African Journal of Biological Sciences

Journal homepage: http://www.afjbs.com

Research Paper   Open Access

Epigaeic invertebrate communities of the Albany Thicket Biome, Eastern Cape Province, South Africa: Implications for conservation management

Augustine Niba[1] and Memani Sanky[2], [1,2]Department of Biological & Environmental Sciences, Walter Sisulu University, Private bag X1, Nelson Mandela Dive, Mthatha

*Corresponding author e-mail address: aniba@wsu.ac.za
ORCHID; 0000-0001-9507-8633

Abstract
A total of 1993 individuals were collected from both riny/wet and Cold dry seasns, out of which 340 species were sorted from 854 individuals were from the Wet/rainy season. The thicket patch with the Open Mixed and low Vegetation site had the highest species richness (S = 48) followed by the Patch with no undergrowth (S= 37), the Patch with grazed undergrowth (S = 34) and the lowest species rich was the Ticket patch with the lowest richness (S =29). The patch with the highest species abundance (N= 408) was the Open Mixed and low vegetation site, followed by followed by the Thicket Patch with Highly Grazed undergrowth (N= 179), and the Thicket patch with grazed undergrowth was (N= 118). The Araneae was the most abundant order, followed by Orthoptera (84), Hymenoptera (61) and then the Coleoptera (50). Araneae had the most abundant species, followed by Orthoptera (84), Hymenoptera (61) and lastly Coleoptera (50). Members of these invertebrate orders were present across all four sites. Certain measured environmental variables accounted for species composition and distribution patterns across site sampling units e.g. leaf litter, pH, vegetation cover % bare ground, and soil chemical properties (e.g. Mg, Ca, K, and Zn). Species richness and abundance of different arthropod taxa are influenced by seasonal changes differently, and this may be due to the different dependencies on plants and intrinsic life history traits of the subgroup of each invertebrate taxon.
Keywords: Thicket, Invertebrates, War, Rainy, Cold Dry

INTRODUCTION

The availability of resources and the seasonality of, weather patterns are significant factors that influencethe activity of surface-active arthropods (Pinheiro, et al. 2002; Suheriyanto et al. 2019,Mathieu *et al.* 2009). However, soil moisture and vegetation structure, rate of parasitism, rate of predation and the number of pathogens present in the environment, among other factors, may affect the activity of surface-active arthropods (Briere et al. 1999; Pinheiro et al. 2002; Silveira et al. 2010; Bowie et al. 2014).

Ground-dwelling invertebrates show high variability and have a significant relationship with aboveground plants and insect biodiversity (Chen *et al.* 2020; De Deyn and Van Der Putten, 2005). Invertebrates serve as a powerful tools for environmental monitoring but are often not utilized for various reasons. According to Salas-López *et al.* 2022, ants are routinely used as

ecological indicators in diverse land-use situations throughout Australia. The Australian experience with ants shows that invertebrate monitoring can be greatly simplified without losing its effectiveness. The usefulness of simplified monitoring protocols means invertebrates can be incorporated into environmental monitoring programs. Invertebrates have become recognized as an important component of biodiversity. They are important in all ecosystems in terms of species richness and diversity. It is estimated that 95% of all invertebrate species play vital roles in ecosystem functioning (Greenop *et al.* 2021). Therefore, they play an important role in terrestrial food webs as arthropod population regulators, whilst also providing food for other predators (Gruner, 2004; Schmitz, 2006).

Their roles are disturbed into natural and anthropogenic activities which may alter canopy structure, vegetation structure, woody debris, and litter and soil layers in forest ecosystems (Laigle *et al.* 2021). The disturbances may lead to less canopy cover exposing ground-dwelling invertebrates, and alteration of the vegetation allowing for certain invertebrate succession. These environmental changes impact forest communities, including ground-dwelling invertebrates which are key regulators of ecosystem processes (Lukina *et al.* 2021).

According to Allan and Crawley (2011), insects that are found in fenced environments are different from insects that are found in non-fenced areas. There are different types of wild herbivores found in fenced environments compared to non-fenced environments. Although invertebrates found in different protected areas may be similar, invertebrates are also vegetation orientated. The distribution is mostly based on a lot of environmental components. Invertebrates have been successfully used in systematic conservation planning in South Africa due to their distribution, according to their environmental requirements. This was implemented in KwaZulu Natal, where databases of distribution records, geographical information system layers, and predicted distribution maps have been developed to support the assessment of land use change applications by the Integrated Environmental Management (IEM) team of Ezemvelo KZN Wildlife (Madibe *et al.* 2021). Also, in 2005 this was implemented in the Eastern Cape on butterflies (Thambu, 2012). Protected areas are important for the protection of wildlife but there are factors threatening invertebrates in protected areas including Global environmental change, land transformation, and contamination which leads to insect diversity loss (Liu *et al.* 2020). This was reported in the companion review Scientists' Warning to Humanity on Insect Extinctions. Although protected areas (PAs) in South Africa are facing challenges which involve size restriction, PAs remain critically important refugia for invertebrates that provide high-quality habitat patches for biodiversity conservation (Clark and Samways, 1997;Niba and Mafereka, 2015).

Smaller native predators rely heavily on invertebrates as a key food sources while larger predators generally prey on invertebrates to supplement their diet when other resources become scarce (Allen *et al*. 2012; Wang *et al*. 2019). While recognizing that complex relationships exist, most ecological studies on invertebrates have examined responses to single processes in the environment, such as fire or rainfall (Henry *et al.* 2024). A few studies have compared multiple processes simultaneously to determine the most important drivers across several factors (Coulter *et al.* 2023). Kwok *et al.* (2016) examined the effect of rainfall, temperature, topography, and vegetation in a long-term (6-year) study in the Simpson Desert. Vegetation was shown to be the most consistent predictor of invertebrate abundance, with a comparatively limited response to rainfall (Silva-Monteiro *et al.* 2022) the study of Kwok *et al*, (2016) was extended by investigating the factors influencing ground-dwelling invertebrate abundance in the sand plains of the eastern Great Sandy Desert, Central Australia. Invertebrates are susceptible to the same key threats as other biodiversity components, namely habitat loss and degradation, invasive alien species, and climate change (Scholtz and Chown, 1993; Zengeya *et al.* 2020). Monitoring programmers for invertebrate conservation in PAs should also consider invasive invertebrates. Alien species tend to thrive and dominate local

communities often causing a loss of biodiversity and impacting ecosystem functioning (Zengaya *et al.* 2020). Whilst a few terrestrial alien invasive invertebrates are well known in South Africa, the majority remain less interesting in local faunas owing to a lack of thorough taxonomic surveys. In the absence of precise taxonomic identification, the number of alien species is often greatly underestimated (Cano-barbacil *et al.* 2024).

Ecosystem diversity refers to the different ecological processes present within the ecosystems concerning habitats, biotic communities, and ecological processes (Govender, 2007; Hoban *et al.* 2020). Species diversity refers to the variety of living species both in terms of the number of species and relative abundances of species (Mugurran, 2021). Biological diversity (biodiversity) was initially coined as an ecological term, which described the number of species in a study site or the distribution of the numbers of organisms among species. Biodiversity is not only crucial for vegetation but also is enormously important in the formation of the system that supports life (Govender, 2007).

Diversity is one of the most striking features of life on the earth, and soil biodiversity influences the soil nutrient cycles and the diversity of plant communities (Bardgett and van der Putten, 2014). Thus, there is a growing curiosity in scientists to elevate the knowledge about the relationship between soil biodiversity and the ecosystem components (Tilman, 2000; Bardgett and van der Putten, 2014). In forest ecosystems, trees constitute the bottom of food webs and play an important role in the formation of the habitat (Snoeks *et al.* 2021). Tree species and composition are two important ecological factors that influence the soil fauna communities via plant nutrient uptake, the litter quality of leaves, rhizosphere interactions, and micro-environmental conditions (li *et al.* 2021; Mueller *et al.* 2016).

According to Tilman *et al.* (1999) over the years more studies have focused on diversity's influence on the ecosystem and ecological processes. Purvis and Hector (2000) have estimated that about 95% of experimental studies support a positive relationship between biodiversity and ecosystem functioning, although McCann, (2000) has suggested that biodiversity does not drive this relationship.

According to McCann (2000), there is a hypothesis stating that a more diverse ecosystem will have a greater chance of containing species, which can replace functionally important ones. The extent to which different species similarly perform the same functions suggests that physiological redundancy in species-rich ecosystems would minimize the effects of the loss of any one species (Schmitt, 2020).

Problem statement

South Africa prioritizes nature protection through fencing and other methods. Only a few studies have been undertaken within PAs to determine levels of threat to rare endemics and/or invertebrate species of phylogenetic uniqueness that may be new to science. Even though the Thomas Baines Nature Reserve is made up of a rich diversity of endemic plants making up the Albany Thicket Biome (ATB), there is little or no baseline data on the epigaeic invertebrate fauna of the reserve, hence the main objective of this study.

Objectives

The main objectives of the study were
1. To document the species richness and diversity patterns of epigaeic invertebrates.
2. Determine drivers of distribution patterns of the invertebrates.
3. Make conservation management recommendations based on the findings of the study.

Ii is hypothesized that the epigaeic invertebrate assemblages would not be across sites in the ATB.

Materials & Methods

Study site description.

This study was conducted at Thomas Baines Nature Reserve from 2021 to 2022. Thomas Baines Nature Reserve (study location) is located 12 km from Grahamstown off the N2

highway. The reserve is 45 500 ha, characterised by rainfall of 435 mm throughout the year with relatively dry winters with temperatures ranging from 0-40°C (Baines, 2020). The reserve is a dweller of animals from large mammals to invertebrates. These animals include African buffalo, chacma baboons, common eland, and the great kudu, which has over 175 species of birds and several invertebrates (Baines, 2020).

Thomas Baines Nature Reserve (TBNR; 33°18'S, 26°32'E), located 50 km from the coastline. The reserve was structured in 2010 and falls within the jurisdiction of Sarah Baartman district municipality, under the Eastern Cape Parks and Tourism Agency (ECPTA), and falls under the Eastern Cape Tourism (Act, of 2010). The main mandate of the reserve is to manage the biodiversity of PAs around the Eastern Cape Province, manage the tourism and everything related to the act (Ramsay, 1990).

Site stratification

From the sampling site, four different sub-sites were selected based on their variation in structural and compositional vegetation cover. The four sampling sites were (Thicket Patch with High Ungrazed Undergrowth (TPHUU), *Callicarpa*, *and Yeastesia viridiflora*. *Randia aculeata* and *Hypoestes* sp as dominant vegetation, Thicket Patch with Open mixture of low Vegetation (TPOMLV), with *Erica multiflora*, *Brachiaria*, *Erica reunionesis/paradoxa* and *Pyrostria* spp as the dominant plant species, Thicket patch with no undergrowth (TPNU), with *Ocimum*, *Solanum,Blechum,* and *Oenathera* spp as dominant vegetation and Thicket patches with grazed undergrowth (TPGU) with *Euclea undulata*, *Rhus crenata*, *Rhus glauca*, and *Erica scoparia* as dominant vegetation) were selected. The sampling location measured 1Ha was further replicated into four sites each measuring 300m^2. Sampling sites were separated from each other by at least 50m, and each stratified into four sampling units. In each sampling unit had 4 pitfall taps placed in a square grid separated from each other by 15m to collect invertebrates.Invertebrate data was collected in 64 traps in total during the sampling period.Traps were serviced after 7 days and contents sorted, placed in plastic vials with 70% alcohol, labelled (using code numbers) and taken to the laboratory for further processing and identification to the lowest taxonomic level possible using a Zeiss dissecting microscope (Model DVM4) and field guides (Dippenaar-schoeman 2006, Picker et al, 2002). Ants were identified using Brian & Bolton. 2016). Unidentified spiders and mites were sent to taxon specialists at the Biosystematics Division of the Agricultural Research Council (ARC), for identification while beetles were identified at the Terrestrial Invertebrate Unit of the National Museum.

Measurement of environmental variables

Samples of 100 kg of soil were collected from each study site using labelled containers and taken to the Soil Analytical Services at the Mthatha Dam laboratory to test for mineral constituents and soil quality (physical properties). The soils were made up primarily of sand, clay, and loam., Percentage bare ground measures as the percentage of sampling unit not covered by vegetation was also estimated. Bare ground is usually about 10% warmer than field interiors (Somme, 2012, Bertoia, 2023).An increase in leaf litter means an increase in decomposers and their predators which will mean an increase in invertebrates (Longino and Colwell, 1997; Lawrence and Wise, 2004; Moore *et al*. 2014). Leaf litter depth was measured using a calibrated 30cm meter rule by placing the ruler perpendicular to the soil surface. Measurements of this parameter was undertaken per sampling unit.Percentage shade was measured per sampling unit by estimating the percentage of total sampling unit that was shaded (Gurera and Bhushan, 2020), and depended on the amount of canopy cover (de Almeida and Viani, 2021). Grazing intensity was measured as the cumulative effects of grazing animals had on rangelands during a particular period (Holechek *et al*. 1998). This

parameter was measured by estimating the animal dung and grazing in the sampling unit 1=no grazing 2=medium grazed 3=extensive graze. Percentage of vegetation cover per sampling unit was estimated was measured by estimating the surface area of the sampling unit-covered by vegetation. This complexity facilitated biodiversity and ecosystem services (Gardner *et al.* 2009). Therefore, measures of vegetation structure can serve as indicators in ecosystem management. In most habitats, vegetation provides the main structure of the environment. This complexity can facilitate biodiversity and provide ecosystem services (Ruiz-Jaén and Aide, 2005, Gardner *et al.* 2009).

