AN ASSOCIATION BETWEEN *PASPALUM DILATATUM* AND BLACK BEETLE IN PASTURE

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Abstract

Field monitoring of black beetle, *Heteronychus arator* (F.), populations in Waikato pasture showed a strong association between black beetle numbers and the presence of ***Paspalum*** *dilatatum* Poir. Increasing paspalum gave higher adult numbers in spring resulting from increased overwintering survival, and in some seasons, reduced autumn dispersal. Numbers of larvae damaging pasture in February were directly related to adult numbers in September. Black beetle preferentially select paspalum plants in mixed pasture. This can place paspalum at a competitive disadvantage relative to other pasture species, but also permits the retention of higher adult black beetle numbers, even at low paspalum levels.

INTRODUCTION

SINCE its establishment in the Auckland area in the late 1930s, black beetle, ***Heteronychus arator*** (F.), has become well known for severe pasture damage caused during sporadic outbreaks (Todd, 1959; Merry, 1964; White, 1972). These outbreaks are closely associated with above-average spring and early summer temperatures (Watson, 1979; King, 1979a). Black beetle now occupies regions of the northern North Island which receive greater than 13°C mean annual temperature (Watson, 1979) . This coincides with the ecological zone in which warm-climate-adapted grasses can form an important component in pasture (Brougham, 1979). Paspalum (*Paspalum* ***dilatatum*** Poir.) is the most widespread and agriculturally important of these grasses (Percival, 1977).

Paspalum has long been associated with high populations of black beetle in New South Wales, becoming decimated during years of very high numbers (Anon., 1944; Wallace, 1946). Similarly, black beetle is thought to have reduced paspalum to low levels in affected areas in New Zealand (Todd, 1964; Reynolds and Langton, 1973; Percival, 1977). The direct association between black beetle and regional reductions in paspalum has been difficult to establish because of the sporadic occurrence of damaging black beetle numbers, and because paspalum in the New Zealand environment also appears to be sensitive to management practices, including overgrazing under summer drought conditions, which often coincide with peak black beetle numbers.

In laboratory studies, paspalum and ryegrass (*Lolium* ***perenne*** L.) supported similar larval weight gains and survival, although a greater quantity of ryegrass roots was consumed (King, 1975, 1976). Adult nutrition, however, as represented by fat accumulaion, fecundity and longevity, was markedly favoured by paspalum (King, 1979b). In small experimental paddocks, black beetle populations attained and persisted at higher levels in a pure paspalum sward than in adjacent ryegrass, white clover, or mixed ryegrass-white clover pastures, although paspalum was tolerant of these higher numbers (King and East, 1979) . Legumes were unfavourable for the nutrition of both adult and immature stages, and very low black beetle numbers occurred in pure white clover or lucerne swards.

The results of monitoring natural field populations of black beetle in Waikato pastures, varying in paspalum content, are discussed in this paper.

METHODS

Monitoring sites for estimation of black beetle numbers were established in the Waikato between 1975 and 1978. Black beetle populations were assessed in September (giving estimates of post-winter, pre-egglaying and pre-spring dispersal numbers), February (post-pasture damage and pre-autumn dispersal numbers), and May (post-autumn dispersal and pre-overwintering numbers). Additional samplings were later included in November and December to obtain assessments of numbers during egglaying and early larval development, and also immediately after major flights in autumn to determine the immediate effects of mass dispersal on the distribution of black beetle.

Populations were estimated using a 10 cm diameter soil corer (Kain and Young, 1975) from which large instars were hand-sorted on trays in the field. When eggs and small larvae were prevalent, insects were extracted by salt-water flotation in the laboratory.

Three sites were established in 1975 at Orini, 20 km north of Hamilton, to monitor seasonal changes in black beetle numbers, development and the distribution between and within sites. Each site consisted of nine contiguous 10 $\times$ 10 m plots from each of which 30 or 50 soil cores were taken for assessment of black beetle numbers at each sampling occasion. In 1977-8, 7 to 15 individual 10 x 10 m plots were located separately around one to several farms in each of three areas (Waikokowai, Te Kowhai, Te Pahu — 30 km north-west, 14 km west, and 22 km south-west of Hamilton, respectively). Fifty cores were taken from each plot at each sampling.

The occurrence of paspalum rooted in the soil cores was also recorded at each sampling. This provided a specific frequency estimate of paspalum content which was relatively independent of the seasonality of growth affecting herbage composition estimates.

