# Sagas of the Solanaceae: Speculative ethnobotanical perspectives on the Norse berserkers

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# Sagas of the Solanaceae: Speculative ethnobotanical perspectives on the Norse berserkers

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ABSTRACT

*Ethnopharmacological relevance:* The Norse berserkers were wild warriors of Scandinavia known to enter a trance-like state that allowed them to fight with increased strength and a rage that granted them immunity to many forms of harm in battle. Though many theories have been advanced as to the cause of this state, the most widely believed is that the intoxicating mushroom *Amanita muscaria* was used.
*Aim of the study:* The following article underlines the issues with this theory and provides an alternate intoxicant that fits with the reports of berserker behaviour much better: *Hyoscyamus niger*.
*Materials and methods:* Literature from a variety of disciplines pertaining to history, toxicology, pharmacology, and botany was compiled to frame and support the argument.
*Results: H. niger* proved to be a more likely intoxicant used to induce the berserker rage state.
*Conclusions:* With its anticholinergic tropane alkaloids and symptom profile, *H. niger* is a much more likely cause of the berserker state than *A muscaria*. Though there is not enough archaeological and historical evidence to prove or disprove this theory, it provides a novel explanation that is at present the most viable means of understanding the berserkers' trance.

## 1. Introduction

Intoxicating plants of the botanical family Solanaceae have found use across both time and space for a variety of purposes. Whether it is *Brugmansia* being occasionally added to the famous Ayahuasca of South/Central America (De Rios, 1970) or *Datura stramonium* L. being added to cider in France (Prado, 2004), these plants have played important religious, medicinal, and recreational roles for humans from many cultures.. Though this family, which contains many common food plants such as tomatoes, potatoes, eggplants, and peppers, is not as widely employed by humans as grasses and legumes, it still ranks among the most used groups of plants (Boyd et al., 1984). This is also one of the few botanical families that contains a disproportionally high number of psychoactive plants, with some of its members containing hyoscyamine/atropine and scopolamine, tropane alkaloids with mind-altering powers (Adamse et al., 2014; Alrashedy and Molina, 2016). These substances are, however, not like most hallucinogens, and are classified as deliriants for their strong psychoactive effects that cloud the mind and cause intense and realistic hallucinations (Díaz, 2010). These plants have also been frequently implicated as being associated with the witches of Europe and their supposed psychoactive flying ointments (Carruthers, 2015).

Along with the famed witches, another widely known group from Europe existed that is often said to have made use of a psychoactive substance: the Norse berserkers. Known for their ferocity, these warriors were said to enter a special trance that aided them in battle (Dale, 2017; Fabing, 1956; Wade, 2016). The substance generally implicated in the entering of this trance state is the famous psychoactive mushroom, *Amanita muscaria* L. Such notions of the berserker trance being caused by *A. muscaria* go back (at least) as far as the 1700s when the theory was recorded by the famed writer, Ödmann (1784). Ergotism, alcohol, mental illness, and many other theories have been put forward since, however *Amanita muscaria* seems to be the most widely accepted theory to date (Alm and Elvevåg, 2012; Dale, 2017).

*A. muscaria*, however, does not fully match the reported profile of berserker warriors; a solanaceous plant containing hyoscyamine/atropine and scopolamine seems a much better fit. This, however, leaves a multitude of possible plants. When the range of these plants and their distribution during the time of the berserkers is taken into account, however, it seems that the best fit is *Hyoscyamus niger* L. As such, *Hyoscyamus niger* is a more plausible cause of the berserker state than *Amanita muscaria* based on the evidence that we have available to us at present.

