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Increase in Biomass and Soldier Production for *Coptotermes formosanus* (Shiraki) Workers Maintained in the Laboratory up to Nine Months

by

Deborah A. Waller[1]

ABSTRACT

The factors that influence rates of soldier production in subterranean termites are poorly understood. In the present study, foraging groups of *Coptotermes formosanus* Shiraki were collected from baldcypress trees in Lake Charles, Lousiana, in November 1985, and February, April/May and August 1986. Termites were maintained in the laboratory for nine months, seven months, four/five months and zero months, respectively, and then examined for survivorship, termite biomass and soldier production after incubation for an additional five weeks at 30°C. Within collection periods, there was no association between survivorship and soldier production or between mean dry biomass and soldier production. However, termites maintained for longer periods in the laboratory had significantly greater survivorship, termite dry biomass and soldier production than recently collected termites. It is unclear whether termite age or season of collection influenced these results.

INTRODUCTION

Termite soldiers perform a number of tasks within the colony, but a primary role appears to be defensive (Waller & La Fage 1987a, 1987b). Soldier number varies significantly among termites, ranging from species with no soldiers to those with fifty percent soldiers (Haverty 1977). Within a species, caste ratios may vary seasonally, often with the highest proportion of soldiers coinciding with the reproductive flights or with periods of intense foraging activity (Howard & Haverty 1981, Watson & Abbey 1985).

Caste ratios appear to be maintained homeostatically within a colony, because removal of soldiers results in the differentiation of some of the workers into replacement soldiers (Haverty 1979). The present study examined soldier number in the Formosan Termite, *Coptotermes formosanus* Shiraki. These termites were collected from mature colo-

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nies in the field and maintained in the laboratory for varying periods of time. Young colonies of this species maintain a caste ratio of approximately ten percent soldiers under laboratory conditions (King & Spink 1974).

METHODS

Foraging groups of *Coptotermes formosanus* were collected from baldcypress trees, *Taxodium distichum* (L.), standing in the Calcasieu River in Lake Charles, Louisiana, in 1985-1986, in November, February, April/May and August. Prior to collections, plastic PVC pipe traps filled with cardboard were attached to holes drilled into the nests in the trees. These traps are readily entered by termites living within the trees (Waller & La Fage 1988a). Traps containing termites were collected after approximately one month and maintained in the laboratory at 22-24°C in gallon plastic containers until laboratory experiments were prepared on August 7, 1986. No reproductives were included in the collections, and no neotenic reproductives were found in these laboratory colonies in August when the experiment was performed. All workers were at least a month old at collection (Waller, personal observation). Therefore, the workers from these colonies that were used in the experiment in August were at least ten months old (November collection), seven months old (February collection), four-five months old (April/May collection) and one month old (August collection). For each colony (November collection – five colonies; February collection – three colonies; April/May collection – four colonies; August collection – six colonies), four experimental units of 100 workers each were assembled. Each unit consisted of a 35cc plastic vial containing a block of southern yellow pine wood, vermiculite and water. Units were maintained at 30°C for five weeks, and then workers and soldiers were counted to determine survivorship and soldier production. Termites were dried at 55°C for at least 48h and weighed to 0.1mg on an electronic balance to obtain dry biomass.

Kruskal-Wallis tests were used to examine differences among collection periods in termite survivorship, termite biomass and soldier production. Regression analyses on the relationship between soldier production and survivorship and between soldier production and termite dry weight were performed for the November and August samples because these collections contained the largest number of colonies. The proportion of soldiers produced and the proportion of termites that survived per unit were first transformed to the arcsin of the square root of the proportion before being subjected to analysis.

RESULTS

Survivorship

Termites kept for long periods of time in the laboratory had significantly greater survival than colonies kept for short periods of time (Kruskal-Wallis H, corrected for ties = 36.188, df = 3, $p < 0.01$). Survivorship was highest in termites collected in November (Table 1).

