## . Table of Contents, Tribolium Information Bulletin 41



To start the ball rolling Sokoloff wrote this short paper, "Interactions in Tribolium: Competition or predator prey?" TIB 36. The only response was from Dr. Charles C. Goodnight in TIB 39: 261-265. For those who may have missed his views, I'll be glad to send copies of both sides of this issue as it stands so far. Remember that the Forum will remain open to contributors to TIB for only two more years.

TRIBOLIUM INFORMATION BULLETIN

VOLUME 41

JULY, 2001

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**CELEBRATING OUR 41ST ANNIVERSARY**

NOTE

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## Acknowledgments

**The editor is indebted to Barbara Sokoloff and Elaine Sokoloff for assistance in the preparation and distribution of TIB 41**

## ANNOUNCEMENT I

## FOR SALE

A SMALL NUMBER OF SETS OF SOKOLOFF'S THREE VOLUME
THE BIOLOGY OF TRIBOLIUM WITH SPECIAL EMPHASIS
ON GENETIC ASPECTS IS AVAILABLE FROM THE EDITOR ON A
FIRST COME-FIRST SERVED BASIS
AND ONLY AS A FULL THREE VOLUME SET.
PRICE: $180/SET (INCLUDING POSTAGE, HANDLING & INSURANCE)

ALSO AVAILABLE FROM THE EDITOR ARE A FEW COPIES OF
SOKOLOFF'S THE GENETICS OF TRIBOLIUM AND OTHER RELATED
SPECIES. ACADEMIC PRESS IN PAPERBACK.
PRICE: $60.00 (INCLUDES POSTAGE, HANDLING & INSURANCE)

## ANNOUNCEMENT XII

At long last we have received permit for importation of 3 species of Tribolium: T. anaphe, T. audax and T. destructor. If you are interested in obtaining samples of these beetles in the near future contact me by fax or e-mail.

## ANNOUNCEMENT III

### REPORT ON THE OPEN FORUM

The participation in discussion of the first topic of discussion entitled "Interactions in Tribolium: Competition or predator-prey?" was very disappointing. Instead of a forum there was one response, enough only for a dialogue. Because the Editor considers the subject worth discussing, the subject considered for the open forum remains open for discussion, and it will be for the next two years.

As usual, the Editor reminds subscribers that the very existence of the TIB is dependent not only on subscription, but also on contributions to the Newsletter. Please be as generous of your time as possible by responding when calls for contribution arrive in your hands. This includes not only research notes but also revision of personnel in your lab, stock lists, and lists of current bibliography.

TRIBOLIUM NEWS EXCHANGE - ELECTRONIC MAIL ADDRESSES

July, 2000

Tribolium News Exchange - ELECTRONIC MAIL ADDRESSES.

The following includes an updated list of people subscribed to the Tribolium News Exchange. The purpose of this group is to provide an informal forum to exchange ideas, techniques and suggestions about Tribolium. To send electronic mail to the group, address it to: tribolium@emerald.tufts.edu

If you have suggestions of other people not included on this list who you think would be interested in participating, please send their addresses to me.

Happy beetling,

Margaret Bloch Qazi

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PEST IMPORTATION PERMIT FACSIMILE

Pest Importation Permit Facsimile

A copy of the Importation Permit Application attached should be filled out and sent to the USDA and who will issue the permit* to move life plant pests or noxious weeds This should be sent to the supplier of the stock you want. The supplier then will send the stock (and a bill), with the importation permit in the package via the port of entry, where an inspector will inspect the package, and if the importation permit has been included, the package will be forwarded to your address.

*Warning: it may take the USDA six months to issue the importation permit.

USDA
Riverside, Maryland
Animal and Plant Health Inspection Service
Plant Protection and Quarantine
Biologoca; Assessment and Taxonomic support

No permit can be issued to move live plant pests or noxious weeds until an application is received (7 CFR 330 (live plant pests) or 7 CFR 360 (noxious weeds))

See reverse side for additional OMB information.

FORM APPROVED OMB NO. 0579-0054

U.S DEPARTMENT OF AGRICULTURE
ANIMAL AND PLANT HEALTH INSPECTION SERVICE
PLANT PROTECTION AND QUARANTINE
BIOLOGICAL ASSESSMENT AND TAXONOMIC SUPPORT
RIVERDALE, MARYLAND 20737

## APPLICATION AND PERMIT TO MOVE LIVE PLANT PESTS OR NOXIOUS WEEDS

### SECTION A - TO BE COMPLETED BY THE APPLICANT

1. NAME, TITLE, AND ADDRESS (Include Zip Code)

2. TELEPHONE NO. ( )

3. TYPE OF PEST TO BE MOVED

* ☐ Pathogens ☐ Arthropods ☐ Noxious Weeds

☐ Other (Specify): ____________

This permit does not authorize the introduction, importation, interstate movement, or release into the environment of any genetically engineered organisms or products.

| A. SCIENTIFIC NAMES OF PESTS TO BE MOVED | B. CLASSIFICATION (Orders, Families, Races, or Strains) | C. LIFE STAGES IF APPLICABLE | D. NO. OF SPECIMENS OR UNITS | E. SHIPPED FROM (Country or State) | F. ARE PESTS ESTABLISHED IN U.S. | G. MAJOR HOST(S) OF THE PEST |
|---|---|---|---|---|---|---|
| 4. | | | | | | |
| 5. | | | | | | |
| 6. | | | | | | |

7. WHAT HOST MATERIAL OR SUBSTITUTES WILL ACCOMPANY WHICH PEST (Indicate by line number)

8. DESTINATION

9. PORT OF ARRIVAL

10. APPROXIMATE DATE OF ARRIVAL OR INTERSTATE MOVEMENT

11. NO. OF SHIPMENTS

12. SUPPLIER

13. METHOD OF SHIPMENT ☐ Air Mail ☐ Air Freight ☐ Baggage ☐ Auto

14. INTENDED USE (Be specific, attach outline of intended research)

15. METHODS TO BE USED TO PREVENT PLANT PEST ESCAPE

16. METHOD OF FINAL DISPOSITION

17. *Applicant must be a resident of the U.S.A. I/We agree to comply with the safeguards printed on the reverse of this form, and understand that a permit may be subject to other conditions specified in Sections B and C.*

SIGNATURE OF APPLICANT (Must be person named in Item 1)

18. DATE

### SECTION B - TO BE COMPLETED BY STATE OFFICIAL

19. RECOMMENDATION

☐ Concur (Approve) ☐ Comments (Disapprove)

☐ (Accept USDA Decision)

20. CONDITIONS RECOMMENDED

21. SIGNATURE AND TITLE

22. TITLE

23. STATE

24. DATE

### SECTION C - TO BE COMPLETED BY FEDERAL OFFICIAL

## PERMIT

25. PERMIT NO.

(Permit not valid unless signed by an authorized official of the Animal and Plant Health Inspection Service)

Under authority of the Federal Plant Pest Act of May 23, 1957 or the Federal Noxious Weed Act of 1974, permission is hereby granted to the applicant named above to move the pests described, except as deleted, subject to the conditions stated on, or attached to this application. (See standard conditions on reverse side).

*For exotic plant pathogens, attach a completed PPQ form 526-1.

| 24. SIGNATURE OF PLANT PROTECTION AND QUARANTINE OFFICIAL | 25. DATE | 26. LABELS ISSUED | 27. VALID UNTIL | 28. PEST CATEGORY |
|---|---|---|---|---|
| | | | | |

PPQ FORM 526 (SEPT 95) *Previous edition may be used*

## STANDARD SAFEGUARDS OF PERMIT

1 . All pests must be shipped in sturdy, escape-proof containers.

2 . Upon repair of pests, all packing material and shipping containers shall be sterilized or destroyed immediately after removing.

3 . Pests shall be kept only within the laboratory or designated area at the permittee's address.

4 . No living pests kept under this permit shall be removed from confined area expect by prior approval from State and Federal regulatory officials.

5 . Without prior notice and during reasonable hours, authorized PPQ and State regulatory officials shall be allowed to inspect the conditions under which the pests are kept.

6 . All pests kept under this permit shall be destroyed at the completion of the intended use, and not later than the expiration date, unless an extension is granted by this issuing office.

7 . All necessary precautions must be taken to prevent escape of pests. In the event of an escape, notify:

Biological Assessment and Taxonomic
Permit Unit
4700 River Road, Unit 133
Riverdale, Maryland 20737

# Insect and Mite Culture Order Form

**Name:** ..........................................................................................
**Address:** ..........................................................................................

..........................................................................................
..........................................................................................

**Tel no:** ................................ **Fax no:** ...................................... **E-mail:** ....................................

**Customer purchase order no:** ....................................................

**For new customers only:** How did you find out about CSL's invertebrate supply service? *(please tick appropriate box)*

| Advertisement in | Website | Conference/ Exhibition | Colleague | Other *(please specify)* |
|---|---|---|---|---|
| ....................................<br>....................................<br>....................................<br>*(please name journal/magazine)* | | ..........................................................<br>..........................................................<br>..........................................................<br>*(please give details)* | | ..........................................................<br>..........................................................<br>..........................................................<br>.... |

| Species | Quantity* | Adult/Larvae | Price* £ |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | **Subtotal** | |
| | | (Note: VAT is not payable for orders paid from outside UK) **VAT** | |
| | | **TOTAL** | |

* An **insect culture** contains **50-100 insects** and costs **£75.00 + VAT.**
Mite cultures can be supplied either **live** or **dead** (min. order 5g dead mite culture). Price **£400.00 + VAT.**
For quantities greater than the above, prices will be increased pro rata.
For special requirements please contact the Invertebrate Supply Unit for a quote.
Invoices will be sent on completion of order. Payments must be made in Sterling

**Date required:** ......................................

**Please send completed form to:**

Mr J Dixon
Central Science Laboratory
Sand Hutton
York Y041 1LZ
UK

**Telephone:** +44 (0)1904 46 26 46
**Fax:** +44 (0)1904 46 21 11
**E-mail:** j.dixon@csl.gov.uk

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**ISU use only**

| Date received:............................ | Date despatched:...................... | CSL order no:.......................... |
|---|---|---|

# STOCK LISTS

Stock Lists

RIVER FOREST, ILLINOIS
ROSARY COLLEGE
DEPARTMENT OF NATURAL SCIENCES

I. Wild type strains
 A. <u>Tribolium castaneum</u>
  1. "Chicago" (originally from Thomas Park)
  2. "Brazil" (originally from Rio de Janeiro; also known as cI)
  3. "Arkansas" (originally from Michael Wade)
 B. <u>Tribolium confusum</u>
  1. "Chicago" (originally from Thomas Park)
  2. "Circle" (collected in Chicago)
  3. bI (derived from "Chicago")
  4. bII (derived from "Chicago")
  5. bIII (derived from "Chicago")
  6. bIV (derived from "Chicago")

II. Mutant strains
 A. <u>Tribolium castaneum</u>
  1. "Chicago" black (derived from "Chicago")
 B. <u>Tribolium confusum</u>
  1. "Chicago" black (derived from "Chicago")

David M. Craig

## Stock Lists

GAINESVILLE, FLORIDA
ARS, USDA
P.O. BOX 14565
INSECT ATTRACTANTS, BEHAVIOR AND BASIC BIOLOGY LABORATORY.

| | |
|---|---|
| Attagenus megatoma | black carpet beetle |
| Cadra cautella | almond moth |
| Cylas formicarius elegantulus | sweet potato weevil |
| Lasioderma serricorne | cigarette beetle |
| Oryzaephilus surinamensis | sawtoothed grain beetle |
| Paramyelois transitella | navel orangeworm |
| Plodia interpunctella | Indian meal moth |
| Sitotroga cerealella | Angoumois grain moth |
| Sitophilus oryzae | rice weevil |
| Tribolium castaneum | red flour beetle |
| Trogoderma granarium | khapra beetle |
| Trogoderma inclusum | |

(Ed.).

KINGSTON, RHODE ISLAND 02881
UNIVERSITY OF RHODE ISLAND
DEPARTMENT OF ZOOLOGY

Tribolium castaneum

| | |
|---|---|
| Purdue Foundation | via Purdue |
| Black Foundation | via Purdue |
| Corn oil unsaturated fatty acid sensitive (cos) | |

Tribolium confusum

| | |
|---|---|
| Chicago | Park 1955 |
| black | via San Bernardino |
| pearl | via San Bernardino |

Tribolium madens — via San Bernardino

Tribolium brevicornis — via San Bernardino

(Ed.).

LAFAYETTE, INDIANA 47907
PURDUE UNIVERSITY
ANIMAL SCIENCES DEPARTMENT

*Tribolium castaneum*

I. Wild type strains

A. Foundation "+" - originated in 1954 at Purdue University from a broad genetic base and maintained with no artificial selection and minimal breeding.

B. Foundation s - Same genetic base as Foundation "+", but genetically marked with the sooty mutant (s).

C. Foundation b - Originated in 1959 at Purdue University with a broad genetic base unrelated to Foundation "+", no artificial selection, minimal inbreeding, and genetically marked with the black mutant (b).

D. Foundation p - Originated in 1959 at Purdue University with a broad genetic base unrelated to Foundation "+" and b, no selection, minimal inbreeding, and genetically marked with the pearl mutant (p).

W.M. MUIR

LEXINGTON, KENTUCKY
UNIVERSITY OF KENTUCKY
AGRICULTURAL EXPERIMENT STATION

I. Base populations

| | |
|---|---|
| 1. Purdue + foundation | Purdue |
| 2. Purdue s foundation (sooty) | Purdue |
| 3. Purdue b foundation (black) | Purdue |
| 4. Purdue p foundation (pearl) | Purdue |

II. Synthetic strains -- with a history of long-term selection for increased pupa weight but maintained in population cages without selection pressure but discrete generations.

| | |
|---|---|
| 1. MRS-1 | Minnesota, 1970 |
| 2. MRS-2 | Minnesota, 1970 |
| 3. P | Purdue, 1976 |

4. C Davis, 1976

III. Synthetic strain IS from a cross of CSI-10 X E1 inbred lines, maintained in population cages with extremely large
1. IS - From a cross of CSI-10 X e1 inbred lines, maintained in population cages with extremely large population size and random mating for 28 generations.

(Ed.).

MANHATTAN, KANSAS
KANSAS STATE UNIVERSITY
DEPARTMENT OF ENTOMOLOGY

LEPIDOPTERA

Phycitidae: Cadra cautella and Plodia interpunctella

Gelechiidae: wild and red eyed strains.

Pyralidae: Corcyra cephalonica

COLEOPTERA

Anobiidae: Lasioderma serricorne and Stegobium paniceum

Bostrichidae: Rhyzopertha dominica

Bruchidae: Callosobruchus maculatus

Cucujidae; Cryptolestes ferrugineus, C. pusillus,

Curculionidae: Sitophilus granarius, S. oryzae, and two strains of S. zeamais.

Dermestidae: Trogoderma inclusum, Attagenus megatoma

Ostomatidae: Tenebroides mauritanicus

Ptinidae: Gibbium psylloides

Silvanidae; Ahasverus advena, Oryzaephilus surinamensis, O. mercator

Tenebrionidae:

*Palorus ratzeburgi*, Kansas 1965
*Tenebrio molitor*, Kansas
*Tenebrio obscurus* Manhattan, Kansas, 1971
*Tribolium castaneum*, Kansas
*Tribolium confusum*, Kansas

Valerie Wright

MANHATTAN, KANSAS 66502
U.S. GRAIN MARKETING RESEARCH LABORATORY

*Tribolium castaneum*

I. Insecticide-resitant strains

1. GA-1, malathion-specific, collected in Georgia, 1980
2. NC-1, malathion-specific, collected in North Carolina. From W.C. CAMPBELL.
3. Kano, malathion-specific, collected in northern Nigeria, 1961. From W.R. wilkin.
4. CTC 12, nonspecific, oxidase type, collected in Kingaroy, Australia, 1968. From W.R. Wilkin.
5. TC 95, nonspecific. From B.R. Champ.
6. DDT C, DDT-resistant, collected in South Africa, 1959. From D.G. Blackman.
7. Rmal-2 allelic to Rmal-1
8. Rdiel--Resistant to lindane, dieldrin and other cyclodienes, linkage group not determined.

