

## CONTROL OF ANOPHELINE BREEDING IN IRRIGATION CHANNELS BY PARIS-GREEN.

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The observations in this paper are based on the effect of paris-green on larval breeding in irrigation channels in the Nagenhalli area. Describing this area Sweet (1933) has said, 'Practically the whole of Nagenhalli area is under "paddy" cultivation, watered by means of irrigation channels derived from the Cauvery river. The area is, however, too far from the river for it to be a factor in producing malaria-carrying mosquitoes. There are two main irrigation channels in the area, one to the south and the other flowing through the northern part. Two larger subsidiaries flow through the centre, one forming the southern boundary of Nagenhalli village and flowing on eastward through the farm, the other flowing approximately north and south through the farm. There are of course very numerous smaller channels, running to separate areas of paddy cultivation and between the smaller plots.'

Paddy in this area is a winter crop, the first transplantations being made about the beginning of July and the crop being harvested in December. During the active cultivation all the channels run full, but in the summer months, commencing from January to June, water is allowed for the first ten days only in the main and first subsidiary channels. As a result of this and the uneven surface of the bed these channels are never completely dry. All the channels are much silted up, with the sides scoured and full of vegetation during the irrigation season, attempts to clean them out being irregular and poorly supervised.

The anophelines reported from this area are :

1. *A. aconitus* Donitz, 1902.
2. *A. barbirostris* Van der Wulp, 1884.
3. *A. culicifacies* Giles, 1901.
4. *A. annularis* Van der Wulp, 1884.
5. *A. hyrcanus* Van der Wulp.
6. *A. jamesii* Theobald, 1901.
7. *A. jeyporiensis* James, 1902.
8. *A. fluviatilis* James, 1902.
9. *A. splendidus* Koidzumii, 1920.
10. *A. pallidus* Theobald.
11. *A. philippinensis* Ludlow, 1902.
12. *A. stephensi* Liston, 1901.

13. *A. subpictus* Grassi, 1899.
14. *A. tessellatus* Theobald, 1901.
15. *A. turkhudi* Liston, 1901.
16. *A. vagus* Donitz, 1902.

Of these 16 anopheline species in the area only two, *A. culicifacies* and *A. fluviatilis*, have been found naturally infected with malaria. An epidemiological study of the relationship of the anophelines of the area to the local malaria problem indicated a definite relationship with the catches of only these two anophelines, *A. culicifacies* and *A. fluviatilis* (Sweet, 1933; Sweet and Rao, 1931).

The types of anopheline breeding places in the area are: (1) irrigation channels, big and small; (2) paddy fields; (3) marshy areas where railway and road embankments obstruct natural drainage; and (4) seepage from channels. The irrigation channels offer the largest surface for anopheline breeding and the two malaria-carriers are found in close association and practically confined to these irrigation channels, except that *A. culicifacies* is found breeding outside the channels in paddy fields, marshes, and seepages from the channels. With the exception of the paddy fields, where the finding of *A. culicifacies* is confined practically to a fortnight or a month in the year (middle of June to middle of July which is a non-transmission season for malaria), the other sources of *A. culicifacies* are negligible. The problem of malaria control in the Nagenhalli area, therefore, reduced itself to the control of *A. culicifacies* and *A. fluviatilis* breeding in the irrigation channels, the breeding of *A. culicifacies* in the paddy fields being neglected for the reasons explained.

The sections of the channels in the area vary enormously, some are so big as to require spraying from both banks. Paris-green has been used in this area as the larvicide since the commencement of control measures in February 1930, but as the road-dust locally available was heavy and difficult to spread in a cloud, ash obtained from a nearby mill was used, in varying proportions with the road-dust, as the diluent, a one per cent mixture of paris-green with the road-dust-ash mixture having been in continuous use from the beginning of the work. The mixture is applied by means of hand blowers and at regular intervals of a week.

The effect of paris-green on the anopheline breeding is determined by making larval dips before and after the application of the paris-green mixture. The usual practice is to dip for larvæ the same day in the area due to be paris-greened and the area paris-greened on the previous day. Further, weekly adult catches in established catching stations for a fixed time both in the control and comparison villages reflect the effectiveness of the larvicide used.