RESULTS AND DISCUSSION

A. Changes in Paspalum Occurrence

There has been a general, though variable decline in paspalum on the monitoring sites (Fig. 1). This has occurred within the

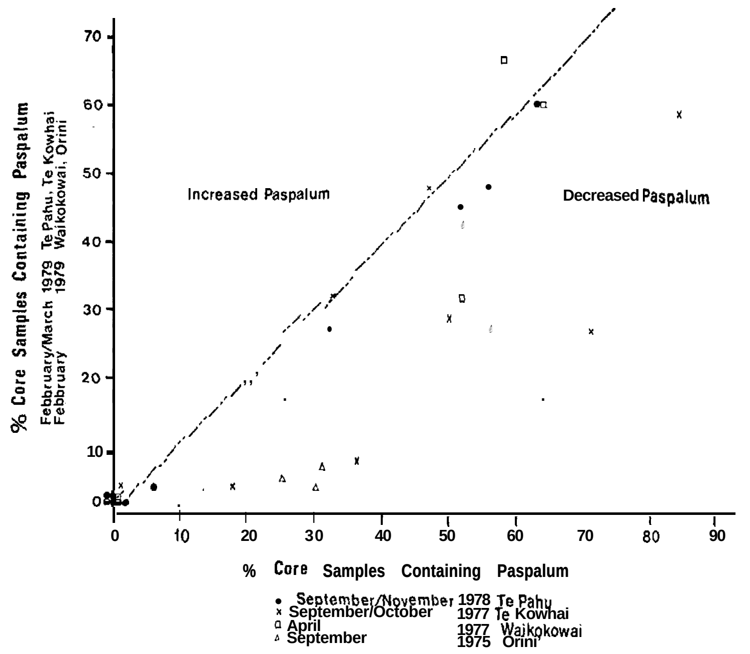


FIG. 1: *Changes in paspalum content on plots in Waikato over recent sampling periods.*

span of a year at Te Pahu. By contrast, at Waikokowai high paspalum levels have remained on some plots, of which one has remained high in paspalum since 1975, even though moderate black beetle numbers (20 to $30/m^2$ in February) were also present in each subsequent season.

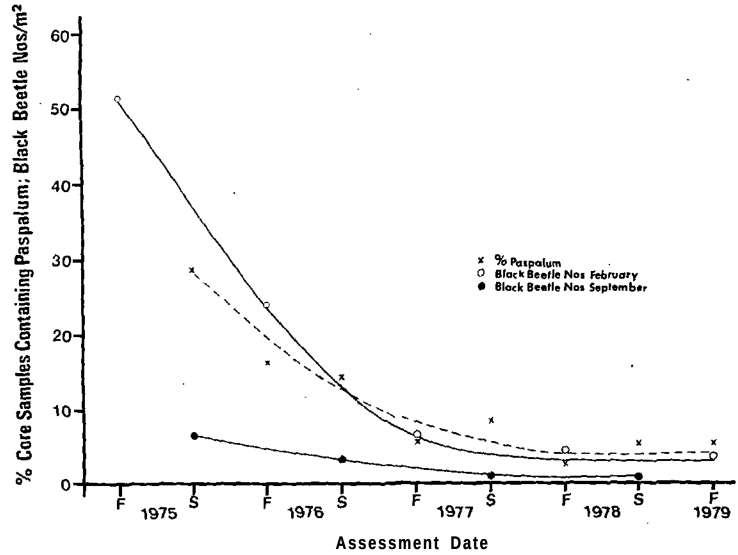
It appears that paspalum can sustain moderately high black beetle numbers but not the high numbers associated with outbreaks ($> 80/m^2$) in paspalum-dominant pasture. Field observations indicate that during outbreaks there may be a spectacular visible decline in turf-bound paspalum in one summer as a result of black beetle feeding, probably acting in combination with the effects of drought. As well as these outbreaks related to seasonal conditions, high black beetle populations have been observed causing pasture damage on light free-draining soils in parts of the Waikato in recent reasons. probably as a result of numbers building up only since the last outbreaks, in areas which still retain large amounts of paspalum. Reduction in paspalum at low levels may possibly occur more insidiously as a result of aggregation under paspalum plants by black beetle, and particularly as a result of selective feeding by the adults.

Paspalum is, however, also sensitive to other changes in environment, especially factors affecting the'competitive balance between paspalum and temperate pasture species once paspalum becomes opened up or weakened. At Orini the initial decline in paspalum occurred in the presence of high black beetle numbers, but the continuing decline appears to be related to a change in grazing since 1975 from sheep to bull beef, with consistently rank conditions occurring during spring (Fig. 2). A similar effect was evident from shutting off paddocks for hay.

