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Effect of *in vitro* environmental conditions on the biological attributes of termite *Odontotermes wallonensis*

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Abstract
An investigation was carried out to assess and understand the effect of moisture, temperature and nutrients on the laying of eggs, hatching of nymphs and development of adults of a termite *Odontotermes wallonensis*. The results of the investigation clearly reveals that, all these environmental factors monitored and regulated in-vitro conditions were highly interdependent and effective individually. 40% moisture content and 20^{0}C temperature were found to be quite effective on the prominent egg laying attribute of *Odontotermes wallonensis*. However, during hatching of nymphs by the eggs 60% moisture content and 40^{0}C temperature were proved to be optimum. Development of adults from the nymphs of *Odontotermes wallonensis* was very healthy at 40% moisture content and 20^{0}C temperature. Further, the red soil of natural mound was found to be better nutrient, when compared to the fine saw mill powder for all the three biological attributes of *Odontotermes wallonensis.*

Keywords: Moisture, Temperature, Nutrient, Biological attributes of Termites

INTRODUCTION

Termites are small, white or black insects and cause severe destruction to wooden structures. They belong to the insect order Isoptera, an ancient insect group that dates back more than 100 million years. Although many people think termites have only negative impacts, in nature they make many positive contributions to the world's ecosystems. Their greatest contribution is the role they play in recycling of wood and plant materials. Their tunneling efforts also help to ensure that soils are porous, contain nutrients and are healthy enough to support plant growth. Termites are very important in the desert regions where their activity helps to reclaim soils damaged by drying heat and wind and the overgrazing by livestock (Noble et al., 2009). Termites become a problem when they consume structural lumber. Termite pests include dry wood, damp wood, and subterranean species. These pests cause serious damage to wooden structures and posts and may also attack stored food, books and household furniture. Physically the largest individual is the queen. Her function is to lay eggs, sometimes thousands in a single day. A king is always by her side. Other individuals have large heads with powerful jaws or a bulblike head that squirts liquid. These individuals are called soldiers. But the largest group of termites in a colony is the workers. They toil long hours tending the queen, building the nest or gathering food. While other species of social insects have workers, termites are unique among insects in that workers can be male or female. Surprisingly, termites can be long-lived: queens and kings can live for decades while individual workers can survive for several years (Noble *et al.,* 2009)**.**

Termites are eusocial insects, that is, insects live in colonies composed of individuals (i) from more than one generations (e.g., Parents and off springs) (ii) Presenting cooperative care of the young and (iii) Showing reproductive division of labor. Termites colonies are normally composed of a reproductive pair (King and Queen) and their offspring comprising thousands of non reproductive individuals. Eventually, the reproductive pair originates reproductive off springs, which swarm out of the nest to establish a new colony. A termite colony, therefore, can be grouped in to morphological 'castes', which can be reproductive (king, queen and their reproductive off springs) or sterile (workers and soldiers) **(**Freymann *et al.,* 2008**).**

Feeding habits of termites are distinctive in that species partitions themselves along the decomposition continuum, feeding not only on wood as dictated by current notion, but on items ranging from living plants and trees at one extreme to highly dispersed organic material in the soil at the other. Interestingly, termites do not restrict themselves to directly derived plant food but can also feed on animal products such as dung, mammalian hooves and even fresh mammalian carcasses **(**Og DeSouza *et al.,* 2011**).**

Subterranean termites require moist environments (Whitford *et al.,* 1999). To satisfy this need, they usually nest in or near the soil and maintain some connection with the soil through tunnels in wood or through shelter tubes they construct. These shelter tubes are made of soil with bits of wood or even plasterboard (drywall). Much of the damage they cause occurs in foundation and structural support wood. Because of the moisture requirements of subterranean termites, they are often found in wood that has wood rot. Most termite species swarm in late summer or fall, although spring swarms are not uncommon for subterranean and dry wood termites (Jouquet *et al.,* 2006). An infestation begins when a mated pair finds a suitable nesting site near or in wood and constructs a small chamber, which they enter and seal. Soon afterward, the female begins egg laying, and both the king and queen feed the young on predigested food until they are able to feed themselves. Most species of termites have microscopic, one-celled animals called

