The use of human hair in green technology to reduce human-wild hog conflict from the agricultural perspective

Nur Suraya Kamsano[1,*], *Johan* Sohaili[2] , *Nur Sumaiyyah* Supian[3], *Shantha* Kumari Muniyandi[4] , and *Mohd. Fadhil* Md Din[5]

[1,3] Department of Water and Environmental Engineering, School of Civil Engineering, Faculty of Engineering, Universiti Teknologi Malaysia
[2,5] Institute of Environmental and Water Resource Management, Universiti Teknologi Malaysia, Johor Bahru, Malaysia
[4] Department of Quantity Surveying, Faculty of Built Environment, Tunku Abdul Rahman Universiti College, Jalan Genting Kelang, 53300 Kuala Lumpur, Wilayah Persekutuan Kuala Lumpur, Malaysia

Abstract. Human scalp hair (HSH) waste has often dumped without undergoing any proper treatment or even being reused. Past studies related to this waste in Malaysia is still not as wide as in others countries. However, in some rural areas, this waste is still used by farmers as pest controller to protect plantation from wild hog attacks. Unfortunately, the past practices does not expose their effectiveness as repellent. This study briefly discuss on the human-wild hog conflict, current practices used to control the invasive activity and to share the result of using HSH as repellent to help farmer of small orchid in Muar, Johor. In this pilot study, HSH were washed using the non-ionic detergent-acetone method as prior treatment to remove all impurities that might stick on them. In order to increase the probability of visitation, fermented corn bait has been used to lure the wild hog into the target area. Four (4) samples (A) 5kg whole corn; (B) 5kg whole corn mixed with 20g HSH; (C) 5kg whole corn mixed with 40g HSH; and (D) 5kg whole corn mixed with 60g HSH have been set on the private orchid and observed. The 5-day test indicates the potential of HSH as temporary wild hog repellent.

1 Introduction

Wild hog is classified under *Sus Scrofa* species along with others similar pests such as razorback, feral swine and any names related to them. This mammal has a highest rate of reproduction and posses good adjustment with the new environment. Despite known with their adverse impact on human economically and as a main agent for disease transmigration [1,2,3,4], this invasive species has an important role in variation and continuity of plantation species through its role as seed dispersal agent [5]. Moreover, the existence of this species has provide many positives values such as contribution in ecological chain,

* Corresponding author: nursuraya@utm.my

scientific purposes, and monetary [6]. However, the extensive number of this species has created a human-wild hog conflict in many countries including Malaysia. Study conducted in Australia show that, the damaged and severity losses due to their presence on agricultural land has cost at least $100M per year [7].

1.1 Wild Hog and Human-Wildlife Conflict (HWC)

Human-wildlife conflict (HWC) is inevitable because human and wildlife share the same habitats and nature resources. It happened when the wild animal gives negative impact to human life, behaviour or action that leads to poor implications to wild life [8]. Past study show that for a damage or conflict to occur, there are three essential elements involved namely; the wildlife species that contributes to the damage; the resources that become the object damaged by wildlife; and the person that is affected due to the damage [9]. This has been summarized as in Figure 1.

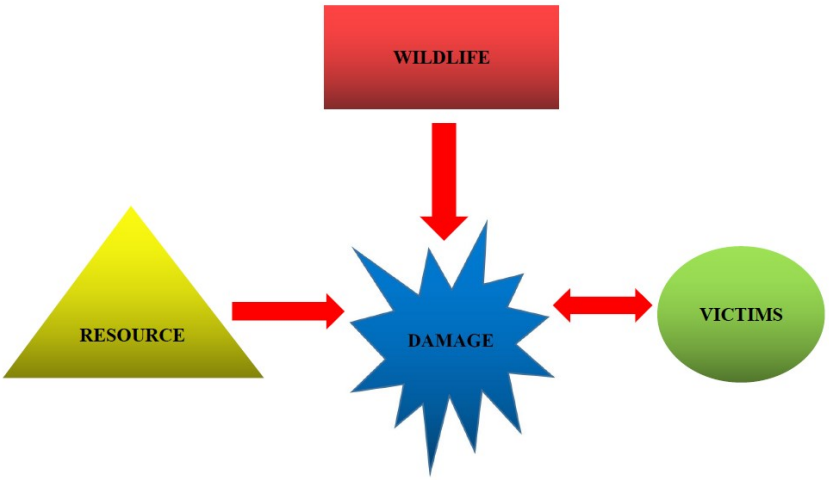

Fig. 1. Elements for a human-wildlife conflict to occur according to [9].

