

Differences in survival and feeding activity among colonies of the Formosan subterranean termite (Isoptera, Rhinotermitidae)

By NAN-YAO SU and J. P. LA FAGE

Abstract

Eight field-collected colonies of the Formosan subterranean termite, *Coptotermes formosanus* Shiraki, were used to determine intraspecific variation for two commonly measured response variables reported in laboratory bioassays. Survival among 5 vigorous colonies varied from 76.4–87.5 % but was less than 20 % in 3 weak colonies at the end of 8-week feeding trials. Wood consumption by the vigorous colonies was significantly greater than by weak colonies (39.74–78.48 mg/g/day vs. 23.80–44.67 mg/g/day). A significant negative correlation was observed between mean worker biomass and wood-consumption rate ($r = -0.82$; $P < 0.05$). It is concluded that a minimum of 3 source colonies should be used in bioassays and that colony origin should be incorporated into the experimental design of such experiments.

1 Introduction

Mortality and wood-consumption are response variables commonly measured in laboratory experiments with termites. Both are affected by a number of extrinsic and intrinsic factors including temperature (BECKER 1969; HAVERTY and NUTTING 1974), humidity (GAY et al. 1955; ESENTER 1977; LENZ et al. 1982), group and container size (GAY et al. 1955; LENZ and WILLIAMS 1980) and past feeding experience (BUTTERWORTH et al. 1966; McMAHAN 1966). There is mounting evidence that differences in colony vigor in the same or closely related populations may also contribute to variation in laboratory test results. GAY et al. (1955) reported significant differences in the vigor of colonies of *Coptotermes acinaciformis* (Frogg) and *Nasutitermes exitiosus* (Hill) and suggested that a control colony be used as a reference to overcome colony variation. SHIMIZU (1965) noted that colony differences in worker body weight, age and caste composition may affect the vitality of *Coptotermes formosanus* Shiraki. It has also been reported that differences in survival among colonies of *Reticulitermes flavipes* (Kollar) may not be evident until colonies are stressed by exposure to unfavorable foods (CARTER et al. 1972).

Despite these indications most laboratory studies with termites have been done with individuals taken from a single field colony (HAVERTY and NUTTING 1974; SMYTHE and CARTER 1970; MANNESMANN 1973, LENZ et al. 1982). This study was initiated to examine differences in survival and wood consumption among colonies of the Formosan subterranean termite, *C. formosanus*.

2 Materials and methods

2.1 Experimental

Eight colonies of *C. formosanus* were collected from an area near Lake Charles, Louisiana and held in 246-L cans in the laboratory at 22–24 °C for 2–4 months prior to testing. 192 experimental units (24/colony) were prepared, each consisting of a glass screw-top jar (5.0 cm diam. × 3.5 cm high) containing 30 ml of acetone-washed sand moistened with 60 ml of deionized water. Each was provisioned with a slash pine (*Pinus elliottii* Engelm. var *elliottii*) feeding block (1.8 × 1.8 × 1.8 cm), oven dried at 80 °C for 48 h and weighed prior to being buried in the sand substrate. 150 termites (120 workers and 30 soldiers) were added to each jar. Mean worker biomass (wet wt.) for each colony was determined prior to testing by weighing 5 groups of 10 individuals each. The experiment was carried out in an environmental chamber at 29 ± 1 °C. Three units were selected at random and disassembled at weekly intervals up to 8 weeks. Surviving termites were counted and the feeding blocks cleaned, oven dried and reweighed.

2.2 Data analysis

The number of live termites remaining in each experimental unit at each sampling date was plotted against time to evaluate survivorship of the 8 colonies. Wood-consumption rates (mg wood/termite/day) were computed for each of the eight colonies by the method described by SU and LA FAGE (in press) and subjected to an analysis of covariance. Significant differences in rates among colonies were separated by Student-Newman-Keuls' test at $P < 0.05$. Correlation analysis was used to examine the relationship between worker body weight and wood-consumption rate.