Data analysis

The species and environmental variables data were arranged according to Clarke and Gorley (2006), Karrouch *et al.* (2017) and Ludwig and Reynolds (1988). The species richness and diversity of the fauna were analyzed in a two-step method. Firstly, the univariate method uses diversity indices and distributional models, and secondly, the multivariate methods of classification and ordination are used as described below.

Univariate Methods

The statistical software program DIVERSE in PRIMER V7 (Clarke and Warwick, 2001) was used to determine the Shannon diversity index (H') and Pielou's evenness index (J) for species data. Ordination methods in PRIMER V7 attempt to give a broad overview of invertebrate community structure and patterns across site sampling units (Clark and Gorley, 2006; Ter Braak and Looman, 1995). Statistical package CANOCO (Ter Braak and Šmilauer, 2002), combines one algorithm Correspondence Analysis (CA) on species data and weighted multiple regressions on environmental variable data. This technique related species composition to known variations in the environment. Canonical Correspondence Analysis (CCA) in CANOCO produced an ordination diagram in which points represented species and sites, and vectors (arrows) represented measured site (environmental) variable gradients. Such a diagram shows patterns of variation in species composition that can be explained best by the measured site variables.

Results

Overall spatio-temporal trends

A total of 1993 arthropod specimens (Appendix 1) in 15 Orders were collected during both seasons with more (total of 1138 species) in the Rainy/wet. Orders were further sorted into 340 species, the most species-rich order was the Araneae, followed by the Orthoptera, the Hymenoptera and the Coleoptera. *Raveniola montana* (Aranease) was abundant in site 4 (TPGU), while*Creugas golusu* (Corinidae: Areneae) was abundant at site 2 (TPOMLV). *Hermacha montana* (Hermacha) Araneae was abundant in site 2 (TPOMLV), While *Coriarachne brunneipes* (Coriarachne: Areneae) was abundant in site 2 (TPOMLV). *Allocosa chamberlini* (Allocosa) Aeneae was abundant in site 3(TPGU), while B*assaniana utahensis* (Bassianiana: Areneae) was abundant in site 2 (TPOMLV), *Ectobius vittivetris* (Ectobius: Blattodidae) was abundant in site 1 (TPHGU). *Luccichormetica verrucosa* (Blattodidae) was abundant in site 3 (TPNU), while *Blattela germanica* (Blattella) was abundant in site 2 (TPOMLV), *Ectobius sylvestris* (Ectobiidae) was dominant in site 3 (TPNU), while *Leptothorax athabasa* (Leptothorax) was abundant in site 4 (TPGU). *Camponotus pennsylvanicus* (Camponotus: Hymenoptera) was abundant in site 2 (TPOMLV), *Linepithema humile* was dominat in site 3 (TPNU), while *Messor aegyptacus* (Messor: Formicidae) was dominant in site 4 (TPGU). Messor andrei (Messor) was dominant in site 4 (TPGU), while *Pogonomyrmex humrotum* (Formicidae) was dominant in site 2 (TPOMLV). *Fragossitidae 1* (Fragossitidae) was domiant in site 2 (TPOMLV). 😊

The Thicket Patch with Open mixture of low Vegetation (TPOMLV) had the greatest number of species and individuals (S= 48, N = 408), followed by the Thicket patch with no undergrowth with lowest individual count (TPNU) (S 37, N = 118), Thicket patches with

grazed undergrowth (TPGU) (S= 34, N= 149), and the Thicket Patch with Highly Ungrazed Undergrowth (TPHUU) (S=29, N= 179) Table 1, Appendix 1.

Analysis of variability between seasons

The medians of species were the same across categories of Sites from the Independent-Samples Median Test (t-test) during the warm/wet season this suggests that the difference in species distribution across sites was not normally distributed hence the Null hypothesis was eliminated. The distribution of individual counts was not the same across categories of Seasons from the independent Mann-Whitney U Test with a p-value<0.001 suggesting that the difference in the distribution of individual counts across sites was statistically significant with the p-value <0.005. The distribution of counts was also the same across categories of sites according to the Independent-Samples Kruskal-Wallis Test with p-value>0.083 that >0.005 which suggests that the difference in the distribution of counts across sites was not statistically significant. The null hypothesis was then rejected.

SAMPLING SITE INFLUENCE ON SPECIES DISTRIBUTION

The warm/wet season Hierarchical clustering showing site sampling units do not have more than 40% similarities (Figure 1) as much as they all share about only between 10%-29% similarity. Bray-Curtis similarity trend (Figure 2A) and dendrogram (Figure 2B), both have shown the relationship between the invertebrate species and habitat characteristics on the sampling sites. The dendrogram showed greater similarities within sites than across sites. As presented in the diagram above (Figure 2A/B) there are low similarities between sub-site 2.3 and 3.4 (28%), and 3.1 and 1.4 (22%); 2.1 and 3.2 29% respectively.

INFLUENCE OF MEASURED SITE VARIABLES ON SPECIES DISTRIBUTION

The CCA tri-plot diagram shows the relationship between the distribution of species and the environmental variables in Table 3. Eigenvalues were 0.902, and 0.880 for axis 1 and axis 2 respectively, while species-environmental variable correlations were strong at 1.000 for axis 1 and 0.996 for axis 2, Cumulative species variance was 9.4 and 18.6 for axis 1 and axis 2 respectively. Cumulative species variance for species-environmental variable relations was 10.4 for axis 1 and 20.6 for axis 2 respectively, meaning that measured environmental variables accounted for 20.6% of species variation. Monte-Carlo Test for all four axes and axis I was not significant (P>0.05). Important variables that accounted for species distribution trends could be inferred from the correlation coefficients on ordinationoutput where Intra-set correlations with Soil cation variables such as K mgL, Ca mg/LMg mg/L, PH (KCL), Zn mg/L% and %Veg Cover and % shade where important as drivers of species distribution across sub-sites of the reserve area sampled as indicated on the CCA diagram (Table 4, Figure3). The bare ground in SU (TPNU) and magnesium influenced a lot of species distribution, more specifically the bare ground having the longest arrow (Figure 3). Leaf litter density deposition and vegetation composition were also important. Most of the soil's chemical properties and the shade affected the distribution of invertebrates across the sites.

The canonical correspondence analysis (Figure 3) illustrates how the epigaeic invertebrate species were distributed across sampling sites, in the tri-plot. Furthermore, they showed that the sampling sites/sample units accounted for the distribution of invertebrates at sites. Soil chemistry Zn, Ca and K, Mg and total cation level played an important role by influencing plant growth. Sampling site 2 (Thicket Patch with Open mixture of low Vegetation (TPOPMLV)had a high concentration of total catio, vegetation cover and shade hence the highest species count compared to other sampling sites.

DISCUSSION

OVERALL SPECIES RICHNESS AND ABUNDANCE TRENDS.

We expected greater species richness and abundance of al taxa in summer, compared to winter because the abundance of arthropods has been reported to increase during the warm rainy season compared to the dry season (Grimbacher et al, 2018). However, our study showed that the change in season affects arthropods differently as species richness and abundance of invertebrate species decreased in winter compared to summer,while species richness and abundance of ants was Similar between seasons (Mavasa (et al, 20220. The greater species richness and abundance in of invertebrates in summer than in winter can be explained by 'the resource-ratio hypothesis, The resource-ratio hypothesis suggests that species with low resource requirements will outcompete other species when the resources are limited resulting in a reduction of the number of species in a community (Tilman 1985). During winter in the TBNR, plants become less productive than in summer (Hutley & Setterfield 2018), which reduces resource availability to arthropods at lower trophic levels, such as herbivores, (Pinheiro et al, 2002); Ajos et al 2016, de Oliveira et al, 2021). The reduction in the abundance of arthropods at lower trophic levels due to a reduction in their resources may have a negative effect on predator arthropods. These bottom-up effects of plants on arthropod communities have been shown to influence assemblages of arthropods positively (Sobek et al 2009, Haddad et al, 2011). In particular, Forkner and Hunter (2000) found that the bottom-up effects of plants on arthropods have a positive relationship with arthropod in vegetation dominated by oak trees in Whitehall Forest in Geogia in the USA. Moreover, Vaca-Sanchez et al. (2021) found that canopy arthropods are more abundant and diverse in diverse Quercus forests. Their results suggest that the availability of resources is a significant factor in shaping the assemblages of surface-active arthropods. Variations in responses of arthropods (abundance and species richness) to season could be due the fact that different taxa and/or species have different preferences in terms of microhabitats and environmental conditions. Species from the warm/wet season had the highest richness and abundance count at the Thicket Patch with Open mixture of low Vegetation (TPOPMLV). Two species *Coriarachne brunneipes* and *Achurum achurum (*Gryllidae; Acridid*ae)* were commonly widespread, occurring across all sample sites. While 69 species were common, habitat specific, occurring in 2-or more site sampling units, 235 were rare-habitat-restricted and occurred only once at a site sampling unit. Protected areas (PAs) are designed to insulate biodiversity from human-induced threats (Chowdhury *et al*. 2022), but they have been mainly designated for vertebrates and plants. Most research on invertebrates focuses on the representation of species (Chowdhury *et al*. 2023), and few studies assess threats to invertebrates or the role that effective PA management can play (Mucina *et al*. 2022). Habitats or sampling units that are unique from each other allow for species variation in the biome.

There is limited information on the common epigaeic invertebrates found in the Albany thicket biome. However, it is known that the thicket species thrive in clay-rich soil and are concentrated in the valleys (Becker, 2013). The thicket contains many endemic plants, in particular, succulent Euphorbia species (Mhlongo *et al*. 2023). The genus Haworthia is also found in the Albany thicket biome (Gildenhuys, 2020). The soil characteristics are a crucial part of the invertebrate survival. Potassium (K) had a hugely positive impact on the distribution and richness of invertebrates because Potassium has a crucial role in several physiological processes that are important for the growth, yield, quality (Oosterhuis *et al.* 2014), and stress resistance in many crops, this element is a crucial characteristic of the soil in Albany Thicket Biome since this biome is rain deficient. Current reports indicate that K, at a global level, is as limiting as nitrogen and phosphorus for plant productivity in terrestrial ecosystems (Sardans *et.al*., 2021). Leaf litter was also important in determining species richness and distribution across sites in the study. Epigaeic invertebrates feed on organic matter found on the soil surface, such as dead leaves, while other types of invertebrates may

feed on plants, and other invertebrates (Chahil, 2014). Figure 3, support the fact that that most species present in the sampling units were influenced by the type of plants, the elements in the soil, and the acidity from decaying organic matter.

Soil pH is a crucial indicator of soil quality, availability, activity of the microbes and the role they play in the decomposition of the soil organic matter. The acidity or alkalinity environment of the soil has a direct impact on the epigaeic invertebrates as they feed on and inhabit soil organic matter. The soil concentration of Ca can vary greatly and is generally related to soil pH (Heidari and Raheb, 2020). Calcium concentration in the earth's crust is approximately 3.6%, while soil contains only 1.37%. The primary source of soil Ca is from weathered limestone and the weathering of certain primary minerals (Heidari and Raheb, 2020). Since the Albany thicket biome is found on sandy soil it is likely to have an impact on the distribution and richness of species.

The mobility of ground-dwelling invertebrates can also vary depending on the habitat. For example, in high alpine environments, there may be changes in the diversity and community composition of ground-dwelling invertebrates along an elevation gradient. Ground-dwelling invertebrates can vary in their mobility, with some being more mobile than others (Pauli and Halloy, 2019). Factors such as habitat, landscape characteristics, and plant diversity can also influence their mobility and diversity.

The Albany Thicket biome is characterized by dense, spiny shrubland with a canopy up to 2.5 meters in height. This dense vegetation may limit the mobility of ground-dwelling invertebrates, as it can create physical barriers and restrict movement (Widegger, 2022). The Albany Thicket biome is known to have abundant succulent plants. These plants often have shallow root systems and may provide hiding places or shelter for ground-dwelling invertebrates. This could potentially affect their mobility, as they may be more inclined to stay within the vicinity of these plants.

The Varying habitat of the Albany Thicket biome can be divided into three sections. The thicket is the richest and dense in the river valleys near the coast, while the climate becomes drier and vegetation less dense as the river valleys climb inland and upstream (Hoare *et al.* 2016). The shrubland in mountain valleys consists predominantly of specific plant species. These variations in habitat may influence the distribution and mobility of ground-dwelling invertebrates within the biome.

