that there is a pattern of tool acquisition close to where the activity is carried out.

Regarding ant fishing, in Assirik, we have evidence of ant-dipping, particularly *Dorylus nigricans*, being a regular practice (Hunt and McGrew, 2002; Baldwin, 1979), constituting 27% of their diet (McGrew, 1983), although it occurs seasonally (Baldwin, 1979) and typically makes up about 2% of their diet (Baldwin, 1979). They use long, straight vegetation rods to harvest "driver ants" from their surface nests (McGrew, 1983), including the legionary ant *Megaponera foetens*, which bites and stings aggressively and seems to be consumed only in Assirik (McGrew, 1983). The technique used is related to what is observed in Gombe (McGrew, 1982) and is known as "ant-dip-wide." This extraction method requires a longer stick, along with bimanual cleaning (Whiten *et al.*,

2001). The descriptions of the branches mention that they are stripped of leaves or leaflets and are submerged at both ends (McGrew *et al.*, 2003).

In Fongoli, there is not much information available about the techniques they use, only some indications that are briefly mentioned in Koops *et al.* (2015: 4): "*At Fongoli, chimpanzees prey only on epigenic army ants and use the pull-through technique most of the time.*" The tools were stripped of small branches and leaves (McGrew *et al.*, 2005). Technological data of the tools of both sites:

- In the tool study in Mount Assirik, in a study by McGrew and others (McGrew *et al.*, 2003), based on eight samples, the average length was 720,00 mm ($\pm 200,00$ mm), the distal thickness was 57,00 mm ($\pm 1,9$ mm), and the proximal thickness was 35,00 mm ($\pm 1,00$ mm).
- In Fongoli, the following data were obtained: the average length was 760,00 mm (with a minimum of 470,00 mm and a maximum of 1520,00 mm), while the thickness ranged from 3,0 mm to 1 mm, based on 21 tools (McGrew *et al.*, 2005).

Once again, there is a significant resemblance in the average measurements between Assirik and Fongoli (720,00 mm and 760,00 mm, respectively), even though the range of possibilities is quite different. In Dindefelo, there is not much information available about the technique used for ant extraction. The results of the study of these tools show a surprisingly similar average in relation to what Assirik and Fongoli show, with the average length of the tools being 713,37 mm (digital length mm) and 686,44 (end-to-end mm). If we had data on how the behavior is in Dindefelo and had a larger sample size, we could potentially establish a more complex connection. However, there are other similarities. At Fongoli, it was observed that 16 tools had been stripped at their proximal ends but were not further modified, while 5 had been cut with incisors. Only 1 proximal end showed signs of fraying due to use. The distal ends of the rods showed many more signs of modification (19 had been cut) and use (10 were frayed) (McGrew *et al.*, 2005). This could correspond somewhat to the number of cut marks identified at the proximal end ($n=5$) in the ant-dipping tools from Dindefelo. However, since we do not have knowledge of the techniques used by the chimpanzees in Dindefelo, it is difficult to establish a direct relationship between both patterns. Thus, future works reviewing the camera traps videos from Dindefelo may shed light on the techniques used by the chimpanzees. If we look at the opposite end, we have a concentration of frayed marks in the materials from Dindefelo ($n=8$), which is very similar to what is reflected in the materials from Fongoli ($n=10$). Thus, we could tentatively compare that perhaps the factors involved may be similar in the formation of these modifications.

Algae fishing, it is not a very common activity among chimpanzee societies, and this could be explained by the diversity of behaviors being subject to environmental variations (Kalan *et al.*, 2021).

Similarly, ecological conditions may favor the consumption of algae (Boesch *et al.*, 2017). There are some records, such as those in Bakoun (Boesch *et al.*, 2017) and Bossou (Humble *et al.*, 2011).

If we delve into the research from Bakoun (Guinea), we find certain relationships that can provide us with information about algae fishing in Dindefelo. In Bakoun, fishing for algae was concentrated during the dry and hot season (similar to when materials were collected in Dindefelo), and tools were always used for this activity. The tool was held with one hand at one end, and they would submerge it until it touched the bottom substrate of the water source. Then, they would guide and rotate the tool to coil the algae fibers (or in some cases scrape the bottom of the water) at the other end of the tool. Afterward, individuals take the sticks out of the water and bring the end where the algae had accumulated to their mouths, pulling it with their lips (Boesch *et al.*, 2017). When they classified the tools, they categorized them into two groups: hooks or smooth. The hook tools were curved or had a hook-like shape, while the smooth tools were more robust and straight. All of them were made from woody branches except for one, which was bamboo. Modifications were observed on the tools, such as removing small branches (24%), fraying one (27%) or both ends (6%) of the tools using teeth or fingers. When comparing this with the tools from Dindefelo, we find fraying marks at the distal end, but we do not identify any specific manufacturing.

If we compare the measurements of the tools used in algae fishing behavior ($n=3$), we find that the average length would be 805,38 mm (with a minimum of 741,02 mm and a maximum of 871,17 mm), an average thickness of 6.80 mm in the middle (with a minimum of 5,50 mm, maximum of 7,60 mm), and an average weight of 13,8 grams (with a minimum of 6,94 g, maximum of 24,93 g). Meanwhile, in the study of Bakoun tools (Boesch *et al.*, 2017), we do not see a significant differentiation in the measurements of length, thickness, and weight for the smooth samples ($n = 455$): length (mm): 763,30 mm (with a minimum of 90,00 mm, maximum of 4310,00 mm), thickness (mm): 6,76 mm (with a minimum of 1,00 mm, maximum of 30,00 mm), and weight: 36,50 grams (with a minimum of 2 g, maximum of 401 g).

Therefore, we have very similar tools in terms of average length and thickness. However, we must once again acknowledge that comparing these sets is difficult not only due to the limited number of samples but also because of the distance between the two societies. It would not be surprising to find that this behavior is occasionally present in the chimpanzee groups of Assirik or Fongoli. Since it is a seasonal behavior (Boesch *et al.*, 2017), especially in dry habitats like those in Senegal and Guinea, it may be crucial for chimpanzees to include more water-related activities in their behavioral repertoire (Pruetz and Bertolani, 2009).

10. CONCLUSION.

Dindefelo Community Natural Reserve is one of the few natural reserves where we can encounter the savanna chimpanzee in its natural habitat in West Africa. It is for this reason that, as a society, we must be more persuasive when it comes to implementing protective measures for these animals. This effort should commence within a framework of dialogue.

Therefore, the need to study the technology of savanna chimpanzees can serve as a reason to support increased restrictions that do not endanger their natural habitat, it adds to the justification and importance of their conservation. The development of this protocol is expected to help establish a framework for analyzing perishable tools, allowing for more complex comparisons by systematizing the data.

The results presented in this study, based on the analysis of 21 tools from Dindefelo, have revealed the wealth of technological information that can be extracted from a type of artifact that has not received as much attention in the primate archaeological research. Here, we have shown that differences in scars resulting from different processes, such as extraction, manufacture, and use, can be identified. Hence, this work aligns with the concepts of "Primate Archaeology" (Haslam *et al.*, 2009) and "Archaeology of Perishables" (Pascual-Garrido and Almeida-Warren, 2021).

During the course of this study, we encountered limitations in the analysis of materials. Therefore, we would like to propose some suggestions for the future:

- Study indirect evidence that indicates the presence of specific activities at certain points. These sources, often overlooked, can provide valuable insights. Such evidence may include tools left inside holes, the number of holes found, hair tracks, and knuckle prints. We propose incorporating these types of evidence into the record sheets.
- Include a field for noting the color of the branch. This could help determine the time the tool spent in the field, potentially shedding light on its use history.
- To understand material selection patterns, analyze the area near termite or ant mounds to identify nearby branches that may have been torn off and determine their species. This can help establish a connection between tool behavior and the selection of specific materials.
- Document the techniques used by chimpanzees in Dindefelo when using these tools. Understanding how they hold the tool can be crucial in deciphering the patterns of fractures and scars.
- Develop research projects focused on studying the technology of chimpanzees in Dindefelo, combining it with ethological studies.

- Investigate convergences and divergences in instrumental behaviors in nearby areas, such as Dindefelo, Fongoli, and Assirik, where more technological information on common activities is available.
- Study potential differences in tools made during dry and wet seasons.
- Identify algae fishing tool in Dindefelo and put in relationship with Guinea.

Despite the limited number of tools examined in this study, the potential for future research is evident. It remains to be seen whether the application of this protocol will facilitate documentation and generate new data for comparative purposes. The study of perishable tools, in conjunction with an understanding of the factors involved in their production, is essential for understanding the evolution of our ancestors. Conducting more studies on these materials will be crucial for translating our interpretations into insights into evolutionary determinants.

With this work, the objectives that were initially set have been achieved. A methodological protocol for studying perishable support technology has been proposed from both a macroscopic and microscopic perspective, which was carried out using the HIROX KH-8700 and Sensofar S Neo microscopes. This constitutes a first approach to the technological of perishable tools of chimpanzees, and thanks to the application of this protocol, we have been able to learn some of the technological characteristics of ant-dipping, termite-fishing, and algae fishing (Annex 6). Also, this protocol will allow for a recording guideline that can be expanded as needed to meet new requirements. The protocol was tested with a group of actual chimpanzee tools, as well as with a group of tools from an experimental program. This allowed us to compare the scars and classify them according to the phase they are in within the operational chain (Annex 6). Ultimately, this will help us better understand the technological aspects of chimpanzee perishable tools, which are gradually gaining the importance that deserve.

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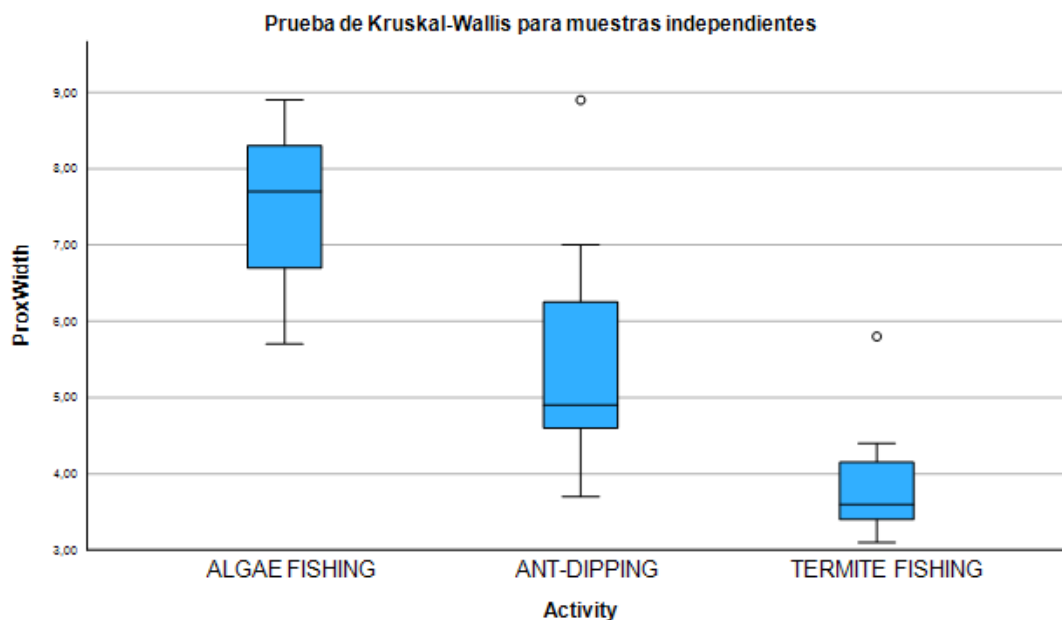
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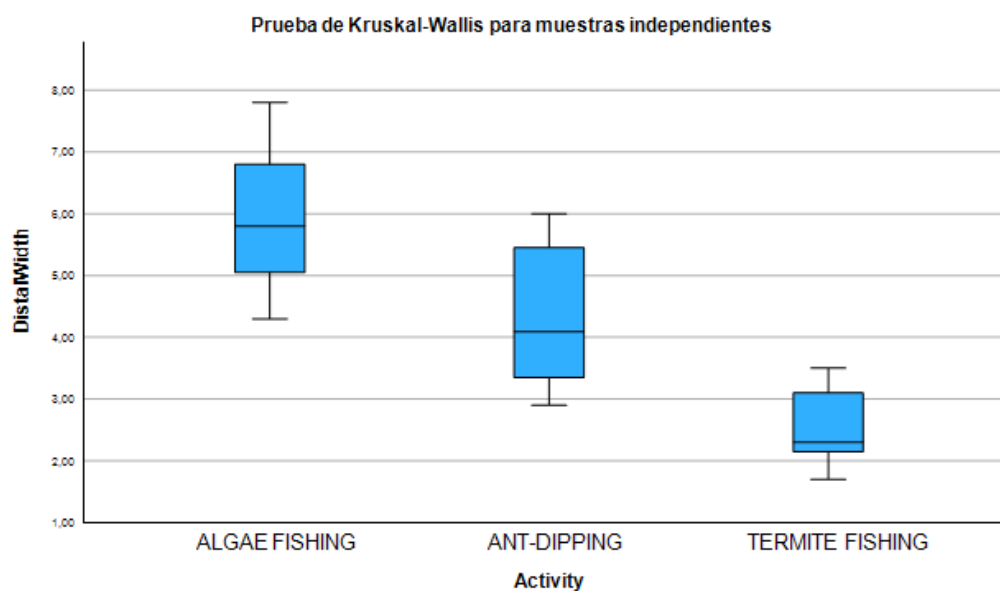
12.ANNEX.

- 1. Kruskal-Wallis with independent samples: Digital length (mm) and End-to-end (mm) with type of activity (Dindefelo samples).**
- 2. Kruskal-Wallis with independent samples: proximal and distal width (mm) with type of activity (Dindefelo samples).**
- 3. Kruskal-Wallis with independent samples: weight (gr) with type of activity (Dindefelo samples).**
- 4. Kruskal-Wallis with independent samples: modifications length (mm) with (Dindefelo samples).**
- 5. Kruskal-Wallis with independent samples: modification type with modification length (mm) (Experimental program).**
- 6. Protocol for the analysis of perishable tools of Chimpanzees, along with simplified operational chain.**
- 7. NA_10dec21_TF_S1_T03.**
- 8. NA_10dec21_TF_S1_T10**
- 9. NA_10dec21_TF_S1_T06.**
- 10. SE_27jan22_AD_S1_T02.**
- 11. SE_AD_25jan22_S1_T01.**
- 12. SE_AD_25jan22_S1_T02.**
- 13. SE_AF_19mar20_S1_T02.**
- 14. SE_AF_19mar20_S1_T05.**
- 15. SE_AF_19mar20_S2_T12.**
- 16. SE_AD_18jan23_S2_T13.**
- 17. SE_AD_19jan23_S01_T05.**
- 18. SE_AD_19jan23_S01_T06.**
- 19. SE_AD_27jan23_S01_T04.**
- 20. SE_AD_27jan23_S01_T05.**
- 21. SE_AD_27jan23_S01_T06.**
- 22. NA_TF_1feb23_S01_T01.**
- 23. NA_TF_1feb23_S01_T02.**
- 24. NA_TF_1feb23_S01_T08.**
- 25. NA_TF_1feb23_S01_T10.**
- 26. SE_AD_6feb23_S01_T04.**
- 27. SE_AD_6feb23_S01_T03.**

2. Kruskal-Wallis with independent samples: proximal and distal width (mm) with type of activity (Dindefelo samples).

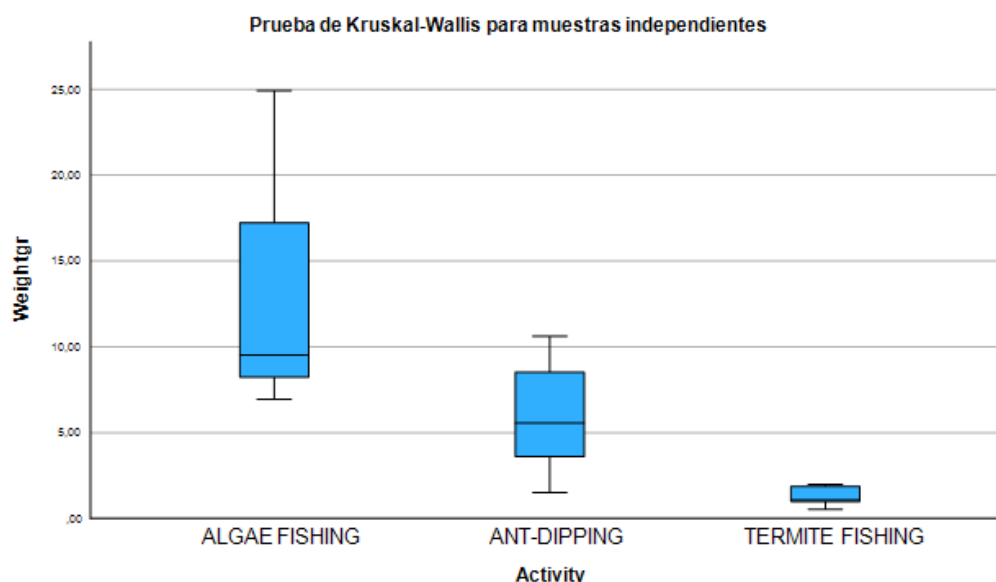


Sample 1-Sample 2	Estadístico de prueba	Error estándar	Estadístico de prueba estándar	Sig.	Sig. ajust. ^a
TERMITE FISHING-ANT-DIPPING	6,786	2,998	2,263	,024	,071
TERMITE FISHING-ALGAE FISHING	12,119	4,279	2,832	,005	,014
ANT-DIPPING-ALGAE FISHING	5,333	4,039	1,321	,187	,560



