THE PLAGUE OF CAERE (C. 535 BCE): AIRBORNE BOTULISM?

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ABSTRACT

An unusual "plague" that occurred in late 6th-century BCE Italy, at Caere – modern day Cerveteri, located approximately 50-60 kilometres north-northwest of Rome, may have been a rare instance of airborne botulism following an atrocity on the Etruscan seashore, to judge from highly specific details furnished in the surviving account by the historian Herodotus. We have revisited the information available and compared the documented symptoms with likely causes. The hypothetical diagnosis we suggest is that of airborne botulism. In conclusion, an examination of the symptoms and possible modes of transmission in this unique event merits further consideration in the light of modern discoveries of terrorist activities and possible consequences of large-scale human disasters.

Keywords: *Botulism; Airborne infection; Etruscan; Plague*

1. PRISONERS AND PLAGUES: HISTORICAL ACCOUNT OF A SUDDEN EPIDEMIC

War was known in the ancient world as a chief cause of sickness as well as traumatic death, and modern examples still abound. A single event that occurred during the 6th century BCE on the Tyrrhenian coast of Italy seems to have provoked a sudden and severe affliction among the population of the affluent Etruscan city of Caere (modern Cerveteri, north of Rome). The only disease that fits the description recorded by the great historian Herodotus is botulin intoxication – it appears that an atrocity committed by the civilian citizens of Caere inadvertently accomplished what modern terrorists have attempted and failed to produce (for the literary sources, some tangential, see Agus 2000; Gras 2000).

In short, the so-called plague occurred after the Etruscans and their allies the Carthaginians had won (or survived) a huge naval battle with interlopers in the Sardinian Sea, a group of colonists from East Greece (Phokaia in coastal Asia Minor) who had settled at Alalia (modern Aleria) in Corsica after escaping the Persian conquest of their land. The Phokaian settlers, short of agricultural land, had turned to piracy, and probably had raided shipping and the coastal towns of Etruria and Punic Sardinia. In the words of Herodotus of Halikarnassos (1.165-167.2)

"...the Tyrrhenians [Etruscans] and Carthaginians made a joint agreement against them, and sailed to attack them with sixty ships each. The Phokaians also manned their ships, sixty in number, and met the enemy in what is called the Sardinian Sea. They joined battle and the Phokaians won, but it was a sort of Kadmeian victory for them, for they lost forty of their ships, and the twenty that remained were unusable, as their rams had been twisted askew. Sailing back to Alalia, they picked up their children and wives and as many belongings as they could fit into the ships and leaving Corsica sailed to Rhegion [on the Straits of Messina].

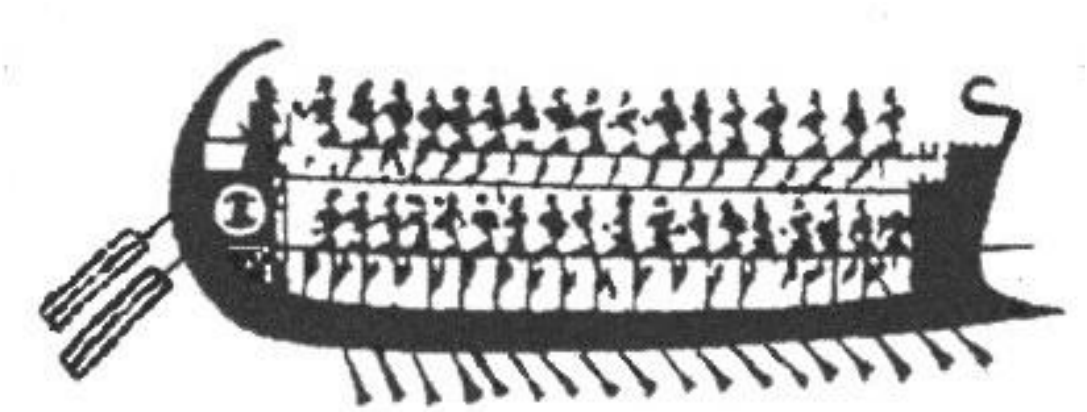
"The Carthaginians and Etruscans cast lots for the men [taken prisoner] from the destroyed ships, for they were more numerous than those who escaped. Of the Etruscans, it was the Caeretans [called Agyllaians after the Greek name for their city, Agylla] who brought them ashore, and stoned them to death. Afterward, all those approaching the area in which the dead Phokaians lay suffered a stroke or became twisted and paralyzed, sheep and draft animals just as much as men. The Caeretans sent a delegation to Delphi to learn how to expiate the offense. And so the Pythia [oracular priestess of Apollo] told them to do what the Agyllaians still do today: they make a great sacrifice and hold contests, both gymnastic and equestrian." (Herodotus 1.166-167.2, translation JMT).

While the exact site of the battle in the Sardinian Sea cannot be precisely known, the site of the atrocity and epidemic is clearly the seashore and port region serving the city of Caere (3-4 miles inland). In the aftermath, the Greek colonization movement was curtailed, as Alalia's settlers removed themselves to other Greek cities such as Marseille and Elea/Velia. There is an extensive literature on the battle and its ramifications, see: Bernardini 2001; Colonna 1989 and 2000; Gras 1997; Jehasse 1962 and Jehasse and Jehasse 1973, 2001 and 2004. The move to Rhegion (Reggio Calabria) implies their intent to continue in piracy, preying upon the traffic passing through the Straits of Messina. The effect on the Etruscan

captors of the Greek prisoners of war was to be even more profound. It is generally assumed that citizens walked out from the city of Caere to witness or participate in the massacre.

