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SURVIVAL AND REPRODUCTION OF *GLOSSINA MORSITANS* WESTW. IN DIFFERENT TYPES OF CAGES EXPOSED TO VARIABLE AND CONSTANT CLIMATIC CONDITIONS

By G. J. W. Dean,[1] J. Paget[2] and B. R. Williamson[3]

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Buxton (1955) has reviewed factors considered to be responsible for the general lack of success in breeding tsetse flies in captivity. Recently, however, de Azevedo & Pinhao (1964) with *Glossina morsitans* Westw. and Nash, Jordan & Boyle (1966) with *G. austeni* Newst. have reported satisfactory survival and breeding of these species under laboratory conditions. The use of the sterile-male principle to eradicate tsetse flies has been indicated by Knipling (1963) and initial investigations have been described by Dame, Dean & Ford (1965). This control technique requires the treatment and release of large numbers of male flies reared from a successful breeding colony. To this end, the survival and reproduction of the tsetse fly *G. morsitans* were investigated in various types of cages exposed to different climatic conditions in the Zambezi valley, Rhodesia, during 1966–67.

Methods

This study involved two major installations. First, an 8 × 16 × 16-ft. cage of galvanised mosquito mesh on 2 × 2-in. wooden frames was erected in the bush (fig. 1A). A cement floor was laid, the walls and roof were shielded from solar radiation by reed matting, and electric lights were installed to give a 12-hr. light cycle. An insert into one side of the cage could be opened from the outside, and this was used to store small cages used in some trials. Secondly, a 10 × 17 × 27-ft. constant environment room (CER) with double walls of cement cavity blocks separated by an air space, and a corrugated iron roof over fibre-board insulated ceiling, was built next to the first cage (fig. 1B). Lighting, two air conditioners and a humidifier were powered by two 6-KVA diesel generators. A large cage (8 × 11 × 21 ft.) of galvanised mosquito netting on a 2 × 2-in. wood framing filled most of the room. Shelves along one wall were used to hold the small cages used in some trials. Maximum and minimum, and wet and dry bulb thermometers and a thermohygrograph were placed in both cages and in an adjacent Stevenson screen. These instruments were read daily at 0800 hr.

Three types of small cage were used. The standard 8 × 8 × 11-in. cage described by Dame & Ford (1966), and the Petana boxes (5 × 8 × 18 in.) designed by McDonald (1961) were of wooden construction and covered with cotton mosquito mesh. The Geigy cages (6 × 3½ × 2 in.) developed by Nash, Jordan & Boyle (1966) had a frame of 3-mm. diameter welding rod covered with cotton mosquito mesh.

Tsetse flies feed exclusively on vertebrate blood (Glasgow, 1963), and oxen were used as host animals in these trials. Two feeding procedures were tried in the large cage within the CER. For most tests, the lights were turned out

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before an ox was led in through the door and tethered at one end of the cage. The lights were turned on over the ox which was freely accessible to the flies for an hour every morning and afternoon. At the end of the feeding period, the light over the ox was turned off and another light at the far end of the cage was turned on in an attempt to move the flies away from the ox. After about 15 min. the ox was led out and any flies that were seen to escape were captured with nets and replaced into the cage. However, it was found that some flies still managed to escape and another method was tried during the last trial. A loose, cotton mosquito-mesh wall was inserted between the main volume of the cage and the area occupied by the ox. The animal was securely tethered and a specially

