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Ethion Resistance in the Cattle Tick (*Boophilus microplus*) in New Caledonia

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Abstract. Following reports of ethion resistant cattle ticks (*Boophilus microplus* (Canestrini)) in New Caledonia, a series of dosage mortality tests was undertaken in an attempt to establish the extent of this resistance. Thirty samples of *B. microplus*, which was introduced from Australia in 1942, were taken from various locations on the main island, and the results compared with similar tests carried out using an Australian susceptible reference strain (Yeerongpilly) and an Australian resistant strain (Biarra). Larvae 6–15 days after hatching were exposed to different concentrations of ethion in olive oil for 24 h. The study showed that varying levels of ethion resistance had developed in New Caledonia, and that it was most strongly marked in tick populations from the east coast region. Some very low levels of resistance are probably of no practical importance, but the LC_{50} value of the most resistant population was eight times that of the Yeerongpilly reference strain. Ethion resistance has appeared on the island after seven years of application. Reasons for the observed regional variation in resistance level are discussed. It is suggested that the concentration of ethion cattle dipping baths should be increased before introducing new acaricides. Alternative control methods should be considered.

Introduction

In New Caledonia several studies have been carried out in the past on the distribution and general biology of the three species of ticks present: *Rhipicephalus sanguineus* (Latreille), *Haemaphysalis longicornis* Neumann and *Boophilus microplus* (Canestrini) (Rageau, 1958; Rageau and Vervent, 1959; Hoogstral *et al.*, 1968). More recently a special interest has been shown in the ecology of the cattle tick *B. microplus* (Daynes and Gutierrez, 1980), but no work has yet been undertaken on the resistance of the cattle tick to acaricides.

In Australia, a considerable amount of research has been undertaken on the cattle tick *B. microplus*, including resistance to acaricides (Roulston, 1969; Roulston and Wharton, 1967; Roulston *et al.*, 1977; Wharton and Roulston, 1970, 1977), the life cycle in relation to control measures (Hitchcock, 1955a; Snowball, 1957; Sutherst *et al.*, 1978) and the survival of non-parasitic stages (Hitchcock, 1955b; Hall and Wilkinson, 1960; Harley, 1966). Many of these investigations, which were conducted in Queensland, are of particular relevance to New Caledonia as there are similarities in the environment and climate and in tick origin.

New Caledonia lies within the tropics at approximately 21°S, 166°E. The island is thus located at a latitude between Rockhampton and Townsville, in the middle of the Australian tick enzootic area. The island is 390 km long and on average 50 km wide; it is extremely mountainous, the major massifs being 1500 to 1600 m high. Cattle raising is mainly centred in the two coastal areas with little exchange of stock between them.

As in Australia, *B. microplus* is the most important cattle ectoparasite in New Caledonia. However, it does not transmit the sporozoan blood parasites (*Babesia* and *Anaplasma*) responsible for 'tick fever'. In New Caledonia, the cattle tick has caused losses through reduced production and the expense of control measures, which will increase rapidly with the use of new acaricides and the escalation of labour costs.

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Introduced into New Caledonia around 1942 with horses and mules imported from Australia (Verges, 1944), *B. microplus* was first found in the south in the Dumbea valley near Nouméa, on the Fayard property (R. Penne, personal communication). From here it quickly spread over the main island in spite of quarantine restrictions by the appropriate departments to prohibit herds of live cattle moving from one region to another. Apart from its main hosts, the Bovidae, *B. microplus* can also sometimes be carried by deer (*Rusa unicolor*) and by various domestic animals, such as horses, sheep and dogs (Rageau and Vervent, 1959).

As in Queensland and New South Wales, recommendations were made to spray or dip herds regularly, at three week intervals, to try to eradicate cattle ticks. The first dip was collective and built near Bourail in the main cattle breeding area. This was quickly followed by private dips, which currently total 270 for an island herd of around 120,000 cattle. The acaricides successively used were: Cooper's arsenic dip from 1943 to 1947–50; Rucide (DDT) from 1947–50 to 1973; and Rhodiacide (ethion) from 1973 until the present.