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## 2. Berserkers

Exactly who the berserkers were is a matter of controversy in itself. Originally, the term is thought to have emerged in reference to a specific hero in Norse mythology who fought without armour, thus leaving him "ber sark" or bare skinned (Fabing, 1956). Then, during the Saga period (870–1030 CE) in Iceland and Scandinavia, a group of warriors arose known by the same name before their sudden disappearance around the 12th century CE (Fabing, 1956). Actual direct references, however, are often unclear; even the meaning of the word berserker has been thought to perhaps mean "bear skin" rather than "bare skin" and refer to these warriors wearing bear or animal pelts in their battles (Liberman, 2004; Wade, 2016). This lack of information exists in large part due to the fact that knowledge of the berserkers was not recorded substantially until after the tradition had been outlawed by the Christian church while seeking to stamp out paganism and because the writings that did exist were often made by Christian writers with an agenda to denounce these traditions (Wade, 2016). Some archaeological items from the period display images of warriors whose bodies are covered in animal skins, and various myths among the Norse peoples point to warriors dressing in the skins of bears and wolves to gain their ferocity, but there is no concrete way to associate these phenomena (Wade, 2016). Iconography from the period does also seem to display that berserkers were among the social elite of the time, though this too is open to interpretation (Dale, 2017). Ultimately, all that can be said with certainty is that they were elite warriors who were known for their recklessness in battle and that they may have fought without armour (Liberman, 2004).

The berserkers were said to be not just ordinary warriors, but rather to fight while in a specific trance-like state, which was likely helpful in dissociating them from the close-up atrocities they would have seen and committed in battle (Wade, 2016). This state has been variously claimed to involve anger, increased strength, a dulled sense of pain, decreases in their levels of humanity and reason, behaviour akin to that of wild animals (including howling and biting on their shields), shivering, chattering of their teeth, chill in the body, and invulnerability to iron (swords) as well as fire (Dale, 2017; Fabing, 1956; Speidel, 2002; Wade, 2016). Additionally, they were said to attack enemies indiscriminately with no sense of friend or foe and to throw off their armour in battle (Fabing, 1956; Wade, 2016).

When the state wore off after about one day, the berserkers were said to experience several days of weakness and dulled mental capacity (Fabing, 1956). Reports also seem to point to clubs being needed to defeat berserkers since blades could not harm them; this has been interpreted by some as potential proof of the term berserker referring to warriors who wore animal skins, since pelts would provide some protection against the cutting of swords but would do very little to protect from the blunt trauma involved in attacks with clubs (Dale, 2017).

Though often thought of out of context within popular culture, it has been suggested that the Norse berserkers were in fact part of a larger tradition of Indo-European "ecstatic" warriors who made use of trance-like states in battle (Speidel, 2002).

## 3. Amanita muscaria

*Amanita muscaria* is a mushroom of up to 20 cm in height; the European form has a red cap, often bearing white flecks of old tissue, and is almost equally as wide as it is tall at maturity once it has flattened into an archetypical toadstool shape (Schultes, Hofmann, & Rätsch, 2001). Eurasian in origin, this species has now been introduced to various other parts of the world (Geml et al., 2008). It primarily grows in acidic soils in birch forests and is most prevalent from late summer to early autumn (Czigany, 1980; Lee et al., 2018).

Discovered in 1869, muscarine was originally thought to be the compound responsible for the psychoactive effects of *A. muscaria* (Schultes, 1977). This substance, however, proved to be a minor constituent of the alkaloid profile of the mushroom, and to merely be a cause of many unpleasant physiological side effects associated with the use of *Amanita muscaria* (Feeney, 2010). Nearly a century later, the true psychoactive components were isolated, proving to be muscimol and ibotenic acid, though to this day it remains unclear if other as of yet unknown substances also play a role (Feeney, 2010; Halpern, 2004; Lee et al., 2018).

The most abundant of the principal compounds, ibotenic acid, appears in levels as high as 40 g/kg dry weight, though this quantity varies vastly, with another study, for example, reporting ibotenic acid as only 1 g/kg dry weight of *A. muscaria* (Feeney, 2010; Lee et al., 2018; Lumpert and Kreft, 2016). Though high in content, this substance is 5–10 times weaker in psychoactivity than its counterpart, muscimol (Feeney, 2010).

