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# Mortality of the subterranean termite, *Odontotermes redemanni* (Wasmann) tested against four different species of entomopathogenic nematodes (EPNs)

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**Abstract**
In the present studies, a termite species *Odontotermes redemanni* (Wasmann), was tested against four different species of EPNs namely, *Steinernemacarpocapsae*, *S. glaseri*, *Heterorhabditis indica* and *H.bacteriophora* at concentrations of 1.00 µL, 5.00 µL and 10.00 µL having approximately 75, 150 and 300 IJs-plate$^{-1}$ respectively along with untreated control on both workers and soldiers under 5 replications. Result indicated that *H. indica* at 5.00 µL (150 IJs-plate$^{-1}$) showed significant performance in killing the termite workers and soldiers termite *O. redemanni*. Soldiers were more susceptible than workers. The sequence of virulence of EPNs observed was *H. indica*> *S. glaseri*> *H. bacteriophora*> *S. carpocapsae* for both workers and soldiers. All the EPNs were effective at 5.00 µl concentration *i.e.* 150 IJs-plate$^{-1}$ but among them, *H. indica* performed best as it was comparatively more virulent than rest.

**Keywords:** Entomopathogenic nematodes, *Odontotermes redemanni*, infective juveniles, virulence, subterranean termites, isoptera, mortality

## Introduction

Termites sometimes also called “white Ants” and they are social insects belong to the order “Isoptera” and include more than 3500 species described in the world (Baïmey, 2017) [9]. Isoptera in Latin means “equal wings” which means that the fore wings are similar in size and shape with the hind wings. The first truly scientific work on termites was carried out in India by J. G. Conig in 1779. The presence of termites in any locality or in any field area is often not readily noticed because of hidden activities. They are herbivores as well as decomposers and feeds on a wide range of living, dead or decaying plant materials (Bignell and Eggleton 2000; Traniello and Leuthold 2000) [10, 11]. On the basis of their habitat, termites can be grouped into three general categories; (a) Subterranean termites, (b) Damp-wood termites and (c) Dry-wood termites (Paul and Rueben 2005) [13]. Subterranean termites live in the soil and wood that is in contact with soil. Damp-wood termites and dry-wood termites live inside the wood having decayed and moisture content at different levels.

Termite *Odontotermes redemanni* is a higher class termite belongs to genus *Odontotermes* and are subterranean type belonging to the family Termitidae. They are majorly mound building species and commonly as fungus growing termites. They construct their mounds (termitorium) during November to March when rainfall and when the temperature is low. They are known to be native from India and Sri Lanka. They also recorded as a majorly damaging pest on sugarcane, tea and wheat. In their colonies, there are generally three types of castes, (a) workers (collect foods, groom and feed to other colony members, construct and repair the nests), (b) soldiers (primary function is to defence) (c) reproductives (reproduction, dispersal and colony formation). Workers and soldiers are sterile castes, where as reproductives only are fertile. Reproductives have hardened pigmented body and large compound eyes. In some species, termite workers and soldiers are dimorphic with larger individuals called as major workers and soldiers and smaller ones called as minor workers and soldiers. Some species have trimorphic soldiers. Both soldiers and workers are usually lacking eyes. The food of termites are cellulose, which is digested by lower castes and they have symbiotic protozoans which live anaerobically in their hind gut for the digestion of cellulose. The termite depends entirely on protozoans for cellulose digestion. *Odontotermes* spp. maintained fungus gardens in their colony.

## Materials and Methods

Four different species of entomopathogenic nematodes *viz, Heterorhabditis indica, H. bacteriophora, Steinernema carpocapsae* and *S. glaseri* were used for testing the mortality of *O. redemanni* workers and soldiers separately. Petriplates with Whatman No. 42 filter papers were sterilized. The termite workers and soldiers were exposed to infective juveniles of all four entomopathogenic nematodes, in following concentrations *i.e.*1.00 µl, 5.00 µl and 10.00 µl with having approx. 75, 150 and 300 IJs respectively along with 1 ml distilled water for dilution by following the filter paper exposure method (Woodring and Kaya, 1988) [5]. 15 numbers of each termite workers and soldiers were taken for experiment and placed in a petriplate lined with filter paper. IJs were inoculated in different concentrations and covered the lid of petriplate with parafilm and kept in room temperature (26±2$^{0}$C) and regular monitoring were done at timely intervals *i.e.* after 24 hrs, 48 hrs, 72hrs, 96 hrs and 120 hrs respectively to check the mortality.

