BLOOD PARASITES OF CATTLE IN PAPUA NEW GUINEA: A REVIEW

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ABSTRACT

A history is given of the occurrence of bovine blood parasites, namely Theileria *spp.*, Babesia bovis, B. bigemina, Trypanosoma theileri, Eperythrozoon *sp. and* Anaplasma marginale, *found in Papua New Guinea. Reference is made to the vectors, the epidemiology and the disease outbreaks associated with some of the parasites. The likelihood of new blood parasites entering the country is considered to be small but the presence of cattle tick* (Boophilus microplus) *and rusa deer* (Cervus timorensis) *in a few localities place at risk the maintenance of the present restricted distribution of the more important parasites and constitute a potential quarantine hazard.*

INTRODUCTION

The earliest record of a bovine blood parasite in Papua New Guinea was included in a report made by an Australian Veterinary Unit in a survey of animal diseases carried out after the close of World War 2 (Anonymous 1946). The parasite, *Theileria mutans*; was referred to as of "no pathogenic importance". Anderson (1960) and Legg (1961) referred to theileriasis in Asian cattle held in quarantine in Port Moresby *en route* from Pakistan to Australia in 1952–4. Legg stated that the parasite concerned was *T. dispar* (syn. *T. annulata*), but Gregory (1961) indicated that there was uncertainty as to whether the species involved was *T. annulata* (syn. *T. dispar*), *T. mutans* or both. Gregory (1961) and Anderson (1960) both mentioned that the same Asian cattle were shown to be carrying *Anaplasma marginale*. Other blood parasites recorded from cattle are *Babesia bovis* (syn. *B. argentina*) and *B. bigemina* (Anderson 1960, 1962–3; Egerton and Rothwell 1964), *Eperythrozoon* sp. (Talbot 1968–9) and

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reports of this species from other countries. The extent of its distribution in Papua New Guinea is not known, but it has been recorded in cattle at an unknown locality in Milne Bay Province (Anonymous 1946) and at Sogeri and Kapogere in Central Province.

REVIEW OF PARASITES

Theileria spp.

Members of the genus *Theileria* are tick-borne protozoan parasites which live in the red blood cells of ruminants, particularly cattle.

If *T. annulata* (syn. *T. dispar*) was present in the Asian cattle held in quarantine in 1952–4, it did not spread to local animals since its tick vector, *Hyalomma*, is not present in Papua New Guinea. The cattle *Theileria* found in the country, and referred to as *T. mutans*, has been observed on several occasions in cattle held at the National Veterinary Laboratory. However, there are no records of clinical pathogenicity due to this organism, even in splenectomised cattle, a result consistent with most

Trypanosoma theileri which is reported for the first time. The information presented is compiled from departmental records and reports, and from the results of published and unpublished studies carried out at the National Veterinary Laboratory.

Workers such as Uilenberg *et al.* (1977), Brocklesby (1978) and Morel and Uilenberg (1981) doubt whether the non-pathogenic species of *Theileria* outside of subsaharan Africa and a few Caribbean islands is correctly identified as *T. mutans*. Serological, morphological and transmission studies indicate that the organisms found in Britain, America and Australia are strains of another species but at present it is uncertain if its correct designation is *T. sergenti*, *T. orientalis* or *T. buffeli* (Morel and Uilenberg 1981; Uilenberg 1981). The current practice in Australia is to refer to the organism as *T. buffeli*. The parasite in Papua New Guinea has not been studied serologically but it is likely to be the same as the Australian species since virtually all imported cattle have come from Australia.

A non-pathogenic species of *Theileria* has been seen also in feral rusa deer, *Cervus timorensis* (Owen 1985). The range of the deer in Central Province coincides with cattle grazing areas but it is not known if the same species of *Theileria* infects both hosts.

