CHAPTER- 1

INTRODUCTION

The general notion among people is that termites are white ants. They are not! The fossil record indicates that termites evolved about 220 million years ago (Collins, 1988; Thorne and Carpenter, 1992).

Termites form a significant proportion of the soil macro fauna. Termites are a highly successful group of insects coevolving for over 300 million years and constituting an integral component of the ecosystem (Dobzhansky, 1941; Emerson, 1943; French, 1988).

Unfortunately, termites are mostly associated with negative values as they cause damage to living trees, many crop plants, power poles, railway sleepers, timber-in-service, both inside and outside of the buildings and non-cellulose materials such as telephone and electrical cables. They are found in wide range of terrestrial environments and are distributed throughout the tropical, subtropical and temperate regions of the world (Smeathman, 1781; Freise, 1949; Krishna and Weesner 1970; Pearce, 1997).

Termites are widely distributed throughout the tropical and sub-tropical regions, close to the equator, while fewer species live at higher latitudes. Some termite species extend their range of occurrence to the relatively cool zones of temperate regions (Emerson, 1955; Araujo, 1970; Wood and Johnson, 1986; Eggleton, 1999).

Termites (white ants) are locally called ***'Udai'*** or ***'Deemak'***. Taxonomically, all termites can be placed into Kingdom Animalia, Phylum Arthropoda, Class Insecta, and Order Isoptera (Gk. *"Iso"* - same/ equal; Gk.

"Ptera" - wing). They are one of the most abundant terrestrial animals on earth. Termites are small, fragile, soft-bodied, social insects, which range in colour from dull white, pale white to rust or dark brown. They are about 2 mm. to 15 mm. in length (without wings). They are social insects and live in small to large colonies, with colony of some species containing about a million or more individuals. They also exhibit polymorphism, with a species represented by three forms or castes, *viz.* workers, soldiers and reproductives. All three castes are different morphologically and functionally. The soldiers have strong chitinised head and mandibles, which mainly take an active part in the defence of the colony. Among three castes maximum numbers of individuals are workers, there are a few soldiers (approx.10 per cent) and usually one pair of reproductives (Parihar, 1981).

1.1. HABIT AND HABITAT

Ecological (Habitat) Classification of Termites:

Ecologically the termites can be grouped into two groups (*i.e.* Wood dwellers and Ground dwellers) according to their habitats in which they live and breed. The information on habitat has considerable importance in their management.

(I). Wood dwellers:

The termites of the families Kalotermitidae, Stylotermitidae and Termopsidae are wood dwelling termites. They do not construct any nest like

the higher termites. They merely excavate a series of chambers and galleries with no external manifestation of their presence in the host wood, except in powder-post termites (e.g. *Bifiditermes, Cryptotermes*), which throws out its faecal matter through exit holes. The wood dwelling termites are further classified into two sub groups:

a) Dry wood termites:

These termites prefer dry and seasoned wood. They are one of the economically most important groups of termites attacking buildings. Presence of these termites is detected by piles of tiny excretal pellets, thrown out from the nest which accumulate on the ground, and hence called as "Powder post termites" (e.g. *Bifiditermes, Cryptotermes).* Termites belonging to the family *Kalotermitidae* obtain water from wood on which they feed and have no contact with soil or any other source of moisture.

b) Damp wood termites:

These termites require constant moisture content in the wood they inhibit. Some genera of family Kalotermitidae (e.g. *Postelectrotermes, Neotermes, and Kalotermes*) and termite species of genus *Stylotermes* (Stylotermitidae) are also considered as damp wood termites.

Further members of the family Rhinotermitidae also live in damp rotting logs or rot pockets in dead or living trees.

(II). Ground dwellers:

All the remaining families, Hodotermitidae, Rhinotermitidae, Macrotermitidae, Termitidae and Indotermitidae, are included under the ground dwelling termites. All members of these families need ground connection for their breeding and other activities. However, some species (e.g. *Coptotermes heimi),* are known from railway coaches and boats, to occur without maintaining any connection with ground.

a) Subterranean (Soil-dwelling) termites

Subterranean termites (species of Termitidae) are ground-dwelling or require contact with soil or some constant source of moisture. These termites are economically most important being pests of buildings and crops of agriculture. These termites do not construct the mounds but live in soil or in diffused chambers, some time containing semi carton sponge-like nest in the wood. Some of the important species of this group are *Coptotermes heimi, Heterotermes indicola* (Rhinotermitidae), *Odontotermes sp., Microtermes obesi* (Macrotermitidae).