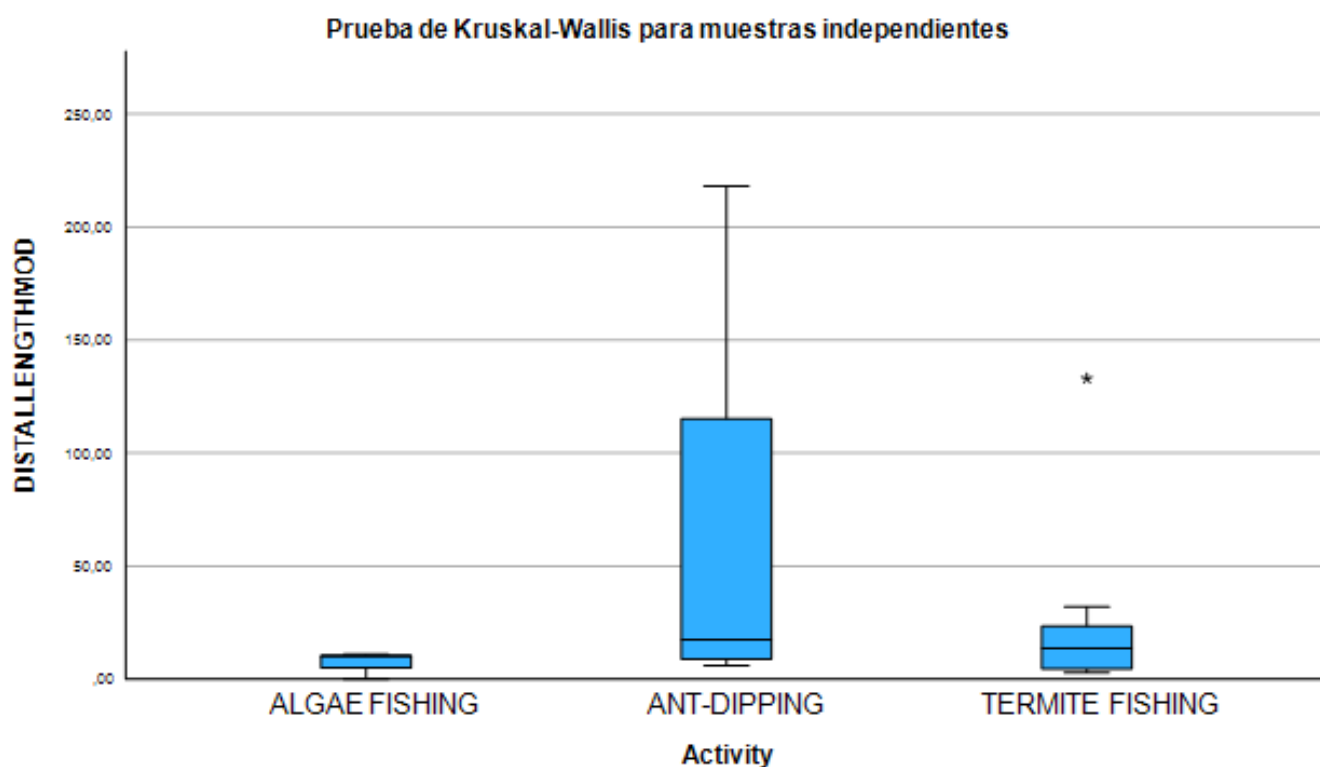
Sample 1-Sample 2	Estadístico de prueba	Error estándar	Estadístico de prueba estándar	Sig.	Sig. ajust. ^a
TERMITE FISHING-ANT-DIPPING	8,325	2,998	2,777	,005	,016
TERMITE FISHING-ALGAE FISHING	12,476	4,279	2,916	,004	,011
ANT-DIPPING-ALGAE FISHING	4,152	4,039	1,028	,304	,912

3. Kruskal-Wallis with independent samples: weight (gr) with type of activity (Dindefelo samples).



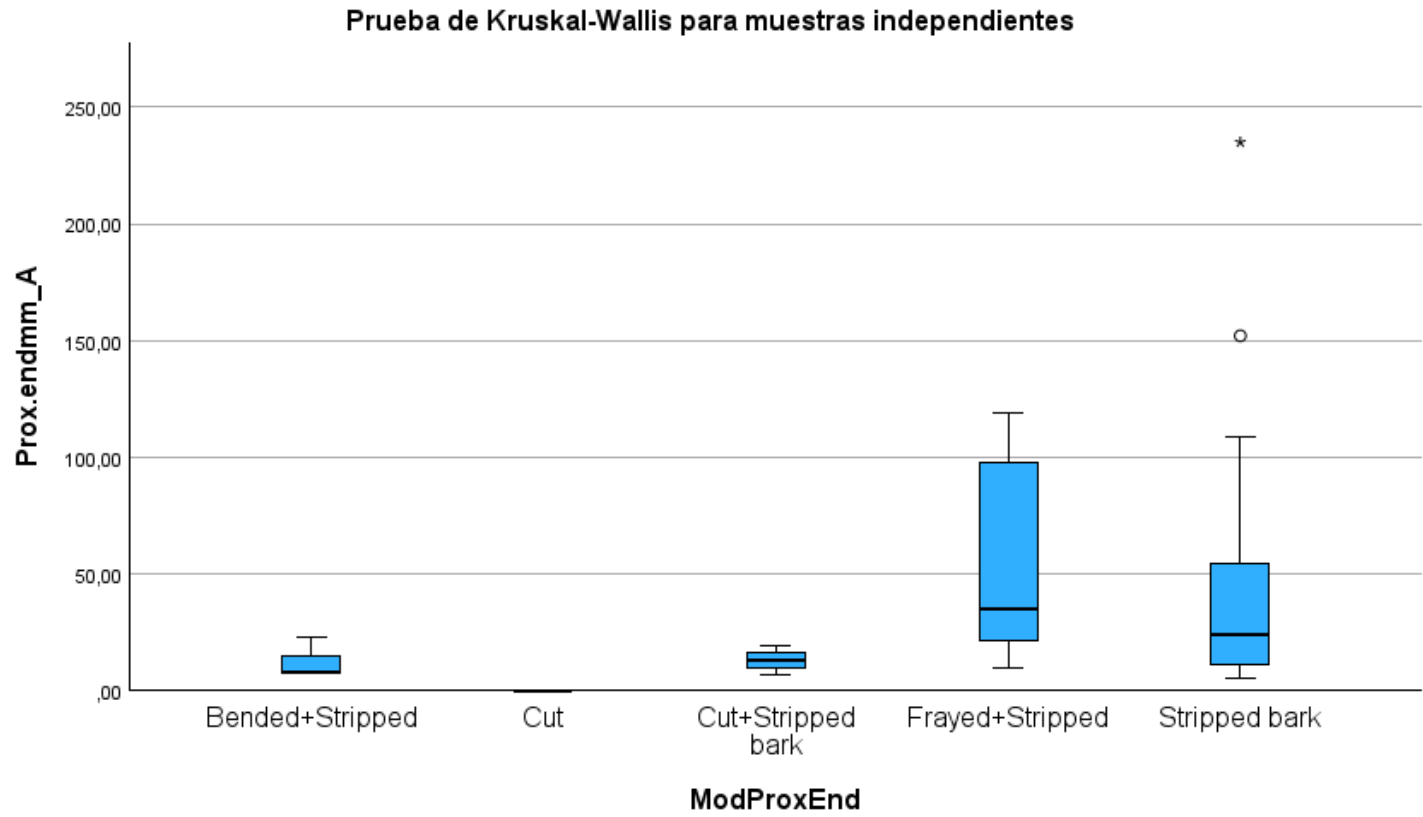
Sample 1-Sample 2	Estadístico de prueba	Error estándar	Estadístico de prueba estándar	Sig.	Sig. ajust. ^a
TERMITE FISHING-ANT-DIPPING	8,753	3,000	2,918	,004	,011
TERMITE FISHING-ALGAE FISHING	13,905	4,282	3,247	,001	,003
ANT-DIPPING-ALGAE FISHING	5,152	4,041	1,275	,202	,607

4. Kruskal-Wallis with independent samples: modifications length (mm) with type of activity (Dindefelo samples).

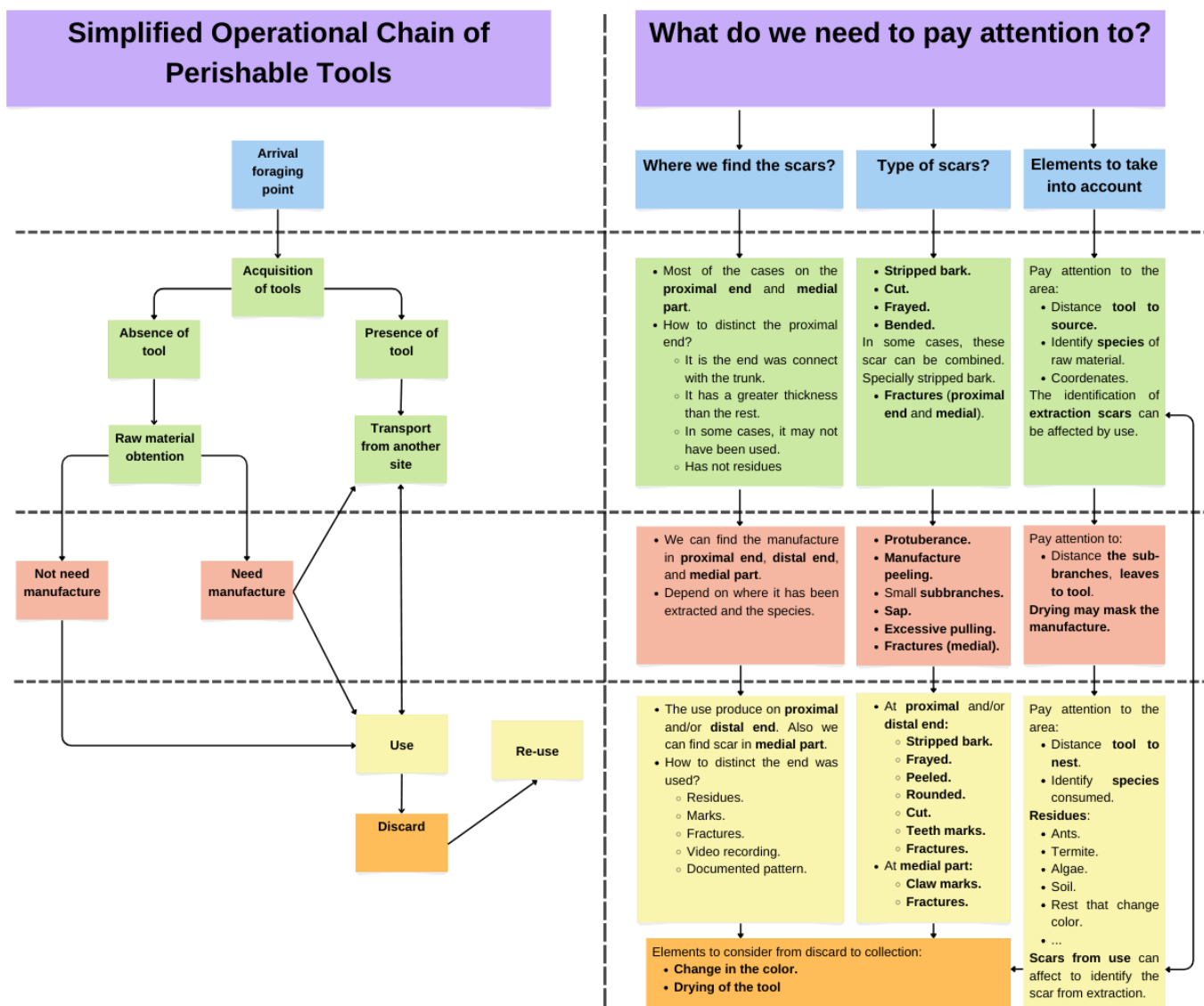


Sample 1-Sample 2	Estadístico de prueba	Error estándar	Estadístico de prueba estándar	Sig.	Sig. ajust. ^a
ALGAE FISHING-TERMITE FISHING	-2,738	4,279	-,640	,522	1,000
ALGAE FISHING-ANT-DIPPING	-6,212	4,039	-1,538	,124	,372
TERMITE FISHING-ANT-DIPPING	3,474	2,998	1,159	,247	,740

5. **Kruskal-Wallis with independent samples: modification type with modification length (mm) (Experimental program).**



6. Protocol for the analysis of perishable tools of Chimpanzees, along with simplified operational chain.



File number: 0001	Tool identification: NA_10dec21_TF_S1_T03	Field site: Dindéfélo	Area: Nandoumary
		Country: Senegal	
Locality: Rockshelter	Day of collection: 10		Activity: ☒ Termite fishing ☐ Ant dipping ☐ Algae fishing ☐ Baobab pounding ☐ Indeterminate
Site code: -	Month of collection: December	Site UTM X: -	
Season: Dry	Year: 2021	Site UTM Y: -	
Species consumed: <i>Macrotermes sp.</i>	Tool type 1: Stick	Tool type 2: ☐ Fixed ☒ Portable	Distance to raw material source (metres) Unknown
Raw material source identified: No	Distance tool – nest entrance (cm): Unknown	Distance to baobab (tree): -	
Plant raw material: <i>Desmodium salicifolium</i>	Stone raw material: n/a	Blank: Twig	Weight (gr): 1,99
Digital length (mm): 452,71		Proximal width (mm): 4,40	
End-to-end length (mm): 422,27		Medial width (mm): 3,20	
Max thickness (for stone tools; mm): n/a		Distal width (mm): 3,50	
Morphology: curved		Numbers used areas: 1	
Proximal end (stick): ☒ Stripped bark ☐ Cut ☐ Bent ☐ Frayed ☐ Unmodified	Proximal end modification (mm): 18,00	Distal end (stick): ☒ Stripped bark ☒ Cut ☐ Bent ☐ Frayed ☐ Peeled ☐ Unmodified	Distal end modification (mm): 32,00
Residue presence: ☐ Yes ☒ No	Type of residue: ☐ Shells ☐ Fruit residues ☐ Insect fragments ☐ Soil ☐ Algae ☐ N/A	Residue species: -	Analysis: ☒ Macroscopic ☒ Hirox ☒ Confocal ☐ Zeiss ☐ ESEM
		Residue location: ☐ Proximal ☐ Mesial ☐ Distal	
Broken tool: ☐ Yes ☒ No	Manufacture peeling: ☒ Yes ☐ No	Presence of leaves: ☐ Yes ☒ No	Presence of sub-branches: ☒ Yes ☐ No
Number adhered fractures: 1	Location of fractures: ☐ Proximal ☒ Mesial ☐ Distal	Researcher conducting the analysis: Daniel Vivar Ríos (IPHES-CERCA)	

Tool description:

Perishable tool collected at the location named by IJGE “Punto de agua” in Nandoumary, also described as the ‘rockshelter’. It was collected in December, which correspond to the dry season. The tool is a portable twig (made of *Desmodium salicifolium*) that was used on activity of termite fishing (*Macrotermes sp.*). The tool measures 422,27 millimeters in length and with a thickness ranging from 4,40 to 3,20 mm. And it has a weight of 1,99 grams.

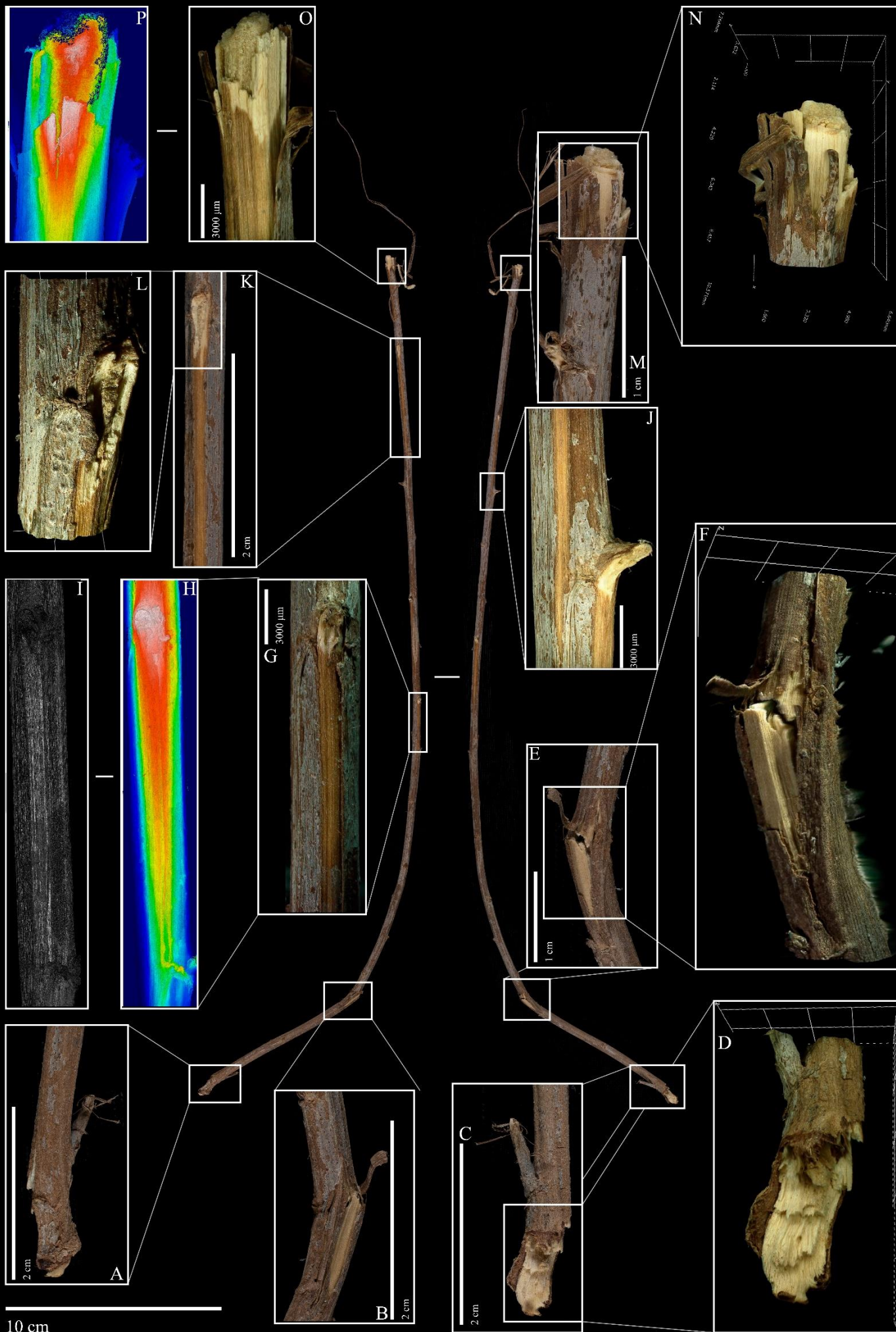
During the analysis, that included the use of the HIROX and Confocal microscopes, we identified some marks located in across the tool. We can assume that the tool was solely used from the distal end.

Morphologically the tool is curved. The tool is complete with its curvature more pronounced in the proximal part, a consequence of its fracture (E). This unique fracture in the tool is not complete (F). The proximal end presents a modification (stripped bark) related to the extraction of the tool from the source. This scar is non-invasive (C, D) with a length of 18 mm. The opposite side of the proximal end does not show any distinguishable mark but shows a protuberance from a previous sub-branch (A). The distal end presents a combination modification including cut and stripped bark with a length of 32 mm (M, N, O, P).

Also, we identified scars related to the manufacture peeling (6 in total). These marks are located from the mesial to the distal end and have different directions but most of them are developed from the distal to the proximal end (G, J). Some of the manufacturing marks required more energy as they have larger development across the piece (K, L), and are clearly recognizable (H, I) when obtaining imagen with the confocal microscope. In the analysis, we did not find evidence of leaves, something that along with the presence of the peeling marks suggests their intentional vy the chimpanzees.