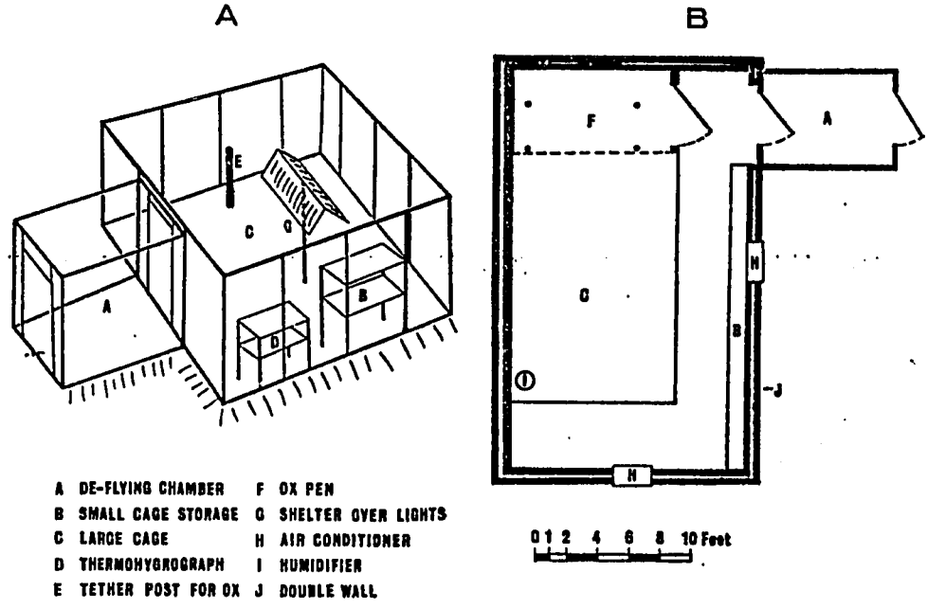

Fig. 1.—Details of the large cage under variable climatic conditions (A) and in the constant environment room (B).

strengthened part of the mesh wall was secured by leather girths flush with the surface of the flanks and back of the ox. The cage was darkened by screens around the walls except during feeding periods, when a spotlight was shone on the panel in the wall through which the flies fed on the ox, and a 4-hr. period of light during the morning. The flies were given an opportunity to engorge for an hour every morning and afternoon. Flies released into the large cage outside were fed in a similar manner. An ox was taken in and tethered to a post when the lights were off and the cage was relatively dark. The lights were then turned on for an hour, after which they were turned off for a short period while the ox was removed. The flies in the three types of small cage were fed by securing the cages with rubber strips to the flank of an ox for half an hour every morning. This feeding was done under a thatched shelter next to the CER. The flies were held in the standard cages prior to the start of all trials and were given a chance to feed by this method.

The survival of known numbers of flies liberated into the two large cages was estimated daily by counting the numbers seen on the walls, and by recapturing all live flies at weekly intervals. The last trial in the CER involved continual releases of larger numbers of flies marked on the thorax with artists' oil paint. Survival was estimated weekly by recapturing and recording the number of flies with a paint spot. Progeny emerging from pupae deposited in the sand covering the floor of the cage for this trial were recognised by the absence of a paint mark.

Tests on survival and reproduction obtained from tsetse held in the small cages followed the procedure described by Dame & Ford (1966) and Dean & Wortham (1969). Dead flies were collected and sexed, daily in some trials and weekly in others. Flies used in tests on reproduction were caught in the bush and were of unknown age. Tsetse are larviparous and can produce a single third-instar larva every 10–14 days which soon after deposition pupates in the soil. The pupal stage lasts for about 28 days at 25°C. The breeding cages were held just above trays containing sand, and larvae deposited in the cages passed through the cotton-mesh walls and pupated in the sand. The puparia were collected once a week, weighed, and stored in mesh-covered jars in the CER to check eclosion rates. The F_1–F_3 generation flies emerging from puparia deposited in the standard cages were put into similar cages soon after eclosion and before they were sexually mature (Dame & Dean, unpublished), in order to investigate their reproductive capability.

The flies used in these trials came from two sources. Batches of puparia collected during studies into larviposition sites (Jackson & Phelps, 1967) were held in the CER and the emerging adult flies were collected daily (0800 hr.) The sexes were held separately in standard cages. 'Wild' flies were caught with nets off black screens carried through the bush. The flies were removed from the nets in 1 × 3-in. glass vials, with cotton mesh covering one end, and these were placed into styrofoam trays wrapped in wet, black cloth. The trays were held in two sections of an insulated metal box separated by a centre section containing cans of dry ice. Flies were positioned for marking by removing the cap from the tube, inserting a wooden piston and gently forcing the fly against the mesh (Pilson, unpublished). A paint spot was put on to the thorax through the mesh. This procedure for holding and marking flies caught in the bush reduced rough handling and consequent damage and mortality.

