This feature has been studied by Mr. R. M. Jones, Entomologist, Liquid Carbonic Corporation of Chicago, Illinois. It may be possible then, to incorporate sufficient carbon dioxide to provide the necessary warning just as chloropicrin is used with HCN gas.

NOTES ON THE LABORATORY REARING OF SOME CANADIAN TICKS (Acarina) *

J. D. GREGSON

Dominion Entomological Laboratory, Kamloops, B.C.

Many of the projects on ticks at the Dominion Entomological Laboratory at Kamloops are dependent, to a greater or lesser extent, on an accurate knowledge of the bionomics of these pests. This study is necessarily a lengthy one, since there are 3 or more stages of each of the 20 or so species involved, and each stage presents a problem of its own, involving a host, and a period of observation lasting for at least several months. As many ticks are highly resistant to unfavourable conditions and can withstand starvation for long periods, the accumulation of data complete with longevity observations, may involve several years' study. Frequently after a number of seasons have been spent in searching for an engorged fertile female of a certain species in order to establish a laboratory strain, progeny have died before a suitable host could be provided. Since knowledge of the host relationships and host specificity of even the more common species of ticks is still fragmentary, certain information relating to these problems gathered at the Kamloops laboratory may be useful.

One of the most important factors in the rearing of ticks is humidity. Although extremely resistant to insecticides, dips, and starvation, practically all Ixodidae require high atmospheric humidity. Species that can survive for a year or more under optimum conditions may desiccate overnight if subjected to normal room humidity. Ticks should be kept in a cool cellar in open-ended glass tubes over damp soil.

As a rule humidity is adequate while ticks are feeding on animals. Nevertheless it is advisable to keep the hosts in a reasonably humid atmosphere. Although this is particularly true for certain ticks from humid areas, it applies also in the dry Interior of British Columbia, for the early stages in the development of ticks are frequently passed either against the moist skin of the host, or in its damp burrows.

While at Kamloops all longevity tests are carried out in a tick cellar (T. 18° C., H. 100%), it has been determined that the best method for holding ticks beyond their normal life span is to store them at 5°C. in pill boxes in a sealed jar containing damp absorbent cotton. In the case of *Ixodes californicus* Banks, the combined periods of preoviposition and incubation normally require four months at 18°C. or two months at 21°C. but can be prolonged for over two years under these conditions.

During storage ticks must be kept free from condensed moisture, as they drown quite as readily as they desiccate. It is advisable to trim off the cotton plug of each vial, and slide it about a quarter of an inch into the tube, to avoid the possibility of water moving up from tray to tube by capillarity. Identification labels should be placed between plug and vial, for if left in the vial the writing soon becomes obliterated by excrement.

Dermacentor andersoni Stiles, the vec-

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tor of many serious diseases, has been studied more than any other species in North America. The techniques of rearing successfully all stages have been worked out by the Rocky Mountain spotted fever laboratory at Hamilton, Montana, where, for the production of spotted fever vaccine, the ticks are, as described by Kohls (1), literally measured by the litre. This is the least specific of Canadian ticks, and feeds readily on nearly all laboratory animals. Adults are commonly fed on sheep for which a very satisfactory infesting method has been devised at this laboratory. The ticks are placed over a clipped and washed area about the size of the tick cage which is a shallow cup of 20 mesh brass gauze about 1½ inches in diameter, with tape-bound rim. The cage is anchored to the skin by six or more opposing linen threads which are first attached to the wool by clove-hitches, then threaded through the edges of the cage and tied. The ticks are inserted before the final fastenings are made. If placed on the shoulders, these cages cannot be scratched off by the animal, and need only occasional adjustments. Nymphs and larvae, usually fed on rabbits or guinea-pigs, may be allowed to feed anywhere on the host, simply by enclosing both host and ticks overnight in a bag made of unbleached cotton, or may be confined to certain areas by means of a screw top capsule, held to the animal by an adhesive band around the belly (1), or in the case of a rabbit, by enclosing the ticks within the ears by means of adhesive tape. Rabbits' ears may also be bagged by slender sacks which tie around the base of the ear. The bags should be taped together to prevent their being torn off.

