INVASIVE ALIEN PLANTS ALONG MTHATHA RIVER AND THEIR EFFECTS ON THE DISTRIBUTION OF INVERTEBRATE TAXA IN LUCHABA NATURE RESERVE, EASTERN CAPE, SOUTH AFRICA

BY

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ABSTRACT

The riparian zone of Mthatha River was surveyed with two aims. The first aim was to record invasive alien plants along the riparian zone of the Mthatha River. Nine sites were visited and 27 species were recorded. The most abundant weed recorded was *Solanum mauritianum* followed by *Acacia mearnsii* and *Lantana camara (L.)*. Out of 27 species, 22 species are known as well-established major invaders and fifteen species belong to CARA category 1. These results revealed that the river has been invaded by the most noxious weeds and these need immediate eradication. The second aim was to identify invertebrate taxa within alien and indigenous vegetation in a protected area, with the objective of comparing the abundance of invertebrates at four a priori-selected sites (i.e. mixed alien, eucalyptus and indigenous acacia and grassland). Three-hundred and Forty-two (342) invertebrate individuals belonging to 11 orders were recorded. Results showed that some invertebrate taxa preferred indigenous vegetation sites whilst others preferred mixed alien sites. However, the least number of individuals and taxa were recorded at the Eucalyptus site. Thus, suggesting that invasive alien plants can seriously affects the composition and distribution of invertebrate assemblages.

The riparian zone of Mthatha River was surveyed with two aims. The first aim was to record invasive alien plants along the riparian zone of the Mthatha River. Nine sites were visited and 27 species were recorded. The most abundant weed recorded was Solanum mauritianum followed by Acacia mearnsii and Lantana camara (L.). Out of 27 species, 22 species are known as well-established major invaders and fifteen species belong to CARA category 1. These results revealed that the river has been invaded by the most

noxious weeds and these need immediate eradication. The second aim was to identify invertebrate taxa within alien and indigenous vegetation in a protected area, with the objective of comparing the abundance of invertebrates at four a priori-selected sites (i.e. mixed alien, eucalyptus and indigenous acacia and grassland). Three-hundred and Forty-two (342) invertebrate individuals belonging to 11 orders were recorded. Results showed that some invertebrate taxa preferred indigenous vegetation sites whilst others preferred mixed alien sites. However, the least number of individuals and taxa were recorded at the Eucalyptus site. Thus, suggesting that invasive alien plants can seriously affects the composition and distribution of invertebrate assemblages. Conservation recommendations were made from findings of this work to relevant stake holders with regards to the management and eradication of these plants within and outside protected areas

Keywords: Mthatha River, riparian zone, Luchaba Nature Reserve, invasive alien plants, invertebrates and taxa

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LIST OF ABBREVIATIONS

DWAF: Department of Water and Forestry.

WfW: Working for Water.

CARA: Conservation of Agriculture Resource Act.

IAPs: Invasive Alien Plants.

SAPIA: Southern African Invaders Atlas.

IASP: Invasive Alien Species Programme

UNEP: United Nations Environment Programme

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1. INTRODUCTION

Human communities and natural ecosystems worldwide are threatened by growing numbers of destructive invasive alien plants (Richardson & van Wilgen 2004). Invasive Alien Plants (IAPs) (also known as exotic, introduced, non-indigenous or non-native) are plants imported into an area that is originally not their own natural habitat and tend to have the ability to displace indigenous plants and animals (Preston 2003; Macdonald *et al*. 2003). These plants are known to have certain characteristics that make them good competitors, and these include their ability to grow faster, mature earlier and produce many more seeds than native plants (IASP 2005). Other invaders are said to affect native plants directly by becoming monopolizers or donors of limiting resources, or indirectly by altering soil stability, promoting erosion, colonizing open substrate, promoting or suppressing fire and accumulation of litter, silt, or other resources, (Mgobozi *et al*. 2008; Magoba & Samways 2008; Brooks *et al*. 2007). Local herbivores are also thought to find some of these invader plants inedible (Tallamy 2004), giving the invaders an advantage over indigenous grazed vegetation. For example, Gerber *et al*. (2008) report that there was almost no herbivore damage on invasive knotweeds (*Fallopia* spp.(L.) Dumort).

In the recent past, human population growth and environmental change have increased the rate of and risk associated with biotic invaders (Pimentel *et al*. 2005). Human activities, such as commerce, trade and travelling or tourism accelerate the problem of invasion, which in turn affects agriculture, forestry and human health, thereby leading to biotic homogenization worldwide (Usio *et al*. 2009; Pimentel *et al*. 2005; Richardson & van Wilgen 2004). Estimates indicate that the global cost of alien invaders exceeds the total economic output of the entire African continent, with impacts predicted to intensify due to global climate change (Musil & Macdonald 2007). For conservation purposes, risk associated with alien species and management plans as well as prevention measures to combat this problem should be clearly scrutinized (Usio *et al*. 2009; Wittenberg 2005). Ecological indicators are useful in assessing environmental conditions or to determine the cause of specific environmental problems (Palmer *et al*. 2004).

Apart from the impact on human communities, invasive alien plants are responsible for many indigenous species extinctions (i.e. over 1000 plant and animal species) (Magoba & Samways 2008), and as a result are regarded as the second major threat (after habitat destruction) to the biodiversity of any particular area (IASP 2005; Van Wilgen *et al*. 2007; Richardson & van Wilgen 2004; Macdonald *et al*. 2003). In other parts of the world, about 80% of the endangered species are threatened and at risk as a result of alien species (Pimentel *et al*. 2005). The decrease in biodiversity and effects of climate change may further increase ecosystem susceptibility to invasions (Manchester & Bullock 2000; Walter *et al*. 2009). This then becomes a major problem when it comes to biodiversity conservation within protected areas.

Theoretically, it is widely expected that invasive plants, simply by occupying a large amount of space, impose a significant impact on the native vegetation and their associated food webs (Gerber *et al*. 2008). Several studies suggest that invasive plants species generally harbour smaller herbivore assemblages than native plant species (Gerber *et al*. 2008; Mgobozi *et al*. 2004). After invasion of a marsh by *Phragmites* *australis* (Cav.) Steud, the species composition of spiders and other herbivorous macroinvertebrates changed (Palmer *et al*. 2004). Gerber *et al*. (2008) also found that sites with *Carpobrotus acinaciformis* are occupied by different invertebrate assemblages than sites that are free of this invasive plant. Three theories underpin this phenomenon; the first one predicts that specialists should be unable to grow and reproduce on plants with which they share no evolutionary history, the second one predicts that the energy stored by alien plants is not available to indigenous specialist and thus unavailable to higher trophic levels that include the insects in their diets, and third theory predicts that these plants may not be palatable to most native insects (Tallamy 2004).

South Africa (SA) is well known to be rich in biodiversity and much of it lies outside of the approximately 6% of the land area under protected area systems (Turpie *et al*., 2008). According to Pimentel (2002), South Africa has a long colonial history which has led to well developed infrastructure with thriving agricultural and forestry sectors. These played an important role in the introduction, establishment and spread of alien invaders. Many invasive plants are already well established in South Africa, while others are at the early stages of invasion, and many more reside as ornamentals in managed gardens (Tallamy 2004; Nel *et al*. 2004). Indications by conservationists and botanists suggest that the future of South Africa’s natural ecosystems/resources is under threat by the invasive alien plants (Le Maitre *et al*. 2004; Nel *et al*. 2004; Magoba & Samways 2008). Van Wilgen *et al*. (2007) and IASP (2005) report that invasion by alien plants poses a significant threat to the ecological integrity or functioning of the ecosystem. Additionally, efforts directed at clearing them result in further disturbances, depending on the duration and severity of the invasion (Beater *et al*. 2008).

Most invader plants are known to have been intentionally introduced by people who thought it was a good idea. Commercial reasons such as trade, forestry, ornamental garden plants, dune binders or simply curiosity, are known as the driving forces behind intentional introductions (Richardson & van Wilgen 2004; UNEP & McGinley 2007; Henderson 2001). However, others were introduced by accident with goods such as grain or fodder contaminants or attached to animals, humans or vehicles, and in case of marine invaders, in the ballast of ships (UNEP & McGinley 2007; Henderson 2001). Many alien invader plants can survive in the adopted country if they are cared for, but a certain proportion manages to survive without human help (Henderson 2001). According to IASP (2005), alien plants were introduced more than two thousand years ago in South Africa. Growing under different environmental conditions and without natural enemies, i.e. diseases or insects (DWAF 2005), alien plants were able to reproduce and spread fast; displacing indigenous plants and animals (Macdonald *et al*. 2003).

