

A quick Laboratory Method of determining the Termite Resistance of Materials

(Isoptera)

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(With 5 Figures)

Combating the termites and the protection of wood against termites are problems of primary importance and many laboratories participate in solving them. Apart from the protection of wood there has arisen a need of studying also the tropicalisation of man-made fibres. Here, as well, the tropicalisation of heightening the insect resistance, above all against the termites is very important.

It is evident that the preliminary test, at least, for termite resistance may be carried out the most comfortably and quickly in the laboratory. Many methods of laboratory tests have already been found and published: e. g. HERFS (1950), BECKER (1952), SCHMIDT (1953, 1955), GAY and co-authors (1955), GÖSSWALD (1956). For laboratory tests the representatives of the family *Rhinotermitidae* LIGHT were used most frequently and that the following species: *Reticulitermes lucifugus* (ROSSI) — HERFS (1950), *Reticulitermes lucifugus* (ROSSI) and *Reticulitermes flavipes* (KOLLAR) — SCHMIDT (1953, 1955). *Reticulitermes hesperus* BANKS — PENCE (1957), *Coptotermes lacteus* (FROGG.) and *Coptotermes acinaciformis* (FROGG.) — GAY and co-authors (1955) and the representatives of the family *Kalotermitidae* ENDERLEIN: *Kalotermes flavicollis* (FABR.) — LÜSCHER (1951), BECKER (1942, 1952), GÖSSWALD (1956, 1958), HRDÝ (1959), *Cryptotermes brevis* (WALKER) — WOLCOTT (1953), HEPBURN (1954) etc. Until today there is not any generally acknowledged standard method of laboratory tests, which would use one or several representative species of termites.

In our laboratory breedings some species of the genus *Reticulitermes* (HOLMGREN): *Reticulitermes lucifugus* (ROSSI), *R. lucifugus santonensis* FEYTAUD, *R. flavipes* (KOLLAR), *R. chinensis* SNYDER, *R. clypeatus* LASH are introduced. So far, however, we have been using for laboratory tests mostly the species *Kalotermes flavicollis*. The question of a higher or a lower suitability of "dry-wood" termites, the representative of which is e. g. *Kalotermes flavicollis*, or "subterranean" termites, represented by e. g. *Reticulitermes lucifugus* has already been taken up several times (e. g. by GÖSSWALD, 1956 and SCHMIDT, 1953). The relatively high reproduction capacity and therefore a relatively quick development of the entire colony by *Reticulitermes* as well are their advantages. A drawback, though, is their low resistance to the lowering of the relative moisture of the air (STRICKLAND, 1950 and ERNST, 1957) and to hunger (SCHMIDT, 1955).

Methods of laboratory tests with the species of the genus *Reticulitermes*

Only such methods as have been applied as "small laboratory tests" or as preliminary experiments are presented in this paper. Our aim was to find out such method, which would enable us to determine the results most readily and by which we might acquire in the shortest time results, even

if negative i. e. results, on the bases of which it would be possible to eliminate the non-resistant test-specimens from further tests. Breeding large colonies of numerous series of test insects requires much attention and feeding material. It is therefore very advantageous to carry out preliminary tests first and then to use those specimens, which have withstood the test in more exacting experiments and finally in the field testing.

In BAYER's laboratory (HERFS, 1950) a method, in which a ring of artificial silk framed by a metal ring is put in a dish with moist soil, is used. On the textile, which is impregnated with test materials, 40—50 individuals of the species *Reticulitermes lucifugus* are placed. These eat into the textile and penetrate into the soil.

SCHMIDT (1955) carries out his experiments in Petri dishes filled with moist soil, the lid is equipped with a wet filter paper. The ratio is one specimen in the jar to 100 to 200 individuals of the species *Reticulitermes flavipes* ("Hamburger termite"). The specimen is placed loosely on the soil or under the surface of it.

PENCE (1957) suggested a method in which the termites are kept in moist test-tubes in which the relatively high humidity is kept by plaster. The tested specimen too, was implanted into the plaster (impregnated or not-treated wood).