D. albipictus (Packard) normally infests deer, cattle and horses, passing all stages on the same host and feeding during the winter months. Flat adults taken from moose, however, have been found to feed readily on sheep and guinea-pigs.

Ixodes californicus Banks, is probably the most delicate of our ticks and is extremely sensitive to desiccation. It has yet to be proved that this is a short-lived tick in nature, but under no circumstances have we been able to keep flat adults alive for more than six weeks under laboratory conditions. Furthermore 100 pairs kept in a cage in their normal Coast habitat during the summer of 1941 were all dead when examined four months later. Adults of the closely related European tick *I. ricinus* have been kept alive from 15 to 27 months by Wheeler (2).

The natural hosts of adults of *I. californicus* are dogs, cats, humans and deer. At the laboratory they can be fed readily on sheep by the cage method mentioned above. They are, however, so dependent upon high humidity, that it is necessary at Kamloops to carry out infestations under a burlap tent, over which water is continually sprayed. The engorging period is about 6½ days. The early stages of this species are hardier than the adults for seeds and nymphs have been kept alive for 17 months. The main host of the early stages in nature appears to be the lizard, *Gerhonotus principis* Baird and Birard. Lizards in captivity can be maintained readily on a diet of mealworms, grasshoppers, cockroaches or crickets. These reptiles make convenient and clean laboratory hosts, although the ticks require three times as long to engorge on them as on mammalian hosts. Both early stages will completely engorge in about 7 days on rabbits and guinea-pigs, but, as pointed out in a previous paper (4) the host may be killed if infested too heavily. *I. californicus* feeds poorly on domestic chicken, and in nature has been taken in abundance on birds as seeds on grouse chicks. Rats and mice, whether domestic or wild, appear to be poor hosts. Although fair numbers of seeds have attached to laboratory rats, the fed ticks were all of a reddish color instead of black. It is presumed that these were of low vitality, as it has been found that very pale *I. texanus* seeds which have engorged on serum only, have

been incapable of moulting to nymphs. *I. californicus* has not been induced to feed on fitches, tortoises, snakes or toads.

I. texanus Banks is as hardy as the preceding species is delicate, and of the strain being maintained at Kamloops, all stages are healthy after having been confined in tubes for over 3 years. The life-cycle of this tick thus may occupy a period of 9 years or even longer. It is resistant to desiccation and feeds readily in all stages on members of the ferret family. In the Interior drybelt of British Columbia, *texanus* is a common parasite of weasels and wild mink. Adults also feed well on dogs and sheep. Fitches have proved to be the best laboratory hosts, though there is a tendency for them to build up a temporary immunity after an infestation (6). No stages have been taken on the red squirrel, which in the drybelt is host to a similar but very specific tick, *I. hearlei* Gregson (3).

Because of the ease with which *texanus* may be reared, and because it is parasitized by *Hunterellus hookeri* How., this tick may prove to be a good intermediate host if that parasite should be cultured for control of *I. californicus*.

Another Drybelt tick, *I. hearlei* Gregson, closely related morphologically to *texanus* has been found only on the red squirrel, *Tamiasciurus hudsonicus* ssp. Attempts to rear specimens on other laboratory animals including flying squirrels, have failed so far. From early observations *hearlei* appears to be a hardy species of tick.

I. cookei var. *rugosus* Bishopp is rare in British Columbia. Our only live specimens were engorged nymphs from a coyote. Several of the resulting adults attached to a guinea-pig, but fed slowly and finally died. Dogs would probably be satisfactory laboratory animals for this tick.

I. dentatus spinipalpis Hadwen and Nuttall, and *I. angustus* Neumann, both Pacific Coast species, are parasites of rabbits and squirrels. They have been taken on the packrat which it is thought will be a suitable laboratory host for at least *spinipalpis*.