The site of the stoning must have been in the vicinity of the great sanctuaries of the port of Pyrgi, dedicated to Uni-Juno-Astarte and Śuri-Apollo. The area where the bodies were left must have been close enough to the main road and the port-towns, Pyrgi and Alsium, that people and flocks/herds could not simply avoid it in their seasonal or daily activities – otherwise no one would have approached closely enough to be stricken.

Herodotus says the captives were more numerous than the oarsmen who escaped with their mangled ships: since 40 Greek ships were lost, if they were all pentekonters (see Figure 1) – open long-ships carrying 50 oarsmen -- then as many as 2000 men could have been captured – although in battle undoubtedly scores or hundreds died, and the crews of naval vessels may not have been complete to begin with. But it would seem that hundreds could have been taken prisoner only to be stoned by as many Caeretans.



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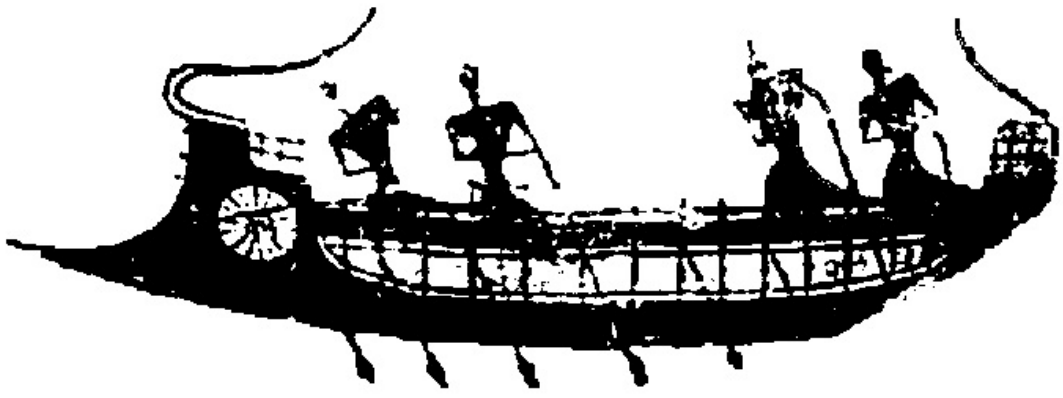

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Figure 1. An artist's version of an early pentekonter. a fore-runner of the bireme and trireme. Pentekonters emerged at a time when there was no clear distinction between merchant vessels and war ships. Pentekonters were very versatile and had a long-range, so they could be used for sea trade, piracy and warfare. They had sails, but as their name suggests, (Pentekonter - *trans.* fifty oared) these

vessels were rowed by fifty oarsmen, arranged in two rows of twenty-five on each side of the ship. You can clearly see the ram that was used to engage other vessels at the prow of the drawings (Upper (A): re-drawn (AH) after a depicted ship on an 8th-century BCE bowl from Thebes shown in McGrail (2002) pg. 128; Lower (B): re-drawn (AH) after a depicted ship on an 8th-century BCE krater found at the ancient cemetery of Dipylon, near the Dipylon Gate at Kerameikos (northwest of the Acropolis) in Athens, and acquired by the Louvre in 1884 - FR 513.2010).

1. IDENTIFICATION OF THE DISEASE

The account describes the local people and their livestock as stricken by a very unusual infection or intoxication that affected multiple species, "equally sheep, draft animals and men" – which constitutes internal evidence, if we believe Herodotus at all, that this is not a case of hysterical paralysis among guilt-stricken men, since sheep and oxen would not have been susceptible to suggestion.

Ancient Italy was prone to a number of zoonoses, such as cutaneous (rather than lethal) anthrax, and Brucellosis (as experienced by Napoleon and others who drank unpasteurized goats-milk - See Turfa 2012, 190, 193). The discovery of a Bronze Age Pompeii, in the site of Nola-Croce del Papa, where, ca. 1800 BCE, Vesuvius covered a village, has revealed humans living in close proximity to their farm animals, and in conditions that were highly unsanitary according to modern standards (see Turfa 2012, 156-158 with references. Prehistoric Nola-Croce del Papa: Mastrolorenzo et al. 2006; Albore Livadie and Vecchio 2005; Albore Livadie 2002). The problem with equating the "Caeretan plague" with any of the significant zoonoses lies in the neurological symptoms in which victims "would suffer strokes and become twisted and crippled" (Purvis 2009, 92). What sort of pathogens could have infected a passerby and fairly soon thereafter have caused paralysis? A number of other serious diseases, like poliomyelitis, were present in the ancient environment and could have produced some of the symptoms (Aufderheide and Rodríguez-Martín 1998, 212), but the Herodotean set of symptoms, coupled with the apparently airborne mode of delivery, precludes most candidates (cf. Dembek et al. 2007, 126). Various poisons have severe effects but are not aerosols (see, recently, Mayor 2010). Botulism and tetanus (which are not zoonotic) will cause paralysis or similar neurological problems, and tetanus toxin, also present in soil, is similar to botulism toxin, but its most striking symptom is muscle spasm such as lockjaw: the proprioception signals (feedback) from muscles to the central nervous system become lost, and the motor cortex over-compensates by contracting the muscles for prolonged periods of time. Further, the effects of tetanus toxin could only be observed 7 to 21 days after infection with *C. tetani*, so in the minds of observers, any connection with exposure to the corpses would be more tenuous (Reddy and Bleck 2009; Rossetto et al. 2011).

