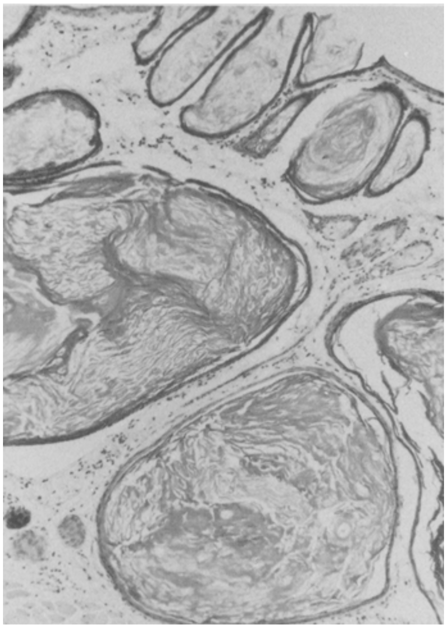
thickening or pigmentation of the skin. At 2 weeks of age, no hairs have erupted around the muffle. Because of the poor fertility of atrichosis females, the segregation data are derived mainly from intercross $+at \times +at$ matings and backross *atat* male $\times +at$ female matings. The intercross and backcross gave normal and atrichosis segregants in good agreement with the expected 1:3 and 1:1 ratio respectively. Thus, a single autosomal recessive gene was proved to be responsible for atrichosis, and the name 'atrichosis', symbol *at* has been adopted.



Multiple follicular cysts in the atrichosis rat. Hematoxylin-eosin stain. × 140.

Histopathology. Histopathological examination did not reveal any abnormality in the lymphoid organs. The thymus developed with Hassal's corpuscles in the medulla and abundant lymphocytes in the cortex. In the spleen, accumulations of lymphocytes were found in malpighian corpuscles with germinal centers. These results indicated morphologically the establishment of an immune system in the atrichosis rats. The mammary ducts, acini and twelve nipples developed normally.

The skin of the atrichosis rats was histologically characterized by multiple cysts with the features similar to those of human epidermal cysts and poorly developed hair follicles with cystic lumens and a lack of normal appearance of hair shafts (figure). The cells lining the cysts consisted of 2 or 3 layers of stratified, squamous epithelium. Concentric lamellar accumulations of keratin were found in the lumen. A stage intermediate between that of poorly developed hair follicles and cysts was frequently present. Sebaceous glands of normal appearance were found associated with cystic hair follicles. The results in the present investigation suggest that the cyst formation might be due to the abnormality of hair production in hair follicles, but the mechanism is not clarified, so further studies are necessary.

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Hybrid sterility in cattle ticks (Acari: Ixodidae)

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Summary. Male offspring resulting from interspecific crosses between the cattle ticks, *Boophilus annulatus* and *B. microplus*, are sterile. Hybrid females were found to produce sterile sons through 3 backcross generations.

Interspecific breeding between *Boophilus annulatus* (Say), the cattle tick, and *B. microplus* (Canestrini), the southern cattle tick, probably occurs naturally in northern Mexico[2]. In cross-mating experiments between these vectors of cattle tick fever, the 2 species intermated readily and fecundity of cross-fertilized females was not reduced[3]. Larvae and resulting adults appeared normal, but sibling crosses of these adults produced infertile egg masses. When these hybrids were backcrossed to pure strains of *B. annulatus* and *B. microplus*, sterility of the hybrid males (testes were either absent or vestigial) exceeded 99%, and fertility of the hybrid females was reduced, presumably because of chromosomal aberrations and mitotic disturbances[4].

Our purpose was to determine whether the hybrid sterility discovered by Graham and Price[2] could be maintained through successive generations thereby identifying it as a potential mechanism for control of *Boophilus* ticks. Pairings of hybrid males with hybrid females or with pure strain females resulted in egg masses with less than 1% hatch. We here show that hybrid females backcrossed to pure strain males through 3 generations produced viable egg masses, but male ticks resulting from these crosses continued to be sterile.

Boophilus annulatus and *B. microplus* were eradicated from the United States in an extensive cooperative Federal-State program that began in 1906 and was completed in 1960[5]. Since 1968, numerous reinfestations have occurred, the majority in the buffer zone along the Texas-Mexico border. These constant reintroductions, the need for environmental safety, and the rising cost of livestock production make the search for alternate methods of pest control and eradication essential. Therefore, it would be desirable if a biocontrol procedure such as the sterile male technique could be developed for use against *Boophilus* ticks.

Cross-mating experiments were conducted at the Cattle Fever Tick Laboratory in Falcon Heights, Texas. Laboratory-reared larvae of *Boophilus microplus* and *B. annulatus* were placed on isolated hosts and allowed to feed for 13 and 14 days, respectively. Replete nymphs were removed and held at 33 °C and 80% RH, with a 12-h photophase for 1-3 days until ecdysis occurred. After ecdysis, 20 *B. microplus* males were placed with 20 *B. annulatus* females (2 replicates) under nylon sleeves cemented to the backs of stanchioned bovine hosts. There were also 2 replicates of the reciprocal cross. The adult ticks were allowed to feed and mate, and replete females were collected and held in individual vials at 27 °C and 80% RH, with a 12-h photophase.