Epigaeic invertebrates can range in size from very small, such as mites and springtails, to larger species like beetles and millipedes (Shuler, 2007). Overall, epigaeic invertebrates play an important role in soil health and nutrient cycling and are an important part of many ecosystems. Ground-dwelling invertebrates play crucial roles in ecosystem functions. They contribute to nutrient cycling, organic matter decomposition, and the maintenance of soil structure. Different-sized soil invertebrates can have varying impacts on this function (Saatkamp *et al.* 2014). For example, earthworms, as larger soil invertebrates, are critical in the biodegradation of contaminants and soil organics. The size of ground-dwelling invertebrates can influence trophic interactions within ecosystems.

Larger invertebrates may serve as prey for predators higher up in the food chain, while smaller invertebrates may be important food sources for other organisms. These interactions contribute to the overall balance and functioning of ecosystems. The size of ground-dwelling invertebrates can serve as an indicator of ecosystem health and environmental conditions (Gerlach *et al*. 2013). Changes in the size distribution of invertebrates can reflect disturbances or alterations in the ecosystem. Monitoring the abundance and diversity of ground-dwelling

invertebrates can provide valuable information about the state of the environment and potential impacts on other organisms.

The observed predominantly positive relationships between invertebrates and vegetation growth are in line with the theory of cascading effects of nutrient availability on arthropods through plant biomass and quality (Andrey *et al*. 2014; Haddad *et al*. 2009; Siemann, 1998). Living and dead plant tissue is, either directly or indirectly through consumption of other invertebrates, the primary food source for most invertebrates. It is therefore perhaps not surprising that the size of the invertebrate communities increases with habitat productivity because more productive habitats simply provide more resources to sustain invertebrates. (Silva-Monteiro *et al.* 2022).

Responses of thicket communities to the ground-dwelling invertebrates in this research showed that the Thicket Patch with open, low vegetation had a high number of species and individuals this may be due to life history strategies and evolutionary adaptation history of the invertebrates. Ground-dwelling invertebrates are integrated into the forest ecosystem mainly because of their most crucial contribution to the ecosystem and their high taxonomic and functional diversity. The life history traits which include the physiological tolerances, the specific habitat preferences, their ability to adapt and their habitat dispersal capacity influenced the responses of invertebrates to the habitat (Perry and Herms, 2019). Ecosystem shifts are mainly caused by the change in climate mostly in terms of decreasing precipitation and altered patterns of rainfall. Therefore, the amount of rainfall in a particular area influences the type of plants that thrive in that environment. The ATB is in a part of the Eastern Cape that lacks rainfall. The types of organisms in higher trophic levels are due to bottom-up effects, in simple words large organisms thrive in an environment because the ground-dwelling invertebrates are thriving (Fischer *et al*. 2022). As much rainfall will influence the availability of ground-dwelling invertebrates but the soil temperature, moisture and particle distribution play a huge role in the distribution of arthropods. Arthropods thrive more in greater soil moisture, which can be related to lower coarse sand content. This is the type of soil that is found mostly ATB, and the air is extremely dry due to the winds (Fischer *et al*. 2022, Laface and Arena, 2021). The ATB has extremely cold winters and extremely hot summers since it is on the leeward side of the mountain (Turunen *et al*. 2021). Soil organisms have directly or indirectly altered plant community composition and influence plant life histories, plant performance, growth, and competitiveness (Setala and Huhta, 1991; Blossey and Hunt-Joshi, 2003; Cifuentes-Croquevielle *et al*. 2020). Plants benefit from increases in soil fauna that increases the pool of available nutrients for root uptake, especially in soils with limited nutrient supply (N and P). Lower-lying areas that are covered by plantations tend to have lower invertebrate species richness, and for some species lower abundance, compared to natural forests and fynbos (Pryke and Samways 2012). Invertebrate assemblages of indigenous natural forests are likely to be more difficult to restore in the thicket than those of fynbos and thus the protection of the remaining natural forests in the TMNP is a conservation priority (Pryke and Samways 2012). Biodiversity varies in space and time (Rosenzweig, 1995). Magnesium is the central core of the chlorophyll molecule in plant tissue. Thus, if Mg is deficient, the shortage of chlorophyll results in poor and stunted plant growth. According to the CCA (Figure 3) disease magnesium and bare ground had more influence in the distribution of different species significantly compared to other environmental variables in sampling units that had greater Mg there was more distribution of the invertebrates compared to areas that had less Mg. The species prefers bare ground with plants that have green leaves. The bare ground can be recognized as any area which is lacking vegetation. Bare ground is important for thermophilic (warmth-loving) invertebrates such as spiders, ground beetles,

solitary bees, and wasps (English , 2005;Phillips, 2020). The soil under bare ground is significantly warmer than soil under vegetation and this allows eggs and larvae of ground-nesting invertebrates to develop faster. Bare ground is also important for several vertebrate species, especially for basking reptiles. Bare ground played a significant impact in the distribution of invertebrates at TBNR, more species were found on the bare ground with plants that have trees meaning there are high levels of Mg. Mg and bare ground seem to be the main drivers of distribution because the soil is warm and allows for fast development and nesting of soil-surface dwelling invertebrates. Litter density, plants, vegetation cover, and acidity are the second to have a great impact on a lot of species distribution and richness at TBNR. Litter density can provide habitat and food sources for ground-dwelling invertebrates. Higher litter density can create a more favourable environment for certain invertebrate species, as it offers shelter, moisture, and nutrient-rich resources. However, extremely high litter density can also limit the movement and accessibility of some ground-dwelling invertebrates, particularly those that require open spaces or specific microhabitats. Hence more invertebrates were present in the sampling units with bare ground. Habitats that had high litter density allowed for greater species richness because this allowed for less movement of the species. Plants play a crucial role in shaping the distribution of ground-dwelling invertebrates (Braschler *et al*. 2020). They provide food, shelter, and microhabitats for various invertebrate species. Different plant species can attract specific invertebrate groups based on their preferences for feeding, nesting, or oviposition sites (Baker and Potter, 2020). The plant diversity of the Albany thicket biome appears to influence the richness and abundance of ground-dwelling invertebrates, as it provides a variety of resources and habitats. In turn, ground-dwelling invertebrates can also have reciprocal effects on plants, such as influencing nutrient cycling and seed dispersal.

CONCLUSION

Invertebrates play a huge role in the ecosystem more like any other animal and they should be treated and prioritised as such. The lack of knowledge on the epigaeic invertebrates in the Albany thicket biome could lead to overestimation/underestimation of the value of this biome. According to the results obtained from this research, it is evident that the Albany thicket biome possesses a higher richness of species as a total of 235 species were rare habitat specific. As this is a single biome, it possesses different characteristics allowing it to be a habitat to many different invertebrates. The soil characteristic plays a great role in ensuring the uniqueness of this biome and the different organisms the biome is home to. In this study, we demonstrate that the factors affecting the changes in abundance, species richness and composition of assemblages of epigaeic arthropods during summer and winter are complex and interconnected and may be explained by more than a single hypothesis. The present study suggests that temporal and dietary niche differentiation plays an important role in driving the assemblage of soil-surface dwelling arthropods. We show that seasonal changes are associated with changes in abundance, species richness and species composition of some surface-active arthropods which can be linked to the seasonal availability of resources. As such, other environmental factors that are associated with changes in season may be significant drivers of fluctuations of assemblages of surface-active arthropods. We posit that seasonality intemparature and soil moisture may affect arthropod assemblages indirectly through their effects on vegetation characteristics. Species richness and abundance of different arthropods taxa are influenced bty seasonal changes differently, and this may be due to different dependencies on plants and intrinsic lifehistory traits of thr particular subgroup of each taxon.

THE MANAGEMENT RECOMMENDATION.

The study generated baseline data on the list of invertebrate species in the main vegetation areas of the reserve as common, widespread, common, habitat-specific, and rare, habitat-restricted. The Araneae had the highest species richness, followed by the Orthoptera, and Hymenoptera. Environmental variables generated during the study can be useful in determining species composition and distribution. This is critical for planning and decision-making for species conservation action. Invertebrates should be incorporated into the conservation management strategies for protected areas. Many protected areas prioritise the conservation of large mammals, while large mammals are more of a threat to the ground-dwelling invertebrates. The abundance of mammals should be kept in so that invertebrates can be able to success or successfully conserve the invertebrates. Local and global conservation has been slacking in incorporating invertebrate taxa into PA designation and management, this is mostly due to the lack of knowledge on invertebrates' composition and distribution (van Klink *et al*. 2022), as much as conducting such assessment seems impossible but citizen science could play a huge role in assisting with such knowledge (Callaghan *et al.* 2021).

References

Allen, L., Goullet, M. and Palmer, R. (2012). The diet of the dingo (Canis lupus dingo and hybrids) in north-eastern Australia: a supplement to the paper of Brook and Kutt (2011). *The Rangeland Journal*, *34*(2), pp.211-217.

Alves da Mata R, Tidon R. (2013). The relative roles of habitat heterogeneity and disturbance in drosophilid assemblages (Diptera, Drosophilidae) in the Cerrado. Insect Conservation and Diversity.6: 663–670. https://doi.org/10.1111/icad.12020

Anjos D., Alves-Silva E. & Ribeiro S. P. (2016) Do fire and seasonality affect the establishment and colonisation of litter arthropods? J.
Insect Conserv. 20, 653–61.

Baines, D. and Elliott, R.J. (2020). Defining misinformation, disinformation and malinformation: An urgent need for clarity during the COVID-19 infodemic. *Discussion papers*, *20*(06), pp.20-06.

Bell KL, Heard TA, Manion G, Ferrier S, Van Klinken RD. (2013). The role of geography and environment in species turnover: phytophagous arthropods on a Neotropical legume. Journal of Biogeography. 40: 1755–1766. https://doi.org/10.1111/jbi.12102

Bertoia, A.J. (2023). *Critters in the cold: understanding how large-bodied alpine invertebrates are influenced by introduced predators and climate change* (Doctoral dissertation, University of Otago).

Cano-Barbacil, C., Radinger, J. and García-Berthou, E. (2024). Interacting effects of latitudinal and elevational gradients on the distribution of Iberian inland fish. *Limnetica*, *43*(2), pp.000-000.

Cheng, L., Lu, N., Wang, M., Fu, B. and Xu, Z. (2021). Alternative biome states of African terrestrial vegetation and the potential drivers: a continental-scale study. *Science of The Total Environment*, *800*, p.149489.

Clarke, K.R. and Gorley, R.N. (2006). Primer. *PRIMER-e, Plymouth*, *866*.

Clark, T.E. and Samways, M.J. (1997). Sampling arthropod diversity for urban ecological landscaping in a species-rich southern hemisphere botanic garden. *Journal of Insect Conservation*, *1*, pp.221-234.

Clarke, K.R. and Warwick, R.M. (2001). A further biodiversity index applicable to species lists: variation in taxonomic distinctness. *Marine ecology Progress series*, *216*, pp.265-278.

Coulter, B., West, R.S., Kingsford, R.T. and Moseby, K.E. (2023). The influence of drought, precipitation and fossorial mammal reintroduction on the density of fossorial arthropods and their burrows in arid Australia. *Austral Ecology*.

Correa CM, Braga RF, Louzada J, Menéndez R. (2019). Dung beetle diversity and functions suggest no major impacts of cattle grazing in the Brazilian Pantanal wetlands. Ecological Entomology. 44: 524–33. https://doi.org/10.1111/een.12729

Connell JH (1978). Diversity in tropical rain forests and coral reefs. Science. 199: 1302–1310. https://doi.org/10.1126/science.199.4335.1302

Copley CR, Winchester NN. (2010). Effect of disturbance and distance from a riparian corridor on spiders in a temperate rainforest. Canadian Journal of Forest Research. 40: 904–916. https://doi.org/10.1139/X10-043

de Ara_ujo W. S. (2013) Different relationships between galling and non-galling herbivore richness and plant species

richness: a meta-analysis. Arthropod Plant Interact. 7, 373–7.

de Oliveira C. P., de Oliveira C. M., Specht A. & Frizzas M. R (2021) Seasonality and distribution of coleoptera families (Arthropoda, Insecta) in the Cerrado of Central

Brazil. Rev. Bras. Entomol. 65, e20210025.

De Deyn, G.B. and Van der Putten, W.H. (2005). Linking aboveground and belowground diversity. *Trends in ecology & evolution*, *20*(11), pp.625-633.

De Visser SN, Freymann BP, Foster RF, Nkwabi AK, Metzger KL, Harvey AW, Sinclair ARE. (2015). Invertebrates of the Serengeti: Disturbance Effects on Arthropod Diversity and Abundance. In: Anthony, RES, Kristine, LM, Simon, ARM., John, MF, editors. Serengeti IV: Sustaining Biodiversity in a Coupled Human-natural System. Chicago, U.S.A.: University of Chicago Press; p. 265–300.

Forkner R. E. & Hunter M. D. (2000) What goes up must come down? Nutrient addition and predation pressure on oak herbivores.

Ecology 81, 1588–600.

Gallé R, Császár P, Makra T, Gallé-Szpisjak N, Ladányi Z, Torma A, Ingle K, Szilassi P. (2018). Small-scale scale agriculturalcapes promote spider and ground beetle densities by offering suitable overwintering sites. Landscape Ecology. 33: 1435–1446. https://doi.org/10.1007/s10980-018-0677-1

Gardner, A. (2009). Adaptation as organism design. *Biology letters*, *5*(6), pp.861-864.

