IMPACT OF WILDFIRE ON INSECT DIVERSITY IN THE SELOUS GAME RESERVE, TANZANIA

Kelvin Ngongolo[1] and Bruno. A. Nyundo[2]

[1]*Kingupira Wildlife Research Centre (TAWIRI) Box 16, Utete-Rufiji, Tanzania.*

[2]*University of Dar-es-Salaam Department of Zoology and Wildlife Conservation, Box, Dar-Es-Salaam*

ABSTRACT

Occurrence of fire is inevitable in the Selous Game Reserve which is among the UNESCO world Heritage sites. Apart from prescribed burning, un-prescribed burning was observed to occur in this reserve which was anticipated to deteriorate the wildlife species including insects. This study aimed at determining the impacts of fire on insects of the Selous. Pitfall traps were used in the collection of insects samples in the three designed study sites namely; burnt grassland, un-burnt grassland and burnt woodland. The findings showed that, fire had significant (what level of significance) impacts on diversity and not on abundance of insects. High diversity was observed in un-burnt grassland than in the burnt grassland. However it was eminent that, habitat heterogeneity had significant impacts on both diversity and abundance of insects. Higher diversity and abundance was observed in woodland habitat than in grassland. It was recommended to adhere with the principles of prescribed burning while enforcing laws on illegal sources of fire such as poaching.

Keywords: *Impact, Wildfire, Insects, Diversity, Selous*

INTRODUCTION

The Selous Game Reserve (SGR) is among the largest game reserves in the world and in Africa with about 55,000 km^2. It is found in South-eastern Tanzania (Wildlife Division, 2003; Williamson, 2005). The reserve is rich in biodiversity whereby big herds of large animals and over 440 species of birds are found, which makes bird watching ideal (Wildlife Division, 2003). The vegetation is mostly *Brachystegia* (Miombo) woodland (50%), followed by open savannah (40%), wetlands (5%), mountains and inselbergs (3%) and riverine and montane forests (2%). There are 21 vegetation types and the preliminary surveys indicated 191 species of trees and shrubs (Wildlife Division, 2003).

Selous Game Reserve is a World Heritage Site since 1982 which harbors large populations of mammals (UNESCO World Heritage Centre, 2012). Among the mammals found in the Selous Game Reserve include, buffalo (138,000), blue and nyasa or white-bearded wildebeest (46,500), impala (29,500), Burchell's zebra (21,500), Lichtenstein's hartebeest (20,000), African hartebeest “kongoni” (11,700), common waterbuck (10,000), giraffe (2,200), lion (3,000-4,000), Hippopotamus (27,000) and Greater kudu, sable antelope (1,600). The reserve has the largest population of the endangered wild dog in Africa (approximately 1,300) (UNESCO World Heritage Centre, 2012). Other relatively widespread mammals include yellow baboon, leopard, spotted hyena, and crocodile. The Reserve is connected to southern Tanzania and northern Mozambique through The Selous-Niassa miombo woodland eco-system corridor which allows migration of Elephants (Wildlife Division, 2003). Despite of the wealth information on large mammals, birds and habitats types, very little is known on insects and the threats they face in this area.

Most insects have more benefits than harms (New, 1995). Insects are the most important component of ecosystems. They are important as a source of food to animals and human beings, increases soil fertility and production due to decomposition of organic matter and by improving soil aeration and porosity. In addition, they play a role in nutrient cycling and pollination (New, 1995). Last but not least, they have great aesthetic value, at the same time providing medicinal and industrial products and good indicator species of biodiversity health (New, 1995). Despite of their great role, the impact of fire on them had not been documented in this area and so it was the task of this study to fill this gap.

Fire has both positive and negative effects in the ecosystem. The benefits of fire include, reduction of competition for surviving species by influencing the survival of fire adapted species while discouraging the non fire adapted species (Rodgers, 1973), increases forbs dominance and new animal colonization (Barratt et *al,* 2009). Also, fire was observed to increases soil fertility (Schoch and Binkley,1986), Fire helps to control soil pH, control of pests and parasites, reduces the over-accumulated hazardous fuels, improve vegetative communities, pasture palatability, accessibility and habitat for wildlife and livestock (Wan *et al.*, 2001). Fire affects animal and vegetation directly by killing, decreases litter decomposition caused by a decrease in microorganisms, promotes pathogens infestation, parasitic organisms and insects to animals and plants through wound and scars caused by fire (Wan *et al.*, 2001).