At first we used in our laboratory a method which was similar to that of SCHMIDT (1955) when using 100 individuals of the species *Reticulitermes lucifugus* or *Reticulitermes clypeatus*. Some of the experiments were also performed in test tubes with the moisture gradient according to PENCE (1957). These methods proved to be efficient, on the whole, but they did not fulfill all our requirements and therefore we tried to find out a method that would meet our demands as are formulated in the introduction of this paper.

Preliminary experiment with termites of the genus *Reticulitermes* based on the escape reaction

Conditions for the preparation of the method: — As mentioned above, termites of this genus similarly as the other subterranean termites are sensitive to the lowered relative moisture of their surroundings and also, as it has been often said, to the lack of food. We tried at first to replace the moist soil or plaster by filter paper. The filter paper was to serve the purpose of retaining a sufficient relative moisture of the surroundings and at the same time as a source of standard food for comparison experiment¹⁾. The enclosed table (Tab. 1) shows that the moist filter paper is a very suitable bases for the maintaining of groups of termites and that the termites of the species *Reticulitermes lucifugus* prosper just as well as on moist soil. We

¹⁾ Doc. HSIA K'AI-LING from the Institute of Applied Entomology of the Chinese Academy of Science in Shanghai uses moist filter paper in his experiments on the species *Reticulitermes chinensis* SNYDER and *Reticulitermes flaviceps* (OSHIMA). In his breedings small termite colonies are doing well on this ground.

made use of this experience and of the method which was introduced by BECKER for the testing of small groups of *Kaloterms flavicollis* and which is based on the application of the escape reaction of termites (BECKER as yet unpublished). Description of the method: — Filter paper is pasted on the tested specimen of wood or other materials with any paste

Table 1. Maintenance of *Reticulitermes lucifugus* (Rossi) on moist filter paper and in moist soil *

| Group No. | Ground and kind of food | Number of workers and adult larvae | The length of the experiment in days | Mortality | |
|-----------|---|------------------------------------|--------------------------------------|-----------|----------|
| | | | | Number | Per cent |
| 1 | filter paper | 100 | 30 | 13 | 13 |
| 2 | filter paper | 100 | 30 | 5 | 5 |
| 3 | filter paper | 100 | 30 | 5 | 5 |
| 4 | filter paper | 50 | 30 | — | — |
| 5 | filter paper | 50 | 30 | 2 | 4 |
| 6 | filter paper | 30 | 30 | 5 | 17 |
| 7 | filter paper | 30 | 30 | 8 | 27 |
| 8 | filter paper | 20 | 30 | 3 | 15 |
| 9 | filter paper | 20 | 30 | 1 | 5 |
| 10 | filter paper | 10 | 30 | 1 | 10 |
| 11 | filter paper | 10 | 30 | 2 | 20 |
| 12 | filter paper | 100 | 19 | 4 | 4 |
| 13 | filter paper | 50 | 19 | 4 | 8 |
| 14 | filter paper | 25 | 19 | 3 | 12 |
| 15 | soil, <i>Ilex purpurea</i> + <i>Pinus silvestris</i> | 100 | 30 | 34 | 34 |
| 16 | soil, <i>Pinus massoniana</i> + <i>Pinus silvestris</i> | 100 | 30 | 67 | 67 |
| 17 | soil, <i>Pinus silvestris</i> | 100 | 30 | 23 | 23 |

* Tested in weighing bottles and Petri dishes. Moist gardening soil, which was sterilised before the experiment, was used.

harmless to the termites. The filter paper is larger on one side than the specimen, on the other three sides the paper is cut to fit the specimen. A plexi-glass ring is attached to the specimen covered over with the filter paper by a rubber band (using a wooden block as a pad) in such a manner that the ring overlaps on two places the edges of the specimen. Such crevices are left as to permit the termites to reach with their mandibles the edges of the specimen, but making it impossible for them to leave the ring. The ring is covered over with a glass (if it is not made of sufficiently polished plexi-glass or of glass). On the specimen thus prepared 100 workers and adult larvae of termites — we used generally the species *Reticulitermes lucifugus* — were placed in the ring (at its inner diameter 30 mm). Smaller glass rings, corresponding a smaller number of termites — 30 to 50 — were also used for the testing of the resistance of some wood. The specimen together with the termites was put into a weighing bottle. On the bottom of the bottle there