Harvester termites (species of Hodotermitidae) forage in the open, feeding mostly on grasses and seeds, e.g. *Anacanthotermes macrocephalus.*

b) Mound-building termites:

The true mound-building termites in India belong to the family Macrotermitidae and a nasute harvester termite, represented by *Trinervitermes biformes* (Termitidae: Nasutitermitinae).

c) Carton-nest building termites:

Termite species such as *Microcerotertermes* (subfamily Amitermitinae), *Nasutitermes* (subfamily Nasutitermitinae) which feed on wood, make carton nest.

1.2. FOOD AND FEEDING HABITS:

The feeding habits of termites are very complex. Termites feed on a wide variety of food items including fresh, dead or decaying woody materials as well as dung and soil rich in organic matter (Waller and La Fage, 1987).

In addition to water, six varieties of food are consumed, of which the most important is cellulose. In some of the most highly evolved forms, fungi form an important item of food. Termites are reported from tropical and subtropical regions of the world, but most of the termite species are known from the tropics (Krishna and Weesner, 1969).

Abundance of termites in terms of biomass is estimated to be several metric tonnes higher for every human being on earth. These tiny creatures

because of their destructive habit were able to draw our attention from the very beginning of human civilization.

Contrary to the general idea that all termites are harmful, there are species which are beneficial to human beings. Most termites are not pests: as they feed on grass, debris; recycle plant nutrients by disintegrating and decomposing dead wood and plant debris and play an important role in maintaining soil fertility. The soil particles of the termite mound, rich in nutrients such as calcium, potassium and magnesium are washed into the soil due to erosion and become available for plant growth. Termite galleries improve soil structure, water entry and storage in soil; as a result of which surface water runoff and subsequent soil erosion are thereby reduced. Termites are also capable of fixing atmospheric nitrogen using gut bacteria. Further, the excavations made by the termites provide necessary spaces as part of the habitat for many vertebrate species including bats, birds, reptiles and arboreal mammals.

Another way of classification of termites in terms of presence of symbiotic microbial community is **Higher termites** and **Lower termites**. The **higher termites** have bacteria and the **lower termites** have bacteria and protozoa.

The higher termites belong to the family Termitidae, which has around 80% of the genera and comprises about 75% of the species in the order Isoptera. These termites are more advanced in their digestive system,

because they contribute cellulase enzyme during cellulose digestion in their hindguts. Few of the higher termites appear to feed on living trees (Lee and Wood 1971).

Many of these termite species feed on dead wood after it is decomposed and possibly the decaying micro organisms could be more important components of their diet. In the higher termites hindgut bacteria are not directly involved in cellulose breakdown (Yamin 1978; Muller, 1993; Lo, 1998), and they do not rely on them for cellulose digestion (O'Brien and Slaytor, 1982). The microbial community (bacteria and protozoa) is transmitted from workers to the newly hatched nymphs.

In the lower termites; nutrition is accomplished by the hindgut microbiotas, which are mainly bacteria and protozoa. They supply the termite with all the nutrients required in adequate amounts and in suitable relative proportions to each other to provide normal functioning of both the host and the symbiont organisms for cellulose digestion. The biomass of the hindgut microbial community in the lower termites may account for one third to one fourth of the body mass (Katzin and Kirby, 1933; Yoshimura, 1995). They are also believed to depend solely on their hindgut micro biota (protozoa) for cellulose digestion (Cleveland, 1928, Hungate, 1939).

Lower termites include families such as Rhinotermitidae, Kalotermitidae, Mastotermitidae, Serritermitidae, Termopsidae, and Hodotermitidae (Thorne, 1998).

Termites live in communities and the workers forage for food for which they travel long distances. Termites make use of available food material in the soil (Agarwal, 1972). Since the principal food of most of the termites is cellulose, they can cause damage directly in many ways to the host.

The termites make use of available food material in the soil, e.g., the cane seed setts, roots, stubbles and the inner tissues of the stalk. Harris (1969) remarked that the ability to feed on living plants has been developed in a limited number of termites.

The foods of termites are mainly of plant origin, which is woody in nature, with cellulose as a main component. The food of termites ranges from living trees, herbs to humus, though wood is main source of cellulose, it is not a natural food of termites (Thakur, 2000). Many species obtain food other than wood, such as grasses, debris, lichens and variety of other host articles containing cellulose (Thakur, 2000).