Additional information:**Photograph:**

- A. Stripped_bark_PP_01_40mm.
- B. Fract_01_MP_01_40mm.
- C. Stripped_bark_PP_02_40mm.
- D. Stripped_bark_PP_02_35x_3D.
- E. Fract_01_MP_02_40mm.
- F. Fract_01_MP_02_35x_3D.
- G. Manufacture_peeling_MP_01_35x.
- H. Manufacture_peeling_MP_01_Confocal_Color_Map.
- I. Manufacture_peeling_MP_01_Confocal_Points.
- J. Manufactures_peeling_MP_02_35x.
- K. Manufacture_peeling_MP_03_40mm.
- L. Manufacture_peeling_Mp_35x_3D.
- M. Cut_stripped_DP_40mm.
- N. Cut_stripped_DP_35x_3D.
- O. Cut_stripped_DP_02_35x.
- P. Cut_stripped_DP_02_Confocal_Color_Map



File number: 0002	Tool identification: NA_10dec21_TF_S1_T10	Field site: Dindéfelo	Area: Nandoumary
		Country: Senegal	
Locality: Rockshelter	Day of collection: 10		Activity: ☒ Termite fishing ☐ Ant dipping ☐ Algae fishing ☐ Baobab pounding ☐ Indeterminate
Site code: -	Month of collection: December	Site UTM X: -	
Season: Dry	Year: 2021	Site UTM Y: -	
Species consumed: <i>Macrotermes sp.</i>	Tool type 1: Stick	Tool type 2: ☐ Fixed ☒ Portable	Distance to raw material source (metres) Unknown
Raw material source identified: No	Distance tool – nest entrance (cm): Unknown	Distance to baobab (tree): -	
Plant raw material: <i>Desmodium salicifolium</i>	Stone raw material: n/a	Blank: Twig	Weight (gr): 1,08
Digital length (mm): 392,73		Proximal width (mm): 3,60	
End-to-end length (mm): 386,69		Medial width (mm): 3,10	
Max thickness (for stone tools; mm): n/a		Distal width (mm): 3,10	
Morphology: slightly curved		Numbers used areas: 1	
Proximal end (stick): ☒ Stripped bark ☐ Cut ☒ Bent ☐ Frayed ☐ Unmodified	Proximal end modification (mm): 13,00	Distal end (stick): ☒ Stripped bark ☐ Cut ☐ Bent ☒ Frayed ☐ Peeled ☐ Unmodified	Distal end modification (mm): 4,00
Residue presence: ☐ Yes ☒ No	Type of residue: ☐ Shells ☐ Fruit residues ☐ Insect fragments ☐ Soil ☐ Algae ☐ N/A	Residue species: -	Analysis: ☒ Macroscopic ☒ Hirox ☐ Confocal ☐ Zeiss ☐ ESEM
		Residue location: ☐ Proximal ☐ Mesial ☐ Distal	
Broken tool: ☐ Yes ☒ No	Manufacture peeling: ☒ Yes ☐ No	Presence of leaves: ☐ Yes ☒ No	Presence of sub-branches: ☐ Yes ☒ No
Number adhered fractures: 4	Location of fractures: ☐ Proximal ☒ Mesial ☒ Distal	Researcher conducting the analysis: Daniel Vivar Ríos (IPHES-CERCA)	

Tool description:

Perishable tool collected at the location named by IJGE “Punto de agua” in Nandoumary. It was collected in December, which correspond to the dry season. The tool is a portable twig (made of *Desmodium salicifolium*) that was used on activity of termite fishing (*Macrotermes* sp.). The tool measures 386,69 millimeters in length and with a thickness ranging from 3,60 to 3,10 mm. And with the weight 1,08 grams.

During the macroscopic analysis and its study using the HIROX microscope, we identified some marks related with the extraction of the blank, manufacture, use and abandonment of the artefact. The tool was uniquely used by one of the ends, the distal one.

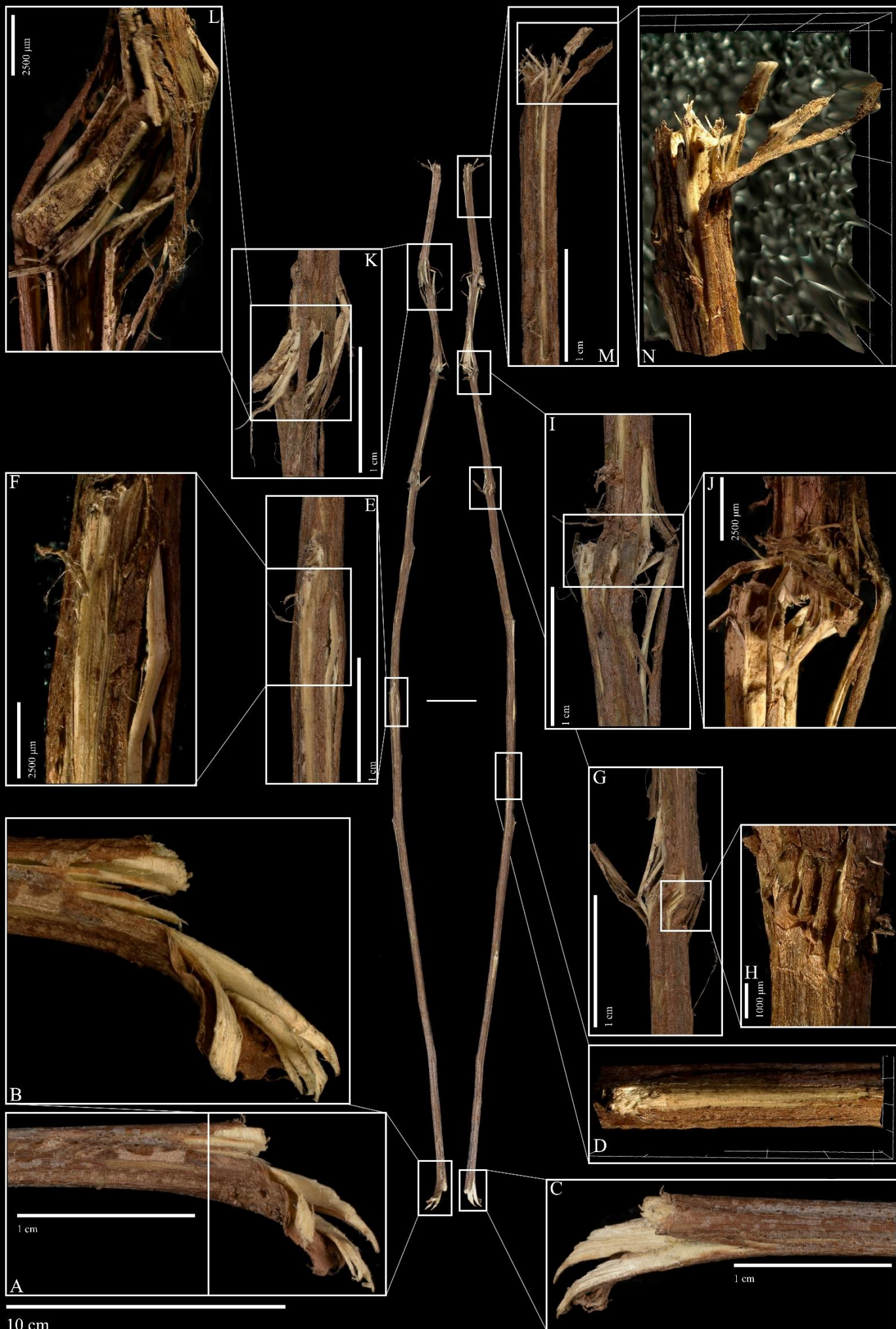
Morphologically the tool is slightly curved. The proximal end presents a combination of modifications related to the extraction of the tool from the rest of the trunk (bent and stripped bark; **A, B, C**), the length of the modification is 13 mm. At the same time, it possesses a kind of burr. The opposite end, the distal, has a combination of modification with frayed and stripped bark (**N**), a modification that measures 4 mm in length. The stripped bark is a little invasive (**M**).

The tool is complete and slightly curvature caused by the bigger fractures located mostly in the distal end. The identified fractures (4) are of different types. In the middle part, we find the first one (**G**), which is not complete and shows some fissures (**H**). The second one, also in the middle area of the tool (**E**), is also a non-complete fracture with fissures (**F**). The last two, are located towards the distal end. The first (**I**) is a complete fracture held to the rest of the stick by the bark (**J**). A similar morphology has the last one (**K**), a bigger fracture attached only by the bark (**L**). Finally, we find some marks associated with the manufacture peeling located in the mesial part (**D**), most of them having a directionality from the distal to the proximal end.

In the analysis, we do not find evidence of sub-branches, leaves, protuberance, or residues.

Additional information:**Photograph:**

- A. Bended_stripped_PP_01_40mm.
- B. Bended_stripped_PP_01_35x_3D.
- C. Bended_stripped_PP_02_40mm.
- D. Manufacture_peeling_MP_01_35_3D.
- E. Fract_01_MP_40mm.
- F. Fract_01_MP_35x.
- G. Fract_02_MP_40mm.
- H. Fract_02_MP_35x.
- I. Fract_03_DP_40mm.
- J. Fract_03_DP_35x.
- K. Fract_04_DP_40mm.
- L. Fract_04_DP_35x_3D.
- M. Frayed_stripped_DP_01_40mm.
- N. Frayed_stripped_DP_01_35x_3D.



File number: 0003	Tool identification: NA_10dec21_TF_S1_T06	Field site: Dindéfelo Country: Senegal	Area: Nandoumary
Locality: Rockshelter	Day of collection: 6		Activity: ☒ Termite fishing ☐ Ant dipping ☐ Algae fishing ☐ Baobab pounding ☐ Indeterminate
Site code: -	Month of collection: December	Site UTM X: -	
Season: Dry	Year: 2021	Site UTM Y: -	
Species consumed: <i>Macrotermes sp.</i>	Tool type 1: Stick	Tool type 2: ☐ Fixed ☒ Portable	Distance to raw material source (metres) Unkown
Raw material source identified: No	Distance tool – nest entrance (cm): Unknown	Distance to baobab (tree): -	
Plant raw material: <i>Desmodium salicifolium</i>	Stone raw material: n/a	Blank: Twig	Weight (gr): 0,53
Digital length (mm): 259,12		Proximal width (mm): 3,30	
End-to-end length (mm): 248,11		Medial width (mm): 2,10	
Max thickness (for stone tools; mm): n/a		Distal width (mm): 1,70	
Morphology: curved		Numbers used areas: 1	
Proximal end (stick): ☒ Stripped bark ☐ Cut ☒ Bent ☐ Frayed ☐ Unmodified	Proximal end modification (mm): 11,00	Distal end (stick): ☒ Stripped bark ☐ Cut ☐ Bent ☒ Frayed ☐ Peeled ☐ Unmodified	Distal end modification (mm): 133,00
Residue presence: ☐ Yes ☒ No	Type of residue: ☐ Shells ☐ Fruit residues ☐ Insect fragments ☐ Soil ☐ Algae ☐ N/A	Residue species: -	Analysis: ☒ Macroscopic ☒ Hirox ☒ Confocal ☐ Zeiss ☐ ESEM
		Residue location: ☐ Proximal ☐ Mesial ☐ Distal	
Broken tool: ☐ Yes ☒ No	Manufacture peeling: ☐ Yes ☒ No	Presence of leaves: ☐ Yes ☒ No	Presence of sub-branches: ☐ Yes ☒ No
Number adhered fractures: 1	Location of fractures: ☐ Proximal ☐ Mesial ☒ Distal	Researcher conducting the analysis: Daniel Vivar Ríos (IPHES-CERCA)	

Tool description:

Perishable tool collected at the location named by IJGE “Punto de agua”, a rockshelter in Nandoumary. It was collected in December, which correspond to the dry season. The tool is a portable twig (*Desmodium salicifolium*) that was used for termite fishing (*Macrotermes sp.*). The tool measures 248,11 millimeters in length and with a thickness ranging from 3,30 to 1,70 mm. And with the weight of 0,53 grams.

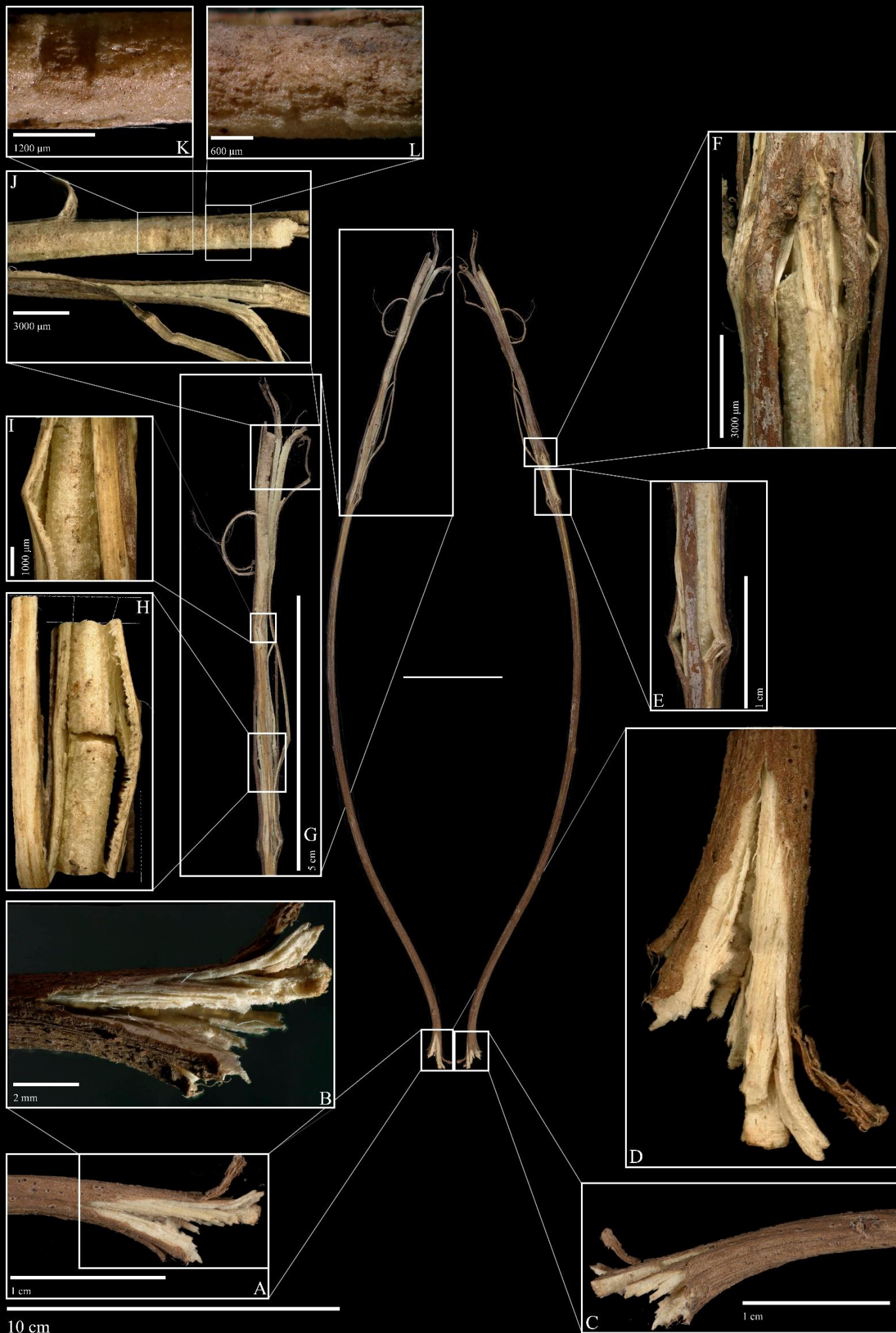
During the analysis that include a macroscopic approach and the use of the HIROX and confocal microscopes, we identified some marks located across the tool. We identified a single used end, the distal one.

Morphologically the tool is curved. The absence of manufacture scars along the blank indicates that the tool did not have any leaves when it was extracted from the source. The proximal end presents a combination of modifications related to the extraction of the stick from the source. The proximal end is bent and it also has non-invasive stripped bark scars (**A, C**) with a length of 11 mm. Also, we can observe a kind of burr thanks to HIROX (**B, D**). On the opposite part, the distal end, the tool exhibits a very invasive combination of modifications including frayed and stripped bark (**G, J**) that covers up to 133,00 mm of the tool.

Associated with the distal end, we find a fracture (**G, E**), which is complete as we can see in the pictures (**H, F**), with an additional presence of some fissures (**I, E**). Finally, during the analysis we observed ‘u’-shaped marks located on the distal end (**K, L**), two unidirectional and parallel grooves with similar lengths, that may have been formed during the phase of use.

Additional information:**Photograph:**

- A. Bent_stripped_PP_01_40mm.
- B. Bent_stripped_PP_01_50x.
- C. Bent_stripped_PP_02_40mm.
- D. Bent_stripped_PP_02_50x_3D.
- E. Descort_01_MP_40mm.
- F. Fract_01_DP_01_50x.
- G. Distal_end_01_40mm.
- H. Fract_01_DP_02_50x_3D.
- I. Descort_02_MP_50x.
- J. Frayed_stripped_01_DP_40mm.
- K. Mark_01_DP_50x.
- L. Mark_02_DP_100x.



File number: 0004	Tool identification: SE_27jan22_AD_S1_T02	Field site: Dindéfélo	Area: Segou
		Country: Senegal	
Locality: Thiangol Ndian	Day of collection: 27		Activity: ☐ Termite fishing ☒ Ant dipping ☐ Algae fishing ☐ Baobab pounding ☐ Indeterminate
Site code: -	Month of collection: January	Site UTM X: 794189	
Season: Dry	Year: 2022	Site UTM Y: 1369923	
Species consumed: <i>Dorylus nigricans</i>	Tool type 1: Stick	Tool type 2: ☐ Fixed ☒ Portable	Distance to raw material source (metres) Unknown
Raw material source identified: No	Distance tool – nest entrance (cm): Unknown	Distance to baobab (tree): -	
Plant raw material: <i>Alchornea cordifolia</i>	Stone raw material: n/a	Blank: Liana	Weight (gr): 8,58
Digital length (mm): 836,31		Proximal width (mm): 6,40	
End-to-end length (mm): 780,19		Medial width (mm): 6,60	
Max thickness (for stone tools; mm): n/a		Distal width (mm): 5,90	
Morphology: curved		Numbers used areas: 1	
Proximal end (stick): ☒ Stripped bark ☒ Cut ☐ Bent ☐ Frayed ☐ Unmodified	Proximal end modification (mm): 331,00	Distal end (stick): ☒ Stripped bark ☐ Cut ☐ Bent ☒ Frayed ☐ Peeled ☐ Unmodified	Distal end modification (mm): 6,00
Residue presence: ☐ Yes ☒ No	Type of residue: ☐ Shells ☐ Fruit residues ☐ Insect fragments ☐ Soil ☐ Algae ☐ N/A	Residue species: -	Analysis: ☒ Macroscopic ☒ Hirox ☐ Confocal ☐ Zeiss ☐ ESEM
		Residue location: ☐ Proximal ☐ Mesial ☐ Distal	
Broken tool: ☐ Yes ☒ No	Manufacture peeling: ☒ Yes ☐ No	Presence of leaves: ☐ Yes ☒ No	Presence of sub-branches: ☐ Yes ☒ No
Number adhered fractures: 2	Location of fractures: ☐ Proximal ☒ Mesial ☐ Distal	Researcher conducting the analysis: Daniel Vivar Ríos (IPHES-CERCA)	

Tool description:

Perishable tool collected at the location named by IJGE as “Thiangol Ndian” in Segou. It was collected in January, which correspond to the dry season. The tool is made of a liana (*Alchornea cordifolia*) that was used on activity of ant dipping (*Dorylus nigricans*). The tool measures 780,19 millimeters in length and with a thickness ranging from 6,60 to 5,90 mm. And with the weight of 8,58 grams.