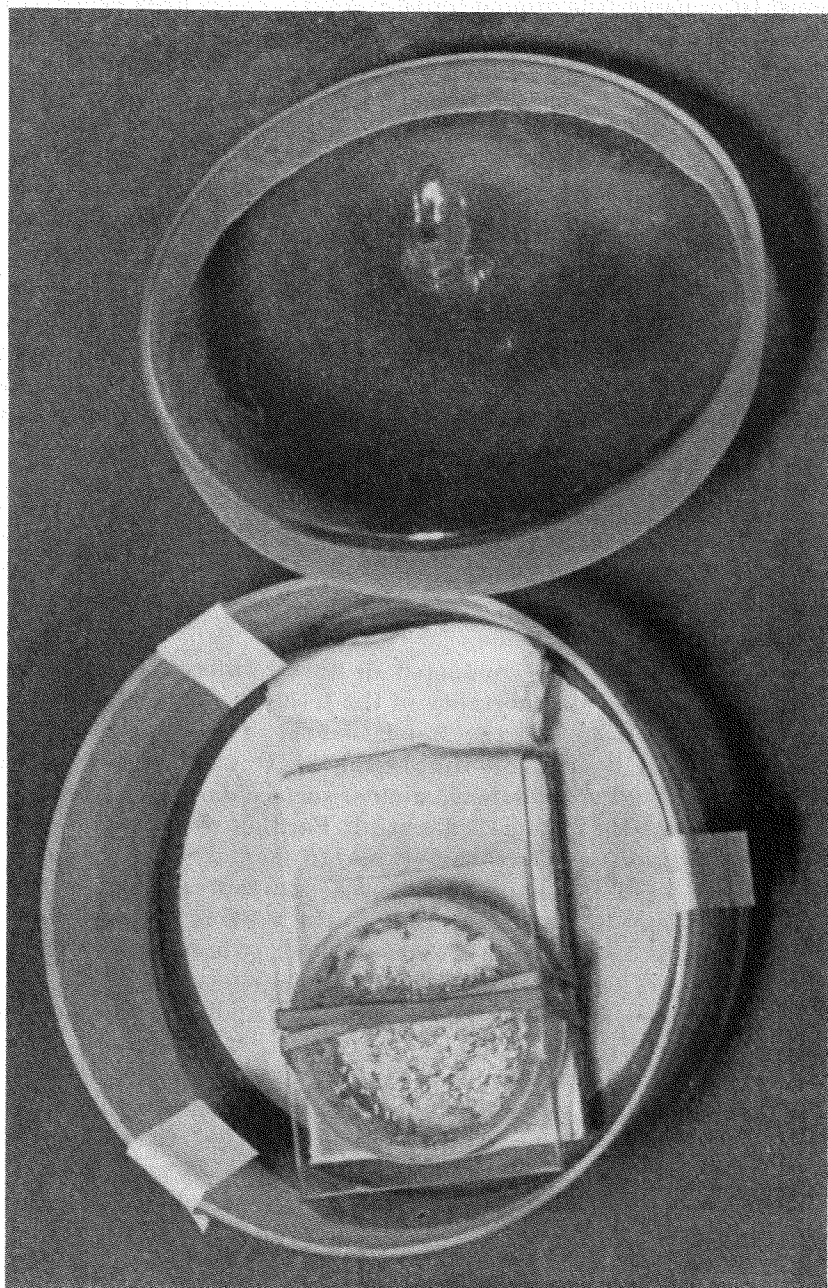


Fig. 1. Test chamber with the termites in the weighing bottle — the arrangement during the experiment

is a moist filter paper (the ground for the termites which after eating trough the specimen escape from the ring) an on the loose end of the filter paper is attached a ball of wading of cellulose which supplies the entire filter paper with moisture (Fig. 1). The experiment was daily checked and if the filter paper gets dry it is wetted at this occasion.