As a management tool, the use of prescribed burning in the Selous Game Reserve has been adopted for maintaining the miombo ecosystem. Generally, Wildlife mortality due to fire is rarely documented apart from anecdotal observations. Direct, fire-induced mortality has been reported for insects in a central Oregon ponderosa pine (*Pinus ponderosa*) of the United States (Gerson and Kelsey, 1997). Post-burn habitat modification was observed to reduce populations due to mortality and flying away of insects in New Zealand (Barratt *et al.,* 2009). A study done in South Africa's Drakensberg mountains, revealed that, distance from the burnt edge affected invertebrate richness and abundance, especially for flying insects. Burning appeared to minimally impact on wingless insects, suggesting they tolerate fire by finding refuge in burrows (Uys *et al.*, 2006). Insect's community structure changed with increasing distance from burnt edge for two weeks, but not 12 weeks post-burn. A distance of 280 m from burnt edge appears to allow sufficient re-colonization to maintain insect's diversity. Taxa found in the unburnt control site closest to the edge in burnt grassland were thought to be fire sensitive (Uys *et al.*, 2006). Few studies have been done in Tanzania in general and in Selous Game Reserve in particular.

In Udzungwa, human disturbances including fire were observed to increase the abundance of dung beetles due to altered vegetation (Rovero *et a.l*, 2008). A study done in two habitats of Mkomazi National Park, Tanzania compared species diversity and abundance of spiders in burnt and unburnt area (Russell-Smith *et al,* 1997). It reported that spider abundance was higher in unburnt than in burnt area during the dry season for the two habitats (*Acacia/Commiphora* bush land and the grassland) . Such studies have not been carried out in the Selous Game Reserve.

In Selous Game Reserve (SGR) fires were observed to affect the distribution of wild animals and shaping the miombo habitats of the ecosystem (Rodgers, 1973). Un-prescribed burning caused by local communities, poachers and Gun bearers ("Magambela") employed by game hunting companies has been observed to occur in this area. A distinct association of fire with insects in Selous has not been investigated (Rodgers, 1973, 1970). This study focused on identifying and determining the impact of fire on the diversity of insects in the Selous Game Reserve.

It is a known fact that fire can have a wide variety of impacts on biodiversity of an area (Whelan, 1995). Some of these impacts are positive (e.g. tree regeneration induced by fires, seed germination of some plant species). In other cases the impact is negative, for example, 40 species of arthropods are attracted and use burnt plants for breeding (Evans, 1971). Most studies on the impact of fire have involved vertebrates and the plants (Whelan, 1995). Very few studies have included insects (Whelan, 1995) and no such a study has taken place in the SGR. The present study is aimed at filling this knowledge gap.

In Selous Game Reserve, fire has been used as a management tool by wildlife managers through prescribed burning. In addition to this, un-prescribed burning is also known to occur in the area on a regular basis. The unintended impact of both prescribed and un-prescribed burning on biodiversity, including that of insects, has not been studied and documented.

The main objective of the proposed study was to assess the impact of fire on the diversity of insects in the Selous Game Reserve with the following specific objectives: To compare the diversity and abundance of insects in burnt grassland and unburnt grassland and to compare the diversity and abundance of insects in burnt grassland and burnt woodland.

We hypothesized that, the diversity and abundance of insects in burnt grassland would be lower than unburnt grassland, the diversity and abundance of insects in burnt grassland would differ significantly with that from burnt woodland.

It is our expectation that, the findings from this study will provide information to the Selous Game Reserve management and the Wildlife Division in the Ministry of Natural Resources on the effect of fire on insect diversity in the reserve. This could be helpful in the designing conservation education program and proper handling of fire by tourist company staff, local communities around the reserve, the tourist hunters and gun bearers (Magambela).

The information will also be helpful to the policy makers for proper formulation of conservation policies and management practices for Selous Game Reserve, where insects will be considered as an important group in the ecosystem conservation while using them as indicators in the ecological monitoring program.