They can damage both living and dead vegetation and some species are recorded as serious pests of agriculture. Termites feed on plant cell wall material, such as wood, leaf litter, roots, dead herbs and grasses, dung etc. Chemically, their food can be characterized as lignocellulosic matter, which is the most abundant organic material in the biosphere. Termites are capable of digesting cellulose and some species can even digest lignin, with the assistance of symbiotic intestinal protozoa and bacteria. Further many termites also have symbiotic relations with nitrogen fixing bacteria.

Termites lack the enzyme required for breaking down and digestion of cellulose. The majority of the wood inhibiting termites however, harbour a varied and rich fauna and flora of micro organisms, such as protozoa (Flagellates, Amoebae and Spirochaetes), bacteria and fungi, as some of the protozoa contain enzymes which are believed to be helpful in breaking down and digestion of the cellulose (Thakur, 2000).

The higher termites (family Termitidae) depend mostly on decomposing wood or vegetable matter, dung and humus. The higher termites, particularly in the Termitidae, have abundant flora and bacteria and spichetes (fungi). The fact that they do not take part in the digestion of cellulose and hemi cellulose directly has been proved by experiments (Hungate, 1936).

Even materials that do not contain cellulose are also sometimes destroyed for reasons not yet fully understood (Thakur, 2000). Fletcher (1914) estimated an annual loss of about 32 million US dollars in wheat crops in the then British India. The situation has not changed much since then (Thakur, 2000).

Termites are lucky that they have an abundant supply of food in the form of cellulose and very few competitors to compete with. In termite colony, food collection is done by pseudoworkers and workers. The nymphs, reproductives, soldiers and alates waiting for swarming take no part in food collection (Thakur, 2000).

1.3. ECONOMIC IMPORTANCE

Termites are both beneficial and harmful to man. Termites play an important role in the ecosystem and some species certainly improve the fertility of soil. (Pearce, 1997). Some species of termites help in recycling plant nutrient, thus playing an important role in maintaining the soil fertility by enriching it with nutrients such as calcium, potassium, etc. Their galleries improve soil structure, water entry and storage in soil. According to Edwards and Mill (1986), Constantino (2002) and Krishna and Weesner (1970) only 10% of termite species have been pointed out as agents of some kind of harm to crops or buildings.

Termites as Agriculture Pests:

Termites have long been recognised as important agricultural and domestic pests, as well as pests of forests and pastures (Logan *et al.*, 1990).

Termites were recorded to cause considerable damage to a large variety of crops. The annual losses caused by their depredation amount to crores of rupees.

Damage to crops depends mainly on the population density of particular pest. Pradhan (1964) opined that an insect becomes a serious pest once its population reaches a critical level. Termites, being social insects, live in colonies. Although each colony is regulated as single unit but with the no. of individuals in a colony being enormous, it may be said that the population of

termites is generally at critical level.

The activity of these insects is concealed and takes place underground, so the damages done go unnoticed until the plants dry up and die. Due to their infestation the yield is greatly reduced but the producer remains unaware of the reason since the damage is under cover (Chhotani, 1980). In India the termite problem is serious because the major cultivated area comes under dry land condition (Agarwal, 1972).

Termites are supposed to feed on the roots thus cutting the nutrition to the plants. Chhabra (1979) reported termite attack to the pulses e.g. black gram, green gram, chick pea and lentil in the pulse growing tracts of Punjab State. Harris (1968) and Wood (1996) have reported damage by termites to Coconut, Cassava, Yam, Cocoa and Tea.

Crop specific damage:

Damage occurs from seedling to maturity in annual and perennial crops (UNEP/FAO, 2000). Termites feed on plants at all stages of growth, and their feeding damages roots, stems, leaves, and seeds of the host plant (Reddy, 1960; Sankaran, 1960).

