TRIBOLIUM

Information Bulletin

10

March 1967

MATERIAL CONTRIBUTED BY WORKERS ON TRIBOLIUM
AND OTHER COLEOPTERA

DEPARTMENT OF GENETICS, UNIVERSITY OF CALIFORNIA
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TRIBOLIUM INFORMATION BULLETIN

Number 10

(Issued in 350 copies)

Editor: A. Sokoloff, Department of Genetics,
University of California, Berkeley, California

1967

NOTE

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This volume of the Tribolium Information Bulletin is dedicated to my friend and colleague, Professor I. Michael Lerner, who suggested the creation of this informal means of exchange of information at a meeting during the Tenth International Genetics Congress in Montreal, August 25, 1958.

TRIBOLIUM INFORMATION BULLETIN

Number 10

March, 1967

Notes - Research (continued)

Notes - Research (continued)

FOREWORD

The present issue of TIB is about the same size as TIB-9 despite the omission of the bibliography (explained elsewhere).

Thanks to a special leave of absence from the California State College, San Bernardino, California, it was possible to return to Berkeley earlier than last year and participate more actively in preparing this volume. Mrs. Mary Jo Rawlins typed the whole issue of TIB-10 and Mrs. Naomi Troth helped proofread it. Mesdames Barbara Daly and Beverly Heinze compiled the stock list and contributed some line drawings. The able assistance of all these persons is gratefully acknowledged.

The publication of TIB-10 was made possible by USPHS grant GM-08942.

A. SOKOLOFF

Berkeley, California
March, 1967

EDITOR'S RANDOM NOTES

Dr. Pushkar Nath Bhat, Associate Professor in the Department of Genetics, Punjab Agricultural University, Hissar (Harayana), India, writes:

"You will be pleased to know that we have established a laboratory devoted to research on Tribolium genetics with a generous grant from the Indian Council of Agricultural Research and PAU research facilities. There are six graduate students with me who have taken up work on various aspects of Tribolium genetics. I am enclosing a list of stocks which we would like to have from your laboratory at Berkeley. . . . We are hoping to develop our centre as a stock centre for Asia."

The editor sends Dr. Bhat and his group his best wishes for success in this undertaking.

* * * *

Dr. L. P. Lefkovitch of the Pest Infestation Laboratory, London Road, Slough, Bucks writes:

"1. After 31st March 1967 my address will be:

Canada Department of Agriculture
Research Branch
Statistical Research Service
Central Experimental Farm
K.W. Neatby Building
Ottawa, Canada

Papers submitted to J. Stored Prod. Res. from N. and S. America can be sent to me at that address from May 1st 1967.

"2. We can supply very limited quantities of larvae of Lasioderma serricorne which, at the time of writing, have been subjected to brother/sister mating for 17 generations at 30°C, 60% r.h. (two distinct lines) and for 11 generations at 25°C, 70% r.h. (also two distinct lines). Anyone requesting this material, after verifying that they can import it, should write to Miss J. E. Currie at P.I.L."

* * * *

Dr. Howard E. Erdman, presently on leave from Battelle-Northwest, Richland, Washington, to the Insect Eradication and Pest Control Section of the Saint FAO/IAEA Division of Atomic Energy in Agriculture (International Atomic Energy Agency--Food and Agriculture Organization of the

United Nations) in Vienna, Austria, informs me that his section publishes an information circular on radiation techniques and their application to insect pests. The Agency publishes Bibliographical Series on Radioisotopes and Ionizing Radiation in Entomology. No. 9 covered 1950-1960; No. 15 covered 1961-1963; and in press is an issue covering 1964-1965. These series are of great value because of their outstanding coverage and comprehensiveness.

* * * *

The tenth issue of the Tribolium Information Bulletin differs from previous ones in one important respect: its size is comparable to previous issues and yet it includes no bibliographic section. The reason this has been omitted is to publish all the research notes received and yet keep within the budget.

This will be the last issue under the present USPHS grant, and on the basis of general world conditions, it may be the last of its existence. The editor has applied for a grant to transfer the Tribolium Stock Center to San Bernardino. If support for the stock center is obtained, then the publication of the bulletin is assured since provisions have been made for inclusion of TIB among the activities of the stock center. If the grant is denied, it is hoped that some colleague will be able to take over where this editor left off.

It is clear that such "Newsletters," although not official publications, serve a need, and even though a number of Tribolium investigators have failed to submit research notes time and again, others have finally realized the value of using TIB as a means of exchanging information. A look at the two sections which are of informative value, the section on new mutants and the section on research, technical and teaching notes (as well as the size of the issue) summarized in the accompanying table reveals the growth of TIB in these 10 years.

Numbers of pages dealing with descriptions of mutants and research, technical and teaching notes and the total number of pages in various issues of TIB.*

Vol. No.	New Mutant Section	Research Teaching Technical	Total No. of Pages
1**	0	0	5
2	0	5	39
3	4	12	51
4	5	18	171
5	7	29	95
6	10	41	136
7	13	50	159

Vol. No.	New Mutant Section	Research Teaching Technical	Total No. of Pages
8	26	105	257
9	14	60	218
10	21	110	227

* Sections on stock lists, bibliography, geographical and alphabetical directory have not been included.

** The first issue was only a formal announcement of the establishment of TIB.

* * * *

The illustrations on the front cover are of an alate prothorax (apt) Tribolium confusum mutant (described elsewhere in this issue of the Bulletin). Two things are remarkable about these illustrations. First, we have here a sex-linked recessive homeotic mutant which forms an extra pair of wings from the prothorax. A similar mutation, behaving as an autosomal recessive and believed to be homologous, was reported last year for Tribolium castaneum. Handlirsch (1919) had reported a three-pair wing condition, one pair of wings in each thoracic segment in Paleodictyoptera. Herskowitz (1949. Genetics 34:10) had reported Hexaptera in D. melanogaster. Ross (1964. Amer. Midland Nat. 71:161) reported a Pro-wing mutation in Blatella germanica. Therefore, it is not really surprising that beetles have produced similar types through mutation.

The specimen shown in the illustrations is not a very strong expression of the mutant. When strongly expressed, the prothoracic wings are more elytra-like than membranous wing-like, and they curve ventro-caudally ending between the coxae of the first and second pair of legs.