Gerlach J, Samways M, Pryke J. (2013). TerrestTerrestrial invertebratesioindicators: an overview of available taxonomic groups. Journal of Insect Conservation. 17: 831–850. https://doi.org/org/10.1007/s10841-013-9565-9

Govender, V. (2007). *Patterns of distribution, diversity and endemism of terrestrial molluscs in South Africa* (Doctoral dissertation).

Grime JP. (1973). Competitive exclusion in herbaceous vegetation. Nature. 242: 344–347. https://doi.org/10.1038/242344a0

Greenop, A., Woodcock, B.A., Outhwaite, C.L., Carvell, C., Pywell, R.F., Mancini, F., Edwards, F.K., Johnson, A.C. and Isaac, N.J. (2021). Patterns of invertebrate functional diversity highlight the vulnerability of ecosystem services over a 45-year period. *Current Biology*, *31*(20), pp.4627-4634.

Grimbacher P. S., Edwards W., Liddell M. J. et al. (2018) Temporal variation in abundance of leaf litter beetles and ants in an Australian lowland tropical rainforest is driven by climate and litter fall.

Biodivers. Conserv. 27, 2625–40.

Gruner, D.S. (2004). Attenuation of top-down and bottom-up forces in a complex terrestrial community. *Ecology*, *85*(11), pp.3010-3022.

Gurera, D. and Bhushan, B. (2020). Passive water harvesting by desert plants and animals: lessons from nature. *Philosophical Transactions of the Royal Society A*, *378*(2167), p.20190444.

Haddad N. M., Crutsinger G. M., Gross K., Haarstad J. & Tilman D. (2011) Plant diversity and the stability of foodwebs. Ecol. Lett. 14, 42–6.

Hanski I, Cambefort Y. (2014). Dung beetle ecology. Princeton, U.S.A: Princeton University Press.

Henry, S.C. (20240. *Legacy effects of fire on the invertebrates of Alpine Tasmania* (Doctoral dissertation, University Of Tasmania).

Hill JG, Summerville KS, Brown RL. (2008). Habitat associations of ant species (Hymenoptera: Formicidae) in a heterogenous Mississippi landscape. Environmental Enologogy. 37: 453 −463. https://doi.org/10.1603/0046-225x(2008)37[453:haoash]2.0.co;2

Hlongwane ZT, Mwabvu T, Munyai TC, Tsvuura Z. (2019). Epigaeic ant diversity and distribution in the Sandstone Sourveld in KwaZulu-Natal, South Africa. African Journal of Ecology. 57: 382–393. https://doi.org/10.1111/aje.12615

Horn HS. (1975). Markovian properties of forest succession. In: Cody, ML, Diamond, JM, editors. Ecology and Evolution of Communities. Cambridge, Massachusetts, U.S.A.: Belknap Press; p.196–211

Hoffmann H, Peter F, Herrmann JD, Donath TW, Diekötter T. (2021). BenefitBenefits oflower areas as overwintering habitats for ground-dwelling arthropods depend on landscape structural complexity. Agriculture, Ecosystems and Environment. 314:107421. https://doi.org/10.1016/j.agee.2021.107421

Hoban, S., Bruford, M., Jackson, J.D.U., Lopes-Fernandes, M., Heuertz, M., Hohenlohe, P.A., Paz-Vinas, I., Sjögren-Gulve, P., Segelbacher, G., Vernesi, C. and Aitken, S., Holechek, J.L., Gomes, H.D.S., Molinar, F. and Galt, D. (1998). Grazing intensity: critique and approach. *Rangelands Archives*, *20*(5), pp.15-18.

Karrouch, L., Chahlaoui, A. and Essahale, A. (2017). Anthropogenic impacts on the distribution and biodiversity of benthic macroinvertebrates and water quality of the Boufekrane River, Meknes, Morocco. *Journal of Geoscience and Environment Protection*, *5*(07), p.173.

Hutley L. B. & Setterfield S. A. (2018) Savanna. In: Encyclopedia of Ecology, 2nd edn (ed B. Fath) pp. 623–33.Elsevier BV, Oxford.

King JR, Tschinkel WR. (2008). Experimental evidence human impacts drive fire ant invasions and ecological change. Proceedings of the National Academy of Sciences of the United States of America. 105: 20339–20343. https://doi.org/10.1073/pnas.0809423105Krebs CJ. 1999. Ecological methodology. 2nd edition. California, U.S.A: Benjamin Cummings.

Kwok, A.B., Wardle, G.M., Greenville, A.C. and Dickman, C.R. (2016). Long-term patterns of invertebrate abundance and relationships to environmental factors in arid Australia. *Austral Ecology*, *41*(5), pp.480-491.

Laigle, I., Moretti, M., Rousseau, L., Gravel, D., Venier, L., Handa, I.T., Messier, C., Morris, D., Hazlett, P., Fleming, R. and Webster, K. (2021). Direct and indirect effects of forest anthropogenic disturbance on above and below ground communities and litter decomposition. *Ecosystems*, pp.1-22.

Lawrence, K.L. and Wise, D.H. (2004). Unexpected indirect effect of spiders on the rate of litter disappearance in a deciduous forest. *Pedobiologia*, *48*(2), pp.149-157.

Li, X., Risch, A.C., Sanders, D., Liu, G., Prather, C., Wang, Z., Hassan, N., Gao, Q., Wang, D. and Zhong, Z. (2021). A facilitation between large herbivores and ants accelerates litter decomposition by modifying soil microenvironmental conditions. *Functional Ecology*, *35*(8), pp.1822-1832.

Li, Y., He, N., Hou, J., Xu, L., Liu, C., Zhang, J., Wang, Q., Zhang, X. and Wu, X. (2018). Factors influencing leaf chlorophyll content in natural forests at the biome scale. *Frontiers in Ecology and Evolution*, *6*, p.64.

Liu, X., Blackburn, T.M., Song, T., Wang, X., Huang, C. and Li, Y. (2020). Animal invaders threaten protected areas worldwide. *Nature Communications*, *11*(1), p.2892.

Ludwig, J.A. and Reynolds, J.F. (1988). *Statistical ecology: a primer in methods and computing* (Vol. 1). John Wiley & Sons.

Longino, J.T. and Colwell, R.K. (1997). Biodiversity assessment using structured inventory: capturing the ant fauna of a tropical rain forest. *Ecological applications*, *7*(4), pp.1263-1277.

Madibe, R.J. (2021). *Determining the impact of a piggery on the Inhlavini and uMkhomazi Rivers, KwaZulu-Natal* (Doctoral dissertation, North-West University (South Africa)).

Malumbres-Olarte G., Vink C. J., Ross J. G., Cruickshank R. H. & Paterson A. M. (2013) The role of habitat complexity on spider communities in native alpine grasslands of New Zealand. Insect Conserv.

Divers. 6, 124– 34.

Mauda EV, Joseph GS, Seymour CL, Munyai TC, Foord SH. (2018). Changes in use alter ant diversity, assemblage composition and dominant functional groups in African savannas. Biodiversity and Conservation. 27: 947–965. https://doi.org/10.1007/s10531-017-1474-x

McCann, K.S. (2000). The diversity–stability debate. *Nature*, *405*(6783), pp.228-233.

Moorhead LC, Philpott SM. (2013). Richness and composition of spiders in urban green spaces in Toledo, Ohio. Journal of Arachnology. 41: 356–363. https://doi.org/10.1636/P12-44

Mueller, K.E., Eisenhauer, N., Reich, P.B., Hobbie, S.E., Chadwick, O.A., Chorover, J., Dobies, T., Hale, C.M., Jagodziński, A.M., Kałucka, I. and Kasprowicz, M. (2016). Light, earthworms, and soil resources as predictors of diversity of 10 soil invertebrate groups across monocultures of 14 tree species. *Soil Biology and Biochemistry*, *92*, pp.184-

Mathieu, J., Grimaldi, M., Jouquet, P., Rouland, C., Lavelle, P., Desjardins, T. and Rossi, J.P. (2009). Spatial patterns of grasses influence soil macrofauna biodiversity in Amazonian pastures. *Soil Biology and Biochemistry*, *41*(3), pp.586-593.

Martínez E, Rös M, Bonilla MA, Dirzo R. (2015). Habitat heterogeneity affects plant and arthropod species diversity and turnover in traditional cornfields. PLoS One. 10: e0128950. https://doi.org/10.1371/journal.pone.0128950

Melliger RL, Braschler B, Rusterholz HP, Baur B. (2018). Diverse effects of degree of urbanisation and forest size on species richness and functional diversity of plants, and ground surface-active ants and spiders. PLoS One. 13. https://doi.org/10.1371/journal.pone.0199245

Moore, J.C., Boone, R.B., Koyama, A. and Holfelder, K. (2014). Enzymatic and detrital influences on the structure, function, and dynamics of spatially explicit model ecosystems. *Biogeochemistry*, *117*, pp.205-227.

Osman R.(2015). The inThe intermediaterbance hypothesis. In: Fath, B, editor. Encyclopedia of Ecology. 2nd edition. Oxford, U.K. Elsevier BV; p. 441−450

Pinheiro F., Diniz I., Coelho D. & Bandeira M. (2002) Seasonal pattern of insect abundance in the Brazilian, cerrado. Austral Ecol. 27, 132–6.

Purvis, A. and Hector, A. (2000). Getting the measure of biodiversity. *Nature*, *405*(6783), pp.212-219.

Pryke JS, Roets F, Samways MJ. (2016). Wild herbivore grazing enhances insect diversity over livestock grazing in an African grassland system. PloS One. 11. https://doi.org/10.1371/journal.pone.0164198

Picker M, Griffiths C, Weaving A. (2019). Field guide to insects of South Africa. 2nd edition. Cape Town, South Africa: Penguin Random House South Africa,

Rahman AU, Jones HP, Hosler SC, Geddes S, Nelson M, Barber NA. (2021). Disturbance-induced trophic niche shifts in ground beetles (Coleoptera: Carabidae) in

restored   grasslands.   Environmental   Entomology.   50:   1075–1087. https://doi.org/10.1093/ee/nvab065

Ruiz-Jaén, M.C. and Aide, T.M. (2005). Vegetation structure, species diversity, and ecosystem processes as measures of restoration success. *Forest Ecology and Management*, *218*(1-3), pp.159-173.

Salas-López, A., Violle, C., Munoz, F., Menzel, F. and Orivel, J. (2022). Effects of Habitat and Competition on Niche Partitioning and Community Structure in Neotropical Ants. *Frontiers in Ecology and Evolution*, *10*, p.863080.

Savitha S, Barve N, Davidar P. (2008). ResponsResponse of to disturbance gradients in and around Bangalore, India. Journal of Tropical Ecology. 49: 235–243

Santos R, Dodonov P, Delabie JH. (2021). Effects of habitat conservation on ant functional groups: a   global   review.   Sociobiology.   68:   e6071.   https://doi.org/ 10.13102/sociobiology.v68i2.6071

Schmitz, O.J. (2006). Predators have large effects on ecosystem properties by changing plant diversity, not plant biomass. *Ecology*, *87*(6), pp.1432-1437.

Scholtz, C.H. and Chown, S.L. (1993). Insect conservation and extensive agriculture: the savanna of southern Africa.

Silva PSD, Bieber AGD, Corrêa MM, Leal IR. (2011). Do leaf-litter attributes affect the richness   of   leaf   litter   ants?   Neotropical   Entomology.   40:   5 4 2− 4 57. doi.org/10.1590/S1519-566X2011000500004

Somme, L. (2012). *Invertebrates in hot and cold arid environments*. Springer Science & Business Media.Invertebrate abundance increases with vegetation productivity across natural and agricultural wader breeding habitats in Europe. *Biological Conservation*, *273*, p.109670.

Sobek S., Scherber C., Steffan-Dewenter I. & Tscharntke T. (2009) Sapling herbivory, invertebrate herbivores and predators across a natural tree diversity gradient in Germany's largest connected deciduous forest. Oecologia 160, 279–88.

Snoeks, J.M., Driesen, M., Porembski, S., Aristizábal-Botero, Á. and Vanschoenwinkel, B. (2021). Contrasting biodiversity and food web structure of three temporary freshwater habitats in a tropical biodiversity hotspot. *Aquatic Conservation: Marine and Freshwater Ecosystems*, *31*(9), pp.2603-2620.

Stenchly K, Clough Y, Tscharntke T. (2012). Spider species richness in cocoa agroforestry systems,   comparing   vertical   strata,   local   management   and   distance   to   forest. Agriculture,   Ecosystems   and   Environment.   149:   189–194. https://doi.org/10.1016/j.agee.2011.03.021

Swart RC, Pryke JS, Roets F. (2019). The intermediate disturbance hypothesis explains arthropod beta-diversity responses to roads that cut through natural forests. Biological Conservation. 236: 243–251. https://doi.org/10.1016/j.biocon.2019.03.045

Ter Braak, C.J.F. and Looman, C.W.N. (1995). Regression. In *Data analysis in community and landscape ecology* (pp. 29-77). Cambridge University Press.

