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Report on a village mosquito population

By Paul McDonald

In an earlier attempt to determine the absolute population size of *Aedes aegypti* in an isolated village, a series of markings of landing-biting captures had been undertaken at Kwa Hamis Mtoro for several days. When the results of these mark-release-recaptures were analyzed it was found that the Lincoln Index estimates of population size were rather variable, ranging from 358 on one day to 1838 on the next day (table 1).

The Lincoln Index estimation of population size is dependent upon the recapture of marked mosquitoes. The recapture of mosquitoes in the population is dependent on the pattern of return of the mosquitoes, and this may be sex and age dependent. If a certain sex and age tends to return more often than another, then the population which has a higher percentage of that sex and age will appear to have a smaller population size.

The purpose of this second marking experiment was to mark all newly emerged mosquitoes in the village for several weeks until arriving at a point where almost 100 percent of the adult population was marked. At that time it would be possible, by remarking each individual upon recapture, to determine patterns of return with respect to sex and age. It would also be possible to see the age distribution of the village population over several weeks.

Another purpose of the experiment was the construction of adult survivorship curves for males and females. With such information it would be possible to determine the portion and life expectancy of fertile females that would be expected to be remaining in the population after releases of sterile males.

The relationship between newly emerged adults and landing-biting-captured adults over time could be estimated with the marking experiment on the basis of the village as a whole. The relationship between emergence and landing-biting-capture could be charted for each of the several houses as well.

Materials and Methods

The village of Mgandini, located in the western region of the MBU field study area, is an isolated village under coconut palms, set off from its nearest neighbors by approximately one half mile of grasses, maize and cassava in a very sparse cover of coconut palms. The village has a collection of 34 huts settled around cattle and goat pens. The initial survey of this village, made in July 1972, showed 50 water containers of which 46 had water and 32 had mosquitoes. Twenty houses were selected on the basis of productivity and location so that an even distribution of productive

houses in the village was obtained.

The experiment was begun on 12 October and terminated on 29 November. This was a period of intermittent light rainfall, moderate to high temperatures and good breezes. Pupae were picked on a daily basis from 12 October to 22 October and thereafter every other day. The pupae were taken from the twenty houses selected, and after 24 October from all the other houses in the village as well, although the other houses were relatively non-productive. Pupae from the 20 selected houses were kept in 20 cups, each marked with the house of origin and number of pupae collected.

Newly-emerged adult mosquitoes were counted and then painted with the date of painting. Painting was done on every other day with HUMBEROL spray paint applied in a small dot to the mesonotum. This technique has been described by Dr. Hausermann in the MBU Annual Research Report. All mosquitoes of one day's painting were given the same color on the same side of the mesonotum. The newly-emerged mosquitoes of two days later were painted with the same color but on the other side of the mesonotum. With twelve different colors mosquitoes were marked for 23 different days. After painting, mosquitoes were to be released in the same house from which they had been taken as pupae. The few mosquitoes taken as pupae from houses not selected for the experiment were killed.

Landing-biting (L-B) catches were organized so that two workers, each collecting 20 minutes in each of the 20 houses, could manage the collecting of mosquitoes as well as the releases at the end of the day. L-B catches were made every other day, on the same days that pupae were picked and newly-emerged adults marked. The mosquitoes from the L-B catches were examined for presence of marking; only those previously painted were painted again with the date of capture. All mosquitoes (1. unmarked from the L-B catch, 2. marked from the L-B catch and 3. newly-emerged marked) were released into the houses from which they came, and this was done only after all L-B catches of the day had been completed. Any mosquitoes dying during treatment were not counted as released for that day.

Results

Attempts to saturate village with marked mosquitoes

One major objective of this marking experiment was the saturation of the village population with marked mosquitoes, each marked with its date of emergence. Saturation did not occur. Table 2 shows a maximum of 36 percent marked in L-B catches at the termination of the experiment.

For the first few days, from 14 to 24 October, no collections were made in the houses not included in the 20 selected for surveillance. After that time pupae from these other houses were removed and killed. Even if 24 October is considered as the starting time for the saturation effect to begin, the saturation had not been achieved after 30 days time, which turned out to be the maximum lifetime for a mosquito in this study.

Soon after the experiment began daily collection of pupae had to be abandoned in favor of collection every other day. According to data collected in the first few days of the experiment less than 25 percent of pupae collected on one day will emerge on the next day. This could account for a greater than 25 percent unmarked L-B catch if these have greater survival than the marked.

Collection of pupae is dependent upon the efficiency of the field assistant, and this efficiency may be reduced when the water in the containers is murky.

It is possible that migration from either outdoor habitats near the village or from distant villages had occurred to some extent, thereby bringing into the L-B catches considerable numbers of unmarked adults.

Survivorship

Survivorship between release date and the next L-B catch two days later has been calculated for males released from 14 October to 19 November and females released between 14 October and 5 November. Accurate survival figures could be determined for only 19 groups of males and twelve groups of females, as will be shown in the next sections. Calculations of survival to two days after release are 139/676 or 21 percent for males and 119/456 or 25 percent for females. The possible explanations for this very low survival are 1) the marking treatment resulted in 67 percent mortality within two days or 2) early migration out of the study area occurred. The possibility of migration of newly emerged mosquitoes out of the study area is reinforced by the finding of a large discrepancy between total captures and marked captures in the L-B catches, suggesting that outsiders may be migrating in.

