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TERMITE CONTROL BY USING PLANT LATEX FROM FAMILY MORACEAE IN HIGH HUMIDITY ZONE OF EASTERN UTTAR PRADESH

***Abhishek Kumar Tripathi and Ravi Kant Upadhyay**

Department of Zoology, Deen Dayal Upadhyaya Gorakhpur University, Gorakhpur-273009.

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***Corresponding Author**
Abhishek Kumar Tripathi
Department of Zoology,
Deen Dayal Upadhyaya
Gorakhpur University,
Gorakhpur-273009.

ABSTRACT

The present review article presents various methods for termite control in the high humidity climatic zone of Eastern Uttar Pradesh. It emphasizes the use of various plant latexes as insecticides to control forest, household and garden termite population. Plant latex is a milky white complex mixture of proteins, alkaloids, starch, sugars, oils, tannins, resins, and gums. It is a natural plant polymer secreted by highly specialized cells known as laticifers. Latex components show multiple deleterious effects like toxic, anti-feedant, repellent, growth and reproductive inhibitory activity in number of in number of insect species. It delays egg maturation, development and inhibit gonad development in insects. Latex constituents display contact and systemic action and primarily used as poison baits to control soil termite. This article suggests the use of plant origin termitisides/biopesticides and botanical methods to control termite menace rather than chemical insecticides. These alternate methods will minimize the risk of poisoning of food-chain, soil and aqueous environment.There is an urgent need to prepare highly effective latex based combinatorial anti-termite formulations. This article also suggests use of control-release of latex components inside soil from poison baits to control field termites. For wider use of natural eco-friendly anti-termite formulations multi-component latex based low cost methods must be developed to replace highly toxic synthetic pesticides.

KEYWORDS: Plant Latex, Anti-termite activity, Natural Pesticides feeding and reproductive inhibition.

INTRODUCTION

Termites are social insects belonging to the order Isoptera (Family: Termitide). These are highly destructive polyphagous insect pests of crop plants. Termites infest a wide range of crops, forest trees and buildings (Hailemichael Taye et al., 2013; Legesse et al., 2013). These also damage green foliages, seedlings, wood, fibers, and other household cellulose based materials. Termites heavily infest post harvest stored products, cereal grains, wood fibres, cloths and papers. Both workers and soldier termites harm non-seasoned commercial wood and its formed materials. In forests, gardens and even in houses termites make tunnels; adjoin them with green biomass, vegetation, or crop fields (Photograph 1e-1f). Termites are agricultural pests found primarily in the tropical regions of the world, where they play an important ecological role in the recycling of wood and other cellulose-based material. Most of the termite species attack crop plants that results in reduction of crop yield significantly. There are currently approximately 2,800 named termite species in 282 genera worldwide.

Termites are one of the most agriculturally important insects and are known to cause enormous economic losses to many crop plants and tree species, buildings, etc. Termites infest at various stages of plant growth (Mitchell, 2002) and cause severe losses in sugarcane, maize, wheat, fruits, etc. (Salihah et al., 1986; Sattar and Salihah, 2001) and caused 50-100% yield losses in different crops (Rao et al., 2000; Sekamatte et al., 2001). Termite mostly resulted in distorting soil structures and compactions. Hence the soil becomes difficult to Plough; it leads to reduction of the productivity of crops.

However, for controlling termite termite attack harmful synthetic chemical pesticides are extensively applied (UNEP, 2000; Venkateswara et al., 2005). For controlling termite on crop plants various synthetic pesticides such as cyclodiene (Sim et al., 1998) (Sisay et al., 2008), cypermethrin (Valles and Woodson), hydroquinone and indoxcarb (Hu, 2006) have been used. Dursban spray found highly effective in the management of wood destroying termites (Roll, 2007). These chemicals put serious deleterious effect on non-targeted biotic and abiotic factors of environment (Dennis, 1981, Pimental, 1995). Though, chemical insecticides are highly effective against termite but they are hazardous to non-target organisms in the ecosystem (Kumar et al., 2012). It's bound residues persists for longer duration in the environment, and through various trophic levels they entered into the food chain. They are occasionally associated with severe damage to rangeland vegetation, particularly, in degraded arid and semi-arid ecosystems.

However, to replace these highly toxic synthetic chemical fungal insecticides, bio-insecticides and botanicals were found suitable (Silva et al., 2012; Sujatha et al., 2012). Plant latexes and some botanicals from Plant species *Calotropis procera, Ipomoea fistulosa, Maesa lanceolata, Croton macrostachyus, Targets minuta, Datura stramonium* and Azadirachta indica are used for the management of termites (Derbalah et al., 2012; Singha et al., 2013; Upadhyay, 2013). There so many plant-based botanicals that could act against termites in crop fields and vegetations.

There are so natural products i.e. extracts, latexes, essential oils, and bio-organic compounds such as quinones, isolated *Diospyros sylvatica* (Ganapathy et al., 2004); *Calotropis procera* (Upadhyay, 2013); *Ipomea fistulosa; Maesalanceolata, Chenopodium spp, Azadirachta indica, Croton macrostachyus, Tagetesminuta, Datura stramonium, Vernonia amygdalina, Phytolaccadodecandra, Nicotiana tobaccum, Shinus mole and Ficusvasta* (Ahmed and Girma, 2013; Gold et al,. 1996) against *Odontotermes obesus* (Rambur). Ipomeacarnea, *Cleome viscose* and *Pavoniaglechomifolia* has been tested against tea termites. (*Microcerotermesbeesoni Snyder* and *Microtermesobesi Holmgren*) (Singha et al. (2012). The use of leaf powders of *Azadirachta indica* and *Maesa lanceolata* were found to be effective in controlling termite on hot pepper at Bako (Sisay, et al., 2008). According to Venmalar and Nagaveni (2005), neem extract contains toxic constituent's that exhibit high toxicities against different and insect pests. Plant and their extracts used in crop field shoe anti-termite efficacy. But there is a need to develop suitable efficacious botanical based formulations to tackle the losses caused by termites. Many ofneem based preparations are used to control and repel termites in crop fields (Dokurugu et al., 2012; Nwilene et al., 2008; UNEP, 2000). The application of crop residue and cattle manure reported reducing the number of termites on crop fields' by 21.6 and 29.7% compared to non-treated fields ((Abdurahman, 1990; Legesse et al., 2013). These new methods could be used after thorough screening, and can make the advancement of already available ecofriendly methods which are traditionally being used by the local people. There is a need to develop promising and highly effective low cost formulations.

Termites pass three to four reproductive cycles in a year and show seasonal variations in population size. Winter and summer reproductive cycle cause mild increase, but spring and rainy season cycle increase termite population. *Odontotermes obesus* the Indian white termite and red termite *Coptotermes sp* found both in tropical and sub-tropical countries. The infestation of drywood termite *Cryptotermes brevis* (Walker, 1853) (Kalotermitidae) is one of the most important wood structural pest in the world (Santos et al., 2017). Soil-feeding termites are the only social insects using soil as both shelter and food and are major decomposers of organic matter in Neotropical forests. (Michel Diouf et al., 2019).

Termite feeding and damage

Termites are detritus feeders and feed on dead plants and trees. The main factors behind the presence of a large population of termites are humidity, mild temperature and other climatic factors. The Indian white termite, *Odontotermes obesus* (Rambur) (Isoptera: Odontotermitidae), is highly destructive polyphagous insect pest, lives in huge mounds, and feeds on cellulose material and almost anything which contains carbohydrate. It causes economic damage to commercial wood, fibers, cellulose, sheets, papers, clothes, woolens and mats, and woody building material and Infests green standing foliages, cereals stored in go down. Both worker and soldier termites harm non seasoned commercial wood and its formed materials (Photograph 1e-1f). Whether it is a rural area or an urban domestic site, termite menace is everywhere. Termites are known as silent destroyers because of their ability to chew wood, clothes and harm to crop fields. Each year termites cause about $ 30 billion in property damage.