During the analysis we identified specific marks related to the phase of extraction, manufacture, use and abandonment. We can assume, that the tool was used only from the distal end.

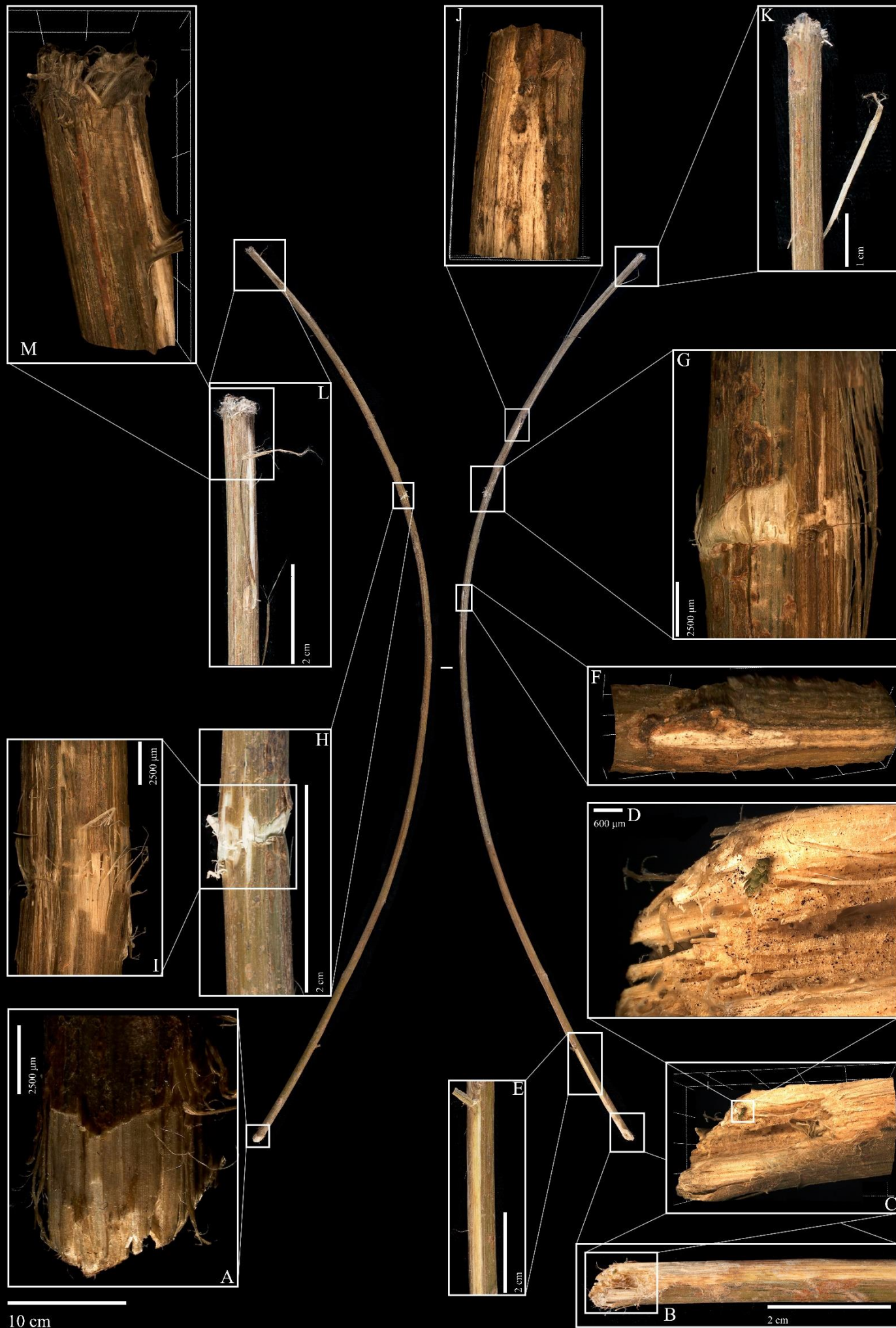
Morphologically the tool is continuously curved. The proximal end presents a combination of modifications related to the extraction of the stick, as it has the end cut and stripped bark (**B**, **C**). These modifications cover a length of 331 mm. This invasive stripped bark is only visible on one side of the proximal end (**E**), while the opposite does not show it (**A**). The distal end also has a combination of invasive modifications formed during the use of the tool. This end was the active one and is frayed (length of 6 mm) (**K**, **M**) with the presence of stripped bark (**L**).

The tool is complete, although it has two fractures (**H**, **G**) located in the mesial part and related one to another. These fractures are non-complete and present some fissures accompanied by debarked areas (**I**). The tool, also bears manufacture peeling scars (2 in total) produced before its use, located in the mesial (**F**) and distal end (**J**).

During the analysis, we did not find evidence of leaves, sub-branch, or residues. Although we find a little growth of protuberance on the proximal point (**D**).

Additional information:**Photograph:**

- A- Stripped_bark_cut_02_Opposite_side_35x.
- B- Stripped_bark_cut_01_PP_40mm.
- C- Stripped_bark_cut_01_PP_35x_3D.
- D- Stripped_bark_cut_01_PP_50x.
- E- Stripped_bark_cut_03_40mm.
- F- Manufacture_peeling_01_MP_
- G- Fract_01_MP_35x.
- H- Fract_01_MP_02_40mm.
- I- Fract_01_MP_02_35_3D.
- J- Fract_02_MP_35x_3D.
- K- Frayed_stripped_01_DP_40mm.
- L- Frayed_stripped_01_DP_02_40m.
- M- Frayed_stripped_01_DP_02_35x_3D.



File number: 0005	Tool identification: SE_AD_25jan22_S1_T01	Field site: Dindéfélo Country: Senegal	Area: Segou
Locality: Thiangol Sanké	Day of collection: 25		Activity: ☐ Termite fishing ☒ Ant dipping ☐ Algae fishing ☐ Baobab pounding ☐ Indeterminate
Site code: -	Month of collection: January	Site UTM X: 794408	
Season: Dry	Year: 2022	Site UTM Y: 1370133	
Species consumed: <i>Dorylus nigricans</i>	Tool type 1: Stick	Tool type 2: ☐ Fixed ☒ Portable	Distance to raw material source (metres) Unknown
Raw material source identified: No	Distance tool – nest entrance (cm): Unknown	Distance to baobab (tree): -	
Plant raw material: <i>Alchornea cordifolia</i>	Stone raw material: n/a	Blank: Liana	Weight (gr): 5,56
Digital length (mm): 722,55		Proximal width (mm): 4,60	
End-to-end length (mm): 717,44		Medial width (mm): 4,30	
Max thickness (for stone tools; mm): n/a		Distal width (mm): 3,80	
Morphology: slightly curved		Numbers used areas: 1	
Proximal end (stick): ☒ Stripped bark ☒ Cut ☐ Bent ☐ Frayed ☐ Unmodified	Proximal end modification (mm): 118,00	Distal end (stick): ☐ Stripped bark ☐ Cut ☐ Bent ☒ Frayed ☐ Peeled ☐ Unmodified	Distal end modification (mm): 6,00
Residue presence: ☐ Yes ☒ No	Type of residue: ☐ Shells ☐ Fruit residues ☐ Insect fragments ☐ Soil ☐ Algae ☐ N/A	Residue species: -	Analysis: ☒ Macroscopic ☒ Hirox ☐ Confocal ☐ Zeiss ☐ ESEM
		Residue location: ☐ Proximal ☐ Mesial ☐ Distal	
Broken tool: ☐ Yes ☒ No	Manufacture peeling: ☐ Yes ☒ No	Presence of leaves: ☐ Yes ☒ No	Presence of sub-branches: ☐ Yes ☒ No
Number adhered fractures: 2	Location of fractures: ☐ Proximal ☐ Mesial ☒ Distal	Researcher conducting the analysis: Daniel Vivar Ríos (IPHES-CERCA)	

Tool description:

Perishable tool collected at the location named by IJGE “Thiangol Sanké” in Segou. It was collected in January, which correspond to the dry season. The tool is made of a liana (*Alchornea cordifolia*) that was used in ant dipping (*Dorylus nigricans*). The tool measures 717,44 millimeters in length and with a thickness ranging from 4,40 to 3,20 mm. And with the weight of 5,56 grams.

The tool was solely used from the distal end.

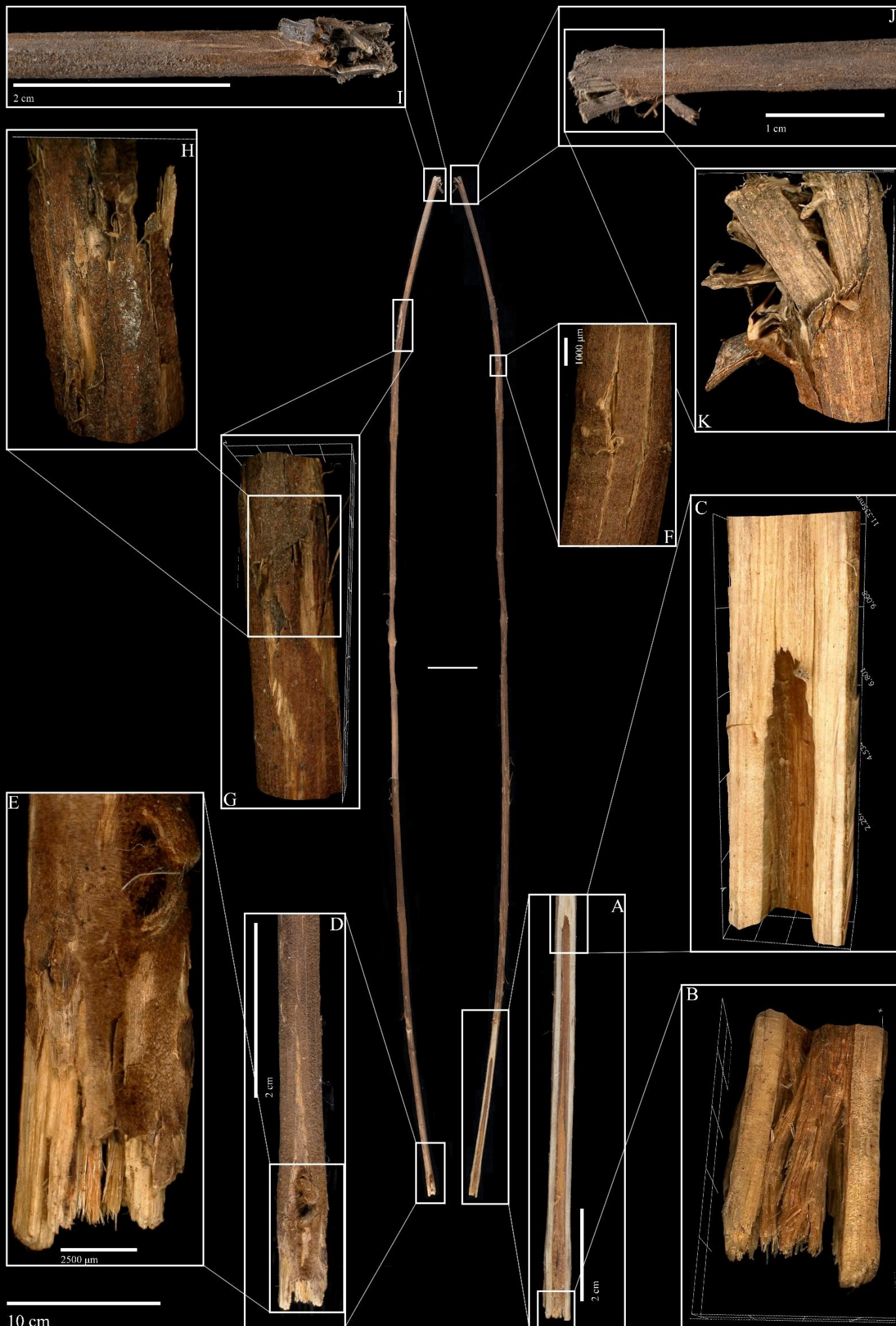
Morphologically the tool is slightly curved. The proximal end presents a combination of modifications related to the phase of extraction, cut end and very invasive stripped bark (**A, B, C**), with a length of 118,00 mm. On the opposite side of the proximal end, we can see the cut (**D, E**), and does not show very invasive stripped bark. While the distal end presents a single modification type, frayed (**I, J**) covering 6,00 mm in length. Also, part of the burr is exposed consequence of the use of the tool (**K**).

The tool is complete, but it presents some fractures, located in the distal part (**F, G**). These fractures are non-complete, and they are associated with some little fissures, which we can see in the pictures of HIROX (**H**).

In the analysis, we did not find evidence of protuberance, leaves, sub-branches, or residue.

Additional information:**Photograph:**

- A- Cut_stripped_01_PP_40mm.
- B- Proximal_end_01_35x_3D.
- C- Final_PP_01_35x_3D.
- D- Cut_stripped_02_40mm.
- E- Cut_stripped_02_35x.
- F- Fract_01_DP_35x.
- G- Fract_02_DP_35x_3D.
- H- Fract_02_DP_02_35x_3D.
- I- Frayed_01_DP_40mm.
- J- Frayed_01_DP_02_40mm.
- K- Frayed_01_DP_35x_3D.



File number: 0006	Tool identification: SE_AD_25jan22_S1_T02	Field site: Dindéfelo Country: Senegal	Area: Segou
Locality: Thiangol Sanké	Day of collection: 25		Activity: ☐ Termite fishing ☒ Ant dipping ☐ Algae fishing ☐ Baobab pounding ☐ Indeterminate
Site code: -	Month of collection: January	Site UTM X: 794408	
Season: Dry	Year: 2022	Site UTM Y: 1370133	
Species consumed: <i>Dorylus nigricans</i>	Tool type 1: Stick	Tool type 2: ☐ Fixed ☒ Portable	Distance to raw material source (metres) Unknown
Raw material source identified: No	Distance tool – nest entrance (cm): Unknown	Distance to baobab (tree): -	
Plant raw material: <i>Sorindeia juglandifolia</i>	Stone raw material: n/a	Blank: Twig	Weight (gr): 3,04
Digital length (mm): 737,28		Proximal width (mm): 4,60	
End-to-end length (mm): 664,29		Medial width (mm): 4,30	
Max thickness (for stone tools; mm): n/a		Distal width (mm): 4,10	
Morphology: curved		Numbers used areas: 1	
Proximal end (stick): ☒ Stripped bark ☐ Cut ☐ Bent ☐ Frayed ☐ Unmodified	Proximal end modification (mm): 38,00	Distal end (stick): ☒ Stripped bark ☐ Cut ☐ Bent ☐ Frayed ☐ Peeled ☐ Unmodified	Distal end modification (mm): 11,00
Residue presence: ☐ Yes ☒ No	Type of residue: ☐ Shells ☐ Fruit residues ☐ Insect fragments ☐ Soil ☐ Algae ☐ N/A	Residue species: -	Analysis: ☒ Macroscopic ☒ Hirox ☐ Confocal ☐ Zeiss ☐ ESEM
		Residue location: ☐ Proximal ☐ Mesial ☐ Distal	
Broken tool: ☐ Yes ☒ No	Manufacture peeling: ☐ Yes ☒ No	Presence of leaves: ☐ Yes ☒ No	Presence of sub-branches: ☐ Yes ☒ No
Number adhered fractures: 0	Location of fractures: ☐ Proximal ☐ Mesial ☐ Distal	Researcher conducting the analysis: Daniel Vivar Ríos (IPHES-CERCA)	

Tool description:

Perishable tool collected at the location named by IJGE “Thiangol Sanké” in Segou. It was collected in January, which correspond to the dry season. The tool is a portable twig (made of *Sorindeia juglandifolia*) that was used on activity of ant dipping (*Dorylus nigricans*). The tool measures 664,29 millimeters in length and has a thickness ranging from 4,60 to 4,10 mm, weighting 3,04 grams.

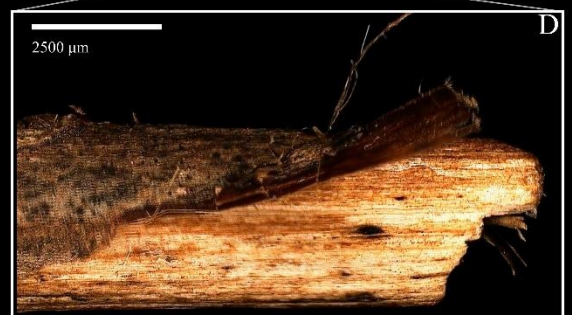
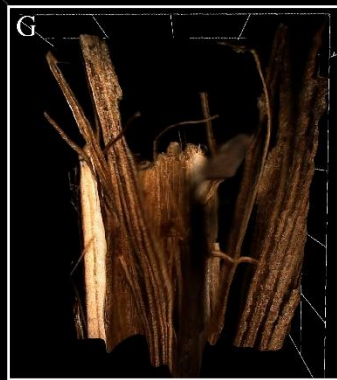
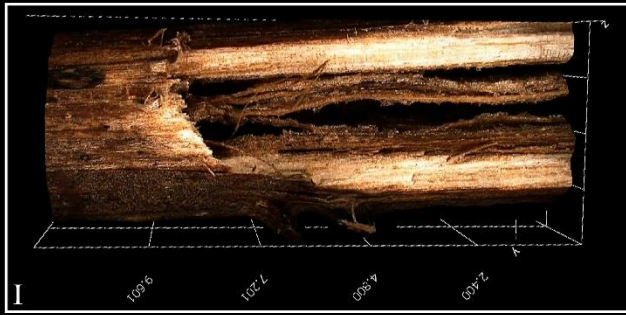
During the macroscopic analysis, that include the use of the HIROX microscope, we documented different marks associated to different phases: extraction, use, abandonment. We can assume that the tool was only used by the distal end.