3 Results and discussion

3.1 Survival

Two patterns of survival were observed among the 8 colonies. In 5 (A, B, C, D and F), there was an initial decrease in termite numbers during the first three weeks of the test, possibly the result of handling individuals during transfer from the parent colonies to test units. After three weeks, these test populations stabilized in the range of 76.4–87.5 % of the original number introduced (table). In the 3 remaining colonies (E, G and H), the numbers of termites declined linearly throughout the experiment. In E all were dead at 4 weeks; in G and H 10–20 % remained alive at 8 weeks. These colonies were clearly less vigorous than the others. The possible reasons for low vigor are many and may relate to colony age, disease, or other intrinsic factors. No attempt was made to determine the cause for decreased vigor in this study.

Only vigorous colonies should be used in laboratory bioassays. With this species we consider colonies with a survival rate greater than 80 % at eight weeks to be "vigorous". Colonies which achieved that level had stabilized populations from the third to eight weeks of the feeding trials. An additional reason for accepting only colonies with greater than 80 % survival arises from the consideration of statistical limitations of Abbott's formula for correction of control mortality (BUSVINE 1971). The American Wood-Preserver's Association standard method for laboratory evaluation to determine resistance to subterranean termites (ANON. 1972) does not set an acceptable level of survival for termites in control units while the European Committee for Standardization requires at least 50 % survival in control groups (ANON. 1980).

Differences in survival, mean worker biomass and wood-consumption rate among 8 colonies of the Formosan subterranean termite

Colony	Survivorship*	Mean worker biomass		Wood-consumption
	(%)	\bar{X}	SD	rate** (mg/g/day)
A	87.5	2.03	.11	78.48a
B	83.3	2.40	.13	56.11b
C	85.5	2.88	.09	53.91b
D	76.4	2.48	.09	47.56c
E	—	2.19	.29	44.67cd
F	84.7	2.98	.25	39.74de
G	—	3.07	.15	35.14e
H	—	3.70	.11	23.80f

* Levels at which survivorship stabilized after 3 weeks. Survivorship of colonies E, G and H declined linearly. — ** Rates followed by the same letter were not significantly different by Student-Newman-Keuls' test ($P < .05$).

3.2 Wood-consumption rate

Wood-consumption rates (mg/g/day) by termites in the 8 colonies are presented in the table. Among the 5 vigorous colonies consumption varied from 39.74 to 78.48 mg/g/day. In the colonies which failed to stabilize populations, the average consumption rate was lower ranging from 23.80 to 44.67 mg/g/day. The overlap of the ranges suggests that there are factors that affect consumption and are independent of survival.

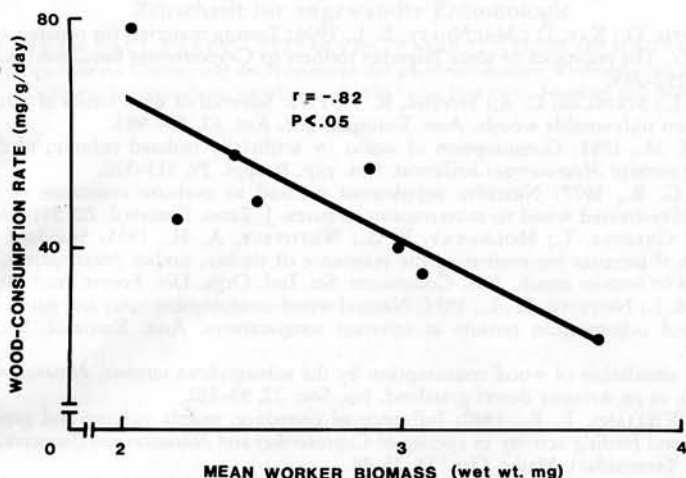
WOOD (1978) listed the wood-consumption rates of 21 termite species which varied from 2.0–90.8 mg/g/day. All of the data presented were obtained from single colonies with 9 falling into the range observed for *C. formosanus*. To date, only COLLINS (1981) has used different colonies to determine wood-consumption rates. He reported a wide range in wood consumption (90–150 mg/g/day) among colonies of *Macrotermes bellicosus* (Smeathman). These data agree with our findings of high intraspecific variation in *C. formosanus* and suggest that the interspecific differences reported by WOOD (1978) might have been less significant if intercolony variation had been considered.