II. Mutant strains

(see next pages)

## Tribolium castaneum: wild-type stocks

| | Stock Name | Stock Origin | Full Name or description | Linkage Group | Stocks | Stock Developed by/Received From |
|---|---|---|---|---|---|---|
| 1 | Abidjan | Ivory Coast | wild-type strain | - | Abidjan | Ivory Coast, 19?? |
| 2 | Bang-1 | Bangladesh | wild-type strain | - | Bang-1 | Bangladesh, 1989 |
| 3 | Bang-2 | Bangladesh | wild-type strain | - | Bang-2 | Bangladesh, 1979 |
| 4 | Banos | Ecuador | wild-type strain | - | Banos | Ecuador, 19?? |
| 5 | Berlin | Germany | wild-type strain | - | Berlin | Germany, 19?? |
| 6 | Bha-4 (slight sq) | India | wild-type strain | - | Bha-H | India, 1988 |
| 7 | Bha-B (squinty) | India | wild-type strain | - | Bha-B | India, 1988 |
| 8 | Blakely | Georgia | wild-type strain | - | Blakely | Georgia, 1993 |
| 9 | BMT Lab | Beaumont | wild-type strain | - | BMT Lab | Beaumont, 1974? |
| 10 | Bordeaux | France | wild-type strain | - | Bordeaux | France, 19?? |
| 11 | BRM | Texas | wild-type strain | - | BRM | Texas, 1988 |
| 12 | BRZ-4 | Brazil | wild-type strain | - | BRZ-4 | Brazil, 1987 |
| 13 | BRZ-5 | Brazil | wild-type strain | - | BRZ-5 | Brazil, 19[illegible] |
| 14 | BRZ-6 | England | wild-type strain | - | BRZ-6 | England, 1943 |
| 15 | BT-15 | Bangladesh | wild-type strain | - | BT-15 | Bangladesh, 1981 |
| 16 | Causey-S | S. Carolina | wild-type strain | - | Causey-S | S. Carolina, 1991 |
| 17 | COL-1 | Colombia | wild-type strain | - | COL-1 | Colombia, 1987 |
| 18 | COL-2 | Colombia | wild-type strain | - | COL-2 | Colombia,1989 |
| 19 | CR-1 | Costa Rica | wild-type strain | - | CR-1 | Costa Rica, 19?? |
| 20 | CRRI-1 | India | wild-type strain | - | CRRI-1 | India,1989 |
| 21 | CRRI-2 | India | wild-type strain | - | CRRI-2 | India,1983 |
| 22 | CSM | Mike Wade | wild-type strain (composite construction) | - | CSM | Chicago |
| 23 | CTC-4 | Australia | wild-type strain | - | CTC-4 | Australia, 1965 |
| 24 | CTC-485 | Australia | wild-type strain | - | CTC-485 | Australia, 1988 |
| 25 | Dwi-1 | India | wild-type strain | - | Dwi-1 | India, 1989 |
| 26 | Dwi-1 , #189 | India | wild-type strain | - | Dwi-1 , #189 | India |
| 27 | Dwi-3 (dark body color) | India | wild-type strain | - | Dwi-3 (dark body color) | India, 1989 |
| 28 | Dwi-3 , #191 | India | wild-type strain | - | Dwi-3 | India |
| 29 | Dwi-3 isoline (ST) | India | inbred isoline | - | Dwi-3 isoline (ST) | India |
| 30 | Estill | S. Carolina | wild-type strain | - | Estill | S. Carolina, 19?? |
| 31 | Ey-Lethal-Free | Manhattan | lethal free from Eyeless | - | Ey-Lethal-Free | Manhattan |
| 32 | FFM-C | Georgia | wild-type strain | - | FFM-C | Georgia, 1993 |
| 33 | FSS2 | England | wild-type strain | - | FSS2 | England, 1943 |
| 34 | Ga-1 | Georgia | Georgia 1, wild type | - | Ga-1 | Georgia |
| 35 | Ga-2 | Georgia | Georgia 2, Ga-1 inbred 20 generations | - | Ga-2 | U.Wisc.-Parkside |
| 36 | Ga-2 iso-M1(HxL) | Georgia | Georgia 2, isoline to M1/M1 | - | Ga-2 iso-M1 (HxL) | Manhattan |
| 37 | Ger-1 | Germany | wild-type strain | - | Ger-1 | Germany, <1989 |
| 38 | GW-13 | Australia | wild-type strain | - | GW-13 | Australia,19?? |
| 39 | GW-3 | Australia | wild-type strain | - | GW-3 | Australia, 1988 |
| 40 | GW-4 | Australia | wild-type strain | - | GW-4 | Australia,1965 |
| 41 | Heng-5 | Thailand | wild-type strain | - | Heng-5 | Thailand, 1989 |
| 42 | HO-TCS | Singapore | wild-type strain | - | HO-TCS | Singapore,1989 |
| 43 | HO-TJC, #121 | Singapore | wild-type strain | - | HO-TJC | Singapore |
| 44 | Ibad-2cf | Nigeria | wild-type strain | - | Ibad-2cf | Nigeria, 1987 |
| 45 | ISR-1 | Israel | wild-type strain | - | ISR-1 | Israel, 1988 |
| 46 | ISR-2 | Israel | wild-type strain | - | ISR-2 | Israel, 1988 |
| 47 | Japan #1 | Japan | wild-type strain | - | Japan #1 | Japan, <1978 |
| 48 | Japan #2 | Japan | wild-type strain | - | Japan #2 | Japan, 1988 |
| 49 | Japan #4 | Japan | wild-type strain | - | Japan #4 | Japan, 1988 |
| 50 | Kent (small eyes) | England | wild-type strain | - | Kent (small eyes) | England, 19?? |
| 51 | Lab-S Rusty | Manhattan | Lab strain, rusty, wild-type | - | Lab-S Rusty | Manhattan |
| 52 | Lancombe | Alberta, Canada | wild-type strain | - | Lancombe | Alberta, Canada |
| 53 | Little Rock | Arkansas | wild-type strain | - | Little Rock | Arkansas, 1988 |
| 54 | Mek-1 | China | wild-type strain | - | Mek-1 | China, 1987 |
| 55 | Montreal | Montreal | wild-type strain | - | Montreal | Montreal, 1973 |
| 56 | NDG-2 (#59) | Manitoba | wild-type strain | - | NDG-2 (#59) | Manitoba |
| 57 | NDG-2 (IN20) | Manitoba | wild-type strain, inbred 20 generations | - | NDG-2 (IN20) | U. Wisc. Parkside |
| 58 | NDJ-11 | Hawaii | wild-type strain | - | NDG-11 | Hawaii, 1976 |
| 59 | NDJ-13 | Vancouver | wild-type strain | - | NDG-13 | Vancouver, 1976 |
| 60 | NDJ-3 | Manitoba | wild-type strain | - | NDG-3 | Manitoba, 1987 |
| 61 | NDJ-6 (some white eye) | Minnesota | wild-type strain | - | NDJ-6 (some white eye) | Minnesota, 1982 |
| 62 | NIG-1 (red eye) | Nigeria | wild-type strain | - | NIG-1 (red eye) | Nigeria, 1988 |
| 63 | PAK-1 | Pakistan | wild-type strain | - | PAK-1 | Pakistan, 1979 |
| 64 | PAK-2 (dark body color) | Pakistan | wild-type strain | - | PAK-2 (dark body color) | Pakistan, 1979 |
| 65 | PAK-3 | Pakistan | wild-type strain | - | PAK-3 | Pakistan, 1988 |
| 66 | PRC-Nan | China | wild-type strain | - | PRC-Nanj | China,1989 |
| 67 | PRC-Ning | China | wild-type strain | - | PRC-Ning | China,1989 |
| 68 | Pruz + | Poland | wild-type strain | - | Pruz + | Poland, 1988 |
| 69 | Pruz-1 | Poland | wild-type strain | - | Pruz-1 | Poland, 1963 |
| 70 | PS-129 | India | wild-type strain | - | PS-129 | India, 1984 |
| 71 | Raj-1 | India | wild-type strain | - | Raj-1 | India, 1<1979 |
| 72 | Ram-B | India | wild-type strain | - | Ram-B | India, 19?? |

| | | | | | | |
|---|---|---|---|---|---|---|
| 73 | Ramsey (MT '88) | Minnesota | wild-type strain | - | Ramsey (MT '88) | Minnesota,1988 |
| 74 | REJ-1 | Philippines | wild-type strain | - | REJ-1 | Philippines,19?? |
| 75 | RINI-3 | India | wild-type strain | - | RINI-3 | India,1989 |
| 76 | RINI-4 | India | wild-type strain | - | RINI-4 | India, 19?? |
| 77 | Shellman | Georgia | wild-type strain | - | Shellman | Georgia,1993 |
| 78 | Sok 16 | California | wild-type strain | - | Sok 16, (TC16, Veracruz) | California, 19?? |
| 79 | Sok 19 | California | wild-type strain | - | Sok 19, (TC19,Berkeley) | California, 19?? |
| 80 | Sok 22 | California | wild-type strain | - | Sok 22, (TC22) | California, 19?? |
| 81 | Sok 25 | California | wild-type strain | - | Sok 25, (TC25, ex.NY) | California, 19?? |
| 82 | Sok 4 | California | wild-type strain | - | Sok 4, (TC4,Davis) | California, 19?? |
| 83 | Sok 8 | California | wild-type strain | - | Sok 8, (TC8, McGill) | California, 19?? |
| 84 | Solet | Israel | wild-type strain | - | Solet | Israel, 1979 |
| 85 | Sylvania | Sylvania, GA | wild-type strain | - | Sylvania | Sylvania, GA |
| 86 | Tiw-1 | India | wild-type strain | - | Tiw-1 | India,1989 |
| 87 | Tiw-5 | India | wild-type strain | - | Tiw-5 | India,1989 |
| 88 | Tiw-6 | India | wild-type strain | - | Tiw-6 | India,1989 |
| 89 | Ug-1 | Uganda | wild-type strain | - | Ug-1 | Uganda, 1989 |
| 90 | UG-3 | Tanzania | wild-type strain | - | UG-3 | Tanzania,1986 |
| 91 | Vienna (GA '93) | Georgia | wild-type strain | - | Vienna (GA '93) | Georgia,1993 |
| 92 | Waunakee (WI '92) | Wisconsin | wild-type strain | - | Waunakee (WI '92) | Wisconsin, 1992 |
| 93 | WI-1 | Wisconsin | wild-type strain | - | WI-1 | Wisconsin? |
| 94 | Z-1 | Alabama | wild-type strain | - | Z-1 | Alabama, 1988 |
| 95 | Z-2 (occ.dk.red eye) | Oklahoma | wild-type strain | - | Z-2 (occ.dk.red eye) | Oklahoma, 1988 |
| 96 | Z-3 (#30) | Kankakee | wild-type strain | - | Z-3 (#30) | Kankakee, IL |
| 97 | Z-4 (occ. dark body) | Iowa | wild-type strain | - | Z-4 (occ. dark body) | Iowa, 1988 |
| 98 | Z-5 | Minnesota | wild-type strain | - | Z-5 | Minnesota, 1988 |
| 99 | Z-7 | S. Carolina | wild-type strain | - | Z-7 | S. Carolina, 1988 |

## Tribolium castaneum: mutant stocks

| | Mutant Name | Mutant Origin | Full Name or description | Linkage Group | Stocks | Stock Developed by/Received From: |
|---|---|---|---|---|---|---|
| 100 | 35.17 | Manhattan | dominant lethal | 2 | 35.17/Ag4,Stm | Manhattan |
| 101 | 3P1 | Purdue | crossover suppressor | 3 | 3P1/au14 | Purdue |
| 102 | 3P2 | Purdue | crossover suppressor | 3 | 3P2/au14 | Purdue |
| 103 | A(Ag1),Stm | Manhattan | abdominal (from Ag), cis Stm | 2 | A(Ag1),Stm /ptlD60 | Manhattan |
| 104 | A(Ag2) | Manhattan | abdominal (from Ag) | 2 | A(Ag2)/ Ag4,Stm | Manhattan |
| 105 | A(mc) | Manhattan | abdominal (from mc) | 2 | A(mc),p/Stm,Cx5 | Manhattan |
| 106 | A10 | Manhattan | Abdominal 10 | 2 | A10 / Ey | Manhattan |
| 107 | A10,mxpA10 | Manhattan | Abdominal 10, mxp fr. A10 | 2 | A10,mxpA10/Ag5,Stm | Manhattan |
| 108 | A12 | Manhattan | Abdominal 12 | 2 | A12/Ey | Manhattan |
| 109 | A14,Ey | Manhattan | Abdominal 14, Stm cis | 2 | A14,Ey / Ag4,Stm | Manhattan |
| 110 | A15, Stm | Manhattan | Abdominal 15, Stm cis | 2 | A15,Stm/Ey | Manhattan |
| 111 | A20 Rdiel | Unknown | Dieldrin resistant | 2 | A20 Rdiel | Unknown |
| 112 | A4 | Manhattan | Abdominal 4 | 2 | A4/Stm,Ag5 | Manhattan |
| 113 | A8 | Manhattan | Abdominal 8 | 2 | A8/Stm,Cx5 | Manhattan |
| 114 | A83 | Manhattan | Abdominal 83 | 2 | A83/Stm | Manhattan |
| 115 | ab | Bogota | antenna bifurcada | 9 | ab,pas30,p | Manhattan |
| 116 | ab | Bogota | antenna bifurcada | 9 | ab/ab | Bogota, Colombia |
| 117 | ab (IN20) | Parkside | inbred line, 20 generations, from ab | - | ab(IN20)/ab(IN20) | U.Wisc.,Parkside |
| 118 | AD100,Stm,Cx5 | Manhattan | Notched gena,Stm,Cx5 (cis) | 2 | AD100,Stm,Cx5/Es1 | Manhattan |
| 119 | Ag | Manhattan | Antennagalea | 2 | Ag/Es1 | Manhattan |
| 120 | Ag | Manhattan | Antennagalea | 2 | Ag/Stb | Manhattan |
| 121 | Ag4, Stm | Manhattan | Antennagalea 4, Stm (cis) | 2 | Ag4,Stm/35.17 | Manhattan |
| 122 | Ag4, Stm | Manhattan | Antennagalea 4, Stm (cis) | 2 | Ag4,Stm/$A^{Ag2}$ | Manhattan |
| 123 | Ag4, Stm | Manhattan | Antennagalea 4, Stm (cis) | 2 | Ag4,Stm/Skl4 | Manhattan |
| 124 | Ag4, Stm | Manhattan | Antennagalea 4, Stm (cis) | 2 | Ag4,Stm/Es1 | Manhattan |
| 125 | Ag4, Stm | Manhattan | Antennagalea 4, Stm (cis) | 2 | Ag4,Stm/sp | Manhattan |
| 126 | Ag4, Stm | Manhattan | Antennagalea 4, Stm (cis) | 2 | Ag4,Stm/vwe | Manhattan |
| 127 | Ag4, Stm | Manhattan | Antennagalea 4, Stm (cis) | 2 | Ag4,Stm/X(ab-1s) | Manhattan |
| 128 | Ag4, Stm | Manhattan | Antennagalea 4, Stm (cis) | 2 | Ag4,Stm/X-31 | Manhattan |
| 129 | Ag4, Stm | Manhattan | Antennagalea 4, Stm (cis) | 2 | Ag4,Stm/X-47 | Manhattan |
| 130 | Ag4, Stm | Manhattan | Antennagalea 4, Stm (cis) | 2 | Ag4,Stm/X-83 | Manhattan |
| 131 | Ag4, $Stm^R$ | Manhattan | Antennagalea 4, Stm (revertant) | 2 | Ag4,$Stm^R$/Es1 | Manhattan |
| 132 | Ag5, Stm | Manhattan | Antennagalea 5, Stm (cis) | 2 | Ag5,Stm/A4 | Manhattan |
| 133 | Ag5, Stm | Manhattan | Antennagalea 5, Stm (cis) | 2 | A10,mxpA10/Ag5,Stm | Manhattan |
| 134 | Ag5, Stm | Manhattan | Antennagalea 5, Stm (cis) | 2 | Ag5,Stm/A14,Ey | Manhattan |
| 135 | Ag5, Stm | Manhattan | Antennagalea 5, Stm (cis) | 2 | Ag5,Stm/Es1 | Manhattan |
| 136 | Ag5, Stm | Manhattan | Antennagalea 5, Stm (cis) | 2 | Ag5,Stm/Es2 | Manhattan |
| 137 | Ag5, Stm | Manhattan | Antennagalea 5, Stm (cis) | 2 | Ag5,Stm/GoPL4 | Manhattan |
| 138 | AgPin | Manhattan | Antennagalea (Pinhead) | 2 | AgPin/Stm,Cx5 | Manhattan |
| 139 | Ahd | Purdue | Arrowhead | 8 | Ahd/Ahd | Purdue |
| 140 | ap | Englert | antennapedia | 8 | ap, b | Manhattan |
| 141 | ap | Englert | antennapedia | 8 | ap, sq2 | Manhattan |
| 142 | ap | Englert | antennapedia | 8 | ap,sq/ap,sq,Bald | Manhattan |
| 143 | ap | Englert | antennapedia | 8 | MMS (s,rb,ap,au,mas) | Manhattan |