## Result and Discussion

The study revealed that, *H. indica* killed both termite workers and termite soldiers more efficiently when compared to other EPNs. In the present study it was found that, 100 % mortality was recorded just after 72 hrs in case of *H. indica*. For *S. carpocapsae*, 100% mortality were recorded after 96 hrs and for *H. bacteriophora* and *S. glaseri* 100 % mortality was found after 120 hrs of inoculation. After 24 hrs, maximum mortality found at 10.00 µl concentration for all the EPNs in both workers and soldiers but later recorded mean mortality was high at 5.00 µl concentration (as shown in Table. 1). The sequence of virulence of EPNs found in the present study was similar for both workers and soldiers as *H. indica*>*S. carpocapsae*>*S. glaseri*> *H. bacteriophora*. At 5.00 µl concentration, all the EPNs gave its maximum kill while for *H. bacteriohpora* maximum mortality was recorded at higher dose *i.e.* 10.00 µl (300 IJs-plate$^{-1}$) for workers but for soldiers it performs best at 5.00 µl (150 IJs-plate$^{-1}$)concentration level. Similar results were reported by Wang *et al.* (2002) [3], who tested the mortality of two subterranean termites, *Reticulitermes flavipes* and *Coptotermes vastator* in the laboratory against four EPN species, *S. carpocapsae*, *S. riobrave, H. indica* and *H. bacteriophora* and found that *H. indica* were more virulent than *H.bacteriophora.* In the present study, it is also found that soldiers were more susceptible than workers. As per the data presented in Table 2, results reveal that fastest complete mortality (100 %) was recorded at 72 hrs in case of soldiers in all the three doses tested in *H. indica* where as among the other species of termites only *S. carpocapsae* recorded 100.00% mortality at 96 hrs *S. glaseri* and *H. bacteriophora* were slow showing complete mortality after 120 hrs. Our findings support those presented by Mankowski *et al.* (2005) [1], who also found higher mortality in soldiers as compared to workers of termite species *Coptoptermes formosanus*. Which may be due to grooming behaviour of workers reduced EPN attachment and hence less mortality were recorded. Rath (2000) [7] also found that soldiers of *Nasutitermes exitiosus* (Hill) as more susceptible to entomopathogenic fungus than workers. In replicated plates containing worker termites, it was found also that live termites surrounds off dead termites by filter paper particles in this test. This walling off behaviour of dead termites by live worker termites may also provide mechanism for less EPN infection. May be due to this behaviour of worker termites protect EPN infection in the colony (Fujji, 1975). Thus, in field level of application using of EPNs against termites does not give satisfactory results as expected.