Morphologically the tool is continuously curved. The proximal end presents stripped bark modification (**A**), a bit invasive as can be seen in the pictures (**B**, **C**), with a length of 38,00 mm. This modification is related to the phase of extraction of the blank. In the other face (**D**), we can see that the removed bark is not very invasive. On the opposite end, the distal one (**H**, **F**, **J**), we can observe a highly invasive modification, caused during the use of the tool. The modification is characterized by stripped bark (**G**), with a length of 11,00 mm. And presents a ‘u-fracture’ of the stick (**I**), with an additional debarking process.

The tool is complete and does not present any fracture, beyond the peeling that we found in the debarked area. Also, we find a little protuberance in the mesial part (**E**). During the analysis, we did not find marks of manufacture peeling, leaves, sub-branches, or residues.

Additional information:**Photograph:**

- A. Stripped_bark_PP_01_40mm.
- B. Stripped_bark_PP_01_35x_3D.
- C. Stripped_bark_PP_01_50x_3D.
- D. Stripped_bark_PP_02_35x.
- E. Descort_MP_01_35x_3D.
- F. Stripped_bark_DP_01_40mm.
- G. Stripped_bark_DP_01_35x_3D.
- H. Stripped_bark_DP_02_40mm.
- I. Final_stripped_bark_DP_02_35x_3D.
- J. Final_stripped_bark_DP_02_35x_3D.



File number: 0007	Tool identification: SE_AF_19mar20_S1_T02	Field site: Dindéfelo Country: Senegal	Area: Segou
Locality: Segou	Day of collection: 19		Activity: ☐ Termite fishing ☐ Ant dipping ☒ Algae fishing ☐ Baobab pounding ☐ Indeterminate
Site code: -	Month of collection: March	Site UTM X: -	
Season: Dry	Year: 2020	Site UTM Y: -	
Species consumed: Indeterminate algae	Tool type 1: Stick	Tool type 2: ☐ Fixed ☒ Portable	Distance to raw material source (metres) Unkown
Raw material source identified: No	Distance tool – nest entrance (cm): Unknown	Distance to baobab (tree): -	
Plant raw material: Indeterminate	Stone raw material: n/a	Blank: Twig	Weight (gr): 24,93
Digital length (mm): 741,02		Proximal width (mm): 7,70	
End-to-end length (mm): 738,77		Medial width (mm): 7,30	
Max thickness (for stone tools; mm): n/a		Distal width (mm): 5,80	
Morphology: slightly curved		Numbers used areas: 1	
Proximal end (stick): ☐ Stripped bark ☒ Cut ☐ Bent ☐ Frayed ☐ Unmodified	Proximal end modification (mm): 0	Distal end (stick): ☒ Stripped bark ☒ Cut ☐ Bent ☐ Frayed ☐ Peeled ☐ Unmodified	Distal end modification (mm): 11,00
Residue presence: ☒ Yes ☐ No	Type of residue: ☐ Shells ☐ Fruit residues ☐ Insect fragments ☒ Soil ☒ Algae ☐ N/A	Residue species: Algae indeterminate	Analysis: ☒ Macroscopic ☒ Hirox ☐ Confocal ☐ Zeiss ☐ ESEM
		Residue location: ☐ Proximal ☒ Mesial ☒ Distal	
Broken tool: ☐ Yes ☒ No	Manufacture peeling: ☐ Yes ☒ No	Presence of leaves: ☐ Yes ☒ No	Presence of sub-branches: ☐ Yes ☒ No
Number adhered fractures: 0	Location of fractures: ☐ Proximal ☐ Mesial ☐ Distal	Researcher conducting the analysis: Daniel Vivar Ríos (IPHES-CERCA)	

Tool description:

Perishable tool collected at the location of Segou. It was collected in March, during the dry season. The tool is a portable twig (made of an unidentified plant) that was used for algae fishing (the algae species were not identified). The tool measures 738,77 millimeters in length and with a thickness ranging from the 7,70 to 5,80 mm. And with the weight of 24,93 grams.

During the analysis, we identified some marks located in the entire tool, as well as residues. These modifications are associated with different phases like extraction, use and abandonment. We can assume that the tool unique by the distal/mesial areas of the blank.

Morphologically is slightly curved. The proximal end is cut (**B, D**) and has also some fissures (**A, C**). On the opposite side, we find a combination of modifications with the presence of cut end and stripped bark (**L, K**) with a length of 11,00 millimeters, and fissures.

The tool is complete, and we did not find marks of fracture, leaves, protuberance, or sub-branches. Although we find some remains of algae on the mesial and distal part (**E, F**). Finally, we identified some conspicuous marks (**G, H**) on the mesial part, that have elongated shapes with some symmetry in their distribution. Occasionally, these marks have also conical shapes (**I, J**). The location and morphology of these marks made us hypothesize that they could be handling marks, produced by the chimpanzees when holding the tool using a pinch grip with the aid of their nails. Nonetheless, this hypothesis should be further investigated to confirm the origin of these marks.

Additional information:**Photograph:**

- A- Cut_PP_01_40mm.
- B- Cut_PP_01_35x_3D.
- C- Cut_PP_02_40mm.
- D- Cut_PP_02_35x.
- E- Algae_residue_MP_35x.
- F- Algae_residue_MP_140x.
- G- Marks_01_MP_40mm.
- H- Mark_01_01_MP_35x.
- I- Mark_01_02_MP_35x.
- J- Mark_01_02_01_MP_140x
- K- Cut_stripped_01_DP_40mm.
- L- Cut_stripped_02_DP_35x.



File number: 0008	Tool identification: SE_AF_19mar20_S1_T05	Field site: Dindéfélo Country: Senegal	Area: Segou
Locality: Segou	Day of collection: 19		Activity: ☐ Termite fishing ☐ Ant dipping ☒ Algae fishing ☐ Baobab pounding ☐ Indeterminate
Site code: -	Month of collection: March	Site UTM X: -	
Season: Dry	Year: 2020	Site UTM Y: -	
Species consumed: Indeterminate algae	Tool type 1: Stick	Tool type 2: ☐ Fixed ☒ Portable	Distance to raw material source (metres) Unknown
Raw material source identified: No	Distance tool – nest entrance (cm): Unknown	Distance to baobab (tree): -	
Plant raw material: Indeterminate	Stone raw material: n/a	Blank: Twig	Weight (gr): 6,94
Digital length (mm): 803,95		Proximal width (mm): 5,70	
End-to-end length (mm): 789,89		Medial width (mm): 5,50	
Max thickness (for stone tools; mm): n/a		Distal width (mm): 4,30	
Morphology: slightly curved		Numbers used areas: 1	
Proximal end (stick): ☒ Stripped bark ☐ Cut ☐ Bent ☐ Frayed ☐ Unmodified	Proximal end modification (mm): 81,00	Distal end (stick): ☐ Stripped bark ☐ Cut ☐ Bent ☒ Frayed ☐ Peeled ☐ Unmodified	Distal end modification (mm): 10,00
Residue presence: ☒ Yes ☐ No	Type of residue: ☐ Shells ☐ Fruit residues ☐ Insect fragments ☒ Soil ☐ Algae ☐ N/A	Residue species: Algae indeterminated	Analysis: ☒ Macroscopic ☒ Hirox ☐ Confocal ☐ Zeiss ☐ ESEM
		Residue location: ☒ Proximal ☐ Mesial ☒ Distal	
Broken tool: ☐ Yes ☒ No	Manufacture peeling: ☐ Yes ☒ No	Presence of leaves: ☐ Yes ☒ No	Presence of sub-branches: ☐ Yes ☒ No
Number adhered fractures: 0	Location of fractures: ☐ Proximal ☐ Mesial ☐ Distal	Researcher conducting the analysis: Daniel Vivar Ríos (IPHES-CERCA)	

Tool description:

Perishable tool collected at Segou. It was collected in March, during the dry season. The tool is a portable twig (the type of plant used was undetermined) that was used for algae fishing. The tool measures 789,89 mm in length and with a thickness ranging from the 5,70 to 4,30 mm. And with the weight of 6,94 grams.

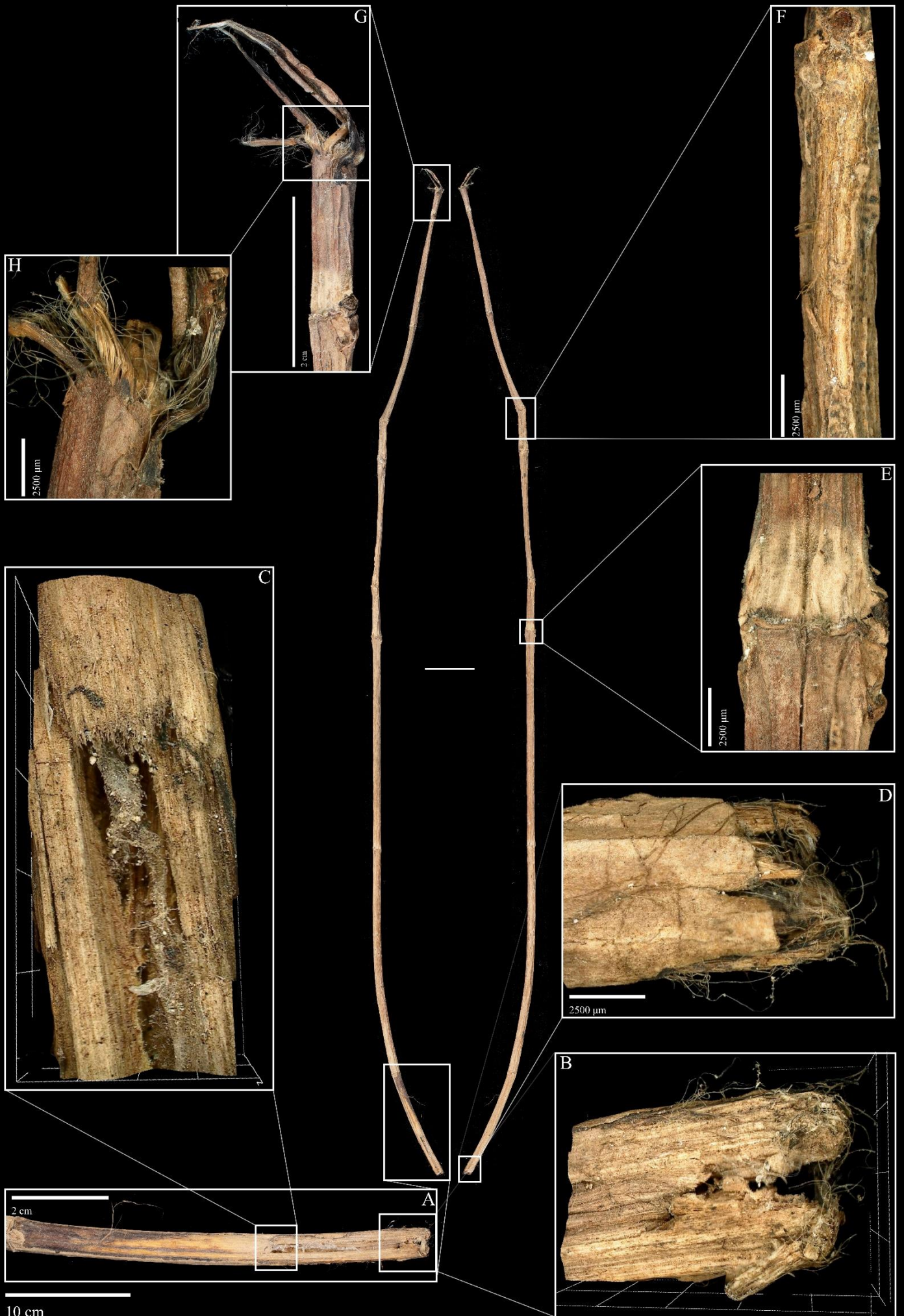
During the current analysis, we study the complete tool from a macroscopic perspective, applying also a microscopic methodology using an HIROX microscope. Overall, we identified modifications related to the different phases of the chaîne opératoire, from extraction to the use, of the tool.

Morphologically the tool is slightly curved. The proximal end presents a modification of stripped bark (**A, D**) with an 81,00 mm length caused by the extraction of the stick from the trunk, making an 'u-fracture' less invasive than the stripped (**C**), whose morphology resembles the peeling observed in other tools. On the opposite end, the distal, is frayed, a modification that has up to 10 millimeters in length (**H**). This was coupled with a debarked area as shown in picture **G**.

The tool is complete, without any fractures, protuberance, manufacture peeling, leaves or subbranches. We did find soil residues on the distal and the proximal end (**G, B**), but it is difficult to link them with the activity or the use of the tool, and probably they were just a transfer of soil from the environment. Also, we identified a slight change in the colour of the mesial part of the tool, which can be related to the alteration process caused by the humidity that the tool had after being submerged in water during the activity (**E, F**).

Additional information:**Photograph:**

- A- Stripped_bark_01_PP_40mm.
- B- Stripped_bark_01_PP_35x_3D.
- C- Final_stripped_bark_01_PP_35x_3D.
- D- Stripped_bark_02_PP_35x_3D.
- E- Color_change_MP_01_35x.
- F- Descort_MP_01_35x.
- G- Frayed_DP_01_40mm.
- H- Frayed_DP_01_35x_3D.



File number: 0009	Tool identification: SE_AF_19mar20_S2_T12	Field site: Dindéfelo	Area: Segou
		Country: Senegal	
Locality: Segou	Day of collection: 19		Activity: ☐ Termite fishing ☐ Ant dipping ☒ Algae fishing ☐ Baobab pounding ☐ Indeterminate
Site code: -	Month of collection: March	Site UTM X: -	
Season: Dry	Year: 2020	Site UTM Y: -	
Species consumed: Indeterminate algae	Tool type 1: Stick	Tool type 2: ☐ Fixed ☒ Portable	Distance to raw material source (metres) Unknown
Raw material source identified: No	Distance tool – nest entrance (cm): Unknown	Distance to baobab (tree): Unknown	
Plant raw material: Indeterminate	Stone raw material: n/a	Blank: Twig	Weight (gr): 9,53
Digital length (mm): 871,17		Proximal width (mm): 8,90	
End-to-end length (mm): 864,34		Medial width (mm): 7,60	
Max thickness (for stone tools; mm): n/a		Distal width (mm): 7,80	
Morphology: Slightly curved		Numbers used areas: 1	
Proximal end (stick): ☐ Stripped bark ☒ Cut ☐ Bent ☐ Frayed ☐ Unmodified	Proximal end modification (mm): 0	Distal end (stick): ☐ Stripped bark ☐ Cut ☐ Bent ☒ Frayed ☐ Peeled ☐ Unmodified	Distal end modification (mm): 0
Residue presence: ☐ Yes ☒ No	Type of residue: ☐ Shells ☐ Fruit residues ☐ Insect fragments ☐ Soil ☐ Algae ☐ N/A	Residue species: Residue location: ☐ Proximal ☐ Mesial ☐ Distal	Analysis: ☒ Macroscopic ☒ Hirox ☐ Confocal ☐ Zeiss ☐ ESEM
Broken tool: ☐ Yes ☒ No	Manufacture peeling: ☐ Yes ☒ No	Presence of leaves: ☐ Yes ☒ No	Presence of sub-branches: ☐ Yes ☒ No
Number adhered fractures: 1	Location of fractures: ☐ Proximal ☐ Mesial ☒ Distal	Researcher conducting the analysis: Daniel Vivar Ríos (IPHES-CERCA)	

Tool description:

Perishable tool collected in Segou. It was collected in March, which correspond to the dry season. The tool is a portable twig (made of an indeterminate plant) that was used on algae fishing (undetermined algae). The tool measures are 864,34 millimeters in length, it has a thickness ranging from 8,90 to 7,60 mm, with a total weight of 9,53 grams.

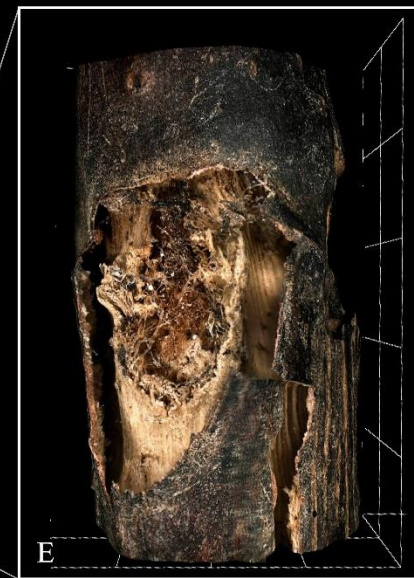
During the macro and microscopic analysis, we identified different modifications associated to the stage of obtention of the tool use, and abandonment. We can assume that the tool was uniquely used from the distal end.

Morphologically the tool is slightly curved. The proximal end presents a modification related to the extraction of the blank, showing a cut proximal end (**A, B, C**). It also bears a small, debarked area, which is a consequence of the dryness of the tool related to the phase of abandonment. The distal end has a frayed modification (**I, J**) related to the use and is accompanied by a single fracture.

The tool is complete, but it has a complete fracture, with some fissures and debarking (**G, H**). At the same time, we see some marks of dryness associated with the abandonment phase, as well as discoloration (**F**) caused by the humidity. Also, on the proximal end, and during the microscopic analysis, we found an undetermined insect (**D**) that is not related to the use of the tool. Finally, we identified a scar that could be from a removed sub-branch on the mesial part (**E**).

Additional information:**Photograph:**

- A- Cut_PP_01_40mm.
- B- Cut_PP_01_35x_3D.
- C- Cut_PP_02_35x_3D.
- D- Insect_residue_PP_01_400x.
- E- Descort_MP_01_35x_3D.
- F- Color_change_MP_01_40mm.
- G- Fract_01_DP_40mm.
- H- Fract_01_DP_35x_3D.
- I- Frayed_01_DP_40mm.
- J- Frayed_01_DP_35x_3D.



