The biology of native and invasive Wild Boar (*Sus scrofa*) and the effect it is having in its invasive range

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Abstract

A series of experiments and research articles were studied to determine the biology of native Wild Boar and invasive Wild Boar, as well as the effect the species currently has on its invasive range, particularly the United States. The primary focus of the biology in the invasive range was the wide range of the species due to a non-specific diet, as well as the animals' ability to give birth to a large number of piglets per litter. The biology of the Wild Boar in the invasive range was focused on the species' fitness in comparison to its competitors, due to a more efficient digestive system and a high reproduction rate. Wild boar has multiple negative impacts on plant and animal species and agricultural areas within the United States. Particular characteristics of the biology of *Sus scrofa* result in the successful invasion of the animal.

Introduction

Wild Boar are so widespread throughout the United States that they can easily be mistaken for a native animal. However, the species is actually quite new to the country. They were introduced into the United States in 1912, and began spreading throughout the country shortly after (Bratton, 1975). Since the invasion of the animal, the Wild Boar has created problems for native species as well as for humans throughout the country (Bratton, 1975). When discussing the biology and effects of the Wild Boar, it is significant to note the meaning of invasive species as applied in this paper. An invasive species, such as *S. scrofa*, is one which must pass over a boundary or barrier with the aid of humans. The species must also survive, establish, and spread throughout the area. The Wild Boar meets these criteria. In order to understand the effects that Wild Boar are having on agriculture and native species in the United States, it is important to understand the native biology, as well as the invasive biology of the animal.

Wild Boar are a native mammalian species of Western Europe as well as of Northern Africa (Dobson, 1998). In the past, Wild Boar populations have fluctuated tremendously in European countries. While some populations have died out, other populations have flourished (Scandura, 2008). In 1975, the population densities began to level off but are now expanding at an extreme rate (Saez-Royuela and Telleria, 1986). Post-glacial expansion explains much of the increase in Wild Boar population, meaning there has been very little human intervention (Scandura *et al*. 2008). Wild Boar have certain characteristics that allow them to inhabit a wide range throughout Europe, and are a terrestrial animal with the largest range in Europe (Dobson, 1998). The broad range of the Wild Boar is a result of its non-specific diet, as well as its large litter size.

Since the Wild Boar is able to vary its diet, it is not limited to a specific region of Europe. The species, *S.scrofa*, can survive eating a variety of food types (Schley and Roper, 2003). Because the animal does not have a very specific diet, it has the ability to spread into areas that have drastically different types of vegetation. An example of this non-specific diet is documented for Wild Boar in Sardina. They were found to have up to nineteen different plant species in their stomachs when their gastric content was measured, including *Castanea sativa, Ceratonia sili- qua, Chamaerops umilis, Cichorium intybus, Hordeum sativum, Juniperus oxycedrus, Myrtus communis, Olea europea, Pirus amygdaliformis,* all of which can be found in the Mediterranean (Pinna *et al*. 2007). This is a large variety of plants to be eaten by a single species and includes, among others, Mediterranean scrub fruit (Pinna *et al*. 2007). Not only was vegetation found in the animals' stomachs, but Wild Boar were also found to have three additional categories of food in their stomach: insect larvae, hairs of mammals, and feathers of birds (Pinna *et al*. 2007). The less specific the diet of a species, the more easily it can spread throughout an area. This is true because there are no limitations due to dietary needs that would prevent the boar from moving. They can survive in almost any area in Western Europe, including northern countries, which do not have the same vegetation as the Mediterranean (Pinna *et al*. 2007). This demonstrates the Wild Boar's versatility. Although it is difficult to pinpoint a particular diet for the Wild Boar in Europe, in general, they consume more vegetation than animal material; however, animal material may be a particularly important food in the diet of the Wild Boar (Schley and Roper, 2003).