The other remarkable feature of the illustrations is that they were obtained with the scanning electron microscope developed in Berkeley by Dr. R. F. W. Pease and kindly used in behalf of the editor to obtain these illustrations. An article describing the principle of this instrument and micrographs illustrating the potentialities of the instrument will be found in the Research Note section of this issue. The scanning electron microscope was first developed in Cambridge. This model and one developed by the Japanese are now available commercially, but they cost about $50,000. The one in Berkeley is the only one available at present on the West Coast, and its availability is, therefore, limited. It is indeed fortunate that Dr. Thomas L. Hayes, familiar with Tribolium confusum, was able to suggest this organism for examination with the scanning electron microscope. As readers of the Pease et al. article in Science (Dec. 1966) know, the beetles are introduced into the chamber of the microscope which is then evacuated. This treatment apparently merely "anaesthetizes" the beetles. Provided they are taken out before 30 minutes elapse, all stages of development of the beetle survive the vacuum and the electron beam!

* * * *

The following letter from the Canada Department of Agriculture, Production and Marketing Branch, Ottawa, dated February 17, 1967, is reproduced here for the benefit of those concerned. (Ed.)

Dear Sirs:

The Plant Protection Division of the Canada Department of Agriculture is charged with the responsibility of preventing the introduction or admission into Canada, or the spreading within or the shipment to other countries, of insects and plant diseases destructive to vegetation.

To prevent, in so far as possible, the introduction of insects and disease organisms, a regulation under the Destructive Insect and Pest Act stipulates that importations of this nature may be permitted for scientific or educational purposes only. Prospective importers are required to submit an application for an import permit to the Director, Plant Protection Division, Department of Agriculture, Ottawa, for each importation, stating the purpose of the importation, the name and address of the supplier, and the scientific names of the pests or diseases required. If the application is approved by specialists of the Research Branch, a permit is issued and sent to the importer. It is his responsibility to advise the supplier of the permit number and forward official mailing labels to be affixed to the shipping containers to route them through an established port of importation to expedite clearance through Canada Customs.

It would appear that certain institutions and school boards are unaware of the requirements and, on a number of occasions, shipments of insects and disease cultures have arrived for which permits have not been issued and deliveries have been delayed.

It is suggested that when orders are received from Canadian sources, for which no permits have obviously been issued, that the orders be held and the customers advised to procure permits and mailing labels from the address given above.

Your cooperation in this regard will be very much appreciated.

Yours very truly,

/s/ L. L. REED for

D. S. MacLachlan
Acting Director
Plant Protection Division

ANNOUNCEMENTS

The Nigerian Stored Products Research Institute is a government organization charged with the responsibility for organizing research into problems of preservation and storage of agricultural products in the country, with particular reference to export commodities. Its staff includes entomologists, chemists and other technical personnel operating from four centers in Nigeria. The Lagos Laboratory serves as headquarters while the other laboratories are located in Port Harcourt (Eastern Nigeria), Ibadan (Western Nigeria) and Kano (Northern Nigeria).

The main export commodities covered include cocoa, palm produce, groundnuts, soya beans, benniseed, and cotton seed. All aspects of infestation and control are studied, and recommendations issued to interested bodies.

Dr. A. K. Onyearu

* * * *

Dr. A. E. Bell, Population Genetics Institute, Purdue University, Lafayette, Indiana, has deposited with the Tribolium Stock Center the following mutants:

1. bowleg (bl)--reported in TIB, 1964.
2. dented (d)--reported in TIB, 1964.
3. urogomphiless (u)--reported in TIB, 1964.
4. bead (bd)--reported in TIB, 1965.
5. miniature appendaged (maD)--reported in the present issue of TIB (allelic with ma and similar in phenotype).
6. reduced elytra (re)--reported in TIB-10.
7. split back (sb)--reported in TIB-10.

These mutants are being unconditionally released in the hopes that someone may be interested in studying them further.

Editor

* * * *

Notices of Symposia

I.U.F.R.O. Working Group on Genetic Resistance to Forest Diseases and Insects.

This newly formed intersectional working group may be of interest. It will meet during the 1967 Congress of the International Union of Forest Research Organizations to be held in Munich, Germany, September 4 to 9.

Further information may be obtained from:

Professor H. D. Gerhold
Forestry Research Laboratory
Pennsylvania State University
University Park, Pennsylvania 16802
U.S.A.

Symposium on Population Biology.

This symposium is of international scope and will be held at Syracuse University from June 7 to 9, 1967. For further information, write to:

Symposium
Department of Zoology
108 Lyman Hall
Syracuse University
Syracuse, New York 13210
U.S.A.

The VIth International Biometric Conference will be held in Sydney over the period August 20 to 25, 1967.

The Food and Agriculture Organization of the United Nations and the International Atomic Energy Agency are arranging the following international meeting:

Symposium on the Use of Isotopes and Radiation in Entomology.

Topics include: Advances in the application of radiation and radioisotopes in various fields associated with entomology--genetics, ecology, physiology, and biochemistry.

Location:	Vienna, Austria
Date:	4-8 December 1967
Scientific Secretary:	Howard E. Erdman International Atomic Energy Agency Kärntnerring 11 Vienna A-1010, Austria