Some diseases cause some subset, but not all, of the symptoms recounted by Herodotus. Only one fits the complete profile. One disease that fits some of the symptoms mentioned by Herodotus is GBS - Guillain-Barré syndrome. This is a disease with many subtypes, one of which presents with acute motor axonal neuropathy (Rajabally et al. 2014). Typically, subjects show signs of symmetrical weakness that usually affects the lower limbs first, and rapidly progresses in an ascending fashion

(Yadegari et al. 2014). As the weakness progresses upward, usually over a period of hours to days, the arms and facial muscles also become affected and subjects often experience respiratory difficulties as the paralysis worsens. This disease matches the paralysis aspect that Herodotus describes, and an outbreak in northern China, which was thought to follow *Campylobacter jejuni* infection, proved to be seasonally (summer) related (Blaser et al. 1991). However, GBS would not be expected to induce twisting – quite the reverse in fact, nor to the best of these authors knowledge would it be transmitted to, or affect animals as Herodotus states.

The symptoms of botulism are the only set that accord with the ancient description of this shocking event. There are seven distinct forms of botulinum toxin, types A–G and four of these (types A, B, E and rarely F) cause human botulism (Hambleton, 1992). Types C, D and E cause illness in other mammals, birds and fish. Botulism toxin E is therefore most likely to have been responsible for the plague at Caere, as this is the only one to affect both humans and animals alike (Hambleton, 1992). Botulinum toxins are ingested through improperly processed food in which the bacteria or the spores survive and subsequently produce toxins. Though mainly a food derived form of intoxication, botulism can also be caused by intestinal infection in infants, wound infections, and by inhalation (Hambleton, 1992; Wang et al. 2014; Sugiyama et al. 1986).

3. SYMPTOMS AND TRANSMISSION OF BOTULISM

The literary evidence seems to closely fit a description of botulism, today commonly viewed as a form of food poisoning, but currently under study for the possibilities of its airborne use in bioterrorism (see Dembek et al. 2007; Greenfield et al. 2002. Smith and Sugiyama 1988, 3-4). However, note that there are sparse data on the disease for antiquity, one of the few proposed instances being 2 *Chronicles* 32:21, in which soldiers and officers of the army of Sennacherib besieging Jerusalem in 701 BCE were annihilated, causing the campaign to be curtailed, but botulism here seems unlikely. Some Byzantine regulations on foodstuffs could reflect an attempt to deal with almost any sort of food poisoning.

The affliction has been detected in many animal species as well as humans. It does not occur directly through infection by the anaerobic bacteria, *Clostridium botulinum,* but rather through intoxication, exposure to the strong neurotoxins it produces. Three main routes are well known: ingestion of toxic foodstuffs (poorly preserved produce, meat or dairy products that allow growth of the bacteria), infection of wounds, or, in infants, colonization of the digestive tract. Today, iatrogenic cases can occur with the improper commercial use or handling of the toxin, Botox, for cosmetic purposes (for basic information on Botulism, symptoms, etc. see Yu et al. 2009; Penn 2010; Dembek et al. 2007; Poulin et al. 2006; Sobel 2005; Greenfield et al. 2002; Maselli 1998; Aufderheide and Rodríguez-Martín 1998, 184; Smith and Sugiyama 1988; Barker 1993).

The airborne version seems rare in today's world: the only well documented case involved laboratory workers handling the bodies of experimental victims, rabbits and guinea pigs, that had been injected with toxins (Holzer 1962); one attempted aerosol spraying of botulin toxin by a terrorist group failed (Greenfield et al. 2002; Park and Simpson 2003). The

disease must have occurred in past eras, but it was only officially described in the late 18th century, when an outbreak was traced to poorly preserved sausage (Latin *botulus*): anaerobic conditions, and drying, pickling or canning with too little salt or heat, are conducive to survival of the bacteria, which grow best around 40 degrees C. They cannot survive in an acid environment (pH <4.6), and must be heated above boiling temperature to be killed, so modern processing and hygiene have greatly changed the picture (Yu et al. 2009).

The various species of *Clostridium botulinum* produce at least 7 strains of toxin, considered the most lethal and dangerous naturally occurring poisons in the world. They affect vertebrates, some species more than others, and especially birds and mammals, but also turtles and some fish (Poulain et al. 2006; Barker 1993; Smith and Sugiyama 1988, 135-164; Maselli 1998, 122-123). The *Clostridia* toxins, of whatever source, seem to produce the same panel of symptoms, attacking the nervous system, targeting neurons and acting on the release of neurotransmitters (see Poulain et al. 2006, 352-376). The toxin prevents transmission of signals in the nerves.

Symptoms of the intoxication could be mistaken for stroke: they begin at the cranial nerves, with slackening of facial muscles, drooling, slurred speech, drooping eyelids, etc., and extend to the limbs; muscle weakness spreads to shoulders, then arms, then legs, and ends with paralysis. In some cases, the paralysis causes breathing to stop and death is inevitable. Modern treatment includes administering antitoxin, and sustaining breathing with a ventilator; with care for complications such as dehydration and constipation, a high proportion of those afflicted can survive, albeit with a long period of recuperation, but supportive therapy would not have been possible in antiquity, and a significant number of sufferers would have died. Animals such as sheep, cattle or horses would be lost to breathing problems that today are dealt with by slings and special bedding (see Wilkins 2007).