Furthermore, the findings are anticipated to provide baseline information for the management and conservation of economically important insects. For example, butterflies pollinate crop plants hence ensuring food security to local communities and provide opportunity for butterfly farming.

MATERIALS AND METHODS

Study area

The study was conducted in the Eastern SGR located at 7°20′10° 30′S to 36°00′-38° 40′E in Kingupira Sector. Kingupira sector is about 65km from Utete district and is among the 8 sectors found in the Selous Game Reserve (Wildlife Division). The Selous Game Reserve (SGR) with approximated size of 55,000 km^2 is about 6% of the Tanzania's land surface (Wildlife Division, 2003). The Selous ecosystem, which is unique in its natural wildness, ecological and genetic resources, has approximately 90,000 km^2 of area. This ecosystem has the following components, Selous Game Reserve (55,000 km^2), Mikumi National Park (3,000 km^2), Udzungwa National Park (1,900 km^2) and Kilombero Game controlled Area (6,500 km^2), Peripheral areas (7,500 km^2) (Wildlife Division, 2003).

Insects sampling

Three study sites namely; Burnt grassland, burnt woodland and unburnt grassland were selected randomly to represent the ecosystem of Selous Game Reserve for the study. In each study site, three transects each of 1Km were identified. In each transect, three quadrates each with 500m^2 set at interval of 300m were identified. In each quadrate 10 pitfall traps were set. To avoid the "digging in" effect, the traps were arranged in square grids with 10m between traps. The distance between the edge of the burnt and unburnt plot was 140m. An area was considered to be "burnt "when the burning has occurred within a year (12 months) from the time of sampling. Sampling involved wet pitfall traps.

Wet pitfall traps each of 1 litter containing water mixed with soap to restrain and kill the insect after capturing were used. All samples collected were preserved in plastic containers with 70% Ethanol. The identification of insects was carried out at the Department of Zoology and Wildlife Conservation laboratory in the University of Dar-es-Salaam.

The Species Diversity and Richness program, Version 2.65 was used to determine the species diversity by calculating, species evenness, species richness, Shannon-Wiener index to determine heterogeneity of the community and Margalef index to standardize the number of species encountered against the total number of individuals encountered. Sørensen index (S) was used to compare the similarity of species in the study sites. Special t-test for comparing the diversity indices was used.

Due to high variance to mean ratio of the Data (non-parametric data), the Wilcoxon-Mann - Whitney test (α=0.05) was used to determine the difference in insects abundances between sites.Using SYSTAT version 10 Standard versions, descriptive statistics was used to analyze the social data.

RESULTS

Introductory remarks

A total of 810 pitfall traps were set at the three sampling sites (Burnt woodland, burnt grassland and un-burnt grassland), each comprising three transects in the study area. These yielded 1186insects of which 942 were adult insects and 244 individuals of larval stages. There was a positive Skewness (G1= 3.2) with standard deviation of 2.2, variance of 4.9, Mean= 1.5±0.078 with a range and Maximum of 21.

Impact of Burning on Insect Abundance and Diversity

Impact on the Abundance of Insects

Generally, the abundance of insects (mean insects per trap) was higher in un-burnt grassland (Mean=2.9±0.68, S.D=7.71) than in burnt grassland (Mean=1.72 ±0.36 S.D=0.118), but this was not statistically significant (Table 3.1). Also the burnt woodland (Mean=6.09 ±2.005, S.D=22.86) had highest abundance of insects than either the burnt or unburnt grassland (Fig 3.1).The most abundant insect species were Meloidae sp1(Coleoptera: Meloidae) (7.93%) equivalent to 94 individuals, *Streblognathus sp1*, (Hymenoptera: Formicidae) (7.93%) equivalent to 94 individuals and *Stomoxys sp* (Diptera: Muscidae) *(*7.34%) while species like *Thermophilum sp2* (Coleoptera, Carabidae)*,Alydidae sp* (Hemiptera, Alydidae)*, Caminara* (Coleoptera: Carabidae*) sp* were observed to occur as singletons. The percentage of singletons was 17.9%.

