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# Impacts of Rodents Pests on Cocoa (*Theobroma cacao* L): A Mini Review

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***Author's contribution***

*The sole author designed, analyzed, interpreted and prepared the manuscript.*

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## ABSTRACT

**Aim:** To assess the impacts of rodent pests on Cocoa (*Theobroma cacao*) production and productivity.

Rodents belong to the mammalian order that is widely distributed globally. Their adaptive potential and capability to face changing environments even when instigated by anthropogenic activities is quite amazing. Also, their importance as vital links in food chain between species of plants and the predators thereby playing crucial roles within the ecosystem cannot be overemphasized. Rodents have been noted to cause ubiquitous damage to agricultural crops including cocoa. They can cause damage in crop fields from planting throughout harvest and storage. The damages caused by rodent pests mostly occur during the sensitive young seedling stage and just prior to harvesting. The pattern and the extent of damage by pest rodents depend upon the species, the intensity of infestation, the type and the growth stage of the crop, and the nature of the surrounding habitat. These damages caused by rodent pests could be direct through the consumption of cocoa beans or indirect through the biting, gnawing or scratching of pods which could range from slight to severe. The stern impacts caused as a result of rodent pest activities are not only felt in the quantity and quality of cocoa pods but also on the social maintenance as well as survival of those growing the crop. Despite the paucity of documented data as regards the kind, form as well as ferocity of rodent damage, it is highly expedient to re-evaluate the rodent pests' impacts on the production of cocoa so as to update the very scarce available information whilst providing a basis for additional investigation.

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## 1. INTRODUCTION

Rodents are vital and ever-present group of mammal species that exist as native or introduced species globally [1]. They make up the biggest and most prosperous group of mammals in the world. They have a high fecundity rate with the capability to adjust to varying habitats (Parshad, 1999). Reportedly, this has made them to be the most diverse order of mammals due to their extraordinary proliferation [2]. They are usually small-bodied animals with a short life span and are important biotic components of a variety of habitats within the environment [3]. Even though rodents have been reported to opportunists, their success is known to be partly attributable to their recent evolutionary history with populations retaining large as well as untapped stock of genetic variability. Another reason is the fact that rodents have a wide range of diet including a variety of plant materials and also invertebrates such as insects, spiders and worms [2]. Some of these rodent species are nefarious in their activities and as such, have been considered as pests to agriculture [4] though they play an important ecological role as prey of various medium sized predators [5].

Cocoa, *Theobroma cacao* L., is one of the main cash crops that are being cultivated especially within the tropical areas of West Africa, South America, the Caribbean, as well as Asia [6,7]. According to Appiah [8], more than 70% of the global cocoa production emanates from West Africa and it is an important component of most West African rural economy since majority of peasant farmers depend on it as their means of livelihood. Cote d'Ivoire alone contributes 40% to the global cocoa production, being a vital global commodity, with an estimated value of over US$10 billion [9]. Within global markets, cocoa has been reported to be a very lucrative and competitive non-subsistent crop and categorized highest as regards being a source of income [10]. In fact, cocoa and cocoa derivatives have recognized as key dietary sources of antioxidants due to their high phenolic composition [11]. In the very recent times, the production of cocoa has been on the drastic decline due to many factors, one of which is the menace of pests [12]. According to the European Crop Protection, pests generally are organisms with peculiar structures that can be seen as destructive, as it disturbs agricultural production by infesting crops or acting as parasites to livestock. In fact, it is very plausible for an animal species to actually be a pest in one hand and as well domesticated or beneficial in another [13]. Examples of insect pests of cocoa include Mirids, Cocoa pod borer, Thrimps, Cocoa beetle, Stemborers, Broad mite, Yellow peach moth and Flower-eating caterpillars. Though animals like monkeys and rodents help in the natural spreading of cocoa especially in the wild by breaking pods that are ripe and feasting on the very sugary mucilage round the beans, their nefarious activities as pests cannot be underestimated [14]. This review therefore tried to examine the impacts of rodents as pests on the quality and production of cocoa (*Theobroma cacao*).