Likely the primary cause of psychoactivity in *A. muscaria*, muscimol is formed through the decarboxylation of ibotenic acid; this occurs through dehydration of the mushroom's tissues, but may also occur in the human stomach (Feeney, 2010; Lee et al., 2018). Along with ibotenic acid, these compounds are both excreted in human urine to various degrees (Støíbrný et al., 2012). These two substances also offer an explanation regarding the vast variability in the psychoactive effects of *A. muscaria*, with seasonal variations in the ratio between ibotenic acid and muscimol likely being the cause (Lee et al., 2018; Schultes, 1977). This may explain why various groups in the far east of Siberia who were known for making use of this mushroom preferred spring and summer specimens to those arising in autumn (Brekham, 1967).

Traditional use also aligns with what has come to be known of the chemistry of *Amanita muscaria*. Known to be used by a variety of tribes in the extreme northeast and extreme west of Siberia for their religious rituals, these mushrooms were often dried before being eaten, or were made into infusions over the course of 5–6 days (Brekham, 1967; Czigany, 1980; Lee et al., 2018; Schultes, 1969; Wasson, 1967). This drying would, as previously mentioned, serve to convert ibotenic acid into muscimol, thus making the mushrooms more potent. As for the infusions, muscimol is more soluble than ibotenic acid, so a beverage made from *A. muscaria* would effectively extract the most psychoactive portion of the mushroom (Feeney, 2010). A typical experience among the Siberian tribes involved a drunken state associated with auditory hallucinations and changes in the colour of the consumer's vision; it was even claimed that reindeer would follow the shamans around to eat snow into which they urinated, thus themselves getting high (Lee et al., 2018).

Muscimol acts as a strong GABA-A agonist, especially in the central nervous system (Satora et al., 2005), though its hallucinogenic action has been reported to arise primarily from its binding at GABA-B sites (Mikaszewska-Sokolewicz et al., 2016). In contrast, ibotenic acid acts most strongly at N-methyl-D-aspartic acid (NMDA) receptors by agonising for glutamic acid (Krogsgaard-Larsen et al., 1981; Satora et al., 2005). The previously discussed muscarine has cholinergic effects related to the peripheral nervous system in smooth muscles of the body, but is not prone to entering the central nervous system, which further explains why it is unable to be the substance responsible for the hallucinogenic actions of *A. muscaria* (Krogsgaard-Larsen et al., 1981; Waser, 1967). The multiple effects of these substances significantly limits their potential usefulness in clinical settings (Krogsgaard-Larsen et al., 1981).

Effects of *A. muscaria* ingestion include nausea, vomiting, diarrhoea, hyperthermia, intense sweating, reddening of the face, excessive salivation, dizziness, twitching/trembling, dilated pupils, increased muscle

tone, hallucinations, delirium, seizures, sleep, coma, and possibly death in rare cases (Davis and Williams, 1999; Fabing, 1956; Kirchmair et al., 2012; Michelot and Melendez-Howell, 2003; Mikaszewska-Sokolewicz et al., 2016; Satora et al., 2005; Schultes, 1969). Though aggressiveness and hyperactivity may occur, these symptoms are rare and not seen as common markers of *A. muscaria* poisoning (Brvar et al., 2006; Schultes, 1969). Hallucinations may take as long as 1.5 h after consumption to occur, while gastro-intestinal symptoms arise much more quickly, with nausea, vomiting, and diarrhoea beginning within 15 min (Mikaszewska-Sokolewicz et al., 2016). Though reports from the literature involving intoxications with this mushroom are fairly rare, enough exist to validate the symptoms often reported (Brvar et al., 2006; Mikaszewska-Sokolewicz et al., 2016; Waser, 1967).

## 4. Hyoscyamus niger

*Hyoscyamus niger* is a pubescent and aromatic annual or biennial with dentate ovate leaves of about 20 cm in length; reaching a height of about 75 cm, this plant bears scorpoidal cymes of small yellow flowers with purple centres and veins, which later mature into capsules (Schultes et al., 2001). Originating from the Mediterranean/Balkan region of Europe, *H. niger* has since found its way throughout Eurasia and North America, where it normally grows in waste areas as a weed (Daunay et al., 2007; Goyal et al., 2009; Hocking, 1947; Passos and Mironidou-Tzouveleki, 2016).