Riek (1982) stated that the only recorded natural vectors of *Theileria* are ticks. However, *T. buffeli* can be readily transmitted in blood, thus mechanical transmission with a contaminated needle can also occur (Callow 1984). In Africa, *Amblyomma* is the principal vector of *T. mutans* (Brocklesby 1978) whereas in Britain, East Asia, Japan, Korea (Uilenberg *et al.* 1977) and America (Brocklesby 1978) the cattle parasite is believed to be transmitted by *Haemaphysalis*. It has long been considered that the vector in Australia is the cattle tick, *Boophilus microplus*, but attempts to prove this experimentally have been unsuccessful (Callow and Hoyte 1961; Riek 1982). According to Riek (1982) the natural vectors in Australia are *Haemaphysalis bancrofti* and *H. longicornis* but experimental transmission using the latter species has failed (Stewart *et al.* 1987a, 1987b). Stewart *et al.* (1987a, 1987b) demonstrated that another tick species, *H. humerosa*, was a more successful vector.

Six species of *Haemaphysalis* are known to occur on mammals in Papua New Guinea, including *H. longicornis*, *H. bancrofti* and *H. humerosa* (Talbot 1968–9; unpublished data). The first of these species has been seen once and only on cattle; the second is recorded from various fauna and also cattle; and the last species is reported from fauna only. The most frequently seen species of *Haemaphysalis* is *H. novaeguineae* which has been found on various hosts, including cattle in all areas where *Theileria* occurs. It has been recorded also from deer in Central Province.

Babesia bovis (syn. *B. argentina*)

This is the most important of the bovine blood parasites in Papua New Guinea. It is a protozoan that infects red blood cells and is the most common cause of the disease babesiosis (tick fever or red water) in cattle. Although the parasite was not recorded in the survey conducted after World War 2 (Anonymous 1946), outbreaks of 'tick fever' were reported subsequently in widely scattered localities where the vector, the cattle tick (*Boophilus microplus*), then occurred, including Morobe, Western Highlands, Eastern Highlands, Madang, Gulf and Central Provinces (Anderson 1962–3; departmental records). In two instances, at Wewak (East Sepik Province) in 1962 and Baibara (Milne Bay Province) in

1963, cases of babesiosis due to *B. bovis* were confirmed by means of blood films and transmission of blood into susceptible cattle. A voluntary tick eradication scheme was begun in 1950, followed by a compulsory programme of eradication which was started officially in 1955 (Anderson 1962–3). By 1966 the tick remained only in a few areas where eradication was difficult or impossible for a variety of reasons. With the elimination of the vector from most of the country, the risk of bovine babesiosis was greatly reduced.

The most significant area, with respect to babesiosis, that remained tick infested was the Port Moresby hinterland, including Sogeri, in Central Province where feral rusa deer (*Cervus timorensis*), acting as hosts, prevented eradication of the tick. Here, the compulsory eradication campaign was replaced in 1966 with a scheme of voluntary tick control. Within a few months it became clear that implementation of the control scheme by farmers was often poor and consequently babesiosis was a potential threat to the area. This was confirmed in mid 1966 by the results of complement fixation (C.F.) tests carried out in Australia on cattle sera from the locality. Later that year, a major outbreak of babesiosis due to *B. bovis* occurred near Port Moresby with a mortality of approximately 30 percent on one farm of 550 cattle (L.A.Y. Johnston, unpublished report). Most of these deaths were amongst locally bred beef cattle. There were relatively few deaths amongst dairy cattle which were generally imported from Queensland. It was concluded that the majority of the animals that died had not been exposed previously to *Babesia* infection. The outbreak was due to (1) a sudden build-up of the tick population brought about by poor cattle musters, (2) inadequate application of acaricide following the change from eradication to control of tick, and (3) a latent infection of *B. bovis* in some animals. Treatment with a babesicide, amicarbalide*, together with improved acaricide spraying, controlled this outbreak and also a smaller one on a neighbouring government farm.

By March 1967, a *B. bovis* vaccine was being produced at the National Veterinary Laboratory using splenectomised calves, and 3665 cattle on nine farms in the tick endemic vicinity of Port Moresby were vaccinated during the first year of production. The policy adopted was to vaccinate and then treat with the babesicide seven or eight days later. The programme was successful in containing the disease although, during this initial period, there were a few deaths on four farms following vaccination. For the first few years the vaccine was produced locally, however, mainly for economic reasons, vaccine has been imported from the Tick Fever Research Centre at Wacol, Queensland, since 1969, following tests to prove its efficacy against the local strain of *B. bovis*.