| | | | | | | |
|---|---|---|---|---|---|---|
| 144 | Apl | Manhattan | Antennapalpus | 2 | Apl,apt,mas,pas | Manhattan |
| 145 | Apl | Manhattan | Antennapalpus | 2 | Apl/Apl | Manhattan |
| 146 | apt | Sokoloff & Hoy | alate prothorax | 2 | apt, pas | San Bernadino |
| 147 | apt | Sokoloff & Hoy | alate prothorax | 2 | b, apt, sa, c | Manhattan |
| 148 | apt | Sokoloff & Hoy | alate prothorax | 2 | Quint (mxp,apt,mas,pas,ub) | Manhattan |
| 149 | au | Hoy | aureate | 3 | b(t),p,lod,au,msg | Manhattan |
| 150 | au | Hoy | aureate | 3 | au,lod isoline (JS) | Purdue |
| 151 | au | Hoy | aureate | 3 | au, lod, p | San Bernadino |
| 152 | au | Hoy | aureate | 3 | mas, p,au | Manhattan |
| 153 | au | Hoy | aureate | 3 | MMS (s,rb,ap,au,mas) | Manhattan |
| 154 | au$^{14}$ | Purdue | aureate 14, lethal | 3 | 3P1/au$^{14}$ | Purdue |
| 155 | au$^{14}$ | Purdue | aureate 14, lethal | 3 | 3P2/au$^{14}$ | Purdue |
| 156 | au$^{14}$ | Purdue | aureate 14, lethal | 3 | 3.2 Bamp/au$^{14}$ | Purdue |
| 157 | au$^{2}$ | Manhattan | aureate | 3 | au$^{2}$ | Manhattan |
| 158 | b | Sokoloff | black body color | 3 | b | San Bernadino |
| 159 | b | Sokoloff | black body color | 3 | b, ap | Manhattan |
| 160 | b | Sokoloff | black body color | 3 | b, apt, sa, c | Manhattan |
| 161 | b(i-2) | Purdue | black body color | 3 | b(i-2) | Purdue |
| 162 | b(M) | Purdue | black body color | 3 | b(M) | Purdue |
| 163 | b(New) | Manhattan | black, dominant | 3 | b(New)/b(ST) | Manhattan |
| 164 | b(ST) | Manhattan | black, dominant | 3 | b(ST)/Chr | Manhattan |
| 165 | b(ST) | Manhattan | black, dominant | 3 | b(ST)/b(New) | Manhattan |
| 166 | b(t) | Dyte & Blackman | tawny body color | 3 | b(t) | San Bernadino |
| 167 | b(t) | Dyte & Blackman | tawny body color | 3 | b(t),p,lod,au,msg | Manhattan |
| 168 | ba | Manhattan | broken antennae | 2 | ba, mxp, apt, pas30 | Manhattan |
| 169 | Bald | Manhattan | Bald (reduced setiferous pits) | 8 | Bald | Manhattan |
| 170 | Bald | Manhattan | Bald (reduced setiferous pits) | 8 | Bald,ap,sq/ap,sq | Manhattan |
| 171 | Bamp27 | Manhattan | Blunt anterior metasternal projection 27 | 3 | Bamp27/+,au/au | Manhattan |
| 172 | Bamp27 | Manhattan | Blunt anterior metasternal projection 27 | 3 | M1/M1,Bamp27/+ | Manhattan |
| 173 | Bamp27,au | Manhattan | Blunt anterior metasternal proj. 27, au (cis) | 3 | Bamp27/+,au/au | Manhattan |
| 174 | Bamp29 | Manhattan | Blunt anterior metasternal projection 29 | 3 | Bamp29/+ | Manhattan |
| 175 | Bamp31 | Manhattan | Blunt anterior metasternal projection 31 | 3 | Bamp31/+ | Manhattan |
| 176 | Bamp58 | Manhattan | Blunt anterior metasterna. projection 58 | 3 | Bamp58/+ | Manhattan |
| 177 | Bamp$^{J-1}$ | Purdue | Blunt anterior metasternal projection J-1 | 3 | Bamp$^{J-1}$/+ | Purdue |
| 178 | BampSp | Manhattan | Blunt anterior metasternal projection Sp | 3 | BampSp/+ | Manhattan |
| 179 | Be | Lasley & Sokoloff | Bar eye | 4 | Be/+ | San Bernadino |
| 180 | Be | Lasley & Sokoloff | Bar eye | 4 | Be/+, s/s | San Bernadino |
| 181 | bge | Manhattan | bug-eyed | ? | bge | Manhattan |
| 182 | box | Manhattan | box (abdominal) | 2 | box / Es | Manhattan |
| 183 | bz | Manhattan | dark brown-red eye color | ? | bz | Manhattan |
| 184 | c | Eddleman | chestnut eye | 7 | b, apt, sa, c | Manhattan |
| 185 | c | Eddleman | chestnut eye | 7 | Nppc | San Bernadino |
| 186 | c | Eddleman | chestnut eye | 7 | sa,c | San Bernadino |
| 187 | cfl | Manhattan | confusum-like | ? | cfl | Manhattan |
| 188 | Cg | Manhattan | Cleft gular (sutures) | ? | Cg/+ | Manhattan |
| 189 | choc | Manhattan | dark brown-red eye color | ? | choc | Manhattan |
| 190 | Chr | Ackermann | Charcoal body color | 3 | Chr/b(ST) | Manhattan |
| 191 | ChrE | Manhattan | Charcoal (Elytra indented) | 3 | ChrE/+ | Manhattan |
| 192 | co | Manhattan | cola body color | 9 | co,p | Manhattan |
| 193 | co | Manhattan | cola body color | 9 | co,Pyr-R | Manhattan |
| 194 | co | Manhattan | cola body color | 9 | Se,co,p/+,co,p | Manhattan |
| 195 | Crab | Manhattan | Crab (warped legs) | 7 | Crab/PL4 | Manhattan |
| 196 | Cx20 | Manhattan | Cephalothorax 20 | 2 | Cx20/Es1 | Manhattan |
| 197 | Cx5,Stm | Manhattan | Cephalothorax 5, Stm (cis) | 2 | Cx5,Stm/A8 | Manhattan |
| 198 | Cx5,Stm | Manhattan | Cephalothorax 5, Stm (cis) | 2 | Cx5,Stm/A(mc),p | Manhattan |
| 199 | Cx5,Stm | Manhattan | Cephalothorax 5, Stm (cis) | 2 | Cx5,Stm/AgPin | Manhattan |
| 200 | Cx5,Stm | Manhattan | Cephalothorax 5, Stm (cis) | 2 | Cx5,Stm/Es1 | Manhattan |
| 201 | Cx5,Stm | Manhattan | Cephalothorax 5, Stm (cis) | 2 | Cx5,Stm/Lu | Manhattan |
| 202 | Cx5,Stm | Manhattan | Cephalothorax 5, Stm (cis) | 2 | Cx5,Stm/Mcs1R5 | Manhattan |
| 203 | Cx5,Stm | Manhattan | Cephalothorax 5, Stm (cis) | 2 | Cx5,Stm/Skl4R3 | Manhattan |
| 204 | Cx5,Stm | Manhattan | Cephalothorax 5, Stm (cis) | 2 | Cx5,Stm/Skl6R1 | Manhattan |
| 205 | Cx5,Stm,AD100 | Manhattan | Cephalothorax 5, Stm, notched gena | 2 | Cx5,Stm,AD100/Es1 | Manhattan |
| 206 | Cx6 | Manhattan | Cephalothorax 6 | 2 | Cx6/Es1 | Manhattan |
| 207 | Dch1 | Sokoloff | Dachshund 1 | 2;9 | Dch1/Es1 | Manhattan |
| 208 | Dch1 | Sokoloff | Dachshund 1 | 2;9 | Dch1/Lu | Manhattan |
| 209 | Dch1 | Sokoloff | Dachshund 1 | 2;9 | Dch1/Skl6 | Manhattan |
| 210 | Dch3 | Manhattan | Dachshund 3 | 2;9 | Dch3/ Ey | Manhattan |
| 211 | Dch4 | Manhattan | Dachshund 4 | 2 | Dch4 / Es | Manhattan |
| 212 | Det43 | Manhattan | Divergent elytral tips | 4;5 | Det43/+ | Manhattan |
| 213 | Df(Dch1) | Manhattan | Deficiency (from Dch1) | 2 | Df(Dch1)/Ey | Manhattan |
| 214 | Df1-3/Ey | Manhattan | Deficiency | 2 | Df1-3/Dp/Es1 | Manhattan |
| 215 | Df1-3/Ey | Manhattan | Deficiency | 2 | Df1-3/Ey | Manhattan |
| 216 | Df1-5/Ey | Manhattan | Deficiency | 2 | Df1-5/Ey | Manhattan |
| 217 | dms | Manhattan | distorted metasternal suture | ? | dms | Manhattan |
| 218 | Dp | Manhattan | Duplication (from Dch1) | 2 | Dp/Es1/Df(Dch) | Manhattan |

| | | | | | | |
|---|---|---|---|---|---|---|
| 219 | Dp | Manhattan | Duplication (from Dch1) | 2 | Dp/Es1/Df1-3 | Manhattan |
| 220 | Dp | Manhattan | Duplication (from Dch1) | 2 | Dp/Es1/pas30 | Manhattan |
| 221 | Dp | Manhattan | Duplication (from Dch1) | 2 | Dp/Ey/Ey | Manhattan |
| 222 | DpLu | Manhattan | Duplication (from Lu) | 2 | DpLu/Ey | Manhattan |
| 223 | DpSpa | Manhattan | Duplication (from Spa) | 2 | DpSpa/Es1/pas30 | Manhattan |
| 224 | Ds | Oregon State U. | Displaced sternellum | 4 | Ds/+ | Manhattan |
| 225 | ds(euD) | Manhattan | displaced sternellum (from euD) | ? | ds(euD) | Manhattan |
| 226 | Ds(New) | Manhattan | Displaced sternellum | ? | Ds(New)/+ | Manhattan |
| 227 | ds-X | Manhattan | displaced sternellum, x-linked | 4?;X | ds-X | Manhattan |
| 228 | Em,A16s | Manhattan | Enlarged mentum, abdominal (cis) | 2 | Em,A16s/Stb | Manhattan |
| 229 | Er | Manhattan | Eye reduced | 2 | Er/mxpD1,Skl6 | Manhattan |
| 230 | Es | Manhattan | Extra sclerite (abdominal) | 2;4 | AD100,Stm,Cx5/Es1 | Manhattan |
| 231 | Es | Manhattan | Extra sclerite (abdominal) | 2;4 | Ag+RptlD1/Es1 | Manhattan |
| 232 | Es | Manhattan | Extra sclerite (abdominal) | 2;4 | Ag/Es1 | Manhattan |
| 233 | Es | Manhattan | Extra sclerite (abdominal) | 2;4 | Ag4,Stm/Es | Manhattan |
| 234 | Es | Manhattan | Extra sclerite (abdominal) | 2;4 | Ag5,Stm/Es1 | Manhattan |
| 235 | Es | Manhattan | Extra sclerite (abdominal) | 2;4 | Es1/AR102-1 | Manhattan |
| 236 | Es | Manhattan | Extra sclerite (abdominal) | 2;4 | Es1/AR2 | Manhattan |
| 237 | Es | Manhattan | Extra sclerite (abdominal) | 2;4 | Es1/AR2a-2 | Manhattan |
| 238 | Es | Manhattan | Extra sclerite (abdominal) | 2;4 | Es1/AR3a-1 | Manhattan |
| 239 | Es | Manhattan | Extra sclerite (abdominal) | 2;4 | Es1/AR4a(Dp)/Ey | Manhattan |
| 240 | Es | Manhattan | Extra sclerite (abdominal) | 2;4 | Es1/AR5a | Manhattan |
| 241 | Es | Manhattan | Extra sclerite (abdominal) | 2;4 | Es1/AR6a-1 | Manhattan |
| 242 | Es | Manhattan | Extra sclerite (abdominal) | 2;4 | Es1/AR6a-2 | Manhattan |
| 243 | Es | Manhattan | Extra sclerite (abdominal) | 2;4 | Es1/AR8a | Manhattan |
| 244 | Es | Manhattan | Extra sclerite (abdominal) | 2;4 | Es1/ARA3 | Manhattan |
| 245 | Es | Manhattan | Extra sclerite (abdominal) | 2;4 | Es1/ARA4 | Manhattan |
| 246 | Es | Manhattan | Extra sclerite (abdominal) | 2;4 | box / Es | Manhattan |
| 247 | Es | Manhattan | Extra sclerite (abdominal) | 2;4 | Es1/Cx5,Stm | Manhattan |
| 248 | Es | Manhattan | Extra sclerite (abdominal) | 2;4 | Cx6/Es1 | Manhattan |
| 249 | Es | Manhattan | Extra sclerite (abdominal) | 2;4 | Cx20/Es1 | Manhattan |
| 250 | Es | Manhattan | Extra sclerite (abdominal) | 2;4 | Dch1/Es1 | Manhattan |
| 251 | Es | Manhattan | Extra sclerite (abdominal) | 2;4 | Dch3/Es1 | Manhattan |
| 252 | Es | Manhattan | Extra sclerite (abdominal) | 2;4 | Det43/Es | Manhattan |
| 253 | Es | Manhattan | Extra sclerite (abdominal) | 2;4 | Dp/Es1/Df(Dch) | Manhattan |
| 254 | Es | Manhattan | Extra sclerite (abdominal) | 2;4 | Dp/Es1/Df1-3 | Manhattan |
| 255 | Es | Manhattan | Extra sclerite (abdominal) | 2;4 | Dp/Es1/pas30 | Manhattan |
| 256 | Es | Manhattan | Extra sclerite (abdominal) | 2;4 | DpSpa/Es1/pas30 | Manhattan |
| 257 | Es | Manhattan | Extra sclerite (abdominal) | 2;4 | DpLu (Es1,Skl6)/Ey | Manhattan |
| 258 | Es | Manhattan | Extra sclerite (abdominal) | 2;4 | Ey/Es1 | Manhattan |
| 259 | Es | Manhattan | Extra sclerite (abdominal) | 2;4 | g/Es | Manhattan |
| 260 | Es | Manhattan | Extra sclerite (abdominal) | 2;4 | GoPL6/Es1 | Manhattan |
| 261 | Es | Manhattan | Extra sclerite (abdominal) | 2;4 | GoPL10/Es1 | Manhattan |
| 262 | Es | Manhattan | Extra sclerite (abdominal) | 2;4 | GoPL11/Es1 | Manhattan |
| 263 | Es | Manhattan | Extra sclerite (abdominal) | 2;4 | GoPL14/Es1 | Manhattan |
| 264 | Es | Manhattan | Extra sclerite (abdominal) | 2;4 | Hw/mxpX9,Es1 | Manhattan |
| 265 | Es | Manhattan | Extra sclerite (abdominal) | 2;4 | Ip69/Es1 | Manhattan |
| 266 | Es | Manhattan | Extra sclerite (abdominal) | 2;4 | LuR1a/Es1 | Manhattan |
| 267 | Es | Manhattan | Extra sclerite (abdominal) | 2;4 | Mc-2,Utx1/Es1 | Manhattan |
| 268 | Es | Manhattan | Extra sclerite (abdominal) | 2;4 | mxp8/Es1 | Manhattan |
| 269 | Es | Manhattan | Extra sclerite (abdominal) | 2;4 | mxp19/Es1 | Manhattan |
| 270 | Es | Manhattan | Extra sclerite (abdominal) | 2;4 | mxp170/Es1 | Manhattan |
| 271 | Es | Manhattan | Extra sclerite (abdominal) | 2;4 | mxpX9,Es1/Ey | Manhattan |
| 272 | Es | Manhattan | Extra sclerite (abdominal) | 2;4 | Ns, Stm/Es1 | Manhattan |
| 273 | Es | Manhattan | Extra sclerite (abdominal) | 2;4 | ptlD16, Stm/Es1 | Manhattan |
| 274 | Es | Manhattan | Extra sclerite (abdominal) | 2;4 | ptlD57, Stm/Es1 | Manhattan |
| 275 | Es | Manhattan | Extra sclerite (abdominal) | 2;4 | Spa/Es1 | Manhattan |
| 276 | Es | Manhattan | Extra sclerite (abdominal) | 2;4 | Stb/Es1 | Manhattan |
| 277 | Es | Manhattan | Extra sclerite (abdominal) | 2;4 | Stbd/Es1 | Manhattan |
| 278 | Es | Manhattan | Extra sclerite (abdominal) | 2;4 | Stm+RSptlD/Es1 | Manhattan |
| 279 | Es | Manhattan | Extra sclerite (abdominal) | 2;4 | Stm-Es1/+NDJ | Manhattan |
| 280 | Es | Manhattan | Extra sclerite (abdominal) | 2;4 | StmR1/Es1 | Manhattan |
| 281 | Es | Manhattan | Extra sclerite (abdominal) | 2;4 | StmR2/Es1 | Manhattan |
| 282 | Es | Manhattan | Extra sclerite (abdominal) | 2;4 | StmR5/Es1 | Manhattan |
| 283 | Es | Manhattan | Extra sclerite (abdominal) | 2;4 | StmR6/Es1 | Manhattan |
| 284 | Es | Manhattan | Extra sclerite (abdominal) | 2;4 | StmR,Ag4/Es1 | Manhattan |
| 285 | Es | Manhattan | Extra sclerite (abdominal) | 2;4 | tr/Es | Manhattan |
| 286 | Es | Manhattan | Extra sclerite (abdominal) | 2;4 | Utx1/Es | Manhattan |
| 287 | Es | Manhattan | Extra sclerite (abdominal) | 2;4 | Utx2,Stm/Es | Manhattan |
| 288 | Es(Skl6) | Manhattan | Extra sclerite (from Skl6) | 2 | Es(Skl6)/+ | Manhattan |
| 289 | Es(Skl6) | Manhattan | Extra sclerite (from Skl6) | 2 | Es(Skl6)GoPL4 | Manhattan |
| 290 | Es1+R1 | Manhattan | Extra sclerite revertant 1 | 2 | Es1+R1/Ey | Manhattan |
| 291 | Es1+R9 | Manhattan | Extra sclerite revertant 9 | 2 | Es1+R9/Ey | Manhattan |
| 292 | Es2 | Manhattan | Extra sclerite 2 | 2 | Es2/Ag5 | Manhattan |