Some species were observed to be habitat specific, for instance, *Anthestia lymphata* and*Bembidion sp1* (Cleoptera: Carabidae)were observed to occur in woodland only, some species like Acrididae sp1, (Orthoptera: Acrididae)*Aphodius sp* (Coleoptera: Scarabaeidae)*, Bengalia sp1* (Diptera: Calliphoridae*),* Meloidae sp1 (Coleoptera: Meloidae)*,* Meloidae sp2(Coleoptera: Meloidae) were observed to occur in all the three study sites although showed variation in abundance. For stance, the abundance of Acrididae sp1,(Orthoptera: Acrididae)was higher in unburnt grassland (with ration of 1:3:1) for Burnt grassland, Unburnt grassland, Burnt woodland respectively and Buprestidae sp1 (Buprestidae: Coleoptera*)* was higher in burnt woodland with ration of 1:1:6 for Burnt grassland, Unburnt grassland, Burnt woodland respectively while Scaritinae sp1(Coleoptera: Carabidae) showed highest abundance in burnt grassland with a ratio of 5:2:3 for Burnt grassland, Unburnt grassland and Burnt woodland respectively.

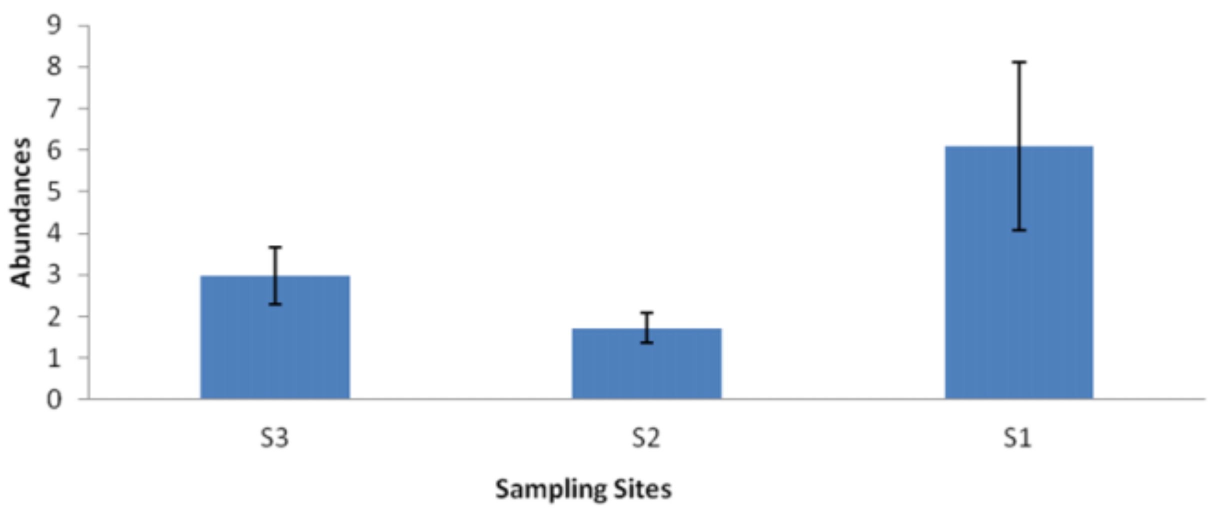

Figure 3.1: The Abundance of Insects (Mean ± SE) in Burnt grassland, Un-burnt grassland and burnt woodland. S1=Burnt woodland, S2=Burnt Grassland and S3=Un-burnt Grassland

Kruskal-Wallis Test Statistic revealed that, the abundance of insects in the burnt woodland was significantly higher than in both unburnt and burnt grassland (H=129.932, $P < 0.05$). Mann-Whitney U test statistic showed that, the abundance of insects in the un-burnt grassland was not significantly higher than in burnt grassland (U = 36450, $p > 0.05$) (Table 3.1).

Table 3.1: Comparison of the variation of insect abundance in the three study sites using Mann-Whitney U test statistic. S1=Burnt woodland, S2=Un-burnt Grassland and S3=Burnt Grassland, U= Mann-Whitney U test statistic, P= Probability.