Results and conclusions

Climatic conditions

Mean monthly climatic conditions for the two cage installations and the Stevenson screen are given in Table I. The climate in the CER was distinctly milder than the ambient climate outside. There were fluctuations in temperature from the desired constant of 25°C. because of difficulties in balancing heating and cooling elements in a room of this size and design. This also caused a variation in the humidity either side of the intended level of 75 per cent. The climate in the cage shielded by reed mats was generally less extreme than the conditions recorded in the Stevenson screen except for the hot, dry months. Rain fell mainly between November and April.

Survival of tsetse flies obtained from different sources

Male and female flies emerging in the CER from puparia collected at Kariba and Chirundu, and caught from the natural population at Chirundu, were held in standard cages under ambient and constant climatic conditions during August–September. Male 'wild' flies survived better under a variable than a constant climate, while for the first three weeks female flies survived equally well under both climatic conditions, though maximum survival was greater under ambient

TABLE I. *Mean monthly climatic conditions for the two cage installations and the Stevenson Screen*

Month	Constant environment room				Cage under ambient conditions				Stevenson Screen				Rainfall (mm.)
	Temperature (°C.)		Humidity (%)		Temperature (°C.)		Humidity (%)		Temperature (°C.)		Humidity (%)		
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	
June 1966	23·6	21·5	82·4	72·6	25·9	12·9	95·7	45·9	27·4	11·8	92·0	35·5	NIL
July	25·4	22·3	77·8	66·9	26·9	10·9	93·4	38·6	28·5	9·6	90·9	30·6	NIL
August	26·4	24·5	74·3	66·0	29·9	14·4	89·7	38·8	30·4	12·1	83·9	29·8	NIL
September	27·3	25·5	70·7	61·7	33·1	18·4	76·1	35·4	33·9	16·3	70·9	29·7	1·8
October	26·7	24·2	62·1	48·5	35·7	21·5	71·8	34·2	36·0	19·2	63·9	27·1	NIL
November	25·0	21·9	64·1	48·9	35·3	23·5	81·3	35·1	36·0	22·0	75·5	29·6	87·3
December	24·8	22·7	77·4	63·4	31·8	24·8	96·2	62·7	33·2	22·4	88·4	46·4	176·4
January 1967	24·0	22·7	86·2	69·9	29·7	24·3	99·4	77·4	33·0	22·8	91·8	51·0	195·1
February	24·6	23·1	86·9	72·8	30·4	23·8	99·1	69·4	32·4	21·8	94·6	48·5	103·7
March	23·7	22·2	86·4	71·7	30·1	23·5	99·3	70·3	32·0	21·2	95·0	44·5	74·5
April	23·6	22·1	83·8	71·8	30·2	20·0	98·1	59·5	32·1	18·1	94·0	38·1	11·4
May	24·0	21·0	87·8	74·2	27·8	14·7	95·3	47·2	29·7	13·3	91·5	30·8	NIL
June	24·4	21·0	85·5	71·4	27·2	12·8	96·1	48·7	28·8	11·1	89·8	30·5	NIL
July	23·3	20·1	86·7	75·1	26·8	12·5	89·6	45·5	27·1	8·0	89·1	28·1	NIL
August	20·1	17·1	89·0	72·4	—	—	—	—	28·5	10·7	83·7	32·1	NIL
September (1st–17th)	25·2	21·2	94·1	79·1	—	—	—	—	30·6	14·6	73·6	30·8	NIL

TABLE II. *Mean survival (%) of 50 males and 50 females of* G. morsitans *caught in the bush, or emerging from puparia collected at Kariba and Chirundu, and held in standard cages under ambient or constant climatic conditions during August and September 1967*