| | | | | | | |
|---|---|---|---|---|---|---|
| 293 | eu | Lasley & Sokoloff | extra urogomphi | 2 | eu | San Bernadino |
| 294 | eu | Lasley & Sokoloff | extra urogomphi | 2 | eu, apt, mas | Manhattan |
| 295 | eu | Lasley & Sokoloff | extra urogomphi | 2 | eu, mas | Manhattan |
| 296 | euD | Manhattan | Extra urogomphi (male sterile) | 2 | euD/+ | Manhattan |
| 297 | Ey | Manhattan | eyeless | 2;5 | A10 / Ey | Manhattan |
| 298 | Ey | Manhattan | eyeless | 2;5 | A12/Ey | Manhattan |
| 299 | Ey | Manhattan | eyeless | 2;5 | A15,Stm/Ey | Manhattan |
| 300 | Ey | Manhattan | eyeless | 2;5 | Dch3 / Ey | Manhattan |
| 301 | Ey | Manhattan | eyeless | 2;5 | Df(Dch1)/Ey | Manhattan |
| 302 | Ey | Manhattan | eyeless | 2;5 | Df1-3/Ey | Manhattan |
| 303 | Ey | Manhattan | eyeless | 2;5 | Df1-5/Ey | Manhattan |
| 304 | Ey | Manhattan | eyeless | 2;5 | DpLu/Ey | Manhattan |
| 305 | Ey | Manhattan | eyeless | 2;5 | Ey/Es1 | Manhattan |
| 306 | Ey | Manhattan | eyeless | 2;5 | LuR1a/Ey | Manhattan |
| 307 | Ey | Manhattan | eyeless | 2;5 | LuRptl/Ey | Manhattan |
| 308 | Ey | Manhattan | eyeless | 2;5 | Mcs1R1/Ey | Manhattan |
| 309 | Ey | Manhattan | eyeless | 2;5 | Mcs1R2/Ey | Manhattan |
| 310 | Ey | Manhattan | eyeless | 2;5 | mxpD1,Skl6/Ey | Manhattan |
| 311 | Ey | Manhattan | eyeless | 2;5 | mxpX9,Es1/Ey | Manhattan |
| 312 | Ey | Manhattan | eyeless | 2;5 | ptlD60/Ey | Manhattan |
| 313 | Ey | Manhattan | eyeless | 2;5 | Skl4R2/Ey | Manhattan |
| 314 | Ey,A14 | Manhattan | Eyeless, Abdominal 14 (cis) | 2 | Ag5,Stm/Ey,A14 | Manhattan |
| 315 | fa | Manhattan | fused antennae | 5? | fa | Manhattan |
| 316 | fe | Manhattan | folded elytra | ? | fe | Manhattan |
| 317 | Ff | Purdue | fused funnicle | 8 | Ff/+ | Purdue |
| 318 | fs(sa) | Manhattan | short antennae, female sterile | ? | fs(sa) | Manhattan |
| 319 | Fta | Sokoloff & St. Hilaire | Fused tarsi and antennae | ? | Fta/+ | San Bernadino |
| 320 | g | Manhattan | glossy | 2 | g/Es | Manhattan |
| 321 | g | Manhattan | glossy | 2 | g,pas30 | Manhattan |
| 322 | Ga-9s | Georgia | Georgia back-X to s 9X, sel. For Rmal gene | 4 | Ga-9s | Manhattan |
| 323 | Gi | Sokoloff & Brownlee | Giant (body size) | - | Gi/Gi | San Bernadino |
| 324 | Go | Manhattan | Goliath (body size) | 7 | Go/+ | Manhattan |
| 325 | Go | Manhattan | Goliath (body size) | 7 | Go/+,c/c | Manhattan |
| 326 | Go | Manhattan | Goliath (body size) | 7 | Go/+ b,sa,c/b,sa,c | Manhattan |
| 327 | GoPL10 | Manhattan | Goliath-derived crossover suppressor | 7;2 | GoPL10/Es1 | Manhattan |
| 328 | GoPL11 | Manhattan | Goliath-derived crossover suppressor | 7;2 | GoPL11/Es1 | Manhattan |
| 329 | GoPL14 | Manhattan | Goliath-derived crossover suppressor | 7;2 | GoPL14/Es1 | Manhattan |
| 330 | GoPL4 | Manhattan | Goliath-derived crossover suppressor | 7;2 | GoPL4/Ag5,Stm | Manhattan |
| 331 | GoPL4 | Manhattan | Goliath-derived crossover suppressor | 7;2 | GoPL4/Crab | Manhattan |
| 332 | GoPL4 | Manhattan | Goliath-derived crossover suppressor | 7;2 | GoPL4/Es(Skl6) | Manhattan |
| 333 | GoPL6 | Manhattan | Goliath-derived crossover suppressor | 7;2 | GoPL6/Es1 | Manhattan |
| 334 | h | Dawson | hazel eye | 4 | h, s | San Bernadino |
| 335 | H-1 (ST) | Parkside | H-factor | 9 | H-1 | U.Wisc.-Parkside |
| 336 | H-2 (ST) | Parkside | H-factor | 9 | H-2 | U.Wisc.-Parkside |
| 337 | Hw | Manhattan | Hairy wing | 2 | Hw/Es,mxpX9 | Manhattan |
| 338 | i | Bartlett | ivory (eye color) | 9 | i,lod | San Bernadino |
| 339 | Is | Manhattan | Incomplete sternellum | ? | Is/+ | Manhattan |
| 340 | j | Park | jet, body color | 5 | j,mc | San Bernadino |
| 341 | j | Park | jet, body color | 5 | mc,rb,j | Manhattan |
| 342 | j | Park | jet, body color | 5 | rb,j | San Bernadino |
| 343 | j2 (Z-4) | Manhattan | jet, body color | 5 | j2 | Manhattan |
| 344 | ju | Sokoloff | juvenile urogomphi | 4 | ju,eu,b | Manhattan |
| 345 | LF-3 (JS) | Purdue | Lethal free strain | 3 | LF-3 (JS) | Purdue |
| 346 | lod | Sokoloff | light optical diaphragm | 3 | au,lod isoline (JS) | Purdue |
| 347 | lod | Sokoloff | light optical diaphragm | 3 | au,lod,p | San Bernadino |
| 348 | lod | Sokoloff | light optical diaphragm | 3 | b(t),p,lod,au,msg | Manhattan |
| 349 | lod | Sokoloff | light optical diaphragm | 3 | i,lod | San Bernadino |
| 350 | lod | Sokoloff | light optical diaphragm | 3 | lod,p | San Bernadino |
| 351 | lod | Sokoloff | light optical diaphragm | 3 | M1,au,lod,p | Manhattan |
| 352 | lod | Sokoloff | light optical diaphragm | 3 | mc(eg),lod,p | Manhattan |
| 353 | lod | Sokoloff | light optical diaphragm | 3 | Rd(HD),lod,p | Manhattan |
| 354 | lod | Sokoloff | light optical diaphragm | 3 | Rd,mc,lod,p | Manhattan |
| 355 | lp69 | Manhattan | labiopedia 69 | 2 | lp69/Es1 | Manhattan |
| 356 | Lu | Manhattan | Lucifer (dorsal head horns) | 2 | Lu / Stm,Cx5 | Manhattan |
| 357 | Lu | Manhattan | Lucifer (dorsal head horns) | 2 | Lu,Skl6/Stb | Manhattan |
| 358 | Lu | Manhattan | Lucifer (dorsal head horns) | 2 | Lu, au/Dch1 | Manhattan |
| 359 | LuR1a | Manhattan | Lucifer revertant | 2 | LuR1a/Es1 | Manhattan |
| 360 | LuR1a | Manhattan | Lucifer revertant | 2 | LuR1a/Ey | Manhattan |
| 361 | m.l. 9.14 | Manhattan | (Male linked) | 2 | 9.14 (male linked) | Manhattan |
| 362 | M1 | Manhattan | Medea 1 | 3 | M1Big III, p | Manhattan |
| 363 | M1 | Manhattan | Medea 1 | 3 | M1 - iso (G12) | Manhattan |
| 364 | M1 | Manhattan | Medea 1 | 3 | M1,au,M3 | Manhattan |
| 365 | M1 | Manhattan | Medea 1 | 3 | M1,au,p,lod | Manhattan |
| 366 | M1 | Manhattan | Medea 1 | 3 | M1,b | Manhattan |
| 367 | M1 | Manhattan | Medea 1 | 3 | M1 G13B inbred | Manhattan |

| | | | | | | |
|---|---|---|---|---|---|---|
| 368 | M1 | Manhattan | Medea 1 | 3 | M1/M1, Bamp27/+ | Manhattan |
| 369 | M3 | Manhattan | Medea 3 | 3 | M3,au | Manhattan |
| 370 | M3 | Manhattan | Medea 3 | 3 | M1,au,M3 | Manhattan |
| 371 | mas | Hoy & Sokoloff | missing abdominal sternite | 2 | mas | San Bernadino |
| 372 | mas | Hoy & Sokoloff | missing abdominal sternite | 2 | mas, p,au | Manhattan |
| 373 | mas | Hoy & Sokoloff | missing abdominal sternite | 2 | ptl, mas, pas | Manhattan |
| 374 | mas | Hoy & Sokoloff | missing abdominal sternite | 2 | Quint(mxp,apt,mas,pas,ub) | Manhattan |
| 375 | mas | Hoy & Sokoloff | missing abdominal sternite | 2 | MMS (s,rb,mas,ap,au) | Manhattan |
| 376 | mas2 | Manhattan | missing abdominal sternite 2 | 2 | mas2 | Manhattan |
| 377 | mc | Sokoloff & Lasley | microcephalic | 5 | j,mc | San Bernadino |
| 378 | mc | Sokoloff & Lasley | microcephalic | 5 | mc,rb,j | Manhattan |
| 379 | mc(eg) | Sokoloff & Lasley | microcephalic (eye growth variant) | 5 | mc(eg),p,lod | Manhattan |
| 380 | mc(eg) | Sokoloff & Lasley | microcephalic (eye growth variant) | 5 | Rd,mc(eg),lod,p | Manhattan |
| 381 | Mc-2,Utx1 | Manhattan | Microcephalic-2,Ultrathorax(cis) | 2 | Mc-2,Utx1/Es1 | Manhattan |
| 382 | Mcs1 | Manhattan | Miscadestral sclerite | 2 | Mcs1/Stm | Manhattan |
| 383 | Mcs1R1 | Manhattan | Miscadestral sclerite, revertant 1 | 2 | Mcs1R1/Ey | Manhattan |
| 384 | Mcs1R2 | Manhattan | Miscadestral sclerite, revertant 2 | 2 | Mcs1R2/Ey | Manhattan |
| 385 | Mcs1R4 | Manhattan | Miscadestral sclerite, revertant 4 | 2 | Mcs1R4/mxpNG | Manhattan |
| 386 | Mcs1R5 | Manhattan | Miscadestral sclerite, revertant 5 | 2 | Mcs1R5/Stm,Cx5 | Manhattan |
| 387 | Mo | Sokoloff | Micropthalmic | 6 | Mo/+ | San Bernadino |
| 388 | msg | Sokoloff & Hoy | melanotic stink gland | 3 | b(t),p,lod,au,msg | Manhattan |
| 389 | mxp | Sokoloff | maxillopedia | 2 | ba,mxp,apt,pas30 | Manhattan |
| 390 | mxp | Sokoloff | maxillopedia | 2 | mxp, apt, pas30 | Manhattan |
| 391 | mxp | Sokoloff | maxillopedia | 2 | Utx1,mxp,apt/A10,mxpA10 | Manhattan |
| 392 | mxp | Sokoloff | maxillopedia | 2 | Quint(mxp,apt,mas,pas,ub) | Manhattan |
| 393 | mxp170 | Manhattan | maxillopedia 170, lethal | 2 | mxp170/Es1 | Manhattan |
| 394 | mxp19 | Manhattan | maxillopedia 19, lethal | 2 | mxp19/Es1 | Manhattan |
| 395 | mxp8 | Manhattan | maxillopedia 8, lethal | 2 | mxp8/Es1 | Manhattan |
| 396 | mxpD1,Skl6/Ey | Manhattan | Maxillopedia, dom. 1, Skl6 (cis) | 2 | mxpD1,Skl6/Ey | Manhattan |
| 397 | mxpNG | Manhattan | maxillopedia, Notched gena | 2 | Mcs1R4/mxpNG | Manhattan |
| 398 | mxpNG | Manhattan | maxillopedia, Notched Gena, lethal | 2 | mxpNG/Es1 | Manhattan |
| 399 | mxpX9, Es | Manhattan | lethal maxillopedia, Es (cis) | 2;4 | mxpX9,Es1/Ey | Manhattan |
| 400 | Npp | Hoy | Non-punctate prothorax | ? | Nppc (Sokl 428) | San Bernadino |
| 401 | p | Park | pearl eye | 9 | p | San Bernadino |
| 402 | p | Park | pearl eye | 9 | ab,pas30,p | San Bernadino |
| 403 | p | Park | pearl eye | 9 | au, lod, p | San Bernadino |
| 404 | p | Park | pearl eye | 9 | b(t),au,lod, p,msg | Manhattan |
| 405 | p | Park | pearl eye | 9 | co,p | Manhattan |
| 406 | p | Park | pearl eye | 9 | lod, p | San Bernadino |
| 407 | p | Park | pearl eye | 9 | M1Big III, p | Manhattan |
| 408 | p | Park | pearl eye | 9 | mas, p,au | Manhattan |
| 409 | p | Park | pearl eye | 9 | mc(eg),lod, p | Manhattan |
| 410 | p | Park | pearl eye | 9 | pas30, p | Manhattan |
| 411 | p | Park | pearl eye | 9 | Rd,mc(eg),p | Manhattan |
| 412 | p | Park | pearl eye | 9 | Rd,mc(eg),lod, p | Manhattan |
| 413 | p | Park | pearl eye | 9 | Rd(HD),lod, p | Manhattan |
| 414 | p | Park | pearl eye | 9 | Se,co,p/+,co,p | Manhattan |
| 415 | p | Park | pearl eye | 9 | Se,p/+,p | Manhattan |
| 416 | pas | Sokoloff | pointed abdominal sternite | 2 | apt, pas | San Bernadino |
| 417 | pas | Sokoloff | pointed abdominal sternite | 2 | ptl, mas, pas | Manhattan |
| 418 | pas | Sokoloff | pointed abdominal sternite | 2 | Quint(mxp,apt,mas,pas,ub) | Manhattan |
| 419 | pas30 | Manhattan | pointed abdominal sternite 30 | 2 | ab,pas30,p | Manhattan |
| 420 | pas30 | Manhattan | pointed abdominal sternite 30 | 2 | ba,mxp,apt,pas30 | Manhattan |
| 421 | pas30 | Manhattan | pointed abdominal sternite 30 | 2 | mxp,apt,pas30 | Manhattan |
| 422 | pas30 | Manhattan | pointed abdominal sternite 30 | 2 | ub,pas30 | Manhattan |
| 423 | pd | Park & Frank | paddle antenna | X | py, pd, plt | San Bernadino |
| 424 | pep | Manhattan | peppered cuticle | X | pep | Manhattan |
| 425 | pnk (NDG-2) | Manhattan | pink eye, from NDG-2 | X | pnk (NDG-2) | Manhattan |
| 426 | pnk (Tiw-1 iso-43) | Manhattan | pink eye, from Tiw-1 iso-43 | X | pnk (Tiw-1 iso-43) | Manhattan |
| 427 | Ps | Manhattan | Pinched sternellum | 2 | Ps/Rd(CS) | Manhattan |
| 428 | pte | Sokoloff | platinum eye | X | py, pd, plt | San Bernadino |
| 429 | ptl | Lasley & Sokoloff | prothoraxless | 2 | ptl | San Bernadino |
| 430 | ptl | Lasley & Sokoloff | prothoraxless | 2 | ptl, mas, pas | Manhattan |
| 431 | ptl(Rd) | Manhattan | prothoraxless from Rd stock | 2 | ptl(Rd) | Manhattan |
| 432 | ptlD16,Stm | Manhattan | Dom. prothoraxless 16, Stm (cis) | 2 | ptlD16,Stm/Es1 | Manhattan |
| 433 | ptlD2 | Manhattan | Dom. prothoraxless 2 | 2 | ptlD2/Stb | Manhattan |
| 434 | ptlD26Y,Stm | Manhattan | Dom. prothoraxless 26, Y-linked | 2;Y | ptlD26Y,Stm/+ | Manhattan |
| 435 | ptlD57,Stm | Manhattan | Dom. prothoraxless 57, Stm (cis) | 2 | ptlD57,Stm/Es1 | Manhattan |
| 436 | ptlD60 | Manhattan | dominant prothoraxless 60 | 2 | A(Ag1), Stm /ptlD60 | Manhattan |
| 437 | ptlD60 | Manhattan | dominant prothoraxless 60 | 2 | ptlD60/Ey | Manhattan |
| 438 | py | Lasley | pygmy | X | py, pd, plt | San Bernadino |
| 439 | py | Lasley | pygmy | X | py,r,ser | San Bernadino |
| 440 | py2 | Manhattan | pygmy 2 | X | py2 | Manhattan |
| 441 | Pyr-R | Peter Collins | Pyrethroid resistant | 9 | co,Pyr-R | Peter Collins |
| 442 | QTC 279 (Pyr-R) | Peter Collins | Pyrethroid resistant | 9 | QTC 279 (Pyr-R) | Peter Collins |
| 443 | r | Lasley | light red eye color | X | r,sp | San Bernadino |

