THE DEVELOPMENT OF POPULATIONS OF *NUMICIA VIRIDIS* MUIR IN SUGARCANE FIELDS

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Numicia viridis Muir (Homoptera: Tropiduchidae) is an indigenous insect which normally feeds on grasses. Over the years it has moved on to sugarcane and in some areas has assumed the proportions of a pest (Dick, 1963). It is now found on both cane and grasses throughout the cane-growing areas of South Africa and Swaziland. Numbers are higher in inland irrigated areas, where most visible damage occurs, and in both cane and grasses there is a synchrony of generations, with three seasonal peaks (Carnegie, 1967).

Throughout the inland irrigated areas it is customary to burn cane at the time of cutting. In most cases the standing cane is fired, after which it is cut, the tops are severed and the sticks stacked and removed for milling. Remaining trash is then raked into inter-rows and burnt, sometimes twice. By then the field consists of little more than ashes and bare ground until the ratooning crop appears, and on it a new population of *Numicia*.

Regarding infestation of a field by *Numicia* there are a number of possibilities to be considered.

1. Residual populations on cane, which has been burnt and cut, may form the nucleus of a new infestation.

If adults are present at the time of burning they may be flushed and fly into adjoining fields, but available evidence suggests that this does not necessarily happen. There is evidence that young adults fly voluntarily from mature cane, but that once oviposition begins they move very little. Adults can survive a cane fire and have been found on the green tops of cut cane where, under very favourable circumstances, it might be possible for them to live long enough to oviposit on the young ratoons.

Nymphs likewise have been found in large numbers on green cane tops after burning, but few could be expected to live long enough to infest new ratoons. Quadrat sampling in fields cut and burnt a few days previously have revealed the presence on new shoots of nymphs too large to have hatched from residual eggs, and which can be assumed, therefore, to have survived the burning (Figure 1). (The possibility of their having moved in subsequently can almost certainly be discounted; see below.) It is unlikely that many survive, for in the course of extensive sampling for migrant adults on young ratooning cane, nymphs were seldom recorded (see Table 4).

If a field is burnt and cut at a time when eggs are plentiful, many eggs may remain in leaves which are too green to burn thoroughly. Eggs in leaves which have been dry for several weeks can produce apparently healthy active nymphs which, under field conditions, might be expected to move on to young ratooning cane and start feeding. Whether many survive is doubtful, for it has been found that under insectary conditions, nymphs survived only when they emerged from eggs in green leaves and were able to feed within a few centimetres of their eggs. Any form of disturbance or impediment between eclosion and feeding jeopardised survival (Harris, in preparation).

2. All stages could be transported passively by various agents. Where seed cane with tops is transported from an infested field to a field to be planted, eggs, nymphs, or even adults may be taken with it. For the reasons stated above infestation from eggs or young nymphs is unlikely, and mature nymphs and adults could affect the new field only indirectly, after spending an intermediate period in an adjoining green field.

It has been suggested that young nymphs could be carried passively in air currents, their terminal waxy filaments having a "parachuting" effect. When it is seen how high and how far ash is carried from a burning cane field, the possibility seems worth considering. This is being investigated, using a Johnson and Taylor insect suction trap, which traps small airborne insects and automatically segregates the catch into successive samples for a predetemined time interval (Johnson, 1950; Taylor, 1951). This has been used, as opportunity has offered, for the last year, but to date no nymphs have been trapped. Neither have nymphs been recovered from the various adhesive traps which have been set up on occasions. Both such forms of sampling are of a very low intensity; but the fact that during routine sampling, nymphs have only rarely been recovered from young plant or ratooning cane, suggests that few if any are spread in this way.

3. Adults flying from older to younger cane, or from grasses, could start an infestation. Of all possibilities considered this is undoubtedly the most important, and during the last three years adult movement has been the subject of three experiments, which were conducted on a large estate in Swaziland.