Following reports of control failure with ethion from several east coast cattle owners, we have undertaken a series of dosage mortality tests to determine the validity of these complaints and, in cases of resistance, to establish its level in 30 samples of ticks from all over the main island (Fig. 1). The laboratory experiments were made in the Office de la Recherche Scientifique et Technique Outre-Mer (ORSTOM) laboratories at Nouméa, in collaboration with the Long Pocket Laboratories, Commonwealth Scientific and Industrial Research Organisation (CSIRO) Division of Entomology, Indooroopilly, Queensland, Australia.

Materials and methods

The method used to determine the resistance of *B. microplus* strains in New Caledonia was the technique of Stone and Haydock (1962) in which larvae, 6–15 days after hatching, are enclosed in filter paper pockets impregnated with solutions of ethion, using olive oil as the solvent.

For each series of tests, two batches of impregnated papers were prepared by CSIRO at Indooroopilly, and one of these was despatched by air mail to Nouméa. Both batches were stored in foil at room temperature until used. The tests were then conducted simultaneously in the CSIRO and ORSTOM laboratories.

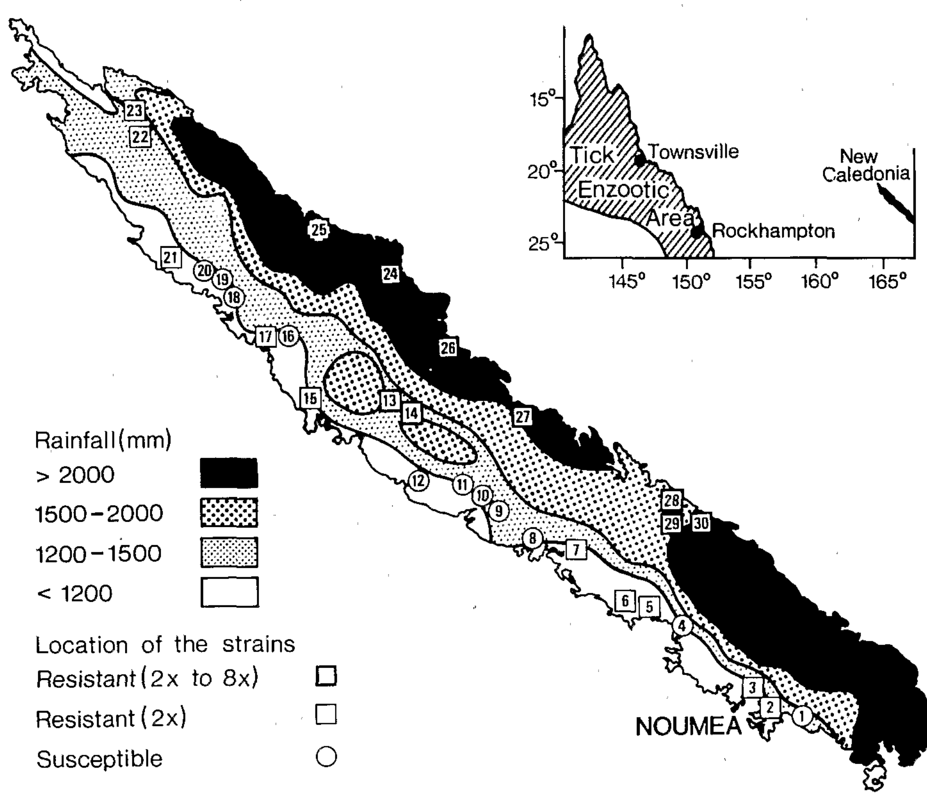

Fig. 1. Locations of *Boophilus microplus* samples tested for ethion response, and rainfall distribution. Inset map shows the situation of New Caledonia in relation to the tick enzootic area in Queensland, Australia.

This procedure has given us results from an Australian susceptible reference strain (Yeerongpilly) and an Australian resistant strain (Biarra), and enabled us to determine the resistance status of the 30 different *B. microplus* samples collected in the field.

Preliminary tests were carried out at the end of October 1980 to check the range of tick susceptibilities in the larval progeny of ticks collected around Nouméa.