## 2. RODENTS: A UBIQUITOUS MAMMALIAN ORDER

The order Rodentia is one of the most widely distributed orders of animals throughout the world. There are more than 2700 rodent species that have been described, and the Rodentia order accounts for nearly half of all mammalian species [15,16]. They are significant contributors to ecosystem biodiversity in sub-Saharan region of Africa [17] and not merely serve as food for reptiles, avian, and mammalian predators but also are vital primary consumers of herbage and seeds [18]. They are primarily seed eaters, but some are insectivorous and some are omnivorous as well. Oosthuizen and Bennett [19] reported that populations of small mammals like rodents are influenced by food availability, plant cover, rainfall and environmental conditions. Pest rodent populations have the ability to grow rapidly in response to good environmental conditions because they have high rates of reproduction and survival [20]. Their importance as vital links in food chain between species of plants and the predators thereby playing crucial roles within the ecosystem cannot be overemphasized. Of noteworthy is the fact that rodents always have preference for a particular habitat throughout their entire life instead of using the very complex environmental indices that delineate a precise habitat [1]. As a result of cover and food requirements, rodents are most likely to be unfavorably impacted through habitat over-usage by larger mammal species of either wild or domestic origin [21]. About two-third of the living rodent species belongs to Murids while the genus *Rattus* accounts for most of the species [22]. As documented by Brown et al.

[23], there are five broad sub-orders of rodents based largely on their jaw structure and gnawing phenology as well as function: Castorimorpha (beavers, pocket gophers, kangaroo rats), Anomaluromorpha (scaly tailed squirrels, springhares), Hystricomorpha (African mole rats, porcupines, cane rats, chinchilla rats, cavies, guinea pigs, capybara, agoutis, nutria, coypu), Sciuromorpha (mountain beaver, dormice, squirrels, chipmunks, prairie dogs, marmots) and Myomorpha (jerboas, muskrats, voles, lemmings, true mice and rats, mole rats, spiny dormice, bamboo rats). Damage to crops by rodents is largely attributed to multi-mammate mouse, *Mastomys natalensis* Smith 1834 and Nile rat, *Arvicanthis* sp. [24].

Rodents constitute one of the main nuisances to man. For thousands of years they have been causing damage to crops, stored grain and infrastructure, and are reservoirs for devastating human diseases such as plague and typhus [23]. The order Rodentia is among the very significant pests of agriculture globally. This is fundamentally as a result their fast breeding response to satisfactory conditions of the environment, high adaptation as well as species diversity, life history characteristics and prevalent geographic distribution [25]. The damages caused by rodent pests mostly occur during the sensitive young seedling stage and just prior to harvesting [26] while the damages and destruction up to 30% of the crops during the pre-harvest periods have been earlier estimated [27]. Also, due to their successful acclimatization to being in the vicinity of humans, and their efficient reproduction, many of these rodent species are a pest for the human populations too as they are vectors of various human diseases [16]. These pest rodents can either be native to a particular area or introduced by humans. Singleton et al. [25] summarized causes of rodent outbreaks and named three categories, which include; outbreaks triggered by masting, changes in abiotic conditions and changes in cropping systems. Succinctly, the actual pattern and levels of rodent infestation, and the extent of damage vary in geographical location, crop variety, length and method of storage, the species involved, and climate [28].