Experiment 1

Twelve sampling sites were chosen, ten of which were at points of contact between irrigated cane and perennial green grass (Figure 2). These included the banks of rivers, reservoirs and canals, and small areas of greenery beside drainage channels in the middle or on the edges of cane fields. Fields used included both plant and ratoon cane, spray and line-irrigated, and the varieties N:Co.376, N:Co.310 and N:Co.382. The other two sites were in permanently green grass communities 500 yards from the nearest cane.

From August, 1966 until December, 1967, these sites were sampled at regular intervals (usually weekly) and records kept of the numbers of *Numicia* nymphs and adults counted in each medium. Sampling was done by a team of five, each of whom sampled 4 square yards in both grass and cane at each site. In grasses and in short cane this was done by placing a yard-square metal quadrat over the plants and counting all *Numicia* included (Figures 1 and 2). Taller cane was sampled by shaking it over a square yard of plastic smeared with molasses and placed in the inter-rows; the trapped insects were then counted (Figure 3). Both methods of sampling give a fair reflection of what is present, but there is an obvious discrepancy between the methods, for which a sampling factor has not yet been established. Firstly, by shaking cane over a yard square area a larger volume is being sampled than in short cane, or grass using a quadrat; and secondly the insects, and especially young nymphs, are more difficult to see and count using a quadrat than when they are trapped on an adhesive sheet. This frequently gave the impression that in one generation adult numbers were higher than those of the nymphs from which they developed.

On each occasion notes were made regarding any physical changes, such as the cane being harvested or the grass being partly burnt or weeded.

The same pattern of adult and nymph numbers was found in both cane and grasses as has been described previously (Carnegie, 1967), there being a synchrony of generations with peaks in adult numbers in February, May and October. In Table 1, maximum numbers of nymphs and subsequent adults are shown for both grass and cane for the four peak periods covered by the experiment and, as mentioned above, numbers of adults are frequently higher than those of nymphs, although our routine sampling for population assessment, which is always done by the shaking method shows a nymphal mortality (see Table 2). This discrepancy is particularly true of grasses (which were sampled only by quadrats) and is undoubtedly due in large measure to a sampling error; but it may not be due entirely to a sampling error.

Another possible explanation is that adult numbers could have been boosted by individuals flying in from elsewhere. When considering records for the various sites individually, the figures sometimes suggest that such a boost could have come from the adjacent medium; but this is not always the case, and on other occasions numbers of adults in both media were higher than nymphs of the same generation even where all sampling was done by shaking. On several occasions young ratooning or plant cane, from which nothing had been recorded since cutting, acquired adults which could not have developed in that field and must therefore have flown in. Likewise grass which had been bare, became inhabited by adults.

It is of interest that a fall in numbers between nymphs and adults of the same generation was most common and most striking in the period from August to November. During this period rain-grown veld grasses are dry and could produce few adults for migration into cane and surrounding green grasses. From figures for overall population counts for the entire estate (means of from 15 to 30 fields for five years), a similar, although less striking situation can be seen (Table 2); the percentage mortality between nymphs and adults being generally higher for this period. Possibly there is more movement by adults during the summer period, and migration into cane from grasses may occur over greater distances than might be expected, although as yet we have no conclusive evidence for this.

At two of the sites sampling was done in the cane not only on the perimeter but at 25-yard intervals into the field up to 100 yards. At a third site sampling was done 80 yards into the field as well as on the edge. For any one field the figures obtained at each distance are remarkably similar, showing that, within those limitations at least, the population was evenly distributed. One of these sites was very young plant cane when weekly sampling started, and contained no *Numicia*. When adults first appeared they did so at 75 yards. Two weeks later they appeared also at 50 yards and two weeks later they were recorded at all distances.

Experiment 2

In April, 1967, young adult *Numicia* were noted in a field of young plant cane adjacent to a field of mature cane which had been heavily infested during the previous generation. Quadrat samples taken at 25-yard intervals into the young cane showed a tendency for numbers to increase into the field. This sampling was continued at approximately weekly intervals until December, and it was found that this trend was constant. In June, nymphs of the following generation appeared, and their numbers too reflected those of their parents. This was so of the third generation as well. Over the entire period numbers fluctuated and dwindled, although the field was never treated with insecticide (Figure 4). (In both Figures 4 and 5, the different results from shake and quadrat sampling may be seen.)