Climate	Origin of flies	Survival period (days)									
		5		10		20		30		40	
		♂	♀	♂	♀	♂	♀	♂	♀	♂	♀
Ambient	'Wild' flies	58	25	80	14	21	14	15	14	5	7
	Chirundu puparia	50	80	32	48	10	27	8	20	0	10
	Kariba puparia	75	100	75	85	63	67	63	50	40	30
Constant	'Wild' flies	25	37	20	20	5	13	0	0	—	—
	Chirundu puparia	72	80	52	80	12	70	10	30	0	10
	Kariba puparia	53	53	43	45	22	38	10	30	10	18

Two replicates.

conditions (Table II). However, flies emerging from puparia generally lived longer than 'wild' flies under both conditions. The flies from Kariba puparia tended to survive better than those emerging from Chirundu puparia under ambient conditions, but this was not so obvious in the controlled environment.

The 'wild' flies were of unknown age and a proportion may have been about to die of old age at the beginning of the trial, while the tests on the insectary flies began soon after eclosion from puparia. Dame (unpublished) investigated the physiological age natural to the Chirundu and Kariba populations of *G. morsitans* using the method developed by Saunders (1960). This comparison of the monthly percentages of nulliparous female flies from Chirundu and Kariba indicated that the Chirundu population is composed of a much higher proportion of young female flies. He suggested that from this the survival rate of flies at Chirundu was lower than at Kariba.

Survival of tsetse flies in small and large volume cages under ambient and constant climatic conditions

The survival of flies in the standard cages was compared with the survival obtained in the large cages inside and outside the CER. 'Wild' flies from

TABLE III. *Mean survival rates of 'wild' males and females of* G. morsitans *in small and large cage volumes in the constant environment room*

Cage type	Month test started	Mean no. of days to indicated survival						Maximum longevity (days)	
		75%		50%		25%			
		♂	♀	♂	♀	♂	♀	♂	♀
Standard small cages	August, 1966	7	11	20	31	27	44	59	116
	September	4	9	17	17	24	39	31	101
	October	2	3	10	11	15	22	44	78
	November	4	7	11	23	18	38	39	125
	December	1	—	2	—	7	—	18	—
	January, 1967	7	6	9	11	12	25	23	64
	February	6	7	12	20	17	33	78	104
	March	9	26	20	45	30	77	77	147
	April	11[a]	3[a]	25	9	42	33	65	99
	May	9	11	30	36	41	45	76	103
	June[b]	—	—	—	—	—	—	—	—
	July[b]	—	—	—	—	—	—	—	—
	August	—	14	—	39[c]	—	—	—	—
	Mean	5·5	10·5	14·6	25·9	21·2	40·4	51	104
Large cage	August, 1966	—	—	—	—	—	—	—	—
	September	1[a]	1	1	2	3	5	19	27
	October	1	1	1	1	1	1	2	2
	November	2[a]	—	2	—	5	—	31	—
	December	1	—	1	—	2	—	9	—
	January, 1967	1[a]	—	2	—	4	—	20	—
	February	2[a]	—	3	—	5	—	17	—
	March	1[a]	—	4	—	8	—	28	—
	April	1[a]	—	2	—	3	—	31	—
	May, June, July, August, September	Mass release trial (fig. 3)							
	Mean	—	—	—	—	—	—	20	14

Two to three replicates.
[a]—Single test only.
[b]—No flies available.
[c]—Trial ended.

Chirundu were used in all tests started in most months between July 1966 and September 1967. Between 20 and 65 flies were used in the small cages, while from 100 to 280 flies were released into the larger cages.