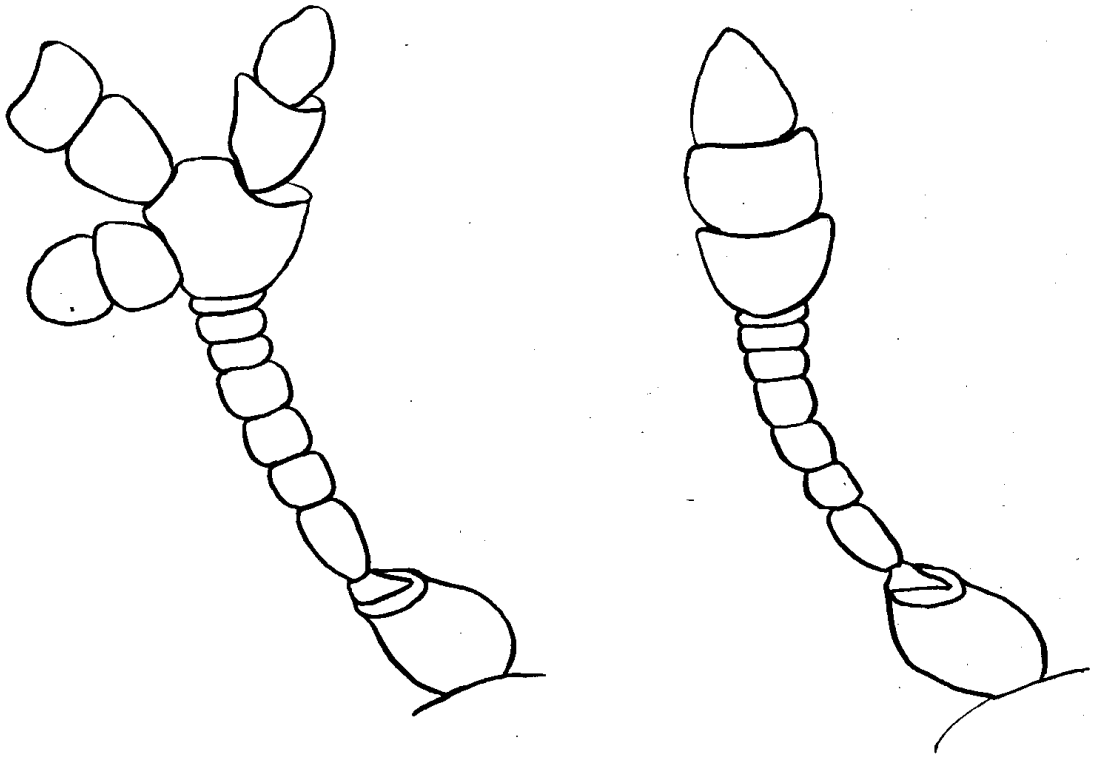
Papers and applications for participation should be submitted through normal official channels.

NEW MUTANTS

A. Dermestes maculatus (Dermestidae)

*REPORT OF D. D. SHAW

1. deformed antennae (def). A mutant reported in TIB 9:58, now proved to be controlled by an autosomal recessive gene of variable penetrance and giving apparently normal viability. The mutant is similar in appearance to the phenodeviant "branched" in Tribolium castaneum. Linkage tests with "rufous" and "fuscous" are being carried out.



Deformed antenna

Normal

2. fuscous (fu) (Mali). This mutant was isolated from a culture from Mali and is phenotypically similar to fuscous already described in TIB 8:42. Tests of allelism are under way.

3. Muddy. An eye-color mutant isolated from a culture of Indian origin. The eyes appear grey-brown compared with the normal brown-

black. Genetics not yet studied.

4. Sexpitless. Originated in a single male offspring from a "rufous" × "white tip" cross. The male has no sex-pit. Genetics not yet studied.

5. White tip (Wt). This mutant was described in TIB 9 and has proved to be controlled by a dominant gene giving normal viability. The mutant is phenotypically similar to that described by Philip (1940) which was controlled by an autosomal recessive gene. Linkage tests with rufous and fuscous are being carried out.

B. Tribolium castaneum (Tenebrionidae)

*REPORT OF CONSTANTINO, DITTMAR, HANCOCK, LANGE AND SHIDELER.

1. corn oil sensitive (cos)--Costantino, 1964. An autosomal recessive gene identified during an investigation of the genetic basis of selection response for small 13-day larval weight in a population of Tribolium castaneum. A preliminary report on this gene was given by Costantino, Bell, and Rogler (Nature 210:221, 1966). The properties of the cos gene are as follows:

   a. Larval growth of the cos homozygote, as measured by 13-day larval weight, varies inversely to the concentration of corn oil in the diet.

   b. Viability also varies inversely to the concentration of corn oil in the diet (83% viable, at 13 days, in the diet with no supplemental corn oil decreasing to 51% in the diet with 5% corn oil).

   c. The degree of dominance, with respect to 13-day larval weight when grcwn in a diet with 5% corn oil, is essentially complete.

   d. Gas-liquid chromatographic analyses of normal (+/+) and sensitive (cos/cos) individuals grown on diets with and without supplemental corn oil suggest that excessive quantities of linoleic acid in the cos homozygote may be the basis for the observed sensitivity to corn oil.

   Linkage studies and further biochemical analyses are presently underway.

2. grossly deformed (gdf)--Lange, 1965. Autosomal recessive of good expression isolated from Purdue Foundation. The pupae have the following appearance:

   a. Elytra shortened and barely extending to the abdomen.

   b. Tibia is narrower in width and curved in a manner similar to bowleg.

c. Urogomphi are reduced in size.

d. Genital lobes are absent.

e. Eyes are similar to squint or bar eye.

f. Club of the antennae is fused.

g. Gin traps are reduced in size.

h. Setae are reduced to a large but variable amount.

The adults have the following appearance:

a. Elytra shortened and cover about half of the abdomen.

b. Flight wings normal.

c. Tibia has a form similar to bowleg.

d. Eyes appear similar to squint but some facets are present.

e. Antennal club is fused with a variable number of stalk segments, with generally the first five segments of the stalk unfused.

The homozygous recessive is lethal in the adult stage probably because of desiccation brought about by the reduced elytra. It is not allelic to squint and is not linked to Bar eye. Further linkage studies are in progress.

3. bumpy (by)--Hancock. Autosomal recessive found in sub-population of Purdue + Foundation, has variable expression and incomplete penetrance, similar in phenotype to Sokoloff's ble, yields 3% recombination with Sa. Bumpy is being forwarded to Sokoloff's laboratory for allelism tests with ble.

4. miniature appendaged (ma^D)--Dittmar. Spontaneous sex-linked recessive found in a multiple recombination study, allelic to Sokoloff's ma and similar in expression.

5. Multi-urogomphi (Mu)--Dittmar. Autosomal dominant found in Purdue b Foundation, incomplete penetrance with expression varied giving one or two additional urogomphi in larvae and pupae. Preliminary recombination studies for Mu suggest independence of linkage groups 2, 3, 4, 5, 7 and 8. Similar in expression to eu described by Lasley and Sokoloff in TIB 3 and has been forwarded to that laboratory for further comparisons.

6. reduced elytra (re)--Shideler. Autosomal recessive of reduced viability found in sub-population of the Purdue black Foundation,

incomplete penetrance and variable expression, elytra are severely reduced and sometimes missing.

