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11. Supported by NIH Grant C-6516 (to the Children's Cancer Research Foundation, Inc.). We thank Drs. H. Falk and E. Sawicki for spectroscopic studies and Dr. W. Lijinsky and N. Mantel for advice.

17 August 1966

Biodegradation of the Gamma Isomer of Benzene Hexachloride in Submerged Soils

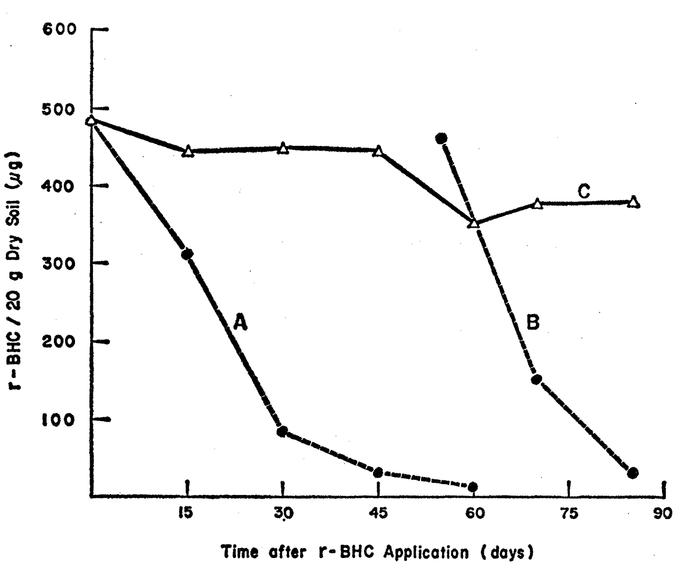
Abstract. *Determination of the residual gamma isomer of benzene hexachloride (γ-BHC) by gas chromatography showed that the insecticide persisted longer in sterilized flooded soils than in nonsterilized flooded soils. A second addition of γ-BHC to one of the nonsterilized soils. (55 days after the first application) disappeared more rapidly than the first addition. These results strongly indicate biodegradation of γ-BHC in flooded soils.*

The gamma isomer of benzene hexachloride (γ-BHC) has been shown to be effective in controlling the rice stem borer *Chilo suppressalis* (Walker) when the insecticide is directly applied to the standing water in a rice field (*1*). Widespread use of γ-BHC to control this major insect pest of rice could lead to substantial increases in yields of this crop in the tropics. However, because of the prolonged persistence reported for this insecticide in unflooded soils (*2–5*) it is essential that information be obtained on the fate of γ-BHC in flooded soils before widespread use of the insecticide is advocated. Information obtained by employing bioassay techniques, as well as by a nonspecific colorimetric procedure for determining residual γ-BHC, indicates that the insecticide persists in unflooded soils for periods ranging from 3½ to 11 years (*2–5*). This insecticide has thus been described as highly recalcitrant (*6*).

To evaluate the significance of biodegradation of γ-BHC in flooded soils, we compared its persistence in sterilized samples of Philippine rice soil to its persistence in nonsterilized samples (*7*). The test tubes containing the soil samples were flooded, treated with γ-BHC (*8*) and incubated in the greenhouse. At appropriate intervals, three replicate tubes of each soil were removed, the γ-BHC was extracted, and the amount of insecticide present was determined quantitatively by gas chromatography (*9*). Identification of γ-BHC was based on R_T (retention time) values, and the amount present was calculated by relating the peak heights to those of analytical standards.

The γ-BHC disappeared more rapidly from nonsterilized flooded soil samples than from sterilized flooded soil samples (Figs. 1 and 2). The γ-BHC disappeared more quickly from the nonsterilized Luisiana clay than from the nonsterilized Maahas clay (compare curve *A*, Fig. 1, with Fig 2). The greater loss of insecticide from the nonsterilized flooded soils indicated that there was active participation of the microflora in the degradation of γ-BHC.

Loss of insecticide from the sterilized soils (Figs. 1 and 2) can be attributed to volatilization. To check this point, at the end of the incubation period we analyzed the cotton plugs which were used to seal the tubes; we found 45 to 64 μg of γ-BHC in the plugs from the tubes of sterilized soil and from 18 to 19 μg in the plugs from



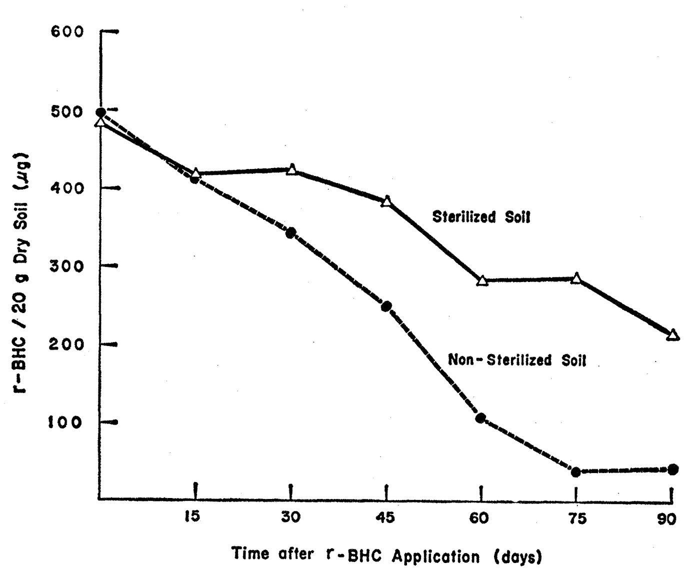


Fig. 1 (left). Persistence of γ-BHC in submerged Luisiana clay. *A*, Nonsterilized soil, first application of γ-BHC; *B*, nonsterilized soil, second application of γ-BHC; *C*, sterilized soil. Fig. 2 (right). Persistence of γ-BHC in sterilized and nonsterilized submerged Maahas clay.

the tubes of nonsterilized soil. Similar volatilization of γ-BHC has been reported (*10*).

