CHAPTER

1

The Prehistory of Poison Arrows

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OUTLINE

1.1 INTRODUCTION

The use of poisonous substances on arrows is an aspect of the study of prehistoric hunting weapons that only recently has been investigated.

The ethnographic documentation teaches us that hunters of every latitude poison their weapons with toxic substances derived from plants and animals (Bisset, 1979, 1981, 1989, 1992; Bisset and Hylands, 1977; Cassels, 1985; Jones, 2009; Heizer, 1938; Mayor, 2008; Neuwinger, 1996; Noli, 1993; Osborn, 2004; Philippe and Angenot, 2005). Indeed, the weapons could be ineffective if the tips were not poisoned (Noli, 1993). In fact, especially in large game, arrows penetrate the prey to a depth

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that is insufficient to kill a big animal. The suspicion that the use of poisoning arrows for hunting is an ancient practice dating back to the Paleolithic era is quite plausible.

During the Paleolithic age, the improvement of the technique of hunting at a distance, with the invention of throwing weapons such as the spear, was a revolution in hunting strategies developed by anatomically modern humans (AMH).

In terms of hunting equipment, this is characterized by the appearance of stone barbs and osseous points for hunting weapons. The desire to optimize the aerodynamic and penetrative characteristics of these artifacts suggests the use of a delivery system: the spearthrower or atlatl, and the bow.

The invention of long-range hunting weapons represents a milestone in human history since it illustrates the replacement of our phenotypic competitiveness with survival strategies based on social cooperation and the use of technology.

Chronologically, the first stone tools which are considered to be part of composite long-range weapons are the backed bladelets (called *demilunes*, segments, or lunates) found in the first South-African AMH settlements dated from 70,000 to 50,000 years BP (before present) (Lombard and Pargeter, 2008; Backwell et al., 2008). These weapons were part of the toolkit of modern humans who migrated from Africa.

Killing at a distance no longer required a direct physical confrontation but instead the use of a "strategy of deceit," which is deeply linked to our species. The deceit lies in the phases of the hunt: the silence of the ambush, the attention to every movement and wind direction, the simulation to allow the approach, and finally the launch of the weapon and capture of the prey (Brizzi, 2005).

The "coward's weapon," as the English playwright John Fletcher defined poison, is a further deceit that man uses against prey, so that it is more quickly incapacitated.

Paleolithic populations were surely able to recognize edible and toxic plants, and likely those which could be used medicinally. In sum, toxic substances were available to the prehistoric hunter/gatherers and the benefits arising from their application for hunting are notable: the safe distance of the hunter from the prey could be increased and the animal's death would be quicker.

Toxic substances prevent the animal from escaping too far, allowing the hunter to retrieve the prey more easily and, at the same time, to have meat and skin in better condition.

Finally, toxic substances are abundant in nature, and the preparation of a poison is relatively easy and not very dangerous, considering that usually (according to ethnographic data) they are handled by a particular person designated to do the job; other members of the group are safe.

1.2 WHAT DO HISTORICAL AND ETHNOGRAPHIC DOCUMENTS TELL US?

The most ancient evidence of toxic substances on arrows dates back to the Egyptian pre-dynastic period. A black compound was noticed on the tips of some arrows found in the site of Naga ed Der, dated to 2481−2050 BC (Stanley et al., 1974). The investigators of this finding proved, via rather cruel animal testing, that the mixture contained a venomous ingredient, but at that time it was difficult to confirm its identity. Samples of that material are now being analyzed at Northumbria University in Newcastle (UK), as part of a project headed by Dr. Michelle Carlin and Dr. Valentina Borgia.

Besides this unique archeological evidence, we can count on some rare literary documents addressing the use of poisons on arrows. In the Atharva Veda (900 BC), the sacred text of Hinduism, the use of aconite to poison arrows (used in war) is mentioned (Bisset, 1989).

Also, in the Greek poems, the Iliad and the Odyssey, c. 8th century BC, arrow poisons are cited. In the latter case, poisons seem to be used mainly in warfare, but the sources suggest a well-established tradition in the knowledge and use of toxic substances more generally (Mayor, 2008).