File number: 0010	Tool identification: SE_AD_18jan23_S2_T13	Field site: Dindéfélo	Area: Segou
		Country: Senegal	
Locality: Thiangol Garage	Day of collection: 18		Activity: ☐ Termite fishing ☒ Ant dipping ☐ Algae fishing ☐ Baobab pounding ☐ Indeterminate
Site code: TG1	Month of collection: January	Site UTM X: 793919	
Season: Dry	Year: 2023	Site UTM Y: 1369814	
Species consumed: <i>Dorylus nigricans</i>	Tool type 1: Stick	Tool type 2: ☐ Fixed ☒ Portable	Distance to raw material source (metres) Unknown
Raw material source identified: No	Distance tool – nest entrance (cm): 184	Distance to baobab (tree): -	
Plant raw material: -	Stone raw material: n/a	Blank: Twig	Weight (gr): 1,52
Digital length (mm): 288,02		Proximal width (mm): 3,70	
End-to-end length (mm): 280,00		Medial width (mm): 2,60	
Max thickness (for stone tools; mm): n/a		Distal width (mm): 2,90	
Morphology: slightly curved		Numbers used areas: 1	
Proximal end (stick): ☐ Stripped bark ☒ Cut ☐ Bent ☐ Frayed ☐ Unmodified	Proximal end modification (mm): 0	Distal end (stick): ☐ Stripped bark ☐ Cut ☐ Bent ☒ Frayed ☐ Peeled ☐ Unmodified	Distal end modification (mm): 9,1
Residue presence: ☒ Yes ☐ No	Type of residue: ☐ Shells ☐ Fruit residues ☐ Insect fragments ☒ Soil ☐ Algae ☐ N/A	Residue species: Soil	Analysis: ☒ Macroscopic ☒ Hirox ☐ Confocal ☐ Zeiss ☐ ESEM
		Residue location: ☐ Proximal ☐ Mesial ☐ Distal	
Broken tool: ☒ Yes ☐ No	Manufacture peeling: ☐ Yes ☒ No	Presence of leaves: ☐ Yes ☒ No	Presence of sub-branches: ☐ Yes ☒ No
Number adhered fractures: 1	Location of fractures: ☐ Proximal ☒ Mesial ☐ Distal	Researcher conducting the analysis: Daniel Vivar Ríos (IPHES-CERCA)	

Tool description:

Perishable tool collected at the location named by IJGE as “Thiangol Garage” (TG1) in Segou. It was collected in January, which correspond to the dry season, being found near the ant-nest entrance (184 cm away). The artefact is a portable twig that was used for ant dipping (*Dorylus nigricans*). The tool measures 280 millimeters in length and possess a thickness ranging from 3,70 to 2,90 millimeters. And with a weight of 1,52 grams. During the analysis we identified some modifications and evidence of soil residues (**G**) mainly in the distal end, which we can assume the one that had an active use.

Morphologically it is slightly curved. The proximal end has a non-invasive cut modification (**A, B, C**). The distal end (**G, H**) bore a frayed modification with a length 9,1 millimeters. In this part, we also identified a short of brush (**H**) with soil residues adhered.

The tool is complete, but it shows a single fracture in the mesial part (**D, E, F**). This fracture is partial and generates a fissure that goes has a longitudinal development from the proximal and to the distal end.

During the analysis, we did not find evidence of manufacturing peeling, leaves, or sub-branches.

Additional information:**Photograph:**

- A. Cut_PP_01_35x_3D.
- B. Cut_PP_01_40mm.
- C. Cut_PP_01_35x.
- D. Fract_01_MP_40mm.
- E. Fract_01_MP_35x.
- F. Fract_01_MP_35x_3D.
- G. Frayed_DP_01_40mm.
- H. Frayed_DP_01_35x.



File number: 0011	Tool identification: SE_AD_19jan23_S01_T05	Field site: Dindéfélo Country: Senegal	Area: Segou
Locality: Thiangol Garage	Day of collection: 19		Activity: ☐ Termite fishing ☒ Ant dipping ☐ Algae fishing ☐ Baobab pounding ☐ Indeterminate
Site code: TG2	Month of collection: January	Site UTM X: 793906	
Season: Dry	Year: 2023	Site UTM Y: 1369814	
Species consumed: <i>Dorylus nigricans</i>	Tool type 1: Stick	Tool type 2: ☐ Fixed ☒ Portable	Distance to raw material source (metres) Unknown
Raw material source identified: No	Distance tool – nest entrance (cm): Unknown	Distance to baobab (tree): -	
Plant raw material: -	Stone raw material: n/a	Blank: Twig	Weight (gr): 9,10
Digital length (mm): 738,95		Proximal width (mm): 7,00	
End-to-end length (mm): 750,00		Medial width (mm): 4,70	
Max thickness (for stone tools; mm): n/a		Distal width (mm): 5,90	
Morphology: curved		Numbers used areas: 1	
Proximal end (stick): ☒ Stripped bark ☐ Cut ☐ Bent ☐ Frayed ☐ Unmodified	Proximal end modification (mm): 131,5	Distal end (stick): ☒ Stripped bark ☐ Cut ☐ Bent ☐ Frayed ☐ Peeled ☐ Unmodified	Distal end modification (mm): 170,00
Residue presence: ☒ Yes ☐ No	Type of residue: ☐ Shells ☐ Fruit residues ☒ Insect fragments ☐ Soil ☐ Algae ☐ N/A	Residue species: <i>Dorylus nigricans</i>	Analysis: ☒ Macroscopic ☒ Hirox ☐ Confocal ☐ Zeiss ☐ ESEM
		Residue location: ☐ Proximal ☐ Mesial ☒ Distal	
Broken tool: ☐ Yes ☒ No	Manufacture peeling: ☐ Yes ☒ No	Presence of leaves: ☐ Yes ☒ No	Presence of sub-branches: ☐ Yes ☒ No
Number adhered fractures: 2	Location of fractures: ☐ Proximal ☒ Mesial ☒ Distal	Researcher conducting the analysis: Daniel Vivar Ríos (IPHES-CERCA)	

Tool description:

Perishable tool collected in January (dry season) at the location named by IJGE “Thiangol Garage” in Segou. The tool is a portable twig (made of an undetermined plant) that was used for ant dipping (*Dorylus nigricans*). The tool measures 750,00 millimeters in length and with a thickness ranging from 7,00 to 4,70 mm. And with a weight of 9,10 grams.

During the analysis we recognised modifications related with the extraction, used and abandonment of the tool.

Morphologically the tool is curved. The proximal end (**A, C**) presents a modification related to the extraction from the tree source and it consists of a highly invasive stripped bark (**B**) with a length of 131,5 millimeters. The opposite end also presents invasive stripped bark (**I, H**) with a length of 170,00 mm, which has exposed the inside part of the tool. This latter modification was formed during the use of the tool. The artefact is complete and presents a continuous curvature. It bears some non-complete fractures located in the distal and mesial parts. The first fracture (on mesial part) (**D, E**) has a length of 21 mm and generates some fissures on the tool. The other fracture, on the distal part, is related to the aperture of the stripper bark and presents also fissures and debarked (**F, G**), with a length of 29 mm. Finally, it is interesting to note the presence of residues related to the activity. In this case, we identified an ant’s head in one of the points of distal edge, attached to a bark fiber (**J, K, L**). This head corresponds to a *Dorylus nigricans*.

In the analysis, we did not find evidence of leaves, protuberance, manufacture peeling.

Additional information:**Photograph:**

- A. Stripped_bark_PP_01_40mm.
- B. Stripped_bark_PP_02_40mm.
- C. Stripped_bark_PP_02_35x_3D.
- D. Fract_01_MP_01_40mm.
- E. Fract_01_MP_02_35x_3D.
- F. Fract_02_DP_01_40mm.
- G. Fract_02_DP_01_35x_3D
- H. Stripped_bark_DP_01_40mm.
- I. Stripper_bark_DP_02_40mm.
- J. Ant_head_DP_01_40mm.
- K. Ant_head_DP_01_140x.
- L. Ant_head_DP_01_140x_3D.



10 cm

File number: 0012	Tool identification: SE_AD_19jan23_S01_T06	Field site: Dindéfélo	Area: Segou
		Country: Senegal	
Locality: Thiangol Garage	Day of collection: 19		Activity: ☐ Termite fishing ☒ Ant dipping ☐ Algae fishing ☐ Baobab pounding ☐ Indeterminate
Site code: TG2	Month of collection: January	Site UTM X: 793906	
Season: Dry	Year: 2023	Site UTM Y: 1369814	
Species consumed: <i>Dorylus nigricans</i>	Tool type 1: Stick	Tool type 2: ☐ Fixed ☒ Portable	Distance to raw material source (metres) Unknown
Raw material source identified: No	Distance tool – nest entrance (cm): Unknown	Distance to baobab (tree): -	
Plant raw material: -	Stone raw material: n/a	Blank: Twig	Weight (gr): 4,23
Digital length (mm): 861,09		Proximal width (mm): 3,80	
End-to-end length (mm): 858,97		Medial width (mm): 4,20	
Max thickness (for stone tools; mm): n/a		Distal width (mm): 3,20	
Morphology: slightly curved		Numbers used areas: 1	
Proximal end (stick): ☒ Stripped bark ☐ Cut ☐ Bent ☒ Frayed ☐ Unmodified	Proximal end modification (mm): 11,9	Distal end (stick): ☒ Stripped bark ☐ Cut ☐ Bent ☒ Frayed ☐ Peeled ☐ Unmodified	Distal end modification (mm): 8,6
Residue presence: ☐ Yes ☒ No	Type of residue: ☐ Shells ☐ Fruit residues ☐ Insect fragments ☐ Soil ☐ Algae ☐ N/A	Residue species:	Analysis: ☒ Macroscopic ☒ Hirox ☐ Confocal ☐ Zeiss ☐ ESEM
		Residue location: ☐ Proximal ☐ Mesial ☐ Distal	
Broken tool: ☐ Yes ☒ No	Manufacture peeling: ☐ Yes ☒ No	Presence of leaves: ☐ Yes ☒ No	Presence of sub-branches: ☐ Yes ☒ No
Number adhered fractures: 6	Location of fractures: ☐ Proximal ☒ Mesial ☒ Distal	Researcher conducting the analysis: Daniel Vivar Ríos (IPHES-CERCA)	

Tool description:

Perishable tool collected during the dry season (in January) at the location named by IJGE as “Thiangol Garage” (TG2) in Segou. The tool is a portable twig that was used for ant dipping (*Dorylus nigricans*). The tool measures 858,97 millimeters in length and with a thickness ranging from 3,20 to 4,20 millimeters. And the weight is 4,23 grams. During the analysis we recognised some modifications through the macroscopic analysis and the observations made with the HIROX microscope.

Morphologically, it is a sinuously curved piece. The proximal end has a frayed modification caused by its extraction from the source (covers 11,9 mm in length) plus a stripped bark relatively invasive (**A, B**). Also, the distal end presents frayed with a stripped bark modification (covers 8,6 mm in length) (**K, L**). In addition, in this part, we could observe a relative grade of brush.

It does not contain samples of residue remains. Although the tool is complete, we identified multiple fractures spread over the mesial and distal parts. The first four are in the mesial part (**C, G**) and two in the distal part (**H, I, J**) are non-complete. The first three fractures are related to the energy propagation when using the stick (proximal to distal direction; they respectively measure 20, 17 and 12 mm in length) (**D, E, F**). The fourth fracture (**G**) also it is non-complete and covers 12,5 mm in length. On the contrary, the fifth fracture is complete, being held together by the bark (12 mm in length) (**H, I**). Finally, the sixth fracture (9 mm in length) is not complete (**J**).

During the analysis, we did not find evidence of manufacturing peeling, the presence of leaves or sub-branches.

Additional information:**Photograph**

- A. Frayed_PP_01_35x.
- B. Frayed_PP_01_40mm.
- C. Fract_01_03_MP_01_40mm.
- D. Fract_01_MP_01_35x_3D.
- E. Fract_02_MP_01_35x.
- F. Fract_03_MP_01_35x.
- G. Fract_04_MP_01_35x.
- H. Fract_05_DP_01_35x.
- I. Fract_05_DP_01_35x_3D.
- J. Fract_06_DP_01_35x.
- K. Frayed_Stripped_DP_01_35x_3D.
- L. Frayed_Stripped_DP_01_40mm.



File number: 0013	Tool identification: SE_AD_27jan23_S01_T04	Field site: Dindéfélo	Area: Segou
		Country: Senegal	
Locality: Thiangol Garage	Day of collection: 27		Activity: ☐ Termite fishing ☒ Ant dipping ☐ Algae fishing ☐ Baobab pounding ☐ Indeterminate
Site code: TG2	Month of collection: January	Site UTM X: 793906	
Season: Dry	Year: 2023	Site UTM Y: 1369814	
Species consumed: <i>Dorylus nigricans</i>	Tool type 1: Stick	Tool type 2: ☐ Fixed ☒ Portable	Distance to raw material source (metres) Unknown
Raw material source identified: No	Distance tool – nest entrance (cm): 72	Distance to baobab (tree): -	
Plant raw material: Unknown	Stone raw material: n/a	Blank: Twig	Weight (gr): 4,15
Digital length (mm): 842,61		Proximal width (mm): 5,20	
End-to-end length (mm): 770,00		Medial width (mm): 5,40	
Max thickness (for stone tools; mm): n/a		Distal width (mm): 4,90	
Kind of morphology: slightly curved		Numbers used areas: 1	
Proximal end (stick): ☒ Stripped bark ☒ Cut ☐ Bent ☐ Frayed ☐ Unmodified	Proximal end modification (mm): 0	Distal end (stick): ☐ Stripped bark ☐ Cut ☐ Bent ☒ Frayed ☐ Peeled ☐ Unmodified	Distal end modification (mm): 60,2
Residue presence: ☒ Yes ☐ No	Type of residue: ☐ Shells ☐ Fruit residues ☒ Insect fragments ☐ Soil ☐ Algae ☐ N/A	Residue species: <i>Dorylus nigricans</i>	Analysis: ☒ Macroscopic ☒ Hirox ☐ Confocal ☐ Zeiss ☐ ESEM
		Residue location: ☐ Proximal ☐ Mesial ☒ Distal	
Broken tool: ☒ Yes ☐ No	Manufacture peeling: ☐ Yes ☒ No	Presence of leaves: ☐ Yes ☒ No	Presence of sub-branches: ☐ Yes ☒ No
Number adhered fractures: 4	Location of fractures: ☐ Proximal ☒ Mesial ☒ Distal	Researcher conducting the analysis: Daniel Vivar Ríos (IPHES-CERCA)	

Tool description:

Perishable tool collected at the location named by IJGE as “Thiangol Garage” in Segou. It was collected in January, which correspond to the dry season. The tool is a portable twig (made of an unknown plant) that was used for ant dipping (*Dorylus nigricans*) and was found 72 centimeters away from the ant nest entrance. The tool measures 770,00 millimeters in length and with a thickness ranging from 5,40 to 4,90 mm. And with the weight of 4,15 grams.

During the analysis we identified some marks across the tool and evidence of residues.

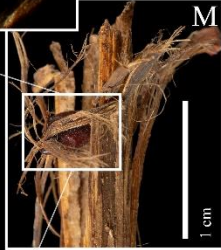
Morphologically, the tool is sinuously curved. The proximal end presents a combination of modifications related to the extraction of the tool from the source, including a cut end (**A, C**) and invasive stripper bark (**B**). The length of the modification is more than 270,00 mm. While, on the opposite, we see a frayed modification (**J, M, L**) with a length of 60,2 mm. This modification is complemented with a debarked area on the piece.

The tool is not complete, the distal part is fractured and broken into 3 pieces, **H, I**). It is notable to indicate that this rupture of the tool happened during its transportation from the field. Along with this fracture, we find 3 more fractures in the mesial and distal zones (**D, G, J**). The first two fractures (**E, F, G**) are non-complete, with a length of 18 mm and 25 mm respectively. The last one (**J, K**) is a complete fracture associated with some fissures and debarking. Furthermore, on the distal end of the tool we found an ant head attached to a fiber (**M, N, O**). The ant corresponds to the head of a *Dorylus nigricans*.

During the analysis, we did not find evidence of manufacture peeling, leaves, sub-branch, or protuberances.

Additional information:**Photograph:**

- A. Cut_Stripped_PP_01_40mm.
- B. Cut_Stripped_PP_02_40mm.
- C. Cut_Stripped_PP_02_35x_3D.
- D. Fract_01_MP_40mm.
- E. Fract_01_MP_35x_3D.
- F. Fract_brokem_01_MP_40mm.
- G. Fract_02_MP_35x_3D.
- H. Fract_broken_02_MP_40mm.
- I. Fract_broken_03_MP_35x_3D.
- J. Point_DP_40mm.
- K. Fract_04_DP_35x_3D.
- L. Stripped_bark_DP_01_35x.
- M. Stripped_bark_DP_02_40mm.
- N. Ant_head_DP_01_35x_3D.
- O. Ant_head_DP_02_140x.



File number: 0014	Tool identification: SE_AD_27jan23_S01_T05	Field site: Dindéfélo	Area: Segou
		Country: Senegal	
Locality: Thiangol Garage	Day of collection: 27		Activity: ☐ Termite fishing ☒ Ant dipping ☐ Algae fishing ☐ Baobab pounding ☐ Indeterminate
Site code: TG2	Month of collection: January	Site UTM X: 793906	
Season: Dry	Year: 2023	Site UTM Y: 1369814	
Species consumed: <i>Dorylus nigricans</i>	Tool type 1: Stick	Tool type 2: ☐ Fixed ☒ Portable	Distance to raw material source (metres) Unknown
Raw material source identified: No	Distance tool – nest entrance (cm): 81	Distance to baobab (tree): -	
Plant raw material: Unknown	Stone raw material: n/a	Blank: Twig	Weight (gr): 6,23
Digital length (mm): 751,70		Proximal width (mm): 4,90	
End-to-end length (mm): 740,00		Medial width (mm): 3,90	
Max thickness (for stone tools; mm): n/a		Distal width (mm): 3,40	
Morphology: curved		Numbers used areas: 2	
Proximal end (stick): ☒ Stripped bark ☐ Cut ☐ Bent ☐ Frayed ☐ Unmodified	Proximal end modification (mm): 27,7	Distal end (stick): ☒ Stripped bark ☐ Cut ☐ Bent ☐ Frayed ☐ Peeled ☐ Unmodified	Distal end modification (mm): 32,1
Residue presence: ☐ Yes ☒ No	Type of residue: ☐ Shells ☐ Fruit residues ☐ Insect fragments ☐ Soil ☐ Algae ☐ N/A	Residue species: Residue location: ☐ Proximal ☐ Mesial ☐ Distal	Analysis: ☒ Macroscopic ☒ Hirox ☐ Confocal ☐ Zeiss ☐ ESEM
Broken tool: ☐ Yes ☒ No	Manufacture peeling: ☐ Yes ☒ No	Presence of leaves: ☐ Yes ☒ No	Presence of sub-branches: ☐ Yes ☒ No
Number adhered fractures: 2	Location of fractures: ☐ Proximal ☒ Mesial ☒ Distal	Researcher conducting the analysis: Daniel Vivar Ríos (IPHES-CERCA)	

Tool description:

Perishable tool collected at the location named by IJGE as “Thiangol Garage” (TG2) in Segou. It was collected in January, which correspond to the dry season. The tool is a portable twig (made of an unknown plant) that was used for ant dipping (*Dorylus nigricans*) and was found 81 centimeters away from the ant nest entrance. The tool measures 740,00 millimeters in length and with a thickness ranging from 4,90 to 3,40 mm. And with the weight of 6,23 grams.

