Social Facilitation Attenuating Insecticide-Driven Stress in Termites (Isoptera: Nasutitermitinae)

by

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ABSTRACT

Group effect of social facilitation is expressed in a variety of ways in animals. Here we test the hypotheses that social facilitation may mitigate stress drastically higher than hunger – insecticide poisoning. When testing groups of termites varying from 1 to 14 individuals exposed to either of two insecticides, the cyclodiene endosulfan and the organophosphate chlorpyrifos, there were differences in the time to die among individuals from the different groups. Both experiments, each with one insecticide and a control treatment without insecticide exposure, showed that social facilitation extends survival time of insecticide-poisoned termites. The extended survival of poisoned insects was determined by the group size in which the termite was confined, which may have practical implications for current methods of termite control.

KEYWORDS: Endosulfan, chlorpyrifos, *Corniteremes cumulans*, stress tolerance, termite control.

INTRODUCTION

Social facilitation is commonly defined as the origin of behavior or the increase in rhythm and frequency of patterns provoked in an organism by the presence of another from the same species (Clayton 1978, Wilson 1980). This group effect of social facilitation is expressed in a variety of ways in animals. Monkeys, when grouped together, showed higher resistance to gastrointestinal pathogens (Schapiro *et al.* 2000) and to the simian immunodeficiency virus (SIV) (Capitano *et al.* 1998). Grouped termites are more tolerant to infection by the fungus *Metarhizium anisopliae* (Rosengaus *et al.* 1998). Chickens and humans have a considerable increase in food ingestion when in groups, as compared with isolated individuals (Zajonc 1965, DeCastro 1995). Tadpoles and termites show higher mobility when grouped (Miramontes & DeSouza 1996, Griffiths & Foster 1998), while hermaphroditic snails have

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increased reproduction when in groups (Vernon 1995). The behavioral patterns reported above and others caused by the group effect may contribute to buffer environmental stress in nature. The present study aimed to test if social facilitation is broad enough to increase tolerance to distinct poisoning conditions caused by broad-spectrum insecticides.

MATERIAL AND METHODS

Poisoning by endosulfan

Two experiments were carried out with 3rd instar workers collected from a termite colony of *Cornitermes cumulans* (Kollar) (Isoptera: Termitidae) in Viçosa County, State of Minas Gerais, southeastern Brazil. The experiments were designed to test the effect of the group size in the median time for termite death under starvation and insecticide exposure.

In the 1st experiment, the cyclodiene insecticide endosulfan was applied in a termite colony following the technical recommendations of dust formulations for termite control (Andrei 1999). The termite mound was broken down until exposing the inner galleries and the insecticide dust was evenly distributed over the exposed mound surface. Termite workers were collected 24 h after the insecticide application and randomly placed in groups of 1, 2, 4, 6, 8, 12, 14 and 16 individuals within transparent-glass test tubes (9.5 x 1.4 cm) tightly closed with rubber lids. Twelve replicates were used for each group. The same colony was subjected to the same procedure, but without insecticide application, some 16 months after the 1st intervention, for use as a control treatment where two additional density groups were assessed – 20 and 24 insects each. Eight replicates were used in the control treatment.

The test tubes used as experimental units were washed and sterilized at 180°C for 1 h prior to termite enclosure. These test tubes containing termites were horizontally placed over a flat surface and individualized with styrofoam (isopor) to prevent mechanical signaling between insects from different test tubes. The test tubes containing the termites were maintained at 25 ± 5°C after an initial period of 12 h for acclimatizing. Provision of water, food and substrate was suppressed during the experiment and the insects were only briefly exposed to light (< 5 min) during the 12 h assessments until the death of all of the insects.

The termite groups with dead individuals showing signs of cannibalism were not included in the data analysis. Such signs were the presence of body parts in the mandibles of the insects (examined under stereomicroscope at each assessment) or if they were biting each other. The presence of body injuries was also assessed, but only at the end of the experiment and again using a stereomicroscope.

The data collected was submitted to regression analysis for the maximum survival time using Weibull's model with two independent variables, endosulfan exposure or not, and a covariable – group size. The median time for death and the respective standard errors were revealed by the analysis of survival and plotted against group size.

