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A novel method for detecting wild boar presence

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Abstract: Populations of wild boar and feral pigs (*Sus scrofa*) are increasing in numbers and distribution worldwide, in parallel with their significant environmental and economic impact. Reliable methods to detect the presence of this species are needed for monitoring its natural range expansion and its occurrence in areas where animals have been deliberately or accidentally introduced. The main aim of this study, carried out in English woodlands recently colonized by wild boar, was to assess the effectiveness of a birch wood tar-based compound, to detect the presence of this species in presence/absence surveys. A pilot trial in woodlands where wild boar had been established for circa 20 years found that wild boar sniffed and rubbed their bodies against stakes treated with this compound significantly more than against control stakes treated with water, thus confirming that the birch wood tar attracted wild boar to stakes. A second trial, carried out by applying the birch wood tar to trees in 8 woodlands surrounding the core range of wild boar, found that these animals left consistently more activity signs such as rubbing, tusk marks, and rooting on or around trees treated with this compound than on or around control trees treated with water. These results suggest that birch wood tar can be used as a method to confirm presence of wild boar in an area. Possible applications of this compound include its use to increase trapping efficiency or its deployment to confirm the success of a local eradication.

Key words: activity signs, rooting, site attractant, *Sus scrofa*, tree-rubbing, wild pigs

Wild boar and feral pigs (*Sus scrofa*; hereafter referred to as wild pigs unless otherwise specified) are associated with significant economic and environmental impacts such as damage to crops and property, reduction in abundance of plant and animal species, predation on native species and on livestock, spread of diseases, and vehicle collisions (Massei and Genov 2004, Seward et al. 2004, Barrios-Garcia and Ballari 2012, Anderson et al. 2016, Bengsen et al. 2017). Increasing trends in wild boar numbers and range have been observed throughout mainland and Southern Europe (Massei et al. 2015). In addition, wild boar recently recolonized or were reintroduced to the United Kingdom and the Baltic states (Rosvold and Andersen 2008, Wilson 2013, Veeroja and Männil 2014). Similar trends in numbers and range expansion of feral pigs have been reported throughout the world and well documented in Australia and the United States as a result of natural expansion and illegal translocations (Centner and Shuman 2014, Bengsen et al. 2017, Lewis et al. 2019). For instance, in the United States, nearly all states where wild pigs occur exhibited increased population size during the last several decades and at the national level wild pig abundance increased from approximately 2.4 million in 1982 to 6.9 million in 2016 (Lewis et al. 2019). In parallel, several states recorded a significant increase in the spread of wild pigs: for instance, in California, USA, the number of counties where this species occurred increased from 9 in the mid-1960s to 47 during 2006 to 2007 (Sweitzer and McCann 2007).

Reliable methods to detect the presence of wild pigs are needed, particularly where the species occurs at low density, for monitoring either natural range expansion or occurrence in new areas where animals might have been deliberately or accidentally introduced and to confirm the success of eradications. Typically, where wild pigs occur at low density, methods based on activity signs, camera traps, or distance sampling might not be efficient or applicable due to low probability of encounter rate (Engeman et al. 2013, Chauvenet et al. 2017, Massei et al. 2018).

Ad-hoc methods to detect the presence of this species have been employed mainly following eradications, with the main aim of confirming, with an estimated degree of certainty, the absence of wild pigs from an area. These methods rely on combinations of baited traps, deployment of carcasses or bait to attract potential survivors, and on Judas pigs equipped with tracking devices to locate remaining groups of pigs (e.g., Cruz et al. 2005, McCann and Garcelon 2008, Parkes et al. 2010, Massei et al. 2011). However, these techniques have been rarely employed to monitor the natural expansion of wild pigs from a core population or to ascertain whether the species had suddenly appeared in a new area. The aim of this study was to test the effectiveness of a commercially available putative attractant to detect the presence of wild boar in presence/absence surveys.

Methods

The study was carried out in and around the Forest of Dean in Gloucestershire, England, United Kingdom (51°48.4′N, 2°33.1′W), managed by the Forestry Commission. Broadleaved trees cover approximately 45% of the forest and comprise mainly pedunculate oak (*Quercus robur*) with beech (*Fagus sylvatica*), sweet chestnut (*Castanea sativa*), rowan (*Sorbus aucuparia*), holly (*Ilex aquifolium*), and sessile oak (*Quercus petraea*). The rest of the woodland consists of stands that are mixtures of conifers, principally larch (*Larix decidua*), Norway spruce (*Picea abies*), Scots pine (*Pinus sylvestris*), Corsican pine (*Pinus nigra*), and Douglas fir (*Pseudotsuga menziesii*). The climate is temperate with annual rainfall of 745 mm and mean daily temperatures ranging from 5°C in January to 18°C in July. The feral boar population originated from escapes from a farm in the late 1990s (Wilson 2013) and is now monitored annually in all the main forest compartments (7,690 ha). Fallow deer (*Dama dama*), roe deer (*Capreolus capreolus*), muntjac (*Muntiacus reevesi*), and domestic sheep (*Ovis aries*) are also resident in the forest. In March 2013 the density of wild boar in the area, estimated using distance sampling, was 8.7 (95% CI 5.3–14.4) animals per km^2 (Gill et al. 2013).