## 3. THE COCOA PRODUCTION AND INDUSTRY IN BRIEF

The African continent has been reported to be the leading producer of cocoa, producing 68% of global cocoa while the main producing African countries are Cote D'Ivoire, Nigeria, Ghana, and Cameroon, in no particular order [9]. In India, cocoa is being cultivated in four states of Kerala, Karnataka, Andhra Pradesh as well as Tamil Nadu resulting in total production of 16,050 MT in an area size of about 78,000 ha [29]. The cultivation of cocoa has been noted in some 50 tropical countries globally [30] while about 90% of global cocoa production is by 5 to 6 million small-holder farmers and generating household income for them [31]. Remarkably, cocoa production also generates foreign exchange for the countries producing them. In 2012, global production of cocoa reached 4 million tonnes while chocolate is the major desired cocoa product whose worldwide trading generates a sum of $105 billion [32]. In lieu of this, cocoa is believed to be an important commodity in developing countries, with some of these countries' economies depending largely on the cocoa market. Traditionally, cocoa is cultivated under varied indigenous tree shade, gradually seen as a way of contributing to the conservation of biodiversity especially within agricultural settings [33]. Consequently, the style of cocoa production has been altered significantly over the last decade, with massive modifications especially in terms of where the crop is grown [34]. Specifically, cocoa cultivated under the canopy of original forest is seen as the most environmentally friendly form of production. Although recent cocoa production has been relatively stable over longer periods with dramatic alterations occurring, [35] opined that full-sun cocoa farming is presently the most prevalent cocoa cultivation system especially in the world's sub-humid and humid regions. The cocoa production system has played a crucial function in the revolution of lowland forest tropical landscapes in Africa, Latin America, and Asia for a long time and even up till now [36]. As a major cash crop, its life span is often between 15 and 40 years. According to Adabe and Ngo-Samnick [32], there are three major varieties of cocoa which are the "Forastero", "Criollo", and "Trinitario". Among these varieties, the "Forastero" is the one that is usually cultivated though it is not as good as the other varieties in terms of flavor. Ecologically, cocoa tree belongs to the Malvaceae family and is a tropical plant grown for its beans, from which cocoa butter and powder are gotten [32].

Cocoa being a perennial crop is grown either in agro-forestry systems in which certain part of the natural forest is left in place or in newly converted or cleared land [37]. The cocoa

agroforestry has been existing for a while now, the supplementary benefit of carbon capture from this farming system where non-cocoa trees make provision for shade for cocoa seedlings has stimulated attention from conservationists [38]. Even though agro-ecosystems with low diversity of species have been reported to be more prone to the attacks of pests, the monocultures of cocoa are not really exempted [39]. The cocoa bean which is used in beverages as flavoring, and in chocolate production, has been found to provide many nutritional and health benefits; including the ability to lower blood pressure, while the pod can be processed into animal feed supplement. Additionally, the cultivation of cocoa has been reported to be a driver of deforestation as well as forest degradation throughout the high forest zone as a result of extensive farming activities and infringement into gazetted human and forests settlements [40]. Therefore, the economic and political significance of cocoa can be said to be of immense importance especially for the producer nations in terms of generating income and foreign exchange earnings.

## 4. MAJOR PESTS OF COCOA

The incidence and infestation of pests is of utmost importance especially in relation to plant phenology and as well as deriving optimal productivity. Among the action areas identified in sustainable cocoa production, pest as well as disease management is of utmost importance in ensuring long-term sustainability in yield [41]. Just like most (if not all) flora species, the cocoa species can be infested by a varying number of pests and as well infected by varying diseases. Most times when this occurs, the production and quantity and quality is often affected while the economies and expectations of the farmers are probably not met [6] Pest infestation has been reported to be a major problem in cocoa production having been reported to be impacted by a variety of pests [42] with few estimation losses pegged at as 30-40% of worldwide production ([43,44]. More than 60 species of vertebrates have been estimated to become pests of cocoa [45]. Some of the mammalian pests even inflict great loss which can be a severe problem on cocoa yield worldwide [46]. Generally, the pests affecting cocoa are classified into insect pests and mammalian pests. Furthermore, some of the mammalian pest inflict unimaginable losses and can be a serious problem on cocoa yield globally [46]. One of the reported mammalian pests of cocoa is civet [47]. Particularly for the palm civets, the nature of their damage to cocoa is such that they bite and break the husk unlike the rodents that gnaw holes on the pods [48]. Generally in civet-damaged pods, two distantly placed markings caused by the canine teeth are very prominent on the husk. Rodents have been noted to cause ubiquitous damage to agricultural crops including cocoa [34]. In spite of improvements in management techniques and control methods, rodents (particularly rats and squirrels) continue to cause severe damage to crops like cocoa [49]. The types of damage imposed by rodents to these agricultural crops include the destruction of seeds after sowing and damage of the stem of a mature crop [50]. Therefore, the ecology, biology, and behavior of rodent species occurring within the diverse environments ought to be assessed carefully so as to come up with fruitful rodent control plans [1]. In lieu of the above therefore, pest management is usually problematic for cocoa farmers, especially in Africa and Asia, because of inadequate farmer's knowledge and practices, including restricted access to resistant varieties and agrochemicals [51]. As such, pest management can be seen as one of the critical components especially in the health management of cocoa.

