1. INTRODUCTION

Certain criteria in pollination are necessary for a plant - insect relationship to evolve (Faegri and Van der Pijl, 1979; Kevan, 1983). The bodies of anthophilous insects should be covered with setae, upon which pollen can readily cling. An ability to recognize and imprint plant forms, as well as a communication system is favourable. The pollinator should not be too specialized as specialization towards utilizing a single food source can lead to decreased flexibility in the absence of the particular food source. Insect pollinated plants should have nectar of good quality and quantity available as reward. The nectar of the more advanced bee plants have their nectar hidden in protective narrow tubes, as in the Asteraceae. A nectar reward for pollination has led to various specialized plant - insect relationships as in orchids, pollinated by euglossine bees.

According to Kevan (1983) the Coleoptera as a group are the most primitive holometabolous pollinators. Diptera are also regarded as primitive anthophilous insects. Adult Lepidoptera, which utilize nectar as energy source, play some role in pollination. The Hymenoptera are important pollinators, with the members of the Superfamily Apoidea as the most important. It is estimated that the Apoidea are responsible for 80% of all pollination by insects. Heteroptera are the most common hemimetabolous anthophilous

insects but their importance as pollinators is uncertain.

Characteristics of commercial sunflower:

The common sunflower (Helianthus annuus L.) belongs to the Asteraceae, which is the largest plant family. Plants in this family have many small flowers aggregated in the form of a head or capitulum. On the outer side of the capitulum a single row of bright yellow sterile flowers, the ray florets are borne. The rest of the capitulum consists of to 2000 disc florets. Each disc floret has the potential to develop a seed or achene.

The conspicuous sunflower capitulum is a perfect example of botanical adaptation to insect pollination (Kevan, 1983; Faegri and Van der Pijl, 1979). The bright yellow ray florets serve as a visual attraction, while the clustered disc florets provide a highly clumped energy reward. Crowding of the florets ensures that a maximum number of florets are pollinated by a single insect visit.

The sunflower (Helianthus annuus) originates from the southwestern USA and was initially cultivated as an important oil-rich crop in Russia early in the nineteenth century (Heiser, 1955; Hurd et al., 1980; McGregor, 1976). Sunflower breeding intensified in America during the 1940's, mostly for earlier maturity, higher oil content of the seeds and disease resistance. These earlier, open pollinated

cultivars were still very variable in development. Different breeding concepts were subsequently applied and these initiated the modern programme of hybrid sunflower seed production. The most revolutionary concept developed since 1970, is the cytoplasmic male-sterile system used in hybridization. A difference is now made between sunflower plantings for commercial purposes and those for hybrid seed production. Sunflower hybrid seed production is totally dependent upon insects to carry pollen from the male-fertile plants to the male-sterile plants (Radford and Rhodes, 1978).

Although the level of self-pollination of modern commercial hybrid sunflowers is better, the level of self-fertility is questioned. According to Lewis (1979) plants have a natural resistance to self-fertilization (autogamy). Self-pollination and self-fertility is controlled in the sunflower by a time difference in the availability of pollen and receptiveness of the stigma of the same floret. Cross-pollination is thus favoured. Pollination and sib-fertilization, i.e. pollen received from another floret on the same head, is possible though. Researchers therefore agree that, in order to achieve a high level of seedset of 70% or more, pollinators are still needed (Birch et al., 1985; Freud and Furgala, 1982; Furgala et al., 1978; Krause and Wilson, 1981).

Pollination of sunflower:

Wind is of little or no importance in the pollination of sunflower as the pollen is heavy and sticky (Robinson, 1978). Insects are the primary pollinators of sunflower as indicated by the following researchers: Cockerell (1914), Free and Simpson (1964), Hurd et al., (1980) and Parker (1981) in the United States, Radaeva (1954) in Russia, Benedek et al. (1972) in eastern Europe, Goyal and Atwal (1973) in India, Diez (1979) in Argentina and Kleinschmidt and Harden (1983) and Radford et al. (1979b) in Australia. Pollinators listed by these authors included not only beneficial insects as honeybees, solitary bees and butterflies, but also agricultural pests such as American bollworm larvae and moths and spotted maize beetles. A wide range of other unimportant insects, including flies and wasps, visit the sunflower capitulum.

The role of honeybees (Apis mellifera L.) as crop pollinators is well established. Researchers quoted above, agree that the honeybee must be considered the major pollinator of cultivated sunflower. Two reasons are given for this fact. Firstly, honeybees are relatively domesticated as they are kept in manageable hives which can be brought into a monoculture otherwise too extensive for pollination. Secondly, the areas planted with sunflower are usually intensively cultivated regions where agricultural activities have led to a reduction in the local honeybee and

solitary bee populations.

The leafcutter-bee (Eumegachile pugnata Say) has only recently been discovered as the primary pollinator of wild sunflower in its natural habitat (Parker and Frohlich, 1983). In South Africa the indigenous honeybee (A. mellifera scutellata Lepeletier) should be regarded as the most important pollinator of commercial sunflower (Birch et al., 1985). Reasons for the limitations of indigenous solitary bees as pollinators will be discussed in the course of this thesis.

Economic aspects of sunflower production in South Africa:
Poor seedset is one of the the major factors affecting the sunflower crop in South Africa. Seedset and yield is determined by the separate but vital processes of initiation of flowering, pollination, fertilization and seed development (Birch, 1981). Birch (1981) and Herring (1981) discuss the factors which influence these processes in South Africa. These include climate, cultivar characteristics, insect pollinators and plant nutrition. Birch (1982) revealed that South Africa was the only large sunflower producing country with a lack of relevant research on bees as pollinators. Preliminary research to investigate the influence of honeybees on crop yields was consequently undertaken (Birch et al., 1985), but a survey of pollinating

insects and a study of their behaviour is still lacking.

Commercial sunflower cultivation in South Africa before World War II was entirely for seed production as poultry feed. After the war a worldwide shortage of vegetable oils led to the development of sunflower cultivars with a high oil content. As elsewhere, the production of sunflower seed as a source of vegetable oil resulted in a decline of the production in sunflower seed as food. In 1974 South Africa followed the world trend of using hybrid cultivars which originated in the early 1970's in the United States (Birch and Engelbrecht, 1978). Today more than 40 hybrid cultivars are available on the South African market, developed to suite a wide range of climatic regions.

In spite of the wide assortment of cultivars available, commercial sunflower planting throughout South Africa is not extensive. Most sunflowers are only planted when weather conditions do not favour the cultivation of other fixed-price crops. In South Africa, sunflower is a short-season crop and can therefore be planted late in the growing season. Before 1983 the country was self-sufficient in its local demand for sunflower seed. However, since 1983 demand could not be satisfied, mainly because of drought. Van Zyl (1985) predicted a total dependance on imports, from as early as 1989. His prediction is based on the previous record harvest of 517 000 tons in 1982. The local demand in

sunflower seed showed a steady increase from 240 000 tons in 1977 to 430 000 tons in 1986, with an estimated 720 000 tons in 1996. This shortage therefore requires an increase in production per unit area as well as the total area planted.

The aim of this thesis is to investigate the insect - pollinator complex of commercial sunflower in South Africa with special reference to the indigenous honeybee, A. mellifera scutellata Lepeletier. Factors which influence or limit the pollination of sunflower by insects are explored and in conclusion recommendations for better pollinator management will be made.