Survivorship curves for males have been made first with 15 groups of male releases, such that each group has the possibility of including all survivors up to the age of the oldest known male survivor. This curve is in figure 1-A with the survivorship on day two after release set to 100 percent. By assuming that the less-than-five percent survivors to the last four ages affect the curve only slightly, then 19 groups of male survivors can be graphed. This gives an essentially identical curve (figure 1-B) to that of 15 groups. Both curves match a survivorship of 60 percent per two-day interval over the time span covered.

Survivorship curves have been made for females, first with nine groups and then with twelve groups, assuming that the less-than-five percent survivors to the last three ages affect the curve only slightly (figure 2-A and 2-B). Both curves match a survivorship of 80 percent per two-day interval over the time span covered.

Survivorship and landing-biting catches

When the 15 groups of males were analyzed with regard to known survivors of an age compared with number of those known survivors caught in a L-B catch at that age, the graph of figure 3 resulted. This indicates that approximately 50 (47 on the average) percent of known survivors of each age were captured in L-B catches under the conditions of this experiment.

When nine groups of females were analyzed with regard to known survivors of an age compared with number of those known survivors caught in a L-B catch at that age, the graph of figure 4 resulted. This indicates that approximately 35 (34 on the average) percent of known survivors of each age were captured in L-B catches under the conditions of the experiment. There does appear to be a higher percent captured on day two followed by lower percentages on days four and six, suggestive of the effect of taking a blood meal on day two after release.

The close correspondence of survivorship curves, which require individual marking - at present practiced only with painting - and L-B catch curves which require group marking only - practical with dusts - suggests that in the future survivorship curves can be approximated, especially for genetic release males, without resort to more laborious marking methods.

Pattern of return in landing-biting catches

Groups of released males were analyzed with regard to their age at time of L-B catch and their probability of return in the next L-B catch. This information is given in table 3. Since the probability of survival for males is the same regardless of age, the figures represent behavioral characteristics. The overall return is nine percent (based on 15 groups); that for young males two and four days after release is ten percent (based on 20 groups). It appears that return of males is independent of age. The estimation of probability of return is based on 14 returnees.

Groups of females were analyzed with regard to their age at time of the L-B catch and their probability of return at the next L-B catch. The information is given in table 4. With a constant survival factor for females, the figures represent behavioral characteristics. The overall return is eight percent (based on nine groups) while females two days after release show a 19 percent return (based on 19 groups); four to ten days after release, ten percent return (based on 19 groups). Very young females have a markedly increased probability of return compared with older females.

It is interesting to note that even when the number of female returnees is eleven (nine groups) the ratio between percent young females returned to percent older females returned is 2 to 1 which approximates the ratio of 1.9 to 1 based on 27 returnees (19 groups).

The probability of return on the average is only slightly different for males (nine percent) and females (eight percent). Male probability of

return is independent of age. However, young females have a probability of return more than twice as great as that of females in general.

Age distribution

The average of the age distribution of known survivors over several days would be expected to reveal a curve of age distribution which reflected the survivorship curve for each sex. Such age distributions have been calculated as far as possible. Averages of three successive catches, four successive catches and five successive catches for males as well as for females are given in tables 5 and 6. These tables clearly show the variability of average age distributions. The variability is due to the particular patterns of emergence of adults into the population. With more catches included in the average the female age distribution averages come more quickly into order than those for males, reflecting 1) the greater longevity of the females compared with the males and 2) a different pattern of emergences. With nine or ten catches averaged the age distribution curves come to closely resemble the survivorship curves (figure 5 and 6).

In general it seems that more stable age distribution averages are obtained if the first day considered is one period (two days) after the emergence of many mosquitoes preceded by a few periods of low adult production and followed by two low production periods. Such a day was 3 November and the period November 3 though November 7 including three catches gave age distributions of both males and females that were reflective of stable age distribution.

The Lincoln Index could best be done with three markings and four catches. Marking is to be done on the catch following a peak of emergence and for two subsequent catches. Recaptures should be made two days after each marking, all during a lull of adult emergence. This would insure that the female age distribution was normal and generally 36 percent of those females would have a high probability of return while 64 would have a lower probability of return.

Population dynamics

The fluctuations in total L-B catch and marked L-B catch, after 24 October (when the collection of all pupae in the village was begun on a regular basis) have been determined and are displayed in figure 7. These fluctuations are generally but not precisely responsive to fluctuations in the numbers of pupae. The fact that the L-B catch is rather constant may be a reflection of a relatively stable population size brought on by the selection out of most pupae and their subsequent dehabilitation as newly-emerged adults by the marking treatment, possibly resulting in the loss of up to 67 percent of the males and females within two days. Those pupae emerging from the water containers in the houses, together with immigrants would then furnish the 64 percent or more of the population which would give shape to the L-B catch fluctuation.

The fluctuations for both male and female numbers of released and captured mosquitoes can be calculated for the marked subpopulation of Mgandini alone. Figure 8 compares 1) the number of those released on a date that are captured at some time later, with 2) the number of known survivors on a date, and 3) the number of marked in the L-B catch. For males it is apparent that after 18 October the number of known survivors reflected the previous released by an interval of a two-day period. Furthermore the L-B catches of the males reflected quite closely the known survivors. For females from 24 October the number of known survivors reflects the releases by an interval of two two-day periods. However, the female L-B catch does not reflect the known survivors closely.