As with some of its familial relatives such as species in the genera *Atropa*, *Brugmansia*, *Datura*, *Mandragora*, and *Scopolia*, the genus *Hyoscyamus* contains tropane alkaloids. In particular, it contains the alkaloids hyoscyamine (of which atropine is a racemic mixture of both enantiomers) and scopolamine. Research has shown the leaves and flowers of *H. niger* to contain 0.05–0.14% alkaloids, with scopolamine being the principal constituent and representing approximately 50% of this content (Arroo et al., 2007; Gaillard and Pepin, 1999). Though hyoscyamine/atropine is also psychoactive, scopolamine is much stronger, for example exhibiting an eight fold increase in central nervous system activity when compared to atropine (Ketchum et al., 1973). As previously mentioned, these alkaloids are deliriants, known to produce complex and convincing hallucinations (Maior et al., 2017).

First isolated in the 1800s, scopolamine has been found in all parts of the plant (Passos and Mironidou-Tzouveleki, 2016). This explains its extensive historical use in Europe since ancient Greece as a narcotic, anaesthetic, pain killer, cure for insomnia, in the treatment for respiratory ailments, in the famous soporific sponge, and many more (Carter, 1996; Daunay et al., 2007; Gorun et al., 2011; Hocking, 1947; Kala and Ratajc, 2012; Lee and Schilling, 2006; Passos and Mironidou-Tzouveleki, 2016; Piomelli and Pollio, 1994; Schultes, 1977). This plant has also found use in Tibetan medicine, traditional Chinese medicine, and Ayurveda for similar purposes (Goyal et al., 2009; Patočka and Jelínková, 2018). In western biomedicine, pure scopolamine is still used for treating motion sickness (Grynkiewicz and Gadzikowska, 2008).

In addition to its medicinal uses, *Hyoscyamus niger* is often claimed to have been a plant used by the witches of Europe (Schultes et al., 2001). It has been suggested that it was used in love potions, witches' brews, and in the famous hallucinogenic flying ointments (Aulakh and Mukerjee, 1984; Disel et al., 2015; Lee and Schilling, 2006). It is also thought by some to have been burned at the ancient oracle in Delphi thus allowing the seers to enter trances and receive their prophecies (Paulsen, 2010). Such magical uses are, however, largely conjecture; flying ointments, for example, are said by some to not have even existed (Ostling, 2016). It was also used extensively in Europe as a means of fortifying beer, and for making other forms of psychoactive beverages (Kromar, 1979; Lee and Schilling, 2006). So often was it used that a law was passed in 1507 in what is now Germany to prohibit its use in the making of ales (Daunay et al., 2007). Repeated use was also known to cause insanity, but this did not impact its popularity as it likely presented a form of intoxicant available even to the poorest people who could not afford more costly pleasures (Müller, 1998; Schultes, 1969). Indeed, repeated doses above 3 mg per day have been shown to cause lasting behavioural and mental changes (Maior et al., 2017). Additionally, the symptoms of Norse berserker warriors align somewhat with those ascribed to werewolves: wearing of animal pelts, raging, and irregular behaviour, which in turn line up with symptoms caused by the anticholinergic tropane alkaloids, believed by some to be the cause of the werewolf phenomenon (Copeland, 2018; Piomelli and Pollio, 1994).

The tropane alkaloids hyoscyamine/atropine and scopolamine antagonise muscarine receptors in the central and peripheral nervous systems in the place of acetylcholine, thus earning them the title of anticholinergic substances (Sayin, 2016). Though five subtypes of muscarinic receptors exist in the human body, these substances do not selectively bond to any one type and thus cause a wide range of symptoms (Gadzikowska and Grynkiewicz, 2002). Their effects are especially pronounced in the smooth muscles and secretory glands of the body as well as in the brain (Moulton and Fryer, 2011; Simone and Margarucci, 2008). These substances produce virtually identical symptoms, though as previously mentioned scopolamine presents a central nervous system effect that is eight times stronger than that seen with atropine (Ketchum et al., 1973).