Several estimates have been done on the extent of invasions in South Africa, and to date, over 9000 alien plant species can be found in South Africa and one hundred and ninety eight (198) of these plants are legally classified as alien invader plants (Wildy 2006). About 8% or 10 million hectores of South Africa is reported to be invaded by approximately 180 species and these are mainly woody invaders that impact on water resources (Richardson & Van Wilgen 2004; Nel *et al*. 2004; IASP 2005; Turpie *et al*.

2008; Turpie 2004). Several studies have also been done throughout South Africa's eight terrestrial biomes, but the best studied and most well known invaded biome is fynbos where invaders from the genera *Acacia*, *Hakea* and *Pinus* dominate (Richardson & Van Wilgen 2004; Tupie 2004). Nel *et al*. (2004) presents two lists of alien invader plants, classified according to similarities in their distribution, abundance and/or biological traits. The first list is for major invaders, which are those species that are well established and already cause a substantial impact on the natural and semi-natural ecosystems of South Africa (Nel *et al*. 2004). The other list is for emerging invaders which are those currently having a lower impact on natural or semi-natural ecosystems in SA and appear to have the ability to have a great impact in the future (Nel *et al*. 2004). In SA, the Southern African Plant Invaders Atlas (SAPIA) records alien plant invaders. Over 500 species with information on their distribution, abundance and habitat types in South Africa, Lesotho and Swaziland have been logged (Nel *et al*. 2004; Richardson & Van Wilgen 2004). According to Richardson & Van Wilgen (2004), SAPIA demonstrates the magnitude of the problem and shows that the largest species numbers occur in the Western Cape.

In response to alien invader plants, South Africa developed numerous alien invader plant control and removal programmes with the aim of restoring indigenous biodiversity and hydrological flows in the rivers (Reinecke *et al*. 2008; Wildy 2006; Holmes *et al*. 2008). Working for Water (WfW), established in 1995, is the national clearing programme targeting mainly large tree species that have a substantial impact on scarce water resources (Henderson 2007; Turpie 2004). Their removal along river banks results in increased stream flow and run-off, and enables recovery of rare and threatened indigenous species, thus enhancing the ecological integrity of the ecosystem (Blanchard & Holmes 2008; Holmes *et al*. 2008). According to Blanchard & Holmes (2008) and Turpie (2004), the WfW programme spent billions on alien clearing and satellite programmes, while promoting job creation for marginalized communities.

In addition to eradication programmes, there is an alien invasive regulation under the Conservation of Agriculture Resources Act (1983) (CARA) and the amendment subdivides the 198 listed species into 3 categories:

> **category 1 -** plants that may not be grown and must be eradicated.
>
> **category 2** - plants with commercial value and may only be grown with permit under controlled circumstances.
>
> **category 3** - plants with amenity value and may be grown but not planted, propagated, imported or traded.

The aim of this regulation is to prevent introduction, control/eradication and/or propagation of alien invader plants which threaten the ecosystems, habitats and/or biodiversity in South Africa. Several attempts have be been made to prioritize alien species based on their invasive potential, but less systematic attention was directed at classifying invasive alien species in a region (Nel *et al*. 2004). Thus, more information based on identification and classification of invasive alien plants at local scale is needed to help formulate regional or national plans for managing invasions.

2. **A SURVEY OF INVASIVE ALIEN PLANTS ALONG THE RIPARIAN ZONE OF THE MTHATHA RIVER**

2.1. **INTRODUCTION**

Worldwide, riparian zones or riverine ecosystems have been degraded as a result of catchment-scale hydrological modifications and invasion by alien plants (Holmes *et al*. 2008). Riparian ecosystems are highly prone to IAP invasions due to the hydrological nature of rivers, their position in lower lying areas in the landscape and the ease with which propagules are transported along the rivers (Beater *et al*. 2008; Blanchard & Holmes 2008; Foxcroft *et al*. 2008). Presence of patches and gaps in the landscape also cause riparian ecosystems to be susceptible to alien plants (Foxcroft *et al*. 2008). Furthermore, both human and natural disturbances (e.g. floods) increase the potential for alien species to be established in the riparian zones (Blanchard & Holmes 2008). This study will attempt to make a contribution by surveying one river system in a remote and underdeveloped area.

2.2. **AIM AND OBJECTIVE**

2.2.1. AIM

To record invasive alien plants that are found along the riparian zone of the Mthatha River.

2.2.2. OBJECTIVE

To collect and identify alien invader plants that are found along the riparian zone of the Mthatha River.

2.3. **MATERIAL AND METHODS**

2.3.1. STUDY AREA

This research was carried out along the riparian zone of the Mthatha River (figure 1) which rises in the plateau region of the Eastern Cape, approximately midway between the Drakensberg escarpment and the Indian Ocean. The catchment itself is about 100 km long and up to 50 km wide. The terrain is generally undulating, and in the Mthatha vicinity, it flows through a wide plain with a flat gradient (Fatoki *et al*. 2001). However, several waterfalls indicate steep escarpments which in turn lead onto plains below (Cloete pers.com.). The geology of the catchment is constituted by mudstones and sandstones, and there are also scattered deposits of alluvium in some valleys. Soils in the catchment are moderate to deep and vary between sandy loam in the upper half to clayey loam in the downstream half. There are extensive pine plantations in the headwaters (Fatoki *et al*. 2001).

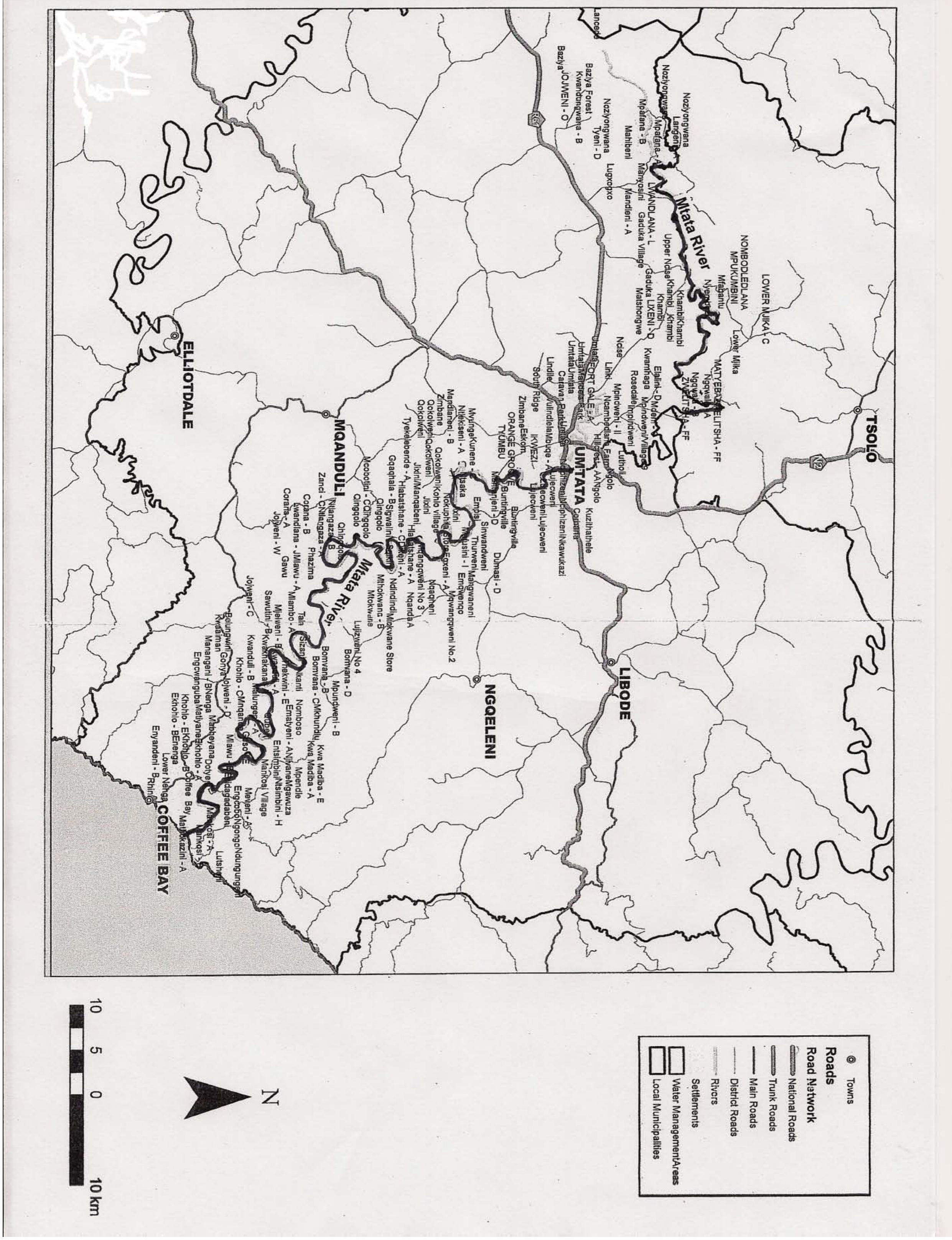

Figure 1: The Mthatha River system

2.3.2. METHOD

A survey was conducted along the riparian zone of the Mthatha River. Nine (9) sites [i.e. Langeni (31º 35`S 28° 47`E), Mjika (31º 29`S 28º 28`E), Slovo, Norwood (31° 35`S 28º 47`E), Mthatha (31º 34`S 28° 47`E), Orange Groove (31º 41`S 28° 53`E), Hlabatshane (31° 41`S 28º 53`E), Ntshilini (31° 56`S 29º 11`E), Mthatha mouth (30° 29`S 28º 28`E)] were selected. Sites were selected to be close to access roads. An attempt was made to survey a representative sample of the river, but due to the inaccessibility of the terrain it was not possible to.