Since vaccination was not compulsory, not all farmers in the tick endemic area vaccinated their cattle, and generally there was little interest shown by them in the follow-up vaccination of young stock. Between 1967 and 1972 there were at least 19 confirmed outbreaks of babesiosis on eight farms, involving 66 deaths. Four of the outbreaks, at separate farms, accounted for 42 (64 percent) of these deaths and involved non-vaccinated herds. The other 15 outbreaks had an average mortality of 1.6 animals and could be attributed largely to negligence in vaccination of new stock and to a relaxation of tick control.

Information on the type, breed and age of cattle affected is too limited for meaningful comments to be made.

* Diampron; May and Baker.

With respect to periodicity, it is noteworthy that 19 of 21 outbreaks recorded between 1966 and 1972 occurred between September and January. This period coincides with the last few months of the dry season and, usually, the first month or two of the wet season in the Port Moresby area. At this time cattle often are under considerable nutritional stress, and farmers consider that tick is less of a problem than at other times. Therefore they tend to relax tick control measures. Johnston (1968) reported that most cases of babesiosis in northern Queensland occurred in winter and spring and that, at least in the coastal region, this was linked to seasonal tick infestation. Dalgliesh *et al.* (1979) found that environmental temperature, by affecting the development of the parasite in larval ticks, may also influence the incidence of babesiosis.

In the intervening period since 1972, vaccination of stock has been haphazard, and over the last few years has involved inoculating only susceptible cattle brought onto a few farms at Sogeri from outside the tick endemic area. It appears that the disease has attained a state of relative stability in the Port Moresby area since clinical cases of babesiosis are seldom reported. The last confirmed farm outbreak was in 1975 when a few animals died at one farm. (The death from babesiosis of 3 out of 107 cattle in 1982 was due to special circumstances. The cattle, from a tick-free area of Milne Bay Province, were held for several weeks prior to slaughter in a tick infested paddock near Port Moresby; their naive condition made them vulnerable to *B. bovis* carried by the ticks.)

Indirect fluorescent antibody (IFA) tests of bovine sera collected from various parts of the country between 1972 and 1974 were carried out at the National Veterinary Laboratory. The only animals, other than those from near Port Moresby and from Sogeri, which had positive reactions to *B. bovis* antigens were from Oriomo (Western Province) and Hagita (Milne Bay Province), both of which were, at the time, areas with an uncertain history of cattle tick. However, there are no confirmed reports of babesiosis from either locality. The presence of *B. bovis*, at least at Oriomo, can be linked to the introduction of cattle from the Port Moresby area in 1971. Even when kept tick-free, infected cattle can carry a latent infection of *B. bovis* for up to three years (Johnston *et al.* 1978).

Babesia bigemina

This species also infects red blood cells of cattle but is regarded as of less pathogenic significance than *B. bovis* (Johnston 1968; Rogers 1971). *B. bigemina* has the same vector, the one-host tick *Boophilus microplus*, as *B. bovis*, however, the latter is transmitted to cattle by the larval stage of the tick whereas the nymph and adult stages transmit *B. bigemina* (Callow and Hoyte 1961).

Although *B. bigemina*, according to Anderson (1962–3), was identified in blood collected from clinical cases in Port Moresby, Goroka and Mt. Hagen in 1948–9, it was not seen during the outbreak of babesiosis involving *B. bovis* in 1966 or in any of the subsequent tick fever cases. However, its presence in the country was confirmed in June 1966 when C.F. tests showed positive reactors amongst cattle in 7 of 11 farms tested from the Port Moresby hinterland. Three of these farms were located at Sogeri, an area that had been tick free for many years until mid 1965 when tick began to reappear due to the presence of feral deer.

The parasite was isolated in 1975 when pooled blood of a few cattle was injected into a splenectomised calf. The animals came from one of the farms near Port Moresby that previously had experienced babesiosis caused by *B. bovis*. No clinical cases resulting from *B. bigemina* have occurred on the farm. This is consistent with the low pathogenic significance of the parasite reported in Queensland (Johnston 1968; Rogers 1971).

It is not known if the parasite is present in cattle in any other tick endemic area but it is of interest to note that *B bigemina* was reported by Zwart (1959) to be in cattle at Merauke in Netherlands New Guinea (now Irian Jaya, Indonesia) which is located close to the border of Western Province of Papua New Guinea.