## 5. RODENTS AS KEY PESTS OF COCOA

Almost all cultivated crops are vulnerable to rodent depredation at some stage or the other of the crop growth and maturity. Globally, rodents and other wildlife pests account for approximately 10% of economic losses to cocoa pods [52]. Globally, rodents represent vertebrate group that inflict substantial damage to an array of agricultural crops [53]. They are mammalian species that possess gnawing incisor teeth with no canine teeth [54]. In fact, rodent pests have been designated as the main cause of crop damage globally thereby seriously capable of jeopardizing food security [49]. Tropical crops damaged by rodents include coconuts, maize, coffee, beans, citrus melons, tubers and cocoa [55]. In addition, recently, they have been identified to be part of the world's most significant pests (Buckle and Smith, 2015) relishing momentous damage to agricultural production throughout the globe [25] even though it has been estimated that less than 10% of rodent species are major pest species of agricultural and urban areas [56,57]. Specifically, rodents have been documented to be the key pests of cocoa in almost all cocoa growing countries of the world [58]. Species such as the black rat (Rattus rattus), Western Ghats squirrel

(Funambulus tristriatus) and South Indian Palm squirrel (F. palma rum) are considered to be the major ones [59]. Aside from the unquantifiable damages to cocoa production, rodent pests also affect the livelihood of farmers [60]. This is to say that these rodent species that are crop pests are a long-standing and costly challenge for small-holder farmers who are the major producers as well as important component of the cocoa production and processing chain. They can cause damage in crop fields from planting throughout harvest and storage [54]. Their adaptive potential and capability to face changing environments even when instigated by anthropogenic activities is quite amazing. Therefore, the pest status as well as species importance are determined by rodents' damage potential and field abundance [14].

## 6. TYPE AND NATURE OF RODENT DAMAGE TO COCOA

Rodents have been listed as pests of cocoa in most growing regions of the world [61]. They are particularly problematical since they can wreak huge economic damage related with their diversity, abundance, feeding habits as well as high fecundity [62]. The pattern and the extent of damage by pest rodents depend upon the species, the intensity of infestation, the type and the growth stage of the crop, and the nature of the surrounding habitat [63]. Different rodent species have been reported to cause damage in varying parts of the cocoa tree [64] while the extent of cocoa pod damage has been documented to range from slight to severe [65]. Whilst the damage potential of rodents to cocoa have been noted [66], these damages to ripe pods are either direct (as a result of the consumption of cocoa beans) or indirect through the biting and scratching of pods. According to [64], the biting damage is highly unique such that a hole is chewed within the mucilage surrounding the ripe pod which is usually but not always in the lower hemisphere. Also, the scratches made on cocoa have been noted to either be a gouging out of a chunk of pod or an array of longer scratches caused by many of the claws as the rodent species scrambles over the pod. Of noteworthy is the fact that neither biting nor scratching damage have been reported on small or unripe pods ([64]. indicating that an alteration in pod appearance as well as texture especially during ripening might have rendered cocoa pods highly susceptible to physical damage.

In cocoa, a species that inflicts high pod damage could be a serious threat while the one that is unable to gnaw through a pod would pose no danger aside from being a secondary feeder [14]. The significant differences in the sizes of holes gnawed by different rodent species can help in facilitating the identification of their damage in the field [14]. Also, it can infer the potential future damage and as well aid in decision-making vis-a-viz the control efforts or programmes to undertake. For instance, the giant Gambian rat (Cricetomys gambianus) species are known to collect and even hoard cocoa pods [67]. Aside from this, they construct large burrows which are frequently found very close to the roots of the large shade trees within the agroforestry system. Squirrels have been observed to attack the abaxial surface and as well create oval-shaped holes near the median or terminal part of several mature ripe cocoa pod walls which typified the kind of feeding and damage to the cocoa pods [68] (Mollineau et al., 2008). [61] also concluded that squirrels preferred to feed on the edges of the cocoa fields inflicting unquantifiable damages. Additionally, most times, squirrels have been noted to attack ripe cocoa pods which are harder pods and their preference for ripe pods has been related to colour and smell rather than taste [69]. Mollineau et al. (2008) opined that rodents generally do not display any preference for neither larger pod, a specific colour of pod wall nor degree of pod wall hardness. According to David [70], squirrels are more important than rats in terms of damage caused to cocoa farms. While a squirrel can attack up to four cocoa pods per day, a rat takes one week to attack up to four pods on the average [71]. In assessing the damage potential of a species, the most critical factor seems to be the number of animal species in the field [14]. Generally, rats often gnaw the pods close to the stalk portion whilst squirrels actually gnaw the pods in the centre [72]. In fact, rats have been known to damage the mature and immature cocoa pods whereas the squirrels inflict damage particularly to the mature ones while gnawing the pods as well as nourishing on the mucilage covering of the beans. Everard [67] reported that inexperienced rodents especially rats would attack cocoa pods after experiencing the inner mucilage. Therefore, evaluating the damage potential of rodent species to further familiarize with their pest status will facilitate the usage of proper management as well as control techniques [14]. Improved comprehension of rodent behaviour is crucial in making plans for obliteration of time-honored rodent population