The results obtained from the two cage volumes and two climates are given in Tables III and IV. In the small cages, there appeared to be little difference in survival under the two climatic conditions, except in October and November when flies held in the CER lived longer under a much lower temperature regime

TABLE IV. *Mean survival rates of 'wild' males and females of* G. morsitans *in small and large cage volumes under ambient climatic conditions*

Cage type	Month test started	Mean no. of days to indicated survival						Maximum longevity (days)	
		75%		50%		25%			
		♂	♀	♂	♀	♂	♀	♂	♀
Standard small cages	July, 1966	9	—	17	—	25	—	63	—
	August	6[a]	30[a]	33	34	55	34	90	35
	September	3	2	10	10	21	22	45	43
	October	1	1	2	2	4	3	22	15
	November	1	1	1	1	1	1	5	28
	December	2	2	6	7	10	14	24	58
	January, 1967	9	9	15	26	20	41	61	92
	February	6	8	10	23	23	35	98	42
	March	17	33	43	54	58	87	113	129
	April	12	4	28	36	53	65	91	141
	May	10	—	27	—	43	—	92	—
	June	—	12	—	30	—	40	—	91
	July	—	19	—	44	—	67	—	71[c]
	August	—	21	—	38[c]	—	—	—	50[c]
	Mean	6·8	10·2	15·8	24·6	25·9	37·5	64	67
Large cage	September, 1966	2	2	2	3	7	9	21	25
	October	1	1	1	1	1	3	7	13
	November	1	1	2	3	3	3	31	23
	December	—	—	—	—	—	—	—	—
	January, 1967	3[a]	3[a]	7	3	12	5	25	6
	February	3[a]	3[a]	7	8	13	16	30	24
	March	1[a]	1[a]	5	4	11	9	26	21
	April	1	1[a]	4	1	8	2	21	13
	May	2[a]	5	6	8	10	9	20	32
	June	—	—	—	—	—	—	—	—
	July	2[a]	4	5	9	11	14	27	27[c]
	August	—	4[a]	—	7	—	13	—	26[c]
	September	2[a]	—	3	—	6	—	15	—
	Mean	—	—	—	—	—	—	22	20

Two to three replicates.
[a]—Single test only.
[b]—No flies available.
[c]—Trial ended.

than those exposed to the higher ambient temperatures outside. Flies lived longer in the small cages than in either of the two larger cages. The flies liberated into the large cage outside generally lived longer than those in the cage in the CER, though maximum longevity tended to be similar. These data indicate that a complex insectary with constant climatic conditions is not necessary for field stations.

The survival of 'wild' flies in the cage outside the CER apparently decreased during the hot, dry months, from August to October–December, and increased

again later in the rainy season, but this was not evident from trials in the CER. However, variations in survival during successive months (*e.g.*, February to May) in the CER indicated differences between the batches of flies. Seasonal variations in the survival of tsetse populations were indicated also by catches made off bait oxen, and these showed an association between a decline in numbers caught during October and high daily temperatures (Dean, Paget & Wilson, in press). Buxton (1955), Dean, Wilson & Wortham (1968) and Dean & Wortham (1969) reported that ' wild ' puparia were less viable in hot dry months than in cool months and that the quality of puparia collected varied in successive weeks. Measurements of the size of adult flies (Jack, 1939; Phelps, unpublished) and weights of puparia collected in the field (Dame, unpublished) showed that the average size of the fly decreased during the dry season.

Reproduction of ' wild ' flies held in standard cages under variable and constant climatic conditions

Four standard cages each containing 25 pairs of male and female tsetse flies caught from the bush were set up under both ambient and constant climatic conditions. Table V summarises the reproduction obtained from the parental and filial generations over a seven-month period between March and September