Each site was visited once off and plant sampling was done randomly depending on accessibility to the riparian zones. Voucher specimens were collected from each of the sites, pressed and dried in the laboratory. They were removed from the drier, placed at 5°C for 24 hrs, then taken to the herbarium and identified and classified.

2.4. **RESULTS**

2.4.1. Species collected

2.4.1.1. Number of species

Twenty-seven (27) species classified into eighteen (18) families and twenty-five (25) genera were recorded (Table1). Out of 18 families, two families (Fabaceae and Solanaceae) had five species each in 4 genera. And, each family had one genus with two species. Salicaceae had 2 species belonging to 2 different genera.

2.4.1.2. CARA Category

Out of 27 plant species recorded, fifteen (15) species belong to the CARA category 1, eight (8) species to CARA category 2 and three (3) species to CARA category 3 (table 1). Furthermore, twenty two (22) species are classified as well-established, major invaders (Table 2) and two (2) species (*Eucalyptus saligna* and *Canna indica*) as emerging invaders (Nel *et al*., 2004).

2.4.2. Relative abundance of alien species

2.4.2.1. Aliens recorded at most sites

The weed/invader plant collected at most sites was the bugweed (*Solanum mauritianum*), which was recorded 7 times followed by *Acacia mearnsii* and *Lantana camara* both recorded 6 times (Table 3). Water hyacinth (*Eichhornia crasspies*) was recorded 5 times and *Opuntia ficus-indica* 4 times (Table 3).

2.4.2.2. Aliens recorded at fewest sites

The least recorded species were *Cassia* (*Senna*) *didymobotrya*, *Populus* X *canescens*, *Datura stramonium*, *Bidens pilosa*, *Pistia stratiotes* (found in a drainage system), *Araujia sericifera* and *Passiflora caerulea*, all recorded once in their respective sites (Table 3).

2.4.3. Abundance of alien species

2.4.3.1. The highest number of alien species

The results show that the Norwood site has the highest number of invader plant species and families (Figure 2 & 3), i.e. 12 species belonging to 11 families. Town (Mthatha) and Ntshilini were the two sites, after Norwood, also showing a great number of invader plant species (Figure 2). The least recorded number of alien species was three (3), i.e. Slovo and Mthatha mouth (Figure 2).

2.4.3.2. Distribution relative to urban disturbance

Langeni, Norwood and town site are the three areas where the greatest man made change has happened. From Langeni to Slovo and Norwood to the Mthatha mouth there is a gradual decrease in number of alien plant species and families, with an exception to Ntshilini showing same number of alien invaders as Town (Mthatha) (Figure 2 & 3). This means that humans play an important role in spreading these invader plants by disturbing the landscape. These areas need to be targeted for alien clearance.

From my observations, almost 90% of riparian zones in Town and Norwood are completely invaded (see figure 4 and 5), while sites upstream (i.e. Mjika, Slovo and Langeni) and sites lower downstream (Orange Groove, Hlabatshane and Mthatha Mouth) show much lower alien invasions than Town and Norwood sites. This evidence is consistent with the view that many alien plant introductions occur in urban areas and that disturbance of natural areas make them vulnerable to invasions. The evidence also may prove that the spread of alien invasions start from urban areas to adjacent ones and that the river plays an important role in transporting alien seed propagules. For example, the water hyacinth (*Eichhornai crassipes*) was recorded from Norwood-Town to other sites lower downstream and bugweed (*Solanum mauritianum*) was recorded form Langeni to Ntshilini (Table 3). However, other plants such as inkberry (*Cestrum laevigatum*) and giant devil's fig (*Solanum chrysotrichum*) were only recorded from the sites lower down stream. Climatic and/or environmental changes also favour the spread of some individual species to occupy different ranges and habitats.

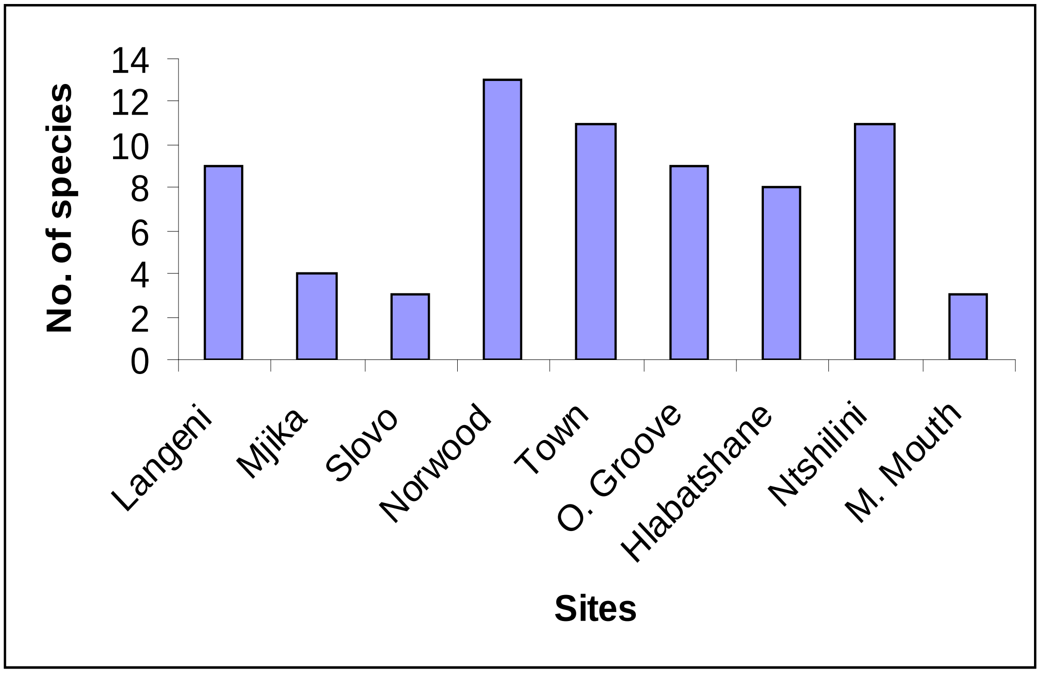

Figure 2: Comparison of the number of species among the sites.

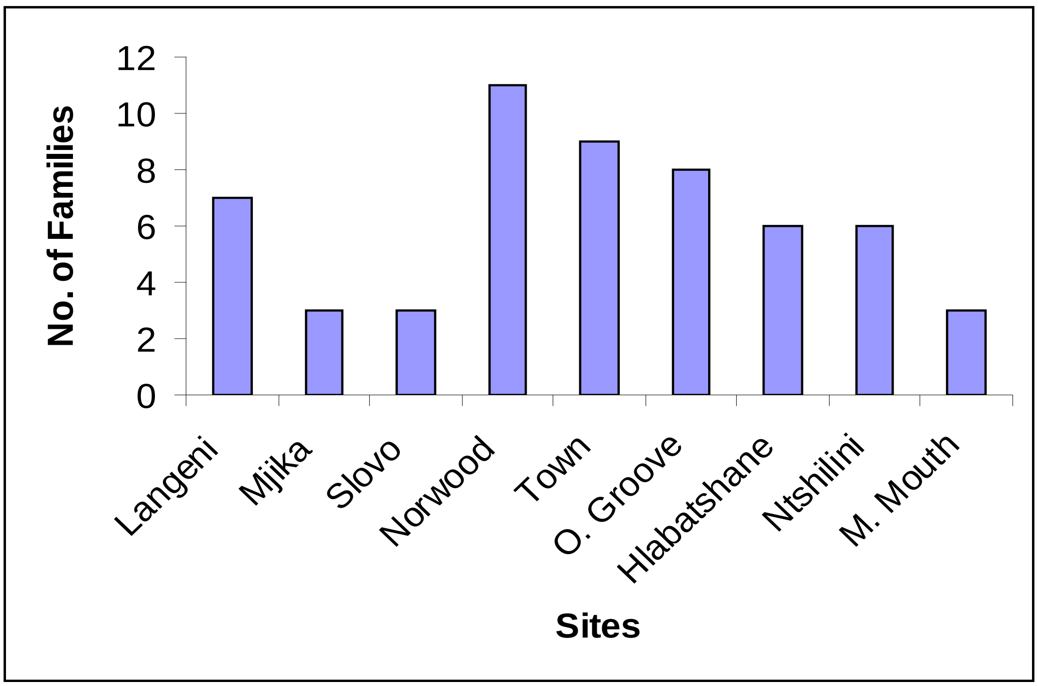

Figure 3: Comparison of the number of families that were found in each of the sites.