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protozoa within their intestines that help in converting wood (cellulose) into food for the colony (Radek , 1999). Once workers and nymphs are produced, the king and queen are fed by the workers and cease feeding on wood. Termites go through incomplete metamorphosis with egg, nymph and adult stages. Nymphs resemble adults but are smaller and are the most numerous stage in the colony. They also groom and feed one another and other colony members. Being susceptible to desiccation (Lewis, 2001), termites require a continual supply of moisture and maintain their nests at nearly 100% humidity. They use moisture from the soil to maintain the colony's humidity and evaporation to regulate its temperature between 25^{0}C and 36^{0}C, depending upon the species and prevailing weather conditions. Subterranean termites can survive without soil contact, but must have an assured and constant moisture supply. Termites favor decaying wood in moist situations within which to establish colonies as it provides them with protein and moisture **(**Brian *et al.,* 1965**).**

In view of the rich biodiversity of red soils and unique ecological conditions, the present investigation was carried out limiting to the selected biogeographical locations of Bidar district, north eastern part of Karnataka, India. Two important termites namely *Odontotermes wallonensis* and *Odontotermes brunneus* from the soils of mounds located in the region have been reported (Bhurli Prahlad *et al.,* 2010). In the present paper, effect of important in vitro environmental conditions such as moisture, temperature and nutrients on the biological attributes of a termite *Odontotermes wallonensis* have been presented and discussed.

MATERIALS AND METHODS

A prominent termite namely *Odontotermes wallonensis* reported (Bhurli *et al.,* 2010) earlier at our research laboratory from the mounds of red soils of Bidar district was employed in the study. Identified and established king and queens of respective termite were made to copulate in the laboratory conditions and further observations were carried out for their biological attributes. Various levels of moisture content 30, 40, 50, 60, 70 and 80 % were maintained and regulated throughout the experimental study. Adequate size of normal filter papers was used to achieve the required moisture content with sterile tap water. The temperature in the range of 15, 20, 25, 30, 35 and 40^{0}C were operated to study their effect on the important biological attributes of the termite. BOD incubator, normal incubator and open aseptic chamber were used to monitor and regulate the ranges of temperature required for the study. Quantities of laying eggs, emergence of nymphs from the eggs and development of adults from the nymphs, in terms of percentage were the three major biological attributes observed and recorded. Both the qualitative and quantitative components of biological attributes were considered in the estimation of percentage. The fine saw mill powder (N1-SP), the fine soil of mound red soil (N2-RS) and combination of these two (N3-SPRS) were also employed as nutrients (N) in the study. All the experiments were designed and carried out in shallow and wide glass trays and petri dishes. All the percent values were the average mean of three experimental observations.

RESULTS AND DISCUSSION

In any given ecosystem, the living beings will continuously keep interacting with the prevailing environmental conditions. A mound is a typical habitat constituting several beings, predominantly variety of termites with unique surrounding environmental conditions (Og DeSouza *et al.,* 2011). major biological attributes such as growth, metabolism, reproduction and several such other attributes are naturally under the influence of prevailing environmental conditions. Moisture, temperature and nutrients obviously would be the strong influencing abiotic conditions on the living beings.