The following concentrations were used:

1. 0.05% Ethion – this concentration would not be expected to kill any of the Australian susceptible reference strain (Yeerongpilly) which has been cultured continuously since 1948 without contact with acaricides (Roulston *et al.,* 1977).
2. 0.5% Ethion – this concentration should kill ticks of the Yeerongpilly strain.
3. 1.5% Ethion – this concentration should kill the Yeerongpilly strain and the resistant strains Ridgeland and Mackay, but not the Biarra strain which exhibits a high level of resistance to all the organophosphorous and carbamate chemicals (Wharton, 1967).
4. 15% Ethion – this concentration should kill all known resistant strains.

Two other consignments of ethion treated papers were used in November 1980 and January 1981 to evaluate the strains collected throughout New Caledonia. Two batches of impregnated papers were available for those tests:

1. Batch No. 1 contained papers of 15, 1.5, 0.5 and 0.05% ethion and controls.
2. Batch No. 2 consisted of a series of ten concentrations of papers at 50% dilutions, from 15 to 0.03% ethion, i.e. 15%, 7.5%, 3.75%, 1.875%, 0.94%, 0.47% and so on, and controls.

Ticks were usually first submitted to the papers in batch No. 1, and if larvae survived in any of the 0.5 or 1.5% packets further tests were carried out with batch No. 2 papers. When a low number of engorged females was collected from the field, tests were made directly with batch No. 2 against the progeny.

Engorged adult females were collected in the field from cattle before dipping or by butchers working in the three main slaughterhouses of the Office de Commercialisation et Entreposage Frigorifique (OCEF). Ticks were brought to Nouméa the same day or the following day, and then placed in an incubator and cultured at 27°C ± 1° and 80–90% r.h. for about four weeks until hatching. Unfed larvae were dropped into the paper packets in clusters of about 100–200. The packets were then stored flat in another room at the same temperature and humidity for 24 h before the mortality was determined. Ticks then showing movements were recorded as live.

Results

The toxicological response of unfed larvae to ethion was determined from dosage mortality tests. Results from the 30 samples from New Caledonia were compared with the LC_{50} values for the susceptible Yeerongpilly strain and the resistant Biarra strain which were tested simultaneously in Australia.

The samples tested were divided into two categories:

1. Those from which no larvae survived a concentration of 0.47 or 0.5% ethion from batch No. 2 or batch No. 1 respectively.

The samples belonging to this category had values for ethion no greater than the Yeerongpilly strain, and consist of the following: St Louis, Ouinane, Mouindou, Bourail-Boghen, Bourail (P), Bourail (T), Bourail le Cap, Pic Kone, Temala, Pouanlotch (S), and Pouanlotch (C). Among these samples, only four (Bourail-Boghen, Pic Kone, Temala and Pouanlotch (C)) were tested over the full range of ethion concentration (Fig. 2).

2. Those from which larvae survived either 0.47 or 0.5% ethion.

All 19 samples in this category have higher LC_{50} values than the susceptible Yeerongpilly reference strain. Among them, the Pinjen and Mueo samples were tested only with batch No. 1 papers due to the small number of engorged females available in the field. A third sample, Tipinje, was tested only with the 0.47% concentration papers and a control, also because of the low number of engorged females that was collected. The 16 remaining samples showing resistance to ethion were tested over a complete range of concentrations and grouped according to their levels of resistance (Fig. 2).

