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REVIEW ARTICLE

Threats to African arthropods biodiversity

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Abstract

African arthropod species are threatened by unsustainable agriculture, over-exploitation of edible species, invasive species and pollution. These drivers of arthropod biodiversity threats has caused not only biodiversity loss but also decline in ecosystem functions leading to low agricultural crop production, food security, and poverty. The causes of arthropod diversity threats and effects in Africa, and some approaches made to salvage the threats are examined in this paper. Desertification, habitat fragmentation and land-use conversion of forested land for developmental projects are major factors that destroy arthropod species habitats. Unsustainable agricultural practices such as non-target insect pest control services, waste water irrigation systems, and casual farming practices all pose serious threats to biodiversity as they reduce ecologically beneficial organisms, cause depletion of nutrients, and eutrophication. In West Africa, casual-farming practice that depend on its water source from the waste water irrigation due to the absence of regular water supply is another contributing factor. This untreated waste water contained in municipal waste water open channels contain chemicals which cause biodiversity threats. Excessive application of agrochemicals in agro-ecosystems cause alteration of soil pH and nutrient levels and reduce soil fauna biodiversity. The black soot generated from petroleum refining activities in Africa cover the surfaces of leaves and reduce herbivorous insect biodiversity leading to reduction in leaf fall and frass with insufficient input of nutrients into the soil, causing biodiversity loss of organisms that depend on such energy input. High concentration of Total Petroleum Hydrocarbons (TPH) and exotic species introduced during clean-up of hydrocarbon pollution and over-exploitation of food insects beyond their regeneration capacity cause biodiversity loss. Non-maintenance of ecosystem health, creation of malnutrition, poverty and agricultural down-turn are some effects of arthropod biodiversity threats in Africa. Some efforts aimed at addressing arthropod biodiversity threats are suggested.
Keywords: Arthropod biodiversity threats, casual-farming, unsustainable agriculture, black soot, ecosystem function.

1.0 Introduction

There are quite a number of various species of organisms including arthropods in Africa because of tropical forests that abound the entire continent. A major proportion of the earth's biodiversity occur in the tropical forests (Myers *et al.*, 1988). A number of these species are

threatened to extinction due to the influence of over-demand for consumption, increase in human population growth and the reduction in resource input into their habitats. Any member of animal species that possess jointed appendages that are likely to attain extinction in the foreseeable future are termed threatened arthropods. Consequently, the decline or disappearance of variety of any species that belongs to the Phylum Arthropoda in Africa is considered as threats to African arthropods biodiversity. It is simply a biodiversity loss of African arthropod species. Three hundred and ninety-four (394) species are listed as critically endangered arthropods species worldwide (IUCN, 2016). The International Union for conservation of Nature (IUCN) further added that 4.1% of all evaluated arthropod species are listed as critically endangered.

Accordingly, only 4,478 species are categorized not threatened at present (IUCN, 2016), 2,100 to 4,990 are threatened while 2,875 arthropod species are listed as data deficient, meaning there is no sufficient information for a full assessment of conservation status, and thus are considered threatened until their status can be assessed.

The causes of biodiversity threats influenced by the three influencers mentioned earlier are divided into two; direct and indirect factors. The direct causes or drivers of arthropod biodiversity threats in Africa are habitat change, unsustainable agricultural practices, over exploitation of edible species, introduction of invasive species, climate change, pollution. Factors that interact in such a way that influence human-induced changes in biodiversity are collectively referred to as indirect factors and includes: economic, cultural, religious and scientific factors, distortion of the nitrogen cycle.

One major ill effect of arthropod biodiversity threats in Africa is the reduction or decline of ecosystem functions leading to low agricultural crop production and food scarcity in the region. It has also generated poverty among the people of the continent. In fact, the absence of the ecological roles of threatened arthropods will cause serious havoc on the ecosystem, including nutrient cycling and retention, enhancement of decomposition processes, and degradation of the ecosystem. WHO (2018) and World Bank (2018) report that one fifth of the population in Africa experiences hunger, while almost half of the population in sub-Saharan Africa live below the poverty level.

In addition to the efforts and approaches made by international organizations such as United Nation Environmental Programme (UNEP) to prevent, halt and reverse the degradation of ecosystems worldwide through support for sustainable land management and ecosystem restoration, it is suggested that the application of organic restoration approach and other techniques can help reverse declining biodiversity of arthropods in Africa.