I. signatus Birula, is normally found on the cormorant. Though refusing to attach to domestic chicks and ducks, seeds and nymphs fed readily on a domestic goose, the engorging period being approximately 7 days. The ticks were caged over the bird's head by means of a voile hood. All attached overnight. The length of life of seeds and nymphs appears to be only about 6 months.

Haemaphysalis leporis palustris Packard and *H. cinnabarina* Koch, the rabbit and bird ticks, each feed on either of these hosts though best results have been obtained by placing *palustris* on domestic rabbits and *cinnabarina* on captured grouse. *H. cinnabarina* engorges rapidly and drops from its host in about 7 days. It is an autumn tick and since oviposition would not take place until spring it appears to have an exceptionally long preoviposition period. Seeds of *cinnabarina* and *palustris* have been kept alive for 7 months, and nymphs of the latter for 19 months.

Although none of the argasid of "soft ticks" have yet been procured for life-history studies at this laboratory, several species have been recorded in British Columbia. Both *Argas persicus* (Oken) and an *Ornithodoros* tick have been collected by Professor G. J. Spencer, the former from a golden-crowned sparrow, the latter from a bat. Both species feed rapidly except in the larval stage. It has been found that *O. turicata* (Duges), a species occurring in the United States, can be maintained easily on rats. The larvae are placed in an infesting cage on the host for about 3 days, after which the engorged ticks are collected and the cage, debris and host fumigated. The several subsequent stages are best fed at the clipped belly of a rat that is held on its back by means of tape over its legs and neck. The ticks engorge in about 30 minutes and apparently do

not harm the host. Nymphs have been induced also to feed through membranes of skin on vials of warm defibrinated rabbit serum; they moulted successfully. This tick is very resistant to desiccation, and may live for many years under cool damp conditions.

Ornithodoros megnini (Duges), the spinose cattle-ear tick, is a species that has recently been taken in British Columbia by the Kamloops laboratory. It differs from all other ticks in that only the larval and nymphal stages feed. The nymphal engorgement is sufficient to enable the adult to oviposit without feeding. Since both the early stages of this species stay on the host and may feed for over 3 months, it is doubtful if any artificial method of feeding can be used in laboratory rearing.

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(5) ———— The Coast Tick (**Ixodes californicus** Banks) problem in British Columbia. Canadian Ent. **74**(1):3-5.

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Asilidae from Robson, B.C.—Dr. S. W. Bromley has sent the following names of species not included in my list in the last number of the "Proceedings" (No. **38**: 14.) *Laphria ferox* Will.; *Bombomima columbica* Walker; *Andrenosoma fulvicauda varlutea* McAtee; *Cyrtopogon praeceps* Will.; *Eucyrtopogon nebulo* O.S.; *Asilus vescus* Hine. It is possible that the following species were misidentified, and should be removed from my List: *Laphria francisana* Bigot; *Asilus auriannulatus* Hine.—H. R. Foxlee.

Hemichroa crocea (Fourcroy). Larvae of this alder sawfly were taken on *Alnus* sp. at Gleneden, near Salmon Arm, June 26, 1941, y A. M. Gilmour of the Provincial Forest Service. In British Columbia the species was known previously only from the lower Fraser Valley. A life history and illustration of the larva has been published by G. R. Hopping, 1937 (Canadian Ent. **69** (11): 243-249, plate 13).—Hugh B. Leech.

Gyrinus pectoralis Leconte. A distinctive little whirligig water beetle which has been collected at Copper Mountain, B.C. by G. Stace Smith (see 61st. Ann. Rept. Ent. Soc. Ontario, (1930), 1931, p. 88) More recently G. J. Spencer has taken it at Kamloops, 18. VIII. 37; and at Bachelor Swamp, between Pass Lake and Lac du Bois, high on the ranges north of Kamloops, 8.VI.41.—Hugh B. Leech.