Variation between	U	P	Comments
S1 and S2	54966.500	<0.05	Significant
S1 and S3	47063.000	<0.05	Significant
S2 and S3	36450.000	>0.05	Not Significant

Impact of Burning on the Diversity of Insects

In overall 130 species of insects were identified. The number of insect species was highest in burnt woodland while being least in burnt grassland (Table 3.2). The dominant species in burnt woodland was observed to be Meloidae sp1 (Coleoptera: Meloidae)(11.139%) equivalent to 70 individuals followed by *Stomoxys sp*(Diptera: Muscidae)(6.995%) and *Curculionidae sp* (Coleoptera: Curculionidae) (6.0413%). *Thermophilum sp2* (Coleoptera: Carabidae) (0.1589%),Reduviidae sp2(Reduvidae:Harpactorinae) (0.1589%),and *Othophagus sp2* (0.1589%) were observed to be rare and occurred as singletons in this area. The burnt grassland was dominated by *Buprestidae sp1* (Coleoptera: Buprestidae)9.259% equivalent to 20 individuals followed by *Streblognathus sp1* (Hymenoptera: Formicidae) (8.333%) while species such as *Thermophilum sp1* (Coleoptera: Carabidae) and *Lucilia sp1* (Diptera: Calliphoridae) were observed to be rare. Species like Meloidae sp1 (Coleoptera: Meloidae) and *Tetramorium sp1* (Hymenoptera: Formicidae) occurred in all the study sites while *Thermophilum sp1* (Coleoptera: Carabidae) occurred in burnt woodland only.

In terms of community similarities between the study sites, there was variation between the three communities. Sørensen index was higher between un-burnt grassland and burnt grassland (S=58.04415%) with intermediate similarity between burnt grassland and burnt woodland (S =46.1167%) while the least similarity was between un-burnt grassland and burnt woodland (S = 43.14534%).

Margalef and Shannon-Wiener indices indicated highest diversity in Burnt woodland and Un-burnt grassland respectively. The species Evenness was higher in Un-burnt grassland followed by burnt grassland and was lowest in Burnt woodland (Table 3.2).

Special t-test revealed that the difference in species diversity (using Shannon-Wiener Index) between the un-burnt and burnt grassland was not statistically significant (t = 0.11114, $P>0.05$), however, using Margalef's index, the difference was significant (t=3.20431, $p<0.05$).

Table 3.2: The number of species (S), Margalef index (D), Shannon-Wiener index (H) and Evenness (E) for different sampling sites.

Sampling areas	S	D	H	E
Burnt Grassland	40	7.2554	3.1868	0.6547
Un-burnt Grassland	62	10.46	3.2982	0.6776
Burnt Woodland	79	12.104	3.0064	0.61764

DISCUSSION

Preliminary remarks

Generally, the abundance of insect collected from Selous Game Reserve during the present study was low (1,186insects) when compared with other studies done in Tanzania. The results from Udzungwa revealed 12,894 individuals of dung beetles which are about 11 times of insects obtained in Selous (Mwambala, 2012). Similarly, this abundance was low when compared with the abundance of insect collected in Mkomazi Natil Park (41,099 insects of 492 recognizable taxonomic units RTL's) (Russell-Smith *et al,* 1997). The low abundance in Selous Game Reserve could be attributed to two main reasons: firstly season during the time of sampling, and secondly, the scope of the sampling and the protocol used. Other reasons that may have a minor contribution to the observed low abundance are quantity of litter, vegetation cover and predation.

Wet season in Mkomazi National Park yielded high abundance than dry season, also predation was observed to affect the abundance (Russell-Smith *et al,* 1997). In Udzungwa Mountain, Tanzania and Kibare forest-Uganda the relative abundance of insectswere affected by season too (Cancelado and Yonke, 1970).

The study in Selous Game Reserve was conducted in December (which year) at the end of dry season and beginning of wet season. In addition, most of the vegetation cover was completely burnt during the time of collecting data .This implies that the low abundance in Selous Game Reserve during the study would be attributed to both season and change in vegetation cover as suggested by Cancelado and Yonke (1970).

In terms of scope of the study, the current study was conducted for a very short period time and involved single method (pitfall) which is in contrast with other studies like that of Mkomazi which took place for long time and involved several methods (Russell-Smith *et al,* 1997).