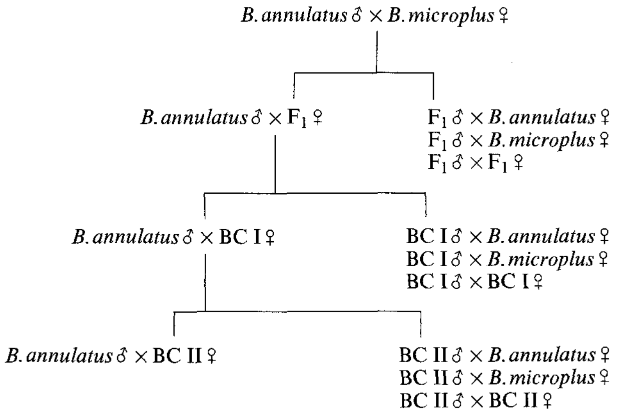

Fig. 1. Interspecific and backcrosses (BC) performed using *Boophilus annulatus* males.

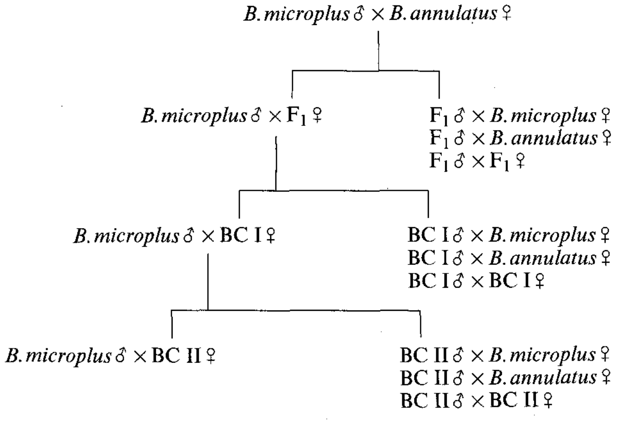

Fig. 2. Interspecific and backcrosses (BC) performed using *Boophilus microplus* males.

Percent hatch of intraspecific, interspecific, and backcrossed (BC I, II) hybrid *Boophilus* ticks*

Type of cross Male	Female	Percent hatch Mean	Range
B. annulatus ×	*B. annulatus***	70.5	0–98
B. microplus ×	*B. microplus***	82.2	0–98
B. annulatus ×	*B. microplus*	76.4	2–98
B. microplus ×	*B. annulatus*	90.3	5–98
B. annulatus ×	F_1^a	16.0	0–50
B. microplus ×	F_1^m	77.2	15–95
B. annulatus ×	BC I^a	29.4	0–98
B. microplus ×	BC I^m	38.0	0–95
B. annulatus ×	BC II^a	38.3	0–70
B. microplus ×	BC II^m	45.8	0–90

* Results from hybrid ♂ crosses omitted since in all cases less than 1% of eggs hatched. ** Pooled average of separate controls for each generation. ^{a} refers to crosses described in figure 1; ^{m} refers to crosses described in figure 2.

The percentage hatch of F_1 larvae was recorded, and crosses were performed as described in figures 1 and 2. For all interspecific crosses, engorged nymphs were removed and handled as previously described. For sibling and control crosses, ticks were left on the original hosts and allowed to feed and mate without interruption.

The following schedule of notations was formulated to facilitate understanding of resulting data: Offspring designated with a superscript "a" (i.e., F_1^a) result from crosses in which *B. annulatus* were used as the male parent (figure 1). Those identified by a superscript "m" (i.e., F_1^m) result from crosses in which *B. microplus* were used as the male parent (figure 2). Therefore, BCI^a refers to backcross offspring of *B. annulatus* ♂ × (*B. annulatus* ♂ × *B. microplus* ♀) ♀.

Boophilus annulatus and *B. microplus* mated readily, either intra- or interspecifically. In the initial interspecific crosses, egg masses producing F_1^a offspring had lower hatchability (76.4%) than masses producing F_1^m progeny (90.3%) (table). Pairings of F_1^a males with siblings (F_1^a females) and pure-strain females (figure 1) produced ticks that mated readily and engorged normally. However, fewer than 1% of the resulting eggs hatched, and the larvae were short-lived. F_1^a females backcrossed to *B. annulatus* males mated readily, but hatch of the ensuing egg masses was significantly reduced ($p = 0.01$) (table), though the resulting larvae were viable.

F_1^m females used in reciprocal crosses (figure 2) also failed to produce viable offspring when F_1^m males were the male parent. Backcrosses to the F_1^m females produced egg masses with reduced hatch (table). Larvae from these crosses (BCI^m) were viable (figure 2).

Crosses in which the BCI and BCII generations were used produced results similar to those obtained from the F_1 crosses. When hybrid males were paired with hybrid or pure-strain females, the hatch of the egg masses was never above 1%, and no larvae survived. Backcrosses of hybrid females to pure-strain males (figures 1 and 2) resulted in egg masses that appeared normal but had reduced hatch (table).

Boophilus annulatus and *B. microplus* are not known to occur sympatrically, except in limited regions of northern Mexico[3]. There, hybrids probably occur naturally, but the absence of distinct morphological markers makes it difficult to ascertain. Moreover, the tendency for the 2 species to occur as discrete units suggests that some natural isolating mechanism must operate. This hypothesis is supported by our findings that crossmatings spanning 3 generations have produced sterile males and females with reduced fecundity.

Hatchability of egg masses resulting from interspecific crosses was normal, but in subsequent crosses (F_1, BCI and BCII) hatchability was reduced (table). Because the subsequent crosses involved hybrid females, hybrid infertility is probably more pronounced.

The sustained infertility of the hybrid males may provide a mechanism that could be utilized in a control program. Certainly, the presence of this natural mechanism dictates that it should be explored further. Additional backcrosses coupled with competition and mating behavior studies are planned.

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