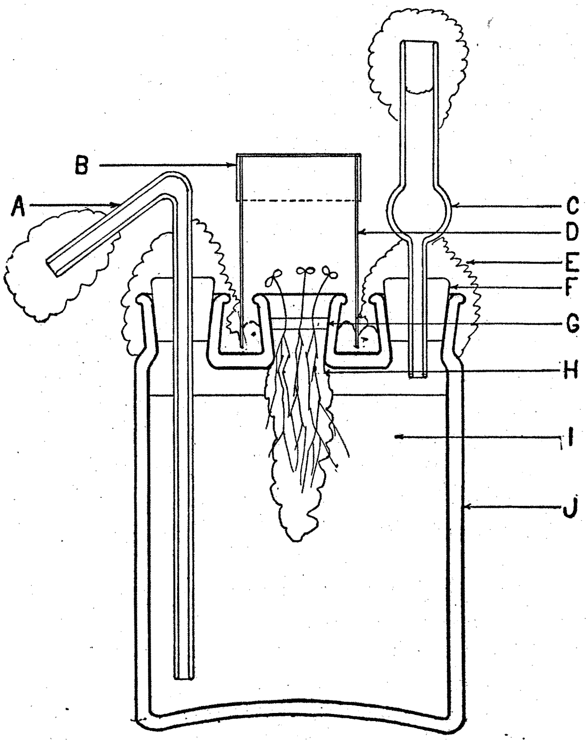
agar is added, the seed planted in it, and the cover put on. A glass cover could under some circumstances be advantageously substituted for the celluloid cover.

Sterile non-absorbent cotton is used for protecting exposed openings. After the plantlets grow large enough to fill the cover, it may be removed, all but



one plant removed and sterile cotton worked around it, if it be desired to grow it further.

This method was especially worked out for tobacco, but seems applicable to any small-seeded plant whose plantlet is small, slow-growing and difficult to transplant under aseptic conditions. It differs from other proposed methods in that (1) the plantlet remains in the original substratum and (2) that a layer of nutrient agar is introduced to indicate asepticism.

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SPECIAL ARTICLES

THE OVERWINTERING IN MASSACHUSETTS OF IXODIPHAGUS CAUCURTEI

THE purpose of this communication is to record the overwintering of *Ixodiphagus caucurtei,* a hymenopterous chalcidian parasite of ticks, introduced upon the Island of Naushon for the control of *Dermacentor variabilis,* the common dog tick of Eastern Massachusetts.

This fly was discovered by Professor E. Brumpt in nymphs of *Ixodes ricinus* taken in the neighborhood of Paris (Chantilly and Fontainebleau). It was described by M. R. du Buysson in 1912 (*Archives de Parasitologie,* xv, p. 246). Its use for the control of ticks responsible for the transmission of diseases, including Rocky Mountain spotted fever, was proposed by Brumpt in 1913 in a short article "Utilisation des Insectes auxiliares entomophages dans la lutte contre les Insectes pathogénes" (*La Presse Médicale,* No. 36 du 3 Mai 1913). In this article Brumpt records the parasitization by this fly of the following species in addition to *Ixodes ricinus*:

Haemaphysalis concinna
Rhipicephalus sanguineus
Dermacentor andersoni

It is pertinent to recall in connection with this report early work of L. O. Howard. In 1907, he described and figured the first chalcid parasite of a tick and established the genus *Ixodiphagus* in his description of *Ixodiphagus texanus.* (*Ent. News,* xviii (1907), pp. 375–378). His specimens were obtained from nymphs of the rabbit tick *Haemaphysalis leporis-palustris,* Packard, collected in Jackson County, Texas. In 1908 (*Canadian Entomologist,* xl, p. 239–241) he described and figured another chalcid parasite, *Hunterellus hookeri* (tribe Ixodiphagini), obtained from nymphs of *Rhipicephalus texanus,* Banks, taken from a dog at Corpus Christi, Texas.

An unsuccessful attempt to introduce *Hunterellus hookeri* into South Africa is described by C. P. Lounsbury in 1908 (Rept. Govt. Entomologist for 1908, Cape of Good Hope, Appendix iv, p. 65.)

The Naushon experiment is probably the first adequately conducted attempt—apparently successful—involving the introduction and acclimatization of a chalcid parasite of ticks. Dr. S. B. Wolbach had long been interested in the possibilities suggested by Brumpt's brief paper, inasmuch as *Ixodiphagus caucurtei* already existed in a climate not too unlike that of certain Rocky Mountain spotted fever territories to preclude probability of acclimatization. The hope of ultimate utilization of the fly for control of the Rocky Mountain spotted fever ticks was the deciding factor in the decision to try first this method in an attempt to alleviate the heavy tick (*D. variabilis*) infestation of the privately owned island of Naushon, near Woods Hole, Massachusetts. Hence an altruistic spirit as well as a desire for relief from annoyance prompted the owners of the island in their financial support of this experiment. The Department of Pathology of the Harvard Medical School made necessary preparations, provided materials and equipment, and an assistant, Mr. Arthur G. King.