Adult black beetles feed on the rhizomatous tissue as well as chewing at the base of tillers. This results in a breaking up of turf-bound paspalum by a ring-barking of interconnecting rhizomes and direct tiller mortality. Adult feeding occurs from February until May, and may continue at much reduced levels under exceptionally warm winter conditions. Feeding intensity again increases from September and continues until the death of most remaining adults between November and January. Under New Zealand conditions, much adult feeding occurs outside the most active growth phase of the paspalum plant.

Larvae, especially the third instar, mainly feed on the fibrous roots in mid-late summer, but may also attack rhizomatous tissue. Depletion of roots, which are often severed close to the soil surface, may severely reduce the ability of the plant to withstand

(a)



(b)

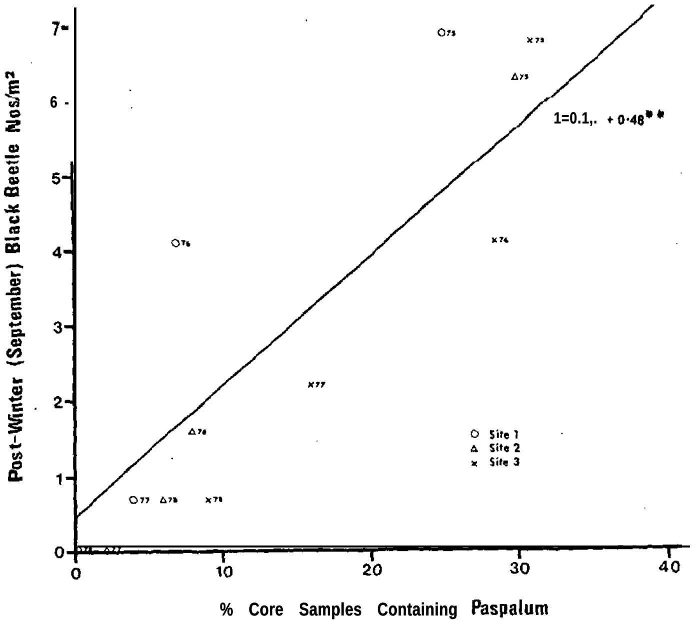


FIG. 2: *(a)* **Reduction in paspalum, and black beetle numbers, since 1975 at Orini (mean of 3 sites); (b) relationship between adult numbers in September and paspalum at Orini since 1975 (3 sites).**

drought and to accumulate the food reserves necessary for successful overwintering. This is of particular importance in New Zealand, where, relative to warmer climates, there is an extended period of slow or arrested growth leading to 'greater competition from temperate species, and often a reduced ability to compensate for insect damage during the growing season because of summer drought.

B. Changes in Black Beetle Numbers

Black beetle numbers on the monitoring site generally reflected paspalum levels. This has occurred on sites where paspalum levels declined over successive years since 1975 (Fig. 2), and also within seasons on different sites on which there was a range of paspalum levels. On all sites monitored in the Waikato since 1977-8, adult numbers in September, and populations in February, were significantly correlated with the amounts of paspalum present on plots ($Y = 4.47 + 0.23X$, $P < 0.001$, and $Y = 23.24 + 0.49X$, $P < 0.01$, respectively),

The difference in populations largely resulted from a differential reduction in black beetle numbers over the winter. As paspalum levels increased, the overwintering mortality declined, and in some seasons there was a lower reduction in numbers during the autumn dispersal period (Appendix 1).

A significantly higher proportion of individuals at all stages of development was found in core samples which also contained paspalum. The attraction of paspafum was slightly higher for adults than for immature stages, and was highest for adults during the late autumn and winter months (Appendix 2). This indicated selectivity for paspalum plants by adult beetles within mixed pasture. The association of the immature stages with paspalum probably reflected the deposition of eggs by females in the proximity of paspalum plants (King, 1979a).

As a result of this selection for paspalum, considerable feeding pressure may be applied to paspalum plants, relative to other pasture species, even when both paspalum and black beetle occur at low levels. Such an association ensures that a greater proportion of the black beetle population is able to utilize the nutritional advantages of paspalum.