The bacteria are ubiquitous, occurring in soil as spores, which are often found in hay that is eaten by animals, or in a decomposing animal body, which also often goes unnoticed in stored fodder or may be consumed by sheep or other animals. Indeed, modern fur farms are responsible for some botulism outbreaks as they feed raw fish or meat to mink, foxes or ferrets. A sheep, cow or horse ingests spores and/or toxin while grazing; spores can germinate in the intestinal tract or in anaerobic conditions in wounds, at temperatures between 15 and 45 degrees C (59-113 F). It is suggested that other cases in animals originate from spores or toxin carried by birds from places where carcasses of large animals such as horses have been buried or dumped (Wilkins 2007, 372 with references).

4. EXPOSURE OF THE CAERETANS

The documented ubiquity of spores today contrasts with a relatively low rate of infection/intoxication – except for man-made cases like contaminated food, victims seem to be infants or trauma cases, not just everyday passers-by. So it has been speculated that some factors of the potential human hosts make intoxication less likely for some (Yu et al. 2009, 167). Likewise, botulism seems to be more prevalent in certain regions or certain flocks/herds than elsewhere, for instance, sheep/cattle in Australia or South Africa (see Wilkins 2007, 372; Maselli 1998, 124; Barker 1993, 624). It has been suggested

that mineral deficiencies in soils in certain regions stimulate the condition of *pica*, causing animals to turn to eating carcasses or bones (cf. Riet-Correa et al. 2012; Smith and Sugiyama 1988, 135-144). Such behaviors, in the warm summertime climate on the Tyrrhenian coast, might have begun the infection, and then the winds and the sheer numbers of exposed human corpses producing large amounts of bacteria and toxins might account for their spread, over short distances, by sea breezes. *C. botulinum* bacteria have been identified in coastal marine sediments and sandy soils in many parts of the world, and have been associated with fish, so the seaside location of the stoned and abandoned bodies could have been a continuing source of contamination (Smith and Sugiyama 1988, 14-15 and *passim* 11-21).

Symptoms seem to develop in proportion to the amounts of toxin or bacteria taken in: the incubation period appears to be shorter and the symptoms more severe when toxin levels are higher (Yu et al. 2009, 167). The climate of the central Mediterranean in the 6th century BCE was similar to today's, and could easily have supported the sprouting of spores; anaerobic conditions in the abandoned corpses could have supported growth and production of toxin. The level of infection and severity of symptoms would be proportional to how closely victims approached the site, how long they remained there, and the status of their individual immune systems. Grazing flocks or herds would have ingested appreciable amounts of bacteria or toxin. Shepherds, say, pasturing several dozen sheep, might have remained at a site all day, seated on the ground or within range of a sea breeze; those Etruscans found regularly at the shore, such as seamen or peasants, might have had poorer nutrition, thus potentially weaker immune systems, than more affluent, urban citizens. Modern studies of horses and other animals, and clinical observations of humans, found that symptoms could begin within 6 hours to several days (up to 10 days) of exposure; the period for wound botulism is usually from 4 to 14 days (Yu et al. 2009, 167; Smith and Sugiyama 1988, 121). The only data on inhalation botulism note that classic symptoms, including paralysis, become evident on the third day (Holzer 1962; Park and Simpson 2003). With modern medical care (in cases of contaminated food), mortality rates are relatively low, but various authors speculate that without use of antitoxin, mechanical means of ventilation, and intensive care for additional problems like dehydration, 50-60% of victims would surely have died (cf. Sobel 2005, 1171). Even the modern recovery period lasts weeks to months.

4. SOURCES OF *CLOSTRIDIA* SPORES

It would seem possible – although a very unusual occurrence – that ubiquitous *Clostridia* spores or toxins were present in the wounded bodies of some of the prisoners who were stoned to death and left to decompose on the shore, and that in the weather of summer (the chosen time for wars, battles and seafaring in the ancient Mediterranean) spores could easily grow and more toxin be produced.

Herodotus mentions that the Phokaians sailed to Corsica as colonists with their wives and children (and fled with their families after the battle), which raises the question as to whether they brought the disease with them? It is quite possible that the Phokaians travelled with botulinum spores in their boats and only infected themselves once wounded. Wound related botulism is rare and only occurs

when botulinum spores gain access to the body through an open wound (Hambleton, 1992), subsequently reproducing in an anaerobic environment – typically a deep wound or cut. The symptoms are similar to those of food-derived botulism.

If we follow the line of thought that the Phokaians might have brought the botulinum spores with them, then a likely source, bearing in mind the fact that they were travelling with their wives and children, could be infant botulism. Although there are several possible sources of infection for infant botulism, spore-contaminated honey has been associated with a number of cases (Arnon et al. 1979). Parents are therefore warned not to feed honey to infants before the age of one year.