| | | | | | | |
|---|---|---|---|---|---|---|
| 444 | r | Lasley | light red eye color | X | py,r,ser | San Bernadino |
| 445 | Rap | Manhattan | Recurved anterior pronotum | 2 | Rap | Manhattan |
| 446 | rb | Dewees | ruby eye | 5 | mc,rb,j | Manhattan |
| 447 | rb | Dewees | ruby eye | 5 | MMS (s,rb,ap,au,mas) | Manhattan |
| 448 | rb | Dewees | ruby eye | 5 | rb,j | San Bernadino |
| 449 | Rd | Dawson | Reindeer, homozygous viable | 2 | Rd | San Bernadino |
| 450 | Rd | Dawson | Reindeer, homozygous viable | 2 | Rd, mas, p | Manhattan |
| 451 | Rd | Dawson | Reindeer, homozygous viable | 2 | Rd,mc,p | Manhattan |
| 452 | Rd | Dawson | Reindeer, homozygous viable | 2 | Rd,pas30 | Manhattan |
| 453 | Rd(CS) | Manhattan | Reindeer, crossover suppressor | 2 | Ps/Rd(CS) | Manhattan |
| 454 | Rd(HD) | Manhattan | Reindeer (honey-dipper style) | 2 | Rd(HD) | Manhattan |
| 455 | Rd(HD) | Manhattan | Reindeer (honey-dipper style) | 2 | Rd(HD),lod, p | Manhattan |
| 456 | Rdiel BC9 Lab-S | Unknown | Dieldrin resistant from Lab-S | - | Rdiel BC9 Lab-S | Unknown |
| 457 | s | Bartlett, Bell & Shideler | sooty | 4 | s | San Bernadino |
| 458 | s | Bartlett, Bell & Shideler | sooty | 4 | h, s | San Bernadino |
| 459 | s | Bartlett, Bell & Shideler | sooty | 4 | Be, s | San Bernadino |
| 460 | s | Bartlett, Bell & Shideler | sooty | 4 | Ga-9s | Georgia,1993 |
| 461 | s | Bartlett, Bell & Shideler | sooty | 4 | MMS (s,rb,ap,au,mas) | Manhattan |
| 462 | sa | Sokoloff | short antenna | ? | b, apt, sa, c | Manhattan |
| 463 | sa | Sokoloff | short antenna | ? | Go,b, sa, c | Manhattan |
| 464 | sa | Sokoloff | short antenna | ? | sa,c | San Bernadino |
| 465 | Sa-8 | Manhattan | Short antenna-8 | ? | Sa-8 | Manhattan |
| 466 | sa-X | Manhattan | short antenna, X-linked | X | sa-X | Manhattan |
| 467 | Se | Manhattan | Short elytra | 9 | Se | Manhattan |
| 468 | Se | Manhattan | Short elytra | 9 | Se,co,p | Manhattan |
| 469 | Se | Manhattan | Short elytra | 9 | Se,p | Manhattan |
| 470 | se 46 | Purdue | short elytra 46 | ? | se 46 | Purdue |
| 471 | Se12 | Purdue | Short elytra 12 | ? | Se12 | Purdue |
| 472 | Se-2 | Manhattan | Short elytra 2 | 8 | Se-2 | Manhattan |
| 473 | ser | Dawson | serrate antenna | X | py,r,ser | San Bernadino |
| 474 | Skl2s | Manhattan | Socketless spontaneous 2 | 2 | Skl2s/Stb | Manhattan |
| 475 | Skl4 | Manhattan | Socketless 4 | 2 | Skl4/Ag4,Stm | Manhattan |
| 476 | Skl4R2 | Manhattan | Socketless 4, revertant 2 | 2 | Skl4R2/Ey | Manhattan |
| 477 | Skl4R3 | Manhattan | Socketless 4, revertant 3 | 2 | Skl4R3/Stm,Cx5 | Manhattan |
| 478 | Skl6 | Manhattan | Socketless 6 | 2 | Skl6/Stm,Cx5 | Manhattan |
| 479 | Skl6 | Manhattan | Socketless 6 | 2 | Skl6/Dch1 | Manhattan |
| 480 | Skl6R1 | Manhattan | Socketless 6, revertant 1 | 2 | Skl6R1/Stm,Cx5 | Manhattan |
| 481 | small | Purdue | small body size | ? | small | Purdue |
| 482 | sp | Sokoloff | spotted | X | r,sp | San Bernadino |
| 483 | Spa | Sokoloff & Hoy | Spatulate antennae | 2;4 | Spa/Es1 | Manhattan |
| 484 | sps | Manhattan | shoulder pads | 2 | sp/Stm,Ag4 | Manhattan |
| 485 | sq | Bywaters | squint eye | 8 | Bald,ap,sq/ap,sq | Manhattan |
| 486 | sq | Bywaters | squint eye | 8 | sq | San Bernadino |
| 487 | sq (Tiw-1) | India | squint (from Tiw-1) | ? | sq (Tiw-1) | India |
| 488 | sq(euD) | Manhattan | squint (from euD) | ? | sq(euD) | Manhattan |
| 489 | sq2 | Manhattan | squint eye 2 | 8 | ap,sq2 | Manhattan |
| 490 | sq-B | Burma | squint (from Burma) | ? | sq-B | Burma |
| 491 | Stb | Manhattan | Stubby antennae | 2;X | Ag/Stb | Manhattan |
| 492 | Stb | Manhattan | Stubby antennae | 2;X | Em,A16s/Stb | Manhattan |
| 493 | Stb | Manhattan | Stubby antennae | 2;X | Ey,pasN/Stb | Manhattan |
| 494 | Stb | Manhattan | Stubby antennae | 2;X | Es/Stb | Manhattan |
| 495 | Stb | Manhattan | Stubby antennae | 2;X | Lu,Skl6/Stb | Manhattan |
| 496 | Stb | Manhattan | Stubby antennae | 2;X | ptlD2/Stb | Manhattan |
| 497 | Stb | Manhattan | Stubby antennae | 2;X | Skl2s/Stb | Manhattan |
| 498 | Stbd | Manhattan | Stubboid (short antennae) | 2 | Lu/Stbd | Manhattan |
| 499 | Stbd | Manhattan | Stubboid (short antennae) | 2 | Stbd/Es | Manhattan |
| 500 | Stm | Manhattan | Stumpy | 2 | Stm/Stm | Manhattan |
| 501 | Stm,Ag4 | Manhattan | Stm, Antennagalea 4 | 2 | X-83/Stm,Ag4 | Manhattan |
| 502 | Stm,Ag4 | Manhattan | Stm, Antennagalea 4 | 2 | X-47/Stm,Ag4 | Manhattan |
| 503 | Stm,Ag4 | Manhattan | Stm, Antennagalea 4 | 2 | vwe/Stm,Ag4 | Manhattan |
| 504 | Stm,Ag4 | Manhattan | Stm, Antennagalea 4 | 2 | sp/Stm,Ag4 | Manhattan |
| 505 | Stm,Ag4 | Manhattan | Stm, Antennagalea 4 | 2 | g/Stm,Ag4 | Manhattan |
| 506 | Stm,Ag4 | Manhattan | Stm, Antennagalea 4 | 2 | X-31/Stm,Ag4 | Manhattan |
| 507 | Stm,Ag5 | Manhattan | Stm, Antennagalea 5 | 2 | A4/Stm,Ag5 | Manhattan |
| 508 | Stm,Ag5 | Manhattan | Stm, Antennagalea 5 | 2 | A10,mxpA10/Stm,Ag5 | Manhattan |
| 509 | Stm,Ag5 | Manhattan | Stm, Antennagalea 5 | 2 | A14,Ey/Stm,Ag5 | Manhattan |
| 510 | Stm,Ag5 | Manhattan | Stm, Antennagalea 5 | 2 | Es2/Stm,Ag5 | Manhattan |
| 511 | Stm,Ag5 | Manhattan | Stm, Antennagalea 5 | 2 | GoPL4/Stm,Ag5 | Manhattan |
| 512 | Stm,Cx5 | Manhattan | Stm, Cephalothorax 5, cis | 2 | A8/Stm,Cx5 | Manhattan |
| 513 | Stm,Cx5 | Manhattan | Stm, Cephalothorax 5, cis | 2 | AgPin/Stm,Cx5 | Manhattan |
| 514 | Stm,Cx5 | Manhattan | Stm, Cephalothorax 5, cis | 2 | Lu / Stm,Cx5 | Manhattan |
| 515 | Stm,Cx5 | Manhattan | Stm, Cephalothorax 5, cis | 2 | AD100,Stm,Cx5/Es1 | Manhattan |
| 516 | Stm,Cx5 | Manhattan | Stm, Cephalothorax 5, cis | 2 | Skl4R3/Stm,Cx5 | Manhattan |
| 517 | Stm,Cx5 | Manhattan | Stm, Cephalothorax 5, cis | 2 | Skl6R1/Stm,Cx5 | Manhattan |
| 518 | Stm,Cx5 | Manhattan | Stm, Cephalothorax 5, cis | 2 | Stm,Cx5/Es1 | Manhattan |
| 519 | Stm,Ns | Manhattan | Stm, Narrow sternellum (cis) | 2 | Stm,Ns/Es1 | Manhattan |

| | | | | | | |
|---|---|---|---|---|---|---|
| 520 | Stm+RSptlD | Manhattan | Stm spontaneous revertant, ptl (dominant) | 2 | Stm+RSptlD/Es1 | Manhattan |
| 521 | Stm-Es1/+NDJ | Manhattan | Non-disjunction | ? | Stm-Es1/+NDJ | Manhattan |
| 522 | StmR1 | Manhattan | Stm revertant 1 | 2 | StmR1/Es1 | Manhattan |
| 523 | StmR2 | Manhattan | Stm revertant 2 | 2 | StmR2/Es1 | Manhattan |
| 524 | StmR5 | Manhattan | Stm revertant 5 | 2 | StmR5/Es1 | Manhattan |
| 525 | StmR6 | Manhattan | Stm revertant 6 | 2 | StmR6/Es1 | Manhattan |
| 526 | Stm-Skl6/+NDJ | Manhattan | Non-disjunction | ? | Stm-Skl6/+NDJ | Manhattan |
| 527 | T(Y;3) | Manhattan | Translocation Y-3 | Y:3 | T(Y;3) | Manhattan |
| 528 | T(Y;4) | Manhattan | Translocation Y-4 | Y;4 | T(Y;4) | Manhattan |
| 529 | tar | Manhattan | anterior melanotic stink glands | 2 | tar | Manhattan |
| 530 | tib | Manhattan | tibialess (from ab) | 9? | tib | Manhattan |
| 531 | Tiw-1 (iso 43) | India | Tiw-1 isoline with homozygous H-factor | - | Tiw-1 (iso 43) | U.Wisc.-Parkside |
| 532 | tr | Manhattan | trembler, homozygous viable | 2;4 | tr | Manhattan |
| 533 | tr | Manhattan | trembler, recessive lethal | 2;4 | Es/tr | Manhattan |
| 534 | ub | Manhattan | unbuckled | 2 | ub | Manhattan |
| 535 | ub | Manhattan | unbuckled | 2 | ub,pas50 | Manhattan |
| 536 | ub | Manhattan | unbuckled | 2 | Quint(ub,mxp,apt,mas,pas) | Manhattan |
| 537 | ue | Manhattan | unsclerotized elytra | ? | ue | Manhattan |
| 538 | Utx(New) | Manhattan | Ultrathorax (New) | 2 | Utx(New)/+ | Manhattan |
| 539 | Utx1 | Manhattan | Ultrathorax | 2 | Utx1/Es | Manhattan |
| 540 | Utx1 | Manhattan | Ultrathorax | 2 | Utx1/Utx1 | Manhattan |
| 541 | Utx2,Stm | Manhattan | Ultrathorax 2, Stm (cis) | 2 | Utx2,Stm/Es1 | Manhattan |
| 542 | vwe | Manhattan | vestigial wings and elytra | 2 | vwe/Stm,Ag4 | Manhattan |
| 543 | w | Eddleman & Bell | white eye | 4 | w | San Bernadino |
| 544 | X(ab-1s) | Manhattan | Lethal revertant from ab | 9 | X(ab-1s)/Ag4,Stm | Manhattan |
| 545 | X-31 | Manhattan | lethal 31 | 2 | X-31/Ag4,Stm | Manhattan |
| 546 | X-47 | Manhattan | lethal 47 | 2 | X-47/Stm,Ag4 | Manhattan |
| 547 | X-83 | Manhattan | Lethal 83 | 2 | X-83/Stm,Ag4 | Manhattan |