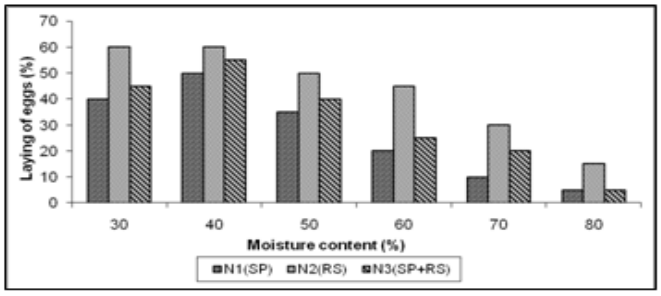

Fig1.Effect of moisture content on laying of eggs by *Odontotermes wallonensis*

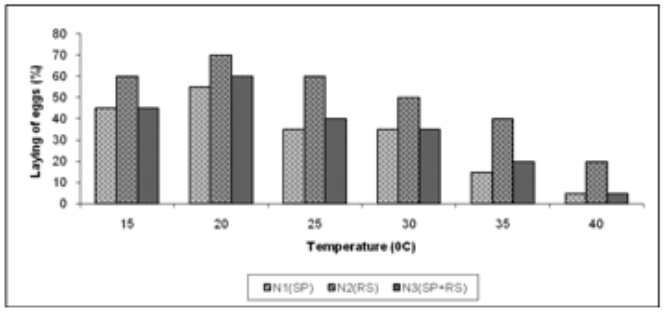

Fig 2. Effect of temperature on laying of eggs by *Odontotermes wallonensis*

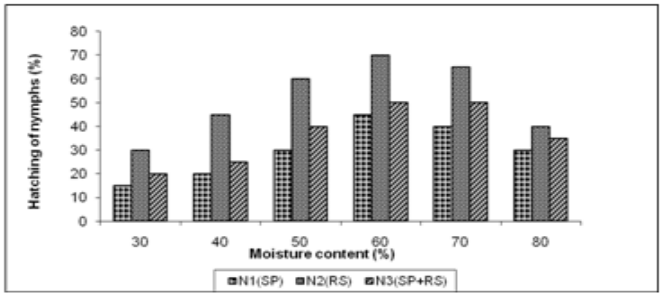

Fig 3. Effect of moisture content on hatching of nymphs by the eggs of *Odontotermes wallonensis*

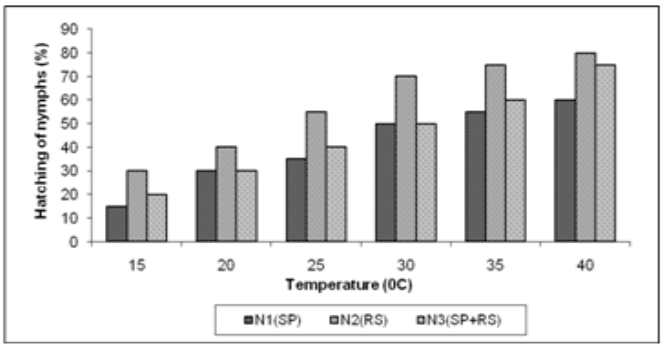

Fig 4. Effect of temperature on hatching of nymphs by the eggs of *Odontotermes wallonensis*

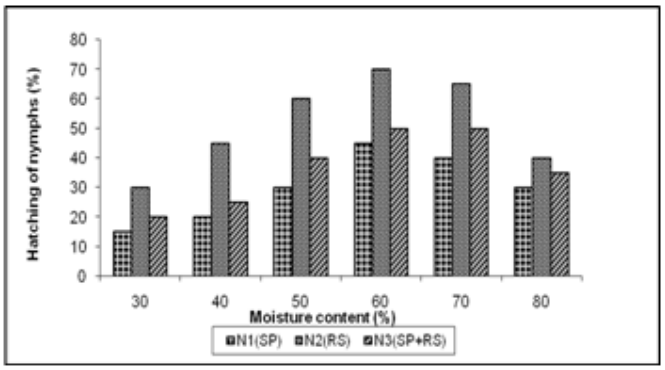

Fig 5. Effect of moisture content on development of adults from the nymphs of *Odontotermes wallonensis*