Professor Brumpt received the idea with great enthusiasm and gave permission for his assistant, Dr. F. Larrousse, to undertake the actual conduction of the experiment, which was begun in May, 1926, following the arrival of Dr. Larrousse in this country.

The fly was obtained from the Forest of Fontainebleau. A total of nine deer skins was examined in Professor Brumpt's laboratory between January 12th and March 23rd, 1925, for ticks. In all, 1,205 were collected, the following species being represented: *Ixodes ricinus, Dermacentor reticulatus, Haemaphysalis inermis, Haemaphysalis concinna.* There were 94 nymphs of *Ixodes ricinus,* one of which was parasitized with *Ixodiphagus caucurtei.* From the parasites which emerged from this nymph the strain was propagated in the laboratory.

Dr. Larrousse brought to this country parasitized nymphs of *Dermacentor reticulatus, Rhipicephalus sanguineus* as well as larvae, unparasitized nymphs and adults of both species.

Adults of two species of ticks (*Dermacentor variabilis* and *Rhipicephalus sanguineus*) were collected at Naushon and nymphs raised from these were parasitized in the laboratory of pathology of the Harvard Medical School.

Dermacentor variabilis proved to be easily parasitized by *Ixodiphagus caucurtei,* though difficult to rear in the laboratory as the larvae attached to guinea-pigs and rabbits in small numbers only. Later with Dr. Larrousse's discovery of a natural host of the larvae and nymphs of this species—the common field mouse, *Microtus pennsylvanicus pennsylvanicus,* the rearing and parasitization of nymphs was much facilitated in the field laboratory established at Naushon. Another species of tick, *Ixodes scapularis,* was found in great numbers upon the island and proved also to be easily parasitized by *Ixodiphagus caucurtei.* The normal host of the larvae and nymphs of this tick was found to be the white-footed wood-mouse, *Peromyscus leucopus,* but both larvae and nymphs readily attached to rabbits and guinea-pigs.

Other species of ticks found in smaller numbers upon the island were *Rhipicephalus sanguineus* and *Haemaphysalis leporis-palustris,* the latter found but once.

Experiment proved that nymphs of *Dermacentor variabilis* attached to rabbits become parasitized in the field by flies liberated at distances of 50 and 100 meters, no greater distances being tried in the experiment.

Three methods were used in introducing the parasites.

1. Large numbers of the flies were liberated in situations where nymphs of *Ixodes scapularis* were numerous and in other regions where *Dermacentor variabilis* abounded.

2. Parasitized nymphs of *Ixodes scapularis* were returned to their original situations, mouse holes, etc.

3. Domestic mice (*Mus domesticus*) and field mice (*Microtus pennsylvanicus pennsylvanicus*) with parasitized nymphs still attached were liberated amidst their natural surroundings.

An overwintering experiment in which 34 parasitized nymphs of *D. variabilis* were placed in artificial burrows during the late fall (1926) was a failure. When recovered (with considerable loss) in the spring the majority of the nymphs contained the adult form of the parasite, none of which were living.

During the summer of 1927, field mice and wood mice were trapped and wild rabbits were shot, with an extraordinary low yield of nymphs; eighty-two engorged nymphs being taken from sixty mice. During the summer of 1926, field mice trapped were heavily infested with larvae and nymphs of *D. variabilis* (several hundred larvae and thirty to forty nymphs each), while the larvae and nymphs of *Ixodes scapularis* were easily collected in great numbers by placing puppies upon dead and decayed tree trunks containing the holes of the wood-mouse (*Peromyscus leucopus*).

Four of the eighty-two nymphs of *D. variabilis* and *Ixodes scapularis* (in almost equal numbers) thus collected in the field in 1927, proved to be parasitized. The nymphs were dissected after varying periods following the appearance of evidence of parasitization. One nymph of *D. variabilis* contained a cluster of eggs with developed embryos of *Ixodiphagus caucurtei,* two contained full-grown larvae. One nymph of *Ixodes scapularis* was dissected after the lapse of ample time with failure of the fly to emerge; fully developed adults were found.