As most of this sampling was done only to a distance of 50 yards, it was decided to investigate invasion more thoroughly.

An opportunity to do so arose when a field on the same estate was ploughed, planed and prepared for a new system of irrigation. The field was bare of vegetation for seven months, during which time an occasional *Numicia* adult was seen on it. The shape of the field was elongated, being about 700 yards across and bounded along one side by a vlei and drainage stream, and along part of the other by a grassy-banked reservoir and non-irrigated grassland.

From the 14th March, 1968, when young shoots first appeared, until the time of writing, this field has been sampled — frequently at first, and subsequently as regularly as possible. On each occasion a transect in approximately the same area was chosen. This ran from the reservoir bank, through the field and ended in the grass on the far side. The cane was sampled at each edge and at 100-yard intervals through the field. Sampling was done as described in Experiment 1, using quadrats until the cane became large enough to change to shake-sampling. Results are shown in Figure 5.

The first sampling produced no *Numicia* in cane and very few in grasses. Three weeks later adults began to appear throughout the cane field (also one or two nymphs, which probably hatched from eggs laid by migrants of the previous (February) generation).

By mid-May a distribution pattern was becoming apparent, with larger numbers towards the centre of the field, a pattern which was maintained by subsequent generations. A likely explanation for this is that, with migration occurring from grasses on both sides of the field, there was an accumulation of individuals towards the centre.

Over the same period, and as frequently as opportunity offered, samples of leaves with eggs were collected from the same sampling points including, initially, leaves of grass from the borders. Whenever possible 25 leaves with eggs were collected from each site, but seasonal scarcity of eggs sometimes prevented this. Eggs were subsequently counted in the laboratory and examined for parasites.

Both the common egg parasites, *Ootetrastichus beatus* Perkins (Eulophidae) and *Oligosita* sp. (Trichogrammatidae) were present. Numbers of eggs per leaf and the percentages of eggs parasitised are shown in Figure 6, where the combined effects of both parasites are considered together.

In the first samples both species of parasite were found in grasses, and in cane in the centre of the field as well as on the perimeter. At first *Oligosita* sp. was the more plentiful, but *Ootetrastichus* soon became equally so.

No obvious pattern is apparent from these figures but it is interesting how quickly and successfully the parasites, which are extremely delicate insects, found their hosts and became established throughout the field.

Experiment 3

In October and November, 1968, on the same estate another field of young ratooning cane was sampled at different distances from mature adjacent cane, which had supported reasonably high numbers of *Numicia* the previous generation. The old standing cane was sampled at its perimeter, and the young cane both at its perimeter and at 50-yard intervals into the field to a distance of 200 yards. (On one occasion one of the transects was sampled at 75-yard intervals to a distance of 375 yards.) Two transects were sampled on the 30th October; six, including the previous two, on the 6th November; and four of these repeated on the 20th November. All transects started at points along a road separating the two fields, the two most distant starting points being about 1,000 yards apart.

Sampling was done with a motor-driven suction sampler (Dietrick, 1961). At each point the sampler was run for 30 seconds along the top of one row at walking speed, and for a further 30 seconds in the opposite direction along the top of another row. All *Numicia* collected were preserved in a mixture of alcohol with glycerine, and were returned to the laboratory for counting, sexing and dissecting. All females were dissected and the numbers of eggs counted. The only eggs included were those which were mature or very nearly mature. Females without mature eggs were classified as either immature or empty, the latter being those which had expelled all their eggs.

The period covered by the sampling included a period of peak adult numbers and activity, although at the time of the first sampling numbers were still relatively low.

The objects of the experiment were to find out (1) whether there was a predominance of one sex; (2) whether females fly only at a certain stage of egg maturity; (3) whether there were any differences in numbers, sex ratio or state of maturity at different distances from the old cane (from which the adults were presumed to have come, since there was no other older cane or green grass in the immediate vicinity).