In May 2013, a pilot trial was conducted with a commercially available, putative attractant for wild boar (Buchenholzteer, Bush Wear, Stirling, Scotland) made from birch wood tar (CAS-Nr.: 91722-33-7) to test whether these animals visited stakes treated with this compound more often than control stakes.

This compound was chosen for 2 reasons: (1). it was recommended by experienced hunters with direct experience of this product, and (2) it was plausible as a candidate attractant due to the wild pigs' habit to rub against resinous trees (Graves 1984, Heinken et al. 2006).

Eight sites were randomly selected where wild boar had been regularly observed. The distance between 2 neighboring sites was 1.4–7 km. At each site, 2 locations were chosen, 200 m apart from each other; each location had a wooden stake 1 m by 6 cm by 6 cm planted in the ground for ~30 cm, ~4 kg maize (*Zea mays*) placed in a plastic pipe tied to a tree about 2 m from the stake and 1 camera trap (Reconyx HC Hyperfire 500) placed at 1.2 m from the ground and overlooking the stake. At each site, 1 stake was treated with the attractant (a single brush stroke) and the other stake was sprayed with water and served as a control. The camera traps and the stakes were removed after 14 days. As on 3 sites neither treated nor control stakes were visited by wild boar, the trial was repeated in August 2013 when 12 new sites were used to increase the experimental sample size.

For each site, the number of wild boar visits was recorded, and each visit was assigned to one of the following categories: (1) "sniffing," (2) "scratching," and (3) "walking." One visit was defined as ≥1 photo of wild boar until there was a lapse of at least 10 minutes between consecutive photos; photos of wild boar taken >10 minutes later were counted as a new visit. "Sniffing" was defined as a wild boar extending its neck and snout within 20 cm from the stake; "scratching" was defined as a wild boar rubbing its body against the stake, and "walking" was assigned to all the visits where sniffing or scratching had not been observed. Data from May and August 2013 were pooled for the analyses, and a chi-square test was used to test whether sniffing and scratching were directed more toward treated than control stakes.

As this pilot test suggested the compound attracted wild boar toward treated stakes (see results section), a new trial was conducted in November 2013 to test whether it could be used to detect the presence of wild boar in 8 wood-

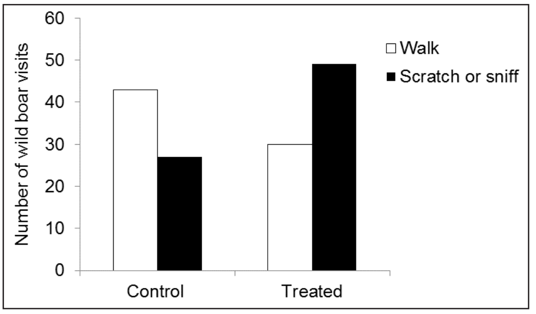

Figure 1. Number of wild boar (*Sus scrofa*) visits at 15 sites during a pilot trial where stakes were treated either with birch wood tar (treated) or with water (control) in May and August 2013. The activity of wild boar during a visit, observed through camera traps, was classified as either walking past the stake or sniffing/scratching against the stake.

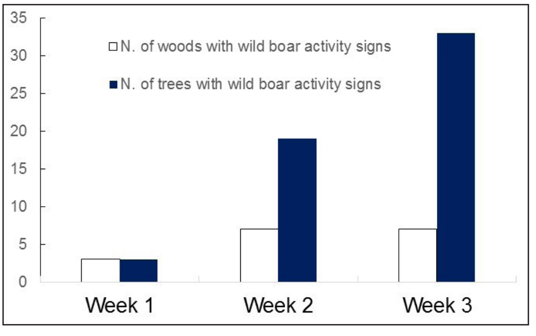

Figure 2. Number of woods with activity signs of wild boar (*Sus scrofa*) recorded on or around trees treated with the birch wood tar and total number of treated trees with wild boar activity signs (rubbing, hair, tusk marks, and rooting) in November 2013.

lands located 2.5–6 km from the edge of the Forest of Dean, where the main population of wild boar occurred. In these woods wild boar had been observed occasionally by forest rangers or dog walkers, but their presence had not been quantified or confirmed. These woods varied in size between 41 and 157 ha. Based on the movements of adult wild boar monitored through radio-tracking in the same area (Quy et al. 2014), these woods could be considered independent from each other (i.e., it was unlikely that the same wild boar visited >1 wood during the 4 weeks of the study). In each of the 8 woods, 9 pairs of broadleaved trees, 2–5 m away from each other, were selected. Where possible, treated and control trees belonged to the same species (oak, beech); conifers were not used, as wild boar tend to prefer these species for rubbing (Graves 1984, Heinken et al. 2006).