There are about 2000 known termite species in the world. There are four types of termites found in all over the world. i.e. (1) subterranean (2) dry wood (3) damps wood (4) powder post. Subterranean termites are responsible for about 95 percent of the damage in all over the world. In Tarai belt of Gorakhpur termites menace is seen in different local regions, mainly in crop fields, household and forests. In this area the main species of termite are *Odontotermes obesus* (Indian white termite and red termite *Coptotermes sp*) Similarly, at the global level in both tropical, sub-tropical countries the infestation of drywood termite *Cryptotermes brevis* (Walker, 1853) (Kalotermitidae) is one of the most important wood structural pest in the world (Santos et al., 2017). Termites have presented human society with some of its greatest development challenges by consuming crops and damaging infrastructure. From report these reported goods and service is a rough estimate that invasive insects cost a minimum of US$30.0 billion per year globally. (Bradshaw et al., 2016) The subterranean termite *Globitermus sulphureus* are an important Southeast Asian pest causes damages to agriculture crops and building structures. (Hussin et al., 2019). The ecological impact of rapid environmental change will depend on the resistance of key ecosystem processes, which may be promoted by species that exert strong control over local environmental conditions. (Veldhuis et al., 2017). Eco-climatic conditions massively cutdown destructive invasive termite species, *Coptotermes gestroi* (Wasmann) and *Coptotermes formosanus* Shiraki. (Tonini et al., 2014).

CONTROL METHODS

1. Synthetic pesticides

For controlling termite population in the field, various synthetic pesticides such as chlordane (Karchesy et al., 2018), cypermethrin (Santos et al., 2017) hydroquinone, and indoxacarb (Abdullah et al., 2015) have been used. There are series of synthetic compounds which show unique modes of action and kill large numbers of termites after treatment (Spomer et al., 2009). Fipronil is a termiticide belongs to phenyl-pyrazole class of chemical compounds. It has broad-spectrum activity particularly against house hold pests such as cockroaches, Mosquitoes, locusts, ticks, and fleas at both larval and adult stages. It is also used to control subterranean termites in buildings. Its two metabolites viz. desulfinyl and sulfide-fipronil persists for longer time after application. Fipronil residues seap inside deeper layers slowly with time and detected up to 30 cm depth (Sharma et al., 2008). Fipronil and Indoxacarb is more toxic for *R. flavipes (*Hu et al., 2005) Imidacloprid foam is more toxic against *C.formosanus* (Osbrink et al., 2005); Boron compounds & borate show 90% mortility against *C.acinaciformis* Petres & Fitzgerald., 2006; Isoborneol shows repellent activity against *C.formosanus* (Blaske et al., 2003).

Chlorpyrifos, an organophosphorus insecticide, has been used to control termite Workers (Jitsunari et al., 1989). Both insecticides indoxacarb and fipronil demonstrated a delayed mode of activity and nonrepellency against the two termite species i.e. eastern subterranean termite, Reticulitermes flavipes (Kollar), and the Formosan subterranean termite, *Coptotermes formosanus* Shiraki. (Hu, 2005). Imidacloprid shows higher water solubility Can be used with less water-soluble termiticides in baits (Sapkota et al.,2020). Thiamethoxam Shows high mortality in Asian subterranean termite *Coptotermes gestroi* workers after 1-3 days exposure time (Acda, 2014). Higher mortality prevented termites from penetrating the entire 5-cm segment of treated sand (Remmen et al., 2005).

Microencapsulated Fenobucarb is a fast-acting termiticide, It is used in micro encapsulater it shows reduced repellent activities and retard entry of termites into treated soil. (Kubota et al., 2007). Bifenthrin-embedded chitosan in surface on the surface of PVC substrates, it is a novel and environmentally friendly technique for termite control. (Zhang et al., 2016). Silk fibroin is used as a carrier to embed bifenthrin that effectively kill termites (Guan et al., 2011). But all such synthetic pesticides are highly poisonous and kill non target Organisms. Due to their longer residual persistence in the environment, these have been banned and new alternatives are discovered the form of natural pesticides. Over the past 8-9 decades, organochlorines and organophosphates, the two prominent classes of termite control agents, have been massively used. It over use of synthetic chemicals caused heavy losses to the environment and human health. Synthetic pesticides create potential risks to the urban environment and human beings, due to biological magnification and residual effect. The persistent use of synthetic termiticides is very harmful to environmental health. More often, termiticides applied in urban soil.

2. Plant natural products

Plants possess a wide array of natural products; many of them show a selective advantage against insect attack. Plants produce large amounts of secondary metabolites in their shoots and roots and store them in specialized secretory structures. Although secondary metabolites and their secretory structures are commonly assumed to have a defensive function, evidence that they benefit plant fitness under herbivore attack is scarce, especially below ground (Huber et al., 2016). For termite control thousands of plant species have been screened for bioactive compounds (Jones et al., 1991). Plant secondary metabolites phenylpropanoid, can be used to deter, repel, and kill termites in their natural habitat. In plants, antibiotic compounds are also synthesized i.e. phytoanticipins) and phytoalexins, the former including saponins, cyanogenic glycosides and glucosinolates found active against range of microbes and insects (MIriti et al., 2009). Some botanical insecticides, such as *Azadirachta indica* oil, severely affect the immune system of various insect species (Duarte et al., 2020). Serine proteases are metabolic enzymes found in the midgut of red palm weevil, *Rhynchophorus ferrugineus* Olivier, they act as feeding inhibitors (Orfali et al., 2020).

Plants produce large amounts of secondary metabolites in their shoots and roots and store them in specialized secretory structures. Latex secondary metabolites produced by the common dandelion (*Taraxacum officinaleagg*) decrease the performance of its major native insect root herbivore, the larvae of the common cockchafer (*Melolontha melolontha*), and benefit plant vegetative and reproductive fitness under *M. melolontha* attack. The plants synthesize "secondary metabolites" in contrast to the "primary metabolites" which are essential for plant growth and development. (Toni et al., 2009). Over and repetitive use of chemical insecticides is responsible for development of resistance and other negative side effects (Mendonca et al., 2011).

Plant flavanoids *Sophora flavescens* and *Callitris glaucophylla* shows antifeedent and repellent activity against *C.formosanus* (Ohmura et al., 2000; *Mao* & Henderson 2007; Watanabe et al., 2005). Seed extract of W*ithania somnifera, Coroton tiglium & Hygrophilia auriculata* disrupt the activity of their gut in *Microtermes Obesi* (Duke et al., 2010). Leaf extact of *Rhazya stricta Decne, Lantana camara shows* antifedent activity against *Psammotermes hybostoma* (Yuan et al., 2012). *Azadirachta indica shows 100% mortality against Macrotermes sp* (Duke et al., 2010).

Plant Latex

Latex is secreated from laticiform tissues of plant belong to Family Euphorbiaceae, Moraceae and campanulaceae. Plant latex is a rich source of pharmaceuticals, pesticides and immune allergens. It also contains important biomolecules such as glycosides, tannins, phytosterols, Flavonoids, acetogenins and saponins, which show diverse biolgical activities against bacteria, fungi, viruses, protozoans, nematodes, insects, and cancer and tumours. It is also used as disinfectant, anticoagulant, anti-inflammatory, antioxidant and antiproliferative agent that provides protection in wounds. It contains a wide variety of industrially important metabolic substances which can be harvested, modified, quenched, and polymerized easily for making goods and materials by up-gradation of technology. Latex from several species showed the deleterious effects on insects and imposes very high toxicity, mortality, antifeedant, growth and reproductive inhibitory activity in them.