In considering the results, the situation was summarised as follows: (1) combining all distances into the cane on each occasion (Table 3); (2) combining available transects for each occasion, and showing each distance into the cane separately (Table 4). (For the 30th October only one of the two transects is shown, because different distance intervals were used in each transect, and combining them added nothing to the information gained.)

From Table 3 the following points may be noted:

1. Both sexes were common throughout the period of sampling with no marked change in sex ratio. This shows that the flight of young adults is not confined to females only, and suggests that mating can occur after flying. In the course of similar sampling on another estate, and from observation, young females are known to mate also in the cane in which they developed.
2. Females will fly when eggs are still immature.
3. Percentage of immature females fell, while that of those which had expelled their eggs rose.
4. At the last sampling, total numbers of males were considerably higher than females; previously they had been much the same. This could have been caused by female mortality following oviposition.
5. Mature females contained an average of 19.5 eggs. This is considerably lower than the figure of 28.2 obtained from insectary-reared material (Harris, 1968). The highest number of eggs recorded per female in this experiment was 49, compared with 162 found in an insectary-reared female.

From Table 4 the following points may be noted:

1. Only at the last sampling (20/11/68) was there a trend for numbers of both males and females to increase into the field. In Experiment 2 it was not until 5 to 6 weeks after adults were recorded that a pattern of distribution began to appear. In the summer months (the time of this experiment), the life cycle is completed more quickly, which may have caused a trend of this sort to show up earlier. The lengths of the transects represented less than a third of the total field

width, and sampling was not done beyond the distances shown for fear of encountering influences from other fields; so it is not known whether the trend continued.

2. There is a slight trend for the percentage of females to increase into the field. Otherwise the situation at each distance was much the same. On the first occasion most females were immature at all distances, showing that before oviposition they may fly quite a long way, i.e. at least 400 yards. At all distances numbers of eggs per female remained moderately constant. The occasional record of a nymph in the young cane is of interest. These were almost certainly survivors from the previous generation.

   No parasites of adults or nymphs were encountered.

   On one occasion one Epipyropid moth larva was noted on an adult.

Discussion and conclusions

Although there are several ways in which *Numicia* may be carried over, in relatively small numbers, from one sugar cane crop to the next, most infestations are built up from adults which fly in from other canefields or from grasses. Observations show that heavy infestations in very young cane are short-lived, but may serve as an initiating element for heavy populations in a following generation.

There is as yet no evidence to show that this flight by young adults is purposeful or migratory. It does not apparently tie in with mating or state of egg development and females may fly considerable distances while still immature. The idea, prompted by observation, that once oviposition begins the female does not move further, was neither substantiated nor refuted by these experiments. Adults have been found, flying fitfully across barren fields, in no particular direction. Their flight is very likely haphazard, resulting in a "fly-paper" effect causing a build-up in suitable media.

In both sugar cane and in adjacent perennially green grasses the life cycle of *Numicia* follows a similar pattern with a synchrony of generations. Adults fly into both grass and cane, but their appearance is not necessarily accompanied by a drop in numbers in the immediate surroundings, and the possibility of their travelling considerable distances should not be discounted. A hazard in infested grass or cane does not necessarily result in a flushing effect of *Numicia* from it.

Within a small area populations are evenly distributed, but numbers build up towards the centre of a field, and when this happens from both sides there is a relatively larger population in the field centre, presumably as a result of accumulation.

Over distances of at least several hundred yards egg parasites follow their hosts and become established within about nine weeks.

Summary

The carry-over from one crop to another of the sugar cane pest *Numicia viridis* Muir (Homoptera: Tropiduchidae) is discussed.

It is concluded that, although the possibility exists for eggs, nymphs or adults surviving harvest hazards and nymphs and adults moving on to the ratooning crop, infestation is caused mainly by young adults flying in from adjacent cane or grass. Passive transportation is considered unimportant. Three experiments concerning adult movement are described.