The total capture to survivor figure from 16 October to 9 November is 241 to 657 or 37 percent. The male catches average 52 percent of male survivors while the female catches average 30 percent of female survivors. These figures are comparable for values obtained with several release groups analyzed over their lifetimes, giving 47 percent for males and 34 percent for females (figures 3 and 4).

The attempt to estimate population size by using two methods is illustrated in figure 9. By the first method the number of males in the L-B catch is multiplied by two and the number of females is multiplied by 3. In the second method the number of males plus females is multiplied by 2.7 (100 percent/37 percent). Both estimates are compared with the known survivors curve for both sexes together. The two methods are very little different in results. An accurate catch by catch estimation cannot be made in either case.

The number of newly-emerged adults marked and the number of marked adults taken in L-B catches has been determined from data of the 20 houses used in this study. The relationship has been plotted in figure 10. Generally the adults are distributed in the same way as the pupae; however, there is the possibility that a house with high pupal production and adult emergence may give few adults in the L-B catch (No. 2) and a house with low breeding will give many adults in the L-B catch (No. 6). Overall, 25 percent of the L-B catch were marked, but this was not true for each house. Some houses gave considerably lower percentages of marked mosquitoes, suggesting that these houses may have been difficult for pupae picking or especially attractive to immigrants.

Conclusions

1. At most 36 percent of captured mosquitoes in L-B catches were marked, after the marking of all newly emerged adults collected as pupae in the village of Mgandini for six weeks.

2. The survivorship of males is 60 percent for a two day interval from two days after release. Survivorship for females is 80 percent for a two day interval from two days after release. If natural survivorship for the two days after release (emergence) is also 60 percent for males and 80 percent for females, then 67 percent mortality was caused to both sexes by the marking treatment.

3. Landing-biting catches of marked mosquitoes closely resemble survivorship curves, especially for males. This suggests that group marking may be successful in determining survivorship curves.

4. The probability of return in a subsequent L-B catch was nine percent for males and eight percent for females. Return probability is independent of age for males but young females have greater than twice the probability of return compared with older females.

5. Stable age distribution occurs over three consecutive catches if the catching begins two days after a peak emergence preceded by a lull and followed by a lull. This would be the best time to do a Lincoln Index.

6. An estimation of the number of marked survivors of the age of two days after release (emergence) and older can be determined by multiplying the number of marked captures by 2.7 under the sampling regime of this experiment.

7. The distribution of marked adults caught in L-B catches generally corresponds to the distribution of newly-emerged adults released in this village.

Table 1

Lincoln Index values for Kwa Hamis Mtoro

Date	Interval between catches	
	one day	two days
19 July	605	---
20	590	679
21	430	1008
22	358	629
23	1838	1126
24	---	1047

Table 2

Date	Percent L-B catch marked
14 October	0
16	9
18	22
20	20
22	31
24	17
26	30
28	20
30	25
1 November	29
3	29
5	34
7	18
9	19
11	35
13	25
15	29
17	21
19	30
21	18
23	35
25	29
27	27
29	36

Table 3

Age of male (days after first released)	Probability of return in next L-B catch: 15 groups	Probability of return in next L-B catch: 20 groups
2	5/38 (9%)	7/74 (9%)
4	5/37 (14%)	5/44 (11%)
6	1/17 (6%)	1/23 (4%)
8	1/9 (10%)	1/9 (10%)
10	0/7 (0%)	
12	0/1 (0%)	
14	0/1 (0%)	
16	0/3 (0%)	
18	0/1 (0%)	

Table 4

Age of female (days after first released)	Probability of return in next L-B catch: 9 groups	Probability of return in next L-B catch: 19 groups
2	5/37 (14%)	15/78 (19%)
4	0/17 (0%)	3/42 (7%)
6	1/15 (7%)	2/33 (6%)
8	2/15 (13%)	4/22 (18%)
10	1/12 (8%)	3/28 (11%)
12	0/7 (0%)	
14	0/8 (0%)	
16	1/6 (16%)	
18	1/5 (20%)	
20	0/2 (0%)	
22	0/1 (0%)	
24	0/2 (0%)	
26	0/2 (0%)	
28	0/0 (0%)	
30	0/1 (0%)	