Trypanosoma theileri

T. theileri is a relatively large flagellate protozoan which is parasitic in the blood stream of cattle. It has a world-wide distribution but is seldom seen during routine blood examinations since it has a low density in the bovine host (Herbert 1964). According to Seddon (1966), it is probably common and widespread in Australia. It is not surprising, therefore, that it occurs in Papua New Guinea but, to date, it has been found only in one herd at Sogeri, Central Province. The original case in 1969 involved a young cow, one of a group imported from Australia about 12 months previously, that had died of unknown causes and which had large numbers of *T. theileri* in liver and spleen impressions. The parasite was seen in blood films and cultures of 2 of 31 other members of the herd. Pooled blood given to two calves, one entire and the other splenectomised, produced parasites in blood films of both animals within five days of inoculation. It caused a low parasitaemia in both animals that persisted for eight to ten days. Neither animal showed any clinical symtoms but a noticeable drop occurred in packed cell volume and haemoglobin levels between days seven and ten post inoculation. Eighteen months later, *T. theileri* was seen in the blood of 1 of 35 cattle from the same herd.

Nine years after the first sighting of the parasite, blood samples from 28 cows, aged one to four years, on the same farm were negative for *T. theileri* in films and culture, and when pooled blood was injected into an entire and a splenectomised calf, both remained free of the parasite. This may mean that the trypanosome failed to transfer from the original imported cattle to local stock and has not become established at Sogeri.

T. theileri is generally classified as non-pathogenic (Herbert 1964; Schlafer 1979) although it has been incriminated by many at various times as the cause of bovine trypanosomiasis (Wyssmann 1935; Carmichael 1939; Bourgeois 1941; Grunet and Andresen 1970; Mitchell and Long 1980). It is a stercorarian trypanosome and is transmitted through contamination of wounds with excreta of the vector (Callow 1984). Blood sucking arthropods such as tabanid flies are considered to be the most common vectors Herbert 1964; Schlafer 1979) but there is some evidence that certain ticks also can carry the parasite (Burgdorfer *et al.* 1973).

Anaplasma marginale

This is a tick-borne rickettsial parasite of the red blood cells of ruminants and causes the infectious disease anaplasmosis. The earliest clinical case recorded in Papua New Guinea occurred in 1954 following inoculation of splenectomised calves, especially imported from Australia, with blood from Asian cattle held in quarantine in Port Moresby (Anderson 1960, 1972; Gregory 1961). The first major outbreak of the disease in local cattle occurred on a mixed beef and dairy farm near Port Moresby in December 1969.

It is likely that the outbreak was linked to two factors. First, cattle had been imported from Australia about nine months previously. There is no record of the origin of these cattle but, as most imports come from Queensland, there is a high probability that the animals were infected with *A. marginale*. Secondly, the farm is located in a tick endemic area where a voluntary tick control programme had been in force for about three years. This control programme was not being carried out adequately at the time since large numbers of tick, particularly seed tick, were present on most of the cattle examined. Poor grazing at the end of a long dry season may have added a nutritional stress factor, although plane of nutrition does not appear to play an important part in field cases of anaplasmosis during the dry season in northern Queensland (Wilson and Trueman 1978).

The outbreak affected only adult dairy cattle and was controlled by therapy and improved cattle tick control, but not before a few deaths occurred amongst two groups of cows. Occasional relapses were recorded during the following few months but vaccination was not initiated owing to the isolated nature of the outbreak. A year later there was a smaller outbreak of anaplasmosis in a neighbouring government dairy farm which resulted in the loss of two animals. It was controlled by treatment and no further occurrence of the disease has been reported.

It is a matter of conjecture why anaplasmosis had not arisen before 1969, or appeared since, as the conditions described were not unique to that year on the affected farms and others in the vicinity. However, the sudden build-up of the tick population towards the end of that year was, possibly, a new phenomenon, at least on the farm which had the first outbreak. It is well known that adult cattle are more susceptible than young animals to severe anaplasmosis (Jones *et al.* 1968). Also, in southern Queensland there are more records of dairy than of beef herds having clinical anaplasmosis (Rogers *et al.* 1978). It is possible that the potent combination of susceptible adult cattle and sudden increases in tick populations has not appeared since 1969/1970 as there are no longer dairy cattle in the area and, subsequently, the tick control programme has allowed a sufficiently large tick population to exist to transmit the parasite to cattle while they are young and thus for immunity to develop and be maintained.