Some results achieved with the suggested method

The applicability of the preliminary experiment with the termites of the genus *Reticulitermes*, based on the escape reaction has been determinted on three kinds of wood and on five kinds of man-made materials. Wood of: 1. *Fraxinus chinensis*, 2. *Machilus* sp. and 3. *Ternstroemia gymnothera*, displayed a relatively high termite resistance in experiments in the field testing. According to the results of an experiment lasting 210 days, which was carried out in the Chinese experimental station, the wood of all the three listed kinds were classified into the first group (most resistant wood) and were only slightly damaged.¹⁾ Man-made materials: 4. Isofol BB — Soft PVC with a content of dioktylfthalate, Palatinol AH, Mesamol and lead stearate, 5. Novoplast 624 — softened PVC, waste product in the production of Novoplast, 6. PE — polyethelene colourless, 7. PEc — with an admixture of 2% of sooth, 8. PEc + PIB — polyethelene with an admixture of 2% of sooth and 5% polyisobutylene.

Comparison experiments conducted in three different manners were checked every day and the mortality of the termites was observed and the damage of the specimen and the standard food (*Pinus silvestris* or filter paper) was marked by the following symbols: O undamaged, + border damage, ++ strong border damage almost surface damage, +++ strong surface damage, + ? the damage is doubtful. For these experiments termites of the species *Reticulitermes lucifugus* (Rossi) (from Italy) and *Reticulitermes clypeatus* LASH (from Roumania) were used and that workers with adult larvae (which cannot be distinguished from the workers in quick handling, and they are self-feeding individuals) from laboratory breedings. The experimental colonies were kept in a thermostate at a temperature of 27 °C (± 1 °C) the relative moisture, in view of the adjusted surrounding in the test dishes, was approaching 100%.

The three mentioned kinds of wood and the control (*Pinus silvestris*) were tested in the first series of experimentes in dishes with soil (moist garding soil, sterilised before the commencement of the experiments). Apart from the tested specimens of wood there was always placed in the dish a block of standard food (*Pinus silvestris*). The results are summarised in Table 2.

¹⁾ My thanks are due to the scientific workers of the Canton Electrotechnical Institute (Canton Science Electrical Institute of the 1st Mach. Ministry, Lou-kan, Canton) for having given to me the reports on the results of field testing, and for the presentation of wood specimens for laboratory testing.

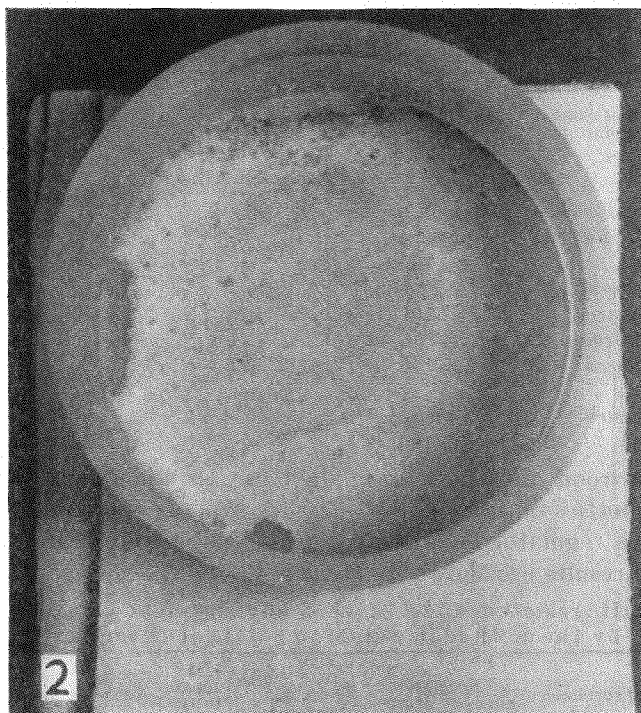


Fig. 2. Test chamber after removing the termites

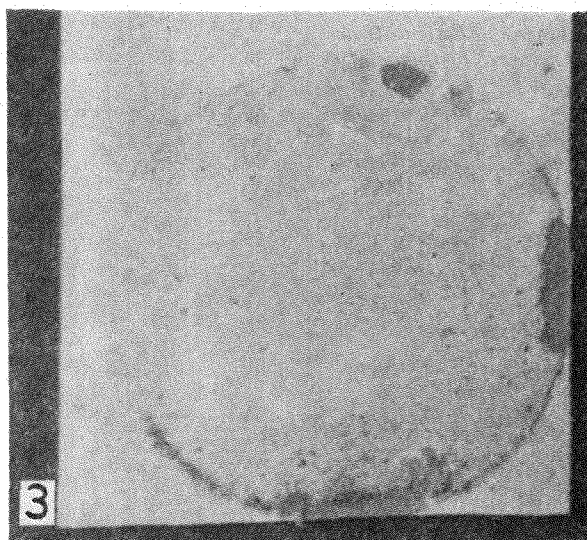


Fig 3. Specimen of Novoplast — on the top and right is seen damage on the filter paper and border damage on the specimen