Table 5: Average age distribution of males

Dates	Percentage at ages							
	2	4	6	8	10	12	14	16
Three catches:								
1, 3, 5 Nov.	51	29	11	0	2	2	2	2
3, 5, 7 Nov.	49	26	16	5	0	0	2	2
3, 7, 9 Nov.	34	31	19	9	3	0	0	3
7, 9, 11 Nov.	65	19	7	7	2	0	0	0
9, 11, 13 Nov.	55	33	8	2	2	0	0	0
11, 13, 15 Nov.	58	25	14	3	0	0	0	0
13, 15, 17 Nov.	36	33	16	11	4	0	0	0
15, 17, 19 Nov.	36	24	19	12	8	2	0	0
Four catches:								
1, 3, 5, 7 Nov.	47	28	13	4	2	2	2	2
3, 5, 7, 9 Nov.	48	25	15	6	2	0	2	2
5, 7, 9, 11 Nov.	57	24	10	5	2	0	0	2
7, 9, 11, 13 Nov.	51	32	11	5	2	0	0	0
9, 11, 13, 15 Nov.	56	25	13	4	1	0	0	0
11, 13, 15, 17 Nov.	52	27	11	7	2	0	0	0
13, 15, 17, 19 Nov.	30	33	19	10	7	1	0	0
Five catches:								
1, 3, 5, 7, 9 Nov.	54	24	11	4	3	1	1	1
3, 5, 7, 9, 11 Nov.	60	22	10	4	1	0	1	1
5, 7, 9, 11, 13 Nov.	47	33	13	4	1	0	0	1
7, 9, 11, 13,15 Nov.	53	25	14	7	1	0	0	0
9,11, 13, 15,17 Nov.	51	27	11	8	3	0	0	0
11,13, 15, 17,19 Nov.	44	28	14	7	5	1	0	0

Table 6: Average age distributions of females

Dates	Percentage at ages			
	2	4	6	8
Three catches:				
22, 24, 26 Oct.	36	28	18	18
24, 26, 28 Oct.	32	30	23	15
26, 28, 30 Oct.	20	30	29	21
28, 30, 1 Oct.-Nov.	23	20	29	28
30, 1, 3 Oct.-Nov.	37	20	17	26
1, 3, 5 Nov.	46	29	14	12
3, 5, 7 Nov.	36	31	22	11
Four catches:				
22, 24, 26, 28 Oct.	33	27	22	18
24, 26, 28, 30 Oct.	27	28	25	21
26, 28, 30, 1 Oct.-Nov.	25	28	26	22
28, 30, 1, 3 Oct.-Nov.	32	21	23	23
30, 1, 3, 5 Oct.-Nov.	35	26	19	20
1, 3, 5, 7 Nov.	39	28	20	13
Five catches:				
22, 24, 26, 28, 30 Oct.	29	26	24	22
24, 26, 28, 30, 1 Oct.-Nov.	29	26	23	21
26, 28, 30, 1, 3 Oct.-Nov.	31	27	23	20
28, 30, 1, 3, 5 Oct.-Nov.	31	26	23	19
30, 1, 3, 5, 7 Oct.-Nov.	32	26	22	20

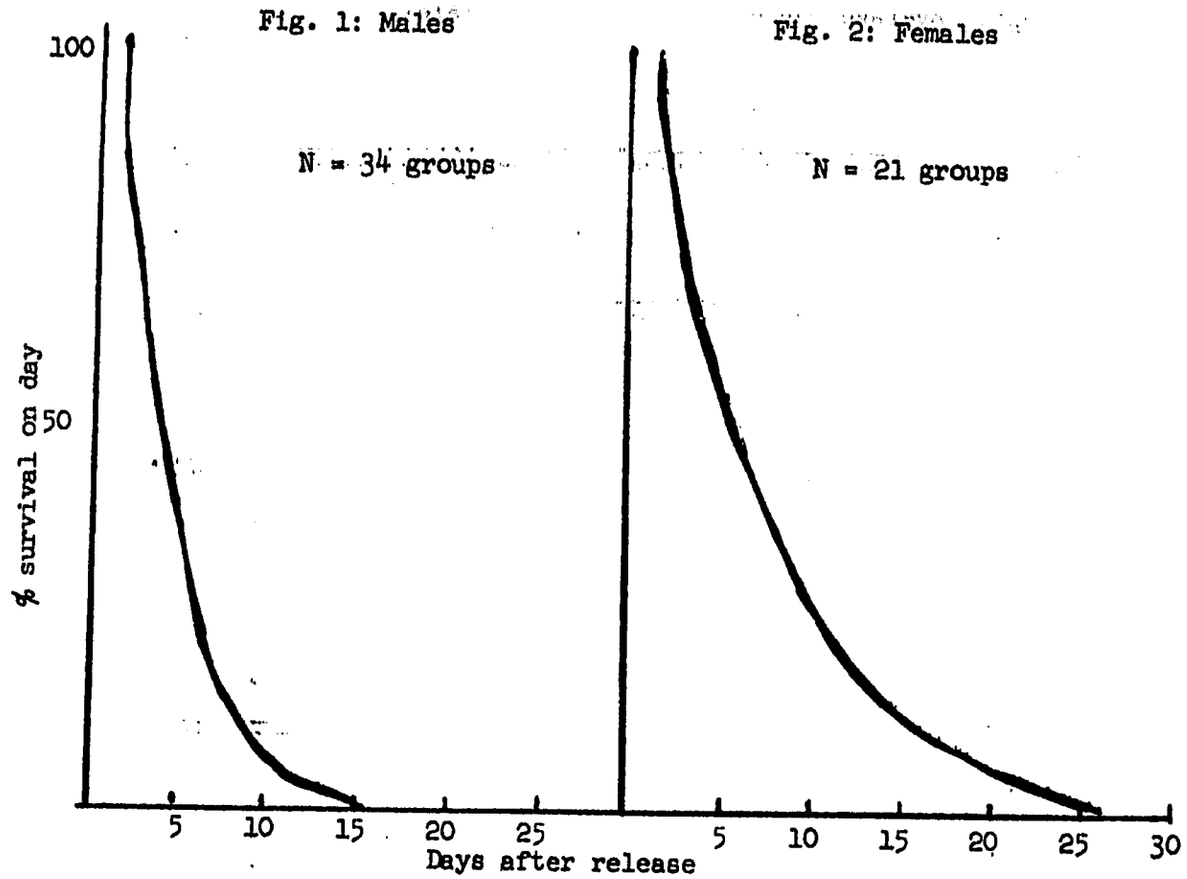


Fig. 1: Males
N = 34 groups
Fig. 2: Females
N = 21 groups
100
50
% survival on day
5
10
15
20
25
30
Days after release

