DARWIN INITIATIVE FOR THE SURVIVAL OF SPECIES

FINAL REPORT

Project Details

Project Title: Invertebrate Biodiversity of the Mkomazi Game Reserve, Tanzania.

Institution: Natural Resources Institute, University of Greenwich.

Round 1	☐	(please tick)
2	☑	
3	☐	
4	☐	

PROJECT EXPENDITURE:

Total grant expenditure:

Breakdown of expenditure:

Staff costs.

Rent, rates etc.

Postage, telephone, stationary

Travel & subsistence

Printing

Conferences, seminars etc.

Training

PROJECT BACKGROUND AND RATIONALE

Why was the project needed ?

This project was a component of the ***Mkomazi Ecological Research Programme***, a three-year venture undertaken jointly by the Royal Geographical Society (RGS) and Oxford University at the request of the Government of Tanzania's Department of Wildlife. Following signing of a memorandum of understanding in August 1993, the programme commenced fieldwork in April 1994. The project addressed the evaluation of biodiversity in a resource-poor country, Tanzania, which is faced with many calls on government funding to assess and protect major wildlife habitats. In so doing the project was closely aligned with principles 6, 7, and 9 of the *Rio Declaration on Environment and Development*, relating to international co-operation and the needs of developing countries..

In focusing on the biodiversity of savanna invertebrates, this project addressed a neglected taxonomic group of organisms in an undervalued ecosystem. By studying the diversity of selected organisms at different trophic levels within the food chain and in conjunction with parallel studies of fire-induced vegetation changes, the project will provide an understanding of the effects of natural and man-induced processes on the biodiversity of semi-arid savannas. The overall aim of the project was therefore to describe in quantitative terms the diversity of the terrestrial invertebrate fauna of the Mkomazi Game Reserve and to assess the influence upon it of natural and human-induced factors.

How is it related to the conservation priorities of the host country ?

Tanzania's Department of Wildlife has overall responsibility for conservation not only of wildlife in the restricted sense (primarily large vertebrates) but also for conservation of all components of biodiversity within the protected areas which it manages. In terms of species, invertebrates account for the largest single component of total biodiversity in any ecosystem and are particularly rich in tropical savannas. Until the present study, the Department had no reliable inventory of any component of invertebrate fauna for any of its protected areas, despite the fact that they include sites such as Ngorongoro which are of global importance. Neither did they have any indication of how management tools, such as burning or grazing, might effect the invertebrate diversity of protected savanna areas. This project has provided a first inventory of selected invertebrate groups for such an area and some indications of the effects of burning on invertebrate diversity. It provides a baseline for measuring changes in invertebrate diversity both within the reserve itself and for comparison with other semi-arid savannas in Tanzania and the East African region in general.

How is the project intended to assist the host country meet its obligations under the Biodiversity Convention ?

1. By assisting the Dept. of Wildlife to establish the identity and distribution of invertebrate biodiversity in the Mkomazi Game Reserve.
2. By assisting the Dept. of Wildlife to protect invertebrate biodiversity by recommending appropriate habitat management procedures.

Project Customer
The Dept of Wildlife and Natural Resources, Tanzania.

PROJECT OBJECTIVES

What were the project objectives ?

1. To conduct a baseline inventory of selected terrestrial invertebrate groups for the MGR by making representative taxonomic collections and identifying these where possible to genus and/or species.

2. To provide quantitative measures of the species numbers and diversity of key invertebrate groups for the major habitat types within the MGR, including calculation of appropriate indices of diversity.

3. To measure the degree of change in species diversity and faunal similarity between major habitat types within the MGR.

4. To determine the effects of burning and grazing on species richness and diversity in different habitat types.

5. To develop secure, well-documented savanna invertebrate biodiversity collections at the TPRI, Arusha, Tanzania.

6. To provide training for Tanzanian personnel in:

* collection and preparation of biological material for diversity studies,
* maintenance of biodiversity reference collections,
* taxonomy of appropriate invertebrate groups, and
* measurement and interpretation of ecological parameters including diversity indices.