1.1.1 Threat to Human Safety

In Malaysia, many cases of wild hog attack associated with losses of crops and livestock. Only few reports found in respect to injuries and death by these animals attacks either by territorial assaults or ungulate-vehicles collisions. Although there is no documentation done on how much losses or statistics of injuries caused by animals attacks in Malaysia, many news related to the attacks have been reported. In July 2015, a report on death of an old couple has been made after being attacked by a wild boar while tapping rubber at a rubber plantation in Kuala Paya near Buloh Kasap, Segamat [10]. Meanwhile, in 2014, a senior citizen has been found injured after being attacked by wild boar in Kampung Ulu, Batang Melaka [11].

Fig. 2. Khatijah showed a stitch on the hand after being attacked by wild hog during on her way home after morning prayer. Source: [11]

Even though, the study up until recent on wildlife-vehicle collision and statistic on injuries and death in Malaysia is still not as wide as in others country, past study related with human injuries from observation done in Europe countries show that ungulate-automobile collision involve ungulates such as wild deer and also wild hog may contribute to most of human injuries and fatalities [9]. The number of cases involving wildlife-vehicle collision is indicated in Figure 3.

Table 3.5 Annual Number of Automobile–Wildlife Collisions in European Countries where Data Are Available (Groot Bruinderink and Hazebrook 1996)

Country	Roe deer	Red deer	White-tailed deer	Fallow deer	Chamois	Moose	Reindeer	Wild boar
Austria	35,000	400			30			140
Denmark	10,000	90						
Finland			700			150	350	
Germany	12,000	950		1800	220			6900
Ireland		2		70				
Netherlands	2500	10						100
Norway	3200	400				1500	3	
Sweden	50,000	30						
						4000		30

Fig. 3. Annual Number of Automobile-Wildlife Collision in European Countries. Source: [9]

1.1.2 Wild Hog as Reservoir for Disease Transmission

According to [12], wild hog is a moving bacterial disease reservoir that is capable of transferring malicious parasites that can affect human, pets or livestock. This phenomenon is known as Zoonoses which defined by [9] as a disease transmitted by animals, acting as host or reservoirs for the bacterial microorganism. Among the diseases that can harm human are leptospirosis, brucellosis, salmonellosis, and rabies [9,3]. The direct transmission happens from pests to human might be rare, but the possibility of the disease transmission to other animals is high and would eventually affect human and livestock [13]. Some of distributed diseases such as rabies, plague, tuberculosis, tularemia, brucellosis, and anthrax can cause fatality to an infected person [13].

1.2 Method Used to Regulate Invasive Activity of Wild Hog

Previous studies show, there are three popular methods used to reduce the invasive activity of wild hog namely through hunting; supplemental food; fences and other repellent system [14,15]. The use of electrical fences has become the most popular method of reducing the invasive activity of this species in Euro countries. However, this system requires a huge amount of money for maintenance, and in terms of economic aspects, this method is considered to be ineffective [15]. Meanwhile, the activity of hunting is less efficient to reduce the invasive activity as this species has the ability to restore its population and has the ability to adapt with new environment [14]. Moreover, in some coutries like Malaysia, the activities of hunting requires special permit as issued under the Firearm Act 1960 for Act 716 under Wildlife Conservation Act 2010. The practicality of the supplementary food has been in doubt of its effectiveness as it allows them to survive and eventually contribute to their reproduction and growth [16]. Apart from that, the use of olfactory repellent has gained people's attention and is widely used to scare this species. The use of predator's urine for example can prevent pests from leaving the area [17]. It is however quite challenging to collect the urine as most predators are dangerous. Besides, the use of artificial predator's urine which involves the chemical use is against the animal act, and it has the possibility to harm humans and plantations.