3.3 Mean worker biomass and wood-consumption rate

The mean worker biomass of termites in the 8 colonies varied from 2.0–3.7 mg (wet wt.) (table), a range nearly as great as reported for 7 rhinotermitids (1.9–3.7 mg) by WOOD (1978). We found a significant negative correlation ($r = -0.82$; $P < 0.05$) between worker biomass and consumption rate (fig.). Larger individuals consumed less wood and suffered greater mortality than smaller workers (table). This observation supports NAKAJIMA's (1960) conclusion that declining colonies produce larger and less vigorous termites.

The implications of our findings are significant for material and preservative testing with termites and for ecologists. If weak or declining colonies are used, the results may be misleading; treatments could be construed as efficacious when in fact they would not provide protection against vigorous colonies.

Feeding capabilities of termites have been established almost exclusively



Correlation between mean worker biomass and wood-consumption rate of 8 colonies of *C. formosanus*

from laboratory feeding trials (BODINE and UECKERT 1975; HAVERTY and NUTTING 1975). Consequently, estimates of detritus cycling in natural ecosystems based on single-colony laboratory data (WOOD 1978) may be subject to the same variation reported here for *C. formosanus*.

We suggest that termites from a minimum of 3 source colonies be used in laboratory bioassays and in field studies and that colony origin be incorporated into the experimental design as a blocking factor for the statistical analysis.

Zusammenfassung

Unterschiede in der Lebensdauer und Fraßaktivität zwischen Kolonien der Formosa-Termite, Coptotermes formosanus Shir.

Acht im Freiland gesammelte Kolonien von *C. formosanus* wurden im Labor auf ihre Lebensdauer und Fraßaktivität untersucht. Die Überlebensdauer von 5 vitalen Kolonien variierte zwischen 76,4 und 87,5 %, betrug aber weniger als 20 % bei 3 schwachen Kolonien, jeweils am Ende einer 8-wöchigen Fütterungsperiode. Der Holzverzehr bei den vitalen Kolonien war signifikant größer als bei den schwachen (39,8–78,5 mg/g/Tag gegenüber 23,8–44,7 mg/g/Tag). Eine signifikante Korrelation wurde zwischen der mittleren Arbeiter-Biomasse und der Holzverzehrtrate beobachtet ($r = -0,82$; $P < 0,05$). Es wird der Schluß gezogen, daß derartigen Untersuchungen mindestens 3 Kolonien zugrunde gelegt werden und deren Herkunft bei der Versuchsplanung berücksichtigt werden sollten.

References

- ANONYMOUS, 1972: Standard method for laboratory evaluation to determine resistance to subterranean termites. Am. Wood-Preservers' Assoc. Standard. M 12–72.
- 1980: Determination of toxic values against *Reticulitermes santonensis* de Feytaud (Laboratory method). European Comm. for Standardization. Brussels.
- BODINE, M. C.; UECKERT, D. N., 1975: Effect of desert termites on herbage and litter in a shortgrass ecosystem in West Texas. *J. Range mgt.* 2, 353–358.
- BECKER, G., 1969: Rearing of termites and testing methods used in the laboratory. In: *Biology of Termites*. Vol. 1. Ed. by K. KRISHNA and F. WEESNER, p. 351–385. New York and London: Academic Press.
- BUSVINE, J. R., 1971: A critical review of the technique for testing insecticides. 2nd ed. Commomw. Inst. Entomol. London.