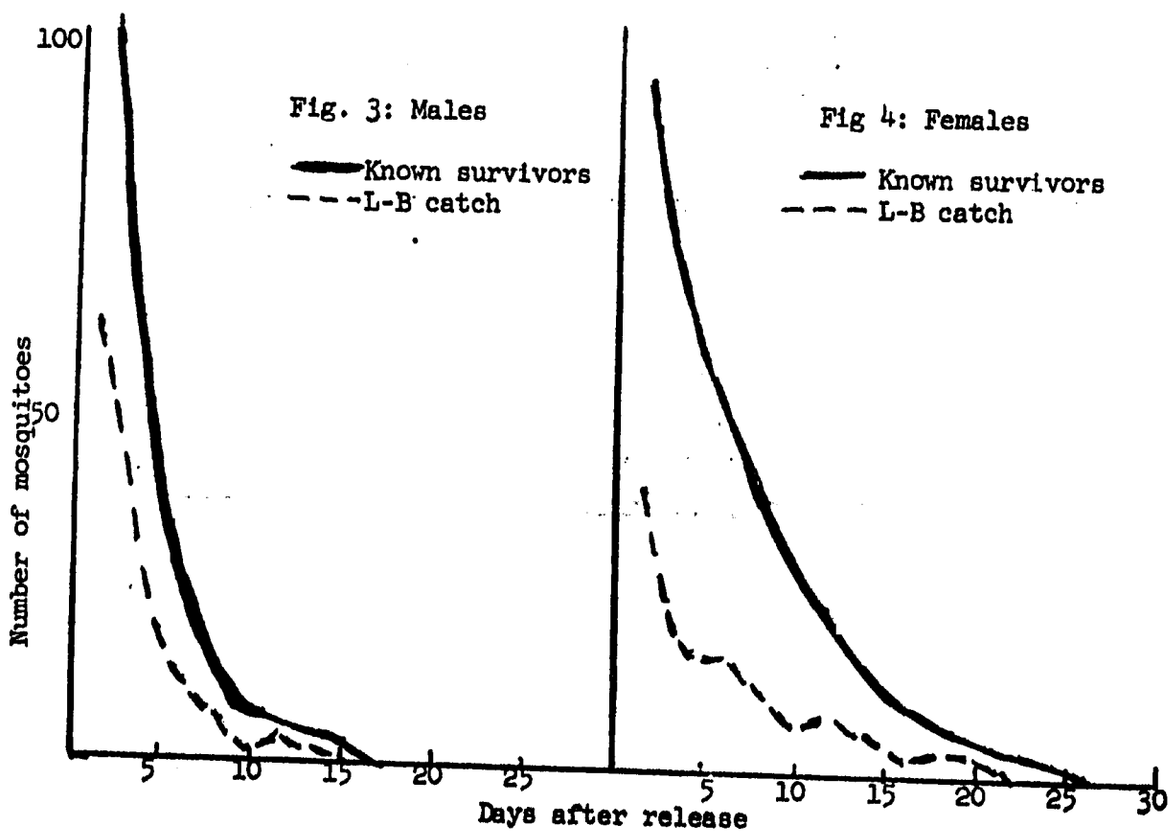


Fig. 3: Males
Known survivors
L-B catch
Fig 4: Females
Known survivors
L-B catch
100
50
Number of mosquitoes
5
10
15
20
25
30
Days after release