Mill (1992) and Sands (1977) explored the role of termites as subterranean pests, damaging the sugarcane setts by excavation leading to the death of the buds and young shoots in Amazons of Brazil. Of all the crops

attacked, sugarcane is the most susceptible in the tropics (Abushama and Kambal, 1977)

In Gujarat, while working on control of termites on wheat and cotton, Patel (1962) recorded two species *viz. Odontotermes obesus* and *Trinervitermis biformis.*

In Wheat crop damage to the plants is generally done at the germinating or during ear head stages. The species *Microtermes obesi* feeds on the roots of seedlings and causes yellowing and wilting of leaves and is reported to cause loss up to 25%, the average being about 6 % (Hussain, 1935)

Roots of young Wheat plants were affected by *Microtermes vadschaggae in* Tanzania, by harvester termites in South Africa, by *Procorintermes triacifer* in Brazil (Harris, 1971).

Akhtar and Shahid, (1993) recorded six species of termites from Wheat crop fields of Pakistan. In Pakistan, *Odontotermes obesus* and *Microtermes obesi* are reported as pests of wheat (Janjua and Khan, 1955).

Bhatnagar (1962) reported that the cotton growers suffered considerable looses due to termite attack on germinating cotton under unirrigated conditions in Rajasthan.

Akhtar and Shahid (1989), recorded four species of termite *i.e. Microtermes mychophagus, M. obesi, M. unicolour and Eremotermes*

pardoxalis, in the cotton fields of Multan. Parihar (1978) reported 7.15 % loss to wheat crop. He also mentioned that Castor was attacked by *Microtermes mycophagus,* both at seedling and growing stage.

Beeson (1941), Harris (1961and1971), Hickin (1971) have given some account on termites that are injurious to agriculture crops and their control.

At a given time irrespective of the crop attacked by termites, hundreds and lakhs of tiny workers, start consuming the cellulosic matter of the plant. As such the rate of damage by termite is much faster and greater than that caused by any other insect pest and is persistent through out the year.

Termite as Wood Pests:

Although termites are never considered as true primary pests, the damage made by them often goes unnoticed until it reaches a considerable level. Termites often damage material they cannot digest, for example, plastics, rubber, metal or mortar. Primarily, the damage occurs when the indigestible items are encountered in the termites' search for food.

Pest species show preference for sapwood to heartwood, which is rich in food content and also without any toxin. Termites attack timber and other household woodwork, which is in an early stage of decay by wood-rotting fungi. Most of termites which are pests belong to four families *viz.* Kalotermitidae, Mastotermitidae, Rhinotermitidae and Termitidae.

1.4. GENERAL BIOLOGY: Thakur (2000) and Pearce (1997)

Castes and their functions:

Termites are social insects and live in colonies containing different castes. Different castes are morphologically and behaviorally specialized to perform various functions. Termites solve the problem of division of labour by dividing the work of the colony among the various castes. A termite colony consists of soldiers, workers or pseudo workers, reproductives, larvae and eggs. Soldiers, workers or pseudo workers are sterile casts. The royal pair (king and queen) is the functional reproductive caste.

Workers:

The majority (90 to 95 %) of the termites in colony are workers, which indulge in, building and maintaining the nest, or gathering food, and feeding the larvae, soldiers and reproductives.

Like the soldiers, workers are also wingless sterile caste with biting and chewing type of mouth parts. Workers exhibit polymorphism comprising minor, intermediate and major forms. True worker caste is absent in some primitive families like Mastotermitidae, Kalotermitidae and Termopsidae, so all functions of workers are performed by immature worker like forms, referred as Pseudergates or Pseudo workers In a colony, workers have an important role in the nest. Due to their activity of tunneling for the food collection and expanding their nesting area, they tend to damage the root system of the

plants and hence are regarded as one of the major agricultural pests. The other jobs of termites include building and maintaining nests, caring and feeding of young and other castes such as soldiers and royal pair. Fully developed worker consist of biting and chewing type of mouthparts, which are quite identical to those of the imago caste.

Soldiers:

Soldiers are fewer (approximately 5 to 10 %) in numbers in a colony. In few species they are absent (Thakur, 1989) and some times rarely present (Roonwal and Chhotani, 1960) e.g. *Speculitermes sinhalensis*. Soldiers have large head with strong jaws. Soldiers protect the colony against predators such as ants and centipedes.

Soldiers are sexually sterile castes and their reproductive organs are incomplete or not matured. As per rule, both sexes contribute to the soldier caste, but in certain genera of higher termites they are restricted to one sex only as in the case of Macrotermitinae where mainly all are females and in Nasutitermitinae all are males

In higher termites (Rhinitermitidae, Macrotermitidae, Termitidae and Indotermitidae) there are several instars before the worker becomes fully sclerotized. During these development stages, it may undergo stationary moult and change into soldier caste. Soldiers are large headed with strong, well developed mandibles. They are used for the defence of the colony from predators and are not useful in cutting or food intake (Thakur, 2000).

