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Electronic Pest Control Devices: A Review of their Necessity, Controversies and a submission of Design Considerations

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----------ABSTRACT----------
The use of Electronic Pest Control Devices has been bedeviled by lots of controversies bothering on their effectiveness. The arguments are that they are ineffective, partially effective or very effective. This work reviewed the underlying factors that led to the introduction of Electronic Pest Control Devices, their advantages over other pest control measures, and examined the controversies surrounding their usage. Investigation reveals that habituation is the reason behind the controversy while delay of habituation by the introduction of variability is a way out of the controversy. Design considerations and practices to technically fortify the device and aid in the delay of habituation were also proffered.

KEYWORDS: *Pests, conventional pesticides, habituation, design considerations.*

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I. INTRODUCTION

The continuing population explosion has confronted mankind with many problems, including the major one of imminent starvation. To cope with this challenge, aggressive agriculture was embarked upon at the turn of the nineteenth century. Agricultural mechanization led to the production of more crops for the populace. Storage programs were vigorously pursued to avoid wastage of surpluses. Then came the advent of pest infestation which also underwent population explosion to become a formidable enemy and threat to food sufficiency. Pests, in this light are unwanted animals that interfere with domesticated plants and animals [1]. They are insects, birds or rodents that cause damage to sown seeds, seedlings, fruits, seeds, flowers, buds, leaves, roots, and tubers of crops either in the field or in the store. Pests are estimated to consume 33 percent of crops grown in the United States. On a worldwide basis, pests consume approximately 35 percent of crops [2]. This represents an annual loss to pests of about $18.2 billion in the United State alone [3], while estimates of annual losses of cereals to the red-billed quelea range from at least $1 million in Somalia to $ 6.3 million in the Sudan.

II. CONVENTIONAL PESTICIDES

In order to devise an effective means to control the various pests that take such a heavy toll of our agricultural crops, pesticides were developed. Pesticides are chemicals designed to combat the attack of various pests on agricultural and horticultural crops. They are believed to affect the central nervous system of pests, resulting in their death. With the manufacture of the first synthetic organic pesticides called DDT (1,1,1-trichloro-2,2-bis-ethane) in 1942, it was estimated to have reduced losses to pest by half. More improvements in pesticides performance were recorded year after year. The acceptance of this technology by farmers led to more research and development in the pesticide sub sector which led to the introduction of a variety of pesticides. As at now, pesticide production is a $32 billion industry with its application standing at more than 5 billion pounds annually [4]. The story in developing and underdeveloped world where pesticides now flood the market attest to the acceptance and wide scale use of pesticides and its dividends. Researchers have shown that a lot of economic losses would be incurred without pesticide use and substantiated the resultant increases in yield from pesticide use [5]. In Ghana, which is the world's premier cocoa exporting country, the application of pesticides has almost tripled the yield and in Pakistan, extensive use of pesticides on sugar crop increased the yield by 30 percent. The United Nations Food and Agricultural Organization (FAO) have estimated that without the use of pesticides, some 50 percent of total cotton production in developing countries will be destroyed by pests. It is clear that pesticides may be the single most important factors in improving food production in the underdeveloped countries [6].

2.1 The Drawbacks

Ideally, a pesticide must be deadly to the targeted pests but not to non-target species, including man. Unfortunately, this is not the case. Their usage has cause havoc on human and other life forms [7]. While some results claim that, in the environment most pesticides undergo photochemical transformation to produce metabolites which are relatively non-toxic to both human beings and the environment [8], most say otherwise. There is now overwhelming evidence that some of these chemicals do pose a potential risk to humans and other life forms and unwanted side effects to the environment [9 and 10]. Pesticides are known to move from treated area by drift at the time of application and subsequently end up in the atmosphere or in the soil [11]. Pesticides collected on the target may be washed off later by rain or in some cases by overhead irrigation. Some estimates have suggested that up to 80% of total pesticides applied to the plant may eventually reach the soil. Contamination of soil in this manner has caused major changes in the population of non targeted organisms [12]. The economic impact of pesticides in non-target species (including humans) has been estimated at approximately $8 billion annually in developing countries [7]. For example, earthworm numbers have been reduced to over 60% following application of benony [13]. This potential danger of pollution from pesticides was put forward by Carson (1963) just a little above half a century of its use. Surface water contamination, ground water contamination, soil contamination and air contamination were the major primary link of toxicity [7]. The aftermaths of this contamination on target and non target organisms of the ecosystem include resistance to chemicals [14], chemical and biological degradation [15], accumulation along food chain [16], effect on fish [17], birds [18] and finally possible toxicity to man. The short and long term effect to the person using the pesticide and to the public that consumes the food grown using pesticides includes mutation, cancers, abnormal birth to mention just a few [19]. Records of death and diseases due to pesticide poisoning stands at about 1 million per year [20].