These alkaloids cause a range of effects such as decreased salivation (and thus dry mouth), slowed gut motility, dilation of pupils (and thus blurred vision), decreased bronchial secretion, decreased sweating (and thus drying of skin), bradycardia or tachycardia (depending on dosage), ataxia, hyperthermia, flushing of the skin, headache, hyperreflexia, incoordination, somnolence, restlessness, decreased ability to pay attention, loss of coherent speaking, hallucinations, memory disturbances, and eventually coma and death (Arroo et al., 2007; Brown and Laiken, 2011; Gadzikowska and Grynkiewicz, 2002; Ketchum et al., 1973; Maheshwari, 2013). These effects, however, are dose-dependent, and thus *H. niger* can be used (and indeed still is in many places) without fatality or the more extreme symptoms. Reports of poisoning arising from this plant are not highly prevalent in the literature (Aparna et al., 2015; Erkal, 2006; Sands and Sands, 1976; Shams et al., 2017; Spoerke et al., 1987), however, related plants with the same alkaloids such as *Datura stramonium* have been extensively reported on in toxicological papers, and from these we can glean information about the state involved when an individual consumes *Hyoscyamus niger*.

## 5. Historical and archaeological perspectives

Though originally a Mediterranean species, *Hyoscyamus niger* was likely introduced to Scandinavia as far back as the Roman Iron Age (Heimdahl, 2009). Since it was not native to the region, it has been suggested that this provides proof of the plant being brought further north and cultivated for its medicinal properties (Karg, 2010). Though this may be true, it cannot be dismissed as a theory that *H. niger* may have migrated with humans accidentally and begun to spread as a weed. It is also worth noting that carbonised remains resulting from burning are the most likely plant tissues to survive in the archaeological record; paleobotanical finds may thus disproportionally represent plants that have been used in manners related to fire (Day, 2013). Whatever the reason for its migration, this plant was an established weed at centres of trade by the Viking age, making it a viable candidate for use by warriors of the time (Heimdahl, 2009).

*Hyoscyamus niger* seeds have been found in association with Viking age sites in Denmark (Rohde Sloth, Lund Hansen and Karg, 2013)

and Finland (Vuorela et al., 1996), with signs of obvious cultivation of the plant tending to emerge around the middle ages (Alanko and Uotila, 2017; Åsen, 2009; Heimdahl, 2009). Though the Viking age findings are inconclusive in many cases, it seems that the plant was being used at this time. Carbonised seeds as well as seeds associated with graves both suggest potential use in these sites. Additionally, a grave from approximately 980 CE in Denmark included a pouch of *H. niger* seeds with a woman whose clothing, jewellery, and other grave goods suggested she was a priestess/shaman of high social class who may have used the seeds to produce visions (Pentz et al., 2009). Though this cannot be proven without further archaeological findings, the fact that the seeds were in a pouch and buried with her suggests their importance and unequivocally points to some form of use in Scandinavia during the Viking age. This in itself provides a much more concrete argument for the use of *H. niger* to produce the berserker trance than any that may be claimed for *A. muscaria*.

Though *Amanita muscaria* is invasive in many regions where it has been introduced, analysis of trade routes in Siberia has shown that it was not ubiquitous at the times when it was more widely used for ritual purposes there (Geml et al., 2008; Lee et al., 2018). Some authors have even suggested that the reason behind the drinking of urine of those who had consumed the mushroom was due to its shortage (Buck, 1963). Though this may be true, it could just as likely be an etic assumption on the part of European observers who were unaware of the ways in which the human body improves the substance by filtering out the non-psychoactive components responsible for many unpleasant physical effects. Regardless, *A. muscaria* would have likely been much harder to come by than *H. niger,* with the former needing to grow in forests where its mycelium can create mutualistic relationships with the roots of the trees (Czigany, 1980; Geml et al., 2008; Lee et al., 2018). *Hyoscyamus niger*, in contrast, grows as a pesky weed and as previously mentioned is known to have done so in inhabited areas of Scandinavia during the period of the berserkers (Heimdahl, 2009).