Ter Braak, C.J. and Smilauer, P. (2002). *CANOCO reference manual and CanoDraw for Windows user's guide: software for canonical community ordination (version 4.5)*. www. canoco. com.

Thambu, D. (2012). *An evaluation of the consequences of environmental impact assessments (EIAs) on KwaZulu-Natal's biodiversity targets* (Doctoral dissertation).

Tilman, J.A., Seybold, S.J., Jurenka, R.A. and Blomquist, G.J. (1999). Insect pheromones—an overview of biosynthesis and endocrine regulation. *Insect biochemistry and molecular biology*, *29*(6), pp.481-514.

Tilman D. (1985) The resource-ratio hypothesis of plantsuccession. Am. Nat. 125, 827–52.

Uhey D, Haubensak K, Hofstetter R. (2021). Mid-elevational peak diversity of ground-dwelling arthropods with high species turnover on the Colorado Plateau. Environmental Entomology. 50: 337–347. https://doi.org/10.1093/ee/nvaa166

Wagner PM, Abagandura GO, Mamo M, Weissling T, Wingeyer A, BradshaW JD. (2021). AbundanAbundance andsity of dung beetles (Coleoptera: Scarabaeoidea) as affected by grazing management in the Nebraska sandhills ecosystem. Environmental Entomology. 50: 222−231. https://doi.org/10.1093/ee/nvaa130

Wang, C.C., Huang, S.L., Wang, X., Xu, P., Huang, X., Liao, Y., Xie, X. and Kwan, K.Y., (2019). Conserving the understudied invertebrates: a call for a systematic monitoring protocol for Asian horseshoe crabs in nursery habitats. *Endangered Species Research*, *40*, pp.369-373.

Zengeya, T.A., Kumschick, S., Weyl, O.L. and van Wilgen, B.W. (2020). An evaluation of the impacts of alien species on biodiversity in South Africa using different assessment methods. *Biological Invasions in South Africa*, *14*, p.489.

Whitmore C, Slotow R, Crouch TE, Dippenaar-Schoeman AS. (2002). Diversity of spiders (Araneae) in a savanna reserve, Northern Province, South Africa. Journal of Arachnology. 30: 344-356. https://doi.org/10.1636/0161-8202(2002)030[0344:DOSAIA]2.0.CO;2
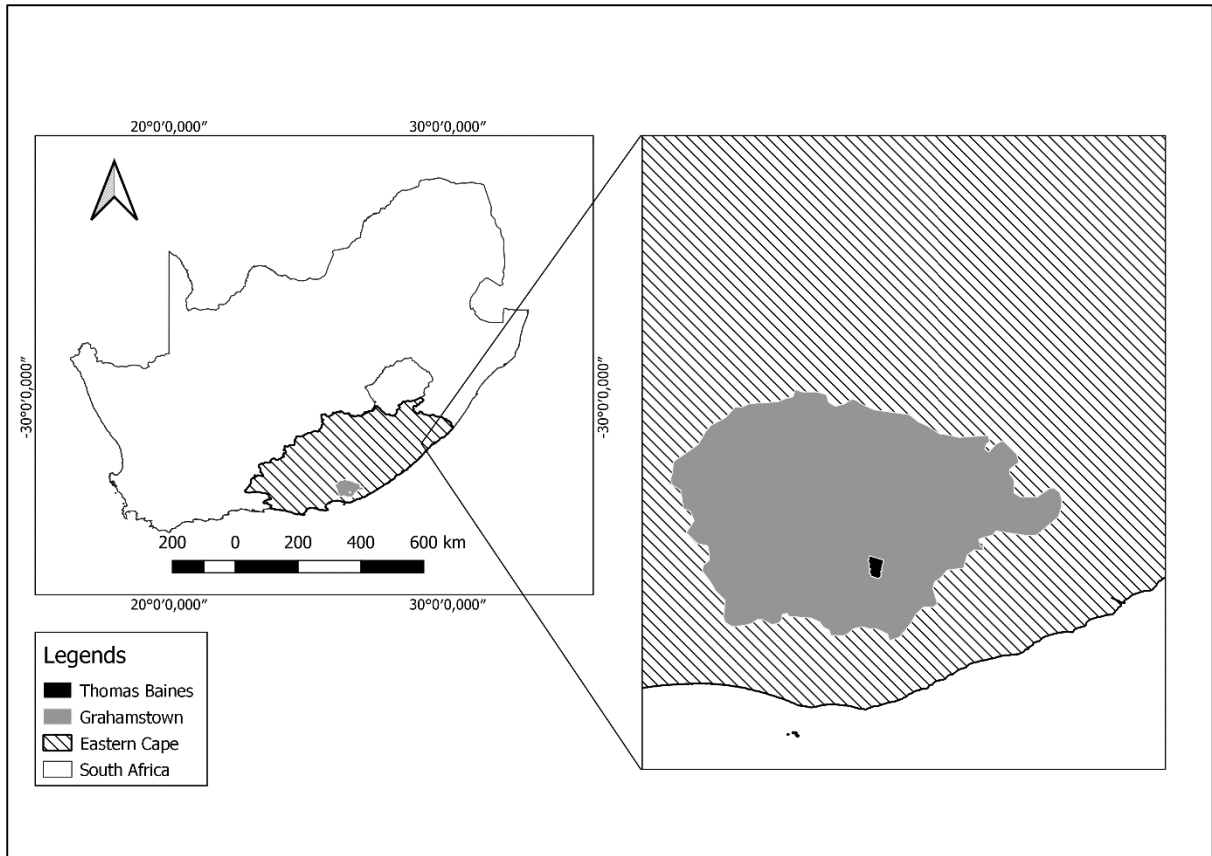
Figure 1: Location of Grahams Town in the Eastern Cape, South Africa showing Thomas Baines nature reserve.
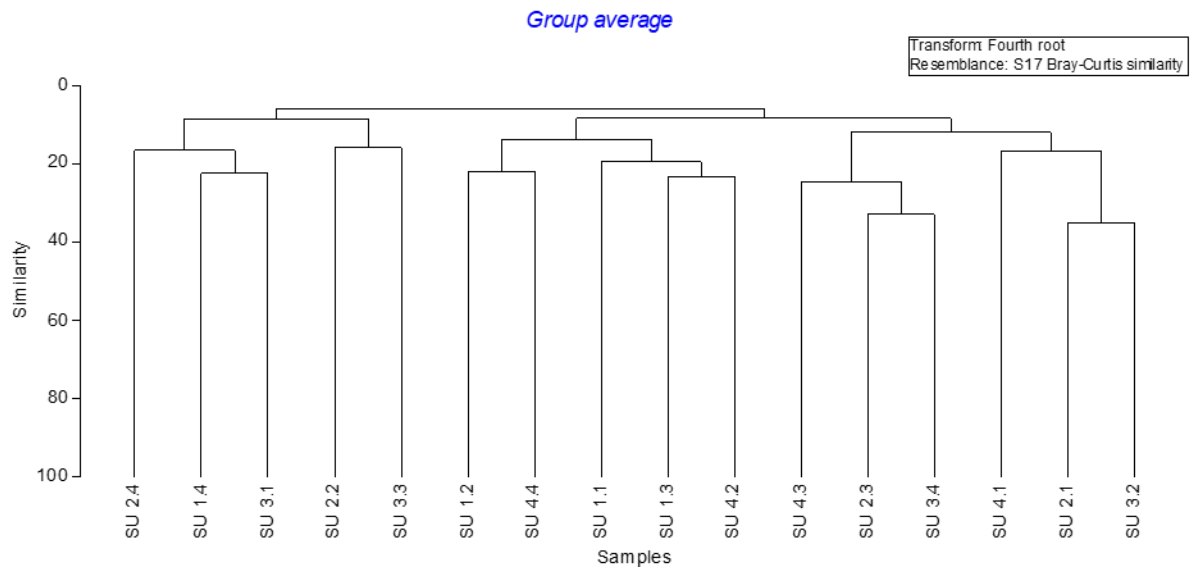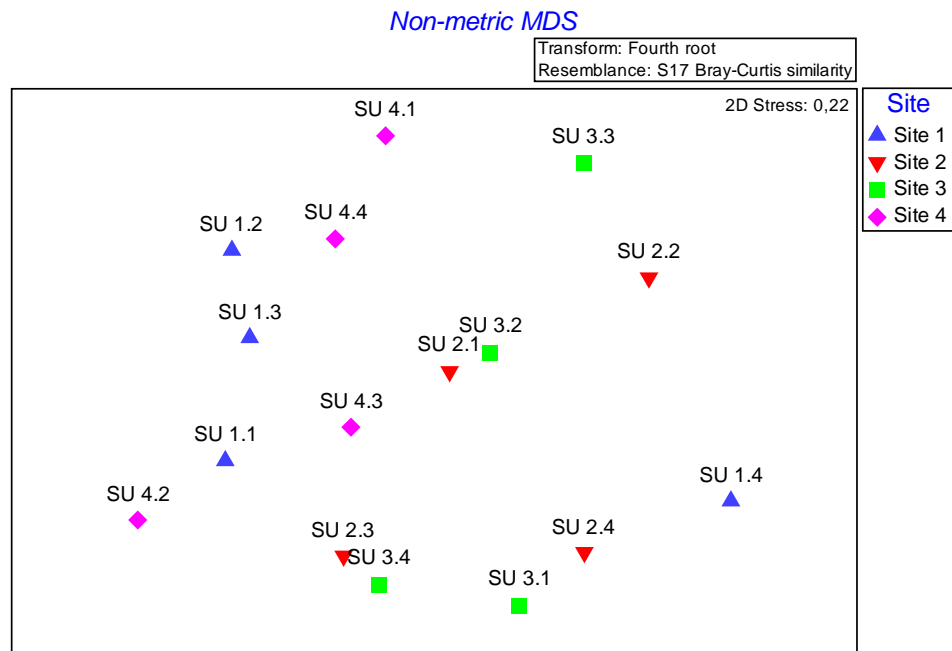
Figure 2: Dendrogram showing (A) Bray-curtis similarity and (B) nMDs epigeaic invertebrate abundance data at subsites at Thomas Baines Nature Reserve.
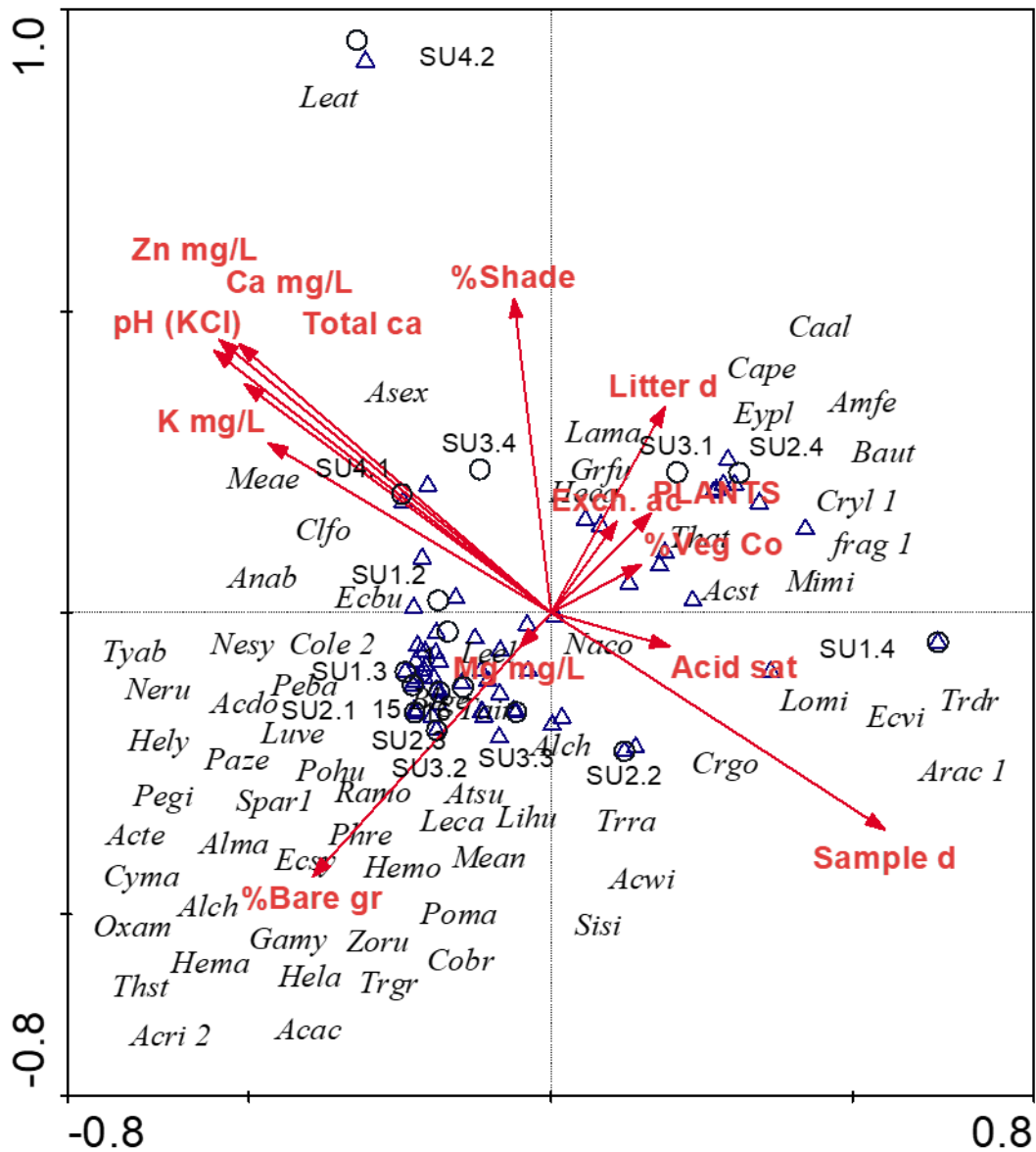
Figure 3: Diagram showing CCA tri-plot for the sampling sites in the warm/wet season, showing a relationship between the sampling units, environmental variables, and the species. Species code and environmental variables (appendix 1 and 2 respectively).