More rapid loss of the insecticide from the Luisiana clay was found following a second application of γ-BHC (compare curves *A* and *B*, Fig. 1). These results suggest the establishment, during the 55 days after the first application, of a microbial population active in γ-BHC degradation. This microbial population was able to degrade γ-BHC (without any apparent lag) following a second application of γ-BHC. We are seeking unequivocal proof of microbial degradation of γ-BHC by the isolation of microorganisms capable of degrading this insecticide. Previous observations (*11*) based on the inhibition by γ-BHC of small crustaceans in submerged soils also revealed reductions in duration of persistence when repeated applications of the insecticide were made. The time taken for recolonization of the floodwater by the crustaceans was used to indicate the persistence of γ-BHC. The more specific chemical assay that we used suggested the same trend. The question now arises whether γ-BHC should be considered a highly recalcitrant molecule.

To control the rice stem borer in the field effectively, the insecticide should be applied in two doses to give a total application of 5 kg of γ-BHC per hectare (*1*). While detectable amounts of γ-BHC were found after 60 and 90 days in the Luisiana clay and the Maahas clay respectively, the amounts that we used were approximately three times greater than those recommended for field application. Therefore, unusually prolonged persistence of the insecticide in the flooded soils studied seems unlikely.

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7. The two soils used (Maahas clay and a latosolic soil) were from Luzon, Philippines, and had the following characteristics: the Maahas clay (*p*H 6.6; organic matter, 2.0 percent; total N, 0.14 percent) and the latosolic soil or Luisiana clay (*p*H 4.7; organic matter, 3.2 percent; total N, 0.21 percent).
8. The γ-BHC used was analyzed by gas chromatography, and was free of any traces of the other isomers of benzene hexachloride.
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19 July 1966

Fossil Occurrence of Murine Rodent (Nesokia indica) in the Sudan

Abstract. *A specimen of the murid rodent* Nesokia indica *has been recovered from a late Paleolithic archeological site in the Sudan. This is a range 1200 km south of the site of any known occurrences, and it indicates a different environment near the Nile River than that which exists at the present time. The late Paleolithic water table is inferred to have been more stable, allowing for permanent moist soil.*

During the course of archeological excavations in the Sudanese portion of the Aswan Dam pool area, several sites were found to contain permineralized bone. One interesting find was the broken jaws of the murid rodent *Nesokia indica*. The specimen (*1*) consists of a left jaw fragment with M_{1-3} and incisor root, and a right jaw fragment with M_1 and incisor root. They were found together (hence, probably from the same individual), at the Sudanese Antiquities Service site number 6B28 (upper Paleolithic age), Dabarosa West, Northern Province, Republic of Sudan, 1 km west of the Nile River, and 1½ km west of Wadi Halfa.

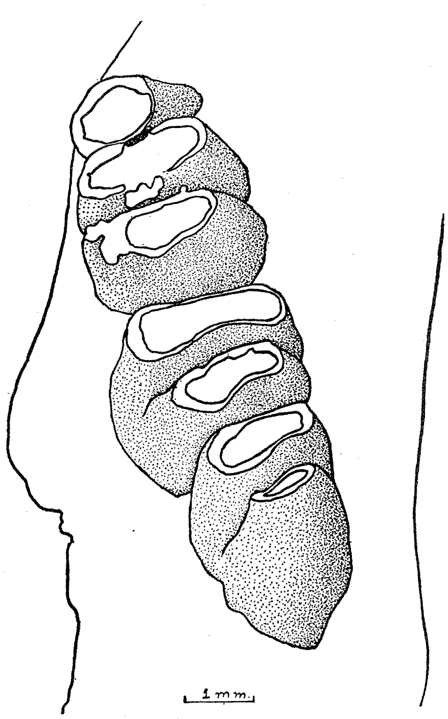

Fig. 1. Crown view of *Nesokia indica* (UCM 27413 A). Left M_{1-3}, from Dabarosa West, Northern Province, Sudan.

This record of *Nesokia indica* from northern Sudan is interesting for several reasons. *Nesokia* is found today in Western Asia and Asia Minor (*2*) but in Africa it is restricted to the Nile Delta and the Fayum marshes. *Nesokia* inhabits the banks of irrigation canals and distributaries of the Nile Delta by burrowing into the soft mud (*3*). Although irrigation is common in the narrow band of arable land on both sides of the Nile in Nubia, the irrigation is seasonal and there are periods when the soil is dry and hard. The same is true of those areas not under cultivation; in these cases, control by the seasonal fluctuation of the water level of the Nile is more obvious. *Nesokia* inhabits areas where the ground is wet the year round. This gives us an indication of what the ecology was like during late Paleolithic time in Nubia. Presumably, if the Nile went through seasonal fluctuations as it does today, these annual changes in water level had little effect on the area near the river. Such a relatively stable water table would imply dense vegetation near the river, with concomitant increase in the fauna dependent on it. Such an area would be of significance to a human population and might allow a permanent campsite or sites near an abundant food supply.

If these inferences are correct, the effect of this environment on the local inhabitants must have been significant; a larger population could have survived for as long as this condition continued. Possibly, similar conditions existed for some distance north and south of the Wadi Halfa area.

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8 August 1966