This article focuses on the causes of threats to arthropod biodiversity in Africa, effects of such threats and approaches made to salvage the threats.

2.0 Causes of Biodiversity Threats to Arthropods in Africa

2.1. Habitat Threats to African Arthropod Biodiversity

Habitat change refers to changes that occur in the natural area where organisms including arthropods inhabit or reside. It includes changes caused by the activities of humans such as activities leading to pollution, sand mining, deforestation, and natural phenomenon such as flooding, drought resulting in modification and consequently loss in habitat.

These changes cause a serious reduction in biodiversity to an extent that habitat loss has been pointed out as a "hefty menace to biodiversity and vital discernment for species extinction" (Singh *et al*., 2021).

Habitat change or loss that reduces biodiversity can be divided into three types; habitat degradation, habitat fragmentation and habitat destruction (Klappenbach, 2020). Degradation of habitat, is the reduction in the quality of resources and ecosystem services provided by the affected habitat. This causes a decline in biodiversity of arthropods inhabiting the habitat. Carrete *et al.*, (2009) identified erosion, nutrient depletion and desertification as causative agents of habitat degradation. In Africa, particularly the Sahel region, biodiversity loss is caused by desertification (Walter, 2016), such that arthropod diversity: beetles, spiders and ants were reported to be greater in protected areas of forests than desert areas in Senegal (Brandon *et al*., 2017).

Habitat fragmentation is the conversion or splitting of habitat which is usually larger in size to smaller habitat called fragments. It is driven by human development tendencies and cause isolation of animal communities (Bright, 1993), creation of boundaries between species and loss of breeding sites. In Nigeria, particularly petroleum oil producing areas, fragmentation in forested and farmland habitats is caused by oil exploitation and exploration pollution. This creates physical demarcation between the impacted and non-impacted landscapes, and is responsible for a decline in biodiversity in both above- and below-soil surface faunal communities. The role of pollution in the reduction of arthropod biodiversity will be discussed separately.

The third factor which is habitat destruction which is defined as the massive destruction or removal of the natural habitat of species making it incapable of upholding the native ecosystems and their species (Singh *et al*., 2021).

Pollution, deforestation, land-use conversion are principal contributors to habitat destruction in Africa, leading to loss in biodiversity and extinction of species. Land-use conversion of forested land for developmental projects such as housing, road construction have immensely caused decline in arthropod diversity. Similarly, land use conversion to agricultural projects also account for the loss in biodiversity of arthropod as their local habitat are destroyed. Conversion of natural habitats of arthropod species for development and agriculture is very prominent in Africa, and this has affected arthropod species, moreso, as impact assessment of the desired projects on arthropod inhabitants are usually ignored and not taken into consideration. The most affected of the natural habitats are the breeding sites of the species which are destroyed due to the ignorance of their ecological roles to the ecosystem and humanity. Lucey and Hill (2012) in a comparative study of insect habitats pointed out there are lesser number of insect species in homogenous forests and tree plantations than there are in forests richer in number of plant species, herbs and shrubs. This indicates that insect diversity occurs more in natural forested ecosystems than human created tree plantations, and their destruction will certainly impact the ecosystem and consequently cause a reduction in biodiversity.

Changes in the quality of arthropods habitats caused by destruction, fragmentation and degradation of habitats definitely reduce species richness and abundance of the affected ecosystems, and this can be discussed separately as we examine the contribution of pollution, and agricultural activities to threats in African arthropod biodiversity.

2.2. Agricultural Threats to Arthropods Biodiversity in Africa

During preparation of agricultural land, forested lands are converted to cropland, threatening the richness and abundance of arthropod species. The conversion or removal of forest cause a decline in biodiversity because forests serve as suitable habitat or biodiversity hotspots.

In Africa, certain methods of agricultural practices such as indiscriminate and non-target use of pesticides and other methods that cause nutrient depletion are termed unsustainable agricultural practices as they encourage ecosystem degradation and inadequate services.

Unsustainable agricultural practices threaten biodiversity of agroecosystems and moreso, as biodiversity contributes to the sustainability of an ecosystem, the more threatened, the lower biodiversity and the less sustainability. Sustainable agricultural practices that encourage higher biodiversity enhances more sustainability indicating that an ecosystem with this quality is better able to carry out its natural processes in the presence of any disturbance.

Unsustainable agricultural practices that threaten biodiversity of arthropods in Africa are the non-target insect pest control services, wastewater irrigation system, and casual-agricultural practices.