**Table 1:** Percent mortality by four different species of EPNs in termite workers of *O. redemanni* (Wasmann)

| Treatments | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **EPN Sp.** | ***Steinernema carpocapsae*** | | | ***S. glaseri*** | | | ***Heterorhabditis indica*** | | | ***H. bacteriophora*** | | | **Control** |
| **Conc.→ Time interval↓** | **1 µL (75 IJs)** | **5 µL (150 IJs)** | **10 µL (300 IJs)** | **1 µL (75 IJs)** | **5 µL (150 IJs)** | **10 µL (300 IJs)** | **1 µL (75 IJs)** | **5 µL (150 IJs)** | **10 µL (300 IJs)** | **1 µL (75 IJs)** | **5 µL (150 IJs)** | **10 µL (300 IJs)** | |
| 24 hrs | 69.33$^{b}$ (56.49) | 84.00$^{a}$ (66.49) | 89.33$^{a}$ (71.39) | 68.00$^{c}$ (55.59) | 64.00$^{c}$ (53.12) | 76.00$^{b}$ (60.89) | 77.33$^{c}$ (61.71) | 82.67$^{b}$ 65.46) | 84.00$^{b}$ (66.75) | 49.48$^{d}$ (42.37) | 72.00$^{c}$ (58.12) | 84.00$^{b}$ (66.88) | 00.00 |
| 48 hrs | 90.67$^{b}$ (72.42) | 96.00$^{a}$ (81.03) | 96.00$^{a}$ (82.71) | 77.33$^{b}$ (61.72) | 81.33$^{a}$ (64.56) | 84.00$^{a}$ (66.88) | 93.33$^{a}$ (76.71) | 96.00$^{a\ b}$ (81.04) | 97.33$^{ab}$ (84.03) | 81.40$^{b}$ (67.15) | 86.67$^{b}$ (68.81) | 94.67$^{a}$ (79.71) | 13.33 |
| 72 hrs | 97.33$^{a}$ (84.003) | 98.67$^{a}$ (87.001) | 98.67$^{a\ b}$ (87.001) | 90.67$^{a}$ (74.13) | 93.30$^{a}$ (78.42) | 93.33$^{ab}$ (76.72) | 100.00$^{d}$ (90.00) | 100.00$^{d}$ (90.00) | 100.00$^{d}$ (90.00) | 84.00$^{b}$ (69.23) | 93.33$^{ab}$ (76.71) | 98.67$^{a}$ (87.00) | 13.33 |
| 96 hrs | 100.00$^{d}$ (90.00) | 100.00$^{d}$ (90.00) | 100.00$^{d}$ (90.00) | 94.67$^{a}$ (79.71) | 98.67$^{ab}$ (87.01) | 98.67$^{ab}$ (87.00) | 100.00$^{d}$ (90.00) | 100.00$^{d}$ (90.00) | 100.00$^{d}$ (90.00) | 94.67$^{ab}$ (79.71) | 98.67$^{a}$ (87.00) | 98.67$^{a}$ (87.00) | 20.00 |
| 120 hrs | 100.00$^{e}$ (90.00) | 100.00$^{e}$ (90.00) | 100.00$^{e}$ (90.00) | 100.00$^{e}$ (90.00) | 100.00$^{e}$ (90.00) | 100.00$^{e}$ (90.00) | 100.00$^{d}$ (90.00) | 100.00$^{d}$ (90.00) | 100.00$^{d}$ (90.00) | 100.00$^{f}$ (90.00) | 100.00$^{f}$ (90.00) | 100.00$^{f}$ (90.00) | 20.00 |
| C.D. (at 5%) | 6.03 | 6.51 | 7.91 | 8.64 | 8.08 | 7.80 | 5.64 | 5.15 | 5.75 | 17.86 | 8.26 | 8.85 | NS |
| S.E. (m)± | 2.03 | 2.19 | 2.66 | 2.91 | 2.72 | 2.62 | 1.90 | 1.73 | 1.93 | 6.01 | 2.78 | 4.21 | NS |

*The values showed in brackets are sine transformed values.
*the similar alphabets in mean rows have shown not significant differences from each other.

**Table 2:** Comparative percent mortality by four different species of EPNs in termite soldiers of *O. redemanni* (Wasmann)

| Treatments | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **EPN Sp.** | ***Steinernema carpocapsae*** | | | ***S. glaseri*** | | | ***Heterorhabditis indica*** | | | ***H. bacteriophora*** | | | **Control** |
| **Conc.→ Time interval↓** | **1 µL (75 IJs)** | **5 µL (150 IJs)** | **10 µL (300 IJs)** | **1 µL (75 IJs)** | **5 µL (150 IJs)** | **10 µL (300 IJs)** | **1 µL (75 IJs)** | **5 µL (150 IJs)** | **10 µL (300 IJs)** | **1 µL (75 IJs)** | **5 µL (150 IJs)** | **10 µL (300 IJs)** | |
| 24 hrs | 62.70$^{c}$ (52.35) | 69.33$^{c}$ (56.55) | 70.67$^{b c}$ (57.32) | 61.33$^{c}$ (51.60) | 66.67$^{c}$ (54.79) | 76.00$^{b}$ (56.38) | 81.33$^{b}$ (64.75) | 80.00$^{b}$ (63.53) | 86.67$^{a b}$ (68.81) | 68.00$^{c}$ (55.58) | 77.33$^{b}$ (61.72) | 80.00$^{b c}$ (63.53) | 00.00 |
| 48 hrs | 73.30$^{b}$ (58.95) | 77.33$^{b}$ (61.79) | 84.00$^{bc}$ (66.49) | 77.33$^{b}$ (61.72) | 78.67$^{b}$ (62.62) | 84.00$^{ab}$ (64.56) | 94.67$^{a b}$ (78.00) | 96.00$^{a}$ (81.00) | 96.00$^{a}$ (82.71) | 80.00$^{b}$ (63.53) | 85.33$^{b}$ (67.52) | 90.67$^{a b}$ (74.13) | 13.33 |
| 72 hrs | 96.00$^{a}$ (81.02) | 97.33$^{a}$ (84.01) | 98.67$^{a}$ (87.00) | 94.67$^{a b}$ (79.71) | 94.67$^{a b}$ (79.71) | 93.33$^{a b}$ (78.00) | 100.00$^{d}$ (90.00) | 100.00$^{d}$ (90.00) | 100.00$^{d}$ (90.00) | 88.00$^{a b}$ (69.84) | 94.67$^{a b}$ (79.71) | 94.67$^{a b}$ (79.71) | 13.33 |
| 96 hrs | 100.00$^{d}$ (90.00) | 100.00$^{d}$ (90.00) | 100.00$^{d}$ (90.00) | 98.67$^{a}$ (87.00) | 98.67$^{a}$ (87.00) | 98.67$^{a}$ (87.00) | 100.00$^{e}$ (90.00) | 100.00$^{e}$ (90.00) | 100.00$^{e}$ (90.00) | 97.33$^{a}$ (84.00) | 98.67$^{a}$ (87.00) | 98.67$^{a}$ (87.00) | 20.00 |
| 120 hrs | 100.00$^{e}$ (90.00) | 100.00$^{e}$ (90.00) | 100.00$^{e}$ (90.00) | 100.00$^{d}$ (90.00) | 100.00$^{d}$ (90.00) | 100.00$^{d}$ (90.00) | 100.00$^{f}$ (90.00) | 100.00$^{f}$ (90.00) | 100.00$^{f}$ (90.00) | 100.00$^{d}$ (90.00) | 100.00$^{d}$ (90.00) | 100.00$^{d}$ (90.00) | 20.00 |
| C.D. Value | 5.61 | 6.86 | 5.17 | 7.92 | 7.80 | 6.28 | 5.36 | 5.28 | 6.55 | 5.91 | 7.60 | 9.17 | NS |
| S.E. (m)± | 1.88 | 2.31 | 1.74 | 2.66 | 2.62 | 2.11 | 1.80 | 1.77 | 2.20 | 1.99 | 2.56 | 3.08 | NS |