Were the objectives of the project revised and if so, how ?

No

Have the objectives been achieved ?

All objectives were achieved, in whole or in part.

What objectives were not achieved or only partly achieved ?

Objective 1. It was originally envisaged that there would be four target taxa, one of which was Acridoidea (grasshoppers). Due to the loss of a key scientist (Dr M. Ritchie) halfway through the project it was not possible to achieve this part of objective 1.

Objective 4. Because grazing within the reserve is seasonal, intermittent and patchily distributed, it was not possible to establish the effects of grazing on invertebrate diversity within the resources available.

PROJECT OUTPUTS

What output targets (if any) were specified for the project ?

No output targets were specified for in the original project documentation, submitted in April 1994. In March 1996, the following output targets were imposed by Pieda Ltd.

1. Production of scientific papers (number unspecified)
2. Production of a book or film to assist in the dissemination of results *
3. Publication of a review of invertebrate biodiversity data
4. Establishment of an invertebrate biodiversity reference collection in Arusha
5. 4 staff trained in field techniques
6. 2 staff trained in taxonomic and curatorial techniques
7. 1 staff trained to M.Sc. level

Note * At the time it was pointed out to Pieda that there was no provision for the production of a book or film in the original project proposal and that project funding was not sufficient to do so. However, no response to this letter was received from Pieda and the suggested output target was subsequently set aside.

Have these targets been achieved ?

All targets other than 2 (see above) and 4 have been fully achieved.

What targets have not been achieved or only partially achieved ?

Target 4 has only been partially achieved in that sorting of the reference collection in the UK is continuing. It is anticipated that this will be completed within 6 months and the collection sent to TPRI, Arusha by the end of the year.

What additional outputs have been achieved ?

(8) Project staff spent a total of 52 weeks working in the host country.

(10) 1 formal key to pollinating Diptera of Mkomazi produced.

(11) 2 papers published in peer reviewed journals. A further 5 papers have been submitted for publication.

(15) 1 national press release in UK.

PROJECT OPERATION

Field sampling methods

Routine sampling methods included pitfall trapping for ground-active arthropods, sweep netting for field layer arthropods and insecticide fogging for tree canopy arthropods. Other methods of sampling included malaise trapping, litter sorting and hand-collecting . Full details of all these sampling methods are provided in the final technical report of the project and are not repeated here. An estimate of the total sampling effort and number of discrete habitats sampled is given in Table 1.

Table 1. Estimated sampling effort and total number of habitats sampled using different techniques in Mkomazi Game Reserve, Tanzania. 1993 - 1997.

Sampling method	Sampling effort	No. of habitat types sampled
Pitfall traps	12,370 trap/days	12
Sweep net samples	22 samples of 10 x 20 sweeps	13
Tree canopy fogging	183 trees, 29 species.	N/A
Hand collection	31 samples of 1-2 hrs	16

We are confident that overall, this represents the single largest sampling effort ever carried out for a discrete area in Africa.

<u>Coleoptera</u>
A total of 675 morphospecies, belonging to 47 families, were collected by pitfall trapping, insecticide mist-blowing, and by hand collection. The pitfall sampling resulted in the collection of 421 morphospecies, while a total of 167 morphospecies, were collected from the 17 trees sampled in the insecticide-spraying study.

The most species-rich families were the Scarabaeidae (with 13.9% of all species), Chrysomelidae (also with 13.9%), Carabidae (13.2%), Curculionidae (9.6%), Staphylinidae (6.5%), and Tenebrionidae (5.9%). With few similar studies to provide comparative data on beetles, it is difficult to assess how rich the beetle fauna of Mkomazi is relative to other areas of Africa. However, the baseline inventory provided by this survey will serve as a standard against which future studies both in Mkomazi and elsewhere may be compared.