Plant latex and other exudates are sapping that are exuded from the points of plant damage caused either mechanically or by insect herbivory. Latex is secreted from 10% of plant families, has evolved independently many times, and is the most effective defense of milkweeds against its chewing herbivores (Agrawal et al., 2019). Latex contains two specialized metabolites such as terpenoids, cardenolides, alkaloids, and phenolics, which are show broad spectrum such as antibacterial, antifungal, anthelmintic, cytotoxic, and insect-repellent activities. Latex is a type of sticky endogenous fluids derived from diverse plants. It contains unique compounds (Abarca et al., 2019) mainly defense molecules which protect plants against microbes and herbivores (Kitajima et al., 2016). Many plants secrete latex exudate to protect from herbivores (kotan kono 20k) (Deng et al., 2019). Latex of *Euphorbia obtusifolia* obstructs mitochondrial functions in mammals (Galvis et al., 2003).

Latex secreted from *E. fischeriana* show antifeedant activity against *H.armigera* (Deng, et al 2019); while *Plumeria rubra* plant latex shows activity against *Aedes aegypti* and *Anopheles stephensi* (Patil, et al, 2011). Latex of *Synadenium grantii* shows activity nematicidal activity on *Meloidogyne incognita* and *Panagrellus redivivus* (Gomes et al., 2018). Plant latex conatins defense metabolites which assist them to protect against insect herbivores and pathogens (Hua et al., 2017). Latex was used traditinonal folk medicine to treat papillae, warts, condylomas, human papilloma virus (HPV) infections (Bauer et al., 2014; Nawrot et al., 2017). Latex of *P.pudica show* inflammatory ulcerative colitis (Oliveira et al., 2019). The synthesized AgNps synthesized from *P. rubra* latex were formed highly toxic than crude latex extract termite species (Patil et al., 2011). Latex of *Thevetia peruviana* show activity against antifungal activity (Sibi et al.,2013) *P. amapa* latex *shows* activity against change *C.megacephala* post embryonic development (Mendonca et al., 2011).

Aqueous and methanolic extracts of DL showed anti-termite effect more pronounced than phenylbutazone (PBZ) against carrageenin while it was comparable to chlorpheniramine and PBZ against histamine and PGE2, respectively (Arya et al.,2005). *Hevea brasiliensis* extract are low cost resources which could be used for various anti-termites activities (Daruliza et al, 2011). Fig latex also contains ficin, collagenolytic protease and chitinolytic enzymes which protect plant from termites (Raskovic et al., 2016). The physiological role of fig latex is to protect the plant from termites. Secondary metabolites i.e. sesquiterpene lactone taraxinic acid β-D-glucopyranosyl ester (TA-G) put negative effect on *M. melolontha* larval growth. Adding purified TA-G to artificial diet at ecologically relevant concentrations reduced larval feeding. (Huber et al., 2016). Secondary plant metabolites cause toxic effects that can be observed at both lethal and sublethal levels, but the most important effect is repellence. Plant latex contains diverse compounds which can be used as insecticides molluscides, acaricides, nematocides, fungicides and bactericides (Chowanski et al., 2016). *C. procera* latex affect reproductive hormone level (Ahmed et al., 2016) (Table 2).

Latex and other exudates in plants contain various proteins that are thought to play important defensive roles against herbivorous insects, mainly termites and various groups of pathogens (Castelblanque et al., 2018). Plants also release volatile organic compounds that attract the natural enemies of the herbivores (War et al., 2012). Morespecifically, extrafloral nectar, food bodies and nesting or refuge sites are produced to accommodate and feed the predators of the herbivores. (Furstenberg-Hagg et al., 2013). Plant latexes are largely used in traditional medicine for infectious and inflammatory disease treatment (Silva et al., 2011). Phloem exudates play a defensive role against the Erie silkworm, Samia ricini (Saturniidae, Lepidoptera) in several cucurbitaceous plants. The leaves, roots, fruits and latex of the plant *Ficus carcia* (Moraceae) contain flavanoids djue to which these showed anti-termite and antioxidant activity of *F. carica* (Ali et al., 2011). The latex from *Calotropis procera* has been reported to exhibit high toxicity to termite workers of termites (Upadhyay 2013). Plant latex, is used in treating rheumatic pain and make defense from predators (Bauer et al., 2013).

Latex released from plants, consists of complex mixtures of organic and inorganic molecules. So many of the have been traditionally used as termiticides. Plant exudates mainly latex, sap, gums, resins etc. are known to possess diverse biological activities including, antimicrobial, anti-inflammatory, antioxidant, and wound healing and anti-termite (Lica et al., 2018). Calotropis procera is known to produce contact dermatitis and the latex of this plant produces intense inflammation. It also found quite effective against termites (Shivkar et al., 2003). Use of latex products/materials and articles cause occupational problems such as immediate hypersensitivity allergic reactions, in health care workers (Salcedo et al., 2001).

Latex is a natural plant polymer secreted by highly specialized cells known as laticifers. Latex is milky fluid secreted by ducts of laticiferous tissue (Hagel et al., 2008). It mainly flow inside laticifer tissues including roots, stems, leaves and fruits of all flowering plants (Pickard, 2008). It is an emulsion like sticky material that exudes from various plant parts after having a small tissue injury. In most plant species latex is squirt out as white glue from bark of plants. It is a complex mixture of proteins, alkaloids, starch, sugars, oils, tannins, resins and gums (Thomas et al., 2008). Latex from various plant species contain cysteine proteases, profilins and chitin-related proteins that act as catalytic enzymes (Domsalla et al., 2008). These provide defense against herbivorous insects, phytopathogenic fungi and other bacterial infections (Yagami et al., 1998; Sequeira et al., 2009). It serves as defense material and prevents herbivorous insects from feeding.(Kitajima et al., 2010). In addition, plant latex also contains hazardous chemical substances that cause allergic reactions.

Latex plays an important role in plant-insect interactions. It is considered as analogous to animal venom. It contains cysteine proteases, which provide defense against herbivorous insects (Kitajima et al.) and phytopathogenic fungi. (Souza et al., 2011) More usually, plant latex contains defense protein MLX56 and cardenoides, which operate inducible defense in infected plants (Loon et al., 2006) and also show complicated molecular interactions to herbivores. (Wasano et al.,2009). Plants possess unique defense molecules, mainly chitinases which effect insect skin (Diaz-Perales et al., 1998). Similarly, papain and cystein proteases found in Papaya latex protect papaya from herbivorous insects (Konno et al., 2004). Similarly, chitinase-like proteins abundantly occur in mulberry latex play a crucial role in defense against herbivorous insects. (Hirayama et al., 2007). Contrary to this, vein cutting behaviour in insects counter play latex defense. (Sourd et al., 1987).

Plants latex deters herbivores like beetles and caterpillars under integrated defensive mechanisms (Pickard et al., 2008). Latices have been implicated in acute and chronic harmful effects on mammals (AlMezaine et al., 2005; Turillazzi et al., 2008; Albuquerque et al., 2009). Detrimental and toxic effects of laticifer proteins from the latex of *Calotropis procera* have been reported on important crop pests (Ramos et al., 2007, 2010). Different latex proteins seem to participate in defensive approaches against insects (Konno et al., 2004). Furthermore, latex has been shown to repel insects (Singhi et al., 2004).

Various latex secreting plants *such as Artocarpus heterophyllus (*Jackfruit*)* show anti-inflammatory (Fang, et al, 2008). Similarly, decoction of Algeria roots shows anti-inflammatory activity (Aichour et al., 2014). *Ficus ampilissima (*Indian Bat fig*)* anti-bacterial, anti-fungal, anti-oxidental (Hashemi et al., 2011); *Ficus carica* (Common fig) *show activity against* inhibition of cancer cell growth in digestive tract(Hashemi et al., 2011); *Ficus elastic (*Rubber fig*)* anthelmintic activity and against parasitic worms (Vedha Hari et al.,2011); *Ficus racemosa* (Goolar) *show activity against* various diseases/disorders including diabetes, liver disorders, diarrhea, inflammatory conditions, hemorrhoids, respiratory, and urinary diseases (Faiyaz Ahmed et al., 2009); *Ficus religosa (*Pippal*)* show activity against treatment of pain, inflammation, impotence, menstrual disturbances, and urine related problems, and as uterine tonic. (Yadav, 2015); *Morus alba* (White mulberry) show activity against toxicity to insects.(Gai et al., 2017); *Ficus benghalensis (*Banyan*)* is used for treatment of neuralgia rheumatism, lumbago, bruies, nasitis, gonorrhoea, inflammations, cracks of the sole and skin disease and in ayurveda for diarrhea, dysentery,and piles (Yogesh et al., 2016).