The first concerned the relationship between *Numicia* populations in cane and in adjacent green grasses at 10 sampling sites, and their movement from one medium to the other. Mention is made of a sampling error which could account for a discrepancy in numbers between nymphs and adults but, since this discrepancy varied with season, it is suggested that it may not be due to sampling error alone, but also to adult movement. It was found that the life cycle in green grasses followed the same pattern as in cane, with a synchrony of generations. Following cutting of cane, adults often appeared on young ratoons, having flown in from elsewhere.

The second experiment concerned the re-population by *Numicia* adults of a field which had been barren for several months, and the pattern of distribution, with larger numbers in the field centre, is described. The two egg parasites *Oligosita* sp. (Trichogrammatidae) and *Ootetrastichus beatus* Perkins (Eulophidae) appeared in the field about 9 weeks after their host.

In the third experiment sampling was done, using a motorised suction sampler, at different distances into a field of young ratooning cane adjacent to tall cane. All *Numicia* material was collected and females dissected to determine the state of their eggs. It was found that at all distances and throughout the sampling period, both sexes were common in approximately equal numbers until the last sampling, when males were 44% more numerous than females. Females with immature eggs flew considerable distances into the cane. Mention is made of relative egg numbers in the field and in the insectary. At the last sampling there was the beginning of a trend for numbers of both males and females to increase towards the field centre.

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TABLE 2

Corresponding numbers of adult and nymph *Numicia* in sugar cane during peak periods on a Swaziland Estate from 1964 to 1968. All sampling done by shaking.

	February			May			October		
	Nymphs	Adults	% Mortality	Nymphs	Adults	% Mortality	Nymphs	Adults	% Mortality
1964	—	—	—	170	69	59.4	300	210	30.0
1965	76	51	32.9	110	113	0.0	1700	450	73.5
1966	500	350	30.0	270	188	30.4	450	82	81.8
1967	138	115	16.7	430	335	22.1	440	37	91.6
1968	90	76	15.6	240	180	25.0	130	22	83.1

TABLE 3

State of *Numicia* (total of all distances) on each sampling date.

Date	Males	Females	Total	% Female	% Immature Female	% Empty Females	Eggs per Female of Remainder	Eggs per Total Female
30/10/68	28	34	62	54.8	88.2	0 0	16.2	1.9
6/11/68	401	460	861	53.4	31.3	4.8	20.7	13.3
20/11/68	374	209	583	35.8	22.9	12.4	21.6	13.9

TABLE 4

State of *Numicia* at different distances into cane on each sampling date.

	Distance into Cane	*Numicia* ♂	*Numicia* ♀	Nymphs	Total	% ♀	% immature ♀	% empty ♀	No. eggs per ♀ of Remainder	No. eggs per total ♀
30/10/68 Total of 1 transect	Edge tall	?	?	6	9	—	—	—	—	—
	Edge short	0	1	0	1	100.0	100.0	0.0	0.0	0.0
	75 yards	10	6	0	16	37.5	100.0	0.0	0.0	0.0
	150 yards	4	3	0	7	42.8	100.0	0.0	0.0	0.0
	225 yards	4	4	0	8	50.0	100.0	0.0	0.0	0.0
	300 yards	5	3	0	8	37.5	66.6	0.0	25.0	8.3
	375 yards	2	3	0	5	60.0	100.0	0.0	0.0	0.0
		25	20							
6/11/68 Totals of 6 transects	Edge tall	2	12	1	15	85.7	100.0	0.0	0.0	0.0
	Edge short	88	53	0	141	37.5	43.4	3.7	19.2	10.9
	50 yards	89	100	1	190	52.9	36.0	2.0	20.1	12.5
	100 yards	89	81	0	170	47.6	24.6	7.4	21.2	14.5
	150 yards	75	113	1	189	60.1	25.6	6.2	21.6	14.7
	200 yards	58	101	0	159	63.6	25.7	4.9	20.7	14.4
		401	460							
20/11/68 Totals of 4 transects	Edge tall	3	1	0	4	25.0	100.0	0.0	0.0	0.0
	Edge short	69	20	0	89	22.4	35.0	15.0	19.7	9.6
	50 yards	73	40	0	113	35.3	20.0	2.5	21.8	16.9
	100 yards	84	49	0	133	36.8	18.3	16.4	22.7	14.9
	150 yards	90	62	0	152	40.7	30.6	6.5	19.7	12.5
	200 yards	55	37	0	92	40.2	10.8	27.0	23.3	14.5
		374	209							

Discussion

Mr. Andries: The effect of Numicia should not be under-rated. The damage it causes to cane is visually obvious but it has not yet been possible to assess the actual loss in sucrose.