Most farmers in Africa apply pesticides that do not target any particular pest(s) in the management of pest incidence and this destroys many arthropods including those beneficial to the environment and humans. This practice has posed a serious threat to the indigenous biodiversity of arthropods in both terrestrial particularly soil, and aquatic ecosystems. In the soil ecosystem, this practice cause a reduction in soil mites that facilitate the process of decomposition and other soil insects (beetles) that create burrows used as channels for mineralization and easy water infiltration. Similarly, in the aquatic ecosystem, run-offs from pesticide-treated farmlands enter the water-system and threatened the life existence of arthropod species. The situation in the aquatic ecosystem is worsened when run-offs from chemical fertilizer-treated farmlands which contain nitrogen and phosphorus increase the nutrient content of the water body (eutrophication) causing a depletion of available oxygen and a consequent decline in species that depend on dissolved oxygen.

Pesticides and fertilizers when properly applied sustain the biodiversity of arthropods in the soil but when improperly applied impacts biodiversity negatively. Nitrogen from chemical fertilizers, for instance alter the pH and nutrient composition of the soil and in turn cause stunting of growth of suitable grass habitat, essential for bees and pollinating insects, thus reducing their biodiversity (Klein *et al*., 2007).

Another way African arthropod biodiversity is threatened is the casual-farming technique or system, usually practiced in the urban and semi-urban areas by persons who are not engaged in active farming. It is usually practiced within and around human homes and called Urban and Peri-urban agriculture (UPA) (Amprako *et al*.,i 2020). In West Africa, this system has caused a dependence on wastewater and arthropods leading to a threat in biodiversity. Water supply to the crops in casual farming systems is not readily available in West Africa and farmers involved resort to the use of waste water irrigation which is not only untreated, but contain mixture of natural dilutes and chemicals, readily available from municipal wastewater open channels. The irrigation system according to Githongo (2020) is worrisome to arthropod biodiversity.

In Africa, casual farming or UPA is dependent more on the available arthropod biodiversity existing in the city it is practiced. This is because of the type of crops predominantly cultivated which are vegetables; Okra (*Abelmoschus esculentus* L.) Moench0, Pepper (*Capsicum annum* L.), and garden eggs (*Solanum melongena*) rely more on insects for pollination, unlike cereal crops such as maize (*Zea mays* L.) millet (*Pennisetum glaucum* L.), and sorghum (*Sorghum bicolor*) which depend on wind for pollination (Stenchly *et al.*, 2017).

The shift in the type of crops cultivated in UPA system has caused an increased dependence on the existing arthropods biodiversity, resulting in a threat to biodiversity (Tilman *et al*., 2017), caused by stress. Threats to insect biodiversity in casual-farming system is aggravated by the insecticidal management of arthropod species associated with the cultivated crops. Casual farmers apply all sort of insecticides that destroys the desired pests as well as the non-target species.

2.3. Pollution threats to Arthropod Biodiversity in Africa.

Pollution from acid rain, pesticides, heavy metals, hydrocarbon and a host of others when introduced into the soil and water ecosystem threaten the biodiversity of arthropods in Africa. Pollution is a type of disturbance; a relatively discrete event that alter the natural condition of discharge of pollutants such as petroleum and crude oil products (Benzene, Naphthalene, Toulene, Total Petroleum Hydrocarbon, Spent engine oil), and other pollutants from industrial and agricultural activities. In Africa, agricultural pollutants, tanker spills, ruptured chemical tanks and oil pipelines, vandalized oil pipeline and artisanal refineries are major sources of pollution.

In Nigeria, expired pesticides are thrown into water bodies and this contaminate the aquatic ecosystem and cause a threat to biodiversity of arthropods (Gbarakoro *et al*., 2019). Farmers in Africa applied chemical fertilizers to boost the nutrients in the soil and increase output and such application increase concentration of nitrates (nutrients commonly derived from fertilizers). The high concentrations of nitrates flow into the aquatic ecosystem through run-offs from the agricultural landscape and cause eutrophication (nutrient enrichment in fresh waters). This situation reduces the stability of the ecosystem as the inhabiting organisms could not tolerate the impact of the nutrient enrichment, resulting in loss of biodiversity.