Greek culture, from the Late Bronze Age through the Hippokratic corpus and Roman-era medical authors like Soranus, associated honey with birth and babies and recommended feeding it to newborns (sources in Giuman 2008: 73-78). Assuming therefore that they travelled with *C. botulinum* spore infected honey, and that this was fed to infants which subsequently infected the boat through their fecal matter (Midura & Arnon, 1976), the Phokaians could then have easily infected themselves during the battle and the spores could have reproduced anaerobically in any deep wounds or cuts.

An alternative source of *Clostridium botulinum* type E, which still poses a real threat even today, is through the consumption of infected fish and fishery products (Hyytiä et al. 1998). Huss and Pedersen (1979) reported a considerably higher prevalence of type E in bottom-feeding fish species as compared to plankton-feeders, and concluded that the sea bed was the primary source of contamination. Thus the sea-faring Phokaians could have become infected through the consumption of infected bottom-feeding fish, caught as they lay off shore prior to the sea battle with the Etruscans.

6. AIRBORNE TRANSMISSION OF TOXINS

The one confusing issue is the means of delivery: airborne transmission is possible, although not at all common. Recent literature attests to governmental concerns over use of the toxins as bioterrorist weapons, but to date no instances have been documented (a Japanese group claimed to be attempting aerosol delivery of botulism, but failed, and no botulin toxins could be identified in their equipment) (Yu et al. 2009, 172; Dembek et al. 2007, 123; Greenfield et al. 2002). Perhaps the combination of some source of bacteria (a wounded captive or a dead, beached sea-creature?), augmented with large numbers of bodies heaped together, the summer weather and sea breezes, and the observation of the infection or intoxication of a group noticed in the vicinity, could have concatenated into the "plague" that terrified the guilty Caeretans. Its sudden onset and the shocking severity of its lethal symptoms would have seemed like a blow from the gods.

Since it is known that airborne transmission of botulism is possible, albeit not at all common, the warning given by the World Health Organization (WHO) concerning inhalation of botulinum toxin should be seen as a very sensible precaution. The WHO advises that "..in order to minimize the risk of inhalation of botulinum toxin, which is a protein, individuals should remove any exposed items of clothing worn by aerosol infected individuals prior to washing them with soap and water.." (WHO, 2013). Such recommendations with regard to airborne

spores of the toxin make one wonder if the spread of this disease in Caere was perhaps *via* the fur of infected animals if the Etruscans were sharing the same air space with their livestock at night? Indeed, one study has proven that *Clostridium botulism* is capable of infecting individuals by means of airborne transmission (Sugiyama et al. 1986). Furthermore, these authors cite the work of Long and colleagues (1985), who report that *C. botulinum* is air-disseminated from its soil /faecal habitats, and that the spores of this toxin can be brought into a home carried on clothes.

Whilst botulism toxin inhalation presents with a very similar clinical footprint to that of food derived botulism (WHO, 2013), the average lethal dose for humans has been estimated at two nanograms of botulinum toxin per kilogram bodyweight, which is a level approximately three times greater than that known to cause food derived cases. Thus for an average size human weighing 70 kg, some 140 ng of botulinum toxin would need to be inhaled. Following toxin inhalation, symptoms become visible within 1–3 days, although a longer onset time is found with lower levels of intoxication. Symptoms proceed in a similar manner to those found with ingestion of botulinum toxin, and culminate in muscular paralysis and respiratory failure (WHO, 2013).

7. ETRUSCAN FUNERARY RITUALS AND THE LIKELIHOOD OF TRANSMISSION OF TOXINS OR SPORES

Larissa Bonfante (2012) has suggested that some incidents of human sacrifice or ritual killing probably reflected native Etruscan rituals for appeasing or assisting the deceased, in a belief system that was misunderstood by Greek observers. The idea of rituals for the benefit of the dead (in this case, perhaps family members lost in the sea battle or prior raids by the Phokaians) might help to explain the unusual aerosol transmission of the toxins. Perhaps those who stoned the prisoners were perceived as offering them to the spirits of the Etruscan dead, with exposure to their blood a part of the ritual. Wounds from battle or from the laming and stoning of the prisoners would have enabled botulism spores to grow, as in the one proven incident of airborne intoxication (Holzer 1962), where technicians were apparently careless in handling fluids and body parts.

The Etruscans were famed for their ability to perform a ritual for the creation or support of human dead as the *dii animales,* the ”spirits made into gods,” but few details are preserved beyond the account of the late 3rd-century Christian apologist Arnobius (*Adversus nationes* 2.62) that it required the killing of an animal victim, and the use of living blood. (On blood-shedding ritual, see also Swaddling and Woodford 2014, 23 with note 6.) This probably involved the handling of small animals, to judge from a few finds of fragmentary bone from young mammals (perhaps piglet, puppy or lamb) cremated with a human corpse and then partially gathered and buried in the urn (for instance, two examples from 7th-century BCE Narce, and two from 6th- century Chiusi are preserved in the University of Pennsylvania Museum) (Becker et al. 2009, 104-108 - for “normal” animal sacrifice, see Donati and Rafanelli 2004). Portions of sheep/goat, pig, cattle, dogs, horse and tortoise sacrificed in the early 7th-century BCE were displayed at the Via San Jacopo tumulus in the necropolis of the city of Pisa; these also attest prolonged ritual handling and exposure to (animal) sacrificial victims (Sorrentino 2004).