2.2 The Way Forward in Pest Control

Non-chemical pest control methods have been advocated as the best way to reduce pesticide contamination in our environment [7]. These pesticide-free alternatives to raising food include biological control, genetic control, cultural practices, physical control and the broad based integrated pest management. All these methods have their challenges from either being ineffective to being too sophisticated, but physical control of pests is most friendly. Physical control means the physical elimination of pest or physical alteration of the environment to make it inimical or inaccessible to the pest [1]. This type is divided into two categories: The physical method may involve the use of physical hand picking, use of barriers and the use of traps and secondly the environmental manipulation method. The later engages ecological factors against pests. Temperature, relative humidity, dehydration and sound among others have been manipulated against pests with some level of success.

III. ELECTRONIC PEST CONTROL

Electronic pest control refers to the various means of repelling pests using electrically powered devices. Such devices are either known as electronic pest repellers, electronic pest chasers, electronic pest deterrent, electronic pesticides or generally as electronic pest control devices. They form part of the physical pest control methods which only recently became popular due to their environmentally friendly nature which is their advantage over the conventional pesticides. There are basically two types of electronic pest control devices widely available: The Ultrasonic devices and the Electromagnetic types. Ultrasonic devices operate by transmitting high frequency sound waves greater than 20,000 Hz. While some animals such as dogs, bats, rodents, birds and insects can hear well into the ultrasonic range. The human ear lacks the capacity to hear such sound. Ultrasonic devices are designed and constructed to emit sound of this frequency, when targeted at pests; they make them uncomfortable within the area of coverage thereby repelling them away from the area without affecting the environment and non-target organisms, including man. Electromagnetic devices are fitted into home wirings and emit electromagnetic waves which are inimical to pests. The advantages of this method over other pest control methods includes the fact that they are cheap, eco-system friendly, environmentally friendly and have no known risk to humans [21].

3.1 Electronic Pest Control Devices, the Controversies

Controversies however surround the effectiveness of electronic pesticides. While some agree that ultrasonic sound devices do have a repellent effect on various insects such as crickets and cockroaches, others say that ultrasonic sound have little or no effect on some pests such as ants or spider [22]. The US Federal Trade Commission had sanctioned a manufacturer of such devices on grounds of ineffectiveness [23]. However, work from independent researchers shows that the device successfully repelled rodents from a protected area in 13 out of 17 sites studied. This represents an 81.3% success rate [24]. Others report that the device repelled rodents from the immediate area of the device for a few minutes to a few days, but later the pest resumed normal

activities. Thus, concluding that electronic pest control devices have a partial effect on pests. Nevertheless, others attest that electronic pest control devices have helped in solving their pest problems and can be rated as being effective [25].

3.2 Way Forward for Electronic Pest Control Devices

From arguments on all sides of the controversy, it is clear that, the idea of electronic pesticides are not a failure neither is theirs eco-friendly nature in contention; but that they only have a partial or temporary effect on pests. Rather than dwell on the controversy, a number of researchers concluded that based on the mixed results, more research is needed to improve these devices [22]. Accordingly, "ultrasound" is being re-examined in the light of modern electronic technology. Taking advantage of the increased awareness of the biology of pests, their response to artificial sounds and vibrations, their hearing range and electronic knowhow, these controversies can be cleared by further fortifying the device. The major reason for this claims and counter claims is a single factor: "habituation". Habituation is what makes a person or animal to become familiar to something through prolonged and regular exposure [26 and 27]. It is an important defensive mechanism in animals and an initial response to a new stimulus. The claim of some users that electronic pesticides have a temporary or partial effect on pests is due largely to the fact that, on receiving the initial ultrasonic stimulus, pests get repelled at first instance, but gradually become familiar with the stimulus and later completely adjust and resume normal activities. This agrees with the observation that it becomes ineffective after a few weeks. Habituation to electronic pest deterrents occurs because they depend on repeated exposure, operating continuously. This occurrence will continue until an antidote for habituation is discovered and electronically incorporated into the design. A lasting antidote for habituation is punishment or reward. So long as no physical harm befalls the pest on sensing the ultrasound signal, they are bound to habituate, finding no need to keep off feeding when no punishment is involved. Such harm as striking or killing may not only generate more controversies as in chemical pesticides but may also be difficult to achieve electronically. The way forward therefore is to delay habituation.

IV. DESIGN CONSIDERATIONS

Electronic pesticides currently in use which are at the centre of this controversy are not technically fortified and not well handled to slow down the rate of habituation. Below are some design considerations and practices to technically fortify electronic pest control device and aid in the delay of habituation.