The distance between the closest pairs of trees within a wood varied between 120 and 300 m. For each pair, 1 tree was treated with the attractant and the other tree was sprayed with water. Treated and control trees were examined 1, 2, and 4 weeks after treatment with the attractant, and the presence of wild boar hair, mud, and tusk marks on the tree and of rooting around the tree was recorded. Camera traps were not used in the new trial, as the pilot study had indicated that wild boar only (but no other non-target species) rubbed against the stakes; hence, the presence of mud marks and hair was expected to be higher on treated than on control trees. A chi-square test was used to test the effectiveness of the site attractant by comparing the number of treated and control trees with wild boar activity signs.

Results

During the pilot trials conducted in May and August 2013, 149 wild boar visits were recorded around 12 out of 20 control stakes (n = 70 visits) and 15 out of 20 treated stakes (n = 79 visits). The wild boar activity of sniffing or scratching against stakes was directed more toward treated than control stakes ($\chi^2 = 7.258$, df = 1, $P = 0.003$; Figure 1).

Although non-target species (several species of deer [Cervidae], badgers [*Meles meles*], and grey squirrels [*Sciurus carolinensis*]) were occasionally observed near treated trees, no obvious pattern emerged to suggest that birch wood tar was attractive to these species.

The results of the trial carried out in the woods surrounding the Forest of Dean in November 2013 confirmed that wild boar occurred in 7 out of 8 woods surveyed. Further surveys in the remaining woods where wild boar presence could not be detected, based on recording activity signs on transects and on camera trap monitoring (J. Coats, Animal & Plant Health Agency, unpublished data), could not confirm that wild boar were present on this site and the woodland was removed from further analyses. At the end of the trial, 4 weeks after the birch wood tar had been applied, 33 treated trees out of 63 available in the 7 woods had tusk marks, mud or hair on the tree trunks or rooting around the tree, while no control tree had any sign of wild boar activity ($\chi^2 = 57.72$, df = 1, $P < 0.001$). If only the activity signs that wild boar left directly on the trees were considered, at the end of the trial 16 treated trees in 6 woods had tusk marks, mud, or hair while no control tree had any sign of wild boar activity ($\chi^2 = 24.52$, df = 1, $P < 0.001$).

The number of activity signs left by wild boar on or around trees treated with birch wood tar increased with time (Figure 2). By the end of week 1, only a single treated tree per wood in 3 woods had signs of wild boar activity; by the end of week 2, all 7 woods had activity signs on or around 1–4 treated trees per wood; and by the end of week 4, the number of treated trees with wild boar activity signs was between 3 and 6 per wood (out of 9 available in each wood).

Discussion

This study confirmed that wild boar were attracted to trees treated with birch wood tar. In the initial trial, the total number of wild boar visits to stakes treated with this compound did not differ from the number of visits to control trees; however, animals were observed sniffing and rubbing against birch wood tar-treated stakes significantly more than against control stakes. The lack of differences in the number of visits to treated and control stakes might have 2 explanations: (1) wild boar might have been attracted to each site by the maize placed in the vicinity of both treated and control stakes, and (2) suids are inquisitive (Wood-Gush and Vestergaard 1991, Kittawornrat and Zimmerman 2011) and wild boar might have been attracted by new objects, namely control and treated stakes. However, the higher number of sniffing and rubbing visits recorded toward treated stakes suggested the birch wood tar could act as an attractant. This was confirmed when the compound was applied directly on trees, as wild boar left signs only on and around the trees treated with birch wood tar but not on control trees monitored simultaneously. The fact that no food attractant was used when the birch wood tar was applied on trees confirms that wild boar were attracted to the site by the presence of this compound.

The number of activity signs such as rooting around the tree, tusk marks, and hair and mud left on the trees treated with birch wood tar increased with time, and the effect persisted for at least 4 weeks following a single application. In addition, birch wood tar did not appear to attract non-target species. The increase of activity signs with time suggested either that local resident wild boar took a few weeks to locate and use treated trees or that the birch wood tar might have attracted wild boar from neighboring areas. Future research should investigate the potential for this compound to attract wild pigs from nearby areas, though this would not be relevant for instances where the birch wood tar was used to test success of eradications or to detect the presence of wild pigs in a new site where immigration from neighboring areas could be excluded.

