of appetite. The diagnosis was further based on negative hematological changes and negative Hirst tests for influenza A and B.

Six human volunteers were inoculated intranasally with chorioallantoic fluid (Spill strain) of the 9th passage in chick embryos. Five developed symptoms of cold, ranging from severe reactions to transitory, aborted manifestations. Five of these men and five new volunteers were inoculated subcutaneously with two doses of infectious chorioallantoic fluid (Spill strain), 1 cc. at weekly intervals. One week following the second inoculation, they were challenged intranasally with Seitz filtrates of nasal washings from naturally acquired cases of common cold infection. All of the individuals who had been immunized with the chick embryo propagated Spill strain cold agent failed to develop symptoms of cold; and with the same challenge inoculum, the two controls who had not been exposed to the Spill strain cold agent both developed marked symptoms (Table 3).

TABLE 3

CHALLENGE INOCULATION OF IMMUNIZED HUMAN VOLUNTEERS (1cc/week/2 weeks)

No.	Intranasal challenge nasal washings (pool of Connoly, Fly & Thompson)	Hours	Symptoms						
			"Stuffy"	Sneezing	Swollen mucosa	Exudate	Headache	Cough	Exercise tolerance
24	1.0 cc.	24	–	–	–	–	–	–	
		48	–	–	–	–	–	–	
		72	–	–	–	–	–	–	
28	1.0 cc.	24	–	–	–	–	–	–	
		48	–	–	–	–	–	–	
		72	–	–	–	–	–	–	
29	1.0 cc.	24	–	–	–	–	–	–	
		48	–	–	–	–	–	–	
		72	–	–	–	–	–	–	
30	1.0 cc.	24	–	–	–	–	–	–	
		48	–	–	–	–	–	–	
		72	–	–	–	–	–	–	
31	1.0 cc.	24	–	–	–	–	–	–	
		48	–	–	–	–	–	–	
		72	–	–	–	–	–	–	
41	Uninoculated control, 1.0 cc.	24	+++	Sniffling	++	++S	"Head tight"	+	Poor
		48	++	+	–	–	–	–	
		72	–	–	–	–	–	–	
32	Pool of Quattlebaum & Jones, 1.0 cc.	24	–	–	–	–	–	–	
		48	–	–	–	–	–	–	
		72	–	–	–	–	–	–	
33	1.0 cc.	24	–	–	–	–	–	–	
		48	–	–	–	–	–	–	
		72	–	–	–	–	–	–	
34	1.0 cc.	24	–	–	–	–	–	–	
		48	–	–	–	–	–	–	
		72	–	–	–	–	–	–	
35	1.0 cc.	24	–	–	–	–	–	–	
		48	–	–	–	–	–	–	
		72	–	–	–	–	–	–	
36	1.0 cc.	24	–	–	–	–	–	–	
		48	–	–	–	–	–	–	
		72	–	–	–	–	–	–	
38*	Uninoculated control, 1.0 cc.	24	++	–	++	+++S	–	+	Fair
		48	++++	–	+++red	+++S	–	–	Poor
		72	+	–	++red	–	–	–	Poor

* This case developed an otitis media and ruptured ear drum 3 days later.

Six control volunteers were inoculated intranasally with normal chorioallantoic fluid from 11-day-old incubating chick embryos, and none developed any of the symptoms of cold infection. The same was true of five control volunteers inoculated intranasally with 2 per cent rabbit serum in physiological saline.

Development of Castes in Higher Termites

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Studies on the determination of castes (*5*, *6*) have been confined to the lower families of termites. The higher termites, the Termitidae, seem to offer more favorable opportunities to study the mechanisms which determine the development of the structurally very different castes. They possess a readily distinguishable worker caste, and the colony consists largely of fully differentiated terminal individuals, workers, and soldiers.

The nymphs of the lower families have been shown to be indifferent up to relatively late instars (*5*). Our findings reported here agree with those of Bathellier (*1*) in placing determination of castes in the Termitidae very early in nymphal development.

The lower termites are amenable to laboratory culture, but the literature shows no records of attempts to culture the higher termites except the method for mass culturing of the sterile castes of *Nasutitermes* (=*Entermes*) *exitiosus* Hill, worked out by Holdaway, Day, etc. in Canberra, Australia. A brief report of certain features of the method was presented in 1936 (*4*) by Holdaway and again in 1938 by Day (*2*).

Although the Termitidae are largely tropical, three genera are common in the southwestern United States: *Amitermes*, of which the most common species is *A. wheeleri* (Desneux); *Gnathamitermes*, with the common and widespread species *G. perplexus* Banks; and *Tenuirostritermes*, the most common species of which is *T. tenuirostris* (Desneux). *Tenuirostritermes* is a nasute termite in which the soldiers have only vestiges of mandibles and a long, pointed projection of the head on which opens the cephalic gland.

The writers devoted the spring and summer of 1946 to studies of the last two species in southeastern Arizona, where both are abundant. Using a method reported elsewhere (*7*), we have found that the incipient colonies can readily be cultivated beyond the point necessary to obtain experimental results. Groups from older colonies present greater difficulties, *Gnathamitermes* being less difficult than *Tenuirostritermes*. More detailed reports of field observations and experimental results will be presented elsewhere.

In these Termitidae, living under essentially temperate conditions, reproduction and caste development were found to be restricted to the warmer months.

In March the only immature individuals in the colonies of *Tenuirostritermes* were the large brachypterous nymphs (with rudimentary wings), destined to become the alates which swarmed in July with the summer rains. The colony consisted almost entirely, therefore, of terminal sterile individuals, the workers, and the nasutes.

