

## REVIEW ARTICLE

## STATUS OF INSECT DIVERSITY CONSERVATION IN NIGERIA: A REVIEW

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## ABSTRACT

With a rapid surge in human population, there has been concomitant increase in anthropogenic threats to biodiversity, especially for ecologically-important groups such as insects. With the loss of about 79% of its forest cover, Nigeria ranked as the nation with the highest rate of forest loss in 2005. How these and other environmental stressors affect insect biodiversity is yet to be fully understood. Nigeria, like most of the countries in the tropics is a treasure trove of insect diversity; however, limited information is available on the taxonomy, ecology, genetics and biogeography of its insect fauna. This dearth of background scientific knowledge impedes successful insect conservation policy and practice. Even though a National Biodiversity Action and Strategic Plan has been formulated in line with the targets of Convention on Biological Diversity, these clear knowledge gaps have to be recognized and filled for sustainable progress to be made in insect conservation. This review identifies the key challenges to insect diversity conservation in Nigerian ecosystems. The need to provide sufficient baseline information on the taxonomy, species distribution and ecology of Nigerian insects at both eco-regional and national scales is proposed. Well designed and targeted insect diversity surveys as well as citizen science programs are suggested as potential approaches to accumulating necessary baseline data to drive conservation of insects in both aquatic and terrestrial ecosystems in the country.

**Keywords:** Citizen Science, Distribution, Diversity Survey, Management, Taxonomy

## INTRODUCTION

Insects are important components in most natural and transformed landscapes. They play crucial functional roles that ensure delivery of various ecosystem services which are important for some aspects of human livelihood such as agriculture, tourism, natural resource use etc. (Samways 1994; Tscharrntke *et al.* 2005). Nigeria is an afro-tropical country endowed with rich flora and fauna biodiversity, typical of most tropical countries of the world. The tropics which has been reported to be home to about 70% of global biodiversity is also a treasure trove of insect diversity which is estimated to parallel the extent of plant diversity of this region (Bradshaw *et al.* 2009). Nigeria's tropical rainforest and savannah vegetation zones lie within the Guinea Forests of West African Biodiversity Hotspots (Myer *et al.* 2000). This region is identified as one of the most severely threatened forests in the world, being left with just 15% of its original forest cover (Conservation International 2010).

Various anthropogenic threats such as intensive agriculture, land fragmentation and deforestation have plagued the success of biodiversity with consequent limitations on the delivery of possible biodiversity benefits (Laurance 2006). Estimates have shown that Nigeria has lost 55.7% of its primary forest to anthropogenic activities such as logging, subsistence agriculture, collection of fuel wood etc. (FAO 2005). The high endemism of insects and other animal and plant taxa, coupled with the extent of threat to these endemic species confer the status of a global hotspot of biodiversity on the Nigerian rainforest and savannah vegetation zones (Myers *et al.* 2000).

Drivers of biodiversity loss act at local, regional and global scales (Green Facts 2012), hence the need for a holistic approach in conservation research and practice, especially for highly mobile groups such as insects which move across local, regional and in some cases across national boundaries. Though insect loss is a global challenge, inventories, assessments and

development of conservation strategies may be better targeted at local or regional scales. This would possibly remove the ambiguity that may result when conservation efforts are approached globally with limited consideration for local scale dynamics that shape insect diversity loss and conservation needs (Tscharrntke *et al.* 2008). This review, therefore, examines the status of insect diversity conservation in Nigeria, a biodiversity rich country, currently faced with incipient biodiversity loss.

### **NIGERIAN FORESTS AND INSECT POPULATION**

Forests are among the world's most important biomes in terms of the area of land surface they cover (approximately 30% of all land, over 3.8 billion hectares) and the biodiversity they contain (approximately 90% of terrestrial biodiversity) (FAO 2000). Forests serve as reservoir of biodiversity and serve as recreation and tourism centres. Invertebrates account for the greatest amount of biodiversity in forest ecosystems. Invertebrates (especially insects) dominate among multicellular organisms in forests in terms of richness, abundance and biomass (Erwin *et al.* 2004). A careful study of the vegetation of Nigeria shows that true and protected forest is mainly found in the southern part of the country and it occupied 93,345 km<sup>2</sup> in 1993 i.e 9.6 % of the total land area of the country. This area increased to 11.4 % in 1994 but dropped to 10 % in 1995 (CBN 2001). Conservation efforts have led to the establishment of game reserves and protected ecosystems in some parts of the country, especially in the northern savannah e.g Yankari in Bauchi state, Borgu in Niger State and the old Oyo National Park in Oyo state just to mention a few.