Wild Boar are considered opportunistic omnivores because they can eat and digest a wide range of food (Schley and Roper, 2003). Wild Boar thus have seasonal and regional differences in their diet based on the availability of food and changes in agricultural crops (Schley and Roper, 2003). Wild Boar have been eating crops and causing problems with agriculture in Europe since the 1940s (Schley and Roper 2003). Variations of dominant crops for farmers in Europe can result in changes in the location of the Wild Boar, as well as their population size (Saez-Royuela and Telleria, 1986). S. scrofa in Europe consume crops such as maize, wheat, barley, rye, oats, rice, sorghum, potatoes and sugar beets (Schley and Roper 2003). Wild boar base their range off of what foods are available to them, and variances in the crops of certain areas can result in either higher or lower populations of wild boar in a particular area. They are also limited by the different seasons of Europe, since certain types of vegetation are more common at different times of the year (Saez-Royuela and Telleria 1986). In the northern parts of Europe, the Wild Boar are affected by the harsh winter seasons that prevent the rooting of certain seeds and fruits, while in the Mediterranean, the summer is a more limiting time due to a lack of material for rooting (Bywater *et al*. 2010).

Not only does the range of the Wild Boar vary due to diet, but the litter size of the Wild Boar varies as well. Changes in latitude of the Wild Boar's location have been found to result in variations in its litter size (Bywater *et al*. 2010). Many birds in past research have been found to have increasing clutch sizes with increasing latitude; however, this relationship has never been seen with large mammals before (Bywater *et al*. 2010). This demonstrates that the Wild Boar maximizes reproductive opportunities in different environments. An increase of 0.15 piglets per degree, or one piglet for every 6.6° increase in latitude has been discovered in the species (Bywater *et al*. 2010). One of the possible explanations for these results relates to the diet of the Wild Boar. In the winter season in higher latitudes, the food

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sources are not as stable and therefore reproduction is not stable in those latitudes; however, when there is a sufficient amount of food, litter sizes are large, resulting in an overall larger litter size (Bywater *et al*. 2010). In lower latitudes, reproduction is stable at a lower litter size because the food supply of the Wild Boar remains constant (Bywater *et al*. 2010). This demonstrates a connection between reproduction and diet in S. scrofa.

In addition to the latitude affecting the litter size, the non-specific diet of the Wild Boar also changes litter size, which allows the Boar to travel over long ranges. The explanation for why Wild Boar populations are continuously expanding varies depending on the country of the Wild Boar (Saez-Royduela and Telleria, 1986). However, one of the main reasons for their spread throughout Europe is their ability to travel across broad ranges (Dobson, 1998). This trait of the Wild Boar is affected by the diet of the animal, as well as its reproduction. Seasonality and availability of resources may also have an effect on their reproduction, varying the litter size of the Wild Boar in a specific area. Due to their ability to move wide ranges, the non-specific dietary needs, and varying litter size due to location, Wild Boar are easily expanding throughout Europe. The animals' native biology has allowed the species to become a nuisance in Europe as well as in invading countries.

Since the Wild Boar has been brought to the United States, certain biological characteristics of the animal have changed. Although S. scrofa, still has similarities to the Western European Wild Boar, (*Sus scrofa scrofa)*, it has been crossed with feral swine producing certain morphological differences (Bratton, 1975). Even though they have been in the United States for quite some time, little research has been done on the biology of the animal, until recently (Bratton, 1975). Wild Boar are ungulates with a short, coarse hair coat. Males have large tusks while females do not (Graves, 1984). They are characteristically large animals. The average weight of a female Wild Boar is 85 Kg and males are typically larger (Millar and Zammuto, 1983). The amount of time that these animals have been in the United States has given them sufficient time to make certain biological changes. These changes have created an invasive mammal with distinctive biological and physical traits. The Wild Boar has become a successful invasive species in the United States because it has an efficient digestive system, greater ability to consume more food than native species, ability to rapidly produce offspring, and social behaviors that benefit the offspring. These biological traits create a species that is more fit, allowing it to spread and survive more easily than many of its competitors.