For so many years, the conventional use of human scalp hair (HSH) has become the alternative to reduce the invasive activity of wild hog in agricultural sector, especially in palm oil industry. Study in the past showed that, as these mammals used snout to detect food and ensure their survival, the use of HSH can potentially cause severe respiratory irritation and trigger fear to the swine [18]. In another word, their snout is important and has enable them to survive since piglet phase [19]. Stephens in his study highlighted that, an ideal repellent should meet several criteria which are user friendly; safe for both animals and human to provide temporary protection from over-grazing, low cost, easy to apply and time saving [20]. The following Table 1 shows the summary of repellent practices that have been practiced by other countries, the application, and the source of citation.

1.3 Human Scalp Hair (HSH) as Repellent and Its Use in Agriculture

Human scalp hair (HSH) waste is among the waste materials that accumulates in most water stream system and eventually causes problems to environment and maintenance due to blocked drainage system. However, its great potential in agriculture has changed the perception of many researchers. According to [22], HSH has become an important element in agriculture over the years especially it use as slow release fertilizer that provides essential nutrient for plantation and soil. There are cases where human hair is used as repellent especially for wild deer, rodent, rabbit and wild hog. The hair will cause discomfort and difficulty in breathing as the pests sniffing the HSH. However, the direct use of HSH on the soil have led to odor problems and pathogen. This is due to no prior treatment to the oil and organic matter that stick on the human hair before it is being used. The use of HSH as repellent for wild hog has proven to reduce the nuisance by reduction from 40% up to 50% [24].

Table 1. Summary of the organic pest repellent practices adopted by other countries.

Practices	Application	Country	Citation source
Human hair	To control rhinoceros beetle (*Oryctes rhinoceros*), to control wild boar (*Sus Scrofa),* other ungulates, also as slow release fertilizer.	India USA Mauritius	[21, 22, 23, 24]
Mixture of dry fish and fragmented human hair	To control squirrel	India (Assam)	[23]
Mixture of fermented urine with spices (*Curcuma domestica Val, Tinospora crispa(L.) Miers.hen jin t), Capsicum frutescens K., Allium sativum Linn.*	Pest repellent, combining combination of bitter component, spices to affect the neural system of pests, heat effects, strong taste, and urine to give a strong smell which at the same time acts as a fertilizer for soil.	Indonesia	[25]
Human urine	Biological pest control, human urine is a cheap and easily available fertilizer. It is rich with essential micro-nutrients for crop and soil.	Uganda	[26]
Local pigs dung spray solution	Traditional pest controller for wild boar. This prevents the movement of wild hog by creating confusion in their territory.	India	[24]
Egg solution spray	To control the browsing activity of wild deer. It also has been used to deter wild hog in India. Some commercialized repellents also use it as deterrent. Among the repellents are; Deer Away ® Big Game Repellent, powder, IntAgra, Inc. Minneapolis and Minn (4.93% putrescent whole egg solids).	USA	[27]
Capsaicin and capsaicinoid product	The material is believed to cause fear to the pests through taste and irritant effects. The pest repellent products that use Capsaicin as an important material in their products are Hot Sauce ®, Miller Chemical and Fertilizer Corp, Hanover PA (0.53% Capsaicin); and Deer Away ® Deer and Rabbit Repellent (DDR)	USA	[27]

Table 2. List of the countries conducting new research new research on HSH as compiled by [22].

New uses/ areas of research	Countries where research is undergoing
Liquid fertilizers	India, USA, Korea, and Bangladesh
Concrete reinforcement	Canada, India
Pollution control	Canada, Singapore, India, Iran, Korea, Egypt, and Jordan
Molded furniture and objects	UK
Engineering polymers	Singapore, China, Japan and India
Follicle cell cultures/ tissue regeneration	Switzerland, UK, Korea and France
Composite for superconducting systems	India, Grace, and The Netherlands
Flexible microelectrodes	China

Normally, the adult female pig or sow can be found (a) in groups, consisting of sow or her litter, (b) while the adult male are mostly companionless as shown in Figure 4.

Fig. 4. Image of wild hog from footage taken in November 2016.

2 Methodology

2.1 Hair Segregation, Hair Washing Process and Procedure

The collected hair from hair salon had undergone manually segregation process to separate the hair from visible pollutant such as shampoo bottle, plastic, hair clips and tissue. Hair that had been separated from the visible pollutant was placed in a clean polyethylene container and subsequently washed. Segregated hair was washed using non-ionic detergent-acetone washing method [28,29,30]. Hair was washed using mild detergent at first to remove all visible dirt and oil. After that, it were washed again with a 5% dilution of non-ionic detergent, rinsed and oven-dried overnight. Hair was then washed with 1:1 acetone and deionized water for 30 minutes and rinsed before oven-dried at 100ºC overnight. The process of hair segregation, hair washing is simplified in Figure 5.