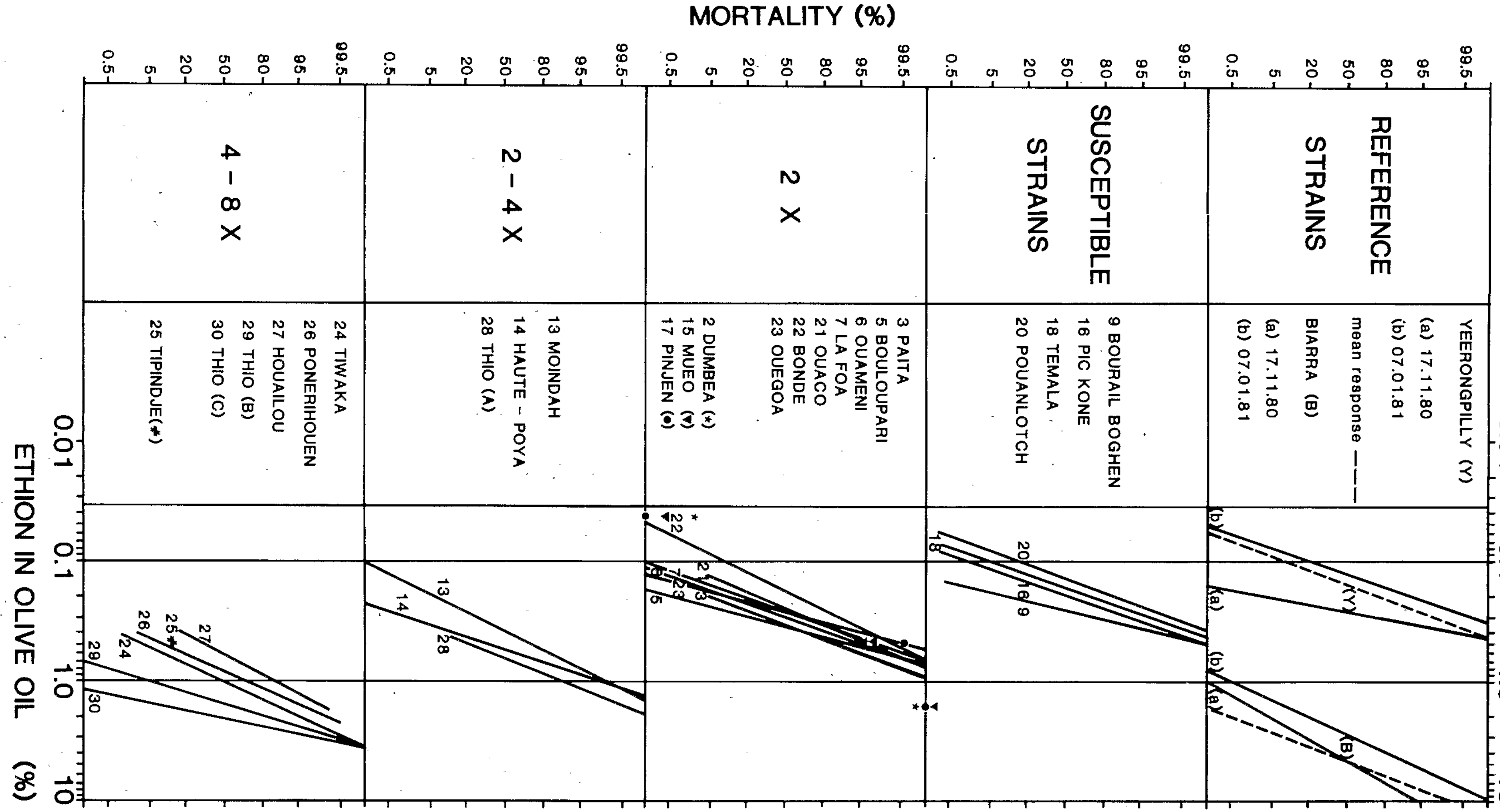

Fig. 2. Dosage mortality responses to ethion of 23 samples of *Boophilus microplus* collected in New Caledonia, compared to the susceptible Yeerongpilly and resistant Biarra strains. Numbers of locations refer to Fig. 1.

Group 1

This comprises the samples in which the $LC_{99.9}$ was up to twice that of the Australian susceptible strain (Yeerongpilly). They come from the following locations: Dumbea, Païta, Ouameni, La Foa, Ouaco, Bonde and Ouegoa.

Group 2

This comprises the samples from Moindah, Haute-Poya and Thio (A), which had an $LC_{99.9}$ two to four times that of the Yeerongpilly susceptible strain.

Group 3

This comprises samples which had an $LC_{99.9}$ four to eight times that of the Yeerongpilly strain. These ticks were collected from Tiwaka, Ponerihouen, Houaïlou, Thio (B) and Thio (C).

The very low level of resistance noted in the samples in Group 1 is probably of no practical importance, as small variations are also frequently encountered in the response of the Yeerongpilly strain. The Group 2 samples show a response to ethion similar to the Ridgelands strain, and the samples of Group 3 appear to be similar to the Tully and Mackay strains. However, the resistances reported in this survey cannot be categorised on the evidence of larval packet tests alone, especially with a response to only one chemical.