Mr. Wilson: Insecticide treatment can, for instance, bring about an increase in aphids in a subsequent season but if this is controllable it might be worth attacking the Numicia with insecticides.

Mr. Carnegie: The fear of aphids should not be such as to deter an insecticidal approach to the Numicia problem.

Mr. du Toit (in the chair): Timing is very important if dusting or spraying is to be carried out.

The suitable time for dusting appears to be short, e.g. the nymphs must be present but not the adults and the eggs must be hatched.

Mr. Carnegie: There are three periods during the year when conditions are suitable for dusting.

Mr. Wise: Does it depend on the time of the year as to how long it takes for predators to appear —a figure of nine weeks is mentioned in the paper.

Mr. Carnegie: In the hot months the time would probably be shorter.

Mr. Carnegie: We had some experience in April last year with the fungus parasite, which built up during the rainy season but since then there has been little evidence of infected Numicia.

TABLE 1

Corresponding numbers of adult and nymph *Numicia* during peak periods at all sites sampled.
Q=quadrat sampling; S=shake sampling; N=nymphs; A=adults.
Grasses always sampled with quadrats.

Site No.	October, 1966				February, 1967				May				October			
	Grass		Cane		Grass		Cane		Grass		Cane		Grass		Cane	
	N	A	N	A	N	A	N	A	N	A	N	A	N	A	N	A
1	22	21	Q 0	Q 3	0	55	Q 9	S 36	90	370	S 210	S 400	480	450	S1100	S 350
2	58	35	Q 16	Q 18	3	82	S 33	S 44	105	350	S 375	S 255	660	38	Q 270	Q 110
3	32	36	Q 16	Q 19	9	58	S 66	S 54	73	83	S 310	S 280	580	25	S 430	Q 205
4a	86	45	Q 12	Q 31	3	46	S 90	S 88	63	105	S 350	S 215	350	165	S 330	Q 225
4b			Q 14	Q 38			S 350	S 110			S 360	S 225			S 430	Q 110
5	11	5	S 73	S 23	0	3	S 24	S 76	0	310	S 480	S 510	150	23	S 420	S 75
6	22	20	Q 14	Q 18	3	35	S 36	S 80	14	155	S 200	S 210				
7	23	24	S 600	S 63	2	100	S 1	S 150	45	150	S 130	S 200	205	65	S 500	S 96
8a			Q 3	Q 20			S 125	S 90			S 135	S 235			S 180	Q 27
8b	33	9	S 90	Q 23	1	47	S 160	S 92	6	530	S 205	S 180	235	53	S 230	Q 28
9	47	23	S 170	Q 9	0	96	S 18	S 77	70	185	S 330	S 350	220	45	S 270	Q 14
10	22	6	S 70	Q 12	1	20	S 33	S 735	16	51	S 745	S 520	46	5	S 145	Q 10
11	61	17			3	4			10	15			60	9		
12	6	12			3	39			76	61			54	10		
No of times adult numbers higher	3/12				12/12				11/12				0/11			
Both shaking			0/2				6/11				6/12				0/3	
Both quadrats			7/7				0/0				0/0				0/1	
Adults shaking			0/0				1/1				0/0				0/0	
Adults quadrats			0/3				0/0				0/0				0/7	

FIGURE 1: Quadrat sampling in a recently-harvested cane field.

FIGURE 2: Quadrat sampling on reservoir bank adjacent to cane.

FIGURE 3: Counting *Numicia* shaken from cane on to adhesive sheet.

