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THE USE OF STERILE FEMALES FOR THE CONTROL OF THE TICK *ARGAS PERSICUS (OKEN)*[1]

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ABSTRACT

Females ***Argas persicus*** cease to lay eggs after exposure to 3 KR. Irradiation with 4 KR does not reduce their mating capacity and they mate 14 times on the average.

Flooding a population of ticks with 10 fold of sterile females increases the mating activity of the normal males. Males produce more than 50 spermatophores in the presence of multiple females, as compared to 12 — 14 spermatophores produced by males kept at 1 : 1 male/female ratio. The number of sperm produced by these males is, however, almost constant. Thus each spermatophore is smaller and contains less sperm. Due to the increased mating activity of the males in the presence of multiple females, the usefulness of sterile females for control of tick populations is doubtful.

INTRODUCTION

Irradiated males of the tick ***Argas persicus*** became aspermic following a mating activity of 2 — 3 weeks, _while normal males remain sexually active over a period of 15—20 weeks. Thus in this long-lived tick, irradiated males are competitive with normal ones only for a very short period of time (Sternberg ***et al.,*** 1972).

In view of the limited competitiveness of the males, the possibility of using sterile females for the control of ***Argas persicus*** was investigated.

The effect of sterile females on population control was mathematically analysed by Ailam and Galun (1967). Their calculations show that when the total number of available matings of the females is greater than that of the males, the rate of extinction of the population increases when the the number of sterile females increases. As the number of matings of the treated ***Argas*** males decreases drastically and assuming that the irradiated females still retain their mating capacity it may be preferable to use sterile females rather than males for the control of ***Argas persicus*** populations.

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MATERIALS AND METHODS

Rearing and irradiations of the ticks were the same as described by Sternberg et *al.* (1972).

For competition experiments 5 normal males and 5 normal marked females in an 8 cm diameter glass jar were used as a standard group. Fifty irradiated females were added to each jar. Four tick groups for each irradiation dose (4, 8, 12 KR) were kept in this state for 75 days. All the eggs laid in the jars were removed by means of an aspirator after 20, 30, 60 and 75 days respectively, counted and kept until hatching. At the end of the experiment, 10 irradiated females from each dose were dissected for spermiophore capsule counts. Number of capsules indicates the number of matings, as in *Argas* the endospermatophore does not invaginate into two capsules like in *Ornithodoros savigni* (Feldman - Muhsam, 1967).

Sperm counts were done in the following manner: A spermiphore capsule which was removed from a dissected female uterus was placed in a drop of 0.9% saline on a glass slide, the surface of which was divided into millimeter squares. The sperms were carefully eased out of their sac by means of a fine forceps and a drop of aqueous eosin was added to stain them. Counting was carried out in a binocular dissecting microscope using 500 fold magnification. In case of broken sperm, only heads were counted.

RESULTS AND DISCUSSION

Females treated with 3 KR or more did not lay eggs at all. Even at a dose of 2 KR, only 1 out of 20 females laid eggs which were almost all fertile eggs.

Table I

Effect of irradiation on fertility of *Argas persicus* females

	Dose			
	0	2 KR	3 KR	4 KR
Treated as adults				
No. of ♀ laying	20/20	1/20	0/20	0/20
% hatching	91	86	–	–
Treated as nymphs *12 days after feeding*				
No. of ♀ laying	13/14	0/13	0/12	0/5
% hatching	93	–	–	–

When the ticks were irradiated as nymphs, and then given a blood meal, none of them molted. However, when the nymphs were irradiated 12 days after the blood meal, i.e. very close to the completion of their molting process, some of them managed to molt, but still none laid eggs even at the low dose of 2 KR (Table I). Thus it seems to be more efficient to irradiate adult females.

An irradiation dose of 8 – 12 KR is required to achieve over 99% dominant lethals in the sperm of the male *A. persicus*. Therefore it was decided to test the effect of these doses on survival and mating potential of the females. If no ill effects following these doses would be observed, then males and females could be released together, and no separation between sexes would be necessary.

As seen from Table II, survival of the females is hardly affected by treatment of 4 KR, but a dose of 8 – 12 KR considerably reduces longevity. At 12 KR, longevity is less than half as compared with the control.

Table II

Survival of irradiated *Argas persicus* females

Dose	Days to 50% mortality	Days to 100% mortality
None	299	253
4 KR	284	499
8 KR	173	356
12 KR	123	251

Mating capacity of the females also seems to be dose-dependent (Table III). While females treated by 4 KR and exposed to 10 males in succession, contained on the average 14.5 spermiphore capsules, those receiving 12 KR containing only 10 capsules. This large number of matings performed by the treated females will outnumber the matings performed by the males when a natural population is flooded with sterile females. It is interesting that treated females contained more spermatophores than the controls. We think that this is due to the fact that oocytes do not develop in the irradiated females, and more room is left in the uterus for the spermiophore capsules. In normal bloodfed mated females, 10 capsules can hardly be squeezed in when the occytes are maturing.