Fig. 5. Collected hair from nearby hair salon was manually segregated and washed.

2.2 Study Area

This study on effectiveness of HSH as wild hog repellent has been conducted between 25th April 2017 and 29th April 2017 at a private orchard located in Kampung Parit Mohamad, Bukit Bakri Muar. This private orchard consists of a variety of corps such as tapioca, banana and fruit trees. Four (4) samples of food were used as baits with each of them comprised of; (A) only whole corn ; (B) whole corn with 20g of HSH; (C) whole corn with 40g of HSH; and (D) whole corn with 60g of HSH. The amount of whole corn used for sampling remained constant throughout the study. The amount of whole corn consumed was calculated by observing the remaining of whole corn throughout the study period.

2.3 Bait Preparation Before Field Test

The mammals under the *Sus scrofa* family are known for their distinctive feature which is snout. This feature developed since the piglet phase acts as their tracking system in order to find food, habitat, to locate their territory and prey. According to the past experience of some farmers, the smell of fish oil, vegetables, sweet and sour food has the ability to attract this species. In this study, fermented corn was used as simple way to lure wild hog to the site [31]. The selection of bait was made on basis of easy to consume and common practice used in baiting [32]. The whole corn was mixed with yeast, flavoured drink (strawberry and grape-flavoured) and water as shown in Figure 6. The mixture was mixed well and kept in clean polyethylene storage to let them fermented for two to three days before it can be used as bait.

Fig. 6. Whole corn was mixed with flavoured drink, yeast and water. The mixture was mixed well before fermented for 2 to 3 days.

2.4 Repellency Test on the Field

Field test was conducted in Kampung Parit Mohamad, Bukit Bakri Muar. 5kg of feed corn was used for four (4) samples per day; (A) 5kg whole corn; (B) 5kg whole corn mixed with 20g HSH; (C) 5kg whole corn mixed with 40g HSH; and (D) 5kg whole corn mixed with 60g HSH. The field test observed the effectiveness of the repellent by measuring the weight before and after feeding baits were used. The process is simplified in Figure 7.

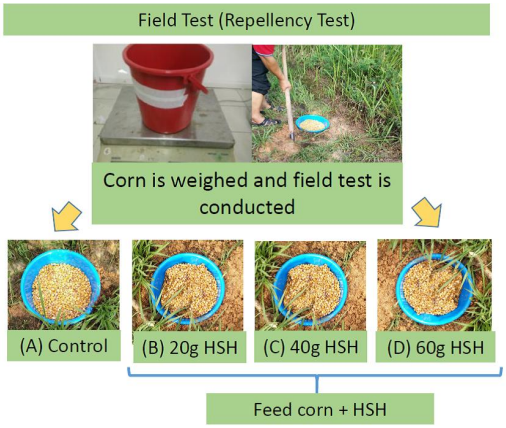

Fig. 7. The whole corn mixtures were weighed before and after the repellency test. The 5-day test results were observed and recorded to analyse the pattern.

Fig. 8. An image of wild hog taken from the study area during the observation.

3 Result and Discussion

The overall result of 5 days feeding test as depicted in the Table 3. The remaining whole corn readings (in percentage) show a slight change in day-1 and day-2 as shown in Figure 9 and Figure 10. For day-1, sample A (control) show about 10.6% of whole corn was eaten, while for day-2, 11% of the total whole corn is consumed during the field test. The reading for eaten whole corn from samples B, C, and D, did not show any significant change with B (2%), C (0.2%), and D (2%) for day-1, while for day-2 is B (4%), C (0.2%) and D (2%). The readings presume there is no presence of wild hog for their activities occur during the period of test. However, the study does not deny the possibility of the presence of other small invasive animals such as birds that may contribute to the slight change in readings for day-1 and day-2.

Table 3. The overall result of 5 days feeding test and weight of sample eaten by hog.