Under laboratory conditions, *A. marginale* has been transmitted to susceptible cattle by a variety of ticks and a range of blood sucking flies, as well as mechanically by means of instruments such as hypodermic needles (Yeruham and Braverman 1981). Pre-natal infections have also been reported (Callow 1984). In the field, the cattle tick *Boophilus microplus* is considered to be the most important tick vector in many countries (Thompson and Roa 1978), but it is believed that members of the dipteran family Tabanidae also can play a significant role in transmission (Wissenhutter 1975; Yeruham and Braverman 1981). Some workers such as Rosenbusch and Gonzales 1927 and Brumpt 1931, as cited by Leatch 1973, claim to have found that transovarial passage of the parasite occurs in the cattle tick, but all recent evidence indicates that *Anaplasma* is transmitted only from stage to stage (transstadial passage) and within stages in

Boophilus microplus (Connell and Hall 1972; Leatch 1973; Thompson and Roa 1978). Although *B. microplus* is a one-host tick, it is able to move from one bovine host to another during the parasitic phase. It has been shown that all three stages (larva, nymph, adult) and both sexes are capable of transmitting the parasite (Connell and Hall 1972; Leatch 1973; Thompson and Roa 1978).

In Papua New Guinea in 1969/1970, the vector of *A. marginale* was probably the cattle tick, although several species of tabanid flies (e.g. *Tabanus dorsobimaculatus* and *T. innotabilis*) occur in the Port Moresby area. The tick *Rhipicephalus sanguineus* also is present in the country. It has been implicated as a vector of *A. marginale* in Africa and, under experimental conditions, in Australia (Parker and Wilson 1979). In Papua New Guinea it is a common parasite of dogs but as the only record of *R. sanguineus* being found on cattle is contained in a report of a survey conducted after World War 2 (Anonymous 1946), it is unlikely to have had a role in transmitting *A. marginale*.

Under experimental conditions *A. marginale* has been successfully transmitted in blood from cattle to rusa deer (*Cervus timorensis*), and *vice versa*, in Papua New Guinea, but it is considered that transmission is unlikely to occur between the two hosts under field conditions (Owen 1985).

Indirect fluorescent antibody (IFA) tests on bovine sera collected between 1972 and 1976 were positive from four farms in addition to those that had the original outbreaks in the Port Moresby area, from two farms at Sogeri where tick occurs and also from locations in the country that had been tick-free for many years. Mott (1957) stated that after an acute infection of anaplasmosis, cattle usually remain carriers (and thus, presumably, have antibodies) for life. If so, the presence of positive reactors in tick-free localities can be explained by the fact that cattle from areas endemic for anaplasmosis, such as parts of Central Province, and Queensland, have been distributed to many parts of Papua New Guinea. The high percentage of reactors at Baiyer River (Western Highlands Province) can almost certainly be attributed to transfers of cattle from a government farm near Port Moresby in 1967 and from Queensland between 1966 and 1969, and at Oriomo (Western Province) to the movement of cattle from the same Port Moresby farm in 1971. *A. marginale* was recorded from cattle at Merauke in Irian Jaya, Indonesia, by Zwart (1959).

Eperythrozoon sp.

This is a rickettsial organism which parasitises the surface of red blood cells. Blood-sucking arthropods are believed to act as vectors. A member of this genus has been recorded only once in the country, in 1968, when a splenectomised calf received blood from another calf that was used at the National Veterinary Laboratory as a reservoir for *Babesia bovis* (Talbot 1968–9). The calf developed a high density of bodies in its blood which were considered to be *Eperythrozoon* sp.

DISCUSSION

All the bovine blood parasites in Papua New Guinea use arthropods as vectors. The three most important species (*Babesia bovis*, *B. bigemina* and *Anaplasma marginale*) utilize the cattle tick. This tick is restricted to a few localities in the southern region (parts of Western, Central and Milne Bay Provinces), and therefore the remainder of the country, where approximately 87 percent of the cattle population occurs (Densley 1980), is not troubled by these blood parasites of cattle.