The larval findings according to their sizes before and after paris-greening for the year 1935 taken as a sample are given in Table 1 below.

TABLE I.  
Statement of larvae of *A. cuticifacies* and *A. fluvialtis* found before and after paris-greening for the year 1935.

Stage of Larvæ.	<i>A. cuticifacies.</i>										<i>A. fluvialtis.</i>									
	Before Paris-greening.					After Paris-greening.					Before.					After.				
	II.	III.	IV.	P.	Total	II.	III.	IV.	P.	Total	II.	III.	IV.	P.	Total	II.	III.	IV.	P.	Total
January ..	55	31	11	..	97	34	4	..	..	38	52	30	17	..	99	3	1	..	..	4
February	183	135	77	..	375	52	5	..	..	57	46	26	30	..	102	20	3	1	..	24
March ..	135	71	37	..	243	16	3	..	..	19	30	13	10	..	53	2	2	..	..	4
April ..	148	90	60	..	298	33	7	2	..	42	25	9	11	..	45	8	2	..	..	10
May ..	156	97	82	..	335	36	1	..	..	37	35	7	7	..	49	1	..	..	..	1
June ..	137	119	133	..	389	38	3	..	..	41	54	24	18	..	96	17	1	..	..	18
July ..	368	534	532	11	1445	238	70	11	..	319	116	108	83	..	307	56	4	..	..	60
August ..	253	249	235	..	737	144	28	3	..	175	105	65	73	..	243	37	3	..	..	40
September	85	55	60	..	200	34	3	2	..	39	26	18	18	..	62	12	..	..	..	12
October ..	29	25	28	..	82	12	1	3	..	16	11	8	6	..	25	11	2	1	..	14
November	15	11	8	..	34	..	..	..	..	..	18	18	9	..	45	4	1	..	..	5
December	19	8	12	..	39	1	..	..	..	1	27	13	13	..	53	8	2	3	..	13

No selection has been made of the figures for any particular year as similar figures are available for all the years the control measures have been in operation. A study of Table 1 brings to light three important facts :

- (1) That paris-green is completely effective in killing all fourth stage larvæ.
- (2) That its action on the second stage larvæ is negligible.
- (3) That a weekly spraying of paris-green is effective in not allowing any of the second stage larvæ to pass through the pupal stage before the next spraying is due.

A study of the adult catches in the catching stations in the control and comparison villages further confirms the effect of paris-green spraying on the anopheline output in the area. The accompanying graphs (figs. 1 and 2) give the monthly catches of the two species *A. culicifacies* and *A. fluviatilis* in the control as well as the comparison villages.

The figures presented in the two graphs cover a period of eight years. During this period, in the first year no antilarval work was done and in the rest of the period the zone of control was varied from a mile, to a half mile, to a quarter mile, and back again to a half mile. The catches of *A. culicifacies* (graph 1) during the first twelve months before starting the antilarval work disclose two peaks, one during March, April and May and the other in July and August. The first peak is due to the breeding of *A. culicifacies* in the pools and puddles in the channels mainly, whereas the second bigger peak is due to the breeding in the channels in addition to the breeding in the paddy fields.

It is seen that paris-green spraying has effectively controlled the first peak during the malaria transmission period, whereas its influence on the second peak is limited only to the output from the irrigation channels. That the presence of this large number of *A. culicifacies* during July and August has no influence in this area on the local malaria has been discussed and clearly shown by the downward trend of both the spleen rate and the parasite rate (Sweet and Rao, 1933), subsequent to the antilarval measures.

The effect of varying the control zone on the adult catches in the control and comparison villages is well illustrated. With a one mile and a half mile zone, the comparison villages, situated just outside the half mile zone, were theoretically protected on at least one side from invasion of dangerous anophelines. With the reduction of the control zone to a quarter mile, the disparity in the *A. culicifacies* catches in these two groups is well illustrated. While there is a small rise in the number of *A. culicifacies* catches in the catching stations of the control villages, the rise in the comparison villages is enormous, showing that the partial protection enjoyed with the half mile control zone was completely removed.