One of the biological traits that benefit the Wild Boar is their efficient digestive system. The Wild Boar is a hind-gut mammal, meaning it can regulate intake and digestion, as well as absorb more nutrients through fermentation (Elston and Hewitt 2010). It also has a longer food retention time as a result of being a hind-gut animal (Elston and Hewitt, 2010). Wild Boar are omnivores that are typically found to eat at least one energy rich food daily: acorns, chestnuts, and pine seeds (Schley and Roper 2003). The vegetation in the diet of the Wild Boar is divided into four groups: mast, roots, green plants, and agricultural crops, on which Wild Boar have a strong impact (Schley and Roper 2003). The digestive system of the Wild Boar is important to the animal because it allows the it to obtain large amounts of nutrients from vegetation that are useless to other animals. The Wild Boar's ability to absorb more nutrients due to its digestive system helps the animal survive on a less specific diet in an invasive habitat. Not only does the digestive system benefit this invasive animal, but its immense size enables it to consume larger amounts of food than a majority of other species in the areas that the Boar invade (Elston and Hewitt). This makes it a fierce competitor to native species that require the foods the Boar consume (Elston and Hewitt, 2010). If the Boar eat the specific types of food certain species need to survive in large quantities, it makes survival for the native species more difficult as it is more difficult to find food. Another characteristic of the Wild Boar that helps it to survive on foods lacking many nutrients is the animals' ability to store large amounts of fat (Elston and Hewitt, 2010). The fat stores retain nutrients that the Wild Boar may need, so they can survive off of foods such as mast. While Wild Boar can survive on this type of food, many native animals cannot (Elston and Hewitt, 2010). A final biological factor that may benefit the Wild Boar is that many European Wild Boar are nocturnal (Graves, 1984). Most species in areas where Wild Boar are most prevalent are diurnal. As a result, Wild Boar have even less competition with other herbivores for vegetation food, making them a better invasive species.

The Boar's diet can affect the its litter size. (Massei and Genov, 2004). They require a certain amount of nutrients and food in order to reproduce (Massei and Genov). In addition to their diet, *S.scrofa* are also a successful invasive species because they have the ability to produce a higher number of offspring than their competition. They have been found to have the highest reproductive rates among ungulates throughout the world (Saez-Ryuela and Telleria 1986, Massei and Genov 2004). If an animal species has a high reproductive rate, it would be easier for the species to spread across large areas due to an increase in population. This is understandable because a larger population needs more resources; therefore it would spread over a larger distance to obtain those resources.

Wild Boar have a high reproductive rate with an average litter of five piglets (Millar and Zammuto, 1983). The number of litters of Wild Boar are typically unknown, however, one study found that they can have two litters a year (Bieber and Ruf, 2005). Female Wild Boar also mature fairly quickly, maturing at two years old, with most females giving birth to their first litter at 3.15 years (Millar and Zammuto, 1983). However, some Wild Boar, known as adolescent breeders, have been found to give birth as young as one year-old. (Bieber and Ruf, 2005). This is significant because the Wild Boar can begin mating sooner, producing more piglets earlier in their life. Another biological factor regarding the reproduction of Wild Boars that results in its successful invasive nature is that S. scrofa have the ability to breed year round (Coblentz and Baber, 1987). A year round mating season, particularly in an animal that produces five piglets a litter can result in a massive Wild Boar population that is extremely difficult to control. The Wild Boar has the ability to increase its population size by 150% annually (Massei and Genov, 2004). An increasing population allows the Boar to expand over broad ranges and to take away habitats of native species.