Day	Sample (in kg)			
	A	**B**	**C**	**D**
Day-1	0.53	0.10	0.01	0.10
Day-2	0.55	0.20	0.01	0.07
Day-3	2.95	0.04	0.00	0.00
Day-4	3.06	0.00	0.00	0.00
Day-5	2.00	0.00	0.00	0.00

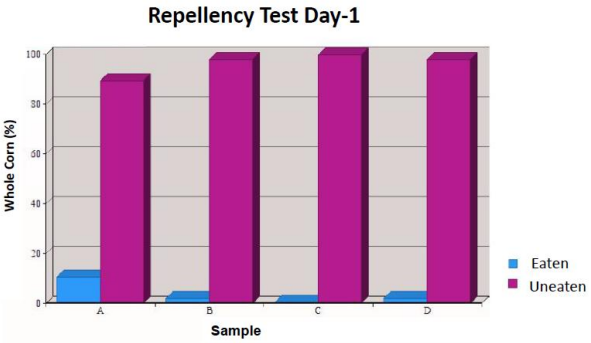

Fig. 9. Percentage of whole corn (%) of field test for day-1.

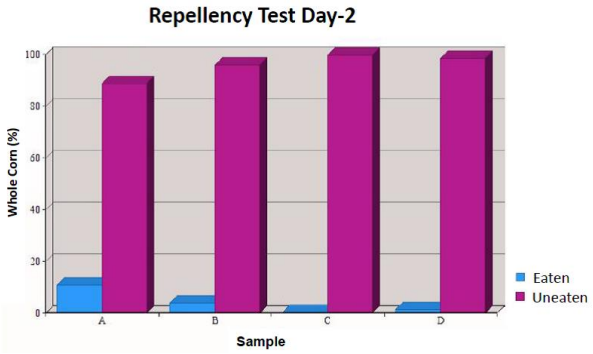

Fig. 10. Percentage of whole corn (%) of field test for day-2.

Meanwhile, day-3 and day-4 indicate the possibility of wild hog browsing activity in the study area because there was a major change in readings especially for sample A (control) as shown in Figure 11 and Figure 12. For day-3, 59% of whole corn was eaten while 61% of whole corn was eaten on day-4 for sample A. Readings for samples B,C, and D for both days did not show any significant change, only minor change can be seen for percentage whole corn eaten from sample B on day-3 which is about 0.8% that might be contributed by small pest like bird. Wild hog rely entirely on their olfactory sense as they have weak mechanism for both hearing and sighting [24]. In order to find locations and territories, food and prey, these mammals use their snout to sniff from one place to another. The use of hair will cause irritation to their respiratory tract as they inhale the hair during sniffing and create fear or sense of aware. This can be seen through sample B, C, and D that are not eaten and shunned by hogs as they mixed with hair.

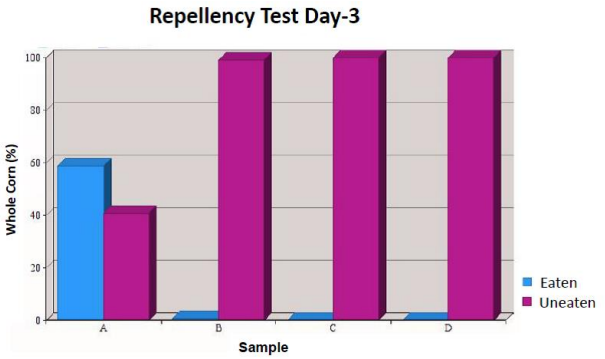

Fig. 11. Percentage of whole corn (%) of field test for day-3

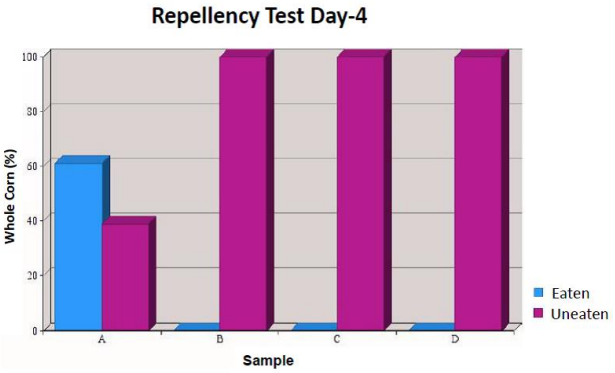

Fig. 12. Percentage of whole corn (%) of field test for day-4.

