deposited particles. It must have a specific gravity approximating that of the carbon particles to be suspended in it in order to prevent rapid settling out. These requirements are rather well met by carbon tetrachloride. The cost of carbon tetrachloride being high, some of the heavier commercial hydrocarbons were used successfully, such as Union Oil Company's Cleaning Naphtha with a Baumé gravity of 55 and an initial and end boiling point of 95 to 145° C., respectively. Gasoline is not satisfactory, as the end point is too high.

b As a source of carbon particles of suitable size, the better brands of lamp black (vegetable black) have been found to be satisfactory. Some ten other kinds of black pigment were tried unsuccessfully. Sixteen grams of vegetable black per liter of fluid are taken, and the mixture shaken vigorously for five or ten minutes. This can be done most conveniently in a mechanical shaker. Grinding in a ball mill or deflocculating in a colloid mill would improve the suspension, but is not a necessity. The suspension is strained through as fine a mesh cloth as possible and stored in pint Mason jars, of the type fitting the pressure gun to be used. When the suspension is stored it must be shaken vigorously prior to use.

c In applying the suspension any well-designed spray gun in which the air issues from an annular orifice surrounding the fluid nozzle would probably be found satisfactory, but the cheaper makes of gun are to be avoided. We have used the "Sharpe" pint-size gun successfully at ten to twenty pounds air pressure. In applying the black it has been found advisable to rotate the drum rapidly on an upright shaft at a distance of 20 to 40 cm from the nozzle of the spray gun. At this distance the naphtha will not wet the surface of the drum excessively, providing the needle valve regulating the mixture of air and fluid is properly set. The spray gun should be shaken occasionally to prevent settling of the carbon. In this manner a thin, uniform coat of carbon particles can be applied quickly and conveniently to the recording surface. Too heavy a layer should be avoided in the interests of diminishing friction of recording levers and of preventing the washing of the carbon in the fixing process after records have been made. An enclosed exhaust booth is a necessity where a large amount of spraying is done. There is nothing critical in the above process and reasonable variations may be individually made.

(2) A very great simplification and improvement in the photographic reproduction of kymograph tracings has been found to be possible by the use of transparent recording material in place of glazed paper. The difficulties of photographic reproduction of varnished kymograph tracings are too well known, and too obvious from the many poor reproductions found in the scientific journals, to need emphasis. We have found it to be simple to avoid these difficulties by direct printing from fixed cellophane records. Colorless, transparent No. 600 cellophane sheets used in place of kymograph paper make a satisfactory recording surface. Cellophane can not conveniently be blackened by smoke and is best prepared for recording by the spray-gun method just described. After records have been made the surface can be fixed by passing the strip through a bath of carbon tetrachloride containing 3 per cent. rosin (the latter put into solution by prolonged mechanical shaking).

The record thus fixed can be used directly for printing positives, in which the graphic records stand out in black against a white background. Direct enlargements up to twenty times have been made retaining sharp delineation, and offer possibilities for closer study of certain phenomena (in our studies particularly isometric tension curves). Direct reduction is also highly successful and is desirable in printing upon lantern slides and in illustrations for publication.

It should also be noted that segments of the original fixed record can themselves be successfully used in making lantern slides by simple mounting between blank glass slides.

Transparent cellophane, No. 600, in strips 7 inches wide, rolled, has been supplied at our request by the E. I. du Pont de Nemours Company, and is priced at such a figure as to make its use more economical than that of glazed paper.

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USE OF ETHYLENE OXIDE FOR THE ERADICATION OF PESTS

The barberry eradication campaign as well as the campaigns for the control of white pine blister rust through the eradication of currants and gooseberries have shown the need of a chemical substance with high toxicity to the plants, yet which will have no lasting detrimental effect on the soil. The practice of digging barberry bushes leaves a possibility of sprouts being produced from pieces of roots not found in digging. The use of common salt is a more desirable practice from the standpoint of the labor involved and the effectiveness of the killing agent. For use in pastures this method may have some objection. The use of chlorates, arsenates, etc., is excluded in pastures where cattle may be poisoned.