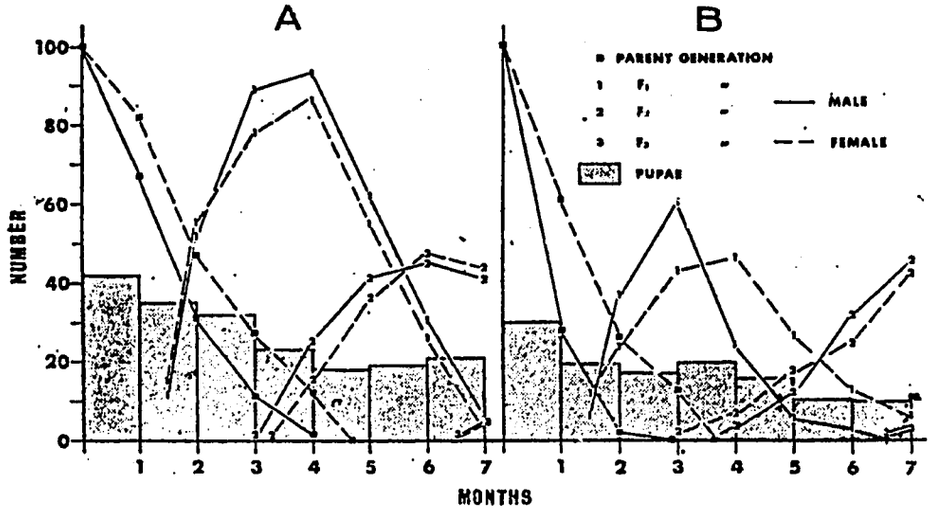

Fig. 2.—Numbers of males and females of *G. morsitans* in each generation, and mean weekly production of puparia, during the seven months when colonies were held in standard cages under ambient (A) and constant (B) climatic conditions.

1967. The colony under ambient conditions produced larger numbers of puparia in each of the four generations, but a smaller percentage of puparia above 25 mg. However, mean puparial weights, the mean number of puparia per surviving female fly per week and the percentage of viable puparia were generally similar under the two climatic conditions. The quantity and quality of reproduction tended to decrease in each succeeding generation in both colonies.

Survival and reproduction during the seven-month period is shown in fig. 2. The parental generation exposed to a variable climatic regime had a relatively slow mortality rate and lived for 18 weeks compared with 14 weeks for the flies

TABLE V. *Reproduction from colonies of* G. morsitans *held in standard cages under ambient and constant climatic conditions between March and September 1967*

Climate	Generation	Initial no. of adult flies		Maximum longevity (weeks)		Total no. of puparia	Mean no. of puparia/surviving female/week	Mean no. of puparia/week	Mean puparial wt. (mg.)	Range of puparial wt. (mg.)	Per cent. puparia above 25 mg.	Per cent. eclosion
		♂	♀	♂	♀							
Ambient climate	Parental	100	100	16	18	392	0·46	23·1	24·9	14·0–34·4	49·6	90·8
	F_1	193	163	25	23	261	0·25	11·9	22·8	11·7–31·5	26·5	86·2
	F_2 (a)	115	110	19	18	127	0·22	9·1	21·8	12·6–29·0	14·3	81·6
	F_3 (a)	24	23	5	5	5	0·18	1·0	31·5	11·4–27·6	—	—
	Total	432	396	—	—	785	—	—	—	—	—	—
	Mean	—	—	—	—	—	0·28	11·3	22·8	—	22·6	86·2
Constant climate	Parental	100	100	11	13	231	0·43	17·8	24·4	14·0–34·9	41·6	85·3
	F_1	110	87	21	25	239	0·44	10·9	23·5	13·5–31·6	32·4	91·1
	F_2 (a)	101	104	16	18	48	0·12	4·8	22·7	11·2–33·0	29·2	82·5
	F_3 (a)	24	21	5	4	2	0·14	0·5	21·6	—	50·0	—
	Total	335	312	—	—	520	—	—	—	—	—	—
	Mean	—	—	—	—	—	0·28	8·5	23·1	—	38·3	86·3

(a) Generation still in existence when trial ended.

held under constant conditions. The F_1 generation in both colonies appeared in the sixth week, and in the third and fourth month under variable conditions almost reached the original parental level when it was approximately twice as large as the F_1 generation in the CER. The F_2 generation appeared after the third month and increased more rapidly under variable than under constant conditions. The F_3 generation started to appear just before the trial ended. Under a variable climate the population did not fall below 50 per cent. of the original level until after the fifth month, whereas this level was reached before the second month in the CER. The total number of flies in the F_1 and F_2 generations was larger, and the P to F_2 generations lived longer, under a variable climate than in a constant climatic environment (Table V).