The day-5 reading shows the sensitiveness of wild hog towards the use of hair as repellent. The use of hair affected the reading. Reading for sample A (control) on day-5 showed a decrease in the consumption of whole corn with 40% of whole corn eaten compare to 61% of total whole corn consumed on the day-4. Meanwhile, reading for samples B, C and D remain unchanged as demonstrated in Figure 13. There are various possibilities, namely; whether the use of hair has caused fear and respiratory irritation to the wild hog or they roam elsewhere for source of food.

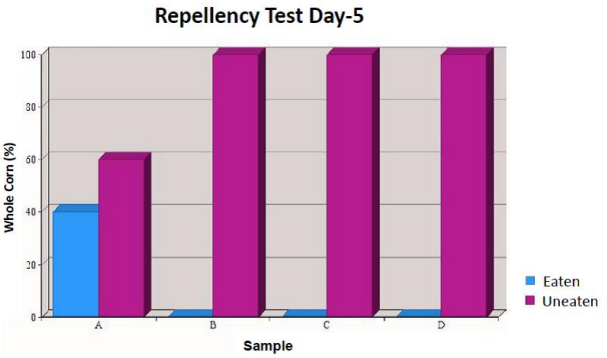

Fig. 13. Percentage of whole corn (%) of field test for day-5.

4 Conclusion

In producing animal repellent, several factors need to be taken into account. Repellent should be; user friendly; provide temporary protection from over-grazing; low-cost; easy to apply; time saving and safe for both animals and human [20]. Result from this pilot test indicates the potential of HSH as temporary repellent from wild hog browsing activity. However, studies in a controlled environment are currently being carried out to obtain the optimum value of hair usage to reduce the activity of these wild animals. This study is not only intended to prove the effectiveness of human hair and the possibility to be used as a repellent, but also to promote the use of HSH and the proposition value of hair waste in agricultural. The proposition value of HSH will significantly contribute to eco-friendly waste management at hair salon and to a safe disposal of waste through prior disposal treatment.

The authors would like to express sincere gratitude to farmers of Kampung Parit Mohamad for letting them to conduct the field study. Appreciation and thanks also to the technical assistant and technician staff from UTM Environmental Engineering Laboratory who were willing to help and provide equipment for the purpose of this pilot study. This study complies with the animal act 1953. No animal was harmed, abused or involved in cruelty as this study used only natural repellent which is not only safe for humans and plantations, but also for wild hog.

References

1. J. Corn, J. Cumbee, B.A. Chandler, D.E. Stallknech, J.R. Fischer. Implication of feral swine expansion: expansion of feral swine in the United States and potential implication for domestic swine. In *PROCEEDINGS OF THE ANNUAL MEETING-UNITED STATES ANIMAL HEALTH ASSOCIATION*, **109,** 295 (2005)
2. G. Massei, & P.V. Genov, . The environmental impact of wild boar. *Galemys*, **16** (especial), 135-145 (2004)
3. N.W. Seward, K. C. VerCauteren, G.W. Witmer, R.M. Engeman, Feral swine impacts on agriculture and the environment. *Sheep & Goat Research Journal,* **12** (2004).
4. R. Engeman, C. Betsill, T. Ray, Making contact: Rooting out the potential for exposure of commercial production swine facilities to feral swine in North Carolina, *EcoHealth,* **8(1),** 76-81, (2011)
5. E.W. Schupp, Quantity, quality and the effectiveness of seed dispersal by animals. In *Frugivory and seed dispersal: ecological and evolutionary aspects,* 15-29 (1993).
6. R.H. Giles Jr, Wildlife management. *Wildlife management,* (1978)
7. R. McLeod, *Counting the Cost: Impact of Invasive Animals in Australia,* 71 (2004)
8. F. Madden, Creating coexistence between humans and wildlife: global perspectives on local efforts to address human–wildlife conflict. *Human Dimensions of Wildlife,* **9(4)**, 247-257 (2004)
9. M.R. Conover, *Resolving human-wildlife conflicts: the science of wildlife damage management,* (2001)
10. K. Ann Kili, Elderly couple mauled to death by wild boar. The Star Online Retrieved from http://www.thestar.com.my/news/nation/2015/07/02/rubber-tappers-killed-by-wild-boar/ (2015).
11. Murali, R.S.N Close call with a wild boar. The Star Online. Retrieved from http://www.thestar.com.my/news/nation/2014/10/05/close-call-with-a-wild-boar-elderly-wo man-survives-dawn-attack/ (2014).
12. E.S. Williams, I. K. Barker, (Eds.) *Infectious diseases of wild mammals,* (2008)
13. T. Hutton, T. DeLiberto, S. Owen, B. Morrison, Disease risks associated with increasing feral swine numbers and distribution in the United States. (2006).
14. H. Geisser, & H.U, Reyer. The influence of food and temperature on population density of wild boar Sus scrofa in the Thurgae (Switzerland). *Journal of Zoology,* **267(1)**, 89-96 (2005)
15. A. Schlageter., D. Haag-Wackernagel, A gustatory repellent for protection of agricultural land from wild boar damage: an investigation on effectiveness. *Journal of Agricultural Science,* **4(5)**, 61 (2012).
16. S. Cellina, (Doctoral dissertation, University of Sussex) *Effects of supplemental feeding on the body condition and reproductive state of wild boar Sus scrofa in Luxembourg 18,* (2008).