Fig 5: Males

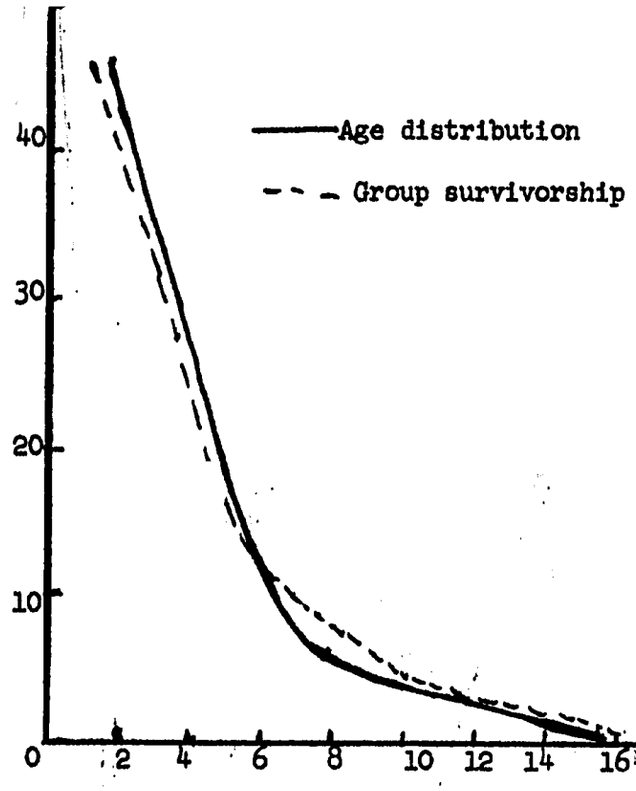


Fig.6: Females

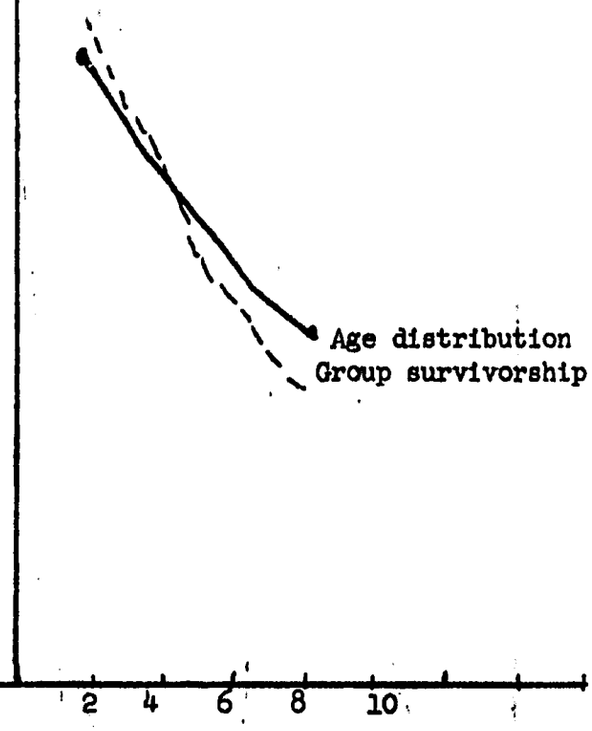


Fig. 7

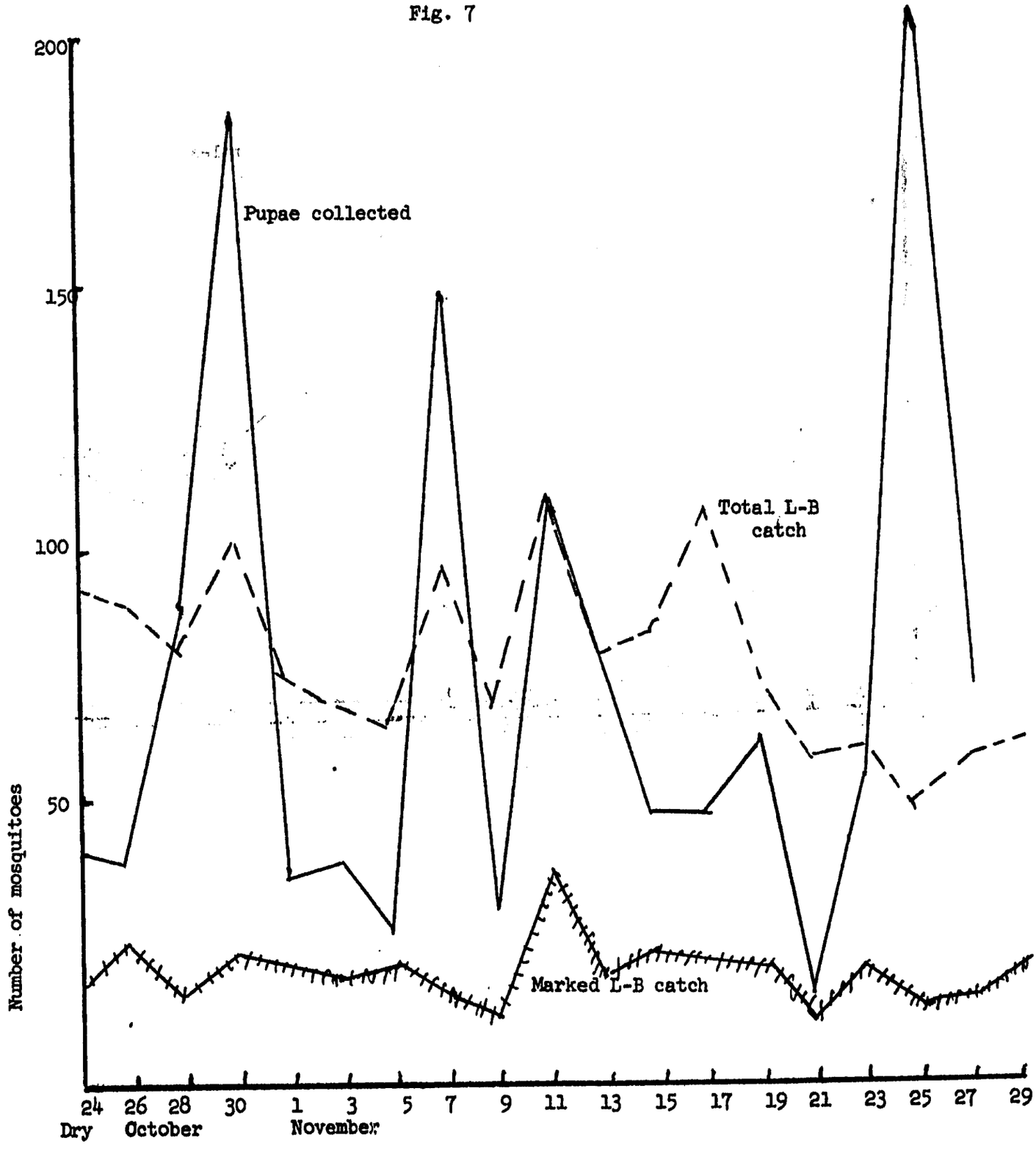

200
150
100
50
Number of mosquitoes
Pupae collected
Total L-B catch
Marked L-B catch
24 26 28 30 1 3 5 7 9 11 13 15 17 19 21 23 25 27 29
Dry October November

