*Proceedings of the Sixth International Conference on Urban Pests*
*William H Robinson and Dániel Bajomi (editors), 2008*
*Printed by OOK-Press Kft., H-8200 Veszprém, Pápai út 37/a, Hungary*

# GLOBAL DYNAMICS OF TERMITE POPULATION: MODELING, CONTROL AND ROLE IN GREEN HOUSE EFFECT

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**Abstract** The importance of termite (Isoptera) population for world ecology is based on: it is extremely populated order; this order increases its population during many years; these insects have a big importance because of destroying wood construction; the taxon has important effect on concentration of global carbon and carbon dioxide having effect on green house effect and world climate. The aim of this work is to suggest model of termite population and their gas productivity, basing of ecological principle and empiric data. Model is based on: models of population dynamics by V. Volterra and G. Gause, and models of cyclical oscillations of population structure suggested by N.Kondratyev. The control of termites by pesticides is not effective. The more effective may be control by operation of their ecological niche. According to both theoretical and empirical data, the maximum of termite population would be gotten during 2020s years. The input of green house gases by termite is three times more than social sources. Green plants would compensate this input. A little global warmer of 2$^{nd}$ part of 20th century would be changed by little colder. The role of termite and human activity in the processes would be not significant. The population of termite would be stable during more than 100 years.
**Key Words** Global dynamics, population, modeling

## INTRODUCTION

Termites (*Isoptera)* are significant order of insects. Their exclusive role in biosphere is based on following facts: Extreme population and biological mass between insects; It is taxon increasing population during many years; They have negative importance because of destruction human wood construction; Their have terrible effect on global carbon metabolism and production on green house gases, having effect on global climate. There are a big number of studies of termite physiology and biochemistry. But the data of their population ecology is not complete. The aim of the work is getting toward understanding the causes of population growth, and making of the model of their distribution basin of both empirical data and principle of global ecology. The model must be predictable.

### Termite Ecology

Termites are social insects, having three casts. Their biological diversity is not high, but population is extremal. World population may be till $10^{7}$ - $10^{8}$ billions. The mass of one specimen may get 3-5 gram. The sum mass of termite per one man may be 3 ton. At the same time “car mass” per human is about 200 kg. Metabolism of termites is more active that human and transport one. Their resource is wet wood. Microorganisms Flagellata (*Hypermastigina*), living within their bowels support processing of the wood. Because of transformation some gases are produced. They are carbon dioxide ($CO_2$), methane ($CH_4$) and ammiak ($NH_4$). They have effect on atmosphere process and the effect is more significant than human one. Human industry increased use of wet wood during many hundred years. This fact increased ecological niche for termites. Modern technology needs less wood than old one. The process of deforestation is stopped. Forest area is increased (Кондратьев et. al, 2003; Lomborg, 2002). Population processes are delayed in relation to niche dynamics. That’s why numbers of such an insects increases. Quantitative grows is accompanied by microevolution and adaptation of termites to cold climate. They got south of Europe, Moldova, Ukraina, Middle Asia.

There are a number of works considering termite physiology, biochemistry, genetics and molecular biology. There is deficiency of works describing global ecology of the insects. Relation of them with other species having good ecological understanding may be useful for progress in termites (Теоретические основы биологической борьбы с амброзией, 1989).

## ROLE OF TERMITES IN NATURAL AND URBAN ECOLOGICAL SYSTEMS

The termites are main destructors of organic remains. They control organic cyclic metabolism and soil production. That's why their ecological role is positive under natural condition. But their may become negative under urban conditions. Wood construction are destroyed by them. Wood house even having stone may be safe only during some years. The insects escape sun light and need high humidity. The built tunnels from particles of clay fixed by special organic compound connecting underground insect homes with people houses. Humidity in such a tunnels is stable. Getting wood construction by tunnels termites destroy them. They use some other thinks but buildings such as books. There is deficiency of old books in South America because it is almost impossible to safe a book from termites. Some times villages and little cities were suffocated if America and Asia because of termite activity. India specialists consider loss by termites in the country as 280 millions rupia per year. There are some new populations within former Soviet Union. Termites are wide spread in Middle Asia deserts, such as Kara-Kum, Kysil-Kum and so on. The most typical species are *Anacanthotermes ahngerianus*, *A. turkestanicus*. This species are destructive for both wood buildings and building from saman (special mixing of bricks with straw). This destroying was prerequisite of terrible loss after Ashkhabad earth shaking. Because of high variability and speed population adaptation, majority of pesticides are not effective against termites. The maximal damage by the insects take place within tropic region. Around the Mediterranean and Black sea the wide spread species, *Reticulitermes lucifugus*, been not so dangerous.