*The values showed in brackets are sine transformed values.

*the similar alphabets in mean rows have shown not significant differences from each other.

## Conclusion

The present results proved that EPNs can be an eco-friendly component of biocontrol in management of termites. Further studies are required on formulations and methods of application at field level.


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## References


1. Mankowski ME, Kaya HK, Kenneth Grace J, Sipes B. Differential susceptibility of subterranean termite castes to entomopathogenic nematodes. Biocontrol Science and Technology. 2005;15(4):367-377.
2. Muthulakshmi M, Kumar S, Subramanian S. Biology of entomopathogenic nematodes Heterorhabditis sp. and Steinernema spp. Journal of Biopesticides. 2012;5:60.
3. Wang C, Powell JE, Nguyen K. Laboratory evaluations of four entomopathogenic nematodes for control of subterranean termites (Isoptera: Rhinotermitidae). Environmental entomology. 2002;31(2):381-387.
4. https://www.britannica.com. Termite – natural history – Encyclopedia Britannica.
5. Woodring JL, Kaya HK. Steinernematid and heterorhabditid nematodes: A handbook of biology and techniques. Southern cooperative series bulletin (USA), 1988.
6. Fujii JK. Effects of an entomogenous nematode *Neoaplectana carpocapsae* Weiser, on the Formosan subterranean termite, *Coptotermes formosanus*. PhD thesis, University of Hawaii, Honolulu, 1975.
7. Rath AC. The use of entomopathogenic fungi for control of termites. Biocontrol Science and Technology. 2000;10(5):563-581.
8. Zadji L, Baimey H, Afouda L, Moens M, Decraemer W. Comparative susceptibility of *Macrotermes bellicosus* and *Trinervitermes occidentalis* (Isoptera: Termitidae) to entomopathogenic nematodes from Benin. Nematology, 2014;16(6):719-727.
9. Baïmey H, Zadji L, Afouda L, Fanou A, Kotchofa R, Decraemer W. Searching for Better Methodologies for Successful Control of Termites Using Entomopathogenic Nematodes. Nematology-Concepts, Diagnosis and Control, 2017, p.53.
10. Bignell DE, Eggleton P. Termites in ecosystems. In: Abe T, Bignell DE, Higashi M (eds) Termites: evolution, sociality, symbioses, ecology. Kluwer Academic Publications, Dordrecht, 2000, pp 363-387.
11. Traniello JFA, Leuthold RH. Behavior and ecology of foraging in termites. In: Abe T, Bignell DE, Higashi M (eds) Termites: evolution, sociality, symbioses, ecology. Kluwer, Dordrecht, 2000, p 141-168.
12. Culliney TW, Grace JK. Prospects for biological control of subterranean termite (Isoptera: Rhinotermitidae), with special reference to *Coptotermes formosanus.* Bull Entomol Res. 2000;90:9-21.
13. Paul BB, Rueben JM. Arizona termites of economic importance. University of Arizona Press, Tucson, AZ, 2005, 9-17.