A study of the catches of *A. fluviatilis* is further a demonstration of the effective control of this species by paris-green. This species is purely a running water breeder and has at no time been found in the paddy plots. A one per cent

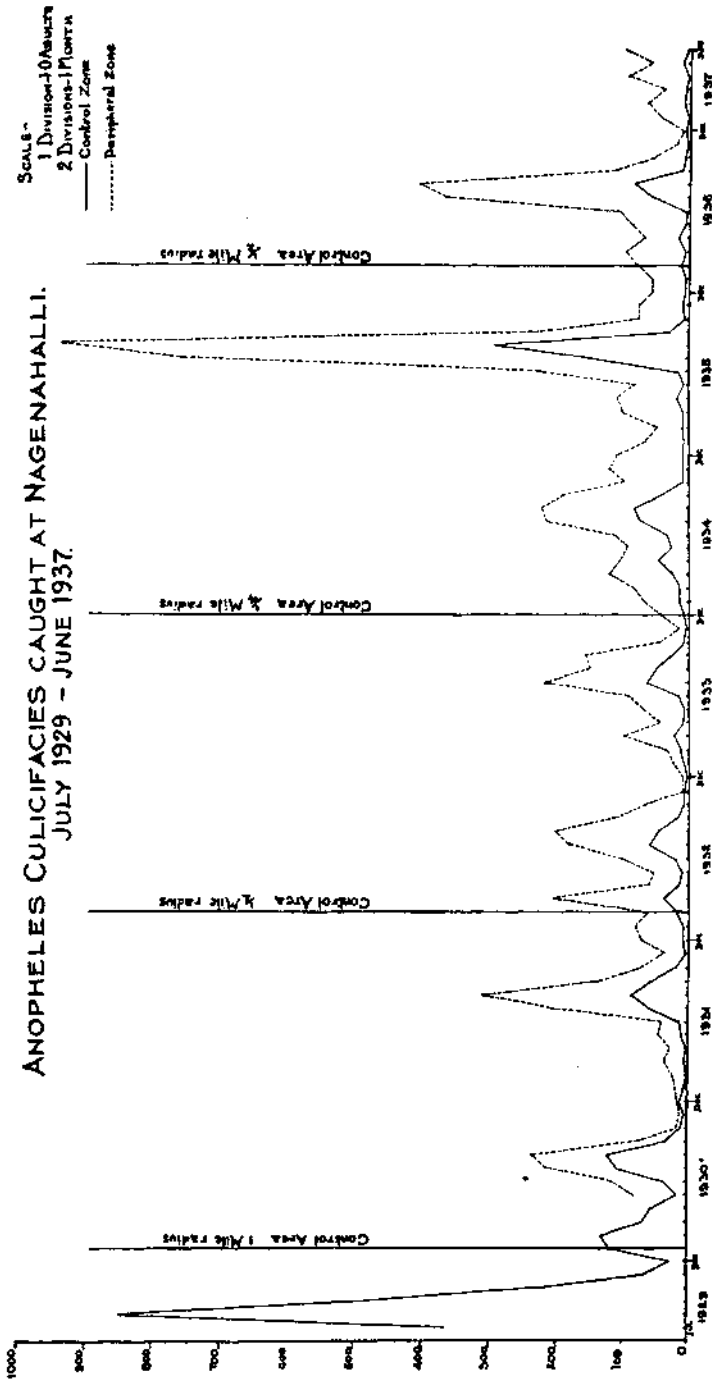


Fig. 1.