The cycle in *Gnathamitermes* differs strikingly from that of *Tenuirostritermes* in several features. In addition to the workers, soldiers, and brachypterous nymphs, there were present in colonies of *Gnathamitermes* many apterous individuals like the workers but slightly smaller and with unpigmented heads. These proved to be the late nymphal instar of the sterile castes.

Beginning in early April some of these nymphs were found to be molting into the worker stage and from May 15 callow soldiers were found in some colonies. Therefore, the older apterous nymphs found in *Gnathamitermes* colonies may be of two types, one destined to become workers, the other to become soldier nymphs; or they may be indifferent, capable of giving rise either to workers or to soldiers.

Eggs were first found in *Tenuirostritermes* colonies on April 3. On April 24 eggs were first recorded in *Gnathamitermes* and probably first appeared there a week or two earlier. Eggs were abundant thereafter in the colonies of both species until our departure in late August, and presumably for some time after that.

The existence of the restricted period of reproduction in our species of Termitidae makes it possible to determine with certainty the lines leading to the several castes, since their appearance from the first eggs may be followed chronologically.

Thus, the junior author was able to trace, in some detail, the lines of development of the different castes of *Tenuirostritermes*. Conclusions made from field observations were checked by segregating the different stages and observing in the laboratory the stage derived from each by molting. The outstanding feature of her findings was that the three major lines leading, respectively, to the nasute, the worker, and the alate types are differentiated very early in development and can be distinguished readily from a very early molt—certainly the first molt for the nasutes and probably also for the other two castes. It seems safe to say that the nasute line is determined sometime during the first stadium. Both Emerson (*3*) and Bathellier (*1*) show the nasute-like "nasute nymph" molting from a pigmented, worker-like stage, whereas we found that the nasute of *Tenuirostritermes* molts from an entirely unpigmented nymph and confirmed this origin in the incipient colony. The reduction by one in antennal segments recorded by Emerson and Bathellier was found to occur also in *Tenuirostritermes*.

Nymphs initiating the worker line arise from large-bodied nymphs probably of the first instar. These do not molt until several days after the appearance of the nymphs of the nasute line.

The time required for the development of each of the various stages of the sterile castes in the primary colonies of *Tenuirostritermes* in the laboratory agreed closely with that in the first brood of the year in older colonies in the field.

The young of the alate line, made obvious by the possession of wing buds, arise from large-bodied young nymphs indistinguishable from those which give rise to the worker line. The first wing-budded nymphs were observed in August, after the alates had flown, whereas the nasute and worker lines were being renewed from the time of the first appearance of young, about May 1.

More than 400 pairs of dealated reproductives of each species were set up and allowed to develop as primary incipient colonies. Many of these seemingly developed normally. The incipient colonies of the two species were found to differ in the development of castes in the same ways as did the older colonies in the field. Flourishing incipient primary colonies of *Tenuirostritermes* consisted of from 15 to 20 nasutes and 45 to 55 workers. In *Gnathamitermes* colonies, the numbers were smaller (20–30), and no soldiers or workers appeared, all developing to the last apterous nymphal stage and remaining in that stage for months beyond the time when all members of *Tenuirostritermes* primary incipient colonies had become either workers or nasutes.

The conditions reported here make it obvious that primary colonies of *Gnathamitermes* are not favorable subjects for experiments on determination of castes, since the nymphs do not complete their development until the following year. The same is true for *Amitermes wheeleri*, whose reproductive cycle parallels that of *G. perplexus*.

The primary colony of *Tenuirostritermes* offers certain important advantages for experimental studies. The primary pair contain all the food necessary to allow the large primary group to develop to the definitive caste, worker or nasute. This development takes place rapidly, the first worker appearing about 60 days after setting up the dealated pair and the first nasute about 3 days later. It should be possible, therefore, to test the inhibiting effect of the presence of introduced workers or nasutes upon the caste development within such primary colonies.

References

1. Bathellier, J. *Faune Col. Franc.*, 1927, **1**, 243.
2. Day, M. F. *J. Coun. sci. ind. Res.*, 1938, **11**, 317.
3. Emerson, A. E. *Zoologica*, 1926, **7**, 69.
4. Holdaway, F. G. *J. Austr. Inst. agric. Sci.*, 1936, **35**, 34.
5. Light, S. F. *Quart. Rev. Biol.*, 1942, **17**, 312; 1943, **18**, 46.
6. Light, S. F. *Univ. Calif. Publ. Zool.*, 1944, **43**, 405, 413; Light, S. F., and Illg, Paul L. *Univ. Calif. Publ. Zool.*, 1945, **53**, 1.
7. Light, S. F., and Weesner, Frances M. *Science*, 1947, **106**, 131.

Lethal Effect of X-Rays on Marine Microplankton Organisms[1]

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Published literature concerning the effect of X-rays upon free-living microorganisms has dealt chiefly with fresh-water life. Ralston (*1*), however, found dosages of about 18,000 r lethal to *Dunaliella salina*. The present experiments deal with four genera of Protista obtained through the courtesy of Vance Tartar, of the State of Washington Department of Fisheries. These may be designated as (1) *Chlorella* sp. (Loosanoff's culture), a 2-μ, spherical green alga; (2) *Nitzschia closterium* (Loosanoff's culture), a diatom; (3) an unidentified green car-

[1] This paper is based on work performed under contract No. W-28-094-eng-33 with the Manhattan District-Atomic Energy Commission.