Deforestation is a serious problem in Nigeria which currently has one of the highest rates of forest loss in the world. Since 1990, the country has lost some 6.1million hectares or 35.7% of its forest covers (FAO 2000). According to the revised deforestation figures from FAO (2005), between 1990 and 2005, Nigeria lost a staggering 79% of its forests and since 2000, the country has been losing an average of 11% of its primary forests per year - double the rate of the 1990s. Intensive farming methods are among the primary causes of habitat destruction in Nigeria as it is

characterized by vegetation destruction and landscape fragmentation. Large scale plantation establishment of cash crops as well as indiscriminate bush burning and overgrazing lead to habitat destruction with consequent impact on insect species (Emma-Okafor *et al.* 2010). At present, the destruction of natural habitats in Nigeria continues apace resulting in the depletion of the country's biodiversity (Imeht and Adebobola 2001). Every year, a considerable part of the nation's forest resources is destroyed through industrialization, urbanization, road construction, commercial agriculture and other activities thereby disturbing the ecological balance that nature maintains with living and non-living resources (Imeht and Adebobola 2001).

Insects are habitat-specific in nature and as a result, they are highly sensitive to disturbance, particularly habitat fragmentation (Kearns *et al.* 1998; Aizen and Feinsinger 2002; Ashworth *et al.* 2004). Most forest insects have narrow geographical range of distribution, often nearly endemic in a particular biogeographic forest type (Spitzer *et al.* 1993). Modifications of the natural environment as a result of sustained human activity will affect the relative abundance of species and in extreme cases lead to extinction of certain species (Groombridge 1992). Several studies from different parts of the world have provided evidence to support the view that deforestation and other forms of habitat disturbance can cause a reduction in insect abundance and species richness. Ricketts *et al.* (2002) in Costa Rica; Kitching *et al.* (2000) in Australia; Holloway *et al.* (1992) in Borneo; Watt *et al.* (1997) in Cameroon; Eggleton *et al.* (1995,1996) in Cameroon. These studies brought about a general consensus in the field of insect conservation that the most important factor in maintaining diversity is maintaining appropriate habitat (Pullin 1995). However, our understanding of the impact of deforestation and other anthropogenic activities on insect species richness and abundance in Nigerian forests is poor due to lack of published information.

Although, appreciable attempts have been made to quantify the impact of deforestation on global species extinction, resulting in estimates of global species extinction rates of 1-10% species per

decade (Reid 1992). These estimates have all been obtained by extrapolating from known relationships between species richness and habitat area. However, the fate of many species of organisms following forest disturbance is uncertain (Lugo 1988) and there is a need to measure directly the impact of deforestation and forest disturbance on insect diversity and abundance. There is also the need to quantify the impact of forest plantations and other land use activities on insect diversity and abundance (Laurance 2006).

Despite the fact that insects account for the greatest amount of biodiversity in forests, they are the least studied of all fauna (Cardoso et al. 2011; Zou et al. 2011). Published research on the impact of tropical forest management practices on insects is currently limited to individual species (e.g. Eggleton et al. 1995, 1996; Estrada and Fernandez 1999; Davis et al. 2001). Knowledge of insect community response to disturbances in forests is scanty. Also, little is known about the population dynamics and management potentials of many forest insects. The possibility of manipulating forest vegetation or harvest practices to maximize or sustain forest insect population in Nigeria is yet to be carefully investigated. Furthermore, no group of insect in the country has received significant attention and this makes it difficult to make knowledgeable decisions about their population, diversity, the likely impact of forest disturbance on these insects and timely conservation strategies to the current losses. As a result, there is need for further studies on insect taxa globally especially in the areas listed as hotspots for biodiversity such as Nigeria. Estimates of the impact of deforestation on insect population and diversity should not be based only on extrapolations derived from biogeography theory but also on direct measurement of species richness and composition (Lugo 1988; Reid 1992).