FIGURE 4: *Numicia* numbers per 10 yd^2 at different distances into a cane field.

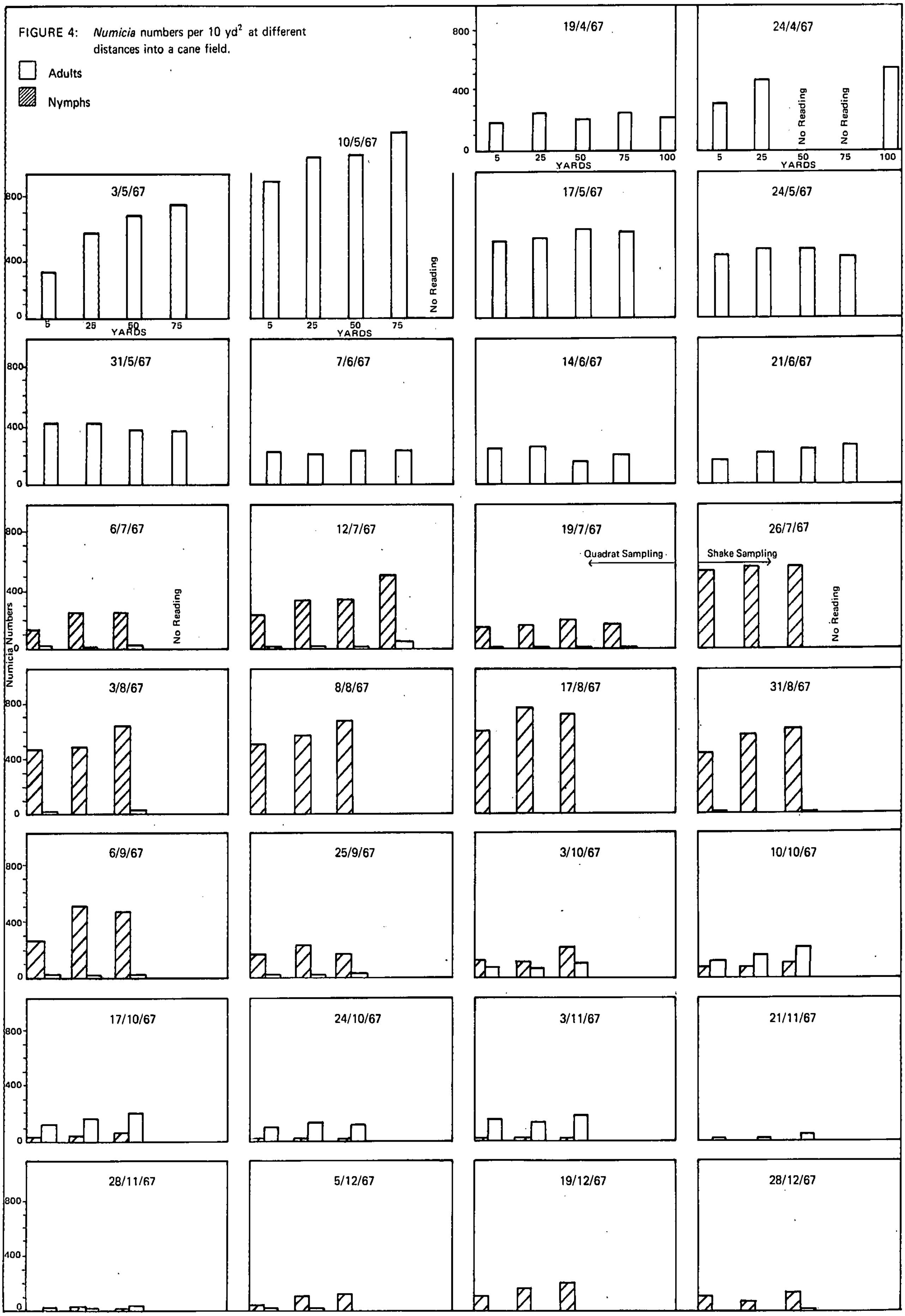

FIGURE 5: *Numicia* numbers per 10 yd² across a cane field and in adjoining grasses.