Some observations made by Vacha and Harvey[1] indicated a high toxicity of ethylene oxide to plant tissues. More recent work by the author has shown that ethylene oxide has many properties which make it suitable for killing noxious plants. By the use of a rod it can be introduced into the soil beneath the bushes. The "depth charge" can be regulated to certain levels of roots in the soil. The materials injected are not accessible to animals. Ethylene oxide is liquid at ordinary temperatures at pressures between eight and twenty pounds per square inch. This gives pressure sufficient to drive it into the soil directly from the tank. A special measuring device fitted to an injecting rod has been devised, which may be called a "gopher stick." Such a device is of use also in killing gophers by similar toxic agents. The ethylene oxide is volatile enough to allow a quick spread through the soil and a relatively short period of its effect in the soil. It is soluble in water, and dilutions with ice-cold water can be made with little loss when it is desired to use a water dilution or a mixture with other toxic agents. Dilutions can be handled in the usual knapsack sprayer with a "gopher stick" in place of the spray nozzle. Mixtures with chlorates or formaldehyde may be used without chemical reaction destroying the toxicity.

The ethylene oxide penetrates quickly up through the tissues, causing marked discoloration of the leaves within a few days. The effect in sterilizing the tissue through which it passes is being investigated since it may be of use in killing fungi or insects within the wood or bark to prevent their dissemination. The use of such a penetrating sterilizing agent would decrease the labor of removing trees which are infected with such pests.

The use of ethylene oxide alone and in water solution has been shown by the killing of several hundred bushes of barberry,[2] currant, gooseberry, poison ivy, prickly ash, scrub oak, popple, boxelder, etc. The size of the charge or dose must be adjusted to the bush to be eradicated. Determinations have been made on the charge required in different types of soils and with various soil moisture contents. Indications are that at the present price of ethylene oxide the cost of materials is about the same as for eradication by common salt while the labor is considerably reduced. Other oxides of the unsaturated hydrocarbon series are being tried for their toxicity and effectiveness.

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[1] *Plant Physiology*, 2: 187–193, 1927.

[2] The author is indebted to Dr. L. W. Melander and the Office of Barberry Eradication, U. S. Department of Agriculture, for cooperation and assistance in the experiments.

SPECIAL ARTICLES

THE BIOLOGY OF THE PETROLEUM FLY

RECENTLY a well-known systematic zoologist, Dr. W. T. Calman,[1] gently admonished physiologists for their tendency to neglect "the unending diversity of structure and habit among animals" and emphasized the danger of making far-reaching generalizations from experiments carried out upon the still somewhat restricted fauna of the physiological laboratory. In no group in the animal kingdom are such generalizations more unsafe than in the Insecta, for nowhere is physiological diversity more marked. And perhaps no insect is more aberrant physiologically than the petroleum fly.

Considering the fact that the existence of this insect has been known to entomologists for over thirty years, it might be thought that all the details of the life history and physiology would have been described long ago. Owing perhaps to the restricted distribution (it appears to be confined to the oil-fields of S. California) this is far from being the case, and although some of the main facts of its structure and life history have been described by Howard[2] and Crawford[3] there still remain many points of interest to be investigated. The subject is one of interest not only to the entomologist but also to the physical chemist and general physiologist, for, as is well known, paraffin hydrocarbons, owing to their power of rapidly penetrating cell membranes, are highly toxic to living tissues.

The writer had the opportunity while working at the Citrus Experiment Station of the University of California at Riverside in 1928 and 1929 of investigating certain matters concerning the nutrition of this insect and its adaptation to a life in oil. The main results of these investigations are here summarized. Full details of the experiments will be published shortly.[4]

The larvae of *Psilopa petrolii* go through their entire development in shallow pools of waste oil, breath-

[1] W. T. Calman, presidential address, Section D—Zoology, British Association for the Advancement of Science, 1930.

[2] L. O. Howard, *Scientific American*, 80: 75, 1899.

[3] D. L. Crawford, *Pomona College Journal of Entomology*, 4: 687–697, 1912.

[4] *Trans. Ent. Soc. Lond.*, 1930.