Though records may not exist to prove that Norse berserkers made use of psychoactive substances to induce their battle trances, Ödmann's writing from the 1700s on the topic also includes a potential explanation: in order to guard their prestige and position in society, Norse berserkers may have kept their use of intoxicants a secret (Fabing, 1956). This would also prevent enemies from gaining access to their increased abilities. Though Ödmann writes of this in reference to *Amanita muscaria*, the theory applies equally well to *Hyoscyamus niger*. This also aligns with the general lack of knowledge of psychoactive substance use in Europe; when the Christian church labelled such plants as heretical and suppressed their use and information about them, they effectively destroyed much of the tradition and knowledge that could be used in the present day to piece together the history of European psychoactive plant use (Harner, 1973).

## 6. Analysis of symptomology

Perhaps the largest problem involved in untangling this historical mystery is the large degree of similarity seen between intoxications of the active compounds of *Hyoscyamus niger* and those of *Amanita muscaria*. So similar are the effects between these two organisms when consumed by humans that scientists spent many years searching for tropane alkaloids in *A. muscaria* (Buck, 1963; Waser, 1967). Despite the similarity of their symptoms, the substances have opposite chemical effects; atropine, for example, is an antidote for muscarine poisoning (Kirchmair et al., 2012). Though there are many similarities in effects, it is worth noting that the increased salivation and sweating seen in *A. muscaria* ingestion as well as the nausea, vomiting, and diarrhoea are symptoms typical for this mushroom but not for plants containing anticholinergic tropane alkaloids; furthermore, anticholinergic alkaloids cause a marked decrease in salivation and perspiration, which stands in stark contrast to the effects of muscarine (Waser, 1967). Unfortunately, such symptoms are difficult to distinguish from historical records.

As previously discussed, both substances may cause increases in strength, altered level of consciousness, wild/delirious behaviour, jerking/twitching, and redness of the face, all of which have been associated with berserkers (Brown and Laiken, 2011; Brvar et al., 2006; Dale, 2017; Davis and Williams, 1999; Fabing, 1956; Grynkiewicz and Gadzikowska, 2008; Gadzikowska and Grynkiewicz, 2002; Ketchum et al., 1973; Kirchmair et al., 2012; Michelot and Melendez-Howell, 2003; Mikaszewska-Sokolewicz et al., 2016; Satora et al., 2005; Schultes, 1969; Speidel, 2002; Wade, 2016; Waser, 1967; Wasson, 1967). What makes *Hyoscyamus niger* a more compelling theoretical cause of the berserker state, however, is its additional symptoms that are not commonly seen in intoxications involving *Amanita muscaria*. In addition to the previous symptoms, *H. niger*'s alkaloids also have pain killing effects unseen in the compounds within *A. muscaria*, which may account for some of the reports of the supposed invulnerability of the Norse berserkers (Dale, 2017; Fabing, 1956; Grynkiewicz and Gadzikowska, 2008; Hocking, 1947; Lee and Schilling, 2006; Passos and Mironidou-Tzouveleki, 2016; Piomelli and Pollio, 1994; Schultes, 1977; Speidel, 2002; Wade, 2016). Even more compelling is the duration of effects; though the berserker state has been reported to involve several days of side effects after the high has subsided, this is not a common feature in intoxications with *Amanita muscaria* (Brvar et al., 2006; Fabing, 1956; Michelot and Melendez-Howell, 2003; Mikaszewska-Sokolewicz et al., 2016; Satora et al., 2005; Waser, 1967). Tropane alkaloids from *Hyoscyamus niger* and its close relatives, however, are known to commonly have such effects lasting for many days, with some symptoms such as headache and dilated pupils (and thus blurred vision) lasting for weeks in some cases (Halpern, 2004). Additionally, rage is not a common presenting symptom in cases of *A. muscaria* consumption, but is prevalent in cases involving anticholinergic tropane alkaloids (Centers for Disease Control and Prevention, 1995; DeFrates et al., 2005; Göpel et al., 2002; Klein-Schwartz and Oderda, 1984; Lazzarini et al., 2006; Spina and Taddei, 2007; Thiermann et al., 2009; Wiebe et al., 2008). Though these cases do not involve *H. niger*, they have been witnessed as a result of related plants containing the same alkaloids, making a comparison here appropriate. In addition, most reports have also observed these behaviours in cases of *H. niger* intoxication (Erkal, 2006; Sands and Sands, 1976; Shams et al., 2017). This effect is also likely long known in Croatia, where the verb “buniti” meaning to fight or protest was derived from the local name for *H. niger* (bunika), and a saying translating to “as if they had eaten *Hyoscyamus niger*” is used to refer to an angered individual (Pronk, 2012). This anger effect can range from agitation to full-blown rage and combativeness depending on the dosage and the individual's mental set. As this is perhaps the most defining component of the berserker state, this symptom is of central importance in identifying potential causes and provides a very critical reason as to why *H. niger* is a more appropriate theoretical intoxicant for the berserkers than *A. muscaria*.