7. split-back (sb)--Shideler. Autosomal recessive found in a subpopulation of the Purdue pearl Foundation, has expression varying from shortened elytra to severe splitting or diverging of elytra. Similar in phenotype to the description of short elytra (Ho and Dawson, $sh^{H \& D}$, Sokoloff, sh^{S}, TIB 1962) and has been forwarded to them for tests of allelism.

*REPORT OF R. W. LEMON AND D. G. BLACKMAN

1. mahogany (my). Autosomal recessive (TIB 9:59), not allelic with black or sooty. Linked with sooty and Bar eye in linkage Group IV (cross over values of 43% and 21.5% respectively). Results of three point crosses not yet known.

2. pearl-like (TIB 9:59). Linkage tests for groups III, IV, V, VII and X proved negative. Crosses with ptl in group IX were inconclusive due to incomplete penetrance of ptl. The tests with Mo in group VI showed possible linkage, but difficulty in classifying Mo beetles made it necessary to repeat the tests which are not yet concluded. However, a very recent cross between "pearl-like" and "ivory" produced an F_1 all mutant beetles; it is therefore possible that "pearl-like" is a reoccurrence of "ivory."

*REPORT OF A. SOKOLOFF

1. Charcoal (Chr)--Ackermann, 1966. Found during the course of determining whether "prothoracic margin irregular," an abnormality involving the anterior margin of the prothorax was heritable (it was probably a phenodeviant). Autosomal dominant with recessive lethal effects. Charcoal beetles resemble tawny and sooty. No synthetic lethal effect has been observed with Spa, Be, Fta and Bamp.

2. diminutive appendages (dim)--Heinze, 1966. Spontaneous in a stock of Bamp. An autosomal recessive with good penetrance and fairly good viability. The elytra are very short, exposing two or three abdominal segments. The membranous wings fail to fold and protrude beyond the elytral tips. Many adults display a split of the abbreviated elytra, beginning about one-third of the length of the elytra from the scutellum. The legs are also much shorter than normal but maintain proper proportions as in miniature appendaged (see figure below). The mutant can readily be identified in the pupa stage by the short elytra which do not completely cover the membranous wings (as in the normal) and the legs are noticeably shorter. A more careful examination reveals fusions of antenna- and tarsomeres. These are summarized in Tables 1 and 2. This mutant is not allelic with ov or aa.

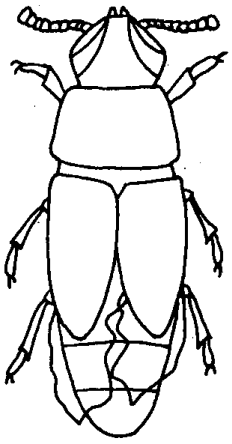


Table 1. Antennal fusions in dim. (15 beetles of each sex scored)

	Males		Females	
	Right	Left	Right	Left
0	11	4	5	7
4-5	4	3	4	2
6-7	--	--	1	--
6-7-8	--	1	--	--
7-8	--	--	2	1
7-8-9	--	--	--	1
8-9	1	1	4	3
8-11	--	--	--	1
10-11	--	--	--	1

Table 2. Number of tarsal segments involved in fusions or missing in dim. (15 beetles of each sex scored)

		Pair of Legs													
		1st pair					2nd pair					3rd pair			
		0	1	2	3	4	0	1	2	3	4	0	1	2	3
Females	Right	5	1	7	1	1	7	4	2	3	-	5	3	7	-
	Left	5	3	4	2	1	5	4	4	1	-	5	6	3	1
Males	Right	8	0	6	2	-	6	1	7	1	-	8	2	5	-
	Left	8	2	3	1	1	11	3	2	-	-	8	1	5	1

3. fused antennal segments-3b (fas-3b)--Heinze, 1966. Spontaneous, in a population of black and pearl scored for these genes for many generations in studies of natural selection. (Originally called "aggregate antennae" but found to be allelic with fas-3, therefore renamed.) Incompletely recessive, with fusions of antennameres as shown in the accompanying table. It may be noted that male antennae exhibit more fusions of the club. Female antennae show more fusions involving both funicular and club segments. Also, male antennae exhibit more fusions which involve fewer segments, while the fusions in female antennae are more extensive (involving more segments).

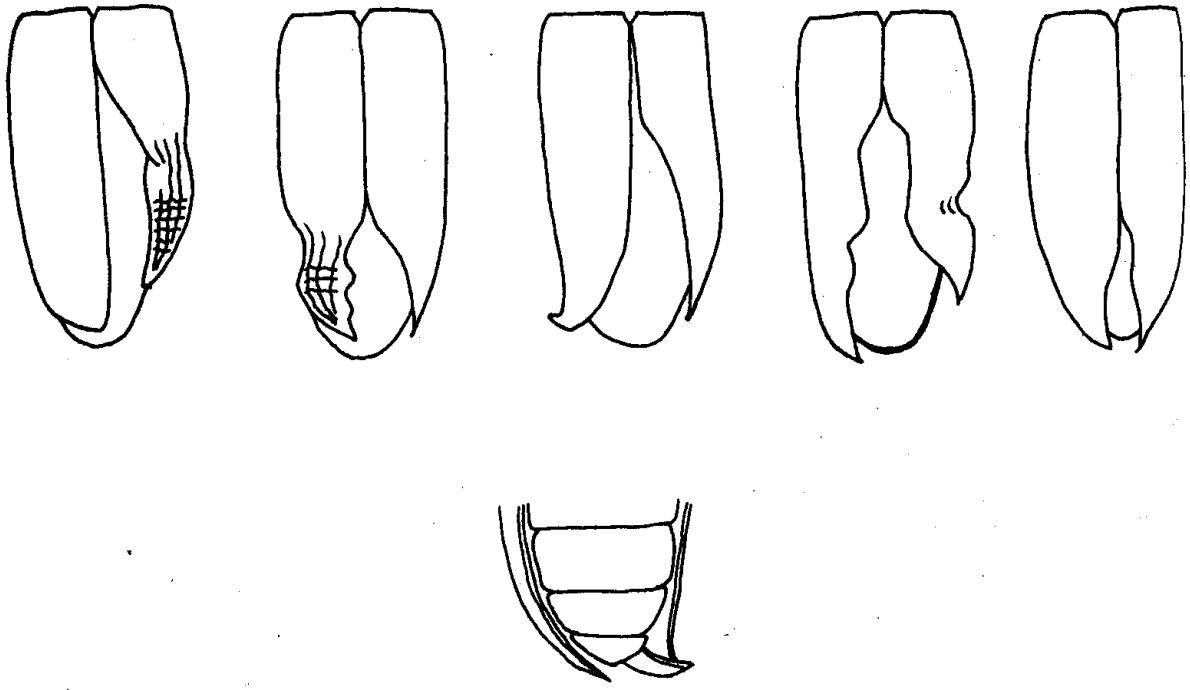
4. knobby prothorax (knp)--Sokoloff, 1966. Spontaneous in a stock of Mo mas. Possibly a phenodeviant, but more likely autosomal recessive of incomplete penetrance. Penetrance is greater when knp females rather than males are used in backcrosses, and greater in backcrosses in general than in $F_1 \times F_1$ crosses (expression in the latter being very weak) characterized by the fact that the prothorax has more or less symmetrical "knobs" extending lateroposteriorly. These are as large as 1/4-1/3 the length of the prothorax. The prothoracic margin continues around the knobs, but many of these have a "suture" more or less continuous with the posterior margin of the prothorax. The dorsal part of the knob is punctate like the prothorax but the ventral part may be sclerotized. This mutation is similar to knp in T. confusum. (TIB 9:62, see illustration on front cover, TIB 9)