Table 1: Diversity indices across sub sites of the warm/wet season.

Sample	S	N	d	J'	H'(loge)
SU 1.1	6	8	2,404	0,9306	1,667
SU 1.2	8	11	2,919	0,9485	1,972
SU 1.3	10	26	2,762	0,7566	1,742
SU 1.4	10	73	2,098	0,6841	1,575
SU 2.1	17	113	3,385	0,7016	1,988
SU 2.2	14	101	2,817	0,6198	1,636
SU 2.3	14	60	3,175	0,7099	1,873
SU 2.4	13	134	2,45	0,7805	2,002
SU 3.1	7	17	2,118	0,8608	1,675
SU 3.2	15	51	3,561	0,763	2,066
SU 3.3	8	74	1,626	0,7978	1,659
SU 3.4	7	7	3,083	1	1,946
SU 4.1	8	36	1,953	0,6048	1,258
SU 4.2	4	48	0,775	0,2182	0,3025
SU 4.3	9	63	1,931	0,7438	1,634
SU 4.4	8	32	2,02	0,6017	1,251

Table 2. All four eigenvalues reported above are canonical and correspond to axes that are constrained by environmental variables. Test of significance of first canonical axis: eigenvalue =   0.90, F-ratio =   0.208

Axes	1	2	3	4	Total inertia
Eigenvalues :	0.902	0.880	0.839	0.816	9.594
Species-environment correlations :	1.000 0.996	1.000	0.996		
Cumulative percentage variance					
of species data:	9.4 18.6	27.3	35.8		
of species-environment relation:	10.4 20.6	30.3	39.7		
Sum of all eigenvalues				9.594	
Sum of all canonical eigenvalues					8.660

Table 3: Correlation between measured variables and sample sites.

Parameter	Inter-set correlation		Intra-set correlation	
	CCA AXIS1	CCA AXIS 2	CCA AXIS1	CCA AXIS 2
K mg/L	**0.4396**	-0.1379	**0.4447**	-0.1425
Ca mg/L	**0.5950**	0.1427	**0.6020**	0.1475
Mg mg/L	-0.0658	-0.3315	**-0.0666**	-0.3426
Exch. ac	-0.1499	-0.0172	-0.1516	-0.0177
Total ca	**0.5941**	0.0520	**0.6010**	0.0538
Acid sat	-0.2600	0.0136	-0.2631	0.0141
pH (KCl)	**0.6131**	-0.0872	**0.6203**	-0.0901
Zn mg/L	**0.4821**	-0.1764	**0.4878**	-0.1823
Plants	-0.5170	-0.5880	**-0.5230**	-0.6077
%Vegetat	**-0.3645**	-0.3478	**-0.3688**	-0.3595
%Shade	-0.0609	-0.1971	-0.0616	-0.2037
%Bare gr	**0.4672**	0.2147	**0.4726**	0.2220

Appendix 1. List of species identified in the study

ORDER/FAMILY/GENUS/SPECIES	CODE	SU 1	SU 2	SU 3	SU 4	TOTAL
HEMIPTERA						
GREENIDEA						

ORDER/FAMILY/GENUS/SPECIES	CODE	SU 1	SU 2	SU 3	SU 4	TOTAL
Greenidea ficicola Takahashi in 1921	*Grfi*	0	1	1	0	2
ARANEAE						
ARANEIDATE						
Acacesia hamata Hentz, 1847	*Acha*	1	0	0	0	1
CHELICERAE						
PHIDIPUS						
Phidipus otiosus Hentz, 1846	*Phot*	1	0	1	0	2
ARANEIDAE						
ACACESIA						
Acacesia tenella L.Koch 1871	*Acte*	4	0	0	0	4
PHILODROMIDAE						
Philodromus dispar Walchenaer 1826	*Phdi*	0	1	0	0	1
LYCOSIDAE						
Allocosa chamberlini Gertsch 1934	*Alch*	0	11	0	1	12
ARANEIDAE						
Ananeus lenzi St Johns 1427	*Anle*	0	1	0	0	1
NEMESIDAE						
Raveniola montana Zonstein & Marusik 2012	*Ramo*	1	0	0	21	22
CYRTAUCHENIDAE						
Bolostromus venustus Ausserer 1875	*Bove*	0	1	0	1	2
GNAPOSIDAE						
Ochyrocera laracna Cizauska & Mota 2018	*Ocla*	0	1	0	0	1
NESTICODES						
Hermacha lanata Purcell 1902	*Hela*	0	1	2	0	3
PHILODROMIDAE						
Philodromus aurelus Hentz, 1847	*Phau*	0	1	0	0	1
NESTICODE						
Nesticode rufipes Lucas, 1846	*Neru*	1	2	0	0	3
CORRIDAE						
Thanatus atratus Simon 1875	*That*	0	1	2	0	3
SICARRIDAE						
Phidippus regius L. Koch, 1846	*Phre*	0	10	0	0	10
DESIDAE						
PARATHEUMA						
Paratheuma armata Bryant 1940	*Paar*	1	0	1	0	2
BARYCHELIDAE						
Cyphonisia manicata Simon 1889	*Cyma*	1	1	0	2	4
CTENIZIDAE						
Stasimophus mandelai	*Stma*	0	0	0	1	1
ORSOLOBIDAE						
Azanialobus lawrencei Giswol & Platnick 1987	*Azla*	0	0	0	1	1
OONOPIDAE						
Australoonops granulatus Hewitt 1915	*Augr*	1	1	0	0	2
PRODIDOMIDAE						

Prodidomus bicolor Bryant 1940	*Prbi*	0	0	1	0	1
SICARRIDAE						
Sicarrinae sicarius Pickard-Cambridge 1899	*Sisi*	0	2	0	2	4
LOXOSCELES						
Loxosceles reclusa Gertsc & Mulaik 1940	*Lore*	0	1	0	0	1
GNAPOSIDAE						
Ochyrocera aragofue cizauskas & Mota 2018	*Ocar*	1	0	0	0	1
GNAPHOSA						
Gnaphosa sericata L.Koch 1866	*Gnse*	0	0	1	0	1
PRODIDOMIDAE						
Thanatus striatus L. Koch 1945	*Thst*	2	1	0	2	5
PHILODROMIDAE						
Platyoides robertsi Haddad 2022	*Plro*	0	1	0	0	1
THERIDIDAE						
Steatoda borealis Hentz, 1850	*Stbo*	0	2	0	0	2
TRACHELIDAE						
*Trachelas tranquillus*Hentz, 1847	*Trtr*	1	0	0	0	1
ORSOLOBIDAE						
Duripelta borealis Foster 1956	*Dubo*	0	1	1	0	2
HERSILIIDAE						
Tyrotama arida Smithers, 1945	*Tyar*	0	1	0	1	2
HERSILIIDAE						
Tyrotama abyssus Foord & Dippenaar-Schoeman 2005	*Tyab*	0	2	2	0	4
HERSILIIDAE						
Hersilia savignyi Lucas 1836	*Hesa*	0	1	0	0	1
PHILODROMIDAE						
Philodromus margaritatus Clerk 1757	*Phma*	0	0	1	0	1
ARANEIDAE						
Angulate orbweavers	*Anab*	1	1	1	0	3
THOMISIDAE						
Xysticus cristatus Clerk 1757	*Xycr*	1	0	0	0	1
CAPONIDAE						
Tarsonops irataylori Bond & Taylor 2013	*Tair*	0	2	4	0	6
CORINNIDAE						
Creugas golusus Thorell 1878	*Crgo*	1	27	0	0	28
AMAUROBIIDAE						
Arctobius agelenoides Emerton 1919	*Arag*	0	0	0	1	1
ENTYPESIDAE						
Hermacha caudata Simon 1889	*Heca*	0	1	4	0	5
GNAPOSIDAE						

Trochanters drassodes Pnomarev & Alieva 2008	*Trdr*	11	0	0	0	11
IDIOPIDAE						
Idiops opifex Somon 1889	*Idop*	0	1	0	1	2
SPARASSIDAE						
Sparassidae 1	*Spar1*	0	19	0	0	19
BEMMERIDAE						
Atmetochilus sumatranus Simon 1887	*Atsu*	0	1	2	0	3
ZODARIIDAE						
Zodarion rubidium Simon 1914	*Zoru*	2	1	0	0	3
CORINNIDAE						
Castianeira alteranata Gertsch 1942	*Caal*	0	32	0	1	33
GALLIENIELLIDAE						
Galleinella mygaloides	*Gamy*	1	1	1	0	3
ENTYPESIDAE						
Hermacha montana Simon 1889	*Hemo*	0	29	1	0	30
BEMMERIDAE						
*Demarchus workman*Tamerlan Thorell 1891	*Dewo*	0	1	0	0	1
AMAUROBIIDAE						
Amaurobius ferox Walckenaer, 1830	*Amfe*	0	13	0	0	13
THOMISIDAE						
Alcimochthes limbatus Simon 1886	*Alli*	0	1	1	0	2
LYCOSIDAE						0
Pardosa saltans Topfer-Hofmann 2000	*Pasa*	0	0	0	1	1
THOMISIDAE						0
Coriarachne brunneipes Banks 1893	*Cobr*	1	18	7	4	30
OXYOPIDAE						0
Oxyopes amoenus L. Koch 1878	*Oxam*	0	2	1	0	3
OXYOPIDAE						0
Oxyopes tridens Brady 1964	*Oxtr*	1	1	0	0	2
THOMISIDAE						0
Ozyptilla brevipes Hahn 1824	*Ozbr*	0	1	0	1	2
LYCOSIDAE						0
Algidus marmoratus Simon 1898	*Alma*	4	0	4	15	23
OXYOPIDAE						0
Peucetia crucifera Lawrence 1927	*Pecr*	0	1	0	0	1
ENTYPESIDAE						0
Hermachola lyleae Simon 1889	*Hely*	2	1	0	0	3
GNAPOSIDAE						0
Hermachola nigra Simon 1889	*Heni*	0	0	0	1	1
ARANEIDAE						0
Araneus diadematus Clerk 1957	*Ardi*	0	1	0	0	1
LYCOSIDAE						0
Allocosa chamberlini Gersch 1934	*Alch*	1	5	15	0	21

GNAPOSIDAE						0
Hermachola maraisae Simon 1889	*Hema*	1	2	0	0	3
OXYOPIDAE						0
Oxyopes daksina Sheriffs 1955	*Oxda*	0	0	1	0	1
CORINNIDAE						0
Castaineira alteranda Gersch 1942	*Caal*	1	0	0	0	1
THOMISIDAE						0
Bassaniana utahensis Gersch 1932	*Baut*	0	24	0	0	24
LYCOSIDAE						0
Malimbosa 1 Malimbosa 1960	*Mali 1*	1	0	0	0	1
Allocosa alticeps Mello-Leitao 1944	*Alal*	0	1	0	0	1
SALTICIDAE						0
Evarcha culicivora Wesolowska & Jackson 2003	*Evcu*	0	0	1	0	1
PALPIMANUS						0
Palpimanus sogdianus Charitonov 1946	*Paso*	0	1	0	1	2
MIMRTIDAE						0
Ero furcate Villiers 1789	*Erfu*	1	0	0	0	1
LOXOSCELES						0
Loxosceles loxosceles Gersch & Mulaik 1940	*Lolo*	0	1	0	0	1
THERIDIDAE						0
Parasteatoda tepidariorum L. Koch 1841	*Pate*	0	0	0	1	1
THERIDIDAE						0
Latrodectus mactans Fabricius 1775	*Lama*	0	2	1	0	3
GRYLLIDIDAE						0
Gryllus fultoni Alexander 1957	*Grfu*	0	1	0	0	1
TETRANYCHIDAE						0
Trombidium urticae Linne 1758	*Trur*	0	0	0	1	1
ARACHEO 1						0
Aracheo 1	*Arac 1*	31	0	0	0	31
BLATTODEA						0
PERIPLANETA						0
*Periplaneta basedowi*Fabricius, 1775	*Peba*	1	0	6	3	10
GRYLLIDAE						0
Acheta domesticus Linnaeus 1758	*Acdo*	0	0	0	10	10
BLATTODIDAE						0
Blatta orientalis Linnaeus 1758	*Blor*	0	0	0	1	1
GRYLLIDAE						0
Gryllus futoni Alexander 1957	*Grfu*	1	0	2	0	3
BLATTODIDAE						0
Ectobius vittiventris Costa 1847	*Ecvi*	19	0	0	0	19
BLATTODIDAE						0
Luccichormetica verrucosa Brunner	*Luve*	0	0	21	0	21