## **INSECT RESOURCES IN NIGERIAN FRESHWATER**

Aquatic insects form an integral part of an ecosystem and they are of ecological and economic importance as they maintain various levels of interaction between their community and the environment (Anderson and Sedell 1979). They are of great importance to water bodies

where they are found and their presence in water serve various purposes; some serve as food for fishes and other invertebrates, others acts as vectors through which disease pathogens are transmitted to both humans and animals (Foil 1998; Chae et al. 2000). Most importantly, aquatic insects are very good indicators of water qualities since they have various environmental disturbance tolerance levels (Arimoro and Ikomi 2008). Some are very vulnerable and sensitive to pollution, while others can live and proliferate in disturbed and extremely polluted waters (Merritt and Cummins 1996). Macroinvertebrates are important components of the food web of aquatic ecosystems. For instance, benthic dipteran larvae e.g. *Chironomus* species and molluscs are consumed in great quantities by many fishes and so play an important role in the ecology of the aquatic ecosystem (Fagade and Olaniyan 1973; Ogari and Dadzie 1987). They have also been used to assess the biological productivity of lakes and rivers (Mehmet et al. 2002). Their diversity and abundance is a reflection of the quality of water and its sediments as well.

In Nigeria, little information is available on aquatic insects (e.g. Edokpayi et al. 2000; Ogbeibu 2001; Adakole and Annune 2003; Ogbogu 2001, 2006). The number of studies on the aquatic insects is far from adequate (Ogbeibu and Victor 1989; Tyokumbur et al. 2002). Presently, no studies have been conducted on the aquatic insect fauna of major water bodies in the country to ascertain or estimate the abundance, diversity, distribution and the contributions of aquatic insects to Nigeria's freshwater ecosystems. According to Marques et al. (2003) the knowledge of the structure of the benthic macro invertebrate community provides precise and local information on recent events, which can be seen in their structuring. Moreover, the taxonomy of aquatic insects in Nigeria has received little attention over the years in spite of the considerably diverse fauna in its freshwater bodies. However, a few orders such as Odonata, Ephemeroptera and Trichoptera have received some attention in the past (Gillies 1980, 1988; Hassan 1981; Ogbogu 2001, 2006; Adu 2012).

Most major cities in Nigeria contain a number of waterways such as bays, harbours and rivers

together with a small network of small streams. Most of these streams have been subjected to an increasing pollution load from contaminated urban run-off water originating from industrial, agricultural, residential, commercial and recreational areas and institutions such as schools and hospitals (Adakole and Annune 2003). Various studies in Nigeria have shown high level of heavy metals in some rivers where industrial wastes are discharged, high level of siltation in areas with extensive logging and farming and other disturbances (Ita 1994). Species confined to running waters are much more likely to be threatened than those that prefer standing waters, especially if their habitat is forested, the main reason being that species connected with running waters have smaller average ranges than those linked to standing waters. Moreover, many forest stream species are niche-conservative; adjusting poorly to changing ecological conditions and are therefore sensitive to the rapid impacts of anthropogenic activity (Wiens and Graham 2005).

The degradation of Nigerian streams is clearly associated with human population density and activity. Anthropogenic activities of humans encourage discharge of untreated animal waste, such as releases from sewage and septic tanks, run-off from agricultural lands, laundering into streams and rivers. Most water bodies have been subjected to increasing pollution loads, consequently affecting their quality and health status greatly (Popoola and Otalekor 2011). Variations in water properties greatly influence the distribution patterns of aquatic insects in the water, since some of them are highly sensitive to pollution while others are somewhat tolerant or completely tolerant to pollution and environmental disturbances (Bauernfeind and Moog 2000).