Poisoning by chlorpyrifos

This experiment was carried out with 3rd instar workers collected from field-colonies of *C. cumulans* from Viçosa County, State of Minas Gerais, Brazil. The aim was to test the effect of group size in termites topically exposed (0.5 ml on the abdomen) to a chlorpyrifos solution (10^{-4} mg a.i./ml; acetone (pa) was used as solvent). Termites were tolerant to the solvent (i.e., acetone) exposure surviving for over 100 h after topical application of 1 ml, as determined in preliminary assays.

The insects exposed to chlorpyrifos were placed in test tubes, as already described in the previous experiment, at the densities of 1, 2, 4, 8, 12, 14, 16 and 20 individuals per tube. The same procedure was replicated five times, one for each termite colony, always maintaining control treatments without insecticide application for insects of the same colonies and same densities as the treated ones. The insects were maintained in the same conditions of the previous experiment with endosulfan. Mortality assessments were also carried out as previously described, but beginning 4 h after the insecticide application and repeated every 8 h interval until the death of all insects. The data was subjected to the same analysis described in the experiment of poisoning by endosulfan.

RESULTS

Both insecticides, endosulfan and chlorpyrifos, caused significant decrease in the median time for termite death as compared with control treatments (Figs. 1 and 2). Nonetheless, even with the insecticides leading to insect death, group size significantly affected the median time for death (Figs. 1 and 2).

Group size affects median time for death in insects exposed to chlorpyrifos and endosulfan. In the case of chlorpyrifos exposure, the time for death extends with group size until reaching a maximum above which the time for death shortens with further increase in group size (Fig. 1). The curve of time for death for endosulfan-exposed insects was distinct from that obtained for chlorpyrifos (Fig. 2). However, the

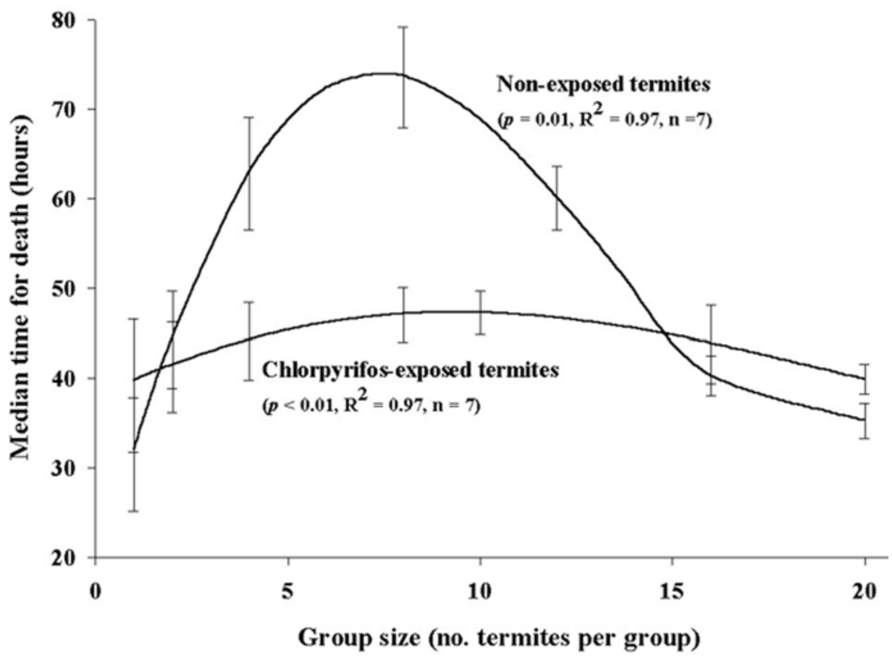

Fig. 1. Effect of group size in the median time for death of individual termites exposed or not to the organophosphate insecticide chlorpyrifos.

obtained results with chlorpyrifos exposure also provide strong evidence that the time for death was also determined by the group size.

DISCUSSION

Social facilitation mitigates stress drastically higher than hunger. Termites and monkeys for instance show increased tolerance to infectious diseases when grouped (Capitano *et al.* 1998, Rosengaus *et al.* 1998, Schapiro *et al.* 2000). The present experiments also show that social facilitation extends survival time of insecticide-poisoned termites. The extended survival of poisoned insects was determined by the group size in which the termites were confined.