von Wattenwyl, 1865						
BLATTODIDAE						0
Schultesia lampyridiformis Roth 1973	*Scla*	0	0	0	1	1
BLATTODIDAE						0
Periplaneta bruinnea Burmester 1848	*Pebr*	0	0	0	1	1
BLATTODIDAE						0
Periplaneta 1 Linnaeus, 1758	*Peri 1*	1	0	0	0	1
Blattella germanica Linnaeus 1767	*Blge*	1	11	1	0	13
ECTOBIDAE						0
*Parcoblatta virginica*Brunner, 1865	*Pavi*	0	0	1	0	1
*Blattella orientalis*Linné 1767	*Blor*	0	0	1	0	1
ECTOBIIDAE						0
Ectobius sylvestris Poda 1761	*Ecsy*	0	0	23	0	23
BLABBERIDAE						0
*Periplaneta americana*Linnaeus, 1758	*Peam*	1	0	0	0	1
ECTOBIIDAE						0
Parcoblatta uhleriana Sassure 1862	*Pauh*	0	0	0	1	1
ECTOBIDAE						0
Parcoblatta zebra Herbard 1917	*Paze*	13	0	0	0	13
BLTTIDAE						0
Periplaneta caudata Bei-Bienko 1969	*Peca*	0	0	1	0	1
ECTOBIDAE						0
Theganopteryx bivitteta Princis 1963	*Thbi*	1	0	0	0	1
CENTIPIDE						0
LITHOBIDAE						0
Lithobidae giganteus Sseliwanoff 1881	*Ligi*	0	0	1	0	1
COLEOPTERA						0
ELATERIDAE						0
Agriotes mancus Say 1823	*Agma*	0	0	0	1	1
FRAGOSSITIDAE						0
Fragossitidae 1	*frag 1*	0	25	0	0	25
CHEILOMETES						0
*Astyris lunata*Say 1826	*Aslu*	0	1	0	0	1
LUCINIDAE						0
Apterodorcus bacchus Hope in Westwood 1845	*Apba*	0	0	1	0	1
SCARABAEIDAE						0
Agrilinus ater De Geer 1774	*Agat*	0	0	1	1	2
CHRYSOMELIDAE						0
Plagiodera versicolora Laicharting 1871	*Plve*	0	1	0	0	1
HISTERIDAE						0
Holopta reichii Jackelin Du val 1859	*Hore*	0	1	0	0	1
CARABIDAE						0
Clivina fossor Linnaeus 1758	*Clfo*	0	0	0	3	3

HISTERIDAE						0
Carcinops pumilio Erichson 1834	*Capu*	0	1	0	0	1
ELATERIDAE						0
Agriotes lineatus Linnaeus 1967	*Agli*	0	1	0	0	1
CARABIDAE						0
Blemus discus Fabricus 1972	*Bldi*	0	1	0	0	1
DYSTICIDAE						0
Capelatus prykei	*Capr*	0	0	1	0	1
CLERIDAE						0
*Tenerus parryanus*Castelnau, 1836	*Tepa*	0	0	1	0	1
ELATERIDAE						0
*Selatosomus aenus*Linnaeus, 1758	*Seae*	0	0	0	1	1
CURCULIDIDAE						0
Xylosandrus germanus C.H Hoffmann 1941	*Xyge*	0	1	0	0	1
CHRYSOMELIDAE						0
Plagiodera 1 Laicharting 1781	*Plag 1*	0	0	1	0	1
DYSTISADAE						0
Agabus uliginosus Linnaeus 1761	*Agul*	0	0	1	0	1
TENEBROINIDAE						0
Helops caeruleus Linnaeus 1758	*Heca*	0	1	0	0	1
ANTHRIBIDAE						0
Trigonorhinus limbatus Say 1826	*Trli*	0	0	1	0	1
ANTHRIBIDAE						0
*Trigonorhinus lipedus*Say 1826	*Trli 1*	0	0	1	1	2
STAPHYLINIDAE						0
*Ocypus olens*O. F. Müller, 1764	*Ocol*	0	0	1	0	1
TENEBROINIDAE						0
Palorus subdepressus Linnaus 1761	*Pasu*	0	1	0	0	1
SCARABAEIDAE						0
Scarabaeus sacer Linnaeus 1758	*Scsa*	0	0	1	0	1
ANTHRIBIDAE						0
Plytyrhinus resinosus Linnaeus 1758	*Plre*	0	0	1	1	2
STAPHYLINIDAE						0
Paedurus littoralis Gravenhorst 1802	*Pali*	0	1	0	0	1
STAPHYLINIDAE						0
Aleochara biineata Gyllenhal 1810	*Albi*	0	0	1	0	1
STAPHYLINIDAE						0
Aleochara immaculata Gyllenhal 1810	*Alim*	0	1	0	0	1
ARITHRIBIDAE						0
Choragus sheppardi Kirby 1819	*Chsh*	1	0	0	0	1
STAPHYLINIDAE						0
Aleochara alpicola Gyllenhal 1810	*Alal*	0	0	0	1	1
TENEBROINIDAE						0
Blaps mortisaga Linnaeus 1758	*Blmo*	1	0	0	0	1

ECNOLAGRIA						0
Ecnolagria tomentosa Fabricus 1775	*Ecto*	1	0	0	0	1
BOLITOPHAGUS						0
Bolitophagus ruticulatus Linnaeus 1767	*Boru*	1	0	0	0	1
CAPNOCHROA						0
*Capnochroa fuliginosa*Melsheimer, 1846	*Cafu*	1	0	0	0	1
DIAPERIS						0
Diaperis boleti Linnaeus 1758	*Dibo*	0	1	0	0	1
STAPHYLINIDAE						0
Aleochara anthomyie Gravenhorst 1802	*Alan*	0	1	0	0	1
ARITHRIBIDAE						0
Anthribidae nebulosus Foster 1770	*Anne*	0	1	0	0	1
STAPHYLINIDAE						0
Aleochara agilis Gyllenhal 1810	*Alag*	0	1	0	0	1
ARITHRIBIDAE						0
*Urodontidius louw*Louw, 1993	*Urlo*	0	0	1	0	1
PSAMMODES						0
Planodes stratus Latreille 1802	*Plst*	0	0	1	0	1
CHRYSOMELIDAE						0
Plagiodera caffra	*Plca*	0	1	0	0	1
LEMA						0
Lema cyanella Linnaeus 1758	*Lecy*	1	0	0	0	1
PLAGIODERA						0
Plagiodera thymaloides Stal 1860	*Plth*	0	1	0	0	1
EROTYLIDAE						0
Dacne rufifrons Fabricus 1775	*Daru*	0	1	0	0	1
COLEMBOLA						0
Colembola 1	*Cole 1*	0	1	0	0	1
COLEMBOLA 2						0
Colembola 2 colembola 2	*Cole 2*	0	1	1	2	4
HEMIPTERA						0
*Dipura ruffrons*Latham 1802	*Diru*	0	0	0	1	1
ASOPHINAE						0
Podisus maculiventris Say 1802	*Poma*	0	1	1	0	2
HEMIPTERA 1						0
*Thyanta perditor*Fabricus 1794	*Thpe*	1	0	0	0	1
HEMIPTERA 2						0
Phymata pacifica Evan 1931	*Phpa*	0	0	1	0	1
HEMIPTERA 3						0
Trioza urticae Linnaeus 1758	*Trur*	0	1	0	0	1
HEMIPTERA 4						0
*Psylla pyrisuga*Förster, 1848	*Pspy*	0	1	0	0	1
HEMIPTERA 5						0
Psylla buxi Linnaeus 1758	*Psbu*	0	0	1	0	1

HEMIPTERA 6						0
Cacopsylla bidens Sulc 1907	*Cabi*	0	0	0	1	1
HEMIPTERA 7						0
*Anthocoris tomentosus*Pericart, 1971	*Anto*	0	1	0	0	1
HEMIPTERA 8						0
Piezodorus guildinii Westwood 1837	*Pigu*	1	0	0	0	1
HEMIPTERA 9						0
Triatoma dimidiate Chagas 1909	*Trdi*	1	0	0	0	1
HEMIPTERA 10						0
Rinodinius prolixus	*Ripr*	1	0	1	0	2
RHOPALOSIPHUM						0
Rhopalosiphum padi Linnaeus 1758	*Rhpa*	0	1	0	0	1
CICADIDAE						0
Pharaoh cicada Linnaeus 1758	*Phci*	0	0	1	0	1
PENTATOMIDAE						0
Pentatomidae 1	*Pent 1*	0	1	1	0	2
LYGAEIDAE						0
Oncopeltus fasciatus	*Onfa*	0	0	0	1	1
REDURIDAE						0
*Lygaues equestris*Linnaeus, 1758	*Lyeq*	1	0	0	0	1
COREIDAE						0
Anoplocnemis curvipes Fabricius 1781	*Ancu*	1	0	0	1	2
APHIDIDAE						0
Uroleucon montanivorum Mordvilko 1914	*Urmo*	0	0	1	0	1
Leptoglossus gonagra Fabricius 1775	*Lego*	1	0	0	0	1
PENTOTOMIDAE						0
Halyomorpha halys Stal	*Haha*	1	0	0	0	1
MICRONETA						0
Microneta citharistia	*Mici*	0	0	1	0	1
HYMENOPTERA						0
FORMICIDAE						0
Dorylus helvolus Linnaeus 1764	*Dohe*	0	0	1	0	1
FORMICIDAE						0
Pheidole capensis Mayr 1862	*Phca*	0	0	1	0	1
FORMICIDAE						0
*Megalomyrmex adamsae*Longino, 2010	*Mead*	0	0	0	1	1
FORMICIDAE						0
*Tetramorium capense*Mayr, 1855	*Teca*	1	0	1	0	2
FORMICIDAE						0
Anoplolepis custodiens Smith 1858	*Ancu*	0	1	0	1	2
FORMICIDAE						0
Campanotus nigriceps Smith 1858	*Cani*	0	1	1	0	2
FORMICIDAE						0
Phelidole megacephala Fabricius 1793	*Phme*	0	0	1	0	1

Species	Code					
FORMICIDAE						0
*Crematogaster peringueyi*Emery, 1895	*Crpe*	0	0	1	0	1
FORMICIDAE						0
Formica fusca Linnaeus 1758	*Fofu*	0	0	1	0	1
FORMICIDAE						0
Monomorium pharaonic Linnaeus 1758	*Moph*	1	0	0	0	1
TETRAMORIUM						0
Tetramorium immigrants Santschi 1927	*Teim*	1	0	0	0	1
PARAPONERA						0
Paraponera clavate Fabricius 1775	*Pacl*	0	2	0	0	2
CAMPONOTUS						0
Camponotus pennsylvanicus De Geer	*Cape*	0	20	0	0	20
VESPULA						0
Vespula vulgaris Linnaeus 1775	*Vevu*	0	0	1	0	1
LINEPITHEMA						0
Linepithema iniquum Mayr 1870	*Liin*	1	0	0	0	1
LINEPITHEMA						0
Linepithema humile Mayr 1868	*Lihu*	0	0	21	1	22
ANOPLOLEPIS						0
Anoplolepis custodiens	*Ancu*	0	1	0	0	1
LEPISIOTA						0
Lepisiota capensis Mayr 1862	*Leca*	4	16	0	5	25
VESIDAE						0
Vespula vulgaris Linnaeus 1758	*Vevu*	0	0	1	0	1
FORMICIDAE						0
Messor galla Mayr 1904	*Mega*	0	1	1	0	2
Messor aegyptiacus Emery 1878	*Meae*	0	1	0	24	25
FORMICA						0
Formica rufa Linnaeus 1761	*Foru*	0	1	0	0	1
POGONOMYRYNEX						0
Pogonomyrynex salinus	*Posa*	0	1	0	0	1
STREBLOGNATHUS						0
*Streblognathus aethiopices*F Smith, 1858	*Stae*	0	0	0	1	1
TETRAMORIUM						0
Tetramorium capense Linnaeus 1758	*Teca*	0	1	0	0	1
POGONOMYRMEX						0
Pogonomyrmex hauchucanus	*Poha*	0	1	0	0	1
POGONOMYRMEX						0
Pogonomyrmex bicor	*Pobi*	0	1	0	1	2
Messor inermis Messor Forel 1890	*Mein*	1	0	0	0	1
LINEPITHEMA						0
Linepithema pulex Mayr 1866	*Lipu*	0	1	0	0	1
Messor bouvier Forskal 1775	*Mebo*	0	1	0	0	1
*Messor hellenias*Santschi, 1926	*Mehe*	1	0	0	0	1