Different sizes of soldiers are found in some species as in some Termitinae, where major and minor soldiers are common. Some species may have no soldiers at all (soldierless).

Soldiers perform work of defence in many ways, like biting with powerful jaws, assuming a threatening posture, throwing small stones or chemicals at enemies or by producing threatening sounds.

Reproductives:

The functional reproductives are two kinds, *viz.* primary and substitute reproductives.

The primary reproductives, the king and the queen, are highly pigmented and large in size than other castes. They are founders of the colony, and are developed from winged forms that fly out of the parent colony during the swarming period. They shed their wings neatly from the basal suture during the process of courtship and tandem behaviour.

If a queen dies or become old, and her egg production is decreasing, substitute queens may be produced. The substitute reproductives are slightly pigmented and with or without short wing pads. As a rule, these are produced in response to loss of primary reproductive pair, from immature stages (Nymphs). There is only one pair of primary reproductive, but when they die, they may be replaced by number of substitute reproductives.

All primitive termite groups have capacity to develop substitute reproductives, but higher termites are incapable to do so. Apart from the fact that this caste carries out the fundamental function of reproduction, it also performs the function of distribution (dispersal) by way of swarming, budding, selection of suitable site for establishment of a new colony A fully matured queen of the mound building termite is capable of laying as many as 30,000 eggs per day.

Breeding:

Periodically, the colony produces numerous winged imagos (alates) which swarm out in considerable numbers usually once or twice a year most often in the rainy season. After a short flight i.e. lasting for few minutes to an hour or so, the alates descend to the ground, cast off their wings, and segregate in pairs, a male chasing a female, tandem fashion. The pair settles down in some hole or crevice and start breeding.

The queen gradually becomes much larger in size due to the enlargement of the abdomen (Physogastry), but the king remains unchanged. The queen lays thousand eggs per days. The eggs are small, white and longish oval with rounded ends; they hatch in few days and the young larvae undergo a number of moults. They produce mostly workers and soldiers. Periodically, they produce fully winged or primary reproductives which swarm out and repeat the cycle (Parihar, 1981).

Randall and Doody, (1934) opined that the cycle of termites is of a incomplete metamorphosis. It is because egg hatches into larvae, which then grow through several instars before developing into an adult worker, soldier or alate.

Longevity or life span:

The life span of individual termite worker or soldier is estimated to be between 2 to 4 years (Krishna and Weesner, 1970; Verkerk, 1990; Watson and Gay, 1991). Countless generations of termites live together in insulated subterranean nests (Watson and Gay, 1991). The life cycle of a termite colony is about 25 to 50 years (Hill, 1942; Verkerk, 1990), though no individual termite lives that long, except for the reproductives.

1.5 AIMS AND OBJECTIVES

There is no exact estimate as to the losses and damages caused by these tiny insects. Farmers and the nursery-owners suffer a considerable amount of financial loss due to the damage caused by the termites to seedlings and plants in various aspects.

Termite fauna in Gujarat is fairly well known and so far 60 species of termites have been recorded (Rathore and Bhattacharya, 2004) but, there is no detail work on termites of agricultural crops in Gujarat. A basic knowledge of pest biology and ecology is a prerequisite for adequate pest management.

Further, such informations are crucial for designing successful control measures of the pest.

To control termites in agro ecosystem its, identity, distribution, nature of damage to crops and field ecology should be known.

During preliminary survey termite attack on the agricultural crops at various stages in various modes was observed. They attack the roots of germinating wheat, roots and stem of sugarcane, maize, jowar and bajra, a number of vegetable crops such as cabbage, cauliflower, pea, potato, brinjal and chilli.

Since there is no availability of comprehensive work on termite damage to crops this study was undertaken keeping in view the following objectives:

Objectives:

1. To survey the termite fauna in study area and different agro-ecosystem of selected crops.

2. To prepare running keys for their identification

3. To study the crop wise distribution of termite pest species at seedling and maturing stage.

4. To study in detail the economic importance of termite pest species at seedling and maturing stage of crops.

5. To suggest management system for termite pests in agro-ecosystem.

Use of Bio-control methods or Integrated Pest Management for the control of termites is still a challenge!