### Termites and Green House Effect

Green house effect is important problem modern world policy and economics. It is connected with methane and carbon dioxide. The importance of first gas is bigger than $2^{nd}$ one 20 times. The dynamics of the carbon dioxide is demonstrated in the average year component of cyclic metabolism of carbon during 1980 - 1989 гг. (GtC/year) [measured is gigatonn (billion) of pure carbon]: **Sources**: **1**) Burning of ancient gases and cement industry = 5±0.5; **2**) Earth and soil use in tropics = 1.6±1.0; **3**) General anthropogenic production = 7.1±1.1. **Distribution within reserve**: **1**) Accumulation in atmosphere = 3.2 ±0.2; **2**) Realization in ocean = 2.0±0.8; **3**) Assimilation by forest restoration in north hemisphere = 0.5±0.5; **4**) Supeumarory source at earth = 1.4±1.5.

**Carbon dioxide.** Different authors suggest different data in carbon and carbon dioxide balance. But general scale is close. The sum of $CO_2$ in atmosphere is about 2.7 billions tons. The mean is under slow growth. 50 years ago the mean was 2.6 billions tons (Кондратьев et. al, 2003, Давиденко, Кеслер, 2005). The activity of photo synthesis by plants increased too. The general mass of forests increased because modern technology needs less wood that the old one. Insignificant increase of world temperature stimulated photo synthesis too. World petroleum input is about 3 billions tons. Under hypothetical combustion of all the petroleum, 7 may be gotten. The real input may get 3 billions. The same input take place because respiration of animals and plants. Metabolism by termites produce more than 55 billions ton of carbon dioxide (Zimmerman et al., 1982, Кондратьев et al, 2003). According to data by Ничипорович (1967), Камшилов (1979), supported by following authors (Давиденко, Кеслер, 2005), photo synthesis accumulates 170 billions ton of carbon dioxide per year. This data is under slow increase. The general input of this gas is about 750 billions ton.

Analysis of all aspects of global climate is out the theme of article. Let us summarize two conclusions. 1. Human effect on carbon metabolism is not significant. 2. Termite effect on carbon metabolism is significant. Looking for global climate, termite role must be analyzed more serious than human one.

**Methane**. Let us consider question on methane processing. Global methane emission is 535 ton (Кондратьев и др., 2003). 375 millions of them have anthropogenic origin. Rice field produced from 50 to 280 millions. Termites produced about 150 millions. The content of $CO_2$, depends on both ocean and land processes. The main origin of $CO_2$ are ecological systems localizing at land. They are dried areas, deposits of carbohydrates, termites colony and so on. Metabolism of termites is more active that within human organism and technical engimes. Effectivity of metabolism is based on interaction of termite-simbiotic microorganisms from sub kingdom *Protozoa* (*Mastotermitidae*, *Kalotermitidae*, *Hodotermitidae, Rhinotermitidae*). Their proteins transfers cellulose to dissolved sugar, which may be assimilated by insect bowel. About 500 protista species, having mutualistic life, are known. They evolved under close connection with termites. Hence, this evolution was co-evolution. Insects by cooperation with Protista produced a big number of methane.

Worldwide production (millions of tons) of methane includes: rice fields = 20; termites = 7; burning of biological mass = 10; carbon holes = 7; natural gas = 8; dust heaps = 7; lakes = 1; marshes = 21; methane hydrates 1; oceans 2; livestock = 15. The nature of all origins of methane is the same. That is ferment transformation of cellulose. Summarizing, the role of termite in green house effect is significant. We can't miss this process.

**Global Distribution of Termite Populations**

**Modern state**. Majority of termites live within tropic. But their area prolongs to increase. They got Italy, Moldova. Within south direction they got Australia and New Zeeland. General area of their registration is more than 10,000,000 square km. According to assay, begun by Догель (1981) and prolonged by other author, general termites number my get $10^7$ - $10^8$ billions. They are big insect having mean mass 3-5 gram. The termite mass per one man is about 3 ton. At the same time "auto mass" per man is about 200 kg. The volume of dry wood, used by humanity, decreases, because of technology progress. The area of forests increases. According to data by FAO, summarized by Lomborg (2002), the extreme of wood cutting took place at 1947. After the Second World War the primitive technology were used for restoration of destroyed industry. The sum of forests was 3.5 billions hectares. Then wood cutting decreased. At the end of 20th century the forests got 4.2-4.3 billions hectares. Hence, ecological niche for termites began to decrease. But because of population delay, increase of termite population prolongs. Population increase was accompanied by adaptation for cold environment.

**Forecast**. Population dynamics of all organisms consist of both reversible and irreversible processes. The principle of irreversible processes was studied by, Verhulst, Gause et al. According to Maltus and Darwin, exponent stage may be typical for every both population and species. According to Verhulst and Gause, exponent growth is limited. It is connected with philosophy principle of limits of every process. According to Gause (1934), the cause of stabilization is exhaust of resources. According to modern ecological data, the complete disappearance of species is very rare phenomena. The species may prolong its existence as "hidden species" (Сапунов, 2002, Heuvelmans, 1981).

