CHAPTER ONE

General introduction

INTRODUCTION

Armoured bush crickets (ABC) (Orthoptera: Ensifera, Tettigoniidae, Hetrodinae) are amongst the most important insect pests of sorghum (*Sorghum bicolor* (L.) Moench) and millet (*Pennisetum americanum* (L.)), in the SADC region. ABC are sporadic pests with major outbreaks typically followed by three to four years of recession (Mviha in prep.). Economically significant crop losses have been recorded during outbreaks in Namibia (Leuschner 1995; Wohlleber 1996; Minja 2000), Zambia (Mbata 1992), Botswana and Zimbabwe (Musonda & Leuschner 1990; Sithole 2000) and South Africa (Van den Berg & Drinkwater 1998). Localised outbreaks of the ABC have also been reported in Tanzania (Leuschner & Manthe 1989; Minja 2000), Malawi and Mozambique (Musonda & Leuschner 1990), and almost certainly occur in southern Angola.

Botswana agro-climate and soils

Botswana is a semi-arid country with erratic seasonal rainfall ranging between 300 mm and 800 mm annually. In general, the year in Botswana can be divided into the following seasons/periods: spring transition or pre-rainy period of September to October, rainy/summer season of November to March, and autumn transition or post-rainy period of April and dry/winter season of May to August.

Evapo-transpiration occasionally exceeds average monthly rainfall. Summer season average daily temperatures range between 20 and 33 ^{0}C. Soils are generally sandy loam with rising levels of silt and clay in drainage lines. The nutrient status of these soils is classified as low to moderate with a pH ranging from 4.8 – 6.4 (Sims 1981).

The country can be divided into eight agricultural zones based on soil and climate characteristics. These zones are indicated in Table 1.1. Production of any crop is extremely difficult in the western parts of the country with low rainfall and very sandy soils.

Cereal production in the SADC region

The dominant cereal crop in the Southern Africa Development Community (SADC) region is maize (*Zea mays* L.). In all the SADC countries except Botswana, the overall production of maize is greater than that of sorghum and millet, with maize predominating in the higher rainfall areas and sorghum and millets in low rainfall areas (Jones 1987; SADC 1987).

Sorghum is grown in all SADCC countries and is second only to maize in importance among the cereal crops. It is grown extensively in Tanzania, Mozambique and Zimbabwe. Although the area sown to the crop is relatively small when compared to maize in the SADCC region, it is an important cereal crop in Botswana, Lesotho, the Shire Valley of Malawi and in parts of Zambia. Most of the sorghum in the region is produced by communal farmers (Rao *et al.* 1989).

Sorghum production in Botswana

Sorghum is the staple food crop grown in Botswana, accounting for about 80 % of the cereal grain area under production (Anonymous 1997). Approximately 90 % of this production lies in the eastern agricultural regions of Francistown, Central, Gaborone and Southern regions. The Ngamiland and Western regions are generally too dry and less crop production is practised. Most of the farms producing sorghum lie within 150 kilometres of the railway line connecting Lobatse and Gaborone in the south with Francistown in the northeast. Most smallholders produce sorghum in a low input subsistence cropping system. Ploughing services are normally provided by animal draught power, though farmers prefer to use tractors where available. Small-scale farmers normally broadcast their sorghum seed. Most of the farmers are in the age bracket 45 - 65 years old (Anonymous 1997). Therefore, farm activities like weeding and pest control are probably more difficult to implement nowadays than previously because old farmers cannot cope with the labour intensive activities required in subsistence farming.

The sorghum area harvested commonly falls 10 - 30 % below the area planted due to drought losses and pest damage (Anonymous 1997). The major insect pests of sorghum in Botswana are the lepidopterous stem borers *Buseola fusca* (Fuller) (Noctuidae) and *Chilo partellus* (Swinhoe) (Crambidae), quelea birds (*Quelea quelea lathamii*) and ABC,

principally *Acanthoplus discoidalis* (Walker) (Orthoptera: Tettigoniidae) (Ingram *et al.* 1973; Manthe 2000; Matsaert *et al.* 2000) (Table 1.2).