5. overhung split (ohs)--Heinze, 1966. Common in au stocks, but does not appear to be linked to au. Its appearance is like that shown

Table 3. Segments involved in fusions in the fas-3b mutant (50 males and 50 females scored)

	Males		Females	
	Right	Left	Right	Left
0	9	7	7	6
4-5	--	--	1	1
4-6	--	--	1	1
4-8	--	1	--	--
4-10	--	--	--	1
4-11	--	1	1	3
5-6	3	4	3	2
5-7	--	--	1	1
5-8	1	1	--	--
5-9	1	--	--	--
5-11	2	3	3	1
6-7	1	5	1	5
6-8	3	--	3	2
6-9	1	2	1	--
6-10	--	--	--	1
6-11	5	4	6	8
7-8	3	3	2	2
7-9	1	--	1	--
7-11	2	3	5	3
8-9	5	2	4	4
8-11	--	1	2	2
9-10	1	3	1	3
9-11	4	7	4	6
10-11	13	13	11	5

in the figure below, with the elytra longer than the abdomen and exhibiting a pronounced split and sometimes tips curling down. Some may extend beyond the abdomen without splitting. Not allelic with we, spl, te, dve, bal, or cye. Probably a recessive with poor penetrance.



6. prothoracic margin irregular (pmi)--Hoy, 1965. Spontaneous in a population started two years previously with 12 Kr irradiated male mated with a non-irradiated female. The anterior ventral margin of the prothorax appears as in the figure on page 77. A phenodeviant. From a cross of two pmi beetles only 2/578 were pmi.

7. red-2 (r-2)--Heinze, 1966. One adult was found in a test cross between au s and Be which had chestnut-colored eyes; this male was mated to produce offspring with pale eyes as young beetles, and darker red eyes as older adults. An allelism test with red showed the mutation to be its allele; mode of inheritance tests showed it to also be an x-linked recessive gene, as is red.

8. reduced tarsi and antennae (rta)--Heinze, 1966. In a "scalloped prothorax" stock (initially derived from an irradiation experiment which had been performed several years before) were found 10 adults and two pupae with antennae and legs reduced in segment number.

Table 4 shows the antennameres, Table 5 the tarsomeres involved in fusions and Table 6 the total number of tarsomeres seen in those legs with no apparent fusions but with 0-5 tarsomeres.

It is evident that the modal number of fusions is in antennameres 4-5, but also there appears to be a sex-difference, males having the club segments affected while that in females does not exhibit fusions. The tarsomeres were reduced to 1-2 per leg in most cases, some legs having no tarsomeres at all. The mutation is readily identifiable in the pupa stage, the legs appearing noticeably shorter than normal, as in Fta (see Plate 5, H, I, J in Sokoloff, 1966). Preliminary crosses suggest an autosomal recessive mode of inheritance.

Table 4. Antennal fusions found in a sample of "reduced tarsi and antennae" (rta) in T. castaneum (N = 21 females and 21 males)

	Males		Females	
	Right	Left	Right	Left
0	11	12	11	13
2-3	--	--	--	1
3-5	--	--	--	1
4-5	8	6	9	5
5-6	--	2	1	--
6-7	1	--	--	--
7-8	--	1	--	1
9-10	4	2	--	--
10-11	1	1	--	--

Table 5. Tarsomeres involved in fusions in "reduced tarsi and antennae" (rta) in T. castaneum (N = 21 females and 21 males)

		Pair of Legs					
		1st pair		2nd pair		3rd pair	
		0	1	0	1	0	1
Males	Right	20	1	19	2	21	-
	Left	16	5	21	-	20	1
Females	Right	20	1	20	1	21	-
	Left	21	-	21	-	20	1

Table 6. Total number of segments observed in the tarsi of "reduced tarsi and antennae" (rta) in T. castaneum (N = 21 beetles of each sex)

		Leg and Tarsus Number														
		1						2						3		
		0	1	2	3	4	5	0	1	2	3	4	5	0	1	2	3	4
Male	Right	3	4	1	0	1	12	-	2	3	-	-	16	1	1	4	-	15
	Left	4	3	0	1	0	3	-	6	1	-	-	14	-	4	3	-	14
Female	Right	2	4	-	-	3	12	-	2	1	-	-	18	1	7	2	1	10
	Left	3	3	1	-	-	14	-	3	1	-	1	16	2	8	2	-	9

9. rugose elytra (rue)--Heinze, 1966. A spontaneous mutation commonly seen in populations derived from aureate. The adult has very finely corrugated elytra, giving them an almost granular appearance. Mode of inheritance tests show that rue can be separated from au but the expression is a little less remarkable in non-aureate adults. The

rue mutation is an autosomal recessive with good penetrance and viability, and not allelic to rough.