Figure 4: Norwood riparian zone

Figure 5: Town riparian zone

Table1: List of species found in the riparian zone of the Mthatha River

Family	Botanical Name	English Name	CARA Category
Araceae	*Pistia stratiotes*	Water lettuce	1
Asclepiadaceae	*Araujia sericifera*	Moth catcher	1
Asteraceae	*Bidens pilosa*	Blackjack	3
Cactaceae	*Opuntia ficus-indica*	Prickly pear	1
Cannaceae	*Canna Indica*	Indian short	1
Euphorbiaceae	*Ricinus communis*	Castor-oil plant	2
Fabaceae	*Acacia mearnsii*	Black wattle	2
	Acacia dealbata	Silver wattle	2
	Caesolpinia decapetala	Mauritius thorn	1
	Cassia (Senna) didymobotrya	Peanut-butter cassia	1
	Sesbania punicea	Red sesbania	1
Halorageaceae	*Myriophyllum aquaticum*	Parrot's feather	1
Meliaceae	*Melia azedarach*	Syringa	3
Moraceae	*Morus alba*	White mulberry	3
Myrtlaceae	*Eucalyptus grandis*	Saligna gum	2
Passifloraceae	*Passiflora cearulea*	Blue passion flower	1
Pinaceae	*Pinus patula*	Patula pine	2
Pontederiaceae	*Eichhornia crassipes*	Water hyacinth	2
Salicaceae	*Populus X canescens*	Grey poplar	2
	Salix babylonica	Weeping willow	2
Sapindaceae	*Cardiospernum grandiflorum*	Balloon vine	1
Solanaceae	*Cestrum laevigatum*	Inkberry	1
	Datura stratumonium	Common thorn apple	1
	Solanum chrysotrichum	Giant devil's fig	1
	Solanum mauritianum	Bugweed	1
	Nicotiana glauca	Wild tobacco	1
Verbenaceae	*Lantana camara*	Lantana	1

Table 2: Plant species of the Mthatha river riparian zone classified as major, well-established invader plants (Nel *et al*. 2004)

Family	Botanical Name	English Name	CARA Category
Araceae	*Pistia stratiotes*	Water lettuce	1
Asclepiadaceae	*Araujia sericifera*	Moth catcher	1
Cactaceae	*Opuntia ficus-indica*	Prickly pear	1
Fabaceae	*Acacia mearnsii*	Black wattle	2
	Acacia dealbata	Silver wattle	2
	Caesolpinia decapetala	Mauritius thorn	1
	Cassia (Senna) didymobotrya	Peanut-butter cassia	1
	Sesbania punicea	Red sesbania	1
Euphorbiaceae	*Ricinus communis*	Castor-oil plant	2
Halorageaceae	*Myriophyllum aquaticum*	Parrot's feather	1
Meliaceae	*Melia azedarach*	Syringa	3
Moraceae	*Morus alba*	White mulberry	3
Pinaceae	*Pinus patula*	Patula pine	2
Pontederiaceae	*Eichhornia crassipes*	Water hyacinth	2
Salicaceae	*Populus X canescens*	Grey poplar	2
	Salix babylonica	Weeping willow	2
Sapindaceae	*Cardiospernum grandiflorum*	Balloon vine	1
Solanaceae	*Cestrum laevigatum*	Inkberry	1
	Solanum mauritianum	Bugweed	1
	Datura stratumonium	Common thorn apple	1
	Nicotiana glauca	Wild tobacco	1
Verbenaceae	*Lantana camara*	Lantana	1

Table 3: Species found in each of the sites visited

Site / Species	1	2	3	4	5	6	7	8	9
Acacia mearnsii	+	-	+	-	+	+	+	-	+
Acacia dealbata	+	-	-	-	-	-	+	-	+
Araujia sericifera	-	-	+	-	-	-	-	-	-
Bidens pilosa	+	-	-	-	-	-	-	-	-
Cassia (Senna) didymobotrya	-	-	-	-	-	-	+	-	-
Caesolpinia decapetala	+	-	-	-	-	+	-	-	-
Canna Indica	+	-	+	+	-	-	-	-	-
Cardiospernum grandiflorum	-	-	+	+	-	-	+	-	-
Cestrum laevigatum	-	-	-	-	-	-	+	+	-
Datura stratumonium	-	-	-	+	-	-	-	-	-
Eichhornia crassipes		-	+	+	+	+	+	-	-
Eucalyptus grandis	+	-	-	+	-	-	-	-	+
Lantana camara	+	-	-	-	+	+	+	+	+
Melia azedarach	-	-	+	+	-	-	-	-	-
Morus alba	-	-	+	+	-	-	-	-	-
Myriophyllum aquaticum	-	-	-	-	+	+	-	-	-
Nicotiana glauca	-	-	+	+	-	-	-	-	-
Opuntia ficus-indica	-	+	-	-	+	+	-	+	-
Passiflora cearulea	-	-	-	-	+	-	-	-	-
Pinus patula	+	-	+	-	-	-	-	-	-
Pistia stratiotes	-	-	-	-	+	-	-	-	-
Populus X canescens	-	-	+	-	-	-	-	-	-
Ricinus communis	-	-	-	+	-	-	+	-	-
Salix babylonica	-	+	+	+	-	-	-	-	-
Sesbania punicea	-	-	-	-	+	+	+	-	-
Solanum chrysotrichum	-	-	-	-	-	-	+	-	-
Solanum mauritianum	+	+	+	+	+	+	+	-	-

NB ***Key**: + ~ present & - ~ absent.
Site1: Langeni; site2: Slovo; site3: Norwood; site4: Town; site5: Orange Groove; site6: Hlabatshane; site7: Ntshilini; site8: Mthatha mouth & site9: Mjika.

2.5. **DISCUSSION**

Invasive alien plants are a global problem (van Wilgen *et al*. 2001). Plant invasions are widely recognized as significant threats to biological diversity conservation (Brooks *et al*. 2004), causing impacts running into billions annually (van Wilgen *et al*. 2001). South Africa has high levels of biodiversity (Brooks *et al*. 2004 & Turpie *et al*. 2008) but like other countries, faces a particular challenge in terms of invasive alien species (Preston 2003). Ecological factors such as lack of natural enemies (biological control) cause alien invasive plant species to become abundant and persistent (Pimentel *et al*. 2005). Proximity to large propagule sources is also an important factor influencing the spread of alien species into natural areas (Alston & Richardson 2006). During the survey, it became apparent that riparian zones of Norwood and Mthatha have a larger number of alien plants (figure 2). The two sites are next to town which may be the potential source of propagules via gardens, introduction of new plants, etc. They are in the most disturbed sites (urban), and thus they are heavily infested and therefore they are the largest source of propagules. The results also showed that most of the sites lower downstream (i.e. after Norwood-Town) had higher numbers of alien invaders than the sites upstream, e.g. Mjika and Slovo sites. This indicates that these species are moving downstream from the large propagule source, i.e. Norwood-Town. Several alien plant species were also present in some sites but not all sites visited, however most of these species were present in Norwood and Town riparian zone.

Invasive alien plants affect the structure and functioning of the ecosystem (Beater *et al*. 2008) and riparian zones have been degraded on a large scale (Holmes *et al*. 2008). From the results, 22 out of 28 species recorded are known as well-established, major invaders (Table 2) and 2 species as emerging invaders (*Eucalyptus grandis* and *Canna indica*) (Nel *et al*. 2004). This suggests that this river is at risk of being severely affected by invasive alien plants, the reason being the fact that alien invaders are able to naturalize without human help thus have the ability to become abundant within this area (Nel *et al*. 2004). These authors also suggest that past invasions by major invader species are also likely to facilitate invasions of many of the emerging invader species. Thus, control/eradication measures should be scrutinized to prevent further damage of the riverine ecosystem.

The riverine ecosystem is dominated by *Solanum mauritianum, Acacia mearnsii* and *Lantana camara*, which were recorded in almost all the site that were visited. It was observed that the vegetation gradually changes as one moves along the river from the source to the mouth with species such as *Cassia didymobotrya*, *Solanum chrysotrichum* and *Cestrum laevigatum* becoming present closer to the coast. The survey was conducted during winter (i.e. from the last week of June, July to first week of August) due to the time constraints, hence many plant species were dormant. This means that there may be more invaders along the river than those recorded in this survey. However, from the results, it is clear that river has been invaded by many of the most noxious invasive plant species (from CARA category 1 & major invaders) and they should be cleared before further damage of the riverine ecosystem occurs.