## Tribolium confusum: wild-type stocks

| | Stock Name | Stock Origin | Full Name or description | Linkage Group | Stocks | Stock Developed by/Received From: |
|---|---|---|---|---|---|---|
| 548 | BA50 - cf | Kansas | Tribolium confusum | - | BA50 - cf | Kansas, ~1986-87 |
| 549 | HP70 - cf | Kansas | Tribolium confusum | - | HP70 - cf | Kansas, ~1986-87 |
| 550 | MN61 - cf | Kansas | Tribolium confusum | - | MN61 - cf | Kansas, ~1986-87 |
| 551 | PAK-3-cf | Pakistan | Tribolium confusum | - | PAK-3-cf | Pakistan, 1988 |
| 552 | P-Ning -cf | China | Tribolium confusum | - | P-Ning -cf | China,1989 |
| 553 | T. confusum (PRC) | P.R. China | Tribolium confusum | - | T. confusum (PRC) | P.R. China |
| 554 | ThaiB-cf (tan eye) | Thailand | Tribolium confusum | - | ThaiB-cf (tan eye) | Thailand, 19?? |
| 555 | UG-2 cf | Uganda | Tribolium confusum | - | UG-2 cf | Uganda, 1989 |

## Tribolium confusum: mutant stocks

| | Mutant Name | Mutant Origin | Full Name or description | Linkage Group | Stocks | Stock Developed by/Received From: |
|---|---|---|---|---|---|---|
| 556 | T. confusum (apt,mas,sti) | San Bernadino | T.cf.(alate prothorax, missing abd. stern., sti | ? | T. confusum (apt,mas,sti) | San Bernadino |
| 557 | T. confusum (b,au,lod,p) | San Bernadino | T.cf. (black, aureate, light optical diaph., pear | ? | T. confusum (b,au,lod,p) | San Bernadino |
| 558 | T. confusum (lod,p) | San Bernadino | light optical diaphragm, pearl | ? | T. confusum (lod,p) | San Bernadino |

## Other Species:

| | Stock Name | Stock Origin | Full Name or description | Linkage Group | Stocks | Stock Developed by/Received From: |
|---|---|---|---|---|---|---|
| 559 | Gnathocerus cornutus | ? | wild-type strain | - | Gnathocerus cornutus | ? |
| 560 | Longheaded flour beetle | ? | wild-type strain | - | Longheaded flour beetle | ? |
| 561 | T. brevicornis | Manhattan | Tribolium brevicornis | - | T. brevicornis | Manhattan |
| 562 | T. freemani | Japan | Tribolium freemani | - | T. freemani | Japan |
| 563 | T. madens | Manhattan | Tribolium madens | - | T. madens | Manhattan |

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Stock Lists

Biological Research Unit
Grain Marketing and Production Research Center
1515 College Avenue
Manhattan, Kansas 66502

**Laboratory Colonies, October 2000**

**COLEOPTERA**

**Curculionidae**

| | |
|---|---|
| Sitophilus granarius (Linnaeus) | Granary Weevil |
| Sitophilus oryzae (Linnaeus) | Rice Weevil |
| Sitophilus zeamaise Motschulsky | Maize Weevil |

**Bostrichidae**

| | |
|---|---|
| Prostephanus truncatus (Horn) | Larger Grain Borer |
| Rhyzopertha dominica (Fabricius) | Lesser Grain Borer |

**Tenebrionidae**

| | |
|---|---|
| Tribolium castaneum (Herbst) | Red Flour Beetle |
| Tribolium confusum Jacquelin du Val | Confused Flour Beetle |
| Tribolium freemani Hinton | Kashmir Flour Beetle |
| Tribolium brevicornis (LeConte) | Giant Flour Beetle |
| Tribolium madens (Charpentier) | Black Flour Beetle |
| Cynaeus angustus (LeConte) | Larger Black Flour Beetle |
| Tenebrio molitor Linnaeus | Yellow Mealworm |
| Latheticus oryzae Waterhouse | Longheaded flour beetle |
| Palorus subdepressus (Wollaston) | Depressed flour beetle |
| Palorus ratzeburgii (Wissmann) | Smalleyed Flour Beetle |
| Gnatocerus conutus (Fabricius) | Broadhorned Flour Beetle |
| Alphitobius diaperinus (Panzer) | Lesser Mealworm |

**Silvanidae** (as classified by Halstead, 1993)

| | |
|---|---|
| Oryzaephilus surinamensis (Linnaeus) | Sawtoothed Grain Beetle |
| Oryzaephilus mercator (Fauvel) | Merchant Grain Beetle |
| Ahasverus advena (Waltl) | Foreign Grain Beetle |
| Cathartus quadricolis (Guerin-Meneville) | Squarenecked Grain Beetle |

**Laemophloeidae** (as classified by Halstead, 1993)

| | |
|---|---|
| Cryptolestes pusillus (Schoenherr) | Flat Grain Beetle |
| Cryptolestes ferrugineus (Stephens) | Rusty Grain Beetle |

**Trogositidae**

| | |
|---|---|
| Tenebroides mauritanicus (Linnaeus) | Cadelle |
| Lophocateres pusillus (Klug) | Siamese Grain Beetle |

**Dermestidae**

| | |
|---|---|
| Trogoderma variabile Ballion | Warehouse Beetle |
| Anthrenus verbasci (Linnaeus) | Varied Carpet Beetle |
| Dermestes ater De Geer | Black Larder Beetle |
| Attagenus unicolor (Brahm) | Black Carpet Beetle |
| Trogoderma inclusum Leconte | Larger Cabinet Beetle |

**(GMPRC Laboratory Colonies, October 2000 - continued)**

**Anobiidae**
Lasioderma serricorne (Fabricius) — Cigarette Beetle
Stegobium paniceum (Linnaeus) — Drugstore Beetle

**Mycetophagidae**
Typhaea stercorea (Linnaeus) — Hairy Fungus Beetle

**Ptinidae**
Gibbium aequinoctiale Boieldieu — A Spider Beetle
Mezium affine Boieldieu — Northern Spider Beetle

**Bruchidae**
Callosobruchus maculatus (Fabricius) — Cowpea Weevil
Acanthoscelides obtectus (Say) — Bean Weevil

**LEPIDOPTERA**

**Pyralidae**
Plodia interpunctella (Hubner) — Indian Meal Moth
Corcyra cephalonica (Stainton) — Rice Moth
Ephestia [Cadra] cautella (Walker) — Almond Moth
Anagasta kuehniella (Zeller) — Mediterranean Flour Moth

**Gelechiidae**
Sitotroga cerealella (Olivier) — Angoumois Grain Moth

**Sphingidae**
Manduca sexta (Linnaeus) — Tobacco Hornworm
[Eggs obtained from Carolina Biological Supply]

**HEMIPTERA**

**Anthocoridae**
Xylocoris flavipes (Reuter) — Warehouse Pirate Bug

**HYMENOPTERA**

**Braconidae**
Bracon [Habrobracon] hebetor — Host: Indian Meal Moth

**Bethylidae**
Cephalonomia tarsalis (Ashmead) — Host: Sawtoothed Grain Beetle
Cephalonomia waterstoni Gahan — Host: Rusty Grain Beetle

**Pteromalidae**
Anisopteromalus calandrae (Howard) — Host: Rice Weevil
Pteromalus [Hybrocytus] cerealellae (Ashmead) — Host: Angoumois Grain Moth, Cowpea Weevil
Theocolax [Choetosphila] elegans Westwood — Host: Rice Weevil, Lesser Grain Borer

*Brenda Waters <waters@usgmrl.ksu.edu>*

Stock Lists

SAVANNAH, GEORGIA
STORED-PRODUCT INSECTS RESEARCH AND DEVELOPMENT LABORATORY

I. Wild type strains

A. Lepidoptera

| | | |
|---|---|---|
| 1. | *Cadra cautella* (Walker) | N.C. Tifton, Ga. |
| 2. | *Plodia interpunctella* (Hubner) | Modesto, Ca. |
| 3. | *Sitotroga cerealella* (Olivier) | Manhattan, Ka Can., and Durham, N.H. |

b. Coleoptera

| | | |
|---|---|---|
| 1. | *Attagenus megatoma* (Fab.) | CSMA strains |
| 2. | *Callosobruchus maculatus* (Fab.) | Fresno, ca. |
| 3. | *Cryptolestes ferrugineus* (Stephens) | S. Carolina |
| 4. | *Lasioderma serricorne* (Fab.) | Unknown |
| 5. | *Oryzaephilus mercator* (Fauvel) | Unknown |
| 6. | *Oryzaephilus surinamensis* (L.) | Manhattan, Kan. |
| 7. | *Rhyzopertha dominica* Fab.) | Unknown |
| 8. | *Sitophilus granarius* (L.) | Manhattan, Kan. |
| 9. | *S. oryzae* (L.) | Ark., Calif., Kan., La. |
| 10. | *S. zeamais* Motchulsky | Estill, S.C. |
| 11. | *Stegobium paniceum* (L.) | Madison, Wis. |
| 12. | *Tribolium castaneum* (Herbst) | Unknown |
| 13. | *Tribolium confusum* duVal | Manhattan, Kan. |
| 14. | *Trogoderma glabrum* (Herbst) | Madison, wis., Riverside, Ca. |

II. Mutant strains. None

Richard T. Arbogast, Laboratory Director.

South Orange, New Jersey
Seton Hall University
Department of Biology

*T. castaneum*

Wild Type Strains

Seton Hall-1

McGill, via California State

Synthetic Strains

Pearl Foundation, via Purdue University

Black Foundation, via Purdue University

Mutant Strains

| | |
|---|---|
| Paddle (pd) | via Cal State U., S.B. |
| Red $(R^{Mo\ Mo})$ | Via Cal State U., S.B. |
| White (w) | Via Cal State U., S.B. |
| short antenna (ca) | Via Oregon State |
| Short antenna (Sa) | Via Purdue University |

*Tribolium confusum* Via Carolina Biological Supply

Eliot Krause

Storrs, CT 06269
University of Biology

*Tribolium castaneum*
Ga-1
sooty
Charcoal
RR strain from Costantino
*Oryzaephilus surinamensis*

J.S. Bancroft

ST. PAUL, MINNESOTA
UNIVERSITY OF MINNESOTA
DEPARTMENT OF ENTOMOLOGY, FISHERIES AND WILDLIFE

I. Wild type strains

A. Coleoptera strains

Dermestidae
- Attagenus megatoma (F.) — Madison, Wis., 1975, Savannah, Ga. 1974
- Trogoderma variabile Ballion — field collected, Mn. 1972

Cucujidae
- Oryzaephilus surinamensis (L)
- Oryzaephilus mercator (Fauvel)
- Cryptolestes pusillus (Schoenherr) Manhattan Ka. 1967
- Cryptolestes ferrugineus (Stephens) Unknown

Silvanidae
- Ahasverus advena Waltl. — Minnesota

| | |
|---|---|
| **Tenebrionidae** | |
| Cyaneus angustus (LeConte) | Winnipeg; Minnesota |
| Tribolium castaneum (Herbst) | Corvallis, Ore |
| Tribolium confusum duVal | Unknown |
| Tenebrio molitor | Carolina Biological, 1984 |
| **Anobiidae** | |
| Lasioderma serricorne (Fab.) | Savannah, Ga. |
| **Bostrichidae** | |
| Rhizopertha dominica (F.) | Manhattan, Ka. |
| Prostephanus truncatus (Horn) | Unknown |
| **Curculionidae** | |
| Sitophilus granarius (L.) | Unknown |
| S. oryzae (L.) | " |

B. Lepidoptera

| | |
|---|---|
| **Pyralidae** | |
| Anagasta kuehniella (Zeller) | Savannah, Ga. |
| **Gelechiidae** | |
| Sitotroga cerealella (Oliver) | Savannah, Ga. |

(Ed.)

St. Paul, Minnesota 55108
University of Minnesota
Department of Entomology
Stored-Grain Pest Management Program

Eight species of stored-product beetles and two species of moths are maintained in the laboratory. These species include: Angoumois grain moth, flat grain beetle, Indian meal moth, larger brain borer, lesser grain borer, merchant grain beetle, red flour beetle, red flour beetle, rusty grain beetle, rice weevil, and sawtoothed grain beetle.
The Angoumois grain moth was obtained in June 1993 from Community Research Service, Kentucky State University, Kentucky. All other species were obtained in January 1992 from the Department of Entomology, Kansas State University, Manhattan, Kansas. Except for the merchant grain beetle, all species originated from farm-stored grain. The origin of merchant grain beetles is unknown.
Areas of research:
Developing and validating sampling schemes for insects associated with farm-stored grain.
Evaluating nonchemical alternatives for suppressing stored-grain traits.
Modeling population trends of insects from life-history traits.

Bhadriraju Subramanyam, Ph. D.

San Bernardino, CA 92407
California State University
Biology Department

Tribolium btrevicornis

Wild Type Strains

1. Original Waterman Population #2
2. Original Waterman Population #1
3, Waterman
4. Waterman
5. Waterman
6. Riverside
7. Riverside
8. Waterman
9. Waterman
10. Waterman
11. Waterman Canyon +/+
12.Waterman Canyhon II
12'. Riverside
13. Riverside
13' Riverside

Mutant Strains.