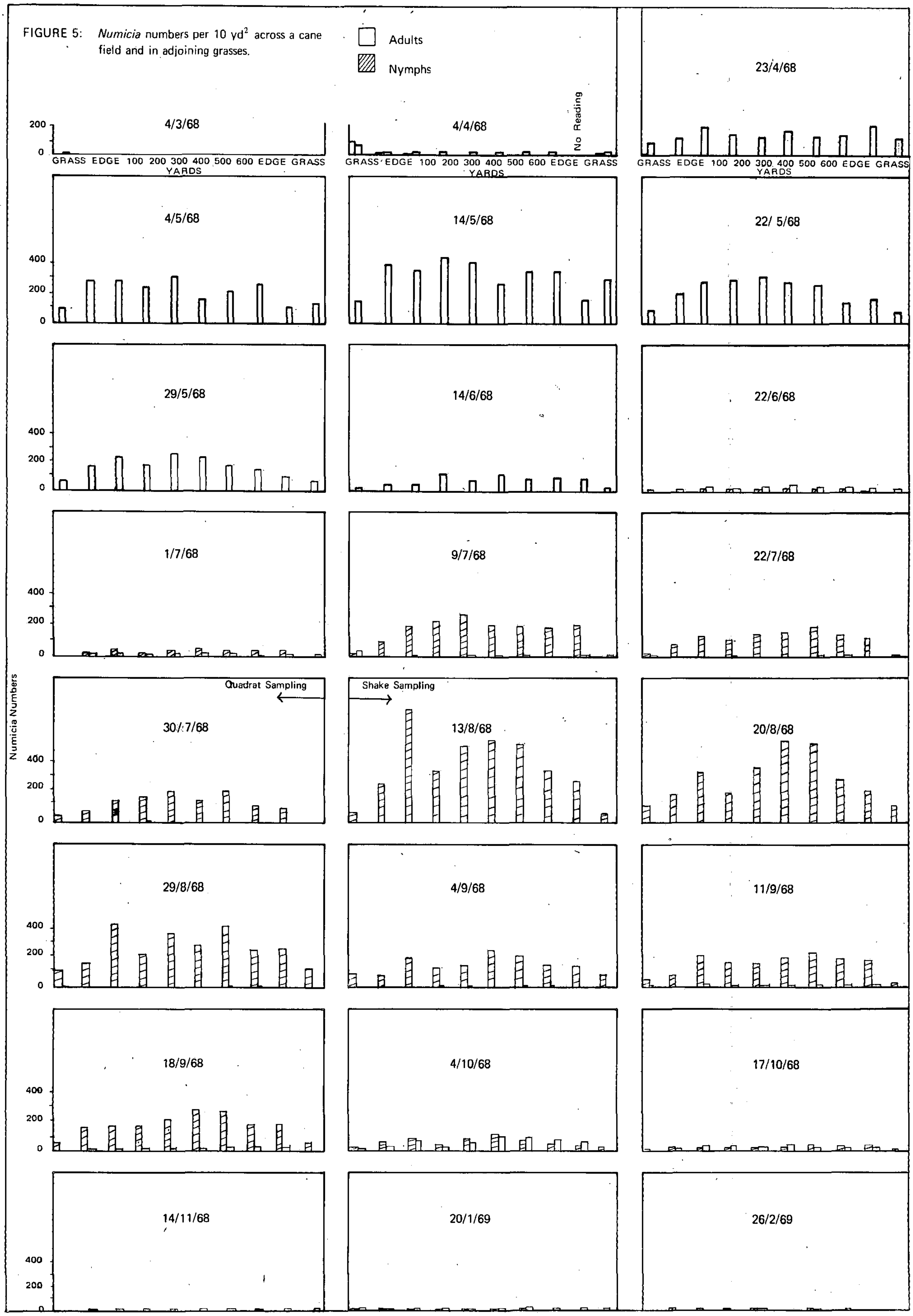

FIGURE 6: Average number of *Numicia* eggs per leaf and percentage parasitised.