10. short antenna-3 (sa-3)--Heinze and Hoy, 1966. In a cye fas stock were found several adults and pupae with very short and stubby legs, as well as short antennae and elytra. In allelism tests with aa-1 47/102 adults were seen to have weakly affected legs; with stock aa ov, 15/233 adults had very weakly affected legs; with stock sa/sa all adults had strongly shortened appendages. The new mutant is, therefore, considered to be allelic with sa and will be called sa-3. A mode of inheritance test shows sa-3 to be an autosomal, incompletely recessive with 100% penetrance and high viability.

11. short median abdominal projection (smp)--Ackermann, 1966. Autosomal recessive of apparently uniform expression and complete penetrance. A mutation somewhat resembling but not as pronounced as Bamp (Blunt abdominal and metathoracic projections, Hoy, 1965). (See TIB 9:60 for illustration of Bamp.) It may be most readily identified by a shorter median abdominal projection of the apparent first abdominal segment, with the result that the tip does not extend between the hind coxae and is not accommodated by the inverted-V-shaped metasternellum of the metathorax (see figure on p. 77). The mesosternellum and the intercoxal process of the metathorax barely join each other between the mesothoracic legs. The mesosternellum appears somewhat ventrally convex. In crosses of smp ♀ × + ♂ the $F_1 \times F_1$ gave 187+:63 smp F_2 and the backcross 196+:123 smp. In the reciprocal cross the ratios were 257+:58 smp for F_2 and the backcross 109+:59 smp. Also noted was a large number of matings which failed and failed again, indicating a possible sterility factor.

12. truncated elytra-2 (te-2)--Heinze, 1966. In a cross between r M^r × syn. wild type several male adults and pupae were seen with short, folded te-like elytra. A good stock was built up and an allelism test with te showed the new mutant to be allelic. Since the new te has very strong expression and seems to be healthier than the old, a new stock shall be maintained.

Sex-linked Lethals

All the sex-linked lethals described below were found in the Berkeley synthetic strain in experiments designed to test the Cavalli-Sforza's model of mutation frequency as a regression on the age of the maternal grandfather (see note by Lerner and Inouye elsewhere in this issue of TIB).

1. lethal-5 (l-5)--Sokoloff and Inouye, 1964. Located about 25 units to the left of py (away from r) (see note by Sokoloff, Inouye and St. Hilaire). Allelic with l_2 and l_4.

2. lethal-6 (l-6)--Sokoloff and Inouye, 1964. Located about 12 units to the left of py (away from r).

3. lethal-7 (l-7)--Sokoloff and Inouye, 1964. Located about 20 units to the left of py (away from r).

Figure Legend (opposite page)

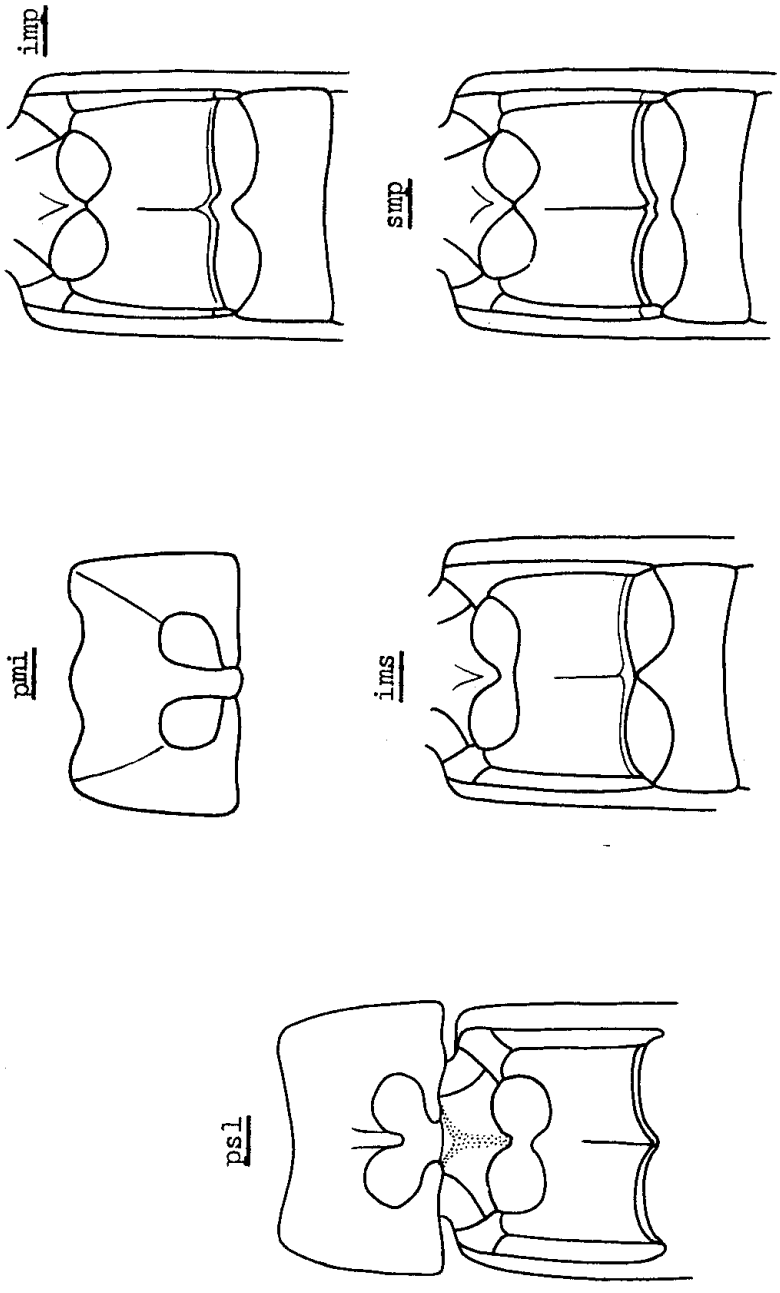
Upper Row, Center.--The "prothoracic margin irregular" phenodeviant in T. castaneum. Note that the probasisternum is indented on both sides between the midline and the tergosternal suture.

Upper Right.--The "incomplete metathoracic projections" mutant in T. confusum. Note the posterior projections of the metathorax are short, failing to form an inverted V to accommodate the medial abdominal projection of the first apparent abdominal segment.