Imagery of animals preying on humans and related themes of bloodshed appear in Etruscan art from the Archaic period onward (see Warden 2009). Sporadic circumstantial evidence suggests some familiarity with earlier traditions of human sacrifice in Iron Age Italy: a wounded sword-fighter apparently dispatched later, in ritual fashion, at mid-8th-century BCE Tarquinia (and other possible killings there – Bonghi Jovino, Malegni and Usai 1997) and painted tombs with scenes of bloodletting such as the Tomb of the Augurs at Tarquinia (Steingräber 1986, pl. 20), painted around the same time as the Caere massacre and plague. If Bernardini (1999) is correct in suggesting as the site of the stoning and abandonment of the bodies, Montetosto, where a large building was erected about this time (Bernardini 1999), perhaps for staging the historical funerary games, it would mean that prisoners were marched a mile or two from the shore into the Caeretan necropolis, and thus imply a deliberate funerary ritual.

The application of such rituals to human victims under special conditions, such as the extermination of pirates, or the aftermath of a major battle with foreign enemies, might not be such a great leap, given the legendary images used in later tombs such as the François Tomb of Vulci (c. 350 BCE) for instance, where murals depict Achilles' throat-cutting sacrifice of Trojan captives after they have been deliberately weakened by bleeding leg wounds (Steingräber 1986, pl. 183; see Bonfante 2012 for full treatment).

Humans have long associated war with the spread of disease, as seen in Near Eastern divination texts and in the Etruscan *Brontoscopic Calendar* (Turfa 2012, 191-203). The Trojan War legends included plagues sent by the Olympian gods, as at *Iliad* 1.8-26, 1.33-108, when Apollo sends a "bad disease" which fells the Greeks' mules and swift dogs, and then strikes the warriors. Such plagues end only when atonement is accepted by the gods. In fact, when the Caeretans obeyed the Delphic oracle and buried the bodies, the "plague" ended. Certainly the burial of the mangled corpses would have done much to remove the danger, even if burial workers suffered exposure to contamination. The Montetosto site seems to have been used for producing the annual athletic and equestrian games of expiation, but no mass grave has been identified, and it may never be possible to prove a diagnosis of airborne botulism, this seems the only complete explanation of this startling phenomenon.

8. CONCLUSIONS

If the plague of Caere is an example of airborne transmission of botulism toxins, then the conditions noted in the ancient historical account, warm weather, seashore conditions, wounded humans and exposed, decomposing bodies in proximity to grazing livestock, bear further scrutiny, in the interests of preparedness for future problems whether iatrogenic or related to cosmetic practices, or as the result of terrorism.

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REFERENCES

Agus, A. (2000). "Le Fonti della Battaglia del Mare Sardonio." In *Μαχη. La battaglia del Mare Sardonio. Studi e ricerche,* edited by P. Bernardini, P.G. Spanu, R. Zucca, 219-246. Cinisello Balsamo: Edizioni La Memoria Storica-Mythos.

Albore Livadie, C. (2002). "A First Pompeii: the Early Bronze Age village of Nola-Croce del Papa (Palma Campania phase)," *Antiquity 76*, 941-942.

Albore Livadie, C., & Vecchio, G. (2005). "Un Villaggio del Bronzo Antico a Nola-Croce del Papa (Campania)," in P. Attema, A. Nijboer and A. Zifferero, eds., *Papers in Italian Archaeology VI. Communities and Settlements from the Neolithic to the Early Medieval Period (Proceedings of the Sixth Conference of Italian Archaeology held at the University of Groningen, Groningen Institute of Archaeology, The Netherlands, April 15-17, 2003* = BAR Int. Ser. 1452[II]), vol. II. Oxford: Archaeopress: 581-587.

Arnon, S.S., Midura, T.F., Damus, K., Thompson, B., Wood, R.M. & Chin, J. (1979). Honey and other environmental risk factors for infant botulism. *The Journal of Pediatrics 94*, 331-336.

Aufderheide, A.C., & Rodríguez-Martín, C. (1998). *The Cambridge Encyclopedia of Human Paleopathology*. Cambridge: Cambridge University Press.

Barker, W.H. (1993). "VIII.19. Botulism." In *Cambridge World History of Human Disease*, edited by K.F. Kiple, 623-625. Cambridge, Cambridge University Press.

Becker, M.J., Turfa, J.M., & Algee-Hewitt, B. (2009). *Human Remains from Etruscan and Italic Tomb Groups in the University of Pennsylvania Museum (Biblioteca di Studi Etruschi* 48). Pisa, Rome: Istituto di Studi Etruschi ed Italici, Fabrizio Serra Editore.

Bernardini, P. (1999). "Il santuario di Montetosto." In *Μαχη. La battaglia del Mare Sardonio. Catalogo della mostra,* edited by P. Bernardini, P.G. Spanu, R. Zucca, 51-52. Cagliari-Oristano: Edizioni La Memoria Storica-Mythos.

Bernardini, P. (2001). "La battaglia del Mare Sardo: una rilettura." *RStFen 29,* 135-158.

Blaser, M.J., Olivares, A., Taylor, D.N., Cornblath, D.R., & McKhann, G.M. (1991). Campylobacter serology in patients with Chinese paralytic syndrome. *The Lancet 338*, 308.

Bonfante, L. (2012). "Human Sacrifice. Etruscan Rituals for Death and Life." In *Interpretando l'Antico. Scritti di archeologia offerti a Maria Bonghi Jovino*, edited by C. Chiaramonte Treré and G. Bagnasco Gianni, 67-82. Milan.