Armoured bush cricket biology

The ABC genus *Acanthoplus* contains three species that are considered pests: *Acanthoplus discoidalis* (Walker), *A. speiseri* Brancsick, and to a lesser extent *A. armativentris* Peringuey. The biology of *A. discoidalis* had been studied by Power (1958) in South Africa and Wohlleber (1996) in Namibia. Mbata (1992) studied *A. speiseri* in Zambia. The two species appear to have a very similar ecology. The life cycle of ABC is illustrated in figure 1.1. Activity is limited to the wet season months of November to April, which coincides with the cropping season of sorghum. ABC eggs take 20 – 28 days to hatch following rainfall amounts greater than 25 mm (Wohlleber 1996; 2000). Approximately three weeks after the first rains, nymphs emerge from under permanent shade trees and shrubs where egg pods were laid in soil during previous seasons. Before ABC nymphs develop into adults, they pass through 6 nymphal stages. Nymphs in stages one to three feed mainly on the vegetative parts of grasses and broadleaf plants, progressively shifting to a diet of flowers and seeds or fruits in the later instars (Musonda & Leuschner 1990). As grass seeds mature and start to dry out, from late February onwards, they fall to the ground and become less acceptable or unavailable to the ABC as food (Leuschner 1988; Musonda & Leuschner 1990). Around this time, late instar ABC nymphs and young adults start to migrate into crop fields where cereal panicles are emerging and feed on flowering panicles and developing grain until April and early May. By this time the grain has become hard and the ABC are dying off as winter sets in.

Control measures against armoured bush cricket

During extensive ABC outbreaks, the Government of Botswana supplies pesticides and sprayers free of charge to farmers. The commonly used insecticides belong to the groups of pyrethroids, organophosphates and carbamates. These products are alpha-cypermethrin 100 EC (fastac®), fenitrothion 95 ULV (folithion®) and carbaryl 85 WP (Karbasprays®) respectively. During localized ABC outbreaks, the government does not assist and farmers spray insecticides only if appropriately trained and also if extension staff

provides technical assistance. The invasion of crop fields by ABC described earlier may occur over several weeks and repeated applications of insecticides are needed in order to minimize crop damage. This may result in environmental damage. It certainly increases costs of control, and without the assistance of government (government support only in extensive outbreak years), resource-poor farmers usually cannot afford to buy pesticides in adequate amounts to repeat applications as required. Furthermore, farmers in Botswana showed great concern about possible health and environmental side effects of ABC control strategies that involve the use of pesticides (Matsaert *et al.* 2000), and so there is need to develop ABC control methods that require reduced quantities of insecticides.

A summary of research previously done on control of ABC is shown in Table 1.3. In addition, Minja (2000) reported on cultural practices used to control ABC in Zambia and Namibia. The sporadic nature of ABC as a pest presents problems for the rigorous evaluation of control technologies under outbreak conditions. Trials have been planned and set up only to fail because of insufficient ABC populations (*e.g.* on several occasions in the present study) on which to work. Conversely, in some cases elsewhere, trials have been hastily implemented without adequate planning and thought to statistical analysis, when an ABC outbreak materialized unexpectedly (S.V. Green *pers. comm.*). In any case, further rigorous assessment of ABC control technologies is badly needed.

Certain control methods are explored in detail in the sections below and in chapters two, three and four of this thesis. In particular, bait-based control methods, trenching and barrier spraying which showed promise in previous preliminary work, but needed further technology development.

Scope of the research

In order to develop more appropriate control techniques against the ABC in Botswana, and to study the impact of these control techniques on non-target invertebrates and assess the level of sorghum damage by ABC, the following studies were undertaken, forming the body of the present thesis:

- Evaluation of suitable insecticide baits for armoured bush cricket control in Botswana.

- Control of ABC, *A. discoidalis* by means of the baited-trench method.
- Efficacy of fipronil as a barrier spray treatment for ABC control.
- Primary environmental impact of carbaryl baited–trench and fipronil barrier spray treatment on the ant, *Anoplolepis custodiens* (Hymenoptera: Formicidae).
- Assessment of damage to sorghum by armoured bush cricket, *Acanthoplus discoidalis*.
- Farmers' knowledge, perceptions and practices on management of armoured bush cricket, *A. discoidalis*.

The chapters of the thesis are arranged as individual papers (Chapters 2-7). The general introduction and discussion are included as chapters 1 and 8 respectively. A general abstract to the thesis is also provided. A farmer survey report in which the author was a key participant is attached to the thesis as appendix 3.

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Table 1. 1. Characteristics of Agricultural zones and regions in Botswana.

Zone	Temperature (Min-max) Summer: winter	Rainfall (mm)	Soil texture	Agricultural regions in the zone
1	18°C - 33°C 12°C - 30°C	600-700	Sandy loam, silty clay, and heavy clay	Ngamiland
2	24°C - 27 °C 16°C - 25°C	500-600	Medium sands, fine sands and silty clay	Ngamiland
3	23°C - 37°C 17°C - 25°C	450-550	Fine sands, sandy loam, silt and clay loams, sandy clay and clay	Ngamiland
4	24°C - 27°C 15°C - 22°C	450-550	Heavy clay, some silts and fine sands	Francistown and Central
5	24°C - 27°C 14°C - 23°C	350-500	Medium and fine sands	Central, Southern and Gaborone
6	20°C - 27°C 8°C - 6°C	400-500	Stony, sandy loam, loam	Francistown, Central, Southern and Gaborone
7	16°C - 33°C 2°C - 30 °C	350-450	Sandy loam, loam, silty clay, clay	Central
8	23°C - 27°C 12°C - 24°C	200-400	Medium and fine sands	Western