Lower Left.--The prosternumless (psl) mutation in T. confusum. Both the probasisternum and mesobasisternum sternella are reduced. The prosternellum forms a small ridge and as a result of its reduction in size the coxae of the forelegs are freer, and not as widely separated. The mesosternellum fails to fuse with the intercoxal process of the metabasisternum, again freeing the coxae of the middle pair of legs and the mesobasisternum acquires a suture-like appearance (represented by stipples).

Lower Middle.--incomplete meso (basi) sternum (ims). Illustration of the mutant in T. castaneum described in TIB 6:25 and in T. confusum in TIB 9:68.

Lower Right.--"short median abdominal projection" mutant in T. castaneum. Note that the "point" of the first apparent abdominal segment is blunt.


imp
smp
pmi
ims
psl

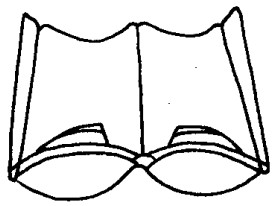
C. Tribolium confusum

*REPORT OF A. SOKOLOFF

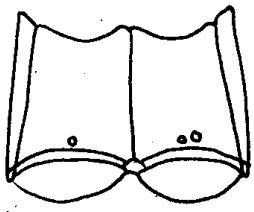
Autosomal

1. black (b)--Ho and Ackermann, 1966. Spontaneous in a mixed population XXIII-12 of T. anaphe and T. confusum. Not allelic with ebony nor with ebony-2. A recessive allele of black.

2. engraved meta(basi)sternum dots (ems^{dt})--Heinze, 1966. Spontaneous. Found in a "frosted" (allele of dpe) stock. In adults, characterized by a very small indentation or hole just above the middle of one or both antecoxal pieces (see sketch) but not connected to the latter as in jac, jagged antecoxal piece (see Plate 7F in Sokoloff, 1966). There may be 1-3 dots per basisternum, and not necessarily the same number of dots on each side. Allelic to ems, and like ems autosomal recessive with incomplete penetrance.



ems



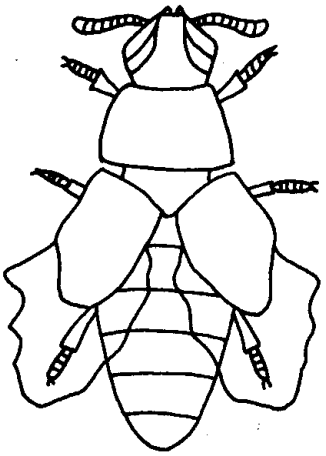
ems^{dt}

3. legless (lgl)--Hoy and Sokoloff, 1966. Spontaneous in a Reduced eye stock, five males and three females were found with a body color resembling mahogany (much lighter than Park's ebony), and both forelegs missing down to the coxa. Outcrossed to wild type and scoring F_2 no or few beetles have legs missing or partly so. But, mated to each other, they produce progeny without one or both prothoracic legs. The elytra in all beetles are rugose, they may be a little shorter than the abdomen in a few beetles, and the proximal third of the elytra may fail to meet at the midline. Those beetles with both legs missing, taken out of the flour, are often seen moving with the lower part of the head on the glass container, being pushed as the beetles attempt to walk. Others can hold the body off the container as they walk. Tentatively this condition has been designated as a phenodeviant because beetles with the legs absent may not be seen at all in F_2. However, since there is some evidence that the legs may develop and turn white, it is possible that this may be an aging effect young beetles exhibiting normal legs which, a few weeks later, fall off. Attempts are therefore being made to work out the mode of inheritance by examining body color and/or the wrinkled condition of the elytra.

4. pointed elytra-like (pel)--Sokoloff, 1963. Elytra mostly divergent and pointed, somewhat shorter than normal resembling dve and/or pointed elytra of T. castaneum. (See Plate 9, i, j in Sokoloff, 1966.) Occasionally, there may be beetles with elytra only short (not divergent) resembling sh in T. castaneum. Another form of expression: elytra longer than abdomen and drooping at the sides. Autosomal recessive, good viability.

5. prosternumless (psl)--Sokoloff, Ackermann and Daly, 1966. Autosomal, incompletely recessive (in reciprocal crosses of psl × + about 10 per cent of the F_1 beetles showed the character). (Found during tests of allelism between sep and dep.) This mutation is characterized by a reduction of the sternellum of the prothorax and mesothorax to a vistigial, keel-like structure (see figure on p. 77). As a result, the globose coxae of the fore- and middle-legs lie ventral to the prosternum and mesosternum ("above" as one examines the ventral aspect of the beetle as it lies on its back). Since the mesobasisternum fails to reach the intercoxal process of the metasternum, the mesobasisternum appears to "sink in" above the coxae (i.e., it is directed postero-dorsally). The mesobasisternum acquires a shiny ridge along the midline resembling a suture. The probasisternum also may develop a less pronounced (and not shiny) suture along the midline. In some beetles the tergosternal suture becomes less pronounced.

6. stunted (stt)--Sokoloff and Lauck, 1966. Spontaneous. Autosomal recessive mutation found in some crosses involving pointed-elytra-like (pel, q.v.). A gene with pleiotropic effects producing, like the sex-linked ma, miniature appendaged, individuals with the whole body shorter than normal, but the effect being most pronounced on the appendages as follows:



a. Antennae. There is considerable, often asymmetrical, fusion of the antennameres. The antennae appear elbowed, and because of fusion and reduction in size of segments 7-8 the antennae

may appear clubbed resembling that in T. castaneum. The distribution of fusions in the two sexes is shown in Table 1 which also indicates that the antennameres most often fused are 7 and 8. It is also evident that the gene often fails to express itself on one side of the body, producing one antenna normal and another abnormal. In the affected antennae there may be as few as two and as many as eight antennameres in fusions, some of which may involve more than two antennameres. When four consecutive segments are fused, usually they will form a kidney-shaped structure pointing one way and the other two another kidney-shaped structure pointing the other way. Summarized in Table 2 are the numbers of antennameres which may be affected in one antenna. Table 3 shows how funicular and club segments or both may be affected.

b. Legs. All the podomeres are reduced (the femur, in particular, becoming globase), resulting in a beetle with all legs considerably shorter (in a manner similar to that illustrated for ma in T. castaneum in Sokoloff, 1960, Can. J. Genet. Cytol 2:28-33). The tarsomeres are affected, the distribution of fusions being as shown in Table 4. Table 5, summarizing the fusions in the antennae and the tarsi of this mutant, appears to indicate that the chief difference between the two sexes is in the tarsi, the males exhibiting a greater number of fusions than females.