One of the final points to identify about the Wild Boar's biology is their social structure. The Wild Boar has social behaviors similar to feral swine (Graves, 1984). Males associate with females when they are sexually receptive, or during breeding (Graves, 1984). Because there is no actual breeding season, and the Wild Boar reproduce year-round, the males and females can interact year-round. However, other than breeding, males and females do not interact in groups (Graves, 1984). In the case of breeding, males typically attempt to breed in the summer months and become extremely aggressive (Graves, 1984). Females and piglets are typically found in groups, but when a female is ready to give birth, they are often solitary and reduce their home range. Being in groups allows the females to protect their piglets, increasing their chances of survival. It also serves certain advantages in competition. The larger a

population of a species, the more easily it can compete for food. A large population can push other species away from a particular area.

Because of the efficiency of its digestive system, consumption of larger quantities of food, ability to produce more offspring, and social behaviors benefitting offspring, Wild Boar have become an extremely successful invasive species in much of North America. Wild Boar have a digestive system that is much more efficient than many of the native species in the areas they are invading, such as the Gray Beech Forest in the Great Smokey Mountains (Bratton, 1975). This digestive system allows the Boar to obtain more nutrients from the food, and since Wild Boar can consume large amounts of food, they can obtain even more nutrients than many of the native species, therefore surviving on lower quality foods at lean times of the year (Elston and Hewitt). Their increased consumption of food also allows Wild Boar to maintain the energy required to produce a high number of offspring (Massei and Genov, 2004). Wild Boars' social behaviors create protection for their piglets, which increases reproductive success (Graves, 1984). Some of these biological factors of S. scrofa are the result of changes in the Western European boars due to the cross breeding of the species with feral pigs, and some of them are similar to those of Wild Boars native to Europe (Bratton, 1975). All of these biological traits, however, have resulted in the successful invasion of Wild Boar in the United States and other non-native countries.

It is not uncommon for invasive species to have a negative impact on the environment it is invading. It has already been established that Wild Boar have certain biological characteristics that greatly benefit the animal in its natural habitat. It has also been discussed that Wild Boar are successful invaders in the United States, among other countries, and that they have an easier time establishing and spreading in these areas because of their biological traits. The animals have multiple natural invasive behaviors that have a negative impact on the ecosystem (Graves 1984). Although Wild Boar are causing a wide range of problems for multiple areas in the United States, they are excessively threatening the environment of the Great Smokey Mountains National Park in Tennessee (Bratton 1974), as well as Oak Woodlands of California (Wilcox and Van Vuren 2009). Wild Boar have negative impacts on the agricultural plots of certain areas within the United states (Massei and Genov 2004). They have also begun to threaten particular plant species due to damaging the land, as well to act as predators towards various types of vertebrates (Wilcox and Van Vuren 2009).

The largest impactWild Boar invasion has had on the United States is on the country's agriculture industry.. The species has a substantial effect on human crops, particularly when there is not a large supply of energy-rich food (Massei an Genov 2004). This means that when the Boar is in an area that is lacking foods high in energy, they can substitute cultivated vegetation to receive the energy that it needs. One article states that nearly every type of plant that is cultivated can be found in the diet of Wild Boar (Massie and Genov 2004). Because they can eat most types of crops, Wild Boar may be a threat to all areas that have agricultural land. There are three primary factors that may influence whether or not Wild Boar will eat or uproot agricultural land. These are the density of the boar, the availability of fruits, and the proximity of the cultivated crops to the forest habitat (Massei and Genov 2004). It is not definite that Wild Boar will eat and uproot the vegetation in all agricultural area. However, based on these three factors, Wild Boar are becoming major problems in certain agricultural areas throughout the United States.

The same biological factors that have made Wild Boar such a successful invasive species are causing the ecosystem of the invasive Wild Boar to fall apart. Twenty years after Wild Boar entered the United States, they began to infiltrate the Great Smokey Mountains National Park, spreading at an incredible rate (Bratton 1974). In this particular area of the United States, Wild Boar have caused immeasurable damage. Particular studies have found that *S.scrofa* are directly affecting the vegetation of the area by uprooting, eating, or trampling up to 50 different plant species in this one area, including *Claytonia virginica, Dicentra cucullarica, Lilium superbum, Phacelia fimbriata, Stellaria pubera and Trillium erectum* (Bratton 1974). Since the numbers of Wild Boar in the area are rising, the number of plants that are being affected and destroyed by the Boar are also increasing (Bratton 1974). This is a concern because the continuation of the uprooting of plants may lead to the extinction of multiple plant species in the area. Botanists and other scientists are worried about the increased destruction from Wild Boar. The area is known to have an extremely diverse and fragile ecosystem of plants and animals, and many are worried that the extinction of certain species could threaten the entire ecosystem (Bratton 1974).