Edward and Ugwumba (2011) pointed out that the characteristically low taxa number observed in the study of the macro invertebrate fauna of a tropical southern reservoir in Nigeria is not unusual in the country and tropical waters in general. Victor and Dickson (1985) and Umeozor (1996) observed a similarly low taxa number and diversity in Ikpoba and Calabar Rivers, respectively in southern Nigeria. In Lake George, Uganda, the bottom fauna was also poor in species composition

(Darlington 1977). Edokpayi *et al.* (2000), Ogbeibu (2001) and Adakole and Annune (2003) reported low taxa number in some streams and rivers in Nigeria. They however, ascribed this low species diversity to some physico-chemical conditions of water like fast flow, high pH, low dissolved oxygen and low conductivity. These factors probably caused disruption of life cycle, reproductive cycle, food chain and migrations or imposed physiological stress on even the tolerant aquatic insects (Adakole and Annune 2003). These changes in the physico-chemical conditions of the water bodies are usually brought about by pollution.

In Nigeria, specific threats to aquatic habitats include damming and mining. Mineral resources in this country are often extracted by open-pit mining. This is especially problematic in highlands composed largely of valuable deposits. Dams can flood critical river habitats, such as rapids and gallery forests; for example, *Paragomphus cataractae* Pinhey 1963 is usually confined to the rapids along large rivers (Clausnitzer *et al.* 2012). Dams also impact downstream flow regimes and sedimentation patterns. However, small-scale mining in rainforests can create valuable habitats for some aquatic insects when the canopy is left intact (Clausnitzer *et al.* 2012). River salination resulting from intensive agriculture and development of navigational canal primarily to enhance the activities of the oil industries may be a bigger threat to aquatic insect resources in Nigeria because some aquatic insects are salt-intolerant (Suhling *et al.* 2006). This is however yet to be fully investigated especially in the oil-rich Niger Delta in southern Nigeria.

Fishes are important predators of most aquatic insect larvae. The introduction of regionally alien species, particularly Nile perch (*Lates niloticus* Linnaeus 1758) or brown trout (*Salmo trutta* Linnaeus 1758), may have severe effects on aquatic insects (Clausnitzer *et al.* 2012). Similarly, invasive alien trees can be a key threat: riparian Australian wattles (*Acacia* sp) may overgrow the natural vegetation along streams, radically altering natural habitats and affecting many widespread aquatic insect species and all localized endemics (Clausnitzer *et al.* 2012). It is obvious that adequate information on Nigeria's aquatic insect resources

is essential to ground-truth the present status of conservation by determining those factors that contribute significantly to their diversity and success in order to facilitate future management practices.

## CHALLENGES OF INSECT CONSERVATION IN NIGERIA

Insect conservation is facing several challenges in Nigeria. Efficient and sustainable biodiversity conservation cannot proceed without addressing the following challenges.

### *Taxonomic challenge*

Taking into cognizance the huge number of species that remain to be discovered, adequate taxonomic knowledge is essential to research in insect biodiversity and the development of insect conservation (Wilson 2000; Godfray 2002). Few insect species have scientific names in Nigeria. About 20% of all insect species found in Nigeria have been catalogued by Medler (1980); others are yet to be identified. Many insects need identification, taxonomic revisions, and many species, even common ones, have multispecies complexes which are sibling species, morphospecies or convergent evolutionary species. In short, the vast majority of insects remain unknown and getting them described before they go extinct, is the taxonomic challenge.

Regrettably however, traditional taxonomy is on the verge of extinction, facing poor funding, and mostly regarded as outdated science with “modern” sciences occupying taxonomy's place (Wheeler 2007; Leather and Quicke 2009; Boero 2010). Insect taxonomists are very few in Nigeria, and may not be up to ten (10) in number. Thus addressing the taxonomic challenge would not be an easy task. There is therefore an urgent need for mass training of parataxonomists who will collect, preserve and identify insect specimens. Inclusion of insect identification methods in the biology curriculum of secondary school students in Nigeria would assist in the training of amateur entomologists who will become proficient in the description of species. There is also the need to develop cybertaxonomy and biodiversity informatics in order to provide efficient and universal access to species lists, distribution databases and ecological data in Nigeria.

Biodiversity informatics facilitates species identification and access to a wealth of information (Wilson 2000, 2003; Borges *et al.* 2010). These approaches may be supplemented with user-friendly keys for none specialists engaged in conservation planning and with the deployment of computer recognition of specimens.