These results, though scanty, proved that *Ixodiphagus caucurtei* had survived a New England winter under natural conditions and had propagated itself. It would be perhaps premature to attribute the extraordinary reduction in ticks noticed in 1927 to the parasite alone. Quantitative methods of estimating the tick population were not employed. The difficulty of obtaining larvae and nymphs of *D. variabilis* and *I. scapularis* in 1927 has been noted above. A similar diminution in adult ticks was also noted. Whereas in July, 1926, the ticks, *D. variabilis* in particular, were so numerous that a brief walk through certain places always resulted in the collection of from 30 to 40 ticks upon one's clothing, in July, 1927, the same procedure would yield only an occasional tick, often none at all. Likewise the heavy infestation of domestic animals, cats, dogs, sheep and horses annually experienced disappeared in 1927. This notable decrease of ticks on Naushon was in marked contrast to conditions on the adjacent mainland—Cape Cod, where ticks were unusually numerous at several different points, hence the influence of climatic conditions may be excluded.

Further observations will be made at Naushon during 1928. It is a great source of satisfaction that a similar and more elaborate experiment with the same strain of *Ixodiphagus caucurtei* is under way in Montana, in the Bitter Root Range, under the able direction of Professor R. A. Cooley (*Medical Sentinel*, December, 1927).

Thanks are due to Dr. L. O. Howard for his kindly offices relative to the introduction of the parasite into this country; to Dr. Henry S. Forbes and the owners of Naushon, for their actual participation in the experiment, hospitality and financial support.

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AN EFFICIENCY FORMULA FOR DAIRY COWS

IN 1901 Jordan[1] called attention to the differences in efficiency of the various species of domestic animals as converters of animal feeds into human food materials. He gave the production of pounds of "edible solids" per 100 pounds of "digestible organic matter" in the ration as, in part, follows:

Animal and Product	Edible Solids
Cow, Milk	18.0
Hog, Carcass	15.6
Calf, Carcass	8.1
Fowl, Egg	5.1
Fowl, Carcass	4.2
Steer, Carcass	2.8
Sheep, Carcass	2.6

These figures still pass current as representing the efficiency of the animal producer. Jordan clearly pointed out that the figures given are average values and subject to considerable variation, according to various conditions of management, and as between individual members of the species.

With respect to milk production by the cow it is well known that the efficiency of production depends to a great extent upon the annual yield of milk. This note presents a formula for the estimation of a coefficient of efficiency based on the weight and annual yield of the cow. It is intended further to suggest the significance of milking capacity in the dairy cow from the standpoint of the future of the milk supply. Foods of animal origin are inherently expensive, and their consumption has always become more or less restricted with increasing population. Naturally, the more efficient the animal converter the less such restriction need apply. The significance of the efficient cow to the people at large may be better appreciated when we realize that about 45 per cent. of all animal foods consumed in the United States come from dairy cattle.[2]

The coefficient here proposed is essentially similar to the ratio of Jordan, but with this modification, that digestible nutrients[3] (D. N.) are substituted for his "edible solids" on the one side, and also for his "digestible organic matter" on the other side. Accordingly the coefficient of efficiency (C. E.) is $100 \times$ (digestible nutrients in milk produced) $\div$ (digestible nutrients in food consumed). How is this coefficient related to the annual milk yield and weight of the cow?

The digestible nutrients of the milk will vary with the quantity and quality of the milk. The richness of the milk may be disposed of by expressing the yield in terms of 4-per cent. (fat) milk by use of the formula,[4] F. C. M. = .4M + 15F, where F. C. M. is fat-corrected milk or 4-per cent. milk, M is the actual milk, and F is fat; all in pounds. One pound F. C. M. = .172 pounds of digestible nutrients; and, therefore (digestible nutrients in milk produced) = .172 F. C. M.

The remaining variable factor in the coefficient may be estimated from Haecker's[5] data. His maintenance standard is, Digestible nutrients for maintenance per year = 2.893 W, where W is live weight of the cow in pounds. His data show[6] that, Digestible nutrients for lactation = .327 F. C. M.

By substitution and a simple transformation we have the formula:

$$\text{C. E.} = 52.6 \frac{\text{F. C. M.}}{\text{F. C. M.} + 8.847\ \text{W}}$$

[1] "The Feeding of Animals."

[2] Pearl, "The Nation's Food." This estimate is based on total calories and allows a small but proper credit for the beef and veal derived from dairy stock. Swine supply another forty per cent. It has been often stated, on the basis of the superior efficiency of the cow and hog, that they will be the surviving animals. From the standpoint of food consumption it might be better to say that they *are* the surviving animals.

[3] Protein + carbohydrates + fat × 2.25. It might be better to replace digestible nutrients by net energy if our knowledge of the properties of various feeds in this respect were adequate.

[4] *Bul.* 245, Ill. Agr. Exp. Sta.

[5] *Bul.* 140, Minn. Agr. Exp. Sta.

[6] *Bul.* ——, Ill. Agr. Exp. Sta. (in press).