Another commonly reported symptom in cases of intoxications with tropane alkaloids from solanaceous plants involves an inability on the part of the intoxicated individual to recognise the faces of people they know (Adegoke and Alo, 2013; Berdai et al., 2012; Korkmaz et al., 2018; Villain et al., 2008). As it has been claimed that the berserkers did not distinguish between friends and foes in battle, it seems that such a mechanism could have been at play. Though this could also be due to hallucinations that could be caused by either intoxicant, it seems more likely that this element of confusion pertaining to identification is here implicated. The berserkers' fearlessness is also

likely a result of this altered mental state produced by *H. niger* and its alkaloids.

Yet another compelling possibility is their removal of clothing; though authors tend to claim that berserkers would throw off their armour (and possibly their shirts, depending on which interpretation of the word berserker we employ) in battle to display their bravery, it is possible that this was a result of intoxication by *Hyoscyamus niger*. In many cases of intoxication by related solanaceous plants, individuals have been known to remove their clothing and be found walking around naked (Centers for Disease Control and Prevention, 1995; Gangl-Žvikart, 2002; Kromar, 1979; Mikolich et al., 1975; Weil, 1977). This trend has also been displayed in my own ongoing research with individuals employing anticholinergic solanaceous plants for recreational and spiritual purposes. Whether this is due to the hyperthermia caused by these tropane alkaloids or for another reason such as increased sensitivity and annoyance by fabric on the skin is unknown.

Finally, the ingestion of anticholinergic tropane alkaloids is sometimes associated with a drop in blood pressure (Brown and Laiken, 2011). Though this may also occur in *A. muscaria* poisonings, increased blood pressure has also been recorded making the exact effects questionable (Kirchmair et al., 2012; Waser, 1967). With significant lowering of blood pressure, the individual would bleed less readily, and this may perhaps be the basis for the notion that swords were unable to harm the berserkers (Arima et al., 2012; Castaneda et al., 2000; Durmus et al., 2007; Hasegawa et al., 2003; Stern et al., 1993). Though obviously inflated with time, perhaps their surprisingly small amount of blood loss would have led to their enemies referring to them as immune to the blade, with the details later being lost through time. Indeed, the antihaemorrhagic properties of *H. niger* were well enough known towards the end of the time of the berserkers for them to be included in Avicenna's *Canon of Medicine* (Aziz et al., 2000). Though this arose far from the geographic range of the berserkers, it is entirely possible that they too were aware of this property of the plant and thus consumed *H. niger* for this reason. Similarly, their supposed immunity to fire may have simply referred to the pain dampening effects of the anticholinergic alkaloids of *H. niger*. It is worth noting here that the closely related *Mandragora* with its similar alkaloid composition has been implicated as the plant of Greek myth that the sorceress Medea used to make Jason immune to fire in his quest for the golden fleece (Harris, 1916). These, however, are by far the most speculative of the symptoms here discussed, and are not strong indicators of the viability of this theory. Such a drop in blood pressure, for example, would also likely cause weakness that would be undesirable in battle.