17. A. Schlageter, *Preventing wild boar" Sus scrofa" damage-considerations for wild boar management in highly fragmented agroecosystems* (Doctoral dissertation, University of Basel). (2015).
18. M.L.K. Murty, Cultural Ecology of the Eastern Ghats (South India) from Pre-historic Times to the Ethnographic Present. *Peoples and Environment in India. New Delhi: Discovery Publishing House,* 51-78. (2001).
19. A. Kittawornrat, & J.J. Zimmerman, Toward a better understanding of pig behavior and pig welfare. *Animal Health Research Reviews,* **12(01),** 25-32. (2011).
20. O.L. Stephens, M.T. Mengak, G. Gallagher, & K.V. Miller, Using Milorganite® to repel white-tailed deer from ornamental plantings, Wildlife Management Publication Series (2005).
21. J.D Scott, & T.W. Townsend, Methods used by selected Ohio growers to control damage by deer. **13(3)**, 234-240. (1985)
22. A. Gupta, (2014). Human Hair "Waste" and Its Utilization: Gaps and Possibilities. Journal of Waste Management. (2014)
23. M.K. Deka, M. Bhuyan, & L.K. Hazarika, Traditional pest management practices of Assam. (2006).
24. V.V. Rao, B. Naresh, V.R. Reddy, C. Sudhakar, P. Venkateswarlu, D.R. Rao, Traditional management methods used to minimize wild boar (Sus scrofa) damage in different agricultural crops at Telangana state, India *International Journal of Multidisciplinary Research and Development,* **2(2)**, 32-36. (2015).
25. P. Rozaq, & N. Sofriani. Organic pesticide from urine and spices modification. *Asian Journal of Food and Agro-Industry,* **2**(Special Issue), (2009).
26. E. Andersson, Turning waste into value: using human urine to enrich soils for sustainable food production in Uganda. Journal of Cleaner Production, **96,** 290-298. (2015).
27. K.K. Wagner., & D.L. Nolte, Comparison of active ingredients and delivery systems in deer repellents. *Wildlife Society Bulletin,* 322-330. (2001).
28. Y.D. Cheng, X.P. Wang, Y.E. Qian, Y.X. Zhang, M.G Tan, Preparation and certification of the human hair reference material. Nuclear Science and Techniques, **3(4)** (1992).
29. J. Sen., & A.B. Das Chaudhuri, Brief communication: choice of washing method of hair samples for trace element analysis in environmental studies. American journal of physical anthropology, **115(3),** 289-291. (2001).
30. J. Sen, Human hair in personal identification and documenting drug and substance abuse. *Anthropologist*, **12(1),** 47-58.(2010).
31. L. B. Hanson, J. B. Grand, M. S. Mitchell, D. B. Jolley, B.D. Sparklin, & S.S. Ditchkoff. Change-in-ratio density estimator for feral pigs is less biased than closed mark–recapture estimates. *Wildlife Research*, **35(7)**, 695-699. (2008).
32. T.A. Campbell, & D. B. Long. Species-specific visitation and removal of baits for delivery of pharmaceuticals to feral swine. *Journal of wildlife diseases*, **43(3)**, 485-491. (2007).