- BUTTERWORTH, D.; KAY, D.; MACNULTY, B. J., 1966: Testing materials for resistance to termite attack. IV. The resistance of some Nigerian timbers to *Cryptotermes havilandi* (Sjost). *Mater. Org.* 1, 257-269.
- CARTER, F. L.; STRINGER, C. A.; SMYTHE, R. V., 1972: Survival of six colonies of *Reticulitermes flavipes* on unfavorable woods. *Ann. Entomol. Soc. Am.* 65, 984-985.
- COLLINS, N. M., 1981: Consumption of wood by artificially isolated colonies of the fungus-growing termite *Macrotermes bellicosus*. *Ent. exp. & appl.* 29, 313-320.
- ESENTER, G. R., 1977: Nutritive supplement method to evaluate resistance of natural or preservative-treated wood to subterranean termites. *J. Econ. Entomol.* 70, 341-346.
- GAY, F. J.; GREAVES, T.; HOLDAWAY, F. G.; WETHERLY, A. H., 1955: Standard laboratory colonies of termites for evaluating the resistance of timber, timber preservatives, and other materials to termite attack. *Aus. Commonw. Sci. Ind. Orga. Div. Forest Prod. Bull.* 277.
- HAVERTY, M. I.; NUTTING, W. L., 1974: Natural wood-consumption rates and survival of a dry-wood and subterranean termite at constant temperatures. *Ann. Entomol. Soc. Am.* 67, 153-157.
- 1975: A simulation of wood consumption by the subterranean termite, *Heterotermes aureus* (Snyder), in an Arizona desert grassland. *Ins. Soc.* 22, 93-102.
- LENZ, M.; WILLIAMS, E. R., 1980: Influence of container, matrix volume and group size on survival and feeding activity in species of *Coptotermes* and *Nasutitermes* (Isoptera: Rhinotermitidae, Termitidae). *Mater. Org.* 15, 25-46.
- LENZ, M.; BARRETT, R. A.; WILLIAMS, E. R., 1982: Influence of diet on the survival and wood consumption of *Porotermes adamsoni* (Froggatt) (Isoptera: Termopsidae) at different temperature. *Bull. ent. Res.* 72, 423-435.
- MANNESMANN, R., 1973: Comparison of twenty-one commercial wood species from North America in relation to feeding rates of the Formosan termite, *Coptotermes formosanus* Shiraki. *Mater. Org.* 8, 107-120.
- MCMAHAN, E. A., 1966: Studies of termite wood-feeding preferences. *Proc. Hawaiian Entomol. Soc.* 19, 239-250.
- NAKAJIMA, S., 1960: Studies on the decline of the colonies of the Formosan termite. Report Tech. Inst. Japanese State Ownership Railway Co. (in Japanese).
- SHIMIZU, K., 1965: Analytical studies on the vitality of colonies of the Formosan termite, *Coptotermes formosanus* Shiraki. I. Analysis of the strength of vitality. *Bull. Fac. Agr. Univ. Miyazaki.* 8, 106-110.
- SMYTHE, R. V.; CARTER, F. L., 1970: Feeding responses to sound wood by *Coptotermes formosanus*, *Reticulitermes flavipes*, and *R. virginicus* (Isoptera: Rhinotermitidae). *Ann. Entomol. Soc. Am.* 63, 841-846.
- SU, N.-Y.; LA FAGE, J. P.: A comparison of laboratory methods for estimating wood-consumption rates by *Coptotermes formosanus* (Isoptera: Rhinotermitidae). *Ibid.* (in press).
- WOOD, T. G., 1978: The food and feeding habits of termites. In: *Production Ecology of Ants and Termites*. Ed. by M. V. BRIAN. Cambridge: Cambridge Univ. Press, p. 55-80.
- Author's address:* Dr. NAN-YAO SU, Dept. of Entomology, University of Hawaii, 3050 Maile Way, 310, Honolulu, HI 96822, USA