Bonghi Jovino, M., Malegni, F., & Usai, L. (1997). "Una morte violenta. Sul rinvenimento di uno scheletro nell'area del 'complesso sacro-istituzionale' della Civita di Tarquinia," in *Aspetti della cultura di Volterra etrusca fra l'eta del ferro e l'età ellenistica, Atti del XIX Convegno di Studi Etruschi ed Italici (Volterra 1995)* Florence: Istituto di Studi Etruschi, 489-498.

Colonna, G. (1989). "Nuove prospettive sulla storia etrusca tra Alalia

e Cuma." In *Atti del Secondo Congresso Internazionale Etrusco (Firenze 1985)*, 361-374. Rome: Leo S. Olschki Editore.

Colonna, G. (2000). "I *Tyrrhenói* e la battaglia del Mare Sardonio." In *Μαχη. La battaglia del Mare Sardonio. Studi e ricerche,* edited by P. Bernardini, P.G. Spanu, R. Zucca, 47-56. Cinisello Balsamo: Edizioni La Memoria Storica-Mythos.

Dembek, Z.F., Smith, L.A., & Rusnak, J.M. (2007). "Botulism: Cause, Effects, Diagnosis, Clinical and Laboratory Identification, and Treatment Modalities." *Disaster Medicine and Public Health Preparedness 1.2,* 122-134.

Donati, L., & Rafanelli, S. (2004). "Il sacrificio nel mondo etrusco." In *Thesaurus Cultus et Rituum Antiquorum (ThesCRA)* vol. I, 135-182. Los Angeles: Getty Publications.

Giuman, M. (2008). *Melissa. Archeologia delle api e del miele nella Grecia antica.* Rome: G. Bretschneider.

Gras, M. (1997). "L'Occidente e i suoi conflitti." In *I Greci: storia, cultura, arte e società. 2. Una storia greca. II. Definizione*, edited by S. Settis, 61-85. Torino : Einaudi.

Gras, M. (2000). "La battaglia del Mare Sardonio." In *Μαχη. La battaglia del Mare Sardonio. Studi e ricerche,* edited by P. Bernardini, P.G. Spanu, R. Zucca, 37-46. Cinisello Balsamo: Edizioni La Memoria Storica-Mythos.

Greenfield, R.A., Brown, B.R., Hutchins, J.B., Iandolo, J.J., Jackson, R., Slater, L.N., & Bronze, M.S. (2002). **"**Microbiological, Biological, and Chemical Weapons of Warfare and Terrorism.**"** *American Journal of the Medical Sciences 323.6* (June 2002), 326-340.

Hambleton, P. (1992). *Clostridium botulinum* toxins: a general review of involvement in disease, structure, mode of action and preparation for clinical use. *Journal of Neurology 239*, 16-20.

Holzer, E. (1962). **"**Botulismus durch Inhalation.**"** *Medizinische Klinik* 57, 1735-1738.

Huss, H.H., & Pedersen, A. (1979). *Clostridium botulinum* in fish. *Nord Vet-Med. 31*, 214-221.

Hyytiä, E., Hielm, S., & Korkeala, H. (1998). Prevalence of Clostridium botulinum type E in Finnish fish and fishery products. *Epidemiol Infect 120*, 245-250.

Jehasse, J. (1962). "La 'victoire à la cadméenne' d'Hérodote (I, 166) et la Corse dans les courants d'expansion grecque." *RÉA* 1962, 241-286.

Jehasse, J., & Jehasse, L. (1973). *La nécropole préromaine d'Aléria (1960-1968) avec une étude des graffites par Jacques Heurgon, Gallia* XXV^{e} suppl. Paris.

Jehasse, J., & Jehasse, L. (2001). *Aléria. Nouvelles données de la nécropole*, Travaux de la Maison de l'Orient méditerranéen 34. Lyon : Maison de l'Orient méditerranéen.

Jehasse, J., & Jehasse, L. (2004). *Aleria métropole. Les remparts*

préromains et l'urbanisation romaine. Ajaccio : Éd. du "Journal de la Corse."

Long, S.S., Gajewski, J.L., Brown, L.W., & Gilligan, P.H. (1985). Clinical, laboratory, and environmental features of infant botulism in southeastern Pennsylvania. *Pediatrics 75*, 935-941.

McGrail, S. (2002). *Boats of the World – From the Stone Age to Medieval Times*. Oxford University Press, January 2002, ISBN 978-0-19-814468-7.

Maselli, R.A. (1998). "Pathogenesis of Human Botulism." *Annals of the New York Academy of Sciences 841.1*, 122-139.

Mastrolorenzo, G., Petrone, P., Pappalardo, L., & Sheridan, M.F. (2006). "The Avellino 3780-yr-B.P. catastrophe as a worst-case scenario for a future eruption of Vesuvius," *Proceedings of the National Academy of Sciences 103.12* (March 21, 2006), 4366-4370.

Mayor, A. (2010). "The Deadly Styx River and the Death of Alexander." Princeton/Stanford Working Papers in Classics, September 2010 = www.stanford.edu/dept/HPST/MayorStyx12.pdf (consulted 12/7/2012).

Midura, T.F., & Arnon, S.S. (1976). Infant botulism: Identification of Clostridium botulinum and its toxins in faeces. *The Lancet Oct 30*, 934-936.