Various Ficus species such *Ficus pumila* (Creeping fig) show activity against skin inflammation. (Rademaker et al., 2018) *Ficus auriculata* (Elephant ear fig) anti-bacterial and anti-oxidental (Pant et al., 2009); *Ficus hirta* (Hairy mountain fig) anti-cancerous(Kunwar et al., 2006); *Ficus hispida* (Devil fig) and anti-diarrhoeal activity(Murti K., et al, 2011); *Ficus lacor* (Java fig) show activity against Anti- antiarthritic, anti-diabitic,anti-innflametry(Kunwar et al., 2006); *Ficus neriifolia* (Willow –leaf fig) *Ficus sycomorus* (Krishna et al., 2014; Kunwar et al., 2006); *Ficus palmate* (Jungli anjir) show activity against anti-microbial, (Kunwar et al., 2010). *Milicia excels* (African Teak) (Udegbunam et al., 2013) and *Morus nigra* (Black mulberry) (Cakılcıoglu et al., 2010); *Ficus benjamina* (Weeping fig) show anti- vitro anti-oxidant, anti-microbial, anti-bacterial.(Kunwar et al., 2010) (Table 2 and 3).

Insects is an important pest of homes, restaurants, and commercial food processing facilities worldwide ((Linnaeus, 1767; Liu et al., 2011). For controlling their population many types of insecticides (Habes et al., 2013), mainly by chlorinated hydrocarbons, organophosphates, compounds based on pyrethroids, and carbamates have been used (Rust et al., 1993). But excessive use of these insecticides has developed resistance (Rust & Reierson, 1991; Zhai & Robinshon, 1992) and also cause harm to humans and the environment (Gagne et al., 1999). The search for new insecticides and ways to control the German cockroach continue because this insect remains one of the most economically and medically important pests of the urban environment. Plants secondary metabolites are known to play a crucial role in pest control because some are selective, biodegradable, non toxic products, and have few harmful effects on non target organisms and the environment (Wink, 1993; Isman, 1995). Indeed, about 250,00 plant species in the world have been reported to contain compounds with insecticidal properties (Silva, 2008). The Euphorbiaceae family, these species grow often in tropical and subtropical environments (Webster, 1994). Euphorbiaceae family is charecetrized by presence of triterpenoids and related compounds (sterols, alcohols and hydrocarbons), phenolic compounds (flavonoids, lignans, coumarins, tannins, phenanthrenes, quinones, phenolic acids, etc.) alkaloids, cyanogenic glucosides, and glucosinolates (Abdel-Fattah, 1987). Due to presence of so much diverse molecules these show insecticidal and pesticidal effects in insects (Kemassi, 2008; Ayatollahi et al., 2010; Singh, 2012; Quezel & Santa, 1963). *Ficus religiosa* shows antimicrobial and anti-termite activity (Chandrasekar et al., 2010). Its latex is rich in triterpenes (Biesboer & Mahlberg, 1979; Yamamoto et al., 1981) (Table 2 and 3).

Plant latex is a good source of various secondary metabolites, which shows toxicity to insects, and act as growth and reproductive cycle inhibitors. *Euphorbia sp*. latex is particularly rich in diterpens and triterpen esters (Khan et al., 1989; Rasool et al., 1989) which show toxicity and could be used as insecticidal and pesticidal natural plant materials (Singh, 2012; Sandhyarani & Kumar, 2014; Vimal & Das, 2014). These also show the amoebic effect (Tona et al., 2000), nematicidal (Liu et al., 2014), molluscicidal (Bakry & Hamdi, 2009) termiticidal activities (Upadhyay, 2013). More specifically, use of latex and its products are environmentally much safer and these are easily recyclable or biodegradable in nature (Upadhyay, 2013) (Table 1). In addition plant latex contains wide diversity of bioactive chemicals which showed different biological activities such as anti-carcinogenic, anti-proliferative, anti-inflammatory, vasodilatory, antioxidant, antimicrobial, antiparasitic and insecticidal (Mesquita et al., 2005) (Table 2 and 3).

2. Plants Extracts

Plants contain significant levels of natural genetic and phenotypic variations between individuals it is intra-specific (Kliebenstein et al., 2009). Plant extracts of various families showed anti-termite activity due to presence secondary metabolites (Royer et al., 2010). Ethyl acetate extract prefer from the Heartwood Moraceae plant family, contains secondary metabolites, mainly 6 marathons [6-O-methyl-moracin M, 6-O-methyl-moracin N and marking Z; previously identified: alboctalol, trans-resveratrol, arachidin 2, trans-oxyresveratrol and artogomezianol, flavonoids, steppogenin, katuranin and dihydromorin, beta-sitosterol and resorcinol (Mariana et al., 2010). These secondary products provide a multitude of defense and perform various signalling functions, generate toxic effects in insects (Klein et al., 2009). Plants also synthesize jasmonate compound mainly hormones (Zhang et al., 2009). Few natural products such as flavonoids (Park et al., 2014), sesquiterpenes (Seo et al., 2009) and thiophenes (Hagel et al., 2008) were found effective against termites (Table 1).

3. Plant essential oil and its constituents

Essential oils are derived from plants and considered as the most efficient alternative in controlling insect pests like termites (Alavije et al., 2013). EOs are mixtures of secondary metabolites or natural organic compounds obtained from plants. These contain mixed functional groups and lipophilic in nature and are highly volatile at a very low temperature. These are obtained in pure form or a complex mixture of several components without making. Essential oils are responsible for plants' defense against general herbivores. The Essential oils are safe and are feasible more alternatives to the hazardous insecticides to control termites and other insects. These show the least residual effect in the non-target organisms, inhibit metabolism in termites and kill them due to antifeeadnt, repellent and toxic action.

Essential oil is extracted from the fresh leaves, flower stems and rhizomes show the multiple uses (Friscic et al., 2019). Essential oils, display numerous beneficial effects for health maintenance and treatment of diseases. Leaf oil from Eucalyptus contains compounds which show widespread biological activities, including antimicrobial, antiseptic, antioxidant, chemotherapeutic, respiratory and gastrointestinal disorder treatment, wound healing (Dhakad et al., 2018; Noura et al., 2018). *Chamisso arnica* (Arnica chamissonis Less.) possesses pharmacologically active. (Danuta Sugier et al., 2019). Citronellal (64.7%) and citronellol (10.9%) isolated from Citrus plants active against insects (Sara Benchaa et al., 2018). These massively affect the physiology and biochemistry of insects (Wan et al., 2019; Gonzalez et al., 2019; Suzuki et al., 2014) (Table 1).

4. Biological control of Termites

For biological control of insects, various groups of pathogens mainly bacteria, fungi and viruses are employed to kill insects. Biopesticide show multiple effects on life and life cycle of insects. Biopesticides cause modification of development of insect and behavior exerts unique approach for management of insect population. Pathoegns are host specific and cause diseases in insects. Mainly three approaches are used for biological pest control: in first phase natural enemies of insects are introduced. In second phase large population of natural enemies is administered for quick pest control; in third or inoculative phase maintain natural enemies through regular reestablishmen. For better control and operational level various predators, aparsitoids, pathogens and competitors are employed. Most of them are predatory birds (Ruth de Jauregui). Termites are the food source of various reptiles and mammals (Keri Gardner). Few insects like wasps, fire ants, praying mantis, spiders and back ground beetles also eat termites (Parsons, 2017).