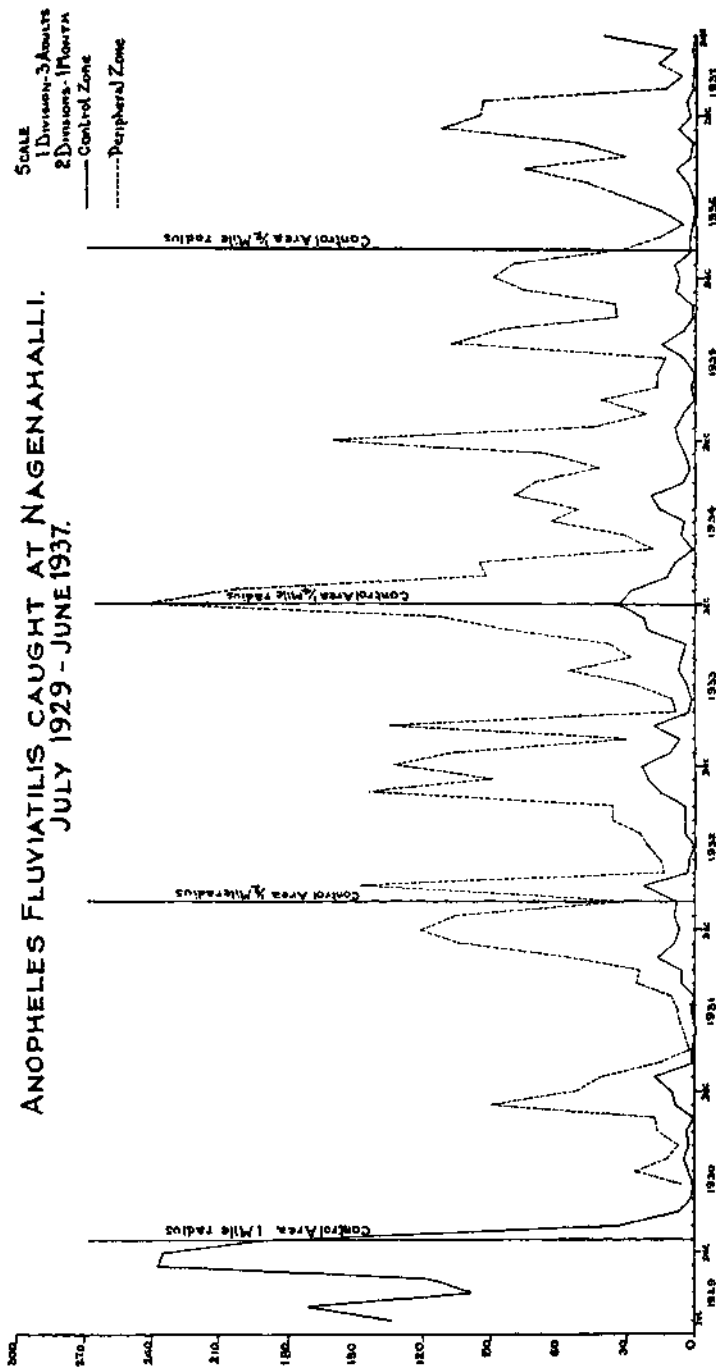


FIG. 2.

paris-green mixture has throughout the period kept down the *A. fluviatilis* catches in the control villages, whereas the catches of this species in the comparison villages is subject only to seasonal variations.

#### DISCUSSION.

One of the objections to the use of paris-green as a larvicide in antimalaria work has been that, judged by the standard of larval catches, it is not one hundred per cent lethal. It is seen from the figures presented in Table 1 that the first and second stage larvæ are almost untouched by paris-green. This is perhaps purely a physical defect in that the size of the particles of paris-green in common use is too big for the larva in the early stages of its growth, but that this is no handicap for effectively controlling anopheline breeding has been amply demonstrated by spraying paris-green mixture once a week (or oftener if necessary), so as to catch these larvæ before they pupate. As regards the necessity for controlling anopheline breeding in paddy plots, the experience reported is with reference to local conditions only.

#### SUMMARY.

In the light of the studies over a period of eight years in the Nagenhalli area it is possible to conclude :

1. That paris-green can be effectively used for controlling anopheline breeding in irrigation channels.
2. That a one per cent mixture with a suitable inert diluent is a quite adequate strength for use as a larvicide.

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