Table 2. Termite resistance test of wood specimens by the method in Petri dish with moist soil

| Group No. | Kind of wood and standard food | Species and number of workers and adult larvae | The length of the experiment in days | Damage to the specimen | Damage to the standard food | Mortality per cent |
|-----------|---|--|--------------------------------------|------------------------|-----------------------------|--------------------|
| 1 | <i>Fraxinus chinensis</i> + <i>Pinus silvestris</i> | <i>Reticulitermes chypeatus</i> 100 | 30 | + | ++ | 47 |
| 2 | <i>Machilus</i> sp. + <i>P. silvestris</i> | <i>R. chypeatus</i> 100 | 30 | + ? | ++ | 24 |
| 3 | <i>Ternstroemia gymnothera</i> + <i>P. silvestris</i> | <i>R. lucifugus</i> 100 | 30 | + ? | ++ | 27 |
| C | <i>P. silvestris</i> | <i>R. lucifugus</i> 100 | 30 | | ++ | 23 |

Both the wood and the man-made materials underwent further testing in weighing bottles on filter paper. The filter paper was kept moist so that it served as a regulator of humidity as well as a source of standard food supply. The results are shown in Table 3.

Table 3. Termite resistance test of wood and man-made material specimens by the method in weighing bottle on filter paper

| Group No. | Kind of specimen and ground | Species and number of workers and adult larvae | The length of the experiment in days | Damage to the specimen | Damage to the filter paper | Mortality per cent | Remarks |
|-----------|---|--|--------------------------------------|------------------------|----------------------------|--------------------|--|
| 1 | <i>Fraxinus chinensis</i> + filter paper | <i>Reticulitermes lucifugus</i> 100 | 30 | + | +++ | ? | Damage observed after 23 days |
| 2 | <i>Machilus</i> sp. + filter paper | <i>R. lucifugus</i> 100 | 30 | — | +++ | ? | |
| 3 | <i>Ternstroemia gymnothera</i> + filter paper | <i>R. lucifugus</i> 100 | 30 | — | +++ | ? | |
| 4 | Isofol BB + filter paper | <i>R. lucifugus</i> 100 | 19 | + ? | +++ | 100 | Attacked by the mite <i>Anoetus myrmicarum</i> SCHENKER* |
| 5 | Novoplast 624 + filter paper | <i>R. lucifugus</i> 100 | 30 | — | +++ | 5 | |
| 6 | PE + filter paper | <i>R. lucifugus</i> 100 | 30 | — | +++ | 2 | |
| 7 | PEc + filter paper | <i>R. lucifugus</i> 100 | 30 | — | +++ | 13 | |
| 8 | PEc with PIB + filter paper | <i>R. lucifugus</i> 100 | 30 | — | +++ | 5 | |
| C | filter paper | <i>R. lucifugus</i> 100 | 30 | | +++ | 5 | |

* My thanks to dr. K. Sarnšihák for the determination.