15. Red eyed mutation and fas-1
16. Strong Rg (reduced gena) fas-1
17. msg-like melanotic stink glands?
18. Short elytra (sshe)
19. she (te-like)
20. short elytra (se)
21. light ocular diaphragm? (lod)
22. incomplete mesosternum (ims)
23 creased abdominal sternites (cas)

## Stock Lists

Tribolium castaneum

Wild type strains

1. Chicago
4. Davis
8. McGill
12. Sacramento
16. Yucaipa
19. Synthetic, marked with sooty
22. Wildtype
23. New York

Mutant strains

| | |
|---|---|
| 31. pg , (p) | pegleg, pearl |
| 33 ros apt | roseate, alate prothorax |
| 38 r | red |
| 51 dve, pd | divergent elytra, paddle |
| 53 pd, py | paddle, pygmy |
| 55 py, r | pygmy, red |
| 56 msg, py, r | pygmy, red, melanotic stink glands |
| 59 .r sp | red. Spotted |
| 68. Malta p | Malta pearl |
| 70 pg | peg leg |
| 74 mas, p (pg) | missing abdominal segments, pearl, pegleg |
| 82. b Chicago | black, Chicago |
| 83. b McGill | black, McGill, UPF background |
| 91. lod, p | light ocular diaphragm, pearl |
| 93. Gi | Giant |
| 94 Gi , ptl | Giant, prothoraxless |
| 96. mt | mottled |
| 99 . $b^t$ | tawny |
| 100. $b^d$ | dusky |
| 101. ap, rb, au, mc, s | antennapedia, ruby, aureate, microcephalic, sooty |
| 105. fas-2 | fused antennal segments-2 |
| 120. spiral | spiral arrangement of all three parts of the body |
| 124. Be, s | Bar eye, sooty |
| 139. mc | microcephalic |
| 143. fas-3a | fused antennal segments-3a |
| 150. rb | ruby |
| 161. Sa, c, mxp | Short andtenna, chestnut, maxillopedia |
| 196. mas | missing abdominal segments |
| 220. Rd, p, knp | Reindeer, pearl, knobby prothorax |
| 256. weird | weird eggs |
| 272 supergiant | |
| 276. Davis low body weight | |
| 295 p, pd | pearl, paddle |
| 338 pd, py, p | paddle, pygmy,. Pearl |
| 381. b, ptl | black, prothorax-less |
| 392. j-2 | jet-2 from Beeman |
| 421. Rd, ptl, p | Reindeer, prothorax-less, pearl |
| 436 au, mc | aureate, microcephalic |
| 444. i, locd, Mo | ivory, light ocular diaphragm, Microphthalmic |

| | |
|---|---|
| 448 ap., Chr | antennapedia, Charcoal |
| 464. i, lod | ivory, light ocular diaphragm |
| 471 R-mal | malathion resistant |
| 478 Spa, p | Spatulate, pearl |
| 484. mxp (ap) | maxillopedia, antennapedia |
| 485. fas-like | fused antennal segments-like |
| 487 by syn | black synthetic |
| 488 .( au), lod, p | aureate,, light ocular diaphragm, pearl |
| 491. fas | fused antennal segments |
| 494 Ag/Es' | Argentum/ Es' |
| S 6 | |
| 495. Dch /ey | Dachshund, eyeless |
| 496. Stbd/Es' | |
| 497. pt/ey | |
| 490. Stm/ey | |

<u>T. confusum</u>

1. apt, msg
2. apt, msg, r
4. au, p
<u>6. au, msg, rus (p)</u>
<u>7. b, (sh., cas, sp)</u>
<u>8. bI</u>
<u>10. b, fas-2</u>
<u>11. b, fas-3 , r</u>
<u>14. b, lod, au, p (sp)</u>
<u>15. b, p</u>
<u>17. b, rus</u>
<u>19. bI</u>
<u>23. sh,, spl</u>
<u>25. b, sp</u>
<u>29. b, twa</u>
<u>33. b-2</u>
<u>35. b (cas, sti, r)</u>
<u>36. b (fas-3)</u>
<u>37. b, r (cas)</u>
<u>39. b Chicago/ b McGill</u>
<u>41. b Donner</u>
<u>43. b Georgia</u>
<u>47. b McGill</u>
<u>49. b McGill ex N.Y.</u>
<u>51 b McGill (syn)</u>
<u>53. b McGill fas</u>
<u>57 b SSM, sp</u>
<u>58. b, spl</u>
<u>59. b, syn</u>
<u>60 b, circle +/+</u>

63. ble (rby)
65. ble, e (cas, sti)
71. btf
73. btt , es (elb)
79. cas, sti
85. Chi +/+ ex N.Y.
87. Chi +/+
89. cru
90. cru, Hg
93. dim'd eye
95. dpe
97. dj (strong)
101. dj , r2
103 dt (see umb)
105. dt, es
109. dt, p
111. e
114. e Winnipeg
115. e, fas-3
117. e McGill
119. e L & H
121 e2 (fas. p, sti)
123. e (fas-1)
124. e-2, p
125. ele
128. e2, p fas-2
129. es
130 e2-lod
131 es, fas
133. es (car)
142. fas-1
145. fas-2
147. fas-2, dj, msg
149. fas-2. lod, p
150. fas-2
151. fas-2, msg
152. fas-4
153. fas-3 Yugo
154. fro
157 lod, p.
159. lod, rs
161. mag
163 +/+ McDonald
165 +/+ McGill.
167 msg (sp)
170. msg inbred
171. msg inbred 113 generations
172. Hg (msg, e-2, p)
176. Hg, es (apt, msg)
177. Hg, es
180. fas-2, lod, p, msg)
181. N.Y. +/+ (msg.sti
182. Npp-like (weak) r/r
183. ov-like
185 ov-like. Sp
187 p (sti, cas)

Stock Lists

188. p (dre)
189. p Slough
192. py-like
193. ptl (msg)
194. +/+ Redlands
195. r (msg, sp)
196. riboflavinless, p
199. ru (sti, cas)
200. r Zagreb (msg, cas. Fas)
203. rby (cas, msg)
205 rus (cas, sti, msg)
206. rus --like (inbred)
210. black found in 206
211. Sacramento +/+
213. San Bernardino +/+
215. sh (Berkeley)
219. sp (spl)
221 spl-1 Sok (ble, sti)
223 sti (msg, cas)
225. stl
227. soy adapted
229. synthetic +/+
230. pearl robpf;avonless (msg)
231. thu (msg)
233. twa
234. umb
236. Xl (sh, sp)
238. +/+ Yugo
239 msg.
250. +/+ Japan
251. autosomal lethal nr b.

Tribolium freemani

| | | |
|---|---|---|
| 1. +/+ | Wild type | Slough |
| 1a. +/+ | Wild type | Slough |
| 1b. +/+ | Wild type | Slough |
| 2. +/+ | Wild type | Japan |
| 2a. +/+ | Wild type | Japan |
| 2b. +/+ | Wild type | Japan |
| 3. b/b | black | San Bernardino |
| 3a. b/b | black | San Bernardino |
| 4. cas | creased abdominal segments | San Bernardino |
| 4a. cas | " " " | " " |
| 4b. cas dve | cr. abd. seg., divergent elytra | " " |
| 5. cor | corrugated elytra | " " |
| 6. ju | juvenile urogomphi | " " |
| 7 fas-1 | fused antennal segs.-1. | " " |
| 8. mdls | median line on abd. sternites | " " |
| 8a " | " " " " | " " |
| 9. ov-like | overshot-like | " " |
| 9a " | " | " " |
| 10. sc | scar | " " |
| 10a. sc | " | " " |
| 10b. sc | " | " " |
| 11. vt | vaulted elytra | " " |
| 12. ims | incomplete mesosternum | " " |

A. Sokoloff

Note:

We now have available Tribolium anaphe, T. audax and T. destructor wild type strains.

WASHINGTON, D.C. 20204
DEPARTMENT OF HEALTH, EDUCATION AND WELFARE
DIVISION OF MICROBIOLOGY

Coleoptera

Anobiidae
Stegobium paniceum (L.)

Anthribidae
Araecerus fasciculatus (Deg.) (poor condition; may be dead).

Bostrichidae
Rhyzopertha dominica (F.)

Bruchidae
Acanthoscelides obtectus (Say)

Cleridae
Necrobia rufipes (Deg.)

Cucujidae
Ahasverus advena (Waltl)
Cryptolestes ferrugineus (Steph.). Poor condition, may be dead.
C. pusillus (Schon.)
C. turcicus (Grouv.)
Oryzaephilus surinamensis (Linnaeus)

Curculionidae
Sitophilus granarius (L.)
S. zeamais Motschulsky

Dermestidae
Anthrenus flavipes LeC. Weak culture
Anthrenus verbasci (Linnaeus)
Dermestes maculatus De Geer
Trogoderma variabile Ballion

Ostomidae
Gibbium psylloides (Czemp.)

Silvanidae
Ahasverus advena (Waltl.)
Oryzaephilus surinamensis

Tenebrionidae
Alphitobius diaperinus (Panz.)
Gnathocerus maxillosus (F.)
Palorus ratzeburgi (Wissm.)
Tribolium brevicornis (LeConte)
T. castaneum (Herbst)
T. confusum Duv.
T. destructor Uytt.--weak culture, may be diseased.

T. madens (Charpentier)

M. Nakashima

AUSTRALIA

Burnley, Victoria
Victoria Plant Research Institute
Department of Agriculture

COLEOPTERA

Tribolium castaneum

Wild type strains
Malathion specific resistant strain
Malathion non-specific strain

Tribolium confusum

Wild type strains
Malathion specific strain

Oryzaephilus surinamensis

Wild type strain
Malathion resistant strain

Oryzaephilus mercator

Alphitobius diaperinus

Cryptolestes ferrugineus

Gnathocerus cornutus

Gnathocerus maxillosus

Latheticus oryzae

Rhyzopertha dominica

Sitophilus granarius

Sitophilus oryzae

Sitophilus zeamais

Tenebroides mauritanicus

LEPIDOPTERA

# Stock Lists

BURLINGTON, NORTH CAROLINA
CAROLINA BIOLOGICAL SUPPLY COMPANY

*Tribolium castaneum*

1. black
2. jet
3. pearl
4. Wild
5. High body weight
6. Low body weight

*Tribolium confusum*

1. Wild

(Ed.).

BURLINGTON, VERMONT 05401
UNIVERSITY OF VERMONT
DEPARTMENT OF ZOOLOGY
STEVENS/GOODNIGHT LAB

| *T. confusum* | *T.castaneum* | *Oryzaephilus surinamensis* |
|---|---|---|
| bI | cI | |
| bII | cSM-+/+ | |
| bIII | cCM-b/b | |
| bIV | cIV-a | |
| b-Chicago b/b | c-Brazil | |
| b-Chicago | c-Costa Rica | |
| b-Circle | c-Thailand | |
| b-yugo-Illinois b/b | c-Spain | |
| b-yugo-Illinois +/+ | c-Israel | |
| bSM | | |
| b-yugo-Kentucky | | |
| b-McGill | | |
| b-Thailand | | |
| b- Nigeria | | |
| b-Pakistan | | |

L. Stevens

CARBONDALE, ILLINOIS 62901
SOUTHERN ILLINOIS UNIVERSITY AT CARBONDALE
DEPARTMENT OF ZOOLOGY

Tribolium castaneum

I. Wild type strains

1. Purdue + Foundation

II. Mutant strains

1. antennapedia (ap)

D.C. Englert

Chicago, Illinois 60637-1573
The University of Chicago
Department of Ecology and Evolution

Stock lists

I. Wild type strains

A. Tribolium castaneum

1. c+, "Chicago" (from Thomas Park)
2. c-ARK, Arkansas
3. c-YUGO, Yugoslavia, now Croatia
4. c-Texas
5. c-BS, collected in Naperville, IL, on birdseed
6. c-Infantes, Spain
7. c-Jerez, Spain
8. c-Campanaro, Spain
9. c-Osaka, Japan
10. c-Nigeria

B. Tribolium confusum (*= infected with Wolbachia pipientis)

*1. b+, "Chicago" from Thomas park)
2. b-I, inbred strain derived from (1).
*3. b-II, inbred strain
*4. b-III, " "
*5. b-IV " "
*6. b-YUGO, Yugoslavia, now Croatia
7. b-YUGO, "
8. b-Illinois
9. b-Mississippi
10. b-Nigeria

Michael J. Wade Norman T. Johnson

Ephestia cautella

Ephestia figulella

Galleria mellonella

Plodia interpunctella

P. Williams

Indooroopilly, Queensland 4068, Australia
Queensland Department of Primary Industries
Plant Protection Unit

Coleoptera

Oryzaephilus surinamensis

Wild type strains

| | | |
|---|---|---|
| VOS 48 | insecticide susceptible | Victoria |
| QOS 42 | fenitrothion susceptible | Queensland |
| QOS 115 | chlorpyrifos-methyl-R a | Queensland |

Rhyzopertha dominica

Wild type strains

| | | |
|---|---|---|
| QRD 369 | phosphine-resistance | Queensland |
| QRD 14 | insecticide susceptible | Queensland |
| QRD 2 | multiresistant | Queensland |
| QRD 63 | multiresistant | Queensland |
| QRD 318 | pyrethroid-resistant | Queensland |

Sitophilus oryzae

Wild type strains

| | | |
|---|---|---|
| LS 2 | insecticide susceptible | Queensland |
| QSO 56 | multi-resistant | Queensland |
| CSO 231 | multi-resistant | W. Australia |
| QSO 388 | phosphine-resistant | Queensland |

Tribolium castaneum

Wild type strains

| | | |
|---|---|---|
| QTC 4 | insecticide susceptible | Queensland |
| QTC 279 | pyrethroid insecticide resistant | Queensland |
| QTC 285 | multi-resistant, composite strain | Queensland |
| CTC 12 | non-specific malathion resistant | Queensland |
| QTC 34 | malathion specific-resistant | Queensland |
| QTC 320 | phosphine-resistant | Queensland |

Lepidoptera

Ephestia cautella Wild — Queensland

Patrick J. Collins, Senior Entomologist

# ECOLOGY OF FIELD AND STORED PRODUCT PESTS SECTION
# AGRICULTURE AND AGRI-FOOD CANADA
# WINNIPEG RESEARCH CENTRE
# 195 DAFOE ROAD
# WINNIPEG, MANITOBA, R3T 2M9

STOCKLIST

| SPECIES | | ORIGIN | |
|---|---|---|---|
| | ***COLEOPTERA*** | | |
| 1. | *Acanthoscelides obtectus* | Phillips, Wis | 1993 |
| 2. | *Ahasverus advena* | Argyle, MB | 1991 |
| 3. | *Callosobruchus maculatus* | Phillips, Wis | 1993 |
| 4. | *Cryptolestes ferrugineus* | Manitoba, MB | 1991 |
| 5. | *Cryptolestes pusillus* | Lac du Bonnet, MB | 1988 |
| 6. | *Cryptolestes turcicus* | | 1971 |
| 7. | *Cynaeus angustus* | Minnesota, MN | 1982 |
| 8. | *Lasioderma serricorne* | Winnipeg, MB | 1984 |
| 9. | *Liposcelis bostrychophilus* | Winnipeg, MB | 1994 |
| 10. | *Oryzaephilus mercator* | Winnipeg, MB | 1994 |
| 11. | *Oryzaephilus surinamensis* | Landmark, MB | 1991 |
| 12. | *Prostephanus truncatus* | Mexico City, Mexico | 1977 |
| 13. | *Rhyzopertha dominica* | Manitoba | 1993 |
| 14. | *Sitophilus granarius* | | |
| 15. | *Sitophilus oryzae* | Coal Lake, AB | 1992 |
| 16. | *Sitophilus zeamais* | | |
| 17. | *Stegobium paniceum* | Winnipeg, MB | 1993 |
| 18. | *Tenebrio molitor* | Winnipeg, MB | 1980 |
| 19. | *Tribolium audax* | | |
| 20. | *Tribolium castaneum* | Manitoba | 1991 |

| SPECIES | ORIGIN | |
|---|---|---|
| **The following *Tribolium castaneum* mutant strains were received in November, 1985 from Dr. Sokoloff's laboratory at California State University.** | | |
| 21. Culture S38 | red eye | |
| 22. Culture S351 | red eye, pygmy, fused antennal segments | |
| 23. Culture S156 | microphthalmic | |
| 24. Culture S136 | jet (dark body) | |
| 25. Culture S113 | sooty (dark body) | |
| 26. Culture S63 | pearl eye | |
| 27. Culture S165 | chestnut eye | |
| 28. Culture S148 | maroon eye | |
| 29. Culture S38 | paddle (antennae fused, flattened) | |
| 30. *T. castaneum* | abbreviated appendages (aa), missing abdominal *sternites* (mas) | |
| 31. *T. castaneum* | Rio Desago Malathion resistance | |
| **The following mutant strains of *Tribolium castaneum* have had no linkage analysis:** | | |
| 32. malathion-specific resistance | | |
| 33. black body and pearl eyes | | |
| **The following mutant strains of *Tribolium confusum* have had no linkage analysis.** | | |
| 34. red eyes | | |
| 35. black body | | |
| 36. *Tribolium confusum* | Winnipeg, MB | 1994 |
| 37. *Tribolium madens* | | |
| 38. *Trogoderma variabile* | | |
| 39. *Typhaea stercorea* | Manitoba | 1991 |
| ***LEPIDOPTERA*** | | |
| 1. *Plodia interpunctella* | Winnipeg, MB | 1990 |
| 2. *Sitotroga cerealella* | Kansas | 1982 |

Dr. Noel D.G. White
Section Head

Stock Lists

Gembloux agricultural University - Unit of general and applied Zoology
**2, Passage des déportés - B-5030 Gembloux, Belgium**
**zoologie@fsagx.ac.be**