Perhaps as a result of the comparative absence of spring flight in recent seasons (Watson, 1979), the populations of larvae in February over all the sites were significantly related to adult numbers in the previous September ($Y = 18.75 + 1.50X$, $P < 0.001$). Field observations and the production estimates from insecticide trials (unpubl. data) indicate that 30 to 50 larvae/m^2 in February are required before serious damage becomes apparent in ryegrass-based pasture, with 80 to 100/m^2 required to cause noticeable damage in paspalum-dominant pasture. In recent seasons, in excess of 10 adults/m* in September were required to give a high probability of larval numbers potentially damaging for ryegrass pasture (Table 1). In general, sites which contained more than 10 adults/m^2 in September had paspalum levels greater than 20%.

TABLE 1: LARVAL NUMBERS IN FEBRUARY ON PLOTS CONTAINING CORRESPONDING NUMBERS OF ADULTS IN SEPTEMBER

Adults/m^2 in *September*	*% Plots with Respective Larval Numbers/m^2 in February (53 plots)*	
	< 40	*> 60*
< 10	87	6
> 10	35	30
> 15	13	40

Black beetle populations persist in paspalum-dominant areas during cool seasons unfavourable for population growth (Watson, 1979; King, 1979a). The occurrence of damaging numbers of larvae in ryegrass-based pasture depends on immigration of adults in spring from surrounding paspalum, either by flight (which only occurs in exceptionally warm springs in New Zealand) or by more restricted surface movement. Any reduction in the occurrence'of paspalum would therefore reduce the total adult population and the likelihood of recurrent outbreaks by black beetle.

Kikuyu (*Pinnesetum clandestinum* Hochst) can maintain even higher populations of black beetle than paspalum (King, 1979a), but the grass at present has a much more restricted distribution in New Zealand (Percival, 1978). In contrast to paspalum, kikuyu does not disappear under black beetle attack. Consequently, where kikuyu occurs freely, black beetle is likely to become a more persistent problem in surrounding farm land.

To conclude, both paspalum and black beetle may, in the long term, attain an equilibrium at low levels, with lesser fluctuations in numbers during seasons which are climatically favourable. Alternatively, black beetle may decline to levels which may permit an increase in paspalum before a subsequent fresh cycle of high black beetle numbers. Paspalum (and kikuyu) is likely to be more vigorous relative to competing temperate species in more northerly areas further from the ecological limits of the grass. There is, therefore, more likely to be a greater persistence of black beetle problems in these areas.

While the effects of black beetle on the vigour of paspalum have long been recognized, the extent to which paspalum directly influences the occurrence and pest status of black beetle in New Zealand has probably been underestimated. Any attempts to encourage the use of paspalum or similar species in New Zealand pastures, either by introduction of improved strains or by adop tion of favourable management practices, should take into account the likely effects on the regional pest status of black beetle.

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Appendix 1

Reduction in black beetle numbers between February and September in relation to February numbers and paspalum content.

Y	X	Regression
% reduction in numbers February-April 1979, Te Pahu/Te Kowhai	Nos. in February	Y = -23.51 + 0.97*X*, *P* < 0.01
% reduction in numbers February-April 1978, Te Kowhai	% paspalum (Xl) Nos. in February (*X2*)	Y = -41.53 -2.63X1 + 5.09*X2*, *P* < 0.05
% reduction in numbers May-September 1978, Te Kowhai	% paspalum	Y = 83.12 -1.03*X*, *P* < 0.01

Appendix 2

Regressions of percentage of black beetle occurring in cores with paspalum (*Y*), and the percentage of cores containing paspalum (*X*) at different sampling times in Waikato since 1975.

Sampling Time	*Regression*	*No. Plot Samplings*
Adults:		
March/April	Y = 13.9 + 1.4x	33
May	Y = 29.8 + 0.90*X*	28
June/August	Y = 27.9 + 1.02x	15
September/October	Y = 8.6 + 1.18X	44
November/December	Y = 14.9 + 1.25x	32
Overall	Y = 16.6 + 1.13x	152
Immatures:		
November/December	Y = 4.6 + 1.12X	53
January/February	Y = 5.8 + 1.15x	50
March/April	Y = 9.4 + 1.12x	29
Overall	Y = 6.5 + 1.12X	132

All regressions significant at $P < 0.001$.

The intercept value differed significantly from zero, and indicated a strong positive association between black beetle and paspalum. The association overall was significantly stronger in the adult stage, and was most marked during the May and June-August (overwintering) samplings.

The regression coefficients did not not vary significantly at different sample times, or from unity, indicating a uniform association at all levels of paspalum.

The relative "feeding pressure" applied by black beetle to paspalum in pastures is determined by the black beetle numbers and stages present, the amount and vigour of the paspalum, as well as the degree of association with paspalum by black beetle represented in the above relationships.