2.6. **CONCLUSION AND RECOMMEDATIONS**

In conclusion, it is clear from this survey and other studies that alien invader plants pose a significant threat to the indigenous plants and animals. Even though these negative impacts are caused by a smaller number of invasive alien plants, a variety of strategies is required for preventing further damage to the ecosystems. For example, public education, sanitation and prevention programs at airports, seaports and other ports of entry will aid to reduce the introduction of biological invaders (Pimentel *et al*. 2005). For management to be successful, we need to understand the mechanisms that promote invasions and lead to subsequent ecological impacts (Brooks *et al*. 2004). The system of identification and classification of invader plants presented here could be used to prioritize species on which to focus management. Furthermore, the legislation categories will also help to define precise management guidelines. For example, there should be a constant effort to eradicate the species listed within the legislation categories as category 1 species and an attempt to reduce the spread of those listed as category 2 species (Nel *et al*. 2004).

Fortunately, the problem of biological invasions has gained attention of policymakers (Pimentel *et al*. 2005). The Center of Invasive Biology (CIB) and the Working for Water (WFW) programme have been formed to help combat non-indigenous plant species invasions, with the aim of eradicating, educating, stimulating research on the biological invasions and formation of partnerships among concerned groups (Pimentel *et al*. 2005) while creating jobs for marginalized communities (Blanchard & Holmes 2007). These programs have invested millions of rands in the clearing of harmful exotic plants. However, while policies and practices may assist in the prevention of alien species introduction, there still a long to go before resources devoted to the problem are in proportion to the risks (Pimentel *et al*. 2005).

I would recommend that further studies be done on the river's riparian zones to document species which were not recorded from this survey. Studies to survey indigenous vegetation on the riverine ecosystem should also be conducted. The river must also be assessed as to the extent of threats that these alien plants pose. Clearing and Prevention measures against further invasions need to be implemented soon as possible to reduce further damage to the environment. Risk analysis and environmental impact assessments also need to be conducted so as provide additional information for management plans against alien plant invasions. Moreover, people must also be encouraged to use native plants for gardening and other purposes. I hope this survey will encourage further research that will help in the restoration of riparian zones.

3. EFFECTS OF NATIVE AND ALIEN VEGETATION ON INVERTEBRATE COMPOSITION AND DISTRIBUTION IN LUCHABA NATURE RESERVE.

3.1. INTRODUCTION

Invasions by alien plants continue to cause ecological concerns globally (Manchester & Bullock 2000). South Africa is one of the countries that are seriously affected by alien plant invasions and there have been several published reviews on their impact on natural and semi-natural ecosystems (Blanchard & Holmes 2008; Richardson & van Wilgen 2004; Nel *et al*. 2004; Brooks *et al*. 2004; Ciruna *et al*. 2004; Gorgens & van Wilgen, 2004). These plants compete with indigenous vegetation for water, space, sunlight and other resources and, by so doing, they alter vegetation structure and lead to lower native plant species richness (Mgobozi *et al*. 2008; Magoba & Samways 2008). This, in turn, changes the functioning of the ecosystem (Usio *et al*. 2009) and influences the number and type of animal species that can be supported by that vegetation (Magoba & Samways 2008). Many indigenous species listed as threatened or endangered under the Red Data list also become negatively affected by ecosystem changes caused by alien species (Pimentel *et al*., 2005).

Native invertebrates have little or no evolutionary history with alien plants, and therefore, should have no adaptations required to use alien invader plants as nutritional hosts (Tallamy 2004). There is great association between most arthropods and native vegetation or microhabitat (Mgobozi *et al*. 2008). On the other hand, insects play an important role in transferring energy from plants to higher trophic levels. Indigenous fauna should, therefore, be restricted to eat vegetation only from plant lineages with which they have an evolutionary history (Tallamy 2004). Thus any decrease or extinction of some native plant species after alien plants colonization will have a negative impact on the species specific herbivores (Mgobozi *et al*. 2004; Palmer *et al*. 2004). Furthermore, changes in vegetation structure will surpass the negative effects caused by alien invader plants and may affect many species belonging to diverse functional groups (Palmer *et al*. 2004). Spiders are good ecological indicators for change as they occupy a diverse range of microhabitats and niches (Mgobozi *et al*. 2004). Thus a change in spider community also indicates changes in the habitat and arthropod herbivore community which supports them (Mgobozi *et al*. 2004). However, little is known about habitat-level impacts of increasing or decreasing levels of alien invasive vegetation on invertebrate assemblage composition and distribution within protected areas.

3.2. **AIM AND OBJECTIVE**

3.2.1. AIM

To identify the invertebrate taxa found within alien and indigenous vegetation ecotopes in Luchaba Nature Reserve, Transkei region of the Eastern Cape.

3.2.2. OBJECTIVE

To compare the abundance of invertebrates at four prior-selected sites in Luchaba Nature Reserve. The hypothesis is that there are no differences among alien invaded and indigenous vegetation habitats in terms of invertebrate assemblage composition at the four sites selected for this study.

3.3. **MATERIALS AND METHODS**

3.3.1. STUDY AREA

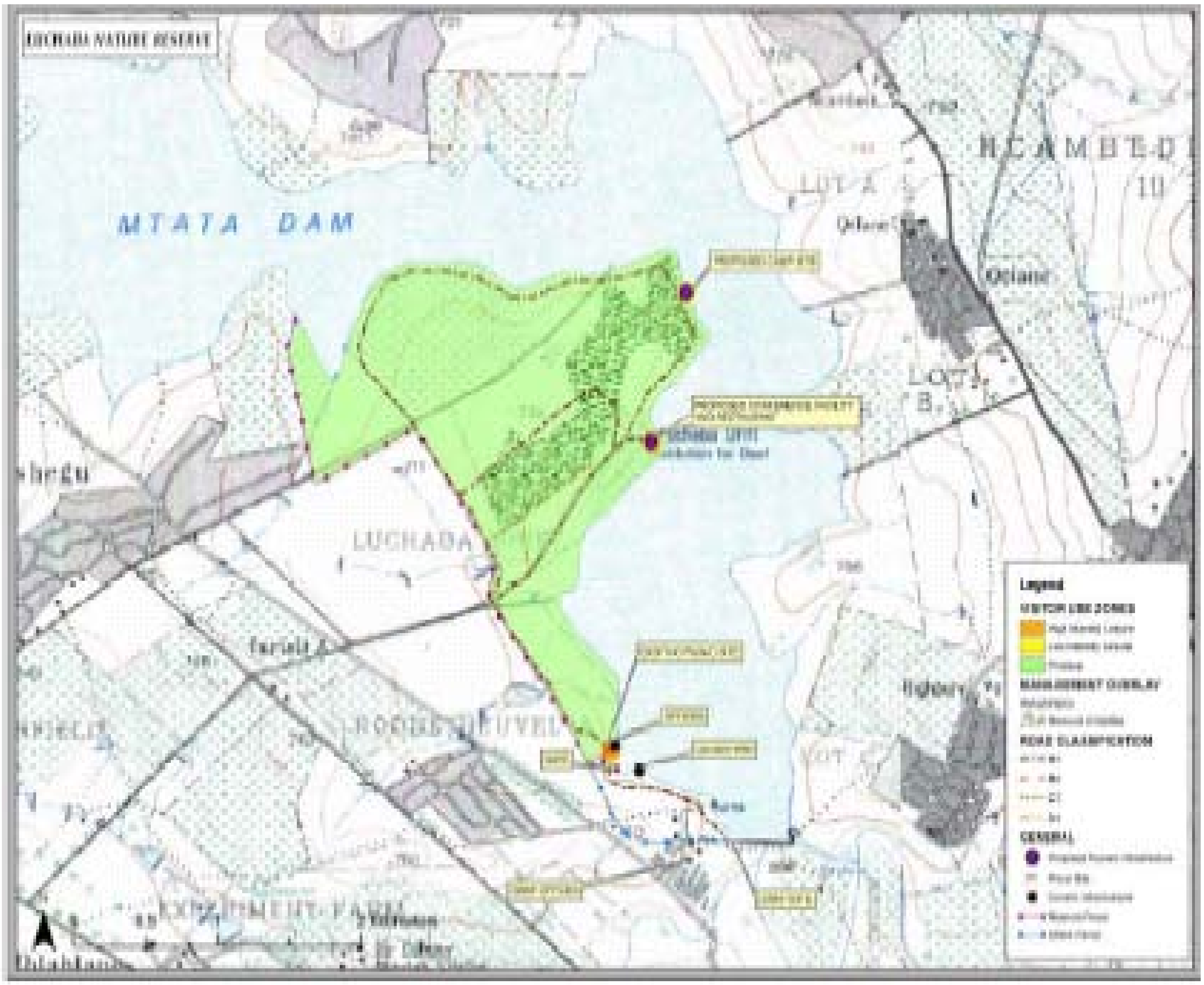

Figure 6: Luchaba Nature Reserve

This research was conducted at Luchaba Nature Reserve, a 460 hectare nature reserve that is situated adjacent to the Mthatha (former Umtata) Dam. Luchaba is managed together with the Nduli Nature Reserve that lies next to the N2 highway, at the southern entrance to Mthatha. Both reserves (Nduli & Luchaba Nature Reserves, NLNR) fall within Umtata Moist Grassland in the Grassland Biome and are the only protected areas in this veld type (also known as highland or Dohne sour veld). Geologically, dolerite dykes, rocky outcrops, shales and sandstones form the predominant components of the landscape.