The mean number of puparia produced per week was somewhat higher throughout the seven-month period under variable climatic conditions. A mean of 1·98 puparia per female for all generations combined was obtained under ambient conditions compared with a mean of 1·67 puparia per female from the colony in the CER. The higher survival rate of the parental generation in the ambient colony was associated with the production of 3·9 puparia per original female, and a larger F_1 generation, compared with 2·3 puparia per female in the CER. The F_1 generation in both colonies had similar reproduction rates with 2·6 and 2·8 puparia per female, respectively. However, the F_2 generation under constant climatic control appeared at a slower rate than the F_2 generation outside, and produced F_3 puparia at a lower rate.

Buxton (1955) reviewed factors probably involved with the poor breeding success of tsetse in captivity and indicated that feeding was a major factor. Mellanby (1937) found a highly significant correlation between puparial weights and intake of blood, and considered that irregular feeds resulted in numerous abortions. In these two colonies, the flies were offered a host for 30 min. every day; this may have been sufficient for survival but not for the large blood meals required to produce heavy weight puparia. However, Nash, Jordan & Boyle (1966) obtained good survival and high reproduction rates with *G. austeni* fed on lop-eared rabbits, and considered this to be due to improved feeding.

TABLE VI. *Reproduction and maximum survival obtained from 25 premated females of* G. morsitans *held in Geigy 25's and Petana boxes in the constant environment room*

Cage type	Mean no. of female flies	Mean maximum longevity (days)	Mean no. of puparia	Mean puparial wt. (mg.)	Mean no. of puparia per female
Geigy 25	25 (25)	104 (69–114)	37·4 (1–65)	25·2 (18·0–27·2)	1·5 (0·1–3·2)
Petana box	49 (46–54)	98 (63–136)	22·8 (7–56)	24·7 (21·7–26·0)	0·5 (0·2–1·2)

Range of results given in brackets.
8 replicates.

Survival and reproduction of tsetse flies held in different types of small cage

Female flies caught from the bush were offered mature, male flies for 24 hr. in standard cages before they were placed into Geigy 25's and Petana boxes and exposed to constant climatic conditions. The number of puparia produced within a cage type varied considerably, but the female flies in the Geigy 25's exhibited a much higher mean reproduction rate that those in the larger Petana boxes (Table VI). Maximum longevity of the flies and mean puparial weights

tended to be similar for the two types of cage. The mean number of puparia per female was appreciably lower than the 2·3–3·9 obtained in the standard cages, but maximum longevity and mean puparial weights were similar.

Reproduction of tsetse flies in the large cage in the constant environment room

Maximum longevity of 'wild' males of *G. morsitans* in this large cage was poor but increased between January and April 1967 (Table III). Since female flies generally live longer than the male flies (Dean & Wortham, 1969) it was hoped that continually releasing flies into the cage would result in some females living long enough to reproduce, and that the resulting progeny might survive under these cage conditions. In this trial, a three-inch layer of sand was spread over the floor as a pupation site for the larvae. Over a 20-week period from