Discussion

The cattle tick population of New Caledonia has the same genetic origin as that of Australia from where it was imported, and the control measures in the island are similar to those used in Australia, i.e. dipping and spraying.

The main specification of the control policy in the island is the use of the same acaricide throughout New Caledonia, as the product is provided by the government free of charge. Delays in marketing new chemicals in New Caledonia delayed the appearance of resistance compared to Australia. DDT was banned in Australia in 1962, but it was still being used in New Caledonia in 1973. Organophosphorous acaricides were widely used from 1960 in Australia and by 1974 eight resistant strains had already been recognised. The first organophosphorous chemical (ethion) was introduced in New Caledonia for tick control in 1973–74.

The present study shows that resistance to ethion occurred after it had been in use for about seven years. This corresponds well with the average life of other organophosphorous compounds as reported by Wharton and Roulston (1977).

Ethion resistance was found to be higher in tick populations on the east coast, where no susceptible samples could be found. As the selection pressure can be expected to be of the same order on both coasts, the different rate at which resistant populations will develop is determined by the possibility of resistant individuals surviving after dippings. This depends on the proportion of larvae finding hosts which is influenced by two major factors, the longevity of larvae on pasture and the stocking rate (Sutherst and Wharton, 1973).

On the east coast, there is a greater longevity of non-parasitic stages due to more favourable climatic conditions, i.e. more days of rain and a greater amount of rainfall. From an annual rainfall of about 3000 mm on the east coast there is a gradual decrease across the island to the west coast, where the annual rainfall ranges from 1000 to 1500 mm (Fig. 1). The higher rainfall on the east coast promotes an almost constant pasture cover, increasing relative humidity and soil moisture which again favour the survival of *B. microplus.*

There is also a higher stocking rate on the east coast, where the average density of herds is generally two to three times higher with a stocking rate of the order of one beast per hectare. Furthermore, on the east coast the herds graze in very narrow valleys which again increases the chance of host-larva contact.

On the west coast, higher levels of resistance have been recorded at Moindah and Haute-Poya. These differences in ethion resistance levels may be explained on the basis of either a higher level of tick survival because of the higher rainfall of this inland area or, more likely, because of the introduction of resistant ticks on cattle brought from the east coast to be slaughtered at Moindah village. Indeed, such movement of genetic material carrying resistance may be extremely important during control campaigns (Sutherst *et al.,* 1978).

In New Caledonia the confirmation of resistance to ethion, with resistant factors of four to eight observed in most samples from the east coast, demonstrates the existence of unsatisfactory tick control with a clear-cut reduction in effectiveness in the field. However, it may be more practical for the future to prolong, for as long as possible, the use of ethion by increasing the concentration of dipping baths, as has been done in Australia with chlorpyrifos to control the Biarra organophosphorus resistance and with the carbamate promacyl which controls all organophosphorus-resistant *B. microplus,* despite low levels of resistance. Increased costs are associated with this approach, but they may be smaller than those incurred by having to change to a completely new type of acaricide (Wharton, 1976).

Up to now the acaricide resistance of the cattle tick has been unrecognised in New Caledonia, but the problem of tick resistance should be investigated further if the cattle industry is to be safeguarded and developed. Firstly, it is necessary to identify the different resistant strains that have appeared in the island since the introduction of ticks in 1942. Investigations should also be undertaken to determine the discriminating dose for ethion and the spectrum of resistance to a large range of acaricides. The possibility of eventual cross resistance with other chemicals which have not yet been used, such as pyrethroids, should be considered. The results of such investigations will allow us to determine if the use of ethion could be extended on the island by changing the concentration of the dipping baths, to make a preliminary selection before testing acaricides on cattle, and to avoid the introduction of new chemicals in areas where cross resistance exists.

It is important for the local cattle industry to look for alternative methods of control to acaricides, because, as elsewhere, resistant strains will continue to emerge as new chemicals are developed.

The only way of reducing the proportion of ticks surviving dipping is by the introduction of pasture spelling or resting periods, which has been demonstrated to be an efficient method of tick control and which entails a minimum use of acaricides (Wilkinson, 1957; Harley and Wilkinson, 1964). The use of resistant cattle provides another method of tick control, which has obvious advantages since the need for acaricides is reduced.

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