Ants are the greatest predators of termites. Mammals, reptiles and birds feed on termites in crop field and potentially regulate termite population (Culliney et al., 2000). Few fungal metabolites (siderophores) show repellent and insecticidal activity against termites (Culliney et al., 2000). Insecticidal proteins secreted by entomopathogenic bacterium *Photorhabdus* *luminescens* sub sp. *laumondii* TT01, a symbiont of the entomopathogenic nematode *Heterorhabditis bacteriophora* is also used for termite control. It is a highly useful alternative method for sustainable control of the Formosan subterranean termite (C. formosanus) and other social insects (Zhao et al., 2008). Fungus *Metarhizium anisopliae* are used as biological control of subterranean termites (Thomas Chouvenc et al., 2012). Endophytic fungus-based biopesticides are used to control *Odontotermes spp.* workers. Fungal conidia and its suspension is directly sprayed on termite worker population (Ambele et al., 2020).

Termites are the natural food of some mammals (myrmecophagy) (Redford 1987) and reptiles (Keri Gardner). Bearing birds feed upon field termites. Some other animals such as scarlet tanager (*Piranga olivacea*) eat termites. Termites are important food resource for birds around the world (Eisenmann et al., 1961; Ruth de Jauregui) (Table 4). Few bird species silently feed on termites and directly collect them from Termitaria (termite nests) by making holes in mud (Hardy et al., 1963). Smaller animals such as genets, civets, mongooses, bats and numbats eat termites. Moles and shrews also eat termites. Dwarf mongoose live in social groups lives inside caves and eat termite mounds. Armadillos live in warm climate excavate termites by using deep into a termite mound and collect termites by using long tongue. Edentate animals also possess long tongue and consume 35,000 ants and termites each day. So many reptilian animals such as Blind snake, legless lizard, Naked-toed geckos, Armadillo girdled lizard, Frill -necked lizard feed on termite colony. Few insects like Wasps, Fire ants, Praying Mantis, Spiders and Back ground Beetles are also eats termites (Parsons. 2017). *Oogpister* beetle (ground beetle) preys exclusively on ants and termites. Blind snake eats Termite *C.formosanus* Alates & workers (Petrakova et al., 2015) (Table 4).

Microbes *Incistermes Scwarzi* showed cumulative mortality against *Drywood termite* (Calleri et al 2010) while *Isaria fumosorosea, Metarhizium anisopliae & Bacillus thuringiensis shows* 100% mortality against *C. formosanus* (Wright et al., 2012); *Metarhizium Anisopilae & Beauveria bassiana gives (*Hussain et al 2017*). Saccharum officinarum bagasse & pennisetum purpureum* causes 70% mortality in *C.formosanus* (Guerrero et al., 2015) (Table 4).

Use of poison baits

Various poison baits are used to control insects and termites. In bait preparation, base material or a carrier that may be grain or animal protein. Second a toxicant or insecticide such as organophosphates, carbamates or pyrethroids is used. Sometimes an additive usually oil, sugar or water is added to increase attractiveness. Examples of biological toxicants are *Bacillus thuringiensis* (Bt), parasitic nematodes and fungi. Many baits are not highly attractive to the insect, but instead function as an arrestant. The insect is not attracted to the base material, but Finds it palatable and will eat it when encountered. For control of subterranean termites *Coptotermes curvignathus* (Holmgren) and *Coptotermes gestroi* (Wasmann) (Blattodea: Rhinotermitidae) poison coated bait matrices are used. These are supplemented with various sugars, amino acids, and cassava.These bait formulation can be added with termiticides that can use to seek wider control of subterranean termite colonies. (Venite Pesigan Castillo et al., 2013). Noviflumuron is used in poison baits to kill molting worker population of Formosan subterranean termite, *Coptotermes formosanus* Shiraki inside nest (Kakkar et al., 2018) (Table 1). Polyacrylamide/attapulgite composite baits are also applied in agricultural soils.These attracts termite population for foraging (Qinxi Xie et al., 2019). Systemic posions or pesticides could be added to these gels to kill termites. Carbon dioxide (CO2) relealse attract termites, It improves effectiveness of an insecticide to kill termites in nests (Bernklau et al., 2005). Termite worker population can be regulated or suppress by using poison bait and killed in pre-adult developmental stages (Hex-1 and Hex-2) (Zhou et al., 2006).

Summon disks and filter paper disks coated with few chitin synthesis inhibitors, i.e. diflubenzuron, hexaflumuron, and chlorfluazuron are used to control forests and field termites (Sbeghen et al., 2011). It obstructs the aggregation, feeding, and recruitment behavior in *Coptotermes obesus* termites**.** Noviflumuron causes 77% mortality in *C. formosanus* (Eger JE et al., 2012). 2- Deoxy – Glactose causes 70% mortality against *C. formosanus* (Veilon et al., 2010*).* Bistrifluron causes 83% mortality against *C.* formosanus (Evans et al., 2010). Feeding behavior is also inhibited by using bait supplements in Summon Preferred Food Source disks (Cornelius et al., 2009) (Xiong et al., 2018) Feeding behavior is also inhibited by using bait supplements in Summon Preferred Food Source disks (Cornelius et al., 2009) (Xiong et al., 2018).

In addition, for enhancing the insecticidal potential of crude plant extracts and various plant species are used in poison baits which successfully exploit feeding, tunneling (Xie et al, 2013). And reproductive behavior in termites (Cheng et al, 2012) Similarly, application of Summon disks and filter paper disks coated with few chitin synthesis inhibitors, that is, diflubenzuron, hexaflumuron, and chlorfluazuron (Sbeghen et al., 2011) controlled the aggregation, feeding, and recruitment behavior in *Coptotermes obesus* termites.

Synthetic protozoacidal lytic peptides have been shown to kill the cellulose digesting termite gut protozoa; these impose inhibition of feeding behavior that results in death of the termite colony (Claudia Husseneder, et al, 2016). If microbial community of found in termite gut is inhibited it directly affect ecological survival (Arora, et al., 2017).

5. Behavioural control of termites

Pheromones are cuticular hydrocarbon that comprises the majority of the chemical profile of queens and their eggs, and also affects behavior in workers; by reducing aggression (Holman, et al, 2010) Trail pheromones play important roles in foraging behavior and building tunnels and nests in termites. Sophisticated social behaviors in termite colonies are mainly regulated via chemical communication of a wide range of pheromones. However, it is almost unclear how termites perceive trail pheromones (Gao et al., 2020).

Termites are also controlled by inhibiting antioxidant defense of winged imagoes, nymphs, soldiers and workers of Formosan subterranean termites (Hussain et al., 2017). This could be achieved through host pathogen interaction by caste-specific volatile chemicals and genes (Hussain et al., 2017). Feeding behavior is also inhibited by using bait supplements in Summon Preferred Food Source disks (Cornelius et al., 2009; Xiong et al., 2018). Termite soldiers produces a vibratory alarm signal to warn conspecific workers. If signal is erupted it causes 100% mortality in these termites (Inta, et al, 2009). WPS E1-09 in choice tests are used to stop feeding preference of Formosan subterranean termites (Little et al., 2012). Treatment with dry DE for 6 h, the mortality of termites reached 100%, which was significantly higher than in the treatment with DE with a 10 and 25% moisture content. The effects of diatomaceous earth (DE) on the penetrating behavior, tunneling behavior, mortality, and body surface characteristics of the subterranean termite Reticulitermes chinensis were investigated in this study (Gao et al., 2018).