Table 1. *Coptotermes formosanus* survivorship during experimental period in August 1986, related to season of collection.

Collection month	Mean + SE % Survival
November 1985	87.2 ± 1.3 %
February 1986	80.5 ± 2.9 %
April/May 1986	53.8 ± 7.7 %
August 1986	59.7 ± 3.3 %

Termite biomass

Dry biomass per termite worker was highest for the February collection and lowest for the August collection (Kruskal-Wallis H, corrected for ties = 9.195, df = 3, $p < 0.01$). Workers from the November collection increased their biomass up to 56% over the nine months since collection (Table 2).

Table 2. *Coptotermes formosanus* dry weight during experimental period in August 1986, related to season of collection.

Collection month	Mean + SE Dry weight/10 termites (mg)
November 1985	7.9 ± 0.3 %
February 1986	9.3 ± 1.0 %
April/May 1986	7.6 ± 0.3 %
August 1986	6.7 ± 0.3 %

Soldier production

There were significantly more soldiers produced in colonies kept for long periods of time in the laboratory than for colonies kept shorter periods of time (Kruskal-Wallis H, corrected for ties = 21.733, df = 3, $p < 0.01$). Colonies collected in November produced an average of greater than eight per cent soldiers, while those collected in April/May and August produced an average of approximately three per cent soldiers (Table 3).

Table 3. *Coptotermes formosanus* soldier production during experimental period in August 1986, related to season of collection.

Collection month	Mean + SE % Soldiers
November 1985	8.3 ± 1.3 %
February 1986	5.4 ± 0.5 %
April/May 1986	2.9 ± 0.8 %
August 1986	3.2 ± 0.4 %

Regression analyses

Within collections, there was no association between survivorship and soldier production per unit (November: R2 = 0.020, df = 19, p = 0.5557; August: R2 = 0.001, df = 22, p = 0.8984). There was also no association between mean dry weight and soldier production per unit (November: R2 = 0.142, df = 19, p = 0.1015; August: R2 = 0.145, df = 22, p = 0.0734).

DISCUSSION

In these experiments *Coptotermes formosanus* maintained in the laboratory over a longer period of time produced more soldiers during the experimental period than termites kept for a shorter period. Colonies collected in fall produced twice as many soldiers during the five-week experiment as colonies collected in the spring and summer. It is unclear which factors were responsible for these results.

One explanation is that the workers maintained in the laboratory for several months were older than newly collected termites and therefore in some way more competent to differentiate into soldiers. The factors that influence termite workers to molt into soldiers are poorly known (Waller & La Fage 1988b). Older workers are likely to have greater biomass, but termite biomass did not appear to play a role in this study; there was no within-collection association between mean termite biomass and soldier production per experimental unit for either the November or August collections.

Perhaps the collection season had some effect on soldier differentiation. In several ant species, overwintering of larvae is important in caste differentiation (Brian 1979). Waller & La Fage (1988b) found that more soldiers *of Coptotermes formosanus* are produced at 30°C than at 25°C in laboratory trials. If high temperatures trigger soldier development, it is possible that in summer termites differentiate into soldiers as soon as they achieve a threshold age or size. Possibly the summer-collected workers that were selected for this experiment may have represented termites below a threshold age or size for competence. In contrast, winter-collected termites that experience low temperatures may have an opportunity to achieve greater age or size prior to warm spring temperatures that stimulate differentiation. Therefore a larger proportion of winter-collected termites might be competent to produce soldiers upon exposure to high temperatures. In a natural cycle, this developmental pattern would result in large numbers of soldiers produced in spring for the reproductive flights in April and May. In support of this scenario, Waller & La Fage (1988a) found that *C. formosanus* termites collected from traps in February through May had greater proportions of soldiers than those collected in November, and that mean termite dry weight was greatest in November and February and declined in April and May.

Much remains to be learned about colony developmental cycles and the regulation of soldier production in termites. Further studies on the factors that affect worker competence to differentiate into soldiers will be valuable.

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