Fig. 8

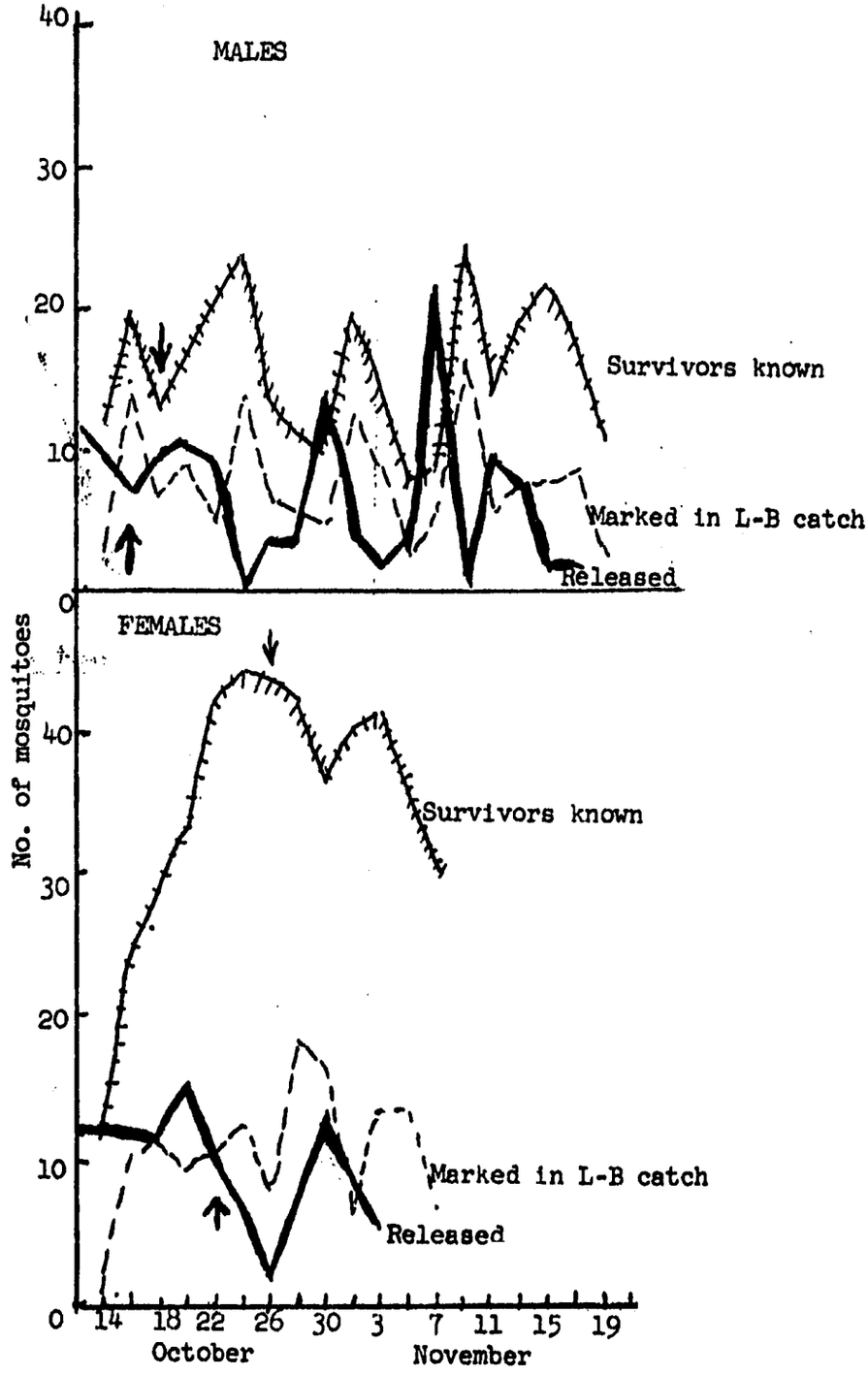

MALES
FEMALES
Survivors known
Marked in L-B catch
Released
Survivors known
Marked in L-B catch
Released
No. of mosquitoes
0
10
20
30
40
0
10
20
30
40
14
18
22
26
30
3
7
11
15
19
October
November