Impact of Burning on Insect Abundance

Burning did not have significant effect on the abundance of insects when the burnt and unburnt grasslands were compared. This can be due to the time lag of sampling from burning season. The area was considered to be burnt if the burning had occurred within the year. This suggests that, possibly the re-colonization could have occurred between the time of burning and sampling, thus masquerading the effect of burning. Similar studies in other places have showed that sampling time had influence in the abundances of insects. In Waubun Prairie of northwestern Minnesota it was realized that, there is inter and intra-annual variation in Coleoptera abundance (Cancelado and Yonke, 1970).

In contrast with Selous Game Reserve, studies from other places have shown different scenario, for instance, in Mkomazi National Park it was observed that, burning had significant effect in abundance of beetles in grassland but not on Hillside. It was concluded that, the biomass of dead grasses in unburnt grassland contributed to the effect (Russell-Smith *et al,* 1997). Burning in Serengeti was taken as a king of the disturbance occurring in this national park as that of Selous Game Reserve. The impact of burning on arthropod showed that, the abundance of most groups of arthropods was lower on burnt sites than on unburnt sites. The reduction in number in the burnt site was considered to be associated with predation and change in grass structure (Nkwabi *et al*, 2011).

The current study took place within a year since the burning occurred. This is enough time for habitat to stabilize and insects to re-colonize the burnt area. Also, results fromboreal forests perceived that, unless uncontrolled burning is applied, the abundance of insects such as beetles was observed to decrease and the difference between the burnt and un-burnt area was significant (Hyvärinen *et al*, 2009). This calls for further studies in Selous to compare the abundance of insects in controlled burning and uncontrolled burning which was not achieved through this study.

The difference in abundance was observed when compared between different vegetation types: woodland versus grassland (both burnt and unburnt). In Selous Game Reserve the burnt Miombo wood land had significantly higher insect abundance than either burnt or unburnt grassland. The higher abundance in woodland would possibly be due to habitat (physiognomy) heterogeneity in the woodland. Mwambala (2012) did her study in Udzungwa and found that, vegetation covers with interval from the time of disturbance had effects on the abundance of the beetles. Stork (1987) agreed that, taxonomic similarity of the trees was the most important variable affecting species composition in his multivariate approach, stressing that closely related tree species have a similar insect fauna. This elucidated that dissimilar plant species influenced the abundance of insects. However, surveillance from Mkomazi revealed that, when the abundance and diversity of in insects were compared in an area with the same genus of *acacia* tree, the effects were not seen

Impact of Burning on Insect Diversity

The 130 species of insects identified in the Selous provide the base for further studies in this area. When the number of species was compared between burnt and unburnt grassland, maximum of number of species were observed in burnt grassland (62 Species). However the woodland (79 Species) was the most species rich area compared to both unburnt grassland and burnt grassland. The variation in species number in these three study sites perhaps was attributed to the discrepancy in vegetation covers, amount of litter, dissimilarity in productivity, soil moisture content and different rate of re-colonization among species.

Margalef’s index revealed significantly higher species diversity in unburnt area than in burnt area. The difference in species diversity probably have been accredited to low vegetation cover, direct killing of other species, change in chemical composition, predation and moisture content in burnt area. Predation in Mkomazi was observed to affect the diversity of insect. Similarly, Russell-Smith *et al* (1997) in Mkomazi confirmed that the sparse and patches left after fire reduced the diversity of beetle by increasing the predation vulnerability. The burnt area in Selous Game Reserve was observed to be openly exposed which can increase the chance of insects to predators.

Rice (1932) studied the effect of fire on prairie animal communities following spring burning. The results showed a decline in species diversity of insects and other invertebrate's species including the charred spiders, tenebrionid beetles, carabid beetles and cut-worm larvae bugs, cut-worm larvae, ground beetle, slug and centipedes. *Aulax* larvae and *Lepidoptera* larvae were observed to be killed. This suggested that, the decrease in insect in burnt area was caused by direct killing by fire, flying to adjacent area while other hibernating under the soil surface. Related findings from New Zealand proved that, post-burn habitat modification could reduce populations and diversity of insects (Barratt et *al,* 2009).

