

ones. Glutamic acid, arginine and lysine are the only amino acids which do not increase in the diapausing pupae. The amino acids that increase greatly are glutamine, histidine, ornithine and alanine. The concentrations of these amino acids are at least double or triple those of non-diapausing pupae.

The great increase in the free amino acid pool of the haemolymph of the diapausing pupae of *Heliothis* is in general agreement with high aminoacidemia found in several diapause pupae⁴. Somme¹⁰ also reported high ninhydrin-positive compounds in diapause larvae and pupae of 2 Lepidoptera. Mansingh³ found that diapause was associated with enormous accumulation of certain amino acids which resulted in almost doubling of the free amino acid pool of the diapausing pupae of *Antheraea pernyi*. The termination of diapause and initiation of pharate adult development of *Heliothis* deplete the amounts of threonine, glutamine, glutamic acid, arginine, histidine, citrulline, ornithine and cystine. The total amount of haemolymph free amino acids varies greatly in the studied pupae. From a minimum level of 5084.3 μ moles/100 ml of haemolymph in non-diapausing pupae, the total concentration of the free amino acid pool increases to 7385.4 μ moles/100 ml of haemolymph in diapausing pupae and then decreases to 5987.3 μ moles/100 ml of haemolymph in pharate adults. Similar patterns of changes in the concentration of individual free amino acids and in the total content of free amino acids of haemolymph have been reported in diapausing and non-diapausing forms of *Antheraea pernyi*³ and during pupal development of some insects^{9,11,12}. Amino acid levels can also be affected by changes in the levels of other substances such as carbohydrates and their metabolic intermediates and derivatives, which also change during metamorphosis^{10,13}. Glucose and its metabolic intermediates can provide the carbon skeleton for the synthesis of amino acids in insects¹⁴. The presence of both ornithine and citrulline in *Heliothis armigera* haemolymph suggests the possible existence of an ornithine \rightarrow citrulline path in this species. However, there is little evidence for such a pathway or for a complete ornithine cycle in insects^{15,16}. The varia-

tion in glutamine concentration in *Heliothis* pupae agrees with that obtained with *Antheraea*³ and may reflect the role of this amino acid in nitrogen transport during pupal-adult transformation. The histidine concentration which is the highest in diapausing *Heliothis* pupae decreases to almost half in pharate adults. This supports the finding of Mansingh³ that histidine concentration which was almost unaffected during the metamorphosis of the non-diapausing forms of *Antheraea* increased throughout diapause then depleted to almost half in pharate adults. The results of the present study suggest pronounced changes in the concentration of free amino acids in the haemolymph of the diapausing pupae as compared with the non-diapausing ones. This difference suggests that amino acids are involved in diapause physiology perhaps with respect to energy production.

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'Atrichosis', a new hairless gene with cyst formation in rats

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Summary. A new hairless gene in the Donryu strain of the rat has been designated atrichosis (*at*). Histological sections demonstrated that atrichotic skin was quite similar to that found in human skin with multiple follicular cysts, which is one type of skin tumor in humans.

Hypotrichosis is known to be a heritable trait. 5 genes in rats, designated hairless (*hr*), naked (*n*), fuzzy (*fz*), hypotrichosis (*hy*) and nude (*nu*), have been shown to influence hair follicle development¹⁻⁵. A new hypotrichosis gene of rats which is reported here causes multiple follicular cyst; this gene may provide more meaningful data for studies of impaired hair growth.

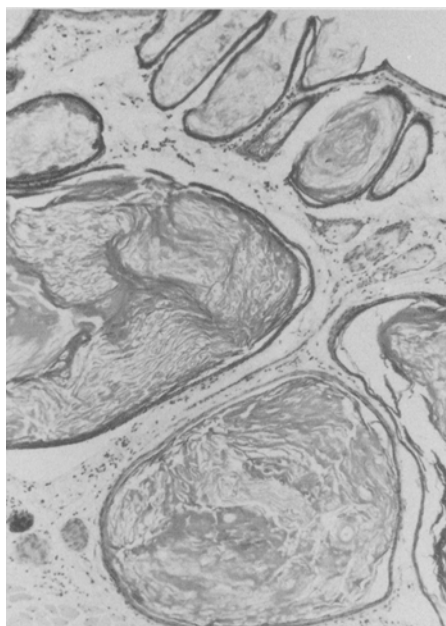
Genetics. The hypotrichosis mutant was found at Ehime University School of Medicine. The mutation arose in a closed but not deliberately inbred stock of the Donryu strain. 2 hairless animals, females, appeared in the stock, together with 19 phenotypically normal animals, 7 males and 12 females. The original hypotrichosis females died without producing offspring. The normal-coated pair were

mated and 6 matings produced hypotrichosis animals. In this way 9 heterozygous animals, 3 males and 6 females, were identified and they formed the basis of the atrichosis stock. The segregation of atrichosis from intercross and backcross matings is presented in the table. Atrichosis rats cannot be classified at birth and there is no delay in the

Segregation of atrichosis

Type of mating	No. of matings	Phenotype of progeny			χ^2	<i>p</i>
		+	<i>at</i>	Total		
+ <i>at</i> ♂ × + <i>at</i> ♀	20	129	49	178	0.0635	0.80
<i>atat</i> ♂ × + <i>at</i> ♀	16	68	78	146	0.0613	0.80

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 backcross $atat$ 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 respec-



Multiple follicular cysts in the atrichosis rat. Hematoxylin-eosin stain. $\times 140$.

tively. Thus, a single autosomal recessive gene was proved to be responsible for atrichosis, and the name 'atrachosis', symbol *at* has been adopted.

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 Mexico². In cross-mating experiments between these vectors of cattle tick fever, the 2 species intermated readily and fecundity of cross-fertilized females was not reduced³. 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 disturbances⁴.

Our purpose was to determine whether the hybrid sterility discovered by Graham and Price² 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 1960⁵. 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