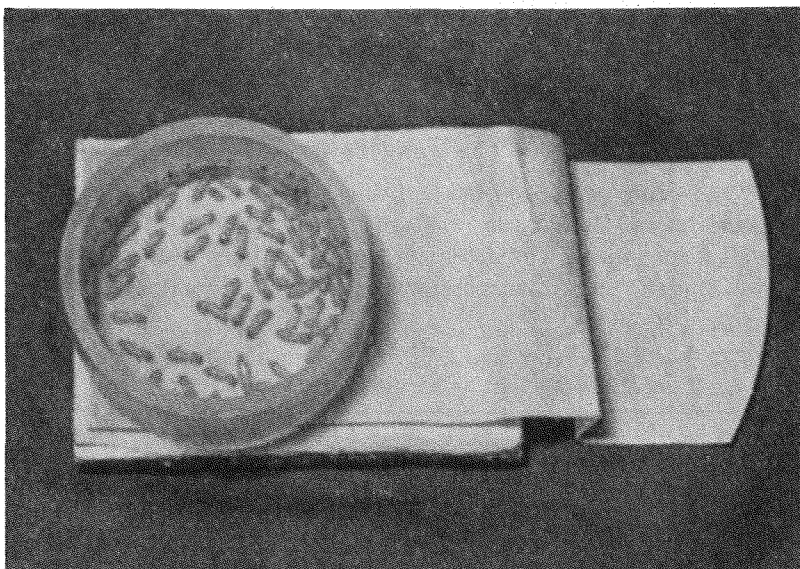


Fig. 4. The termites in the test chamber

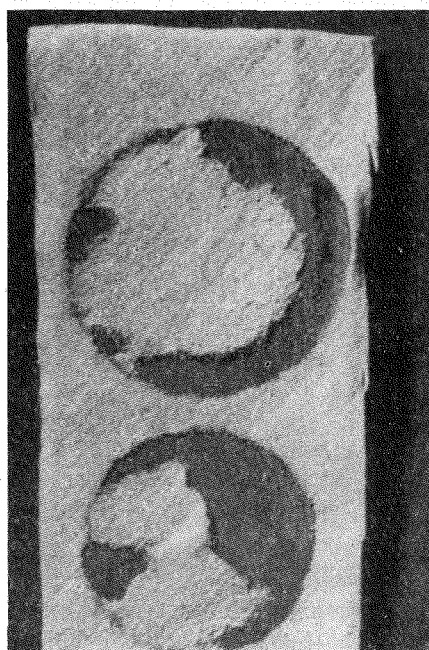


Fig. 5. The damage on the wood specimen
Ternstroemia gymnothera

In the third series of experiments the newly-suggested method was applied as it has been described in this paper. The Table 4 presents the results.

Summary of the results and discussion

From the results presented in the tables follows that only when the method making use of the escape reaction is applied (Tab. 4) the attacking of all the tested specimens was achieved. A slight border damage was observed in two kinds of man-made materials, a border damage in all the tested

Table 4. Termite resistance test of wood and man-made material specimens by the newly suggested method

| Group No. | Kind of specimen | Species and number of workers and adult larvae | The length of the experiment in days | Damage to the specimen | Mortality per cent | Remarks |
|-----------|--------------------------------|--|--------------------------------------|------------------------|--------------------|--------------------------------|
| 1 | <i>Fraxinus chinensis</i> | <i>Reticulitermes lucifugus</i> 30—50 | 4 | ++ | ? | Damage observed after 3—4 days |
| 2 | <i>Machilus</i> sp. | <i>R. lucifugus</i> 30—50 | 4 | ++ | ? | Damage observed after 3—4 days |
| 3 | <i>Ternstroemia gymnothera</i> | <i>R. lucifugus</i> 30—50 | 5 | ++ | ? | Damage observed after 2 days |
| 4 | Isofol BB | <i>R. lucifugus</i> 100 | 3 | + | 1 | Damage observed after 2 days |
| 5 | Novoplast 624 | <i>R. lucifugus</i> 100 | 4 | + | 29 | Damage observed after 2 days |
| 6 | PE | <i>R. lucifugus</i> 100 | 2 | + | 2 | |
| 7 | PEc | <i>R. lucifugus</i> 100 | 7 | + | 4 | Damage observed after 1 day |
| 8 | PEc + PIB | <i>R. lucifugus</i> 100 | 7 | + | 1 | Damage observed after 4 days |

wood specimens as well as in all the other kinds of specimens of man-made materials. Following results of this experiment it is impossible to denote any of the specimens as termite resistant. These results were, however, obtained in a very short period— the damage was observed in the space of time from 1 to 4 days after the foundation of the experiment. On the other hand in those experiments, where the experimental specimen was tested by a method, in which it was put loosely in the dish, regardless whether in soil or filter paper, the damage was determined unambiguously after one month only in one of the tested wood (*Fraxinus chinensis*) and in the remaining two kinds of wood and one kind of man-made material (Isofol BB) the result was dubious.