Some symptoms of the berserkers, however, cannot be well explained in the context of *Hyoscyamus niger* or *Amanita muscaria* poisoning. The chattering of teeth they were said to experience may perhaps have been a result of muscle spasms arising from the use of either substance, though when taken into account that they were also said to experience chills in the body, perhaps they were simply cold and shivering, which would be unsurprising if they were to walk around without much clothing on in cold northern climates. This, however, goes in direct contrast to the hyperthermia that both of these intoxicants cause. Likewise, their shield biting may have simply been an attempt to stop chattering teeth when cold. It is possible that the odd array of symptoms may represent the use of *H. niger* in conjunction with another substance (perhaps even *A. muscaria*) rather than simply *Hyoscyamus niger* alone, however there is not enough historical, archaeological, or modern pharmaceutical evidence to substantiate this. Either way, this constellation of symptoms is difficult to explain in any manner and all theories for this are guesses at best.

For ease of viewing, a comparison of the discussed symptoms has been provided in Table 1.

**Table 1**
Comparison of symptomology. X denotes common presence of symptom.

| "Symptoms" of Berserkers | *Hyoscyamus niger* alkaloids intoxication | *Amanita muscaria* alkaloids intoxication |
|---|---|---|
| Several days of dulled mind after | x | |
| Increased strength | x | x |
| Decreased pain sensitivity | x | |
| Decreased "humanity and reason" | x | x |
| "Wild like animals" (Delirium) | x | x |
| Shivering (Clonic jerking, deep tendon reflexes, convulsions) | x | x |
| Chattering of teeth | ? | ? |
| Chill in body | | |
| Swollen and red face | x | x |
| Rage (Violence) | x | |
| Lack of discrimination between friend and foe | x | |
| Invulnerable to blades | ? | ? |
| Fearlessness | ? | ? |
| Removal of clothing | x | |
| Shield biting | | |
| Invulnerability to fire | ? | |

Table references (Adegoke and Alo, 2013; Arima et al., 2012; Brown and Laiken, 2011; Castaneda et al., 2000; Centers for Disease Control and Prevention, 1995; Dale, 2017; Davis and Williams, 1999; DeFrates et al., 2005; Durmus et al., 2007; Erkal, 2006; Fabing, 1956; Grynkiewicz and Gadzikowska, 2008; Gadzikowska and Grynkiewicz, 2002; Gangl-Žvikart, 2002; Göpel et al., 2002; Hasegawa et al., 2003; Ketchum et al., 1973; Kirchmair et al., 2012; Klein-Schwartz and Oderda, 1984; Korkmaz et al., 2018; Lazzarini et al., 2006; Mikaszewska-Sokolewicz et al., 2016; Mikolich et al., 1975; Satora et al., 2005; Schultes, 1969; Shams et al., 2017; Speidel, 2002; Spina and Taddei, 2007; Stern et al., 1993; Thiermann et al., 2009; Wade, 2016; Waser, 1967; Wasson, 1967; Wiebe et al., 2008).

## 7. Conclusions

The present article has been able to provide a theory: that *Hyoscyamus niger* was used by the famed berserker warriors of the Saga period (870–1030 CE) in Scandinavia to produce their battle trances. Ultimately, future finds will determine if this theory will be proven or disproven. The most reliable form of archaeological/historical data combines paleobotanical and textual/artifactual information in order to provide a complete picture of the past (Merlin, 2003). The present investigation has done just this, showing that at present the data available supports the potential use of *H. niger* as an intoxicating agent to induce the berserker trance. Though *Amanita muscaria* is a popular theoretical cause accepted by many, we have seen here that the symptomology of the berserker state aligns much better with an intoxication arising from the anticholinergic alkaloids hyoscyamine/atropine and scopolamine. Of the plants that contain these alkaloids, *Hyoscyamus niger* is the most viable option as a result of its presence in Scandinavia during this time period and its association with various archaeological sites that show it was being employed by humans in this time and place and that it commonly was growing as a weed in areas of human habitation.

This article must of necessity conclude with the remark that I myself am neither a historian of nor an archaeologist of the Nordic region. As an ethnobotanist studying the use of anticholinergic solanaceous plants in Europe, however, this theory came to me as a result of the information present in the literature. Only future research may now confirm or deny the speculative ethnobotanical perspective here presented.

## Conflicts of interest

The author declares no conflict of interests.

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