Luchaba Nature Reserve (LNR) is a home to some of the most unspoiled countryside, and is made up of a variety of wildlife, a series of wetlands and grassland that support a wide species of birds, and evidence of the rare Stanley's bustard. This reserve was once a home to oribi, Cape buffalo, lion and leopard. Today it supports a fair representation of blesbok, black and blue wildebeest, Burchell's zebra, fallow deer, springbok and various species of antelope that include the red hartebeest. The primary invasive alien plant species present include black wattle, lantana, bugweed, and eucalyptus.

The climate for the NLNR is characterized by mean annual temperature of 17.6^{0}C. Lowest average monthly temperatures occur from June to August with highest monthly temperatures occurring in October and between December and February. The average monthly rainfall is 60mm with an average annual rainfall of 654mm, and wind direction is predominantly South West throughout the year (Eastern Cape Game Reserve & Eastern Cape Parks).

3.3.2. METHOD

Data was collected from four different habitats that were a priori selected, i.e. habitat with eucalyptus only, mixed alien (*Lantana camara* and *Acacia mearnsii*), indigenous acacia and indigenous grassland respectively. Invertebrates were sampled using pitfall traps. Within each of the 4 sites, 4 pitfall traps were set up in a quadrant (2.5 x 1.5m). Small plastic cylindrical cups/vials were sunk into the ground so that the lip of the vial was at the same level with the ground surface. The vials were filled with a mixture of water and liquid soap to about two-third of the vial, and were then left open in the ground. Invertebrates were collected the following day, preserved in 70% ethanol and transported to the Zoology laboratory at Walter Sisulu University (WSU). Data was collected on four occasions from the field.

3.3.3. **DATA ANALYSIS**

Only data on soil-surface dwelling invertebrates, such as ants and spiders were used in the analysis. Others like beetles, cockroaches, termites, grasshoppers and crickets were included as they were taken as not true flyers. Flying invertebrates such as butterflies and other small flying invertebrates were excluded. Invertebrates identification was done up to the order level given the time constraint and difficulties associated with identifying specimens to the species level at the time of data analysis. The result are illustrated using graphical methods such as bar graphs, tables and univariate statistical methods, i.e. using Chi-square (X^2), Shannon's Diversity Index (H'), and Pielou's Evenness index (J').

3.4. **RESULTS**

A total of 342 invertebrates were collected and classified into 11 orders. However, further sampling would probably have resulted in a greater number of captured individuals. The habitats/sites with most invertebrates were mixed alien, indigenous grassland and indigenous acacia with 118 invertebrates belonging to 8 orders, 96 invertebrates belonging to 7 orders and 82 invertebrates belonging to 8 orders respectively (Table 4). High numbers of invertebrate individuals at the mixed alien site indicate the fact that the impact of invasive plants on native biodiversity does not necessary have to be negative (Gerber *et al*. 2008). Eucalyptus site consisted of the least number of invertebrates compare to other sites, with only 6 orders (Table 4). The results are further illustrated in Figures 7 & 8.

The orders with most abundant invertebrates individuals were Araneae (114 individuals), Hymenoptera i.e. Formicidae (161 individuals) and Orthoptera (24 individuals). When comparing the sites using the total number of taxa recorded in each of the sites, the results prove no significant difference among the sites (X^2 = 0.37931; $P<0.95$) (Table 4). However, total number of invertebrate individuals showed some significant difference (X^2= 32.03509; $P<0.01$) among the sites (Table 4). Chi-square test results revealed significant differences among the site for Araneae (X^2= 24.31579; $P<0.01$) and Hymenoptera (X^2= 11.39752; $P<0.01$), meaning that these groups are not homogenously distributed across the sites. Orthoptera showed no significant difference across the site with X^2 = 7.666667 and $P<0.10$ (Table 4). This means that some groups of invertebrates are probably not affected and/or respond slowly to the introduction of invasive vegetation than other groups. Comparison of different invertebrate taxa for each of the sites is shown from Figures 9 to 12. From these figures is notable that eucalyptus site had the least number of individuals from the three groups, i.e. Araneae, Hymenoptera and Orthoptera, than all of the sites.

Table 4 below shows total number of invertebrates and orders (taxa), Shannon's Diversity Index (H'), Chi-square (X^2) and Pielou's Evenness index (J') of all the sites.

The table also shows the total number of each invertebrate taxon found in each of the site. Mixed alien site had a large number of invertebrates and Shannon's diversity index than any other site (Table 4), hence the most diverse site with Eucalyptus site being the less diverse. All sites showed similar evenness indicating that a large number of invertebrates may be proportionally abundant and evenly distributed within the sites

Table 4: total number of invertebrates and orders (taxa), Shannon's Diversity Index (H'), Chi- square (X^2) and Pielou's Evenness index (J') of all the sites

Order	Eucalyptus	Mixed aliens	Indigenous Acacia	Indigenous Grassland	Chi-square	P-value
Araneae	13	36	19	46	24.31579	0.01
Blattodea	-	-	-	1		
Coleoptera	1	4	5	-		
Diplopoda	1	7	3	-		
Hymenoptera	27	56	43	35	11.39752	0.01
Hemiptera	3	4	1	-		
Isopoda	-	1	-	-		
Isoptera	-	-	-	2		
Lepidoptera (larvae)	-	5	2	1		
Opiliones	-	-	1	1		
Orthoptera	1	5	8	10	7.666667	0.10
No. of taxa	6	8	8	7	0.37931	0.95
Total invertebrates	46	118	82	96	32.03509	0.01
H'(Diversity)	1.100	1.418	1.395	1.175		
J' (Evenness)	0.661	0.684	0.729	0.593		

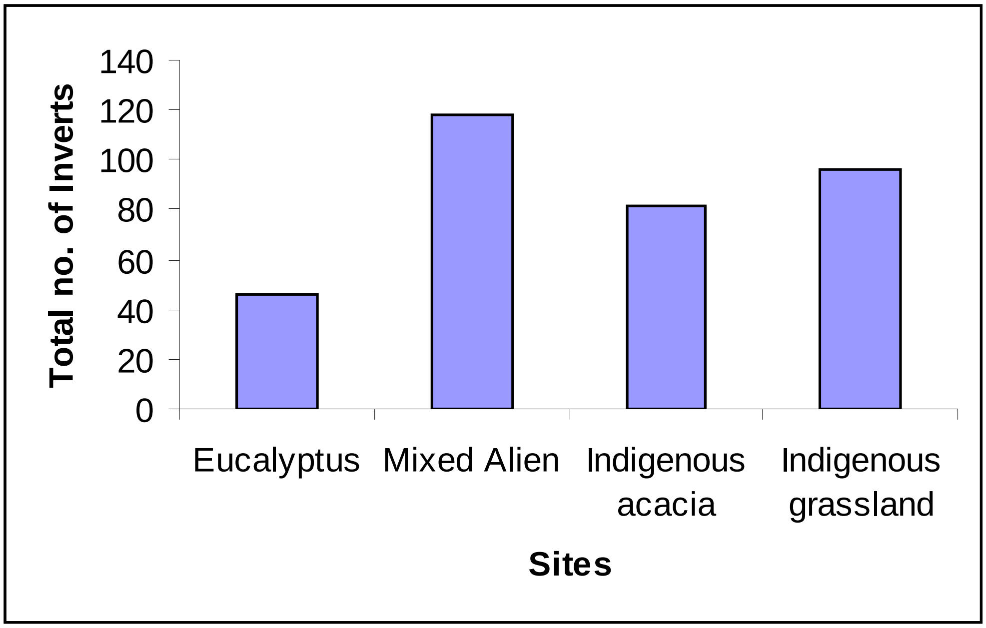

Figure 7: Comparison of total number of the invertebrates found in each of the sites.