The species richness of the ground-dwelling beetle faunas from ten different habitat types throughout Mkomazi was assessed. High species richness was found in the two Dindira habitats (*Combretum* bush and *Dichrostachys* bush), two Ibaya Hill habitats (*Spirostachys* forest and *Setaria* grassland) and two Ibaya Camp habitats (hillside *Acacia/Commiphora* bush and footslope grassland). These sites in the west of the Reserve, are highly significant for beetle diversity in Mkomazi. In contrast, the dry habitats around the Umba River (Riverine bush and *Commiphora* woodland) and Ndea Hill (*Acacia senegal* woodland and *Acacia drepanolobium* vlei) produced much lower numbers of species. Although the wetter habitats had a greater diversity of beetles than the drier areas, a large proportion of their species seem to be relatively common throughout Mkomazi. In contrast, despite yielding relatively few species, the drier habitats tend to contain species not found elsewhere in the Reserve, and may thus contribute significantly to beta diversity (i.e. the overall species complement of the region).

Species richness and dominance varied considerably between tree species. The greatest number of species (46) was collected from the *Acacia mellifera*, which was a small tree with a limited canopy. Four other tree species, *Lannea stuhlmannii*, *Terminalia* sp., *Acacia reficiens* and *Acacia tortilis* produced similar numbers of species (from 32 to 37), while all other trees had fewer than 15 species. The smaller number of species from the three *Acacia drepanolobium* bushes (which produced a total of only eight species and 11 individuals between them), and the four *Acacia zanzibarica* trees, are probably related to their small size and limited canopy area. However, *Melia volkensii*, *Acacia anthelmintica* and the two *Acacia senegal* also exhibited low species diversity despite their relatively large heights, canopy areas and collecting areas.

Beetle species richness and abundance for burnt and unburnt habitats at Ibaya were recorded at four different times of year. None of the differences in species richness between burnt and unburnt habitats were found to be statistically significant, but there were significant differences in terms of the number of individuals caught. In the hillside *Acacia/Commiphora* bushland sites, beetle abundance in November 1994 was significantly higher in the unburnt area, while in April 1995 and January 1996 it was higher in the burnt area. This suggests that burning initially reduces beetle populations, but in the longer term increases beetle abundance and activity. This could be due to the removal of the large biomass of dead grass, or to the rejuvenation of the site by release of recycled nutrients to the soil. By contrast, in the footslope grassland sites the only major difference between burnt and unburnt habitats was in April 1995, when beetle abundance/activity was significantly higher in the unburnt patch. This means that in April 1995 beetle abundance on the hillside was significantly higher in the burnt area while in the grassland it is higher in the unburnt area.

Spiders

The most immediately evident feature of the spider fauna of the reserve is the very high family diversity. The 46 recorded from Mkomazi represent nearly half of all currently recognised spider families (total 105).

Among the 427 morphotypes recognised so far, the two most species rich families are the jumping spiders (Salticidae) with 55 species (13 % of all species) and the ground spiders (Gnaphosidae) with 51 species (12 % of all species). Wolf spiders (Lycosidae) and lynx spiders (Oxyopidae) were both represented by 22 species and Zodariidae by 19 species. Corinnidae (formerly included in the sac spiders - Clubionidae) were represented by 18 species. The two other families with more than 10 species were the Oonopidae and Linyphiidae. Mkomazi is richer in both spider species and spider families than Etosha National Park in Namibia. This may be attributable to the lower rainfall in Etosha which is also not as well distributed as in Mkomazi (unimodal as opposed to bimodal rainfall distribution). However, historical and geographical factors may also play a role in maintaining the high diversity in Mkomazi.

The family composition of ground-active spider communities varied with both habitat and season. In the closed montane forest on Ibaya hill, Salticidae were completely absent from the ground layer and their place taken by Linyphiidae. The average proportion of Salticidae in woodland, bushland and grassland habitats was relatively constant. The proportion of both Zodariidae and Gnaphosidae increased twofold and threefold respectively between grassland and woodland and these families were clearly most abundant in shaded habitats. By contrast, wolf spiders (Lycosidae) were on average twice as abundant in grassland habitats as in the closed montane forest. Species richness was greatest in closed *Dichrostachys cinerea* scrub near Dindira Dam (38 spp.) and was also high in well developed open *Acacia senegal* woodland near Ndeya (32 spp.) and in montane grassland on Ibaya hill (33 spp.). Relatively low species richness was found in unburned foot-slope grassland at Ibaya (22 spp.), vlei grassland with scattered *Acacia drepanolobium* near Ndeya (24 spp.) and in riverine scrub on the Umba River (24 spp.). Species diversity as measured by α was closely related to species richness and, across all 10 habitats, there was a significant correlation between the two measures of diversity ($r = 0.7508$, $P < 0.02$).