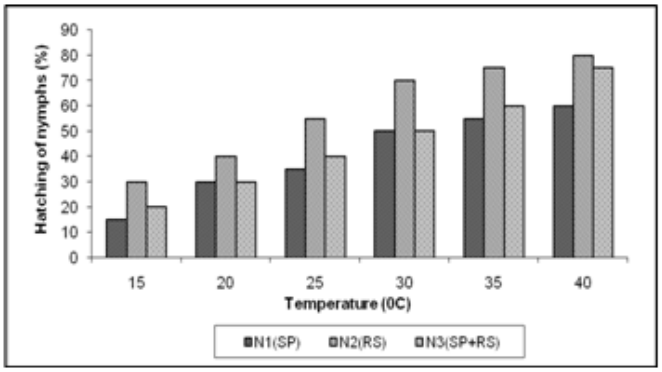

Fig 6. Effect of temperature on development of adults from the nymphs of *Odontotermes wallonensis*

In the present study, an attempt was made to study the effect of moisture, temperature and different types of nutrients on three major biological activities such as, egg laying pattern, hatching of nymphs and development of adults *Odontotermes wallonensis.* The effect of moisture content and temperature on egg laying pattern by *Odontotermes wallonensis* are as presented in figure 1 & 2, respectively. The effect of moisture and temperature on the egg laying attribute was studied in presence of three different nutrients like saw mill powder (N1-SP), red mound soil (N2-RS) and combination of the both nutrients (N3-SP+RS). The observations recorded clearly reveals that 40% moisture content and temperature of 20^0C were effective and optimum for the prominent and maximum laying of eggs by *Odontotermes wallonensis*. Similarly, the effect of moisture and temperature in the presence of three different nutrients on the hatching of nymphs by the eggs of *Odontotermes wallonensis* was also examined and the observations presented in figure 3 & 4, respectively. 60% moisture content and 40^0C temperature were found to be very effective on the hatching of nymphs by the eggs. The higher moisture content and the temperature are expected to rise humidity in the surrounding environment of the eggs to ensure the early hatching of nymphs by the eggs. However, the influence of level of humidity on hatching of nymphs required to be studied in depth. The development of adults from the nymphs of *Odontotermes wallonensis* under the influence of various levels of moisture and temperature as shown in figure 5 & 6 respectively. Unlike earlier observations, the moisture as less as 40% and temperature as low as 20^0C were found to be optimum for the development of healthy adults from the nymphs of *Odontotermes wallonensis.*

In all, the result considerably reveals that, varied levels of moisture and temperature were effective on the different biological attributes of *Odontotermes wallonensis.* High variations in the physiological and metabolic activities of *Odontotermes wallonensis,* at different growth stages, naturally expected to be influence under varied moisture and temperature levels. Termites species have been classified in to at least four 'feeding groups' or 'functional taxonomic groups', according to the portion of the humification gradient they feed on, Wood and grass feeders - Group I: Lower Termites (that is non termitidae) feeding on dead wood and grass; Litter Feeders - Group II: Termitidae with a range of feeding habits including dead wood, grass, leaf litters, micro-epiphytes, fungus comb and conidia; Soil wood Feeders - Group III: Termitidae feeding in the organic rich upper layers of the soil, presumably feeding on the soil wood interface; and Soil Feeders - Group IV: Termitidae which are called 'true-soil-feeders', ingesting apparently mineral soil to feed on organic maters usually found highly dispersed there in. Based on the nutrient pattern observed in the present investigations, at different levels of moisture and temperature, the termite *Odontotermes wallonensis* was categorized under group IV as, true-soil-feeders.

Krishna and Weesner (1969 and 1970) and Abe *et al.,* (2012) have investigated the different biological attributes of termites under varied environmental conditions but, the effect of moisture, temperature and nutrients together under in-vitro conditions on *Odontotermes wallonensis* is a different approach and quite interesting. However, various aspects investigated have been attended and answered only partially and required further detailed investigations. The total effect of these environmental conditions on the biological attributes is not only complex but puzzling and remains a fascinating area of research.

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