Another way, eutrophication threaten biodiversity in the aquatic ecosystem, is the increase in productivity, in which algae production will be tremendous, such that scums will be formed to cover the water surface and reduce transparency. The scum cover prevents the penetration of light and arthropods that visit the water surface and those that inhabit just below the surface are affected leading to death as they could no longer replenish their gases by obtaining atmospheric oxygen. The insects affected mostly are those that respire through the use of hydrofuge hairs, and post abdominal structures which are usually extended to the water surface to obtain oxygen, while the insect remain submerged. The inability of the insects to obtain atmospheric oxygen pose a serious threat to the biodiversity of these insects and their ecosystem services.

Availability of oxygen in the water body is affected by the increase in algae pollution caused by eutrophication because when algae die and biodegrade, oxygen is consumed. This reduction in available oxygen changes the condition of the water body and cause a loss in biodiversity of arthropods.

Excessive application of fertilizers and pesticides in agriculture has been described as being deleterious for soil biodiversity (Singh *et al*., 2021) because nitrogen from fertilizers alter the pH and nutrient level of the soil. The changes in the condition of the soil threaten soil biodiversity by directly reducing the species richness and abundance and indirectly by encouraging the overwhelming growth of grass species and stifling growth of wildflowers, essential for arthropods species (Singh and Verma, 2018), causing loss of insects such as bees.

In the Niger Delta region of Nigeria where hydrocarbon pollution from petroleum oil refineries, including artisanal refineries abound, threats to arthropod biodiversity occur. The black soot generated from the refining activities cover the surface of vegetation particularly the leaves and reduces herbivorous insects' biodiversity. This affects the ecosystem services of the herbivores and causes a reduction in nutrients or energy input into the soil ecosystem thereby causing a reduction in ecosystem services. The reduction in the abundance of soil mesofauna, for instance, reduces the secretion of frass-aggregation substances leading to loss of water retention capacity of the soil and inadequate distribution of mineral nutrients in the soil ecosystem.

In the soil, petroleum hydrocarbon pollution may bio-accumulate in soil arthropods and become toxic to soil-dwelling species at the range of 20-100 mg/kg (Sverdrup *et al*, 2002; Maliszewska-Kordybach *et al*., 2010) and cause threats to biodiversity.

A relatively high concentration of Total Petroleum Hydrocarbons (TPH) threaten soil biodiversity, particularly soil microarthropods. Gbarakoro *et al*. (2010) reported that soil microarthropods' biodiversity was higher in soil ecosystem with lower concentration of TPH as compared to polluted sites with higher concentration. According to the authors, those species which couldn't tolerate the pollutant die, others migrate to deeper soil profile before they eventually die, while the tolerant species become less abundant (Table 1).

Other types of pollution that greatly impact biodiversity of arthropods in Africa are acid rain and light. Pennanen *et al*. (1998) stated that soil prone to acid rain have reduced microbial activity and cause a threat to biodiversity of arthropods that depend on food chain influenced by such microbial activity. Light-attracted arthropods such as immature stages of termites and adult moths are threatened by artificial light disturbances. On the streets of African cities, dozens of these organisms are crushed by moving vehicles, particularly during the raining season. The importance of these species, particularly moths cannot be underrated as they are anthophilous (Macgregor *et al*., 2017). Light therefore poses a threat to the existence of these species.

2.4. Invasion Threats to Arthropod Biodiversity

One major cause of threats to biodiversity is through the introduction of species that are non-indigenous to an environment or ecosystem. The non-native species are called exotic or invasive species, and can be introduced intentionally and non-intentionally into a foreign or non-native habitats. The exotic species are introduced either in biological control programmes; certain arthropods which are natural enemies to other arthropods that are pests are introduced into an environment to control pest outbreak. In this programme, the newly introduced species (exotic species) become established and eliminate native species by out-competing them for food and shelter and cause more harm to the ecosystem, thereby threatening arthropod biodiversity. This situation occurs when the biological control programme is not properly

implemented and other untargeted arthropods are eliminated. Improper implementation also cause the release of generalist natural enemies which lack high level of host-and habitat-specificity, become invasive and attack native species other than the target pests.

Table 1. Species richness and densities (cm^2) of mites at undisturbed and polluted habitats.