Biodiversity surrogacy, either by higher taxa or indicator taxa (Pearson and Cassola 1992; Gaston and Williams 1993) can be an efficient way of obtaining useful information for conservation without the need to identify every single species. This approach allows the retention of broad biological information enabling the understanding of distribution patterns and efficiency in the definition of conservation priority areas (Cardoso *et al.* 2011). Its use is, however, limited and for most conservation questions it is important to know the species identity. A way out of the current taxonomic challenge is the recognition that there is need to enhance the funding of traditional taxonomy with compilation of inventories using adequate standardized and optimized protocols.

## ECOLOGICAL CHALLENGE

In addition to inadequate taxonomic knowledge, the ecological knowledge of Nigerian insects is poorly understood. The distribution and abundance of many species in the country are unknown while the ecosystem services associated with them are mostly assumed. Not knowing what species contribute to what ecosystem services means that the full consequences of species extinctions are extremely hard to predict (Kozłowski 2008). Anthropogenic effect on insect diversity is known only for a limited number of species (Kozłowski 2008). Even in the best-documented faunas, the threats to most individual species can be suggested in only general terms, often drawing on knowledge of biologically different but related species elsewhere.

Improvement of sampling and analytical methods for biodiversity assessment and monitoring has been identified as an important priority in insect conservation and diversity research (Didham *et al.* 2010; Kim 1993). Standard protocols have been proposed for large-scale comparative inventories

of different taxa such as ants and butterflies (Agosti and Alonso 2000; Pollard and Yates 1993). Long term ecological studies are needed to monitor ecosystem change through time and such studies also require standardized and optimized protocols.

Insect studies should be targeted in key geographical locations, ecosystem and habitats (Basset 2001; Cardoso *et al.* 2007; Odling-Smee 2005). Analyses of insect distribution at the community and population levels may benefit from recent advances and syntheses addressing concepts such as ecological and evolutionary factors influencing diversity at local and regional scales; additive partitioning of diversity, metapopulation dynamics, gene flow, inbreeding and introgression (Hill *et al.* 1995; Hawkins 2001; Gering *et al.* 2003; Zeh *et al.* 2003).

Conflicts between conservation and human needs have hampered efforts to prevent biodiversity loss in Nigeria. Areas of high conservation value are now characterized by high human population density, high agricultural productivity, road construction and industrialization (Andrew *et al.* 2001). Conservation centers are opened up to meet up with the increasing societal demands. Conservation and developmental needs must be reconciled in Nigeria so that efforts of past conservationists are not wasted.

Human impacts in different combinations result in a fragmented secondary forest that is devoid of woody vegetation. For proper conservation of Nigerian insects we need to know how we are altering the structure of these tropical communities, what degree of disturbance is consistent with the persistence of acceptable levels of tropical forest biodiversity and which groups of organisms apart from insects are most seriously affected. This will cater for inter-species competition, relationship, dependence and any other factors of ecosystem that will directly or indirectly affect conservation of insects.

### **POSSIBLE CONSERVATION APPROACHES**

Mitigating biodiversity loss in Nigerian ecosystems requires urgent attention by all stakeholders as well as a synergy of approaches

ranging from preservation of pristine natural habitats to wildlife friendly use of resources. In line with the National Biodiversity Strategy and Action Plan prepared in 1995, Nigerian government should foster productive partnership that will engage and enlighten all stakeholders about the conservation targets, the processes involved and the potential benefits.

There has been no consistent approach to the conservation of insects in Nigeria and several gaps are still to be filled in terms of research and management strategies that can support conservation of this important group of organisms in the country.