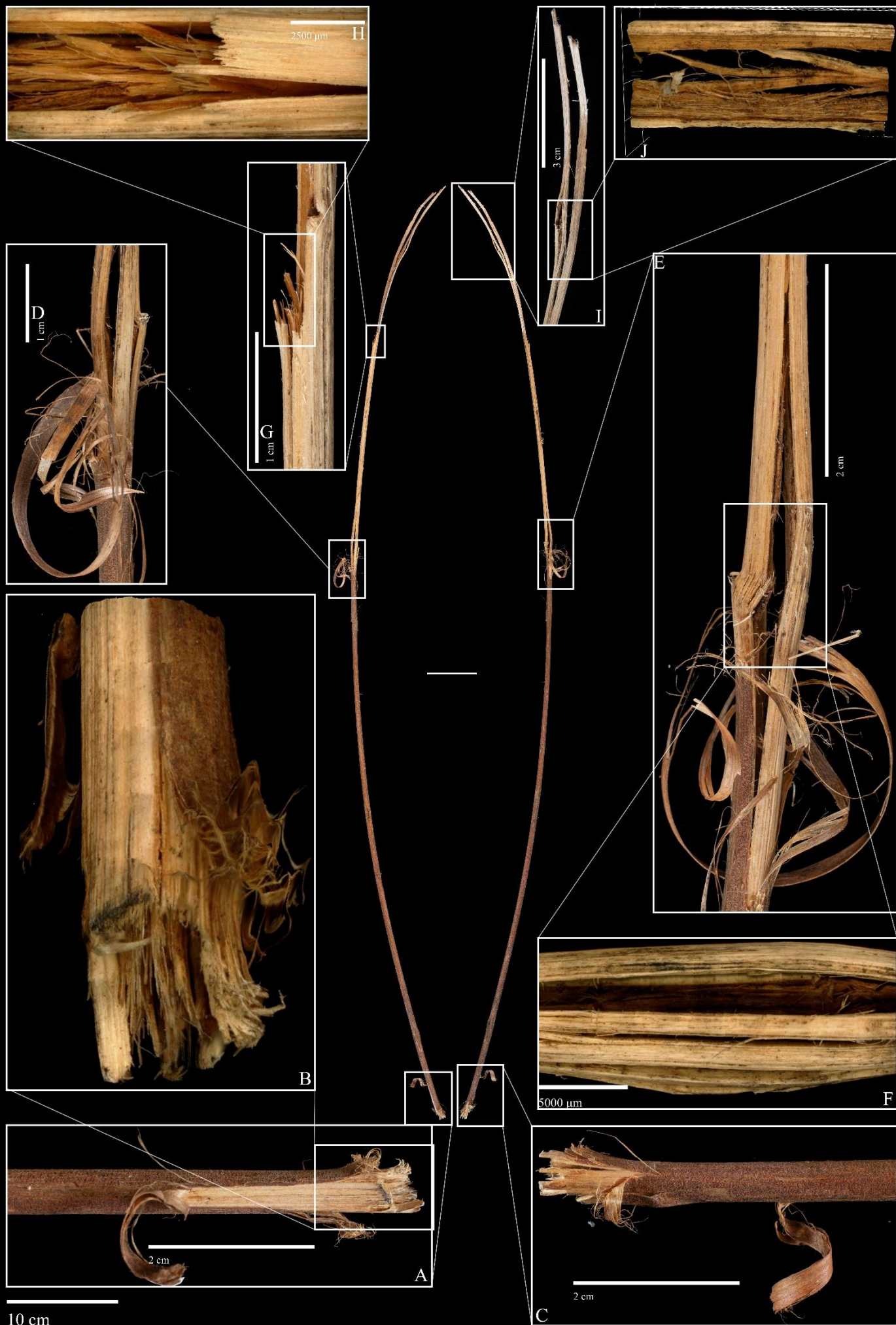
In this case, the extensive modifications recognised on the tools led us to determine that both ends (proximal and distal) were used.

Morphologically, the tool is curved. The proximal end presents non-invasive stripped bark (**A, B**). This modification is 27,7 mm in length, developed only along one side of the proximal end, while the opposite face (**C**), the stripped bark is non-invasive. We also find stripped bark on the distal end (**I**), in this case, it has a very invasive modification, reaching the mesial part of the tools (**G, H**). From this latter point to the final end, we identify some non-complete fractures. The first one (**E, D, F**) with a 19 mm of length is associated with fissures and debarking. The second one (**J**) is associated with the slit of the bark and has a length of 17 mm.

The tool is complete. We did not identify the presence of manufacture peeling, protuberance, leaves, or sub-branches.

Additional information:**Photograph:**

- A. Stripped_bark_PP_01_40mm.
- B. Stripped_bark_PP_01_35x_3D.
- C. Stripped_bark_PP_02_40mm.
- D. Fract_01_MP_01_40mm.
- E. Fract_01_MP_02_40mm.
- F. Fract_01_MP_02_35x.
- G. Final_groove_MP_01_40mm.
- H. Final_groove_MP_01_35x.
- I. Stripped_bark_DP_01_40mm.
- J. Fract_02_DP_35x_3D.



File number: 0015	Tool identification: SE_AD_27jan23_S01_T06	Field site: Dindéfelo	Area: Segou
		Country: Senegal	
Locality: Thiangol Garage	Day of collection: 27		Activity: ☐ Termite fishing ☒ Ant dipping ☐ Algae fishing ☐ Baobab pounding ☐ Indeterminate
Site code: TG2	Month of collection: January	Site UTM X: 793906	
Season: Dry	Year: 2023	Site UTM Y: 1369814	
Species consumed: <i>Dorylus nigricans</i>	Tool type 1: Stick	Tool type 2: ☐ Fixed ☒ Portable	Distance to raw material source (metres) Unknown
Raw material source identified: No	Distance tool – nest entrance (cm): 67	Distance to baobab (tree): -	
Plant raw material: Unknown	Stone raw material: n/a	Blank: Twig	Weight (gr): 2,50
Digital length (mm): 575,88		Proximal width (mm): 4,80	
End-to-end length (mm): 555,00		Medial width (mm): 3,90	
Max thickness (for stone tools; mm): n/a		Distal width (mm): 3,30	
Morphology: curved		Numbers used areas: 1	
Proximal end (stick): ☒ Stripped bark ☒ Cut ☐ Bent ☐ Frayed ☐ Unmodified	Proximal end modification (mm): 157,1	Distal end (stick): ☒ Stripped bark ☐ Cut ☐ Bent ☒ Frayed ☐ Peeled ☐ Unmodified	Distal end modification (mm): 17,4
Residue presence: ☒ Yes ☐ No	Type of residue: ☐ Shells ☐ Fruit residues ☐ Insect fragments ☒ Soil ☐ Algae ☐ N/A	Residue species: Soil Residue location: ☐ Proximal ☐ Mesial ☒ Distal	Analysis: ☒ Macroscopic ☒ Hirox ☐ Confocal ☐ Zeiss ☐ ESEM
Broken tool: ☐ Yes ☒ No	Manufacture peeling: ☐ Yes ☒ No	Presence of leaves: ☐ Yes ☒ No	Presence of sub-branches: ☐ Yes ☒ No
Number adhered fractures: 2	Location of fractures: ☐ Proximal ☒ Mesial ☐ Distal	Researcher conducting the analysis: Daniel Vivar Ríos (IPHES-CERCA)	

Tool description:

Perishable tool collected at “Thiangol Garage” (TG2) in Segou. It was collected in January, which correspond to the dry season. The tool is a portable twig that was used for ant dipping (*Dorylus nigricans*) found 67 cm from the ant nest entrance. The tool measures 555,00 millimeters in length and with a thickness ranging from 4,80 to 3,30 millimeters. And with the weight of 2,50 grams. During the analysis we identified different modifications and residues.

Morphologically, the tool is continuously curved. The proximal end has a combination of modifications including very invasive stripped bark and cut-end, modifications that reach the middle zone of the tool (157,1 mm) (**A, B, C**). In addition, we are seeing relative rounding the point of this end (**B**). The distal end presents also stripped bark combined with non-invasive frayed (**H, I, J**), measuring 17,4 mm in length. The distal end of the tool also has evidence of residues consisting of soil grains (**I**) potentially adhered due to the friction motions against the ground during the activity.

The tool is complete, but we can find two fractures in the mesial part (**D, F**). The first fracture (**D, E**) is a non-complete formed consequence of the second one. This second fracture (**F, G**) is complete, measuring 26 mm in length and attached to the tool by the cortex fibers. This last fracture changes the natural morphology of the tool. In addition, the fractures have also caused some stripped bark peeling across the tool (in both directions, proximal and distal).

In the analysis, we did not find evidence of manufacturing peeling, leaves, or sub-branches.

Additional information:**Photograph**

- A. Cut_stripped_bark_PP_40mm.
- B. Cut_stripped_bark_PP_35x_3D.
- C. Stripped_bark_01_PP_40mm.
- D. Fract_01_MP_40mm.
- E. Fract_01_MP_35x_3D.
- F. Fract_02_MP_40mm.
- G. Fract_02_MP_35x_3D.
- H. Frayed_stripped_DP_01_40mm.
- I. Frayed_stripped_DP_35x.
- J. Frayed_stripped_DP_02_40mm.



File number: 0016	Tool identification: NA_TF_1feb23_S1_T01	Field site: Dindéfélo	Area: Nandoumary
		Country: Senegal	
Locality: Punto animal	Day of collection: 1		Activity: ☒ Termite fishing ☐ Ant dipping ☐ Algae fishing ☐ Baobab pounding ☐ Indeterminate
Site code: PA1	Month of collection: February	Site UTM X: 786826	
Season: Dry	Year: 2023	Site UTM Y: 1365545	
Species consumed: <i>Macrotermes subhyalinus</i>	Tool type 1: Stick	Tool type 2: ☐ Fixed ☒ Portable	Distance to raw material source (metres) 4,63
Raw material source identified: Yes	Distance tool – nest entrance (cm): 0	Distance to baobab (tree): -	
Plant raw material: <i>Flueggea virosa</i>	Stone raw material: n/a	Blank: Twig	Weight (gr): 1,03
Digital length (mm): 306,22		Proximal width (mm): 5,80	
End-to-end length (mm): 290,40		Medial width (mm): 2,90	
Max thickness (for stone tools; mm): n/a		Distal width (mm): 2,10	
Morphology: curved		Numbers used areas: 1	
Proximal end (stick): ☐ Stripped bark ☐ Cut ☒ Bent ☐ Frayed ☐ Unmodified	Proximal end modification (mm): 0	Distal end (stick): ☐ Stripped bark ☐ Cut ☐ Bent ☐ Frayed ☒ Peeled ☐ Unmodified	Distal end modification (mm): 13,6
Residue presence: ☐ Yes ☒ No	Type of residue: ☐ Shells ☐ Fruit residues ☐ Insect fragments ☐ Soil ☐ Algae ☒ N/A	Residue species:	Analysis: ☒ Macroscopic ☒ Hirox ☐ Confocal ☐ Zeiss ☐ ESEM
		Residue location: ☐ Proximal ☐ Mesial ☐ Distal	
Broken tool: ☐ Yes ☒ No	Manufacture peeling: ☐ Yes ☒ No	Presence of leaves: ☐ Yes ☒ No	Presence of sub-branches: ☐ Yes ☒ No
Number adhered fractures: 2	Location of fractures: ☐ Proximal ☒ Mesial ☒ Distal	Researcher conducting the analysis: Daniel Vivar Ríos (IPHES-CERCA)	

Tool description:

Perishable tool collected at the location named by IJGE as “Punto Animal” (PA1) in Nandoumary. It was collected in February during the dry season. The tool is a portable twig, made of *Flueggea virosa*, and was used on activity of termite fishing (*Macrotermes subhyalinus*). This tool was found lying on top of the termite mound, and it was possible to identify that the shrub that was used to source the tool was 4,63 m from the location of the tool. The tool measures 290,40 millimeters in length and with a thickness ranging from 5,80 to 2,10 millimeters. And with the weight of 1,03 grams. The tool only has one used zone (the distal end)

Morphologically, the tool is curved. The proximal end is slightly bent (**A, B**). This end is associated with a larger part of the trunk as it presents a typical protrusion of the sub-branches. While in the opposite, the distal end, it is possible to identify a peeled modification (**E, G**) with a length of 13,6 mm. Associated with this latter feature, we find a fracture (**F**) caused during the use of the tool.

We also identified two fractures. The first one is complete (**C, D**) and is exceptionally long, occupying a bigger part of the mesial part of the blank. Generate fissures in both directions (proximal and distal end). The second one is not complete, in the distal part of the tool (**E, F**). During the analysis, we did not find evidence of manufacturing peeling, leaves, or sub-branches.

Additional information:

- A. Bent_PP_01_40mm
- B. Bent_PP_01_35x_3D.
- C. Fract_01_MP_01_40mm.
- D. Fract_01_MP_01_35x_3D.
- E. Distal_part_01_40mm.
- F. Fract_02_DP_35x.
- G. Peeled_DP_01_35x_3D.

File number: 0017	Tool identification: NA_TF_1feb23_S1_T02	Field site: Dindéfélo	Area: Nandoumary
		Country: Senegal	
Locality: Punto animal	Day of collection: 1		Activity: ☒ Termite fishing ☐ Ant dipping ☐ Algae fishing ☐ Baobab pounding ☐ Indeterminate
Site code: PA1	Month of collection: February	Site UTM X: 786826	
Season: Dry	Year: 2023	Site UTM Y: 1365545	
Species consumed: <i>Macrotermes subhyalinus</i>	Tool type 1: Stick	Tool type 2: ☐ Fixed ☒ Portable	Distance to raw material source (metres) 2,24
Raw material source identified: Yes	Distance tool – nest entrance (cm): 0	Distance to baobab (tree): -	
Plant raw material: <i>Flueggea virosa</i>	Stone raw material: n/a	Blank: Twig	Weight (gr): 1,89
Digital length (mm): 512,35		Proximal width (mm): 3,50	
End-to-end length (mm): 495,00		Medial width (mm): 2,50	
Max thickness (for stone tools; mm): n/a		Distal width (mm): 2,30	
Morphology: Slightly curved		Numbers used areas: 1	
Proximal end (stick): ☐ Stripped bark ☒ Cut ☐ Bent ☐ Frayed ☐ Unmodified	Proximal end modification (mm): 0	Distal end (stick): ☐ Stripped bark ☐ Cut ☐ Bent ☒ Frayed ☐ Peeled ☐ Unmodified	Distal end modification (mm): 14,8
Residue presence: ☒ Yes ☐ No	Type of residue: ☐ Shells ☐ Fruit residues ☐ Insect fragments ☒ Soil ☐ Algae ☐ N/A	Residue species: -	Analysis: ☒ Macroscopic ☒ Hirox ☐ Confocal ☐ Zeiss ☐ ESEM
		Residue location: ☐ Proximal ☐ Mesial ☒ Distal	
Broken tool: ☐ Yes ☒ No	Manufacture peeling: ☒ Yes ☐ No	Presence of leaves: ☐ Yes ☒ No	Presence of sub-branches: ☐ Yes ☒ No
Number adhered fractures: 4	Location of fractures: ☒ Proximal ☐ Mesial ☒ Distal	Researcher conducting the analysis: Daniel Vivar Ríos (IPHES-CERCA)	

Tool description:

Perishable tool collected at the location named IJGE as “Punto animal” (PA1) in Nandoumary. It was collected in February, which correspond to the dry season. The tool is a portable twig, made of *Flueggea virosa* whose shrub was located 2,24 meters from the tool. This artefact was used for termite fishing (*Macrotermes subhyalinus*). The tool measures 495,00 millimeters in length and with a thickness ranging from 3,50 to 2,30 millimeters. And with the weight of 1,89 grams.

The tool exhibit evidence of soil adhered on the distal part (**K**), but they cannot be associated with the use of the tool, as at the time of its collection, the artefact was dry, meaning that it was not being used recently.

Morphologically it is slightly curved. The proximal end is cut (**A**, **B**), and it is associated with a first little fracture (**C**) that caused the displacement of part of the bark. On the other end, the distal part, we see a frayed modification with a length 14,8 millimeters (**J**, **K**).

The tool is complete, and we can find multiple fractures distributed in the distal and proximal ends. The first one, is associated with the extraction of the twig (**C**). While the distal end (**F**) has three fractures associated between them. The first one (**G**) is not complete and we see the final fissure of the propagation of energy. The second fracture (**H**) is complete, but it is still attached to the tool by the bark fibers. This one is the beginning of the matrix breakdown. The third fracture (**I**) presents an 'H'-like morphology.

During the analysis, we could also identify scars related to the manufacturing peeling (3 in total) distributed in the mesial part (**D**, **E**). Finally, we did not recognize any presence of leaves and sub-branches.

Additional information:**Photograph:**

- A. Cut_PP_01_40mm.
- B. Cut_PP_01_35x_3D.
- C. Fract_01_PP_35x_3D.
- D. Manufacture_peeling_01_MP_40mm.
- E. Manufacture_peeling_01_MP_35x_3D.
- F. Fracts_DP_40mm.
- G. Fract_02_DP_35x_3D.
- H. Fract_03_DP_35x_3D.
- I. Fract_04_DP_35x_3D.
- J. Frayed_DP_40mm.
- K. Frayed_DP_35x_3D.



File number: 0018	Tool identification: NA_TF_1feb23_S1_T02	Field site: Dindéfelo	Area: Nandoumary
		Country: Senegal	
Locality: Punto animal	Day of collection: 1		Activity: ☒ Termite fishing ☐ Ant dipping ☐ Algae fishing ☐ Baobab pounding ☐ Indeterminate
Site code: PA1	Month of collection: February	Site UTM X: 786826	
Season: Dry	Year: 2023	Site UTM Y: 1365545	
Species consumed: <i>Macrotermes subhyalinus</i>	Tool type 1: Stick	Tool type 2: ☐ Fixed ☒ Portable	Distance to raw material source (metres) 1,87
Raw material source identified: Yes	Distance tool – nest entrance (cm): 58,5	Distance to baobab (tree): -	
Plant raw material: <i>Flueggea virosa</i>	Stone raw material: n/a	Blank: Twig	Weight (gr): 0,95
Digital length (mm): 370,45		Proximal width (mm): 3,10	
End-to-end length (mm): 360,00		Medial width (mm): 2,40	
Max thickness (for stone tools; mm): n/a		Distal width (mm): 2,20	
Morphology: slightly curve		Numbers used areas: 1	
Proximal end (stick): ☐ Stripped bark ☐ Cut ☒ Bent ☐ Frayed ☐ Unmodified	Proximal end modification (mm): 10,00	Distal end (stick): ☐ Stripped bark ☐ Cut ☐ Bent ☒ Frayed ☐ Peeled ☐ Unmodified	Distal end modification (mm): 2,8
Residue presence: ☐ Yes ☒ No	Type of residue: ☐ Shells ☐ Fruit residues ☐ Insect fragments ☐ Soil ☐ Algae ☒ N/A	Residue species: -	Analysis: ☒ Macroscopic ☒ Hirox ☐ Confocal ☐ Zeiss ☐ ESEM
		Residue location: ☐ Proximal ☐ Mesial ☐ Distal	
Broken tool: ☐ Yes ☒ No	Manufacture peeling: ☒ Yes ☐ No	Presence of leaves: ☐ Yes ☒ No	Presence of sub-branches: ☐ Yes ☒ No
Number adhered fractures: 3	Location of fractures: ☐ Proximal ☒ Mesial ☒ Distal	Researcher conducting the analysis: Daniel Vivar Ríos (IPHES-CERCA)	

Tool description:

Perishable tool collected at the location named by IJGE as “Punto Animal” (PA1) in Nandoumary. It was collected in February (dry season). The tool is a portable, made of *Flueggea virosa*, a shrub that was located 1,87 m away from the place where the tool was abandoned. The artefact was used on termite fishing (*Macrotermes subhayalinus*) and was found 58,5 cm from the termite mount. The tool measures 360 millimeters in length and with a thickness ranging from 3,10 to 2,20 millimeters. And with the weight of 0,95 grams.