Park, J.-B., & Simpson, L.L. (2003). "Inhalational Poisoning by Botulinum Toxin and Inhalation Vaccination with its Heavy-Chain Component." *Infection and Immunity 71.3* (March 2003), 1147-1154.

Penn, A.S. (2010). "Chap. 138. Botulism and antibiotic-indiced neuromuscular disorders." In *Merritt's Neurology*, 12th ed., edited by L.P. Rowland, T.A. Pedley and H.H. Merritt, 853-854. Philadelphia: Lippincott/Wolters Kluwer.

Poulain, B., Stiles, B.G., Popoff, M.R., & Molgo, J. (2006). "Chap. 19. Attack of the nervous system by clostridial toxins: physical findings, cellular and molecular actions." In *The Comprehensive Sourcebook of Bacterial Protein Toxins*, edited by J.E. Alouf and M.R. Popoff, 348-389. Amsterdam: Elsevier Academic Press.

Purvis, A.L. (trans.) (2009). *The Landmark Herodotus, The Histories*, edited by R.B. Strassler, New York: Anchor (original edition 2007).

Rajabally, Y.A., Durand, M-C., Mitchell, J., Orlikowski, D., & Nicolas, G. (2014). Electrophysiological diagnosis of Guillain-Barré syndrome subtype: could a single study suffice? *J Neurol Neurosurg Psychiatry* – doi: 10.1136/jnnp-2014-307815.

Reddy, P., & Bleck, T.P. (2009). "*Clostridium tetani* (Tetanus)." In *Mandell, Douglas, and Bennett's Principles and Practice of Infectious Diseases*, 7th ed., edited by G.L. Mandell, J.E. Bennett and R. Dolan, chap 244. Orlando, FL: Saunders Elsevier; 2009. See also PubMedHealth (National Library of Medicine = www.ncbi.nlm.nih.gov/pubmedhealth/PMH0001640 (consulted 12/10/2012).

Riet-Correa, F., Medeiros, R.M.T., Tokarnia, C.H., de Carvalho, C.J.S.,

Franklin, F.L.A.S., Dias, A.C.S., Ferreira, R.M.M., & Silva, S.M.M.S. (2012). "Botulism by *Clostridium botulinum* type C in goats associated with osteophagia." *Small Ruminant Research 106*, 201-205.

Rossetto, O., Pirazzini, M., Bolognese, P., Rigoni, M., & Montecucco, C. (2011). "An Update on the Mechanism of Action of Tetanus and Botulinum Neurotoxins." *Acta Chimica Slovenica 58.4*, 702-707.

Smith, L.DS., & Sugiyama, H. (1988). *Botulism. The Organism, Its Toxins, The Disease*, 2nd ed. Springfield, IL: Charles C. Thomas.

Sobel, J. (2005). "Botulism." *Clinical Infectious Diseases 41*, 1167-1173.

Sorrentino, C. (2004). "Il materiale osteologico animale del tumulo di via San Jacopo." In *Archaeologica Pisana. Scritti per Orlando Pancrazi, edited by* S. Bruni, T. Caruso and M. Massa, 366-369. Pisa: Giardini Editori.

Steingräber, S. (1986). *Etruscan Painting. Catalogue Raisonné of Etruscan Wall Paintings* (eds. D. Ridgway and F. R. Serra Ridgway). New York: Harcourt, Brace Jovanovich.

Sugiyama, H., Prather, J.L., & Woller, M.J. (1986). Lyophilized airborne *Clostridium botulinum* spores as inocula that intestinally colonize antimicrobially pretreated adult mice. *Infection and Immunity 54*, 260-261.

Swaddling, J. and S.Woodford (2014). "Lokrian Ajax and the new face of Troilos: the Troilos mirror in the British Museum," *Mediterranea* 11, 11-26.

Turfa, J.M. (2012). *Divining the Etruscan World. The Brontoscopic Calendar and Religious Practice.* Cambridge: University of Cambridge Press.

Wang, J.F., Mao, X.Y., & Zhao, C. (2014). The changes of serum proteome and tissular pathology in mouse induced by botulinum toxin E injection. *Mol Biol Rep 41*, 2509-2519.

Warden, P.G. (2009). "The Blood of Animals. Predation and Transformation in Etruscan Funerary Representation." In *New Perspectives on Etruria and Early Rome: In Honor of Richard Daniel De Puma,* edited by S. Bell and H. Nagy, 198-219. Madison WI: University of Wisconsin Press.

WHO – Fact Sheet No. 270. Botulism. Updated August 2013 www.who.int/mediacentre/factsheets/

Wilkins, P.A. (2007). "Chap. 46. Botulism." In *Equine Infectious Diseases*, edited by D.C. Sellon and M.T. Long, 372-376. St. Louis, MO: Saunders/Elsevier.

Yadegari, S., Kazemi, N., & Nafissi, S. (2014). Clinical and electrophysiological features of Gullain-Barré syndrome in Iran. *J Clin Neuroscience* – dx.doi.org/10.1016/j.jocn.2013.11.041.

Yu, P.A., Maslanka, S.E., St.Louis, M.E., & Swerdlow, D.L. (2009). "Chap. 7. Botulism." In *Bacterial Infections of Humans: Epidemiology and Control*, edited by P.S. Brachman and E. Abrutyn, 159-176. New York: Springer.