It is very interesting to note that the Greek word *toxic*, used to indicate something poisonous, has the same root of the word *toxon* (bow), and both are linked to *taxon* (yew), that is the tree used to make bows, but also one of the most toxic Mediterranean-region plants. *Aconitum napellus* is a toxic plant and *acontizo* means to hurl a javelin. These words are important since they tell us how a particular tradition of poison use (especially related to aconite/monkshood) became culturally established over an extended period. Very broadly then, it is possible to say that, during the time that ancient Mediterranean civilizations flourished, knowledge of medicinal and toxic plants was already advanced and the use of poison arrows widespread (Borgia et al., 2017).

More recently, we find the tradition of using poisonous plants in the Gaul and Celtic populations. *Limeum* (probably an extract of *Helleborus*) is the name they gave to the poison used for their arrows According to the record (Pliny, 27:76), it was used for hunting, and the part of the meat affected by poison had to be cut away.

An extensive ethnographic literature is available for the use of poisonous substances by ancient and modern hunter-gatherers (Bisset, 1979, 1981, 1989; Bisset and Hylands, 1977; Cassels, 1985; Jones, 2009; Mayor, 2008). In terms of major figures, Norman Bisset (1925−93), a former Professor of Pharmacognosy at King's College London, was the most important expert in the field of arrow poisons. Born in Glasgow (United Kingdom), Bisset had a lifelong interest in ethnopharmacology—the study of the use of natural substances as drugs in ethnic groups. He was also involved in the launch of the *Journal of Ethnopharmacology*. Much of the knowledge we have on this fascinating subject we owe to him.

From a societal point of view, throughout the world and within any group, there is typically a designated individual (e.g., shaman, group leader) who takes on the role of formulating poisons, usually in secret.

The variety of plants and animals used in the composition of poisons is huge.

Nevertheless, some plants have proven more popular than others, and the recipes have been handed down from generation to generation. *A. napellus* (Aconite, Monkshood), one of the most poisonous plants, is certainly one such. It contains alkaloids (aconitine, mesacotine, hypaconitine, and jesaconitine) having effects on the cardiovascular and respiratory systems (Haas, 1999; Bisset, 1972).

Usually the roots of the plant are dried in the sun, and pounded and mixed with water and other ingredients to form a thick consistency (Jones, 2009).

Exemplifying the famous Paracelsus dictum, "*dosis sola facit ut venenum non fit*" (only the dose permits something not to be poisonous), aconite, as many other toxic plants, also has pharmacological properties, and even today it is employed in homeopathy to treat anxiety and neuralgias, or cold and fever.

Antiaris toxicaria, the Upas tree (Ipoh in Javanese means "poison"), emits an extremely poisonous latex containing antiarine, a cardiac glycoside. This plant is used mostly in South-Eastern Asia to poison darts (Carter et al., 1997; Kopp et al., 1992; Shrestha et al., 1992).

In South America a variety of arrow poison recipes goes under the name of curare (derived from the Portuguese or Spanish and said to mean "he to whom it comes falls"). Usually curare is a mix of *Strychnos* genus plants containing curarine and turbocurarine (Bisset and Leeuwenberg, 1968; Geneviéve et al., 2004). The compound is very powerful and capable of killing an animal in a few minutes, but it only affects the blood, ensuring safety in ingesting the meat.

In Africa, many plants have been used to poison arrows. In a recent paper, Bradfield et al. (2015) collected recipes currently used by South-African Bushmen (San) hunter-gatherers. The larvae of a leaf beetle called *Diamphidia* are the main component of the mixtures, but toxic plants such as *Acokanthera, Adenium, Boophane, Euphorbia, Strophantus,* and *Swartzia madagascariensis* are also used.

Hundreds of plants have been used by hunters throughout the world to kill or weaken prey (Bisset, 1989). Furthermore, it should be noted that in poisonous preparations, while there is often a "primary source," other substances are usually added to thicken the mixture or provide ancillary properties, including magical ones.

1.3 WHAT IS THE CURRENT STATE OF RESEARCH?

The only study published to date on the use of arrow poisons among prehistoric populations concerns a wooden stick 32 cm long found in Border Cave, South Africa, and dated about 24,500 BP (d'Errico et al., 2012a,b).