Pheromonal control

Trail pheromones in termites are secreted by a unique exocrine gland source, the sternal gland present in the abdominal sternites of all termite castes. In the majority of termite species, trail pheromone comprises a single compound. (Cristaldo et al., 2014). The trail pheromone components of *T. subterranea* include both E- and Z-citrals. Differences in pheromone composition between species may reduce interspecific trail following in stingless bees. (Zablotny et al., 2009) They are also able to use the odor they have associated with their nests to Identify and return to the nest entrance. A single component, 3-ethyl-2, 5-dimethylpyrazine, is present in the poison glands of several species of Myrmica and is able to induce trail-following all those species, but there are some other species that do indeed use multiple components. Argentine ants use (Z) -9-hexadecenal, which lasts about 4 h before the signal fades for use by other workers if it is not replenished. (Klowden et al., 2008) Trail pheromones communicate information about food quality to nestmates that have not had direct experience with a food source. Trail-laying behavior regulates the pheromone concentration i.e., the amount of pheromone deposited on a trail, which in turn controls a colony's response. After deposition on the substrate, a trail pheromone diffuses. The distance between the food source and the nest is retrieved, by trail pheromones that are highly useful for colony's foraging (Klowdenet et al., 2013). Different ant and termite species show variations on the theme of mass communication that likely are associated with the foraging ecology of individual species (Traniello et al., 2009).

Many semiochemicals are secreted from Sternal glands of Isoptera reproductives are decadienal, dodecanal, dodecadienol, dodecatrienol, neocembrene, and tetradecyl propionate, which function as sex pheromones (Leonardo et al., 2009). Subterranean termite, *Reticulitermes flavipes* release an alarm pheromone and other defensive chemicals from the frontal glands (Funaro et al., 2019). Similarly, *Macrotermes annandalei, R. speratus & R.santonensis* secrete few hormones trans-8-dodecatrienol &Z,Z E-3,6,8-dodecatrien-1-ol (Raina et al.,2005); Z- dodec-3 en-1-ol. These are used to induce orientation & recruitment in termites *Macrotermes annandalei (*Peppuy et al., 2001*).* E-1- nitropentadec-1-ene & E-E-alpha-farnesene is used for trapping termites against Secreted from *pror-hinotermes canalifrons* (Sobotnik et al., 2008); norsesquiterpene alcohol (E)-2,6,10-trimethyl-5,9-undecadien-1-ol is reflects communication behavior in *Mastotermes darwiniensis against Porotermes adamsoni* and *Stolotermes victoriensis* (Sillam-Dusses et al., 2007). Juvenogens are used to disruption social structure and ultimately the death of the termite colony against *Zootermopsis angusticollis, Kalotermes flavicollis, Cryptotermes declivis, Reticulitermes santonensis* and *R. flavipes* (Hrdy et al., 2004).

6. Genetical control of termite

Metagenomic methods there is alarge term association of microbial communities which have inside gut of these member provide termites, wood-boring beetles and livestock pests, and transcriptomic approaches reveal molecular bases behind wood-digesting capabilities to wood boring beeteles and livestock pests and termites of these insects. (Poelchau et al., 2015) *Nasutitermes corniger* (Motschulsky), (Thorne et al., 2019) Termites of the genus Reticulitermes are some of the most significant pests of structural timber and tree farming in the northern hemisphere, causing losses in the billions of dollars annually because of direct damage and termite control costs (Cameron et al., 2007).

Termites are social insects of economic importance that have a worldwide distribution. Identifying termite species have traditionally relied on morphometric characters. In the present study, 100 termite individuals of *Anacanthotermes ochraceus* were collected from two Saudi Arabian localities with different geoclimatic conditions (Riyadh and Taif) (Alajmi et al., 2019) *Laboulbeniopsis termitarius* (Thaxt) and *Antennopsis gallica* (Buchli and Heim) are two of the most common ectoparasitic fungi found on the body surface of termites (Guswenrivo et al., 2018). Behavioral control of termites is environmentally safer (Andrew E Christie et al., 2015). Mastotermes darwiniensis is the most basal living members of the Isoptera (termites), yet it exhibits an extremely advanced level of social organization. Termites of the genus Reticulitermes are widespread invaders, particularly in urban habitats. Their cryptic and subterranean lifestyle makes them difficult to detect, and we know little about their colony dynamics over time(Baudouin et al., 2017). *Coptotermes suzhouensis* (Isoptera: Rhinotermitidae) is a significant subterranean termite pest of wooden structures and is widely distributed in southeastern China (Juan et al., 2018). Caste-specific genes regulate antioxidant defense in winged imagoes, nymphs, soldiers and workers of Formosan subterranean termites (Hussain et al., 2017). These could be disturbed by gene knock out use of chemical obstructs (Cristaldo et al., 2015).

7. CULTURAL CONTROL OF TERMITES

Use of neem

Neem, *Azadirachta indica*, is a well known source of natural compound s with potent insecticidal, feeding deterrent and insect growth regulator activity (Ahmad, & Grainge, 1986). Its oil is environmentally safe, cheap and best for termite control (Nwilene et al., 2008). It is easily available to farmers as a natural pesticide. Some specific components, Azadirachtin, Nimbin, Nimbidin, Meliantrol and Salanin have shown strong repellent, growth inhibiting and insecticidal potentials against *Coptotermes formosanus* (Delate et al., 1995b).

Use of organic material to the soil

Termites prefer to eat dead plant material. Their attacks are thought to be related to soils with low organic matter content. This is because such soils do not contain enough food for termites to live and they resort to feeding on living plant material. Adding compost or well-rotted manure to the soil and growing green manures helps to increase the organic matter in the soil. Where possible, green manure crops can be ploughed into the soil. Moisture plus organic matter attracts the termites and prevent them from attacking the target crop. Castor press cake can be incorporated into the soil in order to control the termite infestation. It is suggested to add it into the opened furrow before sowing the crop.

Crop rotation: Planting the same crop on the same land year after year reduces soil fertility and structure. Crops growing in such conditions will be weaker and susceptible to termites. Crop rotation can play an important role in reducing termite attack. This can prevent pest and disease buildup and also help the soil to recover nutrients. In some parts of India, farmers cultivate castor (*Ricinus communis*) crop in severely termites infested field and doing so, they found that the termite infestation has substantially been decreased in the next cropping season. (HDRA Report, 2001)

Full land watering: Irrigation is also used to minimize the effect of the termites. When the farm is regularly irrigated, the activities or damages of termites are reduced.

8. Traditional methods used for termite control

It is estimated that termites cost the global economy more than 40 billion USD annually, and considerable research has been done on their management. The available information related to sustainable and integrated termite management practices (ITM). (Ahmad et al.,2019) for control of *Reticulitermes flavipes* (Kollar) termites low body water percentage is harmful (Arquette et al.,2005)A soil chemical barrier is the most important and common way to control termites (Yang et al., 2018)assay and evaluation on chemical soil barrier also used for termite prevention in buildings.

The Formosan subterranean termite, *Coptotermes formosanus* Shiraki, is one of the most economically important subterranean species. There are alteranates of chemicals; and biological control employed byusing natural enemies - predators, parasitoids and pathogens also more effectively suppress termite populations (Culliney et al., 2000). Further more, natural products show repellent action in termites and its low-dose found effective, specific and generate low-toxicity in comparison to conventional pesticides (Chris Peterson, 2003). Lambda-cyhalothrin is released from the impregnated polyethylene film into adjacent sand prevent termite penetration. (Nan-Yao et al.,2004). Chlorfenapyr is a pyrrole insecticide that is use against termites (Guessan et al., 2007). There must be a check on the use of conventional termiticides, attention should focused on finding safer alternative methods for termite management (Raina et al., 2007).

Modern methods and technology

Technical chlordane is a mixture of four main isomers (i.e., heptachlor, cis-chlordane, trans-chlordane, and trans-non-achlor)It is used treatment of house for termites control (Cassidy et al., 1994). Variety of methods to identify mixtures and a modified concentration-addition approach to estimate their potential toxicity at 845 stream sites across the United States sampled between 1992 and 2001 for organochlorine pesticides and polychlorinated biphenyls (PCBs) in bed sediment (Phillips et al., 2009).

Climate change and its impact on Termite Population

Fipronil is very highly toxic to termites and put long-lasting negative impacts on termite populations. But it presents a long-term risk to nutrient cycling and soil fertility where termites are "beneficial" key species in these ecological processes. Its toxicity to termites also increases the risk to the ecology of habitats in which termites are a dominant group, due to their importance as a food source to many higher animals (Tingle et al., 2003).The synthesized AgNps from P. rubra latex were highly toxic than crude latex extract termites species.