Species	**Habitat types**	
Cryptostigmata (Oribatida)	**Undisturbed**	**Polluted 1year pre-study**
Scheloribatid spp (3)*	1857	232
Galumna spp. (3)*	1467	254
Parallonothrus nigeriensis	338	58
Bicrythermania nigeriana	302	30
Mixacarus sp.	324	-
Aunecticarus sp.	298	-
Atropacarus sp.	312	-
Belba sp.	380	-
Cephalid sp.	272	-
Oppia sp.	229	-
Basilobelbidae sp.	213	-
Epilohmaunia sp.	169	-
Mesoplophora sp.	109	-
Archegazettes magnus	150	-
Nothrus lasebikani	81	-
Sub- total	6501	574
Densities **	7.64	0.67
Mesostigmata (Gamasida)		
Polyaspid sp.	558	-
Trachyuropod sp.	352	-
Prodinichus sp.	252	-
Uropod sp.	490	-
Parasitid sp.	381	53
Rhodacarus sp.	417	81
Asca sp.	74	-
Sub-total	2524	134
Densities	$2.97/cm^3$	$0.16/cm^3$
Prostigmata (Actinedida)		
Bdellida sp.	282	65
Densities (cm^3)	$0.33/cm^3$	$0.08/cm^3$
Total	9307	773
Cumulative density (cm^3)	$10.94/cm^3$	$0.91/cm^3$

* Densities are number of mites per unit volume. The soil volume was 850.14 cm^3.
Source: Gbarakoro *et al* (2010)

Another way invasion threats occur is during the cleaning or bioremediation of hydrocarbon pollution in which certain hydrocarbon feeding microorganisms are introduced from other habitats into the polluted sites. These exotic species when established eliminate native species upon which arthropods obtain food, and thereby pose serious threats to the arthropods biodiversity.

Exotic species threaten arthropod biodiversity by diluting the endemic biodiversity through homogenization of global biota. This occurs when the same species are involved in biological control or hydrocarbon cleaning in various countries, and results in the establishment of the same biodiversity of species in the affected countries. This changes the community structure and threatens the native biodiversity.

Agricultural practice in the urban cities in Africa called UPA assist in the invasion of non-native species and cause biotic homogenization where native species are eliminated, because the cities are transformed to hotspots of biological invasion (McKinney, 2006; Sanchez-Bayo and Wychkuys Huys, 2019).

Another source of biotic homogenization that contributes to biodiversity threats is the hybridization of exotic species with native species which cause a decline in genetic diversity (Dorherty *et al.*, 2016).

Sand mining in Africa poses a tremendous threat of the removal of suitable habitats. Sand mining that involves the removal of aquatic macrophytes which provides suitable habitats for aquatic arthropod species negatively impact arthropod biodiversity. Gbarakoro *et al.* (2021), showed that various types of sand mining vary in impacts on arthropod diversity in Eleme Rivers, Rivers State, Nigeria.

Table 2: Abundance of Macroinvertebrate Community at Eleme River during the Period of Study

S/N	Species	Family	Mechanical	Manual	Unmined
1.	*Ophidonais* sp.	Naididae	-	22	-
2.	*Nais* sp.	Naididae	7	18	-
3.	*Paranais* sp.	Naididae	3	10	-
4.	*Chaetogaster* sp.	Naididae	-	14	-
5.	*Aeolosoma* sp.	Aeolosomatidae	-	27	-
6.	*Elseniella tetrahedral*	Lumbricidae		24	-
	Sub-Total		10	115	-
7.	*Diplonychus rusticus*	Belostomatidae	3	-	1
8.	*Lethocerus indicus (americanus)* (waterbug)	Belostomatidae	-	-	6
9.	*Naucoris* sp. (creeping water bug)	Naucoridae	1	-	4
10.	*Leptonea* sp.	Hydropsychidae	-	-	9
11.	*Aphelocheirus grik*	Aphelocheiridae	-	-	4
12.	D*ytiscus* sp.	Dytiscidae	-	-	5
13.	*Chironomus* sp. (larvae)	Chironomidae	-	-	3
14.	*Dragonfly* nymphs	Libellulidae	-	-	8
	Sub-total		4	-	33
15	*Daphina barbata*	Brachipoda	6		2
16	*Apus* sp	Brachipoda			36
17	*Macrobrachium* sp	Malacostraca	30	152	3
18	*Sudanonautus africanus africanus*	Malacostraca	29	34	
	Sub-Total		65	188	41
	Grand Total		79	303	74

Source: Gbarakoro *et al.* (2021).

Accordingly, mechanical methods have a higher impact by reducing arthropod diversity, such that species collected from the habitat-type was fewer than manual method (Table 2). Shannon-Wiener Diversity Index indicated that diversity was high at the unmined than the mechanical and manual-mined stations.