It seems, therefore, that the suggested method fulfills indeed the requirements, which are expected of a quick preliminary method. Even a smaller number of termites may be used (as may be seen from the experiments on wood) and the experiment is of a short duration. The termites may, thus, be soon removed back to the breedings (naturally if there has been no testing with toxic specimens) and the colonies are not markedly reduced. The achieved results show that this method even in its rapidity is very demandful as for the tested specimens. The damage is achieved, obviously by using the escape reaction, even in such specimens which remain for a long time intact in the usual comparative experiments. This fact is valid for those kinds of wood which may be more resistant according to the field or laboratory comparative experiments.

The relatively low mortality during the experiments proves also the fact that the suggested arrangement of experiments fulfills quite well the ecological requirements of the species *Reticulitermes lucifugus*.

Zusammenfassung

Aus den Ergebnissen in den beigefügten Tabellen ist ersichtlich, daß eine Beschädigung aller untersuchten Holzarten nur mit einer Methodik erreichbar war, die von der Fluchtreaktion der Termiten Gebrauch macht. Ein leichter Randfraß wurde bei zwei Arten synthetischen Materials beobachtet, Randfraß bei allen untersuchten Holzarten und allen anderen Proben synthetischer Stoffe, so daß keiner der untersuchten Materialproben die Bezeichnung termitenresistent zugesprochen werden kann. Diese Ergebnisse wurden innerhalb kurzer Versuchszeiträume (zwischen 1 und 4 Tagen nach Versuchsbeginn) erzielt. Andererseits ergaben sich bei Versuchen mit dem Testmaterial lose in Petrischalen (auf Erde oder Filterpapier) unzweideutige Schadbilder nach einem Monat nur bei einem der untersuchten Hölzer (*Fraxinus chinensis*), während bei den beiden anderen Holzarten und dem synthetischen Werkstoff Isokol BB das Ergebnis zweifelhaft war. Demnach scheint die hier angewandte Methodik den Anforderungen an eine orientierende Schnellmethode zu genügen. Sogar geringere Zahlen von Versuchstieren können verwendet und mit Rücksicht auf die Erhaltung des Individuenbestandes der Zuchtkolonien nach kurzer Versuchsdauer wieder entfernt werden. Die Ergebnisse zeigen, daß die Methode auch noch angesichts ihrer kurzen Dauer, offensichtlich wegen der Ausnutzung der Fluchtreaktion, sehr empfindlich für die untersuchten Materialarten ist. Die relativ geringe Mortalität beweist, daß die Versuchsanordnung den ökologischen Anforderungen der Termiten *Reticulitermes lucifugus* weitgehend entspricht.

Резюме

1. В работе предлагается метод лабораторного испытания термитоустойчивости с применением термита *Reticulitermes lucifugus*. Термиты помещаются прямо на испытуемый образец, накрытый постоянно увлажняемой фильтровальной бумагой. Стеклое кольцо с термитами прикреплено непосредственно к краю образца, где оставляется небольшая щель, которую термиты расширяют (использование стремления к бегству подобно как и в методе Беккера с применением вида *Kaloterms flavicollis*). Предлагаемый метод служит лишь для ориентировочных испытаний. Это значит, что устойчивые образцы должны подвергаться дальнейшим испытаниям с применением других методов.

2. Новый метод сравнивается с другими широко применяемыми методами. Предлагаемый метод выгоден в том отношении, что с его помощью достигается повреждение даже таких образцов, которые в случае применения других методов остались невредимыми.

3. При помощи вышеуказанного метода удалось получить краевые повреждения на образцах следующих пластмасс: Изофоль ББ (мягкий поливинилхлорид с прибавлением диоктилфталата, палатинола АН, мезамола и стеарата свинца), Новоласт 624 (мягкий поливинилхлорид), бесцветный полиэтилен, полиэтилен, содержащий 2% сажи, и полиэтилен, содержащий 2% сажи и 5% полиизобутилена. Слабо повреждалась также древесина *Fraxinus chinensis*, *Machilus* sp. и *Ternstroemia gymnothera* (предварительные результаты.)

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