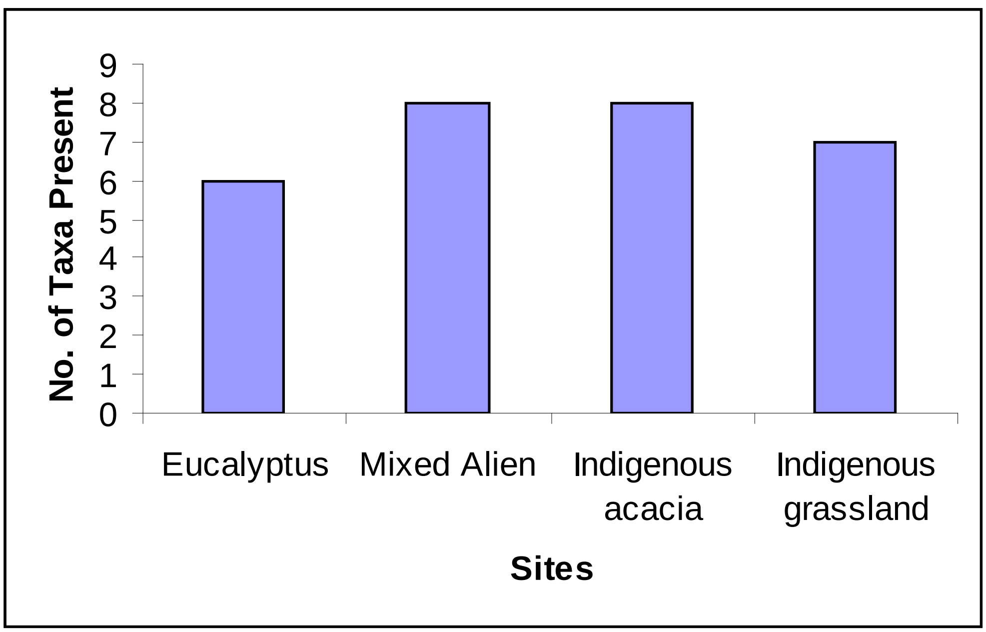

Figure 8: Comparison of number of invertebrate taxa that were present across the sites.

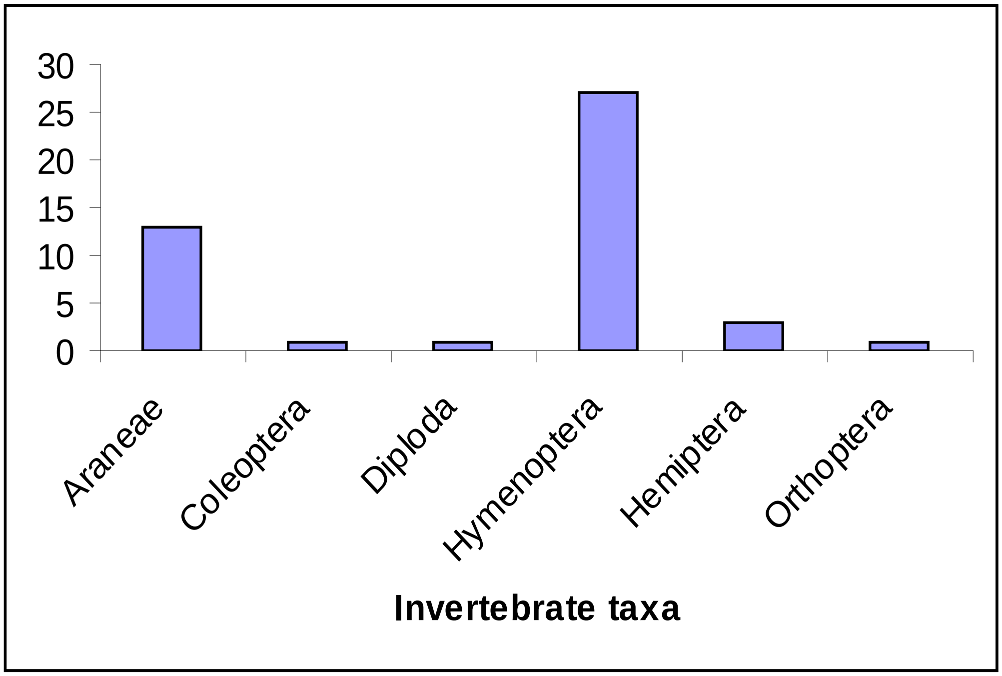

Figure 9: No. of invertebrate individuals of each taxa at the Eucalyptus site.

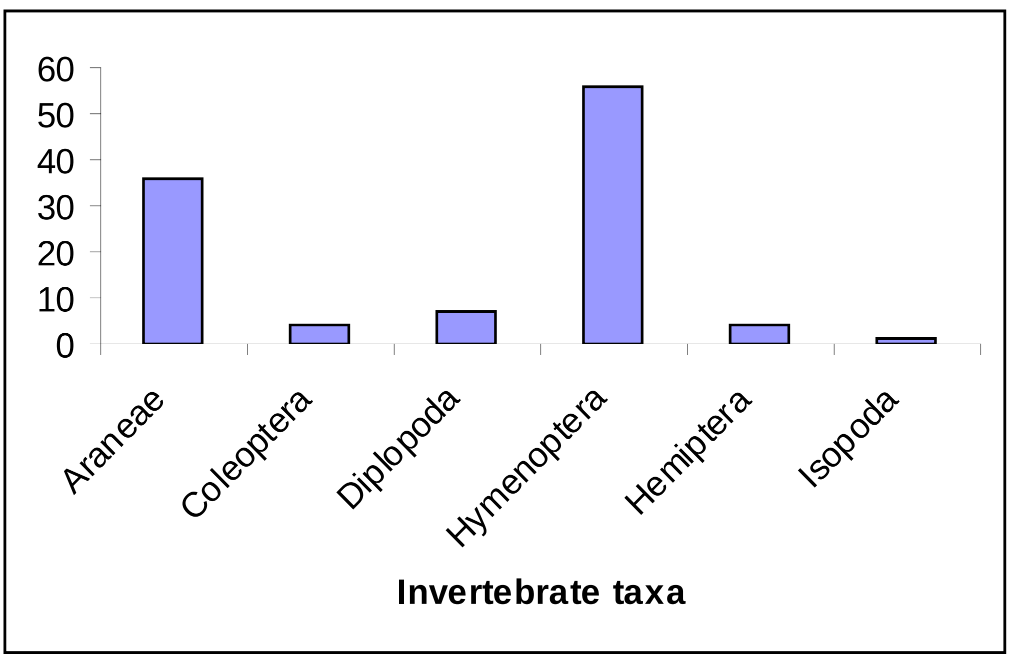

Figure 10: No. of invertebrate individuals of each taxa at the Mixed alien site.

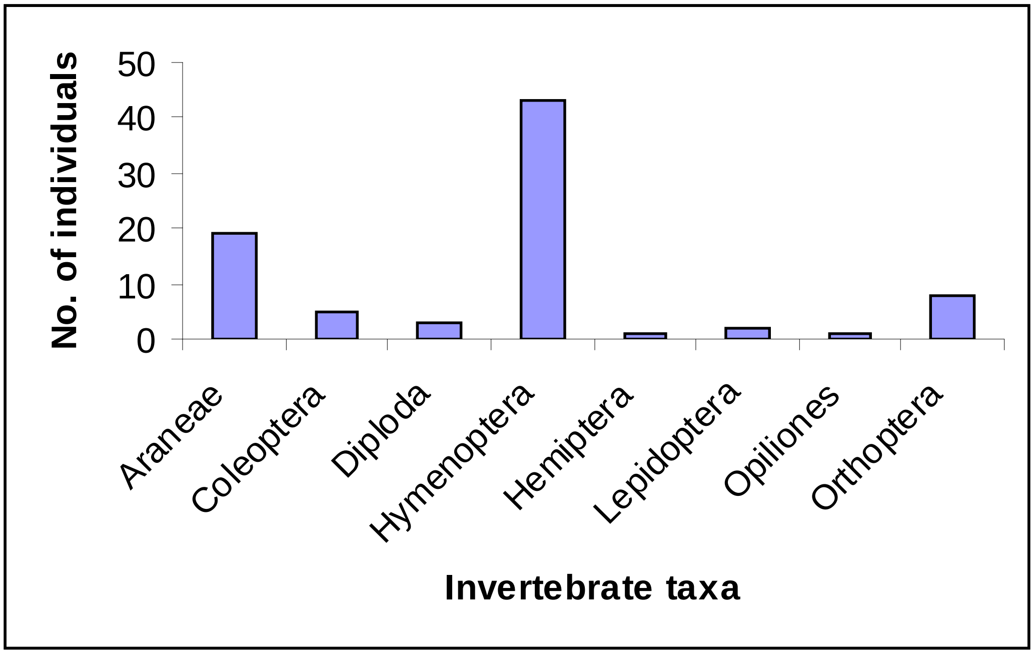

Figure 11: No. of invertebrate individuals of each taxa at the Indigenous Acacia site.