Evolution of every species has regular, that is repeating components. General theory of cyclical processes was suggested by N.Kondratyev (Кондратьев, 1991). There are edogenic cycles, controlled by intra population processes. Genetic drift is example of such a process. There are exogenic cycles controlled by repeating factors of environment. They may be biotic, e.g. effects of predators and parasites, described by Volterra (Вольтерра, 1976) models. They may be abiotic controlled by sun activity and other space factors. Keeping in mind such a factors we would get other model, demonstrated at Fig. 2. Approximal formula is N = A + B Sin Ct. Where, A, B, C — are constants. There are different cycles, in accordance to mean of C. They are long, medial and short. Interaction of them has effect on population size. One of possible variant of population development is demonstrated in Fig. 3.

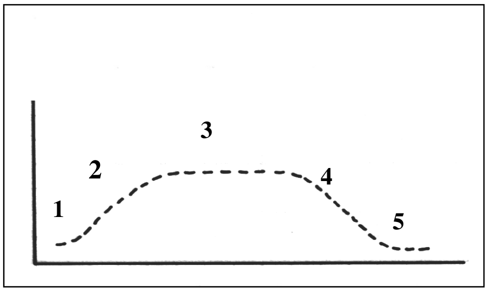


**Figure 1.** Population dynamics in general view. 1 — adaptation for environment, 2- exponent growth, 3 — stabilization, 4 — extinction, 5 — state of hidden species.

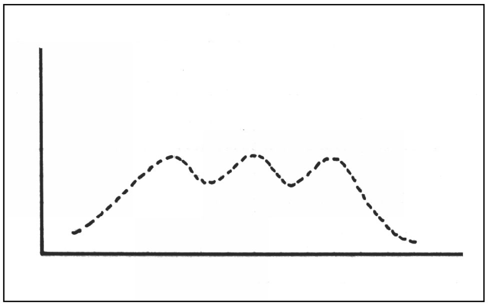

**Figure 2.** Periodic oscillation of population.

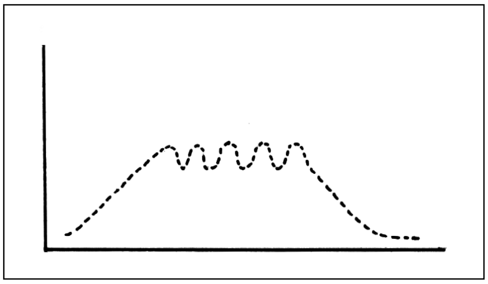

**Figure 3.** Population dynamics by interaction of reversible and irreversible factors

Termite Populations

The area occupied by termites is more than 10 millions square km. The main resource of termites is dry wood. The use of such a material my humanity was increase during long time. Hence, civilization increased ecological niche for termites. Their population increased during some hundred years. Within the 18th century humanity having population 1 billion used 18 * $10^8$ ton of dried wood. The mean increases 5 times to the middle of 20th century. Then it began to decrease by ousting of woods by plastics. Foundation basis for termites began to decrease. The population prolongs to increase by evolutionary inertia. Soon would be gotten the state of stability (3 part of Fig.1), then would began population decrease. Prognosis based on mathematic modeling is demonstrated if Table 1.

**Table 1.** Global characters of termite populations.

| Year | Population | Mass, Ton | $CO_2$ billions | $CH_4$ millions |
|---|---|---|---|---|
| 1985 | $10^{17}$ | 2* $10^{10}$ | 150 | 165 |
| 2008 | 1.05* $10^{17}$ | 1.05 *$10^{10}$ | 157 | 173 |
| 2012 | 1.1* $10^{17}$ | 1.1* $10^{10}$ | 165 | 181 |
| 2017 | 1.15* $10^{17}$ | 1.15*$10^{10}$ | 172 | 190 |

## CONCLUSION

Ecological problems have a big importance under present time. One of them is problem of possible global warming based on green house effect. Majority of countries signatured “Kyoto protocol” at 1997. This document limited pollution of green house gases by industry and transport. Scientific basis for such a protocol appeared to be sick. Main input of such a gases has natural origin. The only insect order such termites have more significant effect on atmosphere content. The number of carbon dioxide produced by abiotic factors is more than biotic production. The general pattern of atmosphere gases is stable during many years because of homeostasis by biosphere. Supernumerary input is compensated by photo synthesis by green plants, which mass began to increase. The human role of $CO_2$ metabolisms is not significant. It is controlled by natural atmosphere cycles, processes within soil and living organisms. General scales of the processes is schedule till now. The data on termite physiology, biochemistry and ecology suggest that their role in global processes is significant. At the same time we can’t miss human activity. Sometimes its indirect results are bigger that direct ones. Social activity may be considered as trigger regulation termite reproduction. The increase of wet wood use stimulated termite population. Decrease of the use would stabilize termite population. The connection of this process is complicated, having delayed effect. There is reason to wait decrease of termite population in close future. The modern state of physiology, ecology and population genetics of termites may suggest correct model of their global evolution and distribution.

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