Fig. 9

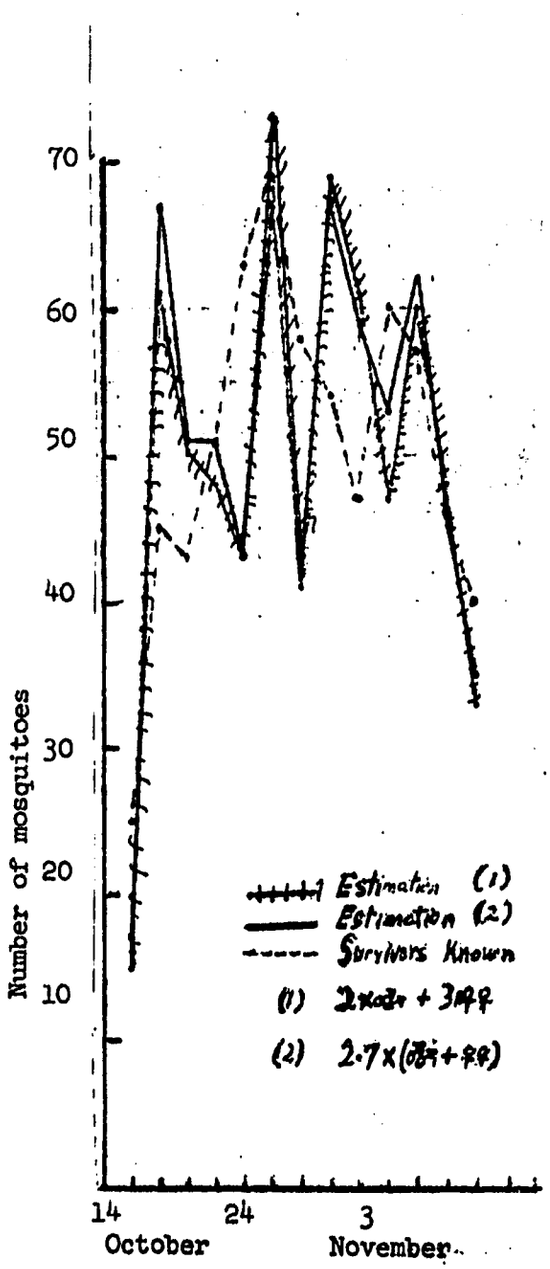
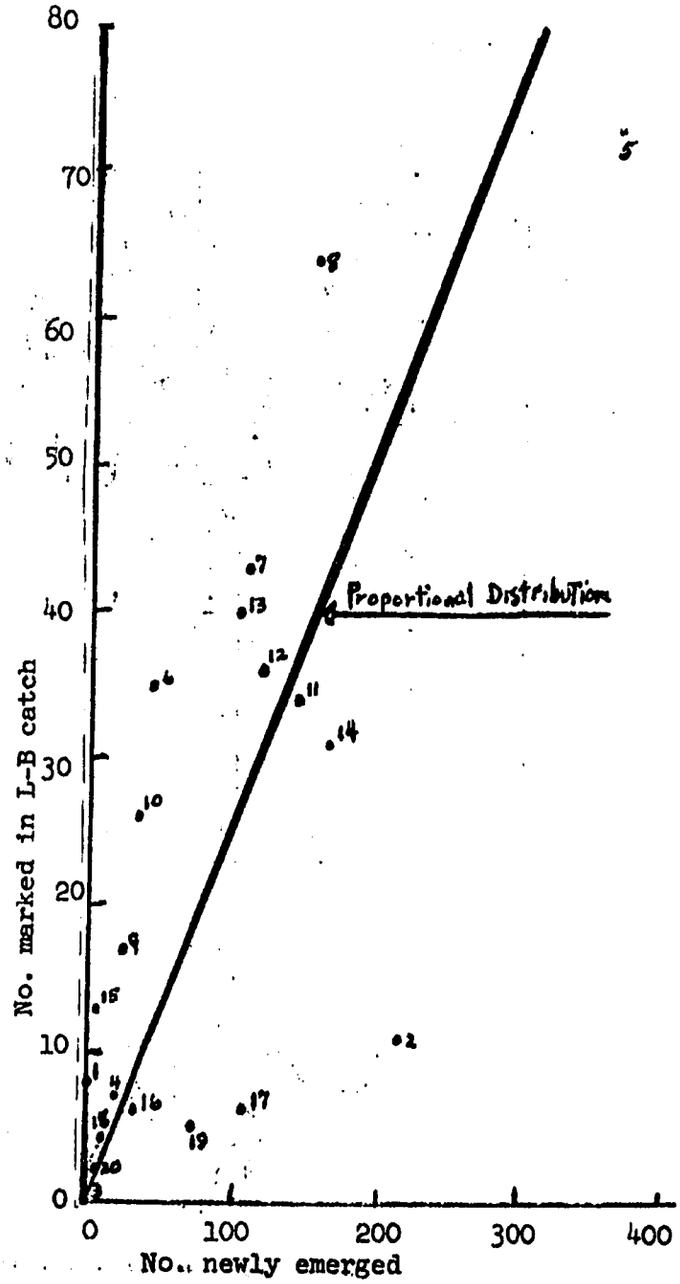

Number of mosquitoes
70
60
50
40
30
20
10
14
24
3
October
November
Estimation (1)
Estimation (2)
Survivors Known
(1) 2×♂♂ + 3♀♀
(2) 2.7×(♂♂+♀♀)

Fig. 10


No. marked in L-B catch
80
70
60
50
40
30
20
10
0
0
100
200
300
400
No. newly emerged
Proportional Distribution