In the Port Moresby area of Central Province where cattle have blood parasites, only two species (*B. bovis* and *A. marginale*) are likely to be troublesome. Even with these two organisms, the risk of a major disease outbreak occurring is low probably under the current conditions of tick control, vaccination of vulnerable stock in the case of *B. bovis*, and control of internal movement of cattle from high-risk areas. However, the potential exists for babesiosis and anaplasmosis to spread beyond their present restricted endemic locality as long as the cattle tick remains. Eradication of the tick from the Port Moresby hinterland is impractical at present due to the presence of feral deer which can act as an alternate host (Owen 1977).

Although there is a far larger population of deer carrying tick in Western Province, the situation there with respect to bovine blood parasites is of less immediate concern than in the Port Moresby area. This is because there are relatively few cattle in the province and they are located at widely scattered centres, there is no road link with other parts of the country, and no cattle or deer are moved outside the province. However a reported sighting of deer near the border of Western Province and Southern Highlands Province in 1989 is potentially a matter of concern. In contrast, there is a need for constant vigilance in Central Province to ensure tick control is being implemented satisfactorily since, if a sudden increase in tick population coincided with laxity in vaccinating susceptible cattle or with the importation of a different strain of parasite, another outbreak of babesiosis or anaplasmosis could occur. Strict adherence to quarantine procedures is necessary for animals destined to be sent from Central Province to any other part of the country in order to maintain the *status quo* of the cattle tick and tick-borne diseases.

The danger of new bovine blood parasites entering Papua New Guinea is very low probably since importation of cattle is permitted only from Australia and is under strict quarantine control. The only blood parasites occurring in Australia which have not been detected in Papua New Guinea are the rickettsial organisms *Anaplasma centrale* and *Haemobartonella bovis*. *A. centrale* is a relatively non-pathogenic form which was deliberately introduced into Australia for immunization of cattle against anaplasmosis (Seddon 1966). *H. bovis* is a pleomorphic organism which could be mistaken for anaplasms or *Theileria*. It is rarely detected in cattle blood in Australia and, apparently, is not pathogenic (Callow 1984).

Importation of cattle from two other neighbouring countries, Solomon Islands and Indonesia, is prohibited, but the entry of a disease by accident from either country could occur due to their physical proximity. With respect to the Solomon Islands, there appears to be no risk at present as no bovine blood parasites have been recorded from there; also it is free of cattle tick (de Fredrick and Reece 1980). The Papua New Guinea border with Indonesia is the most likely point of entry of exotic blood parasites. The range of cattle blood parasites in Indonesia is similar to that in Papua New Guinea but with the addition of *Trypanosoma evansi* which causes the disease surra in cattle and some other domestic animals. Surra is transmitted mechanically by biting insects and is a more serious problem in horses and dogs than in cattle.

The disease was reported to be present in Papua New Guinea during World War 2 after the Japanese occupation forces imported horses from the Philippines into Bougainville (Anonymous 1946). Japanese veterinarians diagnosed surra in horses on two occasions in 1943, when *T. evansi* was said to have been demonstrated in blood smears. The affected animals, and all horses in contact with them, were destroyed. Other animals were reported not to have had contact with the affected horses. Only a few cattle, running wild, remained on the island when a post-war survey was conducted, and tests carried out on the remaining horses in 1945–6 were negative (Anonymous 1946).

T. evansi has not been reported from the Indonesian province of Irian Jaya. However the 700km land border between that province and Papua New Guinea, which passes through inhospitable and sparsely populated country, would make it almost impossible to police the movement of animals adequately if the disease situation were to change. The fact that people on both sides of the border have strong traditional links with each other, and that the large population of deer in the southern part is free to cross the border, would add further difficulties to the task of applying quarantine measures.

ACKNOWLEDGMENTS

Many individuals who have worked in the Department of Agriculture and Livestock at various times, either at the National Veterinary Laboratory or in the field, have contributed to these findings. In particular, the work of Drs Margorie Reid, J.C. Copland and N.T. Talbot, National Veterinary Laboratory, and L.A.Y. Johnston, CSIRO, Indooroopilly, Queensland, is acknowledged. Dr J.P.J. Ross, assisted by Ms Frances Liem, conducted the IFA tests between 1974 and 1976. The technical assistance given over many years by Mr C. Awui and Mr M. Abari is gratefully acknowledged as also are the typing skills of Ms M. Penrose and Ms N. Kwalahu.

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