Wild Boar are also causing multiple indirect effects on the environment as a result of uprooting. Areas where Wild Boar do the most uprooting have far less variety of plant species than many of the areas without hog uprooting (Bratton 1975). As a result of the destruction of certain vegetation in the park, plant coverage of certain areas has decreased immensely. In areas where Wild Boar had not disturbed the vegetation, there was 87.3% coverage, whereas, in areas where there was uprooting due to the Wild Boar, there was 12.6% coverage, as well as soil erosion (Bratton 1974). Lastly, there have also been changes in the composition of species, possibly due to what the Boar choses to eat and uproot. This often depends on whether or not the plant is poisonous (Bratton, 1974). Since Boars avoid plants that could be dangerous to them, there has been an increase in the percentage of poisonous plants in the area such as Veratrum viride and Podophyllum peltatum (Bratton 1974).

Not only are Boar affecting the vegetation in the United States, but they are also having a negative indirect effect on the native animal species (Massei and Genov 2004). An increase in the number of poisonous plants in a particular area can greatly affect the other types of wildlife in these areas. When an environment loses its variety in vegetation, it may change the animals that feed at those locations. A change in the composition of species in a certain area is affecting native animals as well. When S. scrofa uproot certain areas, soil loosens and areas that have slopes can erode (Massei and Genov, 2004). This change in soil makes it nearly impossible for small rodents to make tunnels necessary for their survival (Massei and Genov 2004).

Numerous studies have also demonstrated that Wild Boar have a direct affect on other animal species. It has been reported that Wild Boar feed on multiple types of vertebrate and invertebrate species, in addition to vegetation (Massei and Genov 2004). S. scrofa in the United States, as well as in other countries, have been found to act as predators on various species of animals (Wilcox and Van Vuren, 2009). In Australia, one study showed that the predation of Wild Boar was reported to have an affect on 32% of newborn lambs (Massei and Genov, 2004). They were also reported to have a significant negative affect on ground-nesting birds as a result of eating their eggs (Massei and Genov, 2004). Both of these species numbers are greatly being diminished as a result of the predation of Wild

Board. Conservation of these animals may become a concern to people in the United States if Wild Boar numbers are not controlled.

Due to the threat Wild Boar have inflicted on the ecosystem, people have begun to fight against them to reduce their numbers. Game managers have encouraged hunting Wild Boar (Bratton, 1974). The national park also developed a program to control the population (Bratton, 1974). The population in one 78,500 acre area has ranged anywhere between 600 and 800 (Bratton, 1974). Even though they have been removing Boars at a constant rate, the species seems to be continuously expanding throughout the national park and other areas throughout the United States. There are numerous possible explanations for their continuous spread, including their opportunistic eating habits and high reproductive rates (Massei and Genov, 2004).

The biology of the Wild Boar in its native habitat and in its invasive habitat demonstrates specific characteristics that have created an invasive animal that is particularly successful throughout the United and numerous other countries. Because the boar has been found to have a very non-specific diet, an ability to gain large amounts of nutrients, and the tendency to increase litter size as they increase the latitude of their location, Wild Boar have easily established and spread throughout the United States, in areas such as Tennessee. As a result of their invasion, Wild Boar have caused immeasurable amounts of damage to the environment. They have also proved to be very difficult to stop. Wild Boar have become a nuisance to the United States, and it is certain that they are here to stay. Whether it will be possible to control the species is uncertain.

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