and to ensure an effective rodent control mechanism [73].

## 7. CONTROL OF RODENTS PESTS OF COCOA

Since rodent pests have been causing deleterious impacts or losses on cocoa from time immemorial, it can be said that rodent control is inevitably as old as the rodent menace itself. The regulation of pest rodents does have both an economic as well as ecological constituent having a dynamic interaction [74]. The links that exist between these constituents are characterized by the control plans impacting the death of rodents including their damages on cocoa. In lieu of this, knowledge of the social behaviour, population biology, taxonomy and community ecology of rodent pests is a crucial in developing effective control strategies [75]. Both non-chemical and chemical methods of rodent pests control have been enumerated within the literatures; however, there is need to have a very brief mention of them. The mechanical method of control involves killing, hunting, and trapping which usually comprise of high labour costs and are as well less practicable for large expanse of land. Even though rodent trapping in the wild can be seen as a common old drill, it is still being employed till date. For instance, [71] opined that for an effective trapping, using wire mesh/wooden/metallic single catch live traps is preferable or highly recommended. The biological method of control involves predator usage. This method of control of rodents especially in Africa is almost an unexplored area [76]. The main rodent predators include mongoose, cats, rats, mice, foxes, jackals, hawks, owls, monitor lizard, kites, and snakes. The chemical method of control which involves the use of rodenticides is a common practice in the world today. The effectiveness of this method is dependent on the choice of suitable compounds, their formulations, as well as the timing and technique of application. There are a varying range of rodenticides available for use which can be categorized as acute and anticoagulant [23]. Lastly, the Ecological-Based Rodent Management (EBRM) is a combination of the above enumerated rodent pests control methods though carried out in such a way that it is most acquiescent to both the ecology as well as the biology of the particular rodent species [23]. As documented, the EBRM emanated from the integrated pest management (IPM) system though with more attention or focus on specific design of involved strategies. In order to develop an impactful rodent management strategy, it may be highly sacrosanct to identify the specific rodent species of concern within the exact ecosystem.

## 8. CONCLUSION

Rodents are small mammals which belong to the order Rodentia and have been noted to be the most diversified and populous order of mammals that are living. They are often identified as pests due to their habit of gnawing, which can lead to economic losses, structural damages and decomposition of crops. Rodents generally have been identified as major pests of cocoa in almost all cocoa-producing countries of the world. They cause almost unquantifiable damage to cocoa which could be slight or severe through the gnawing, biting and scratching depending on the extent of damage in varying parts of the cocoa tree. The impact of these damages on cocoa also has a ripping effect on the livelihood of farmers growing it as well as the local economy. Greater comprehension of pest species, their threats as well as the efficacy of varying management seem to be significant drivers of control acceptability. Information on the type, severity and nature of damage to cocoa are very scarce and the very few ones that are available are relatively obsolete but it should be said that the extent of damage to cocoa can be easily felt especially as regards loss of yield and quality of the cocoa pods. Therefore, there is need to conduct or re-assess the impacts of rodent pests on cocoa especially in naturally-producing areas of the world so as to enrich the available literature by expanding the knowledge and providing the background for further research.

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## COMPETING INTERESTS

Author has declared that no competing interests exist.

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