Competitiveness of irradiated females with the normal ones is also considerably reduced at doses of 8 – 12 KR. When a population containing normal males and normal females was swamped by 10 fold of females irradiated with 4 KR and observed for 75 days, only 15% of the normal females were fertilized. When flooding was done with females treated with 8 – 12 KR, 70 – 80% of the normal females were fertilized (Table IV). The expected number of fertile eggs under such conditions was calculated according to the formula developed by Ailam and Galun (1967). When flooding is done by females receiving 4 KR, the number of fertile eggs obtained was almost the

same as those expected, while the number of fertile eggs from the groups competing with 8 – 12 KR–treated females was many fold higher (Table IV)– indicating the low competitiveness value of these irradiated females. As females exposed to 8 – 12 KR could mate 10 – 12 times when sufficient males are available (Table III), we had to assume that when both normal and treated females are available, the male prefers the normal ones. In order to verify this assumption, the irradiated females were dissected and the number of their spermiophore capsules determined. To our surprise 70 – 80% of the irradiated females were inseminated. The number of capsules in each female, exposed to 4 KR was very high, and much lower in the 12 KR treated females, while females from the 8 KR group gave an intermediate value (Table IV). The ratio between normal males and treated females was 1 to 10. Simple arithmetic based on the data given in Table IV shows that, on the average, each male produced more than 54 spermatophores during the 75 days of exposure to 10 4 KR irradiated females, while about 14 spermatophores were produced by males flooded with 12 KR –treated females. Males kept with untreated females at a ration of 1 : 1 normally produce 12 spermatophores during the 75 days (Sternberg *et al.*, 1972).

Table III

No. of spermiphore capsules found in normal and irradiated *Argas persicus* exposed to 10 males in succession

Dose	No. of capsules	Range
None*	9	
4 KR	14.5	7 – 19
8 KR	11.7	6 – 15
12 KR	10.0	5 – 14

* The females were exposed to all the 10 males simultaneously.

This observation leads to several conclusions:

4 KR–irradiated females are much more attractive to males than untreated females. Thus, while 90% of the irradiated females were inseminated, only 15% of the untreated ones laid eggs and presumably the rest were not inseminated. This may perhaps be related to the fact that irradiated females digest the blood meal much slower than untreated ticks (Galun and Warburg, 1968). Freshly fed females are much more attractive to males than females which have already digested the imbibed blood.

As can be seen in Table IV the number of fertile eggs produced by this group is very close to the calculated expected number. Calculations of the expected number were based on the mating rate found in populations having a male–female ratio of 1 : 1. If the highly increased mating capacity of the males is taken into account – a much higher number of fertile eggs should be expected. We therefore believe that the higher attractivity of the treated females could explain the low percentage of insemination in the untreated females.

As indicated by the percent of insemination (Table IV), 8–12 KR–treated females were not more attractive to males than the untreated ones; possibly they became lethargic due to the high radiation dose and then the excited males turned to the untreated females.

The mating activity of the males greatly increases when they are flooded by a large number of irradiated females. As males contain a limited amount of sperm, and the observed 4–5 fold increase in the number of matings was further investigated.

Table IV

Effect of flooding of normal population by 10 fold sterile females

Experiment lasted 75 days*			
	Irradiation Dose		
	4 KR	8 KR	12 KR
% fertilized normal females	15 (3/20)	80 (16/20)	60 (12/20)
% fertilized irradiated females	90	80	70
Average number of sperimophore capsules per treated female	5.3 (0-11)	2.4 (0-6)	1.4 (0-4)
Estimated No. of spermatophores produced by each male	>53	>24	>14
Expected number of fertile eggs **	241	239	235
Observed number of fertile eggs	296	1869	978

* Results are based on 4 groups each containing 5 normal ♀, 5 normal ♂ and 50 irradiated ♀.

** Calculated according to Ailam and Galun (1967).

Normal males were placed together with 4 KR–treated females of 1 : 1, 1 : 5 and 1 : 10 males to females. At the end of two weeks all the females were dissected for spermiophore capsules count. A sperm count from 10–20 capsules in each group was also carried out. Ten males and the appropriate number of females were used in each combination. Within this short period mating frequency of the male was enhanced in the presence of multiple females. Thus, while at a ratio of 1 : 1, a male produced on the average 4.3 spermatophores, at a ratio of 1 : 10, 8.2 spermatophores were produced (Table V), but the sphermatophores looked much smaller than those produced by the males of the first group. When the number of sperm in these

spermatophores was examined it was indeed found that the capsules from the males flooded with females, contained in this case about half the number of those found in the larger spermatophores produced by males kept at a 1 : 1 ratio. These findings indicate that sperm did not mature at a higher rate in males flooded with females. The sperm was, however, divided into smaller spermatophores and thus a larger number of females were inseminated (Table V). The nature of this change in the mating behavior of the male is now being investigated. The number of sperm per spermatophore was around 800 in the 1 : 1 ratio, this is a relatively small number and may not be enough to fertilize all the eggs laid by the female during her lifetime. Thus the fact that the female mates several times is important to ensure the high fertility of eggs found in this species. A similar low number of sperm is found in several insect species such as *Drosophila* (Lefevre and Johnson, 1962) and *Oncopeltus* (Gordon and Gordon, 1971) and indicates a very efficient method of sperm utilization.

The unexpected increase in *Argas* male sexual activity in the presence of multiple females casts a great doubt on the efficiency of sterile females for the control of this species.

Table V

No. of spermatophores and sperms produced by male *Argas persicus* when flooded with irradiated females (4 KR) during two weeks

	Flooding ratio ♂ : ♀		
	1 : 1	1 : 5	1 : 10
Av. No. of spermatophores/♂	4.3	7.7	8.2
% ♀ fertilization	100	54	36
Av. No. of females mated/♂	1	2.7	3.6
Av. No. of sperm./spermatophore	793	508	475
Total sperm. production/♂	3410	3910	3895

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