Messor Andrei Mayr 1886	*Mean*	0	2	0	26	28
LINEPITHEMA						0
*Linepithema aztecoides*Wild, A. L., 2007	*Liaz*	0	1	0	0	1
POGONOMYRMEX						0
*Pogonomyrmex mayri*Kugler 1979	*Poma*	0	1	2	0	3
SPHECIDAE						0
Sphex nudus Fernald 1903	*Spnu*	0	0	1	0	1
FORMICIDAE						0
Pogonomyrmex Emery	*Pogo 1*	0	0	0	1	1
FORMICIDAE						0
Pogonomyrmex humerotum	*Pohu*	0	33	1	0	34
FORMICIDAE						0
Messor nondentatus He & Song 2009	*Meno*	0	1	0	0	1
POGONOMYRMEX						0
*Pogonomyrmex inermis*La Pampa	*Poin*	1	0	1	0	2
ACROPYGA						0
*Acropyga kinomurai*Terayama & Hashimoto 1909	*Acki*	1	0	0	0	1
ECITON						0
*Eciton burchellii*Holldobler and Wilson, 1990	*Ecbu*	0	1	1	2	4
ACROPYGA						0
Acropyga apedana Holldobler and Wilson, 1990	*Acap*	0	1	0	0	1
Acropyga stenotes LaPolla, 2004	*Acst*	1	0	1	1	3
ARMANIELLA						0
Armaniella dlussky Dlussky, 1983	*Ardl*	0	0	1	0	1
LEPISIOTA						0
*Lepisiota rothneyi*Forel, 1894	*Lero*	0	0	1	0	1
POLYRHACHIS						0
Polyrhachis illaudata Walker 1859	*Poil*	0	0	0	1	1
LEPTOTHORAX						0
*Leptothorax crassipilis*Mayr, 1855	*Lecr*	0	1	0	0	1
LEPTOTHORAX						0
Leptothorax pacis Kutter 1950	*Lepa*	1	0	0	0	1
LEPTOTHORAX						0
*Leptothorax Athabasca*Kutter, 1967	*Leat*	1	0	1	45	47
POLYRHACHIS						0
Polyrhachis dives Smith 1857	*Podi*	0	0	1	0	1
POLYRHACHIS						0
Polyrhachis laboriosa Smith 1858	*Pola*	1	0	0	0	1
ACROPYGA						0
*Acropyga goeldii*Forel, 1912	*Acgo*	0	1	1	0	2
LEPISIOTA						0

Lepisiota elegantissima Stantschi 1926	*Leel*	1	1	1	0	3
LEPISIOTA						0
Lepisiota nigra Sala Torre 1893	*Leni*	0	0	1	0	1
LEPTOTHORAX						0
Leptothorax duloticus Wesson 1937	*Ledu*	0	0	1	0	1
LEPTOTHORAX						0
Leptothorax scamni Ruzsky 1905	*Lesc*	0	1	1	0	2
LEPTOTHORAX						0
Leptothorax angustulus Nylanda 1856	*Lean*	0	0	1	0	1
POLYRHACHIS						0
*Polyrhachis schistacea*Gerstäcker, 1859	*Posc*	0	0	0	1	1
PHEIDOLE						0
Pheidole megacephala Fabricius 1759	*Phme*	0	0	0	1	1
DOLICHODERUS						0
*Dolichoderus plagiatus*Mayr in 1870.	*Dopl*	0	1	0	0	1
PEGONOMYRMEX						0
*Pegonomyrmex apache*Wheeler, 1902	*Peap*	0	0	0	1	1
PEGONOMYRMEX						0
Pegonomyrmex hoelldobleri Wheeler, 1902	*Peho*	0	1	0	1	2
ISOPTERA						0
TERMITIDAE						0
*Microcerotermes septentrionalis*Light, 1933	*Mise*	0	0	1	0	1
ANOPLOTERMES						0
*Anoplotermes vindai*Noirot 2001	*Anvi*	0	0	1	0	1
MACROTERMES						0
Macrotermes 1	*Macr 1*	0	1	0	0	1
ANOPLOTERMES						0
*Anoplotermes fumosus*Muller. 2009	*Anfu*	0	0	1	0	1
NASUTITERMES						0
*Nasutitermes corniger*Motschulsky, 1855	*Naco*	0	1	0	2	3
NASUTITERMES						0
Nasutitermes ephatae	*Naep*	0	0	1	0	1
ISOPOD						0
ONISCIDEA						0
Porcellio laevis Latreille 1804	*Pola*	0	0	0	1	1
TRACHELIPUS						0
Trachelipus rathkii Brandt 1833	*Trra*	0	45	0	0	45
ONISCUS						0
Oniscus asellus Linnaeus 1758	*Onas*	0	0	1	0	1
HERMILEPISTUS						0
Hermilepistus reamuri	*Here*	0	0	1	0	1

TERMITIDEA						0
Anoplotermes 1	*Ano 1*	0	1	0	0	1
ORTHOPTERA						0
ACRIDODEA						0
Conozoa hyaline MacNeill 1901	*Cohy*	1	0	0	0	1
ACRIDIDAE						0
Calephorus compressicornis Latreille 1804	*Caco*	0	1	0	0	1
ACRIDA						0
Acrida willernsei	*Acwi*	0	12	0	0	12
GRYLLIDAE						0
*Dichromorpha viridis*Scudder, 1863	*Divi*	0	1	0	0	1
ACRIDA						0
GASTRIMARGUS						0
Gastrimargus africanus Saussure, 1888	*Gaaf*	0	0	1	0	1
GRYLLATAPIDAE						0
Neoscapteriscus vicinus Scudder 1869	*Nevi*	0	0	1	0	1
TRIGONIDIUM						0
*Trigonidium cicindeloides*Rambur, 1838	*Trci*	0	1	0	0	1
TELEOGRYLLUS						0
*Teleogryllus nipponensis*Omachi & Matsuura, 1951	*Teni*	0	0	0	1	1
PTERONEMOBIUS						0
*Pteronemobius heydenli*Fischer, 1853	*Pthe*	0	0	0	1	1
MITIUS						0
*Mitius minor*Shiraki, 1911	*Mimi*	1	0	0	0	1
GRYLLIDAE						0
TELEGRYLLUS						0
*Telegryllus emma*Ohmachi & Matsuura, 1951	*Teem*	0	0	0	1	1
ACRIDIDAE						0
LOCUSTA						0
Locusta migratoria Linnaeus 1758	*Lomi*	0	0	0	1	1
GRYLLIDAE						0
VELARIFICTORUS						0
*Velarifictorus khansiensis*Shiraki, 1930	*Vekh*	0	0	1	0	1
ACRIDIDAE						0
STETHOPHYMA						0
Stethophyma grossum Linnaeus 1758	*Stgr*	1	0	0	0	1
TRIMEROTROPIS						0
*Trimerotropis pallidipennis*Burmeister, 1838	*Trpa*	0	0	0	1	1
ACRIDA						0
Acrida cinerea Thurnburg 1815	*Acci*	1	0	0	0	1

GRYLLIDIDAE						0
MENONIA						0
Menonia 2	*Meno 2*	0	0	1	0	1
ASSAMACRIS						0
Assamacris assamacris Uvarov, 1942	*Assa 1*	0	1	0	0	1
ACHURUM						0
*Achurum achurum*Saussure, 1861	*Acac*	1	2	6	1	10
GRYGLOTALPIDAE						0
GRYLLOTALPA						0
*Gryllotalpa gorkhana*Ingrisch, 2006	*Grgo*	0	0	1	0	1
MELLIACRIS						0
Melliacris melliacris Ramme 1941	*Meme*	1	0	0	0	1
GRYGLOTALPIDAE						0
GRYLLOTALPA						0
Gryllotalpa vineae Bennet Clerk 1970	*Grvi*	0	0	0	1	1
ACRIDIDAE						0
JUMANDIACRIS						0
*Jumandiacris perlata*Poulain. 1998	*Jupe*	0	1	0	1	2
CRYLLIDIDAE						0
CRYLLIDIDAE 7						0
Cryllididae 1	*Cryl 1*	1	2	0	0	3
ACRIDIDAE						0
ACRIDA						0
Acrida acrida1	*Acac*	1	0	0	1	2
GRYLIDAE						0
SVERCUS						0
Svercus palmetorum Krauss 1902	*Svpa*	1	0	0	0	1
GRYLLOTALPIDAE						0
TRIGORIUM						0
Trigorium trigonum	*Trtr*	0	0	0	1	1
ACRIDIDEA						0
PEZOTETTIX						0
Pezotettix giornae Rossi 1794	*Pegi*	0	1	1	1	3
ANACRIDIUM						0
Anacridium aegyptium Linnaeus 1764	*Anae*	1	0	0	0	1
GRYLIDAE						0
GRYLLUS						0
Gryllus bimaalatus De Greer 1773	*Grbi*	0	1	0	0	1
ACRIDIDAE						0
EYPNEPOCNEMIS						0
Eypnepocnemis plorans Walker 1870	*Eypl*	5	16	7	0	28
TROPIDAPOLA						0
*Tropidapola cylindrica*Uvarov, 1922	*Trcy*	0	1	0	0	1
GRYLLIDIDAE						0

LEBINTHUS						0
*Lebinthus sanchezi*Bolívar, 1889	*Lesa*	1	0	0	0	1
OMOGRYLLUS						0
Omogryllus 1	*Omog 1*	0	0	0	1	1
ACANTHOGRYLLUS						0
Acanthogryllus acus Gorochov, 1988	*Acac*	0	0	2	0	2
NEOGRYLLODES						0
Neogryllodes ottes	*Neot*	1	0	0	0	1
ACRIDIDAE						0
DICHOROPLUS						0
Dichoroplus 1	*Dich 1*	1	0	0	0	1
HILETHERA						0
Hilethera Bolívar, 1902	*Hile 1*	0	0	1	0	1
AULOCARA						0
Aulocara Scudder 1889	*Aulo 1*	0	1	0	0	1
GRYLLIDIDAE						0
THIERNOGRYLLUS						0
Thiernogryllus Roy 1969	*Thei 1*	0	0	0	1	1
NOCTITRELLA						0
Noctitrella Gorochov, 1990	*Noct 1*	0	1	0	0	1
ACRIDIDAE						0
LOCASTA						0
Locasta 1	*Laca 1*	0	1	0	0	1
OXYA						0
Oxya Serville, 1831	*Oxya 1*	0	0	0	1	1
GRYLLIDEDAE						0
TAFALISCA						0
*Tafalisca tafalisca*Walker, 1869	*Tata*	0	1	0	0	1
ACRIDIDEA						0
HETERACRIS						0
Heteracris 1 Stål, 1876	*Hete 1*	0	0	0	1	1
GRYLLIDEDAE						0
PHONORELLUS						0
Phonorellus 1	*Phon 1*	0	0	0	1	1
TRISTIRIDAE						0
ACRIDOMORPHA						0
*Acridomorpha 2*Thunberg, 1810	*Acri 2*	0	0	2	1	3
ACRIDIDAE						0
STENOBOTHRUS						0
*Stenobothrus aurasius*Maran, 1958	*Stau*	0	0	0	1	1
STENOBOTHRUS						0
Stenobothrus 1 Fisher 1853	*Sten 1*	0	0	0	1	1
MELANOPLUS						0
Melanoplus bivittatus Say 1825	*Mebi*	1	0	0	0	1

STENOBOTHRUS						0
*Stenobothrus lineatus*Panzer, 1796	*Stli*	0	0	1	0	1
ROMALEIDAE						0
TROPIDACRIS						0
Tropidacris dux Drury 1773	*Trdu*	0	0	0	1	1
ACRIDIDAE						0
SchistocercaDrury						0
*Schistocerca gregaria*Forskål, 1775	*Scgr*	1	1	0	0	2
LOCUSTA						0
Locusta migratoria Linnaeus 1758	*Lomi*	2	0	1	0	3
ROMALEIDAE						0
*Tropidacris tropidacris*Stoll, 1813	*Trtr*	0	0	0	1	1
ACRIDIDAE						0
*Oedaleus decorus*Germar, 1825	*Oede*	0	1	0	0	1
ROMALEIDAE						0
*Tropidacris grandis*Thunberg, 1824	*Trgr*	0	2	0	1	3
CRYLLIDIDAE						0
Acanthophalas confraterna	*Acco*	0	0	1	1	2
GRYLLIDIDAE						0
Mitius minor Shiraki, 1911	*Mimi*	0	3	2	0	5
ACRIDIDAE						0
Calephorus compressicornis Latreille, 1804	*Caco*	0	0	0	1	1
GRYLLIDIDAE						0
*Loxoblemmus taicoun*Saussure, 1877	*Lota*	0	0	1	0	1
ACRIDIDAE						0
*Acrididae Acrididae*MacLeay, 1821	*Acac*	0	2	0	0	2
NEMOMBIUS						0
Nemombius 1	*Nemo 1*	0	0	1	0	1
TROPIDACRIS						0
*Tropidacris tropidacris*Stoll, 1813	*Trtr*	0	1	0	0	1
NEMOMBIUS						0
*Nemombius sylvestris*Bosc, 1792	*Nesy*	2	0	0	1	3
STENOBOTHRUS						0
*Stenobothrus stenobothrus*Eversmann, 1848	*Stst*	0	0	0	1	1