c. Mouth parts. Although this point was not investigated thoroughly there seems to be a partial fusion at least of some maxillary palpomeres.

d. Elytra and membranous wings. These are considerably reduced: the elytra are about half as long as the abdomen, often divergent, and often they exhibit a blister on the lateral margin. The veins and striae on the caudal half of the elytron become less pronounced and often hardly visible. The membranous wings trail (the tips of the wings fail to fold under the proximal portion), but they extend beyond the elytra, almost as far as the tip of the abdomen. All the veins appear to be present, but the cells are considerably reduced.

e. Other parts of the body. The prosternal process and the postcoxal bridges are reduced, with the result that a fairly extensive area of the prosternum in front of the mesobasisternum appears unsclerotized. The lateral parts of the coxae sockets appear to be more open than in the normal, so that at least the coxae of the fore- and hind-legs have a greater freedom to rotate within them. The intercoxal process of the apparent first abdominal segment appears somewhat shorter so it does not fit as well between the metasternella. The tergal aspect of the abdomen is, of course, exposed. This circumstance, as well as the fact that the hind-legs are too short to enable the beetle to free its hind-end and the fore-legs are too short to free

Table 1. Distribution of fused antennameres in the T. confusum mutant "stunted" (N = 20 males and 20 females)

Segments Involved	Males		Females	
	Right	Left	Right	Left
1-4	--	--	--	1
3-4	3	1	2	--
3-5	1	1	2	1
3-8	--	--	1	1
4-5	2	1	2	1
4-8	2	1	--	--
4-11	1	--	1	--
5-6	4	5	3	--
5-7	3	--	1	1
5-8	1	--	1	--
5-11	1	--	1	--
6-7	2	1	2	2
6-8	1	3	1	2
6-11	--	--	1	--
7-8	11	9	8	10
7-9	--	2	--	1
7-11	--	--	--	1
8-9	--	--	2	2
8-11	--	--	--	1
9-10	5	3	2	4
9-11	1	1	--	--
10-11	2	1	1	1

Table 2. Numbers of segments involved in antennal fusions of "stunted" (N = 20 males and 20 females)

N Segments Involved	Males		Females	
	Right	Left	Right	Left
2	32	21	20	22
3	4	8	4	4
4	1	1	2	1
5	--	1	2	1
6	2	1	--	--
7	1	--	1	--
8	--	1	--	--

Table 3. Part of antennae where fusions were found in "stunted" (N = 20 males and 20 females)

	Males		Females	
	Right	Left	Right	Left
Funicle	30	25	20	21
Club	8	6	3	4
Both	1	2	5	5

Table 4. Distribution of fused (or missing) tarsomeres in the T. confusum mutant "stunted" (N = 20 males and 20 females)

Leg Pair	N Tarsomeres in Fusion or Missing	Males		Females	
		Right	Left	Right	Left
1	0	1	--	1	4
	1	2	5	11	-6
	2	15	12	3	6
	3	3	2	3	3
	4	--	1	2	1
	5	--	--	--	--
2	0	1	2	6	9
	1	5	6	6	5
	2	10	13	7	5
	3	3	1	--	1
	4	--	--	1	--
	5	--	--	1	--
3	0	--	--	4	2
	1	7	7	4	1
	2	13	18	13	18
	3	2	1	--	--
	4	--	--	1	--

Table 5. Number of fused segments in antennae and tarsi of male and female stunted T. confusum (N = 20 males and 20 females)

		Antennae				Tarsi	
Sex	Side	Total Fusions N	Ave. No. of Fusions	Segments Involved N	Ave. No. Segments/ Fusions	Segments Fused N	Ave. No. Segments/ Fusions
Males	R	36	1.8	97	4.8	114	5.7
	L	33	1.6	75	3.7	120	6.0
Females	R	42	1.4	79	3.9	97	4.8
	L	28	2.1	79	3.9	86	4.3

the head from the pupal skin, results in a great mortality in the imago attempts to eclose from the pupa. It is quite probable that because of such major changes in the appendages and the overall size reduction of the body that this mutant might be recognized in the larval stage.

It is clear that both in the case of antennamere and tarsomere fusions (or deletions) occur more frequently in females than in males. In both sexes the first three segments appear to escape fusion. In males the modal group appears to be in the fusion of segments 4-5; in females these segments as well as segments 8-9 appear equally susceptible to fusion. Also, if club segments are involved, they appear to fuse more often in females than in males. The females showed somewhat more fusions of tarsomeres than did the males.

7. wide split-1 (wspl-1)--Lauck, 1966. A mutation involving the elytra was found in the legless mutation. It appears as the figure on Plate 11 of Sokoloff, 1966, and is allelic with a similar mutation found, but apparently not reported, by P. S. Dawson.

Sex-linked

1. alate prothorax (apt)--Strong, 1966. Originally found in a T. confusum synthetic strain maintained in soy plus yeast for many generations. This recessive, sex-linked, homeotic mutant is apparent in both pupae and adults. Both show large elytra-like growths on the dorso-lateral aspect of the prothorax. Although somewhat

distorted, these growths show many of the characteristics of elytra (see illustration on front cover). The normal expression is similar to the strongest expression found in T. castaneum, apt, and rarely is as weak as the normal expression of T. castaneum, apt (i.e., small knobs on the dorso-lateral aspect of the prothorax). The expression is fairly constant and the penetrance appears to be complete. The viability, about 75%, is surprisingly high for such a drastic mutation. Most deaths take place during the molt from the pupa to the adult stage. Linkage data with es^{lt} and lp are available (see note elsewhere in TIB) and experiments with red eye are in progress.

Tests of Allelism

1. black (b)--Ho and Ackermann, 1966. black (b) in T. confusum has proved to be a recessive allele of the semidominant black. It has been redesignated as b-4, Ho and Ackermann, 1966.

2. frosted, reported in T. confusum (TIB 8:62) is allelic with dirty pearl eye (dpe) and it is therefore re-named dpe-1, Hoy and Heinze, 1966.

Addenda and Corrigenda

incomplete metathoracic projections (imp) (TIB 8:52) in T. castaneum is an autosomal recessive with slightly variable expression and incomplete penetrance (about 15% of individuals fail to show the character).