Although the study in Selous Game Reserve is showing higher diversity in unburnt grassland, yet some studies from other area have showed variation on insect response to fire. For instance Cancelado and Yonke (1970) observed Coleopterans and Hemipterans to increase following burning. They concluded that, most grasshoppers came from areas having light to moderate amounts of litter. Optimum grasshopper habitat consisted of vegetation that was recovering from burning rather than that freshly burnt or long unburnt. This was correlated to the sparse litter found on both sites. This may also be due to increased productivity following burning. In Newzland, the Impacts on some of the larger groups, such as *Coleoptera, Diptera and Hemiptera*, were found to be very variable, depending upon their trophic group and the seasonal characteristics of the fire (Barratt et *al,* 2009).

Also some studies have revealed that, Herbivore and none-herbivore insects respond differently between the burnt and unburnt areas. Nagel (1973) quantitatively measured the effect of a single spring burn on the biomass and density of arthropods in the native True Prairie near Manhattan, Kan. The numbers of non-herbivorous insect species were equal on both areas, but non-herbivorous insect biomass was higher on the burnt than on the unburned areas. The burnt area contained significantly greater numbers of arthropods and greater biomass than the unburnt area.

Distance from the burnt edge in South Africa affected the diversity of insects especially for flying insects with minimal impact on wingless insects, suggesting that they tolerate fire by finding refuge in burrows (Uys *et al*, 2006) while Grasshoppers in Newzland were observed to fly away during burning .

Moreover some species like *Scaritinae sp1* (Coleoptera: Carabidae) in Selous Game Reservewere observed to occur in high frequency on the burnt grassland than either on unburnt grassland or on burnt woodland. This can be due to the ability to survive during the occurrence of fire by burrowing under the soil surface or escaping from fire with early re-colonization or being attracted to the burnt area. Rice (1932) found that, ants and ground-dwelling beetles do survive during the burning by escaping heat from fire by going below the soil surface and emerging again after fire. Ground insects are unharmed by fire and change in vegetation architecture. Fire causes an immediate decrease in insect populations (except ants and other underground species), followed by a gradual increase in numbers as the vegetation recovers. The insects eventually reach a population level higher than in adjacent areas, then decline to near preburn levels as vegetation and soil litter stabilize. Furthermore, studies from Western Conifers, United state have found that, insects are attracted to burnt area for instance, however, Whelan (2005) pointed out that, the increase of insects like ants and beetles in the burnt area can be due to increase in their activities such as searching the place for hiding from predation and food.

CONCLUSIONS AND RECOMENDATIONS

Conclusion

Generally, the burning in the Selous Game Reserve had significant impact in diversity of insects but not in their abundance. Some species like *Bembidion sp1*, *Batozonellus sp*, *Bantua sp*, *Apidae sp1*, *Alydidae sp*, *Abisaries sp* were observed to occur in the burnt grassland but not in the un-burnt grassland. The variation in species diversity between the burnt and un-burnt area could have been attributed by different factors such as altered vegetation cover, litter, moisture contents and predation in the burnt area.

Wildfire from this reserve was observed to be associated to different socio-economic activities of the local communities around the Selous. The findings from this study provide profound information on monitoring the impact of fire in the reserve by using insects as indicator species. Also the socio-economic activities which influence the occurrence of wildfire around the reserve are to be managed.

Through this study, it was noticed that, when fire is used wisely, it can bring positive effects in the conservation of wildlife in Selous Game Reserve. However, if the uncontrolled burning in the reserve, especially in Kingupira will continue without proper management, it is expected to devastative not only insect species but also other wildlife species.

Recommendations

It is recommended to ensure that, the principles of prescribed burning are adhered to under the supervision of the wildlife managers. The prescribed burning keeps some part of the area unburnt during burning season, which provides opportunity for insects and other wildlife species to take refugee when the other areas are burnt. The un-burnt area acts as source for re-colonization during post fire.

Last but not least, it is recommend that, further studies should be done to determine the impacts of prescribed and un-prescribed burning on insects diversity and abundance, to determine the burning frequencies and occurrence of wildfire in Selous Game Reserve, to determine the impacts of wildfire on other wildlife species and to determine the immediately response of insects to fire.

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