Light: Mainly Termites avoid light, but the subterranean species in particular exhibit a strong tendency to stay away from light. Termites are blind and cannot detect light of any form to termites have varying sensitivity to varying types of light waves with some species of termites being extremely sensitive to the light waves that humans (and other predators) see. Formosan termite is a subterranean species that spends most of its life underground and away from light Except during swarming (reproductive release) by the adult winged stage. As such worker and soldier termites have no functional eyes. Termite workers were found to perceive and avoid light of 0.6 Lux intensity and above. Pre-soldiers, a transient stage between workers and soldiers, and newly formed soldiers also showed similar responses to light. Continual exposure to light that foraging would recommence after the construction of an opaque mud screen. (Park and Raina, 2005) (The Role of Light in Termite Control DIY Phil Robins)

Humidity: Wood block weights were taken weekly, and constant wood moisture content (MC) was maintained throughout the experiment by addition of water to the wood. Survival of subterranean termites, Reticulitermes flavipes (Kollar), under conditions of saturated relative humidity and wood moisture content ranging from 20 to 30%, and no soil contact was evaluated. (Manamy et al., 2008)

Teperature: *C. gestroi* and *C. formosanus* are strongly linked to urban development. It will population growth and biotic distribution of both termite species (Tonini et al.,2014). Global warming as a consequence of climate change, rising human population and intensifying international trade will allow these costly insects to spread into new areas, but substantial savings could be achieved by increasing surveillance, containment and public awareness The analysis of sex ratios and average weights of the alates suggests that intrinsic colony factors warm climate affecting timing of the maturation of alates, dispersal and flight. (Chouvenc et al., 2017). (Bradshaw, et al, 2016).

CONCLUSION

This is an established fact that termite menace is a serious problem in sub-tropical countries, Though, this problem present world wide except few cold temperate regions. Due to the rising toxicity of synthetic pesticides in agriculture soil and its biomagnfication there pesticides have been fully banned. This article emphasizes of various plant latexes as insecticides to control forest, house hold and garden termite population. Latex components show multiple deleterious effects like toxic, anti-feedant, repellent growth and reproductive inhibitory in number of insect Species. It delays egg maturation, development and inhibit gonad development in insects. Latex constituents display contact and systemic action and primarily used as poison baits to control soil termite. For environmental safety and sustainable use of plant origin termiticides / biopesticides and botanical methods must be supported and widely used rather than chemical insecticides. For eco-friendly control of termites bio-organic pesticides, plant exxential oils, plant extracts, microbial control, behavioural control and genetic control have proved much better that chmeicla pesticides. These alternates minimize the risk of poisoning of food-chain, soil and aqueous environment.

There is an urgency to prepare highly effective Latex based combined anti-termites formulations. This article also emphasizes show controlled-release or latex based components baits to control field termites. For wider use of natural eco-friendly anti-termite formulation will multi-component latex based low cost methods are too developed.

Table 1: Anti-termite activities of plant latexes.

Name of plant	Common Name	Activity against species	Source (Ref)
P.pudica	Golden Arrow	Animals against inflammatory ulcerative colitis (UC)	Oliveira et al., 2019
P. amapa	Amapa-Amargoso	Ahange C. megacephala post embryonic development	Mendonça et al., 2011.
Euphorbia tirucalli's	Indian tree spurge	Aetermine the molecular basis of the laticifer's functions in this plant	Kitajima et al., 2016
Euphorbia obtusifolia	Spurge	Inhibitory activity on the mammalian mitochondrial	Galvis et al., 2003
E. fischeriana	Grape ground pearl	Antifeedant function	Deng et al., 2019
Plumeria rubra	White Frangipani	Against Aedes aegypti and Anopheles stephensi	Chandrashekhar et al., 2011
E. peplus	Radium weed	Aonstitutive defense metabolites against insect herbivores and pathogens for the plant.	Hua et al., 2017
Synadenium grantii	African milk bush	Nematicidal activity on Meloidogyne incognita and Panagrellus redivivus	Gomes et al.,2018
Hevea brasiliensis	Rubber tree	Aoagulation mechanisms among the more than 20,000 Latex-bearing plant species are lacking	Bauer et al.,2014
Chelidonium majus	Greater celandine	Traditinonal folk medicine to treat papillae, warts, condylomas, which are visible effects of human papilloma virus (HPV) infections.	Nawrot et al., 2017
Thevetia peruviana	Yellow oleander	Antifungal activity against the isolates followed by Manilkarazapota	Sibi et al.,2013

Table 2: Anti-termite activity of different plants of Family Moraceae.

S.N.	Name of plants	Common Name	Activity against speces	Source
1.	*Artocarpus heterophyllus*	Jackfruit	Anti-inflammatory effects of phenolic compounds	Fang et al.,2008
2.	*Ficus ampilissima*	Indian Bat fig	Anti-bacterial,anti-fungal,anti-oxidental activity	Hashemi et al.,2011
3.	*Ficus carica*	Common fig	Anhibition of cancer cell growth in digestive tract.	Hashemi et al.,2011
4.	*Ficus elastic*	Rubber fig	Anthelmintic activity and Parasitic worm infection etc.	Hari et al.,2011
5.	*Ficus racemosa*	Goolar	Aarious diseases/disorders including diabetes, liver disorders, diarrhea,	Ahmed et al., 2009

			inflammatory conditions, hemorrhoids, respiratory, and urinary diseases.	
6.	*Ficus religosa*	Pippal	Treatment of pain, inflammation, impotence, menstrual disturbances, and urine related problems, and as uterine tonic.	Yadav.,2015
7.	*Morus alba*	White mulberry	Showed more toxicity to insects.	Gai et al.,2017
8.	*Ficus benghalensis*	Banyan	It is used for treatment of neuralgia rheumatism,lumbago, bruies, nasitis, gonorrhoea, inflammations, cracks of the sole and skin disease and in ayurveda for diarrhea,dysentery,and piles.	Yogesh et al.,2016
9.	*Ficus pumila*	Creeping fig	Cause phytophotodermatitis potentially serious skin inflammation.	Rademaker et al.,2018
10.	*Ficus auriculata*	Elephant ear fig	Anti-bacterial and anti-oxidental activity	Pant et al.,2009
11.	*Ficus hirta*	Hairy mountain fig	Anti – bacterial and anti-cancerous	Kunwar et al.,2006
12.	*Ficus hispida*	Devil fig	Anti-diarrhoeal activity	Murti et al.,2011
13.	*Ficus lacor*	Java fig	Anti- antiarthritic, anti-diabitic,anti-innflametry	Kunwar et al.,2006
14.	*Ficus neriifolia*	Willow –leaf fig	Anti-inflammatory effects of phenolic compounds	Kunwar et al.,2006
15.	*Ficus palmate*	Jungli anjir	Anti-microbial,anti-bacterial activity.	Kunwar et al.,2010
16.	*Ficus sarmentosa*	Nepal fig	Anti-bacterial,anti-fungal,anti-oxidental activity	Kunwar et al.,2010
17.	*Ficus semicordata*	Drooping fig	Anti-oxidative and anti-bacterial activities	Kunwar et al.,2010
18.	*Ficus sycomorus*	Sycamore fig	Anti-bacterial,Anti-inflametry	Njoroge et al.,2007
19.	*Ficus virens*	White fig	Anti-Inflammatory activity	Krishna et al.,2014
20.	*Milicia excels*	African Teak	In vitro anti-oxidant staphylococcal Activity	Udegbunam et al.,2013
21.	*Morus nigra*	Black mulberry	Anti-oxidant activity.	Cakilcioglu et al.,2010
22.	*Ficus benjamina*	Weeping fig	Anti-microbial,anti-bacterial activity.	Kunwar et al.,2010

Table 3: Termites eating Animals.