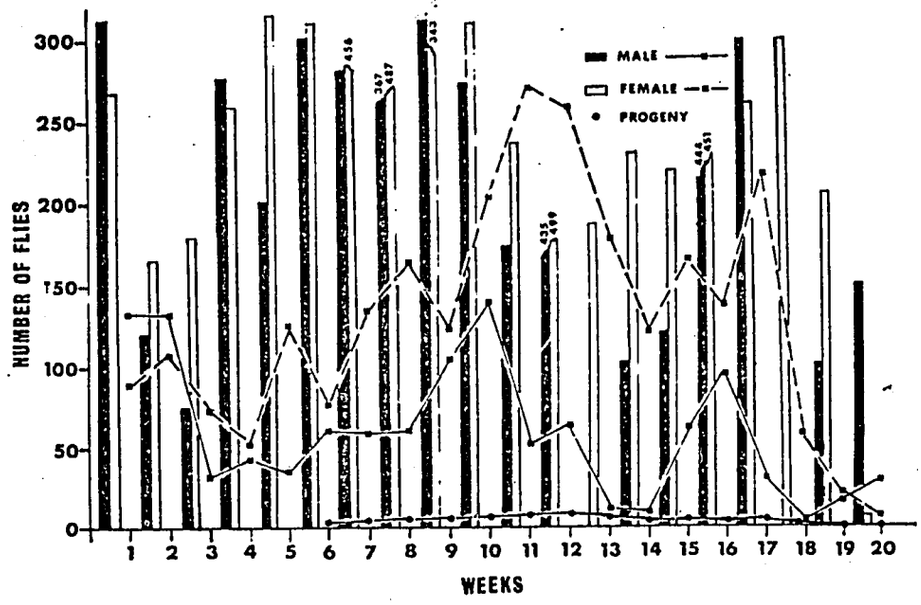

Fig. 3.—Numbers of males and females of *G. morsitans* released into the large cage in the constant environment room (histograms) related to numbers of adults and progeny surviving.

April to August 1967, 4,258 'wild' male flies and 6,524 females were released into the cage (fig. 3). The majority of the female flies used had emerged from Kariba puparia held under insectary conditions. They were premated with mature male flies for 24 hr. after becoming sexually mature three days after eclosion (Dame & Dean, unpublished).

Large differences between the numbers released into the cage each week and the number found alive during the weekly surveys indicated that survival was poor. A few puparia were found from the third week onwards in 8 × 12-in. sample trays immersed in the sand covering the floor. The first unmarked progeny were seen during the sixth week. Survival and reproduction remained at a very low level throughout the trial. The number of surviving parental flies decreased considerably from the 18th week onwards and no F_1 adults were found during this period.

Dissection and microscopic examination of spermathecae from female flies released at different times showed that insemination rates ranged between 12 and 100 per cent., with a mean of 82 per cent. The male flies recaptured each week were inspected for visible blood in the gut, and 30·4 per cent. (20–40 per cent.) had probably fed on the ox in the preceding day. Observations made during the feeding periods showed that many flies landed on the cotton mesh panel covering the ox and probed through it.

The results obtained in this trial indicated that insemination rates, though somewhat lower than those normally obtained in laboratory tests using standard cages (Dean & Wortham, 1969), were not entirely responsible for the poor reproduction. Failure to find regularly the host probably resulted in insufficient quantities of blood being ingested to prevent numerous abortions (Buxton, 1955). Temperature and humidity were unlikely to have been very important since the reproduction was much better in the smaller cages held in the same room (Table V). The importance of the photoperiod on reproduction is not fully known. Insemination is generally poor or absent in the dark (Dean & Clements, unpublished), but inspection of spermathecae showed that mating was not affected by a six-hour light cycle, and female tsetse will larviposit in the dark (Dean & Phelps, unpublished). Reproduction and survival were found to be poor also in the trials using quarter-acre cages enclosing the lower bush canopy at Chirundu (Phelps & Williamson, unpublished). However, preliminary laboratory trials in Salisbury have indicated that the type of climatic conditions and photoperiod may be important in tsetse breeding (Dame & Dean, unpublished).

Summary

Investigations into the survival and breeding of the tsetse fly *Glossina morsitans* Westw. in large and small cage volumes under insectary and ambient climatic conditions in the Zambezi valley, and using oxen as host animals, are described. Under ambient conditions, flies emerging from puparia collected at Kariba, and held in the insectary, survived longer than flies emerging from puparia collected at Chirundu. Flies caught from the bush did not live as long as flies emerging from puparia held in the insectary, and generally lived longer under variable than under constant climatic conditions. The survival of 'wild' flies decreased during the hot, dry months under ambient conditions. Flies lived longer and were more reproductive in small cages than in large cages. Reproduction in small cages was higher when the flies were exposed to a variable climate instead of controlled conditions, but two colonies of 'wild' flies declined under both climatic conditions. Reproduction was better in the small, standard cages (8 × 8 × 11 in.) than in Petana boxes, while Geigy 25's were intermediate in this respect, but survival and mean puparial weights tended to be similar. The results show a complete failure to breed *G. morsitans* in large cages.

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