

shorten the pulse length. This will permit the counting of scatterers in more densely populated regions. In addition, a measurement of the echo intensity will help to establish the size range of the scatterers. The possibility exists of using a surface-controlled camera in conjunction with the transducer. This should constitute marked improvement over the random picture-taking technique now in use.

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References

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Pure Cultures of Fungi Produced by Ants

Experiments and observations elucidating the mechanisms by which pure cultures of fungi are cultivated and maintained in the nests of attine, or fungus-growing, ants have been conducted in Panama and Florida in 1954, and at Swarthmore College in 1953-54, with similar results. The ants' habit of stripping the leaves of economic plants causes the larger attine species to be ranked as major agricultural pests throughout much of Latin America. Heretofore, an explanation for the ability of the ants to create pure cultures of fungi despite the constant bringing in of alien bacteria and fungi has been lacking.

The attine ants are found exclusively in the New World and primarily in the tropical regions. The fungi that the ants cultivate have not been recognized outside of ant nests, and the ants are dependent on the fungus for their food supply. In most of the species, a nest, consisting of one or more chambers in which a fungus garden is developed, is formed in the soil. The fungus garden is usually formed on a vegetal substrate, such as triturated leaves. Removal of the ants from a fungus garden causes it to be soon overwhelmed by alien fungi and bacteria. The fungi are clearly unable to maintain themselves and do not grow except under the care of the ants.

The northernmost of the fungus-growers, *Trachymyrmex septentrionalis* McCook from New Jersey, has been kept under observation since September 1953, at Swarthmore. Two types of fungi appear regularly in the artificial cultures and have been cultured on potato dextrose and Sabouraud's agar. A few workers are able to maintain a fragment of fungus garden in its normal condition on an agar plate, despite flourishing alien fungi of *Penicillium*, *Aspergillus*, and *Mucor* types and bacterial colonies that are close to the garden. The ants walk over these regularly as they forage for substrate.

In Panama, fungus gardens and parts of colonies of *Cyphomyrmex costatus* Mann and species of *Atta*,

Trachymyrmex, and *Apterostigma* were kept under observation at the Gorgas Memorial Laboratory, and their fungi were cultivated on Sabouraud's agar. Several types of fungi were produced. *Atta* and *Trachymyrmex* strains produced bromatia, a concentrated form of gongylidia that is eaten by the ants, and which grew in these artificial cultures much as in ant nests. These were fed back to the ants after culturing for 2 mo or more. The ants accepted them as food and used them as a nucleus for a fungus garden. As at Swarthmore, it was found that the ants of these genera could maintain fragments of fungus gardens in the pure condition on agar plates despite a forest of surrounding alien fungi.

At the Archbold Biological Station in Florida, *Trachymyrmex septentrionalis seminole* Wheeler and *Cyphomyrmex rimosus minutus* Mayr were kept under observation in the same manner. Ants of *T. septentrionalis seminole* from Florida adopted and cultivated fungus gardens of the New Jersey form at Swarthmore.

This Florida *Cyphomyrmex* fungus developed, on Sabouraud's agar, two strains quite different from that of the Panama *Cyphomyrmex costatus* or from that of any of the other attines. One strain developed a morel-like or vermiculate form that has been recorded in the literature [*Rev. de Ent.* **16**, plate 1, Fig. 2 (1945)], and which the author developed in 1935 from the same ant in Trinidad. After the fungus had been reared in artificial culture for more than a month, it was fed back to the ants, which used it as food and cared for it as though it were their normal fungus.

On the basis of these and other data to be published more extensively elsewhere, it is postulated that the salivary and anal secretions of the ants may play a primary role in creating conditions for pure cultures of ant fungi. Identifications of these fungi are desired, and cultures will be submitted to mycologists upon request.

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Modern Cosmology and the Fixed Stars

Herbert Dingle's article, "Science and modern cosmology" [*Science* **120**, 513 (1 Oct. 1954)] is a most provocative and explicit statement of the uneasiness and dissatisfaction that any thoughtful student of modern cosmology must feel. It might be remarked, however, that this unhappy situation cannot wholly be blamed on the "newer" cosmologies; it reflects as well a growing realization that general relativity itself is inadequate to the claims that are often made in its behalf.

Dingle, of course, makes no such rash claims, and rightly stresses the *relativity* of the theory, the emancipation of physical reality from coordinate systems. This, with the allowance for curved metrics and consequently the incorporation of gravitational "forces" as inertial effects, is the great advance—and it is truly