Successful biodiversity conservation research and implementation is founded on a synthesis of other biological science disciplines such as ecology, taxonomy, genetics, biogeography, evolution, among others (Khuroo *et al.* 2007). A timely engagement of practitioners in these conservation related disciplines is needed to estimate how much genetic, species, community, biotope and ecosystem diversity are available and at what rate they are being lost and to give possible directives on how to arrest declines (Samways 1993). For insects in particular, a good understanding of the spatio-temporal distribution of insect diversity is essential for effective conservation strategies (Lewis and Baset 2007). Basic biological, ecological and taxonomic information of insects in Nigerian terrestrial and aquatic ecosystems is scanty. Consequently, these knowledge gaps have to be filled to guarantee successful conservation planning and action. The current trend of poor inventory of insect fauna in the nation may imply that several species would be lost before they are ever accounted for. Urgent action is needed to embark on extensive inventories that will lead to the discovery of new species as well as provide distribution and abundance data of insects in the different vegetation zones within the country. This will provide base line information that can be used in conservation planning as well as in modelling response to ecologically important scenarios like climate change, agriculture, tourism etc.

### PROPOSED RESEARCH ACTION

Possible research-oriented approaches include; i) Research coordinated by Entomologist and Taxonomist ii) Citizen science program for insect distribution

#### *Research coordinated by Entomologist and Taxonomist*

This involves independent as well as combined effort of insect biologists and taxonomists in various tertiary institutions and research institutes all over the country. Taxonomy which involves discovery, description and identification of new species has suffered a lot of setbacks ranging from poor perception to inadequate funding as well as dearth of trained taxonomists and parataxonomists who specialize in description of various taxa from the vast array currently known to science (Godfray *et al.* 2002). Concerted effort has to be geared towards surmounting these evident challenges through the provision of grants locally, training opportunities for potential insect taxonomists as well as establishment of insect collection museums in different eco-regions in the country that will house collections of various taxa. Researchers should also be supported to attract foreign grants that will complement funds that are available locally to drive goal oriented projects in this field.

#### *Citizen science program for insect distribution*

Citizen science is the gathering of data for the advancement of scientific knowledge through coordinated activities of volunteer members of the public who are not necessarily professional scientists (Oberhauser and Prysby 2008). This approach has been used successfully to compile distribution and abundance data for various taxa in different regions globally (Table 1). Country wide citizen science program coordinated by Professional Nigerian Entomologists is a potential tool for compilation of insect diversity data. Due to increased accessibility to technical tools and facilities that promote dissemination of information about projects and gathering data from the public, there has been an upsurge in the use of citizen science programs for biodiversity inventory (Silvertown 2009). Electronic, web-based programs such as ESRI Conservation Program Biodiversity Survey Platform are freely available for hosting citizen science programs and biodiversity surveys (ESRI 2012). Citizen science programs are now involved in projects on climate change, invasive species, ecological restoration and conservation biology.

**Table 1.** Successful Citizen Science Programs in Different Regions of the World

<b>Program name</b>	<b>Focus taxa</b>	<b>Region</b>
Audubon Christmas bird count	Birds	North America
Butterfly Counts	Butterfly	North America
Cornell Laboratory of Ornithology Citizen Science Program	Birds	Global
Dragonfly Migration Project	Dragonfly	USA
Terrestrial Salamander Monitoring Program	Salamander	Pacific Northwest
British Trust for Ornithology	Birds	Britain
The Lost Ladybird Project	Beetles	North America
Protea Atlas Project	Protea plant	South Africa

### SUSTAINABLE MANAGEMENT ACTION

Management action towards sustainable insect conservation has been categorized into coarse-filter/landscape and fine-filter/species level management approaches (Samways 2007). Critical investigation of the ecology of insects in Nigerian ecosystems approached from both the insect taxon and habitat perspectives should precede conservation management decisions. Germane considerations that take into account the needs and limitations of various taxa such as food, nesting sites, habitat pollution and fragmentation will proffer valuable insight for sustainable management of both terrestrial and aquatic insect communities.

Nigeria has environmental laws which legislate against various threats to biodiversity such as deforestation and habitat pollution, however, these laws which could have a far reaching positive effect on conservation efforts are violated consistently by individuals, companies and corporate bodies all over the nation. Enforcement of these environmental protection laws holds promise for protection of the nation's endemic biota, which include insects and other taxa with which they interact to provide indispensable ecosystem services (Klein 2007). Nigerian government being signatory to Convention on Biological Diversity is under obligation to implement the National Biodiversity and Strategic Action of the country.

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