2.5. Over exploitation of food arthropods threats to arthropod biodiversity

Food arthropods are arthropods, including insects that are edible and consumed by humans. In Africa, food insects includes *Rhyncophorous phoenicies, R. ferrygnieus papuanus* consumed in Nigeria and Guinea, respectively, R. *palmarum* in Venezuela, caterpillars of *Cirina forda* in Democratic Republic of Congo, termites in Togo, Nigeria, and mole crickets (*Brachytrapes membranaceous*), Grasshoppers (*Zonocerus variegatus*) in Nigeria.

The prevailing economic hardship in Africa has made the collection of these food insects to be over exploited in such a manner that the number of insects collected from their natural habitats exceeds regeneration capacity of the local communities and pose serious threats to sustainable entomophily (food insect collection). Collection of food insects is carried out without any preference to the age of the insects, making mature insects be collected prior to oviposition. The over-exploitation or over collection of food insects its one factor responsible for reduction of arthropods biodiversity in Africa.

2.6. Climate change threats to Africa arthropod biodiversity

Photochemical oxidants (smogs) that increase atmospheric carbon dioxide and the decrease in surface roughness of land caused by land-use which involve land conservation form forested to agricultural land contribute immensely to climate change that have impact on arthropod biodiversity.

In Africa, smogs produced from exhaust of old automobiles and artisanal refineries contain carbon monoxide and particulate matter that are seen on roofs of buildings and on cars in cities of the Niger Delta area of Nigeria in particular. The high level of smog production is so noticeable that fresh air masses is insufficient to dilute it and may impact biodiversity.

One major way, climate change threatens arthropod biodiversity is the reduction in nutrient input into the soil ecosystem which cause a reduction in arthropod that depended on such nutrients. The inadequate and insufficient addition or supply of necessary nutrients to the soil ecosystem will cause a decline in soil arthropod and consequently threaten soil arthropod biodiversity.

The nutrients are contained in soil surface inputs such as grass deposits and green fall inputs collectively referred to herbivore inputs. Climate change that increase contain dioxide (CO_2) and Ozone (O_3) concentration in the atmosphere reduce herbivore inputs through the reduction in the species richness and abundance of herbivores. The lower the population density of herbivores, the lower the herbivores inputs into the soil ecosystem as the growth, survivorship and abundance of herbivores are altered by climate change which alter the quality of forest trees (Hillstrom *et al*., 2010). Climate change threatens the density of both arthropod particularly herbivores and arthropod biodiversity that depended on the nutrient inputs contributed by such herbivores.

2.7 Drought and Flood

Two natural disasters that threaten arthropod biodiversity are floods and droughts, though do not occur frequently in Africa. Floods for instance reduce biodiversity though reduction in breeding sites as water cover natural habitats. Extreme drought reduces the moisture contents of soil ecosystem and reduce soil microarthropods (Gbarakoro *et al.,* 2010), as the organism could not tolerate such soil moisture.

3.0 Effects of Arthropod Biodiversity Threats

There are various effects caused by threats to biodiversity of arthropods and they include; non-maintenance of ecosystem health, malnutrition and poverty of the rural population, agricultural down turn and collapse of ecosystem services and sustainability.

3.1 Non-Maintenance of Ecosystem Health

Low arthropod biodiversity in an ecosystem indicate a weakness of the ecosystem and poor health status because there is low variety of genes and species in that ecosystem. This type of ecosystem is unhealthy as it cannot carry out its natural processes in the presence of external disturbance. Generally, the ecosystem cannot maintain its health status.

3.2 Collapse of Ecosystem Sustainability

Threatened arthropod biodiversity ecosystem which cannot effectively carry out its services will be less sustainable and cannot sustain the environment and its inhabitants. An ecosystem is more sustainable when the arthropod biodiversity is higher and provides source of food, medicine and economy, as well as other services. Centrally, threatened ecosystem with low arthropod biodiversity will not be able to provide such sustainability. A less sustainable ecosystem is poorer in health and incapable of dealing with external disturbance.

3.3 Malnutrition and Poverty

Malnutrition and poverty occur among the rural people in African countries where arthropod biodiversity is reduced. Rural population that rely on arthropod food for nutrient supply are most negatively affected, and income earners from the commercial sales of such arthropods are left frustrated. Reduced abundance of arthropod biodiversity aggravates poverty among the rural dwellers.