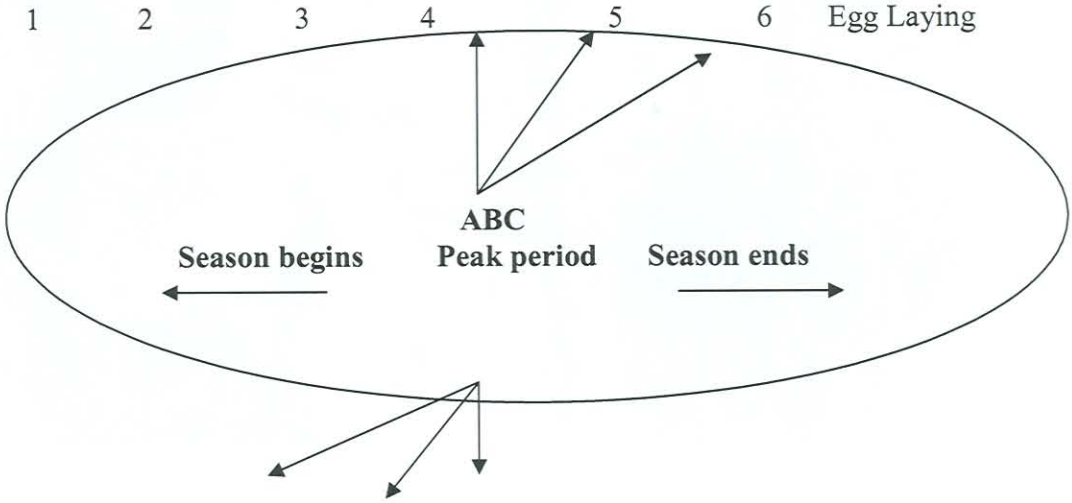
Table 1.2. Major pests of sorghum in Botswana. Compiled from Ingram *et al.* (1973) and Bashir *et al.* (1991), Manthe (2000).

Pest	Order	Family	Crop attacked
Helicoverpa armigera	Lepidoptera	Noctuidae	sorghum, maize, millet
Busseola fusca	Lepidoptera	Noctuidae	maize, sorghum
Chilo partellus	Lepidoptera	Pyralidae	sorghum, maize, millet
Quelea quelea lathamii	Passerine	Ploceidae	sorghum and millet
Acanthoplus discoidalis	Orthoptera	Tettigoniidae	sorghum, maize, millet
Melanaphis sacchari	Homoptera	Aphididae	sorghum and maize
Rophalosiphum maidis	Homoptera	Aphididae	sorghum and maize
Calidea dregii	Hemiptera	Pentatomidae	sorghum, maize, millet
Zonocerus elegans	Orthoptera	Pyrgomorphidae	sorghum, maize, millet
Hodotermes spp.	Isoptera	Termitidae	sorghum, maize, millet
Nezara viridula	Hemiptera	Pentatomidae	sorghum, maize, millet

Table 1.3. Control methods previously tested against armoured bush crickets, the researchers and level of research work.

Control method	Status of research work	Researcher	Research location
Planting a strip of cotton around the crop to be protected	The trial was conducted in one season but failed due to poor establishment.	Musonda and Leuschner (1990)	Zambia
Trenching plus insecticide sprinkled inside the trench	Raw data available but not analysed to give conclusive recommendations.	Musonda and Leuschner (1990)	Zambia
Spray barriers with a contact insecticide	Compounds tested required frequent spraying because they were not stable under UV radiation.	Musonda and Leuschner (1990) Wohlleber (1996)	Zambia, Namibia
Change of sowing date	Method evaluated in one part of Namibia on millet only.	Wohlleber (1996)	Namibia
Change of harvesting procedures in order to establish ovipositing attractants.	The study is incomplete in that studies validate population reduction were not conducted.	Wohlleber, 1996 Minja (2000)	Namibia
Insecticide bait applied at field margins	Bait formulation tested but field data not presented or analysed. Study incomplete	Wohlleber 2000	Namibia

Hatchling 1 2 3 4 5 6 Egg Laying



Developing egg

1:0.10

Stage 0

Germination

Nov/Dec

Stage 6

Flowering

Feb/March

Stage 7

Grain filling

March

Stage 9

Maturity

April

Harvesting

May

Fig. 1.1. ABC life cycle and sorghum development stages. The sorghum development stages are adopted from Vanderlip & Reeves (1972). ABC migrates to crop fields in February/March when natural grasses dry out.

1:0.42

Fig. 1.2. A farmer displaying sorghum panicles with (on left) and without cricket damage.