Insecticide effects can vary depending on the mode of application. Topical application of insecticides allows the delivery of exact doses on the insect. In contrast, field application of insecticides does not usually target individual insects reducing their exposure and social behavioral patterns, such as mutual cleaning care, can lead to a decreased exposure to insecticides, especially when applied as dust. Therefore it is expected a lessened effect of group size with topical insecticide application as compared with surface treatments with insecticide

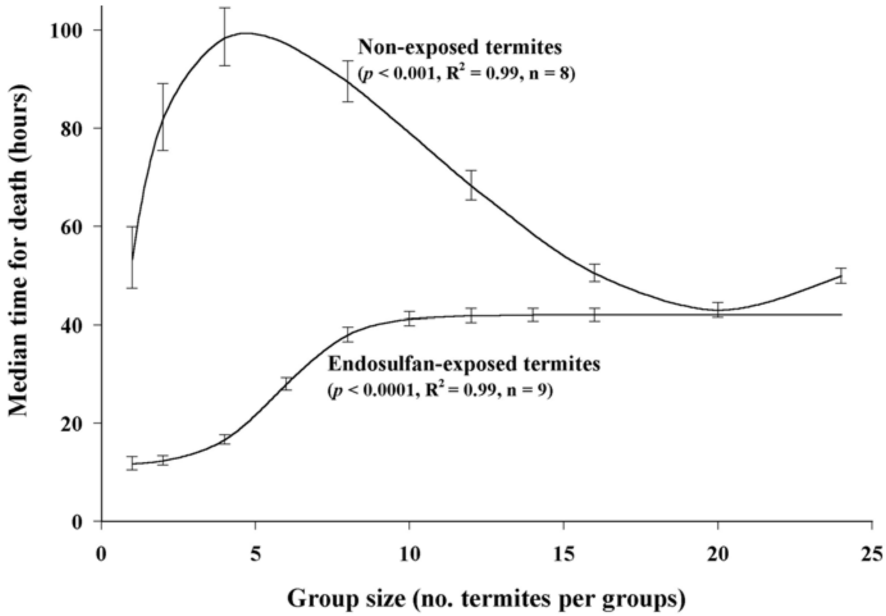

Fig. 2. Effect of group size in the median time for death of individual termites exposed or not to the cyclodiene insecticide endosulfan.

dusts. Nonetheless social facilitation was evident in both cases, topical application of insecticide in laboratory conditions and field application of insecticidal dust. Both experiments do not allow strict comparisons because of the distinct methodology and insecticides used, but they emphasize that social facilitation manifest itself in very distinct situations.

The expression of social facilitation in the laboratory experiment is suggestive that the extended insect survival may be due to behavioral patterns characteristic of group associations. However, social facilitation may also be the result of physiological alterations inducing the metabolic detoxification of insecticides or alternatively preventing activation of pre-insecticides such as chlorpyrifos, which requires oxidative desulfuration to chlorpyrifos oxon to express its toxic potential (Wilkinson 1976, Matsumura 1985).

The toxic effect of a given insecticide is sparked after its penetration in the insect body in a large enough amount to reach its target site and compromise the insect survival. Once in the insect body, the insecticide is the target of the organism defensive mechanisms mainly represented by detoxification enzymes that may sequester or break them down impairing their biological activity (Wilkinson 1976, Matsumura 1985). Ironically, some insecticides, such as chlorpyrifos, require activation to exhibit toxic effect and the insect detoxification enzymes frequently perform the task. Cytochrome P450-dependent monooxygenases, besides esterases and glutathione *S*-transferases, are the main enzymes involved in insecticide detoxification in arthropods (Matsumura 1985, Omura 1999, Strange *et al.* 2001). Their activation properties are also known (Matsumura 1985, Omura 1999, Strange *et al.* 2001), but their role in social facilitation mitigating insecticidal effects has yet to be assessed as specific group-associated phenomenon of potential importance.

Social facilitation is a phenomenon so important that it is expressed in unexpected and distinct situations, such as insect poisoning by insecticides either through topical exposure in laboratory or contact exposure in field conditions. This finding has practical implications since density of individuals in the nest is likely to be more important than nest size for insecticide dose recommendations aiming termite control. Current dose recommendations are based on nest size, not nest density, which probably leads to the use of higher dose rates increasing control costs and environmental problems.

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