Termite eating animals	**Common name**	**Scientific name**	**Reference**
Birds	Pileated woodpeckers	*Dryocopus pileatus*	Ruth de Jauregui
	Red-headed woodpecker	*Melanerpes erythrocephalus*	Ruth de Jauregui
	Toco toucan	*Ramphastos toco*	Ruth de Jauregui
	Yellow-rumped cacique	*Cacicus cela*	Ruth de Jauregui
	Marabou stork	*Leptoptilos crumeniferus*	Ruth de Jauregui
	Chickens	*Gallus domesticus*	Ruth de Jauregui
	Guinea fowl	*Numida meleagris*	Ruth de Jauregui

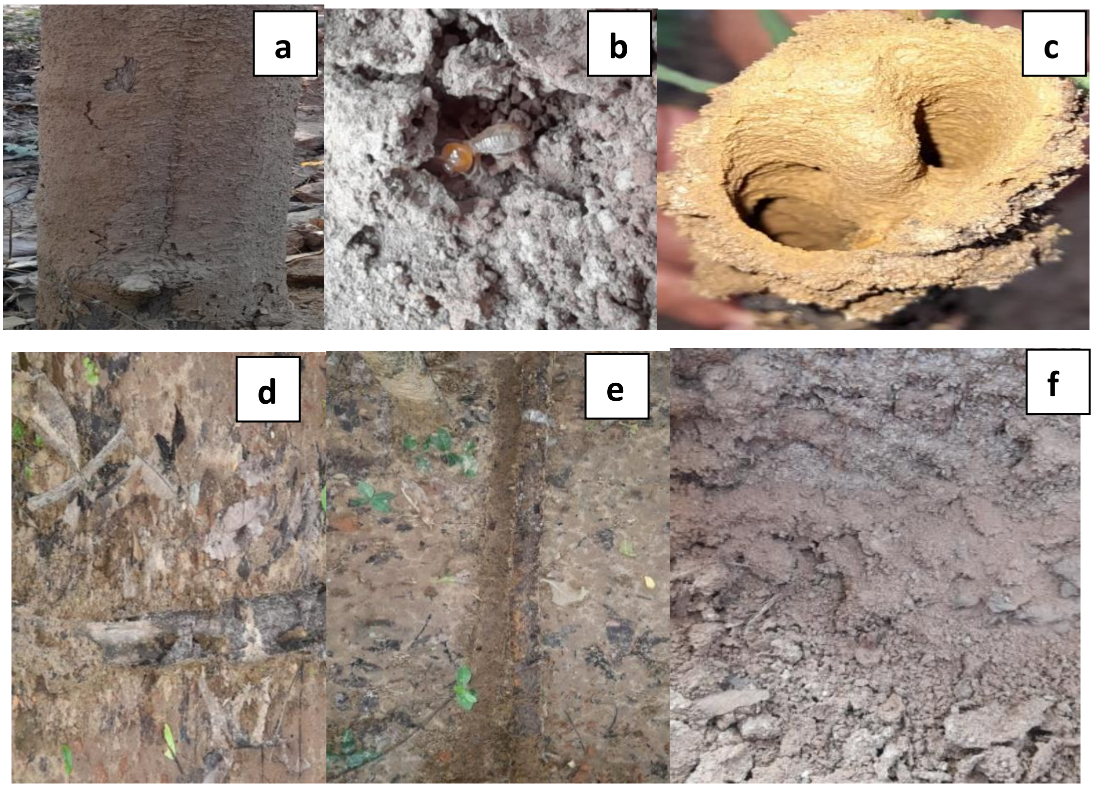
	Egyptian goose	*Alopochen aegyptiacus*	Ruth de Jauregui
	American robin	*Turdus migratorius*	Ruth de Jauregui
	Common yellow throat	*Geothlypis trichas*	Ruth de Jauregui
	Golden-crowned sparrow	*Zonotrichia atricapilla*	Ruth de Jauregui
	Bluebird	*Sialia Mexicana*	Ruth de Jauregui
Reptiles	Blind snake	*Indotyphlops braminus*	Keri Gardner
	Naked-toed geckos	*Gymnodactylus amarali*	Keri Gardner
	Armadillo *girdled lizard*	*Ouroborus cataphractus*	Keri Gardner
	Frill -necked lizard	*Chlamydosaurus kingi*	Keri Gardner
	legless lizard	*Lialis burtonis*	Keri Gardner
Mammals	Humans	*Homo sapiens*	Keri Gardner
	Civets	*Viverricula indica*	Keri Gardner
	Mongooses	*Herpestes edwardsi*	Keri Gardner
	Bats	*Desmodus rotundus*	Keri Gardner
	Echidna	*Tachyglossus aculeatus*	Keri Gardner
Insects	Spiders	*Achaearanea tepidariorum*	Paul Parsons, 2017
	Back ground Beetles	*Carabidae spp.*	Paul Parsons, 2017
	Wasps	*Vespa* spp.	Paul Parsons, 2017
	Praying Mantis	*Mantis religiosa*	Paul Parsons, 2017
	Fire ants	*Solenopsis spp.*	Paul Parsons, 2017

Table 4: Various Mathods for Termites Control.

Methods	Product Used	Effect	Termite Species	Reference
Synthetic Pesticides	Fipronil	More toxic	*R. flavipes*	Hu et al, 2005
	Indoxacarb	Toxic	*R. flavipes*	Hu et al, 2005
	Imidacloprid foam	Latent mortility	*C.formosanus*	Osbrink et al., 2005
	Boron compounds & borate	90% mortility	*C.acinaciformis*	Petres & Fitzgerald.,2006
	Isoborneol	Repellent	*Subterranean termites*	Blaske et al.,2003
Plant Natural Products	Flavanoids	Antifeedent	*C.formosanus*	Ohmura et al,2000
	Sophora flavescens contain alkaloids	Antifedent & repellent	*C.formosanus*	Mao & Henderson 2007
	Callitris glaucophylla	Repellent	*C.formosanus*	Watanabe et al.,2005
	Seeds of withania somnifera,coroton tiglium & Hygrophilia auriculata	Distrupt the activity of their gut	*Microtermes Obesi.*	Duke et al., 2010
	Leaf of Rhazya stricta Decne, Lantana camara	Antifedent	*Psammotermes hybostoma*	Yuan et al., 2012
	Azadirachta indica	100% mortality	*Macrotermes sp*	Duke et al., 2010
Microbial Control	Incistermes Scwarzi	Comulative mortality	*Drywood termite*	Calleri et al., 2010
	Isaria fumosorosea, Metarhizium anisopliae & Bacillus thuringiensis	100% Mortality	*C.formosanus*	Wright et al., 2012

Table 5: Pheromonal control of termites.

S. N.	Product in use	Effect	Against	References
1.	Trans-8-dodecatrienol &Z,Z E-3,6,8-dodecatrien-1-ol	Evoke trail-pheromones of Macrotermes annandalei	Trail pheromones of R. virginicus, R. speratus &R.santonensis	Raina et al.,2005
2.	Z- dodec-3 en-1-ol	Induces orientation & recruitment	Secreted by sternal glands of Macrotermes annandalei	Peppuy et al.,2001
3.	E-1-nitropentadec-1-ene & E-E-alpha-farnesene	Used for trapping termites	Secreted from pror-hinotermes canalifrons	Sobotnik et al.,2008
4.	norsesquiterpene alcohol (E)-2,6,10-trimethyl-5,9-undecadien-1-ol	Reflects Communication behaviour	Sternal glands of Mastotermes darwiniensis, Porotermes adamsoni and Stolotermes victoriensis	Sillam- Dusses et al, 2007
5.	Juvenogens	Disruption of the social structure and ultimately the death of the termite colony.	Zootermopsis angusticollis, Kalotermes flavicollis, Cryptotermes declivis, Reticulitermes santonensis and R flaviceps	Ivan Hrdy et al, 2004



Photograph 1 (a-f) showing plastering of green trees, termite worker inside mound, invaded tree, green biomass and digested soil.

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