3.4 Agricultural Downturn

Agricultural development will be at standstill in areas where arthropod biodiversity is tremendously reduced. Herbivore inputs of necessary nutrients into the soil ecosystem will be reduced and crops cultivated on such soil will be starved of the nutrients. Furthermore, soils that lack arthropods that construct burrows will not have adequate distribution channel for available nutrients, and the ability to glue soil particles together, thereby leading to weakening the water retention capacity. Thirdly, the rate of decomposition of organic matter and its formation into soil organic matter will be slow in the absence or presence of low arthropod biodiversity. These will enhance agricultural downturn as it will reduce the number of agribusinesses.

Threats to arthropod biodiversity will cause serious problem in respect of agricultural development, particularly when the species involved are pollinators, predators and biological control agents. The reduction in this group of species will reduce the development of agricultural sector.

4.0 Efforts to Salvage Biodiversity

4.1 International Effort

The United Nations (UN) has launched a globally coordinated response to biological loss and degradation of habitats, with a content of building political willingness and capacity to restore interrelationship between nature and living organisms. This programme is called a decade on ecosystem restoration (2021-2030) and is focused on the prevention, and reversion of the degradation of ecosystems over one hundred countries, including African countries have endorsed the treats on this global approach to halt biodiversity threats.

The United Nation Environmental Programme (UNEP) is leading the decade on ecosystems restoration by ensuring that the science and best practices on ecosystems are gathered together and also encourage and collaborate with biodiversity-related conventions and scientific bodies.

The UNEP through its organ, world conservation monitoring center (UNEP-WCWC) collaborates with scientists and policy makers worldwide to put biodiversity as its front priority of the environment and development decision making. In spite of the effort made by the UN, no significant attention has been paid to address threats to arthropod biodiversity worldwide.

Samways (2018) stated that it is only recently that arthropod (insect) biodiversity has been made to address threats to arthropod biodiversity through semi-cultivation practices of preferred food insect species. The practice is devoted of consideration of arthropods particularly insects that bear relevance to ecological services, indicating that only those that are important on the rural people's livelihood are captured in the practice. In the practice, the insect's habitat is manipulated, for instance, in Guinea, palm trees that produce small quantities of starch are reserved for palm weevil larvae production, and in Venezuela, *R. pamarum* is encouraged to grow on moriche palm (*Maucitia flexuosa*). The larvae is then collected from the *M. flexuosa* after four weeks and fed on banana pseudostem, vegetable refuse and fruits and pineapple-sugar cane diet all in plastic containers.

In Democratic Republic of Congo, caterpillars of *Ciria forda* are reared on Acasia trees near residential houses and harvested for food while some are allowed to emerge to adult butterflies. In Togo, termites are reared using Canari (comprising plastered water-storage recipients), dry sorghum stems or other cereals, water, jute bag piece and some moist soils.

In Nigeria, *R. phoenicis* has been reared using substrates such as cereal shafts water, honey all stored in air-free cages.

In semi-cultivation practices, rearing of food insects begins in the wild by falling of trees deliberately to stimulate the production of palm weevil larvae.
It is clear that much has not been done on the avoidance of threats to arthropod biodiversity in Africa and the following suggestions may help:

- Food insects should be reared in artificial substrates and habitats.
- The roles played by insects and mites such as pollinators, herbivores, soil burrowers, nutrient suppliers, decomposition, parasitoids should be understood and prioritized in conservation programmes.
- There should be maintenance of the interactions between arthropods and other organisms, and physico-chemical parameters of the ecosystems. This should be understood and maintained
- Formulated organics should be incorporated into arthropod biodiversity restoration programme as it will restore impacted soil ecosystems, particularly arthropods abundance, nutrients and water-holding capacity.

Conclusion

Arthropod biodiversity world-wide and particularly in Africa are threatened mostly by habitat loss and fragmentation, over-exploitation of preferred food insects, unsustainable agricultural practices, pollution and recently climate change. This has caused poverty on the rural population as it impacts their livelihood and in addition affected the habitats ability to render its services maximally. Consequently. food production is not adequate in the region and in spite of these issues, no appropriate method of conservation of arthropods has been employed by both government and individuals. In view of this, formulated organic restoration technique is suggested among others to be employed. An inventory of ecologically important arthropod species should be taken in Africa and conservation programmes designed for them.

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