The dominant spider families in sweep net samples from 11 grassland sites in January 1996 were Thomisidae (mean 38%) and Araneidae (mean 22%) Other well represented families included Philodromidae (12%), Salticidae (12%) and Oxyopidae (5%). Species richness of spiders was highest in *Acacia senegal* woodland near Ndeya hill and lowest in open grassland in the Nyati and Simba experimental plots. Species richness was positively and significantly correlated with estimated percentage tree or bush cover for each site ($r = 0.7417$, $P < 0.01$). Species diversity (α of the log series) was also greatest in *Acacia senegal* woodland but was lowest in *Cynodon* grassland below Kisima experimental plot and in *Themeda triandra* dominated grassland near Ndeya hill. Species diversity was even more closely correlated with estimated tree or bush cover for each site than species richness ($r = 0.8711$, $P < 0.001$).

Both species richness and diversity of spiders were clearly much more influenced by burning in the hillside bushland than in the grassland below. Although monthly species richness was higher in burnt bushland than unburnt in six out of nine months, principally during the dry season, there was little difference between the two habitats over the whole period of study. Species diversity, however, was clearly reduced in the burnt habitat in most months and over the whole nine month period was 26 % lower in burnt than unburnt bushland. In the grassland differences in species richness or diversity between the burnt and unburnt sites were quite small and unlikely to be particularly significant.

At present, the reasons for the differences in the effect of burning between grassland and hillside bushland are a matter for speculation. The burnt hillside was quite badly eroded with a thin layer of soil between exposed stones. It is possible that the productivity of this habitat was much more severely affected by burning than the grassland below and that this was reflected in the diversity of predators in this environment. However, given the apparently elevated activity of certain species in the burnt bushland, it is more likely that habitat structure or physical constraints permitted only a limited number of species to compete in this relatively harsh environment. In the grassland, although burning left the soil surface exposed, rapid regrowth of a dense sward was evident following rains and this may have permitted re-invasion of a diverse fauna from adjacent unburnt grassland.

Canopy arthropods

Quantitative arthropod samples have been obtained from the canopies of 266 trees representing 30 species. The total canopy area sampled for all tree species is a little over $480m^2$. This work represents the biggest single study of savanna tree canopies ever undertaken.

Only 31 of the 266 tree samples taken has been fully sorted, analysed and identified, comprising 11.6% of the estimated 0.5 million specimens. Species richness and abundance is very much greater than previously recorded in the only similar savanna study of 6 species of *Acacia,* 5 species of *Commiphora* and one species of *Lannea* carried out in the Kora National Reserve, Kenya (West, 1986). In this study, conducted from early November 1983 to late January 1984, 6,742 specimens, assigned to 496 morphotypes, were collected from 49 tree samples each of $4m^2$ (a total of $196m^2$). The mean density of arthropods in the Kora study was $34.4 /m^2$ as compared with a mean density of $666 /m^2$ (excluding larvae) in the present study. The huge difference in the relative numbers of specimens collected must be largely due to the to the superior sampling efficiency of a motorised mistblower over a manually-operated backpack sprayer.