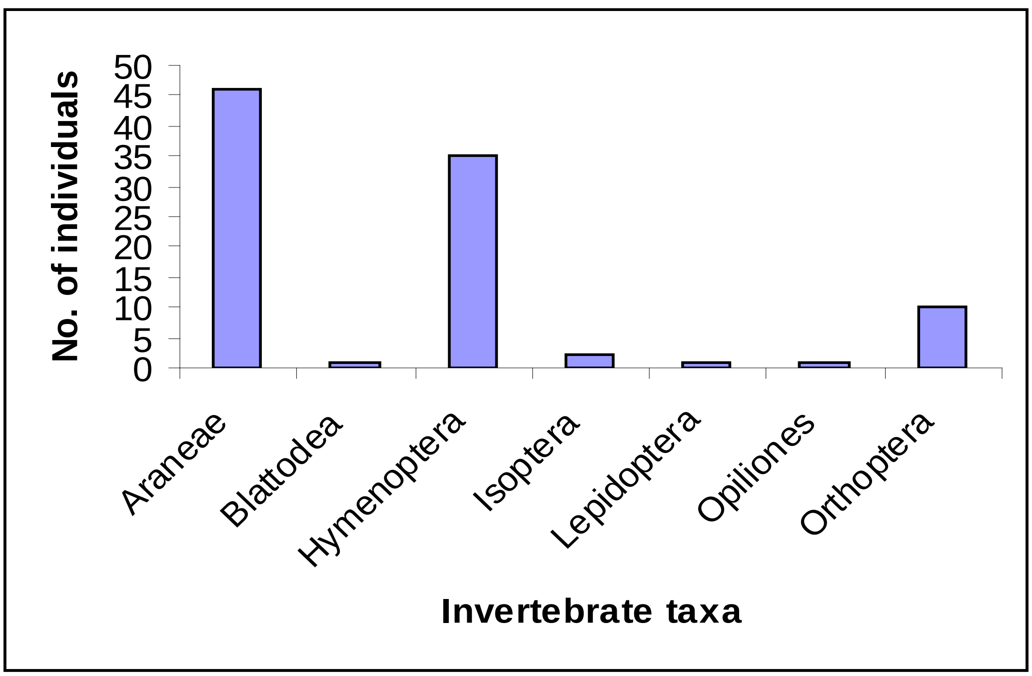

Figure 12: No. of invertebrate individuals of each taxa at the Indigenous grassland site.

3.5. **DISCUSSION**

Biological invasions are a significant component of human-mediated global change (Palmer *et* al. 2004) and constitute a serious threat to biodiversity (Usio *et al*. 2009). Biological Invasions along with climate change have resulted in altered population dynamics and structure of native species as well as the functioning of ecosystems (Walther *et al*. 2009) and loss of economic value (Palmer *et al*. 2004). However, these negative effects are typically exerted by a small number of non-native species (Palmer *et al*. 2004). This study provides evidence that habitats invaded by alien plants support fewer invertebrates compared to those with native vegetation. The Eucalyptus site clearly had an impact on invertebrate assemblage composition within the reserve, with a statistically significant decrease in number of invertebrate individuals sampled at this site compared to the other three sites (mixed alien, indigenous acacia and on indigenous grassland), even though there was no significant difference in number of taxa sampled across the four sites (Table 4). Although Lee (1997) suggests that higher taxa are good surrogates for species, this is not generally the case. The argument here is that most invertebrates sampled during the study could not be identified beyond order level as at the time of data collation and analysis, and therefore this taxon (order) was used according to Beattie and Oliver (1994). One Orthoptera, 1 Coleoptera and 1 Diplopoda individuals were caught in the eucalyptus site, which may suggest that this habitat probably impeded species movement and establishment or may have properties that have been transformed, leading to adverse changes in biological communities (Standish 2004; Usio *et al*. 2009). Other plant species may not have been able to compete with the eucalyptus for limiting resources, or they may have suffered from reduced propagule availability inside the eucalyptus invaded site (Yurkonis *et al*. 2005). The three most abundant taxa, i.e. Araneae, Hymenoptera and Orthoptera, also showed a clear preference for indigenous habitats with exception of the mixed alien habitat. Theoretically, such a pattern could arise from an increased risk of eucalyptus invasions in invertebrate-poor habitats.

The effect of eucalyptus on overall invertebrate abundance at the habitat level are therefore of conservation importance. A direct comparison of the invertebrates dwelling on the selected invaded and native plant habitats showed significantly lower invertebrate assemblages on eucalyptus habitat. Standish (2004) also found that *Tradescantia* has an impact on the active epigaeic invertebrates of native lowland forest remnants. The abundance of herbivore invertebrates was lower in *Fallopia*-invaded areas than in native vegetation (Gerber *et al*. 2008). While an increasing number of studies assess the effects of invasive plants on native biodiversity and the underlying community dynamics (Levine *et al*. 2003), there may be a significant effect of invasive plants like eucalyptus on the production of higher trophic levels. Consequently, if herbivorous invertebrate biomass is reduced in invaded habitats, this could also have an effect on predatory invertebrates, amphibians, birds and even mammals (Maerz *et al*. 2005).

The different assemblages of invertebrate individuals associated with exotic compared with indigenous vegetation in this study, suggest that some individuals are good indicators of exotic or indigenous vegetation (Samways *et al*. 1996). *Chromolaena odorata* invasion resulted in a reduction of dominant spiders and changes in spider assemblage patterns, species richness and diversity (Mgobozi *et al*. 2008). This study showed that the abundance of spiders (as representatives of the predatory guild) was highest in the indigenous grassland habitat, but did not differ much between indigenous acacia and eucalyptus sites. This may probably indicate that invertebrate predators can still be represented in invaded habitat, despite the significant reduction in overall invertebrate abundance. Furthermore, it could indicate that spiders display a higher activity level, e.g. spending more time searching for food in invaded habitats (Gerber *et al*. 2008). Nevertheless, at the habitat level illustrated in this study, herbivorous insect groups are likely to be particularly vulnerable since invasive plants negatively affect plant species richness and hence the availability of essential resources for monophagous and oligophagous herbivores (Valtonen *et al*. 2006).

Maximum richness is not always reached at undisturbed sites, but each group displays a specific pattern (Palmer *et al*. 2004). Also, current evidence suggests that the impact of invasive plants on native biodiversity does not necessary have to be negative (Harris *et al*., 2004) as observed in the mixed aliens site. Furthermore, biodiversity estimators indicate that undisturbed habitats can be less diverse than invaded habitats (Palmer *et al*. 2004). De Groot *et al*. (2007) found that the response of insect groups occupying higher trophic levels to invasion by *Solidago canadensis* on insect groups were less consistent. From this study, it was found that mixed alien (i.e. *Lantana camara* and *Acacia mearnsii*) site had more invertebrate individuals than any of the sites (Figure 7). The site was also found to have similar number of taxa with indigenous acacia site (Figure 8). More data and sampling techniques are however needed on a broader spatial and temporal scale to validate the taxon-specific patterns reported in this study.

3.6. **CONCLUSSION AND RECOMMEDATIONS**

More information would be obtained from relating and assessing the impact of alien plant species on invertebrates at the species level than using higher taxonomic levels (orders) as undertaken in this study (Beattie & Oliver 1994; Standish 2004). However, this study shows that vegetation type (native or indigenous) is important in determining the composition and distribution of invertebrate assemblages as there were significant differences in invertebrate populations across study sites. However, I recommend that more replication of this work be done on a greater spatial and temporal scale, and using more invertebrate sampling protocols. This would certainly give more information about invertebrate species trends under variable habitat conditions. Furthermore, conservative management decisions at Luchaba Nature Reserve should aim at preserving endemic vegetation as much as possible. This may include replacing the eucalyptus habitat patches with indigenous acacia or other vegetation that is endemic to South Africa. Management decisions must also be implemented in time to prevent further damage to both natural and managed habitat patches and ecosystems within the reserve in the medium to long term.

4. **GENERAL CONCLUSSION**

Invasive alien plants threaten indigenous vegetation as they make use of valuable and limited water resources and space. A change or decrease in indigenous vegetation structure also has a negative impact on herbivore invertebrate assemblages associated with them. If invertebrate biomass is reduced, predatory invertebrates and/or higher trophic levels will also be negatively affected. Thus, introduction of non-indigenous or alien plants into undisturbed ecosystems should be a serious concern as these ecosystems remain important stores of biodiversity (Mgobozi *et al*. 2008). In areas where there already is an alien invasion, there should be ongoing preventive, control and eradication managements or methods to prevent further damage to the ecosystem, thereby enhancing indigenous biodiversity. I hope the findings of this study would encourage further research and help prioritize clearing operations to target protected areas and riverine ecosystems.

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