The stick is similar to the poison applicators used until recently by Kalahari San populations. The results from gas chromatography analysis show traces of ricinoleic acid (castor oil, *Ricinus communis*).

The toxicity of this substance has been debated (Evans, 2012; d'Errico et al., 2012a,b); in fact although the ricin present in castor oil is indeed one of the most toxic substances in the world, this extreme potency tends only to be demonstrated with modern purification techniques; the lethal dose of castor oil is otherwise 2–15 beans, a quantity hardly compatible with an arrow. Moreover, the toxic effect appears only after several hours and causes gastroenteritis, perhaps not a first choice for an arrow poison.

There is no ethnographic evidence for the use of castor oil as an arrow poison (Bradfield et al., 2015), although castor beans have been found in more recent archeological excavations. The oil from the beans was used in facial cosmetics and in wick lamps for lighting (Al-Tamimi and Hegazi, 2008).

It is possible that in the stick analyzed by d'Errico et al., another component, more toxic, was not identified. In the same site a lump of organic material was found to contain traces of *Euphorbia tirucalli*; this can be more interesting, as *Euphorbia* is often mentioned in the ethnographic literature as an arrow poison (Bisset, 1989).

A project on the detection of plant poisons on prehistoric arrows was designed by Borgia et al. (2017); the aim of the project was twofold:

1. To form a database of the most toxic plants known in the scientific literature. Major attention has been given to plants that can be found in Europe, especially *A. napellus* (monkshood—Fig. 1.1), *Datura stramonium* (devil's snare), *Conium maculatum* (hemlock), *Veratrum album* (white veratrum), *Helleborus* (hellebore) and *Taxus* (Taxus). The purpose of this first phase was to gather current scientific data on those plants (ecology, chemical composition—using liquid chromatography/mass spectrometry—starch morphology) in order to compare the standards with the archeological (hopefully prehistoric) samples.
2. To use ethnographic samples to design more and more effective analytical methods, making use of the information gathered in the database.

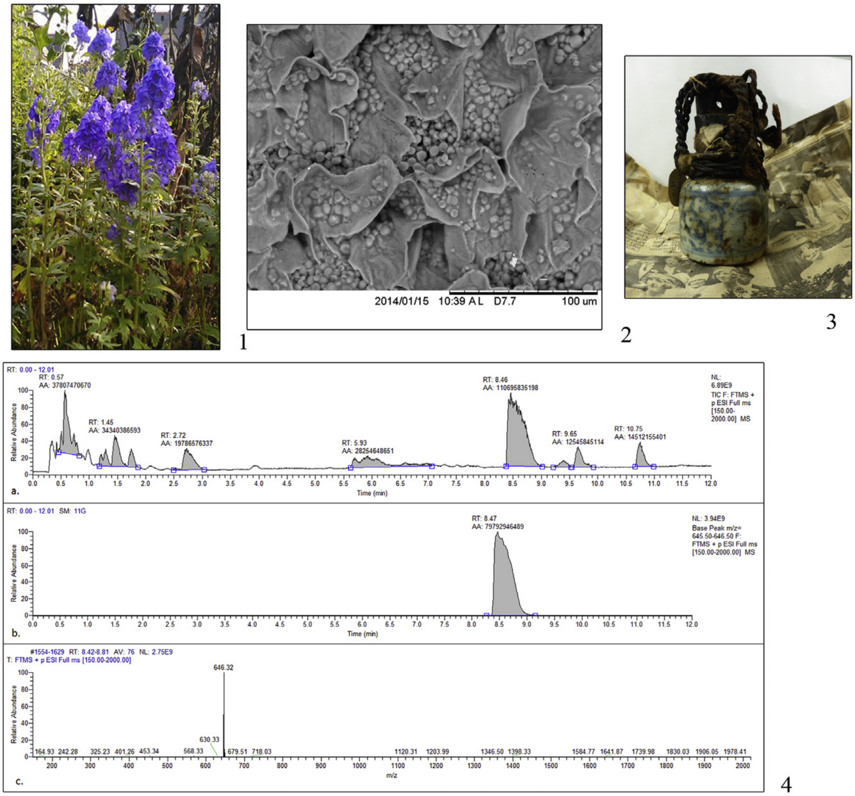

FIGURE 1.1 1—*Aconitum napellus* (monkshood); 2—Starches of the roots of the plant photographed at scanning electron microscope (photo V. Borgia); 3—Aconite pot from China at the Museum of Archaeology of Anthropology, University of Cambridge; 4—Mass spectrum for aconite.