As wild pigs expand their range, due to natural emigration from core areas but also widespread deliberate introductions (e.g., Spencer and Hampton 2005, Saito et al. 2012, Wilson 2013, Centner and Shuman 2014), it is important to map the natural expansion of the species and confirm its presence in new areas to define areas for intervention. In these circumstances, wild pigs typically occur at relatively low densities, and methods traditionally employed to estimate the presence of the species (e.g., Engeman et al. 2013, Chauvenet et al. 2017, Massei et al. 2018) might not be cost-effective. For instance, detecting this species at low densities over large areas using camera traps or pellet counts might require too large an effort to be feasible (Davis et al. 2020). Similarly, detecting activity signs by wild pigs at low densities, either randomly or on transects, might not be practical, particularly during the dry season when trails and rooting signs can be hardly detected on the hardened soil (Welander 2000, Acevedo et al. 2007).

Little work has been conducted so far to detect the presence of wild pigs at low density. Notable exceptions are studies on eradications, as the success of such interventions depends on providing evidence that the whole population has been removed from an area. During eradications, detecting the last few animals is a task that requires significant effort of staff and time devolved to locating and removing survivors. To address this problem, managers often use an integrated approach where bait stations with food and carcasses (occasionally laced with toxicants) as well as traps and Judas pigs are placed in areas where the remaining animals might occur (McCann and Garcelon 2008, Parkes et al. 2010). As survivors are typically trap- and bait-shy, the removal of these survivors might take months, and confirming the success of eradication might take years (Morrison et al. (2007).

Food additives and other lures have been widely tested to attract wild pigs to traps (Lavelle et al. 2017, Sandoval et al. 2019) with various levels of effectiveness. The main problem with food attractants is their general lack of species-specificity, the fact that in some seasons the availability of natural food resources may limit their attractiveness and the restrictions imposed by many countries about the use of food attractants (Lavelle et al. 2017). Species-specificity is important when the aim is to attract target animals to traps while minimizing the trapping of non-target species. Specificity is also essential if the lure is employed to attract wild boar to bait containing compounds such as vaccines, contraceptives, or toxicants. To solve the latter issue, wild boar-specific devices such as the BOS (Boar-Operated-System) have been developed to prevent bait ingestion by non-target species (e.g., Massei et al. 2010, Campbell et al. 2011, Ferretti et al. 2014).

Compared to food attractants, scent-based lures do not require being replaced very often, particularly if effective for several weeks, can be stored in smaller spaces, and are generally species-specific (McIlroy and Gifford 2005, Sandoval et al. 2019). The use of birch wood tar tested by the current study had several advantages over other attractants previously evaluated: (1) low cost, as 2.5 L of birch wood tar that can be used for circa 100 applications on trees or stakes costs €14 EUR; (2) efficiency, as staff effort is limited to the initial application and to monitoring the effects in subsequent visits (i.e., 1 and 4 weeks later); (3) no observable effect on non-target species; (4) long-lasting effect, as the attractant maintains its effectiveness for at least 4 weeks and does not need to be replaced (unlike food attractants); (5) unlike food that might not attract wild boar when high-energy natural food is available, birch wood tar is likely to be effective, as a site attractant, in all seasons; and (6) no need to "pre-bait" as often done with food attractants, as a single application maintained its efficacy for at least 4 weeks.

The pungent odor of the birch wood tar might explain its attractiveness to this species. Wild boar wallow in mud and rub against trees, probably to remove ectoparasites. Conifers are preferred to other tree species (Graves 1984, Gerard et al. 1991, Heinken et al. 2006), possibly due to the anti-microbial properties of the resin (Savluchinske-Feio et al. 2006). Rubbing against substances with a strong smell (scent rubbing) is also widespread among mammals and associated with scent marking (e.g., Gosling and McKay 1990, Sato et al. 2014).

Overall, these results suggest that birch wood tar could be used to improve the probability of detecting the presence of wild pigs in areas where the density of the species is relatively low, such as newly colonized sites. Future studies should establish the long-term effectiveness of 1 or multiple applications of the attractant, the number of trees or stakes to treat per unit area to maximize the probability of detection, and the effectiveness of birch wood tar to attract animals throughout the year and in different habitat types.

Management implications

Birch wood tar could be employed to monitor the presence of wild pigs in a new area, to assess whether an eradication has been successful, and to quantify the range of this species at local scale, the latter assuming that the radius of action of this attractant could be estimated. The limitation of this method is that if wild pigs cannot be detected in an area where trees have been treated with the attractant, it would not be possible to infer absence of the species from that area. In this instance, employing other methods such as activity signs or distance sampling could also be used to determine whether wild pigs are present. Additional work should assess whether birch wood tar could be employed to increase the efficiency of trapping and/or of attracting this species to areas where vaccines and contraceptives are delivered in devices such as the Boar-Operated-System.

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