4.1 Specificity

Nearly all electronic pesticides claim to control more than one pest. Others are even intended to control insects rodents and birds. But the theory behind these devices is to target the hearing range of these pests and operates within the range [28]. From the biology of pests, hearing range differs from insect to insect or from rodent to rodent [29] or specie to specie [30]. Therefore, for a device to be effective, it must target a pest, identify its hearing range and be specifically designed for the targeted pest and a few others that may share same auditory biology. Specificity goes beyond a target pest, but location also. The specie of weaver birds at work in a farm in the U.S may differ from those devastating farms in northern Nigeria. Environment plays a major role in the biology of even same species of animals [31]. Therefore, for an electronic pest control device to be effective, it must be both pest specific and site specific.

4.2 Variability

Animals, pests inclusive, exhibit habituation [32]. They tend to become familiar with the initial scaring effect of an electronic pesticide [22]. The practicable remedy for habituation advocated in this work is variability. Habituation begins gradually but, depending on the target pest, might take up to months [33]. Weaver birds, for instance, take about two months to fully habituate. There is therefore a need to always introduce unpredictable parameter changes; for instance, change in frequency, pitch, intensity, incorporated sound and so on. Changes in stimulus tend to delay habituation [34], as a variation introduced further fortifies the device's efficacy followed by a gradual habituation and then another variation. By so doing, complete habituation is delayed and in farm situation, this delay may be long enough to last up to the end of harvest.

4.3 Propagative Power

Existing electronic pest control devices are propelled by simple low power amplifiers. Thus, they have a low power output resulting in small area of coverage. In some cases, just a few meters away from the stand might be secured while pests further away have a field day feasting on farm produce. Ultrasound can travel a distance of about 300 meters in the atmosphere depending on the frequency of propagation, but with a high-power built-in amplifier, the reach will increase and the magnitude of disturbance responsible for the scary effect is further increased and propagated to farther distances.

4.3 Tripping System

The rate of habituation can be delayed by judicious use of electronic pest control devices. Rather than having these devices operating continuously or at regular intervals, they should be activated only when the pests are actively present on the farm. For instance, weaver birds feed all through the hours of daylight. It makes no sense having an electronic device operating continuously all through the night as repeated (or continuous) presentation of a stimulus will cause a decrease in reaction to the stimulus thereby initiating habituation [32]. Active pest period noted during field survey should be considered and accommodated in designing an electronic pest control device incorporated with features capable of identifying such periods or even sensing pest activities and then tripping on and off when necessary.

4.4 Field Study

When a farm or any place infested by pest is identified, an electronic pesticide should not be applied until an intensive field study is first carried out. Such a study will reveal the type and specie of pest, hearing range, threshold sound hearing capacity, stage(s) of attack, behaviour of the pest to various test parameters such as sound, light, smell, images and their respective times for habituation. The outcome of such a survey will be useful in designing an electronic device using parameters of interest that will be effective on that farm against the targeted pest. The existing approach which is devoid of field study contributes to the controversy surrounding the efficacy of electronic pesticides because shortly the pesticides are introduced and they begin to work, the pests later habituate, prompting the conclusion about the inefficiency of the device. With thorough field studies, effective scaring parameter can be identified and some variability introduced to further fortify the device.

4.5 Timeliness

Electronic pesticide does a better job when introduced at the right time. A targeted pest severely attacks at specific stages of crop development. For instance, milking, fruiting, ripe/matured grain stage and so on. These stages when identified during field survey serve as guide to timely introduce the device. This helps to take care of habituation as the pests are stopped at a damaging stage by a yet effective device, so that by the time habituation sets in the crop should have passed the critical stage of vulnerability. This is more effective than a case where the device is stationed on a farm all through the farming season. In such cases, the pests get familiar with the device and may completely habituate even before greater damage begins. The rate of habituation also differs. For instance it takes two to four weeks for song birds to completely habituate to sound [33]. A user is therefore guaranteed of a better pest cover at delicate crop stage within this period. As part of timeliness, it is also advocated that crops be harvested at the instance of maturity. Farmers should not delay in harvesting, even at the presence of an electronic pesticide on their farm, as habituation can set in at such point leading to significant losses.

V. CONCLUSION

Looking at the economic impact of conventional pesticides to non-target species (including humans) and its benefit vis-à-vis that of electronic pest control devices, the path of safety can be drawn by weighing all the risks against the benefits on both sides. The safety associated with electronic pest control devices cannot be overemphasized. The controversy trailing its usage can be overcome by judiciously implementing the design considerations proffered in this work. The focus of further research is on how these ideas can be implemented to put forward an effective electronic design for electronic pest control devices capable of surmounting the challenge of pest infestation and settling the controversies surrounding the efficacy of such applications.

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