A noninvasive method of sampling, consisting of rubbing the archeological material with cotton (imbued with distilled water), has been developed to comply with the constraints related to preserving the archeological materials, thus precluding the possibility of abundant samples.

The method provided positive results in the majority of the 20 analyzed samples (including poisoned arrows and darts, spatulae to apply arrow poison, and a container of poison between 50 and 100 years old—Fig. 1.2). It was fairly easy to detect the main components of the toxic plants within the samples. The origin of these samples, their geographic area, the kind of poisons usually used in the area, and in some instance the poison itself (e.g., a pot of aconite or curare) were known, thus making the overall results of the research preliminary.

FIGURE 1.2 Various poisoned weapons at the Museum of Archaeology and Anthropology, University of Cambridge, analyzed within the project of Borgia et al. (2016). 1—Spatula covered with poison from Malaysia; 2—Quiver with darts from Borneo; 3—Single barbed iron arrow from Malaysia; 4—spearhead from Samoa with label "Care has been poisoned"; 5—Spatula for poison and iron arrowheads for crossbow China. *Photo: R. Hand, Copyright Museum of Archaeology and Anthropology, Cambridge.*

The challenge for the future is to detect unknown substances and, ideally, to reconstruct the entire toxic compound, formed by one (or more) main ingredients and other additives.

A South-African team (Bradfield et al., 2015; Wooding et al., 2017) is working toward this result. In 2015, one of the most complete and valuable collections of arrow poison recipes of San hunter-gatherers and a large database of their biochemistry were published (Bradfield et al., 2015). This impressive collection makes it clear that even in a relatively small territory an incredible variety of plants and animals with toxic properties are known and adapted to various needs: "*For example, fowl cannot be hunted using coniine, as this toxin will contaminate the meat. In contrast, a mammal poisoned with coniine can be eaten, but the milk will be contaminated*" (Bradfield et al., 2015).

In an important recent pilot study (Wooding et al., 2017), the chemical characterization of poisons, by means of ultra-high performance liquid chromatography quadrupole time-of-flight mass spectrometry (UPLC−QTOF−MS), has been performed, working on three different levels:

1. Eleven well-known toxic plants used by the San living in the Kalahari desert have been characterized from a chemical point of view, contributing to a worldwide database.
2. One of the authors recreated a recipe used by Kalahari San to poison their arrows, containing *Acokanthera oppositifolia*, *E. tirucalli*, and *Adenium multiflorum;* the compound has been analyzed in a blind test.
3. An ancient (about 100 years old) poisoned arrow from Namibia has been analyzed to detect the poisonous substances on it.

The study highlighted the difficulty of unambiguously identifying particular substances. In fact, the same chemical compounds can occur in different plant species.

Nonetheless, the results have been encouraging. In a blind test, two of three toxic plants were identified, based on unique markers. The archeological sample (very small) provided chemical signatures, although not very clear. A marker on the extract was common to *Strychnos madagascariensis*, a species that is not present in the region, but the trace can also be related to *Akokanthera oppositifolia* and *Euphorbia virosa*.

1.4 CONCLUSIONS

The investigation into the use of poisons in prehistoric periods is an innovative field of research, which adds to our understanding not only of ancient hunting techniques and rituals, but also of how the plant world was understood and exploited by ancient populations.

The use of poisons to enhance a hunting weapon, in particular a composite system such as the spear/spearthrower or bow/arrow, is an important step from the point of view of cognitive evolution, as it implies a complex knowledge of the environment. Future works on ethnohistorical and archeological arrow poisons must necessarily be aimed at expanding the database of the biochemical fingerprints of the compounds, and in parallel to consider other analytical methods. This will be possible only within a network of scholars engaged in researching prehistoric hunting strategies from various points of view: archaeology, paleobotany, ethnography, chemistry, forensic toxicology, and ethnopharmacy.

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