A total of 41,099 insect specimens, belonging to 14 orders, 133 families and 492 recognisable taxonomic units (RTUs) were recognised from the 61.28m^2 area sampled. The average insect density was 666 per m^2 (if larvae are included this figure rises to 800-900 per m^2) and the mean number of RTUs per tree was 93. The variation in terms of the number of RTUs between individual trees covers a five range fold, and a fourteen range fold with regard to the number of individuals (Table 8). A graph of cumulative area / RTU relationship for the entire fauna sampled shows that, according to the two true richness estimators, between 77 and 100 % of the insect fauna is represented in the samples

The RTU richness was highest for the Hemiptera, followed by the Coleoptera, Hymenoptera and Diptera. The most diverse families were the Cicadellidae, Chrysomelidae, Miridae and Formicidae with 7.9, 5.5, 4.1 and 2.9% of the total RTU richness respectively. In terms of abundance, thrips (Thysanoptera) and ants (Formicidae) were much more important than Coleoptera but the Hemiptera had the highest abundance. The families with the highest abundance's were the Thripidae, Formicidae, Cicadellidae and Miridae with 19.2, 18.2, 12.3 and 12.1% of the total abundance respectively.

For the entire insect fauna, the observed abundance distribution is best described by a log normal model ($R^2 = 0.908$, d.f. = 12, $P < 0.001$. There was no significant deviation between observed abundance distribution and the log normal model ($\chi^2_{12} = 20.99$, $P > 0.05$) but a highly significant deviation from two other models.

Insects were assigned to nine major ecological guilds and the distribution of species diversity and biomass was analysed. The data cover a 1,000,000-fold body weight range. Between tree variation in the proportion of RTUs and biomass in most guilds is large and covers a 2.5-fold range. RTU diversity was highest in the phytophagous sapsucker guild (mainly Hemiptera and some Diptera), followed by the parasitoid (Hymenoptera) and phytophagous chewer (Orthoptera, Phasmatodea and some Coleoptera) guilds.

PROJECT IMPACT

It is far to early as yet to say how the research findings will be used by the host country, if at all. We have had no feedback from the Dept. of Wildlife as to what actions are expected to be taken as a result of the project.

Training has been provided in invertebrate systematics and biodiversity assessment for one student at M.Sc. level in the UK. Two students have attended short courses on insect identification in the UK (IIE). On the job training in practical field sampling for biodiversity assessment has been provided for 4 Tanzanian technicians. Whether these address real skill needs depends on the definition of that term; certainly the skills were not present at the outset, although whether they will be used in future is problematic. All students and trainees have returned to existing jobs either in TPRI or the University. Most of these jobs are only marginally concerned with invertebrate biodiversity conservation which appears to have a fairly low priority in Tanzania.

Good collaboration between UK and Tanzanian institutions was achieved at field level but it is unlikely, in the absence of further funding, that this will lead to any future joint work. As mentioned above, invertebrate biodiveristy conservation is not seen as a first call on resources in Tanzania.

ADDITIONALITY

Had Darwin funding not been available for this project it is likely that it would have proceeded with other funding, although with slightly differing emphasis. As part of the overall Mkomazi Ecological Research Project, a group of South African researchers were funded by the Commonwealth Foundation to investigate the biodiversity of a range of invertebrate groups not covered by the DI project. These included ants, parasitic Hymenoptera, butterflies, Neuroptera and cicadas. It is thus clear that other organisations were capable of meeting the Dept. of Wildlife's needs in this matter.

KEY POINTS

Key success factors

1. Availability of infrastructure (camp, transport, administration and local staff) provided by Royal Geographic Society Mkomazi project.

2. Good collaboration in the field with Tanzanian scientists and technical staff.

3. Reasonably supportive attitude of the Dept. of Wildlife and TPRI.

Key problems and difficulties

1. Shortage of time for sorting and identifying the massive number of arthropod specimens from sampling programmes.

2. Difficulty of finding taxonomists able and willing to collaborate in identification of critical groups.

3. Difficulty of identifying suitably qualified Tanzanian candidates for M.Sc. level training.

Key lessons to be drawn

1. Ensure that adequate infrastructure, both physical and organisational, are in place in the host country to permit the achievement of the project's goals. The more complex/ambitious the project, the more crucial adequate infrastructure becomes.

2. Choose host-country partners carefully, based on personal contacts and ensure they are involved in project planning and decision making.

3. Be realistic and flexible in setting and revising scientific objectives.