Morphologically the tool is slightly curved. The proximal end is bent, and a small part of the bark was removed when the tool was extracted (**A, B, C**). While the opposite end, the distal one presents a modified frayed tip, with a 2,8 millimeter (**I, J**). This end seems like a kind of brush rounded.

The tool is complete and presents some marks consequence of the manufacturing phase, showing also some fractures located in the mesial and distal sides. The tool has a single manufactured peeling with a directionality coming from the proximal to the distal end (**D**) and has associated a fracture (**E**). In this way, we find some fractures (3) (**E, F**). The last two fracture (**G, H**) located in the distal end, is associated between them, and join for a stripped bark.

During the analysis, we did not find evidence of leaves and sub/branches. Although it has some protuberances related to the presence of ungrown sub-branches.

Additional information:**Photograph:**

- A. Bended_01_PP_40mm.
- B. Bended_01_PP_35x_3D.
- C. Bended_01_PP_02_40mm.
- D. Manufacture_fracture_01_MP_40mm.
- E. Fract_01_MP_35x_3D.
- F. Fracts_02_03_DP_40mm.
- G. Fract_02_DP_35x_3D.
- H. Fract_03_DP_35x_3D.
- I. Frayed_DP_40mm.
- J. Frayed_DP_35x_3D.

File number: 0019	Tool identification: NA_TF_1feb23_S1_T10	Field site: Dindéfelo	Area: Nandoumary
		Country: Senegal	
Locality: Punto animal	Day of collection: 1		Activity: ☒ Termite fishing ☐ Ant dipping ☐ Algae fishing ☐ Baobab pounding ☐ Indeterminate
Site code: PA1	Month of collection: February	Site UTM X: 786826	
Season: Dry	Year: 2023	Site UTM Y: 1365545	
Species consumed: <i>Macrotermes subhyalinus</i>	Tool type 1: Stick	Tool type 2: ☐ Fixed ☒ Portable	Distance to raw material source (metres) 1,66
Raw material source identified: Yes	Distance tool – nest entrance (cm): 62,5	Distance to baobab (tree): -	
Plant raw material: <i>Flueggea virosa</i>	Stone raw material: n/a	Blank: Twig	Weight (gr): 1,86
Digital length (mm): 462,18		Proximal width (mm): 3,90	
End-to-end length (mm): 445,00		Medial width (mm): 3,40	
Max thickness (for stone tools; mm): n/a		Distal width (mm): 3,10	
Morphology: curved		Numbers used areas: 1	
Proximal end (stick): ☒ Stripped bark ☐ Cut ☐ Bent ☐ Frayed ☐ Unmodified	Proximal end modification (mm): 34,3	Distal end (stick): ☐ Stripped bark ☐ Cut ☐ Bent ☒ Frayed ☐ Peeled ☐ Unmodified	Distal end modification (mm): 5,2
Residue presence: ☒ Yes ☐ No	Type of residue: ☐ Shells ☐ Fruit residues ☐ Insect fragments ☒ Soil ☐ Algae ☐ N/A	Residue species:	Analysis: ☒ Macroscopic ☒ Hirox ☐ Confocal ☐ Zeiss ☐ ESEM
		Residue location: ☒ Proximal ☐ Mesial ☐ Distal	
Broken tool: ☐ Yes ☒ No	Manufacture peeling: ☒ Yes ☐ No	Presence of leaves: ☐ Yes ☒ No	Presence of sub-branches: ☐ Yes ☒ No
Number adhered fractures: 4	Location of fractures: ☐ Proximal ☒ Mesial ☒ Distal	Researcher conducting the analysis: Daniel Vivar Ríos (IPHES-CERCA)	

Tool descriptionn:

Perishable tool collected at the location named by IJGE as “Punto Animal” (PA1) in Nandoumari. It was collected in February; this is during the dry season. The tool is a portable twig (made of *Flueggea virosa*) that was used on termite fishing (*Macrotermes subhyalinus*). The tool was sourced from a shrub located 1,66 m away from the place where the tool was found, and very close to the termite mound (62,5 cm away). The tool measures 445,00 millimeters in length and with a thickness ranging from 3,90 to 3,10 mm. And with a weight of 1,86 grams.

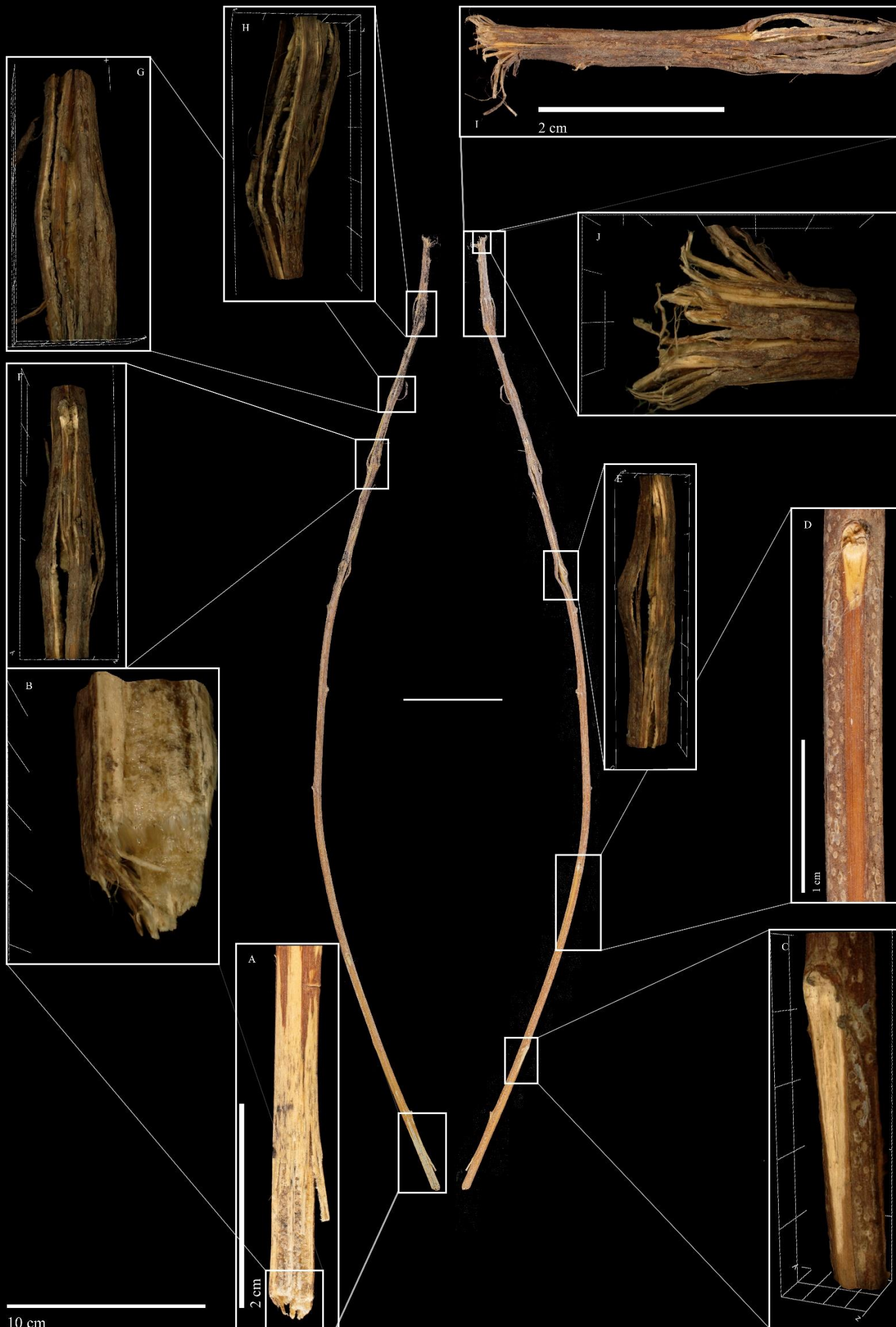
Morphologically the tool is slightly curved. The proximal end presents a stripped bark modification, a bit invasive (**A, B**) and with a length of 34,3 millimeters. Adjacent to this, we find a protuberance of a sub-branch and a manufacture peeling (**C**). While on the distal end, we identified a kind non-invasive frayed (**I, J**) with a length of 5,2 mm.

The tool is complete, but it has a fracture in the distal part. Additional fractures (4) are in the mesial and distal parts. The first one (**E**), in the mesial zone, is a non-complete fracture and shows some fissures. While the last three (**F, G, H**) are associated between them, while the most distal fracture is complete (**H**), only held to the rest of the stick by the bark. At the same time, we find some pieces of evidence of the manufacturing process after the extraction of the stick, with various scars located in the proximal and mesial parts (**D, E**). And for last, we identified some rest of the soil in the proximal end, but these residues most likely are not related to the activity nor the use of the tool

We did not find evidence of leaves or sub-branches.

Additional information:**Photograph:**

- A. Stripped_bark_PP_01_40mm.
- B. Stripped_bark_PP_01_35x_3D.
- C. Manufacture_peeling_PP_01_35x_3D.
- D. Manufacture_peeling_PP_01_40mm.
- E. Fract_01_MP_35x_3D.
- F. Fract_02_DP_35x_3D.
- G. Fract_03_DP_35x_3D.
- H. Fract_04_DP_35x_3D.
- I. Frayed_DP_40mm.
- J. Frayed_DP_35x_3D.



File number: 0020	Tool identification: SE_AD_6feb23_S1_T04	Field site: Dindéfelo Country: Senegal	Area: Segou
Locality: Thiangol Ndian	Day of collection: 6		Activity: ☐ Termite fishing ☒ Ant dipping ☐ Algae fishing ☐ Baobab pounding ☐ Indeterminate
Site code: TN3	Month of collection: February	Site UTM X: 794097	
Season: Dry	Year: 2023	Site UTM Y: 1369884	
Species consumed: <i>Dorylus nigricans</i>	Tool type 1: Stick	Tool type 2: ☐ Fixed ☒ Portable	Distance to raw material source (metres) Unknown
Raw material source identified: No	Distance tool – nest entrance (cm): 67,00	Distance to baobab (tree): -	
Plant raw material: <i>Alchornea cordifolia</i>	Stone raw material: n/a	Blank: Liana	Weight (gr): 8,48
Digital length (mm): 752,05		Proximal width (mm): 6,10	
End-to-end length (mm): 741,00		Medial width (mm): 6,70	
Max thickness (for stone tools; mm): n/a		Distal width (mm): 5,00	
Morphology: curved		Numbers used areas: 1	
Proximal end (stick): ☒ Stripped bark ☐ Cut ☐ Bent ☐ Frayed ☐ Unmodified	Proximal end modification (mm): 49,4	Distal end (stick): ☒ Stripped bark ☐ Cut ☐ Bent ☒ Frayed ☐ Peeled ☐ Unmodified	Distal end modification (mm): 218,00
Residue presence: ☒ Yes ☐ No	Type of residue: ☐ Shells ☐ Fruit residues ☒ Insect fragments ☐ Soil ☐ Algae ☐ N/A	Residue species: <i>Dorylus nigricans</i> Residue location: ☐ Proximal ☐ Mesial ☒ Distal	Analysis: ☒ Macroscopic ☒ Hirox ☐ Confocal ☐ Zeiss ☐ ESEM
Broken tool: ☐ Yes ☒ No	Manufacture peeling: ☐ Yes ☒ No	Presence of leaves: ☐ Yes ☒ No	Presence of sub-branches: ☐ Yes ☒ No
Number adhered fractures: 3	Location of fractures: ☐ Proximal ☒ Mesial ☒ Distal	Researcher conducting the analysis: Daniel Vivar Ríos (IPHES-CERCA)	

Tool description:

Perishable tool collected at the location named by IJGE as “Thiangol Ndian” (TN3) in Segou. It was collected in February, which correspond to the dry season. The tool is a portable artefact made of a liana (*Alchornea cordifolia*), that was used on activity of ant dipping (*Dorylus nigricans*). The tool was found 67 cm away from the ant nest entrance. The tool measures are 741,00 millimeters in length and with a thickness ranging from 6,70 to 5,00 mm. And with the weight of 8,48 grams.

During the analysis we identified different marks located related to different phases of extraction, use, and abandonment.

Morphologically the tool is curved. The proximal end presents a modification related to the phase of extraction and consists of stripped bark that is a bit invasive (**A, C**), measuring 49,4 mm in length. And where we can appreciate how the proximal part is split in half (**B**). The opposite end also bears stripped bark, coupled with a frayed modification (**N, O**). The modification on the distal end is long and invasive (measuring 218,00 mm). In the same part, we also see an association between this frayed modification with a series of three non-complete fractures (**D, E, J, L**). that are causing the shredding of the distal part of the tool (**M, K**).

Finally, we also identified residues located in one of the fibers on the distal part (**F, G**). These correspond to an ant’s head (*Dorylus nigricans*) holding onto the stick (**H, I**). We did not find any evidence of manufacture, protuberance, or sub/branches.

Additional information:**Photograph:**

- A. Stripped_bark_PP_01_40mm.
- B. Stripped_bark_PP_02_40mm.
- C. Stripper_bark_PP_02_35x_3D.
- D. Fract_01_MP_01_40mm.
- E. Fract_01_MP_01_35x.
- F. Ant_head_DP_01_40mm
- G. Ant_head_DP_02_40mm.
- H. Ant_head_DP_02_140x.
- I. Ant_head_DP_02_140x_3D.
- J. Fract_02_DP_01_40mm.
- K. Fract_02_DP_01_35x_3D.
- L. Fract_03_DP_01_40mm.
- M. Fract_03_DP_01_35x_3D.
- N. Frayed_stripped_DP_01_40mm.
- O. Frayed_stripped_DP_01_35x_3D.



10 cm

File number: 0021	Tool identification: SE_AD_6feb23_S1_T03	Field site: Dindéfelo	Area: Segou
		Country: Senegal	
Locality: Thiangol Ndian	Day of collection: 6		Activity: ☐ Termite fishing ☒ Ant dipping ☐ Algae fishing ☐ Baobab pounding ☐ Indeterminate
Site code: TN3	Month of collection: February	Site UTM X: 794097	
Season: Dry	Year: 2023	Site UTM Y: 1369884	
Species consumed: <i>Dorylus nigricans</i>	Tool type 1: Stick	Tool type 2: ☐ Fixed ☒ Portable	Distance to raw material source (metres) Unknown
Raw material source identified: No	Distance tool – nest entrance (cm): 28,00	Distance to baobab (tree): -	
Plant raw material: <i>Alchornea cordifolia</i>	Stone raw material: n/a	Blank: Liana	Weight (gr): 10,62
Digital length (mm): 740,63		Proximal width (mm): 8,90	
End-to-end length (mm): 694,00		Medial width (mm): 6,90	
Max thickness (for stone tools; mm): n/a		Distal width (mm): 6,00	
Morphology: curved		Numbers used areas: 1	
Proximal end (stick): ☒ Stripped bark ☐ Cut ☐ Bent ☐ Frayed ☐ Unmodified	Proximal end modification (mm): 46,4	Distal end (stick): ☒ Stripped bark ☐ Cut ☐ Bent ☒ Frayed ☐ Peeled ☐ Unmodified	Distal end modification (mm): 210,00
Residue presence: ☒ Yes ☐ No	Type of residue: ☐ Shells ☐ Fruit residues ☒ Insect fragments ☐ Soil ☐ Algae ☐ N/A	Residue species: <i>Dorylus nigricans</i>	Analysis: ☒ Macroscopic ☒ Hirox ☐ Confocal ☐ Zeiss ☐ ESEM
		Residue location: ☐ Proximal ☐ Mesial ☒ Distal	
Broken tool: ☐ Yes ☒ No	Manufacture peeling: ☒ Yes ☐ No	Presence of leaves: ☐ Yes ☒ No	Presence of sub-branches: ☐ Yes ☒ No
Number adhered fractures: 1	Location of fractures: ☐ Proximal ☒ Mesial ☐ Distal	Researcher conducting the analysis: Daniel Vivar Ríos (IPHES-CERCA)	

Tool description:

Perishable tool collected at the location named by IJGE as “Thiangol Ndian” (TN3) in Segou. It was collected in February, which correspond to the dry season. The tool is a portable artefact made of liana (*Alchornea cordifolia*) that was used on activity of ant dipping (*Dorylus nigricans*) and found at 28 cm from the ant nest entrance. The tool measures 694,00 millimeters in length and with a thickness ranging from the 8,90 to 6,00 mm. And with the weight of 10,62 grams.

During the analysis we found modifications related to the phases of blank extraction, use, manufacture, and abandonment.

Morphologically the tool is continuously curved. The proximal end presents stripper bark (**A, C**), related to the extraction of the stick from the rest of the source. We also identified slightly rounded fibers from the proximal end (**B**). Stripped bark was identified on the proximal end of the tool, measuring a total of 46,4 mm in length. On the distal end, we find a combination of modifications, including a frayed end and stripped bark (**K, L**) and a complete fracture (**I, H**). Also, it has a peeled morphology (**M**). The length of the modification in the distal part covers 210,00 mm.

The tool is not complete, it was broken during the transport from the field. This fracture is complete and only held by some bark fibers (**J, I**). Also, we find a series of manufacture peeling on the mesial and proximal part (**D, E**), very long. Finally, we also recognised residues located on the mesial part (**F**), consisting of an ant's head without any part of the body, and hold on the fibers, corresponding to a *Dorylus nigricans* (**G**).

In the analysis, we did not find evidence of leaves, protuberance, or sub/branches.

Additional information:**Photograph:**

- A. Stripped_bark_01_PP_40mm.
- B. Stripped_bark_01_PP_35x_3D.
- C. Stripped_bark_01_PP_40mm.
- D. Manufacture_peeling_MP_40mm.
- E. Manufacture_peeling_MP_35x_3D.
- F. Ant_head_01_MP_40mm.
- G. Ant_head_01_MP_140x.
- H. Distal_end_MP_40mm.
- I. Fract_post_deposicional_down_part_40mm.
- J. Fract_post_deposicional_up_part_40mm.
- K. Frayed_stripped_01_DP_40mm.
- L. Frayed_stripped_02_DP_40mm.
- M. Frayed_stripped_02_DP_35x.



10 cm