Dr Eric Haubruge & Ludovic Arnaud

| Insect | Strain | Origin | Year | From |
|---|---|---|---|---|
| **Bostrychidae** | | | | |
| *Prostephanus truncatus* | Togo | Togo | 1993 | - |
| | Dalaba | Guinea-Konakry | 1996 | - |
| *Rhizopertha dominica* | | | | |
| Insecticide susceptible | Canada | Canada | 1991 | P. Fields |
| Insecticide resistant | Methyl bromide, phosphine | Kenya | | P. Golob |
| **Bruchidae** | | | | |
| *Callosobruchus maculatus* | Senegal | Senegal | 1989 | D. Seck |
| | Campinas (black strain) | Brazil | 1975 | O. Legros |
| **Curculionidae** | | | | |
| *Sitophilus granarius* | Belgium | Belgium | 1991 | - |
| *Sitophilus zeamais* | Senegal | Senegal | 1995 | G.Pierrard |
| | Dimbokro | Ivory Coast | 1998 | - |
| **Gryllidae** | | | | |
| *Gryllus bimaculatus* | | Spain | | E.H. Morrow |
| **Tenebrionidae** | | | | |
| *Tribolium anaphe* | | Nigeria | 1956 | Slough, UK |
| *Tribolium audax* | | Canada | 1969 | Slough, UK |
| *Tribolium brevicornis* | | | | A. Sokoloff |
| *Tribolium confusum* | Dalaba | Guinea-Conakry | 1996 | - |
| | Hoielaert | Belgium | 1999 | - |
| *Tribolium castaneum* | | | | |
| Insecticide susceptible | Abidjan | Ivory Coast | 1989 | F.Fleurat-Leussard |
| | Lab-S | USA | | R. Beeman |
| | Japan | Japan | | H. Nakakita |
| | Mozambique | Mozambique | | N. White |
| | Ex-maff | UK | 1991 | P. Golob |
| Insecticide resistant | | | | |
| | A20 Rdiel (dieldrin, lindane) | USA | | R. Beeman |
| | Argyle, malathion-specific | Canada | 1992 | N. White |
| | CTC-12 (malathion, cross resistant) | Australia | 1968 | D. Wool |
| | Dalaba, malathion-specific | Guinea-Conakry | 1996 | - |
| | Dimbokro (malathion-specific, lindane) | Ivory-Coast | 1997 | - |
| | Ga-1, malathion-specific | Geaogia, USA | 1980 | R. Beeman |
| | Kano, malathion-specific | Nigeria | 1961 | D. Wool |
| | Landmark, malathion-specific | Canada | 1991 | N. White |
| | Pakistan, malathion-specific & lindane | Pakistan | | P. Golob |
| | Paulo d'Amico (malathion-specific) | Canada | 1976 | N. White |
| | PRm, malathion-specific | Philippines | 1989 | P. Golob |
| | Rio desago, malathion-specific | Canada | 1976 | N. White |
| | Steinback (malathion-specific) | Canada | 1989 | N. White |
| | Sun Chong (malathion, cross resistant) | Canada | 1976 | N. White |
| | Thailand (malathion-specific & phosphine) | Thailand | 1989 | P. Golob |
| | Waseco, malathion-specific | Canada | 1982 | N. White |
| Mutant strain | Black Jack | - | 1993 | - |
| *Tribolium destructor* | | Ethiopia | 1968 | Slough, UK |
| *Tribolium freemani* | | Japan | 1980 | H. Nakakita |
| *Tribolium madens* | | | | A. Sokoloff |

SANTA FE DE BOGOTA, D.C.,
UNIVERSIDAD NACIONAL DE COLOMBIA
FACULTAD DE CIENCIAS
DEPARTAMENTO DE BIOLOGIA
APDO. AEREO #14490

*Tribolium castaneum*

I. Wild type strains

| NAME | ORIGIN | DATE |
|---|---|---|
| 1. ABBC | Synthetic, Bogota | 1982 |
| 2. Apulo | Apulo (Cund.) Col. | 1982 |
| 3. Bogota | Inst. Publ. Health, | 1978 |
| | Bogota, Col. | 1981 |
| 4. Bucaramanga | Bucaramanga, (Sant.) | 1981 |
| 5. Cartagena | Cartagena, Bol., Col | 1980 |
| 6. Fusa | Fusagasuga, Cund. Col | 1986 |
| 7. Honda | Honda, tol. Col. | 1986 |

II. Domestic mutants

Mutant strains discovered in Colombia

| NAME | SYMBOL | LINKAGE GROUP | ORIGIN | DATE OF ENTRY |
|---|---|---|---|---|
| 8. Antennapedia | $ap^N$ | VIII | Bog. | 1981 |
| 9. Argentum eyes | ae | I | Bog | 1993 |
| 10. Bifurcated antenna | ab | II | Bog. | 1980 |
| 11. Black | $b^N$ | III | Bog. | 1983 |
| 12. colossal pupae | cp | ? | Bog. | 1993 |
| 13. Charcoal | $Chr^b$ | III | Bog. | 1979 |
| 14. Disjuncted elytra | ed | ? | Bog. | 1990 |
| 15. Fused antennameres | af | ? | Bog. | 1980 |
| 16. Glass legs | pv | ? | Bog. | 1980 |
| 17. Globose antenna | Ag | VII | Bog. | 1989 |
| 18. Light eyes-1 | oc | ? | Bog. | 1990 |
| 19. Light eyes-2 | ? | ? | Bog. | 1990 |
| 20. Light eyes-3 | ? | ? | Bog. | 1991 |
| 21. Light eyes-4 | ? | ? | Bog. | 1993 |
| 22. Metathoracic scar | sc | III | Bog. | 1983 |
| 23. Miniature appendaged | $ma^V$ | I | Bog. | 1981 |
| 24. Narrow eyes | oje | ? | Bog. | 1980 |
| 25. Red eyes | or | ? | Bog. | 1986 |
| 26. White eye | obl | IV | Bog. | 1982 |

III. Imported mutants from Tribolium Stock Center, 1985

| | | |
|---|---|---|
| 27. Antennapedia | $ap^D$ | VIII |
| 28. Black | b | III |
| 29. Charcoal | Chr | III |
| 30. Miniature appendaged | ma | I |
| 31. Microcephalic | mc | V |
| 32. Microphthalmic | Mo | VI |
| 33. Pearl eye | p | II |
| 34. Platinum eye | pte | I |
| 35. Pygmy | py | I |
| 36. Short antenna | Sa | VII |
| 37. Sooty | s | IV |

Fernando Nunez del Castillo

## DENMARK

LYNGBY
STATENS SKADEDYRLABORATORIUM
(DANISH PEST INFESTATION LABORATORY)

*Anthrenus museorum*
*A. vorax*
*Attagenus smirnovi*
*A. unicolor* (*piceus*)
*A. woodroffei*
*Dermestes hemorrhoidalis*
*Lasioderma serricorne*
*Oryzaephilus surinamensis*
*Prostephanus truncatus*
*Ptinus tectus*
*Sitophilus granarius*
*S. oryzae*
*Stegobium (Sitodrepa) paniceum*
*Tenebrio molitor*
*Thylodrias contractus*
*Tribolium confusum*
*T. destructor*
*Trogoderma angustum*
*T. granarium*

K. Arevad and H. Mourier

## FRANCE

VILLEURBANE (LYON) RHONE
INSTITUT NATIONAL DES SCIENCES APPLIQUEES
LABORATOIRE DE BIOLOGIE

A. Wild type strains

1. Sitophilus granarius L.

2. S. oryzae L.
   a. FB strain (La Reunion)
   b. SFr strain (lyon) (56,500+3,000 ovarian symbiotes)
   c. W strain (Villeurbane) (22,700+1500 ovarian symbiotes)

3. S. zea-mais Mots--from PIL, Slough

B. Selected lines of Sitophilus oryzae

1. SS/Sfr strain:aposymbiotic strain (0 ovarian symbiotes) obtained from Sfr
2. LL strain (slow development) (42,000+3000 ovarian symbiotes)
3. RR strain (fast development) 88,000+5000 ovarian symbiotes)

P. Nardon
(No updated list available, Ed.).

GERMANY

ZOOLOGISCHES INSTITUT I
(ZOOLOGIE) DER ALBERT LUDWIGS UNIVERSITAT
D 78 FREIBURG IM BREISGAU
KATHARINENSTRASSE 20

Wild type strains
1. <u>Oryzaephilus surinamensis</u> Freiburg
2. <u>Tribolium castaneum</u> San Bernardino
3. <u>T. confusum</u> San Bernardino

Mutant strains (All from San Bernardino)
A. <u>Tribolium castaneum</u>
4. alate prothorax (apt)
5. Bar eye (Be)
6. black (Brazil background)
7. black (Chicago background)
8. Dachs (Dch)
9. Fused tarsi and antennae (Fta)
10. Microphthalmic (Mo)
11. nude (nd)
12. pygmy (py)

13. short antenna (sa)
14. Short antenna (Sa-2)
15. sooty (s)
16. Spatulate antenna (Spa)
weird eggs (wd)

B. <u>Tribolium confusum</u>
18. black-3 (b-3)
19. ebony (e)
20. ebony-2 (e-2)
21. McGill black (McGb)

K. Sander

MUNICH,
BAYER. LANDESANSTALT FUR BODENKULTUR
UND PFLANZENBAU, ABT. PFLANZENSCHUTZ

Coleoptera

Bruchidae--<u>Acanthoscelides obtectus</u> (Say)

Cucujidae--<u>Cryptolestes turcicus</u> Grouv. Munich, 1966

Ptinidae
<u>Gibbium psylloides</u> (Czemp) Regensburg, 1960
<u>Ptinus tectus</u> (Boi.) Munich, 1972

Silvanidae

| | | |
|---|---|---|
| *Oryzaephilus mercator* (Fauv.) | Munich, | 1966 |
| *O. surinamensis* (L) | ? | 1971 |

Munich (cont'd)

Tenebrionidae

| | | |
|---|---|---|
| *Gnathocerus cornutus* (F.) | MUNICH, | 1966 |
| *Tribolium castaneum* | ? | 1971 |
| *T. confusum* Duv. | Munich, | 1960 |
| *T. destructor* Uyttenb. | " | 1957 |

Lepidoptera

| | | |
|---|---|---|
| Phycitidae--*Ephestia kuehniella* (Zell.) | " | 1966 |

E. Naton.

GERMANY

D-80333 München
Institut fur Zoologie
Luisenstrasse 14

WILD TYPE

*Tribolium castaneum*

MUTANTS provided by A. Sokoloff

*Tribolium castaneum*
- Bar eye, sooty (Be, s)
- Black, microcephalic pearl (b,mc,p)
- Microcephalic (mc)
- Microcephalic aureate (mc, au)
- Microphthalmic (Mo)
- Squint (sq)

*Tribolium confusum*
- Diminished eye (dim)

Stock Lists

## INDIA

NEW DELHI
INDIAN AGRIC. RESEARCH INSTITUTE
DIVISION OF ENTOMOLOGY
INSECT GENETICS LAB.

STOCK LIST

| STRAIN | RESIST LEVEL | REARING MEDIA |
|---|---|---|
| 1. Malathion-resist. | >x200 | common wheat flour charged with tech malathion. |
| 2. lindane-resist. | >X100 | c. w. f. charged with tech. lindane |
| 3. DDT-RESISTANT | >x100 | c.w.f. charged with tech ddt. |
| 4. pirimiphosmethyl resistant | >X100 | C.W.F. CHARGED WITH tech. pirimiphosmethyl |
| 5. phosphine-resistant | > 6.3 | c.w.f. |
| 6. delta-methrin resist | >2819.3 | cwf chargedwwith tech deltamethrin |
| 7. fenitrothion-resist. | >25.96 | c.w.f. |
| 8. susceptible | – | c.w.f. |
| 9. black mutant | – | " |

*Tribolium confusum*

| | | |
|---|---|---|
| 10. susceptible | – | c.w.f. |
| 11. nigrat- melanic mutant | – | " |

J.D. Saxena.

## Tel Aviv University, Israel

*Tribolium castaneum* -wild type :

| | | |
|---|---|---|
| **1) Ishaaya** | | Israel |
| 2) **CTC-12** | | Slough, England |
| 3) **Kano-C** | | Slough, England |

-mutants

| | | |
|---|---|---|
| 1) csbb | black | Tribolium stock center |
| 2) cs pearl | pearl | Tribolium stock center |
| 3) cs mc | microcephalic* | recovered from cs pearl stock |
| 4) cs eu | extra urogomphi* | recovered from csbb stock |
| 5) cs pygmy | pygmy | Tribolium stock center |

* it is uncertain if the mutations are still maintained in the stocks.

*Tribolium confusum* - wild type

| | | |
|---|---|---|
| 1) CF Chicago | | Tribolium stock center |

-mutants

| | | |
|---|---|---|
| 1) CF bb | black | Tribolium stock center |
| 2) CF xl | extra large | Tribolium stock center |

*Tribolium brevicornis*

1) Riverside ++ — Tribolium stock center

*Tribolium freemani*

1) Tsukuba strain — Gembloux, Belgium

Prof. David Wool,

## JAPAN

NATIONAL FOOD RESEARCH INSTITUTE
MINISTRY OF AGRICULTURE, FORESTRY AND FISHERIES
2-1-2 KANNONDAI, YATABE-MACHI
TSUKUBA-GUN, IBARAKI-KEN 305

Psocoptera
Liposcelidae
Liposcelis bostrychophilus Badonel Wild
Liposcelis [illegible] (Enderlein) Wild
Trogiidae
Lepinotus reticulatus Endelein Wild

Coleoptera
Anobiidae
Lasioderma serricorne (Fabricius) Wild
Stegobium paniceum (L.) Wild
Ptinidae
Gibbium equinoctiale Boieldieu Wild
Bostrichidae
Rhyzopertha dominica (Fabricius) Wild
Dinoderus minutus (Fabricius) Wild
Cucujidae
Cryptolestes turcicus Wild
Cryptolestes pusilloides (Steel & Howe Wild
Silvanidae
Oryzaephilus surinamen sis (L.) Wild
Tenebrionidae
Alphitobius diaperinus (Panzer) wild
Gnathocerus cornutus (Fabricius) Wild (Okayama str.)
Palorus ratzeburgi (Wissmann) Wild
Tribolium castaneum (Herbst) Wild
T. confusum Jacquelin du Val Wild
T. freemani Hinton Wild
Tenebrio molitor L.
Bruchidae
Callosobruchus chinensis (L.) Wild
Anthribidae
Araecerus fasciculatus Degeer Wild
Rhynchophoridae
Sitophilus zeamais Motschulsky Wild
Sitophilus oryzae (L.) Wild

Lepidoptera
Pyralidae
Ephestia cautella (Walker) Wild
E. kuhniella (Zeller) Wild
Plodia interpunctella Wild
Corcyra cephalonica Wild
Gelechiidae
Sitotroga cerealella (Olivier) Wild

H. Nakakita H. Ikenaga

OKAYAMA
LABORATORY OF APPLIED ENTOMOLOGY
COLLEGE OF AGRICULTURE
OKAYAMA UNIVERSITY

1. Wild type strains

COLEOPTERA

| | | |
|---|---|---|
| 1. | Alphitobius diaperinus | Miyazaki |
| 2. | Callosobruchus chinensis | Okayama |
| 3. | C. maculatus | |
| 4. | Gnathocerus cornutus | Miyazaki |
| 5. | Lasioderma serricorne | Okayama |
| 6. | Latheticus oryzae | Miyazaki |
| 7. | Oryzaephilus surinamensis | Miyazaki |
| 8. | Palorus ratzeburgii | Miyazaki |
| 9. | P. subdepressus | Miyazaki |
| 10. | Rhyzopertha dominica | Miyazaki |
| 11. | Sitophilus oryzae | Okayama |
| 12. | S. zeamais | Okayama |
| 13. | Tenebrio molitor | Okayama |
| 14. | Tenebroides mauritanicus | Okayama |
| 15. | Tribolium castaneum | Miyazaki |
| 16. | T. confusum | Miyazaki |
| 17. | T. freemani | |

HYMENOPTERA

| | | |
|---|---|---|
| 1. | Anisopteromalus calandrae | Okayama |
| 2. | Choetospila elegans | Okayama |
| 3. | Lariophagus distinguendus | Okayama |

Toshiharu Yoshida

INSTITUTE OF BIOLOGICAL SCIENCES
UNIVERSITY OF TSUKUBA
SAKURA-MURA, IBARAKI
300-31 JAPAN

Bruchidae

Callosobruchus chinensis

13 wild type strains from different localities in Japan and abroad

Black colored mutant derived from Shusenji strain.

cC Mainland China
fC Fukushima, Japan
hC Hirosaki, Japan
h1C Hirosaki, Japan

jC Kyoto, Japan, 1936
mC Morioka, Japan
nC Niigata, Japan, 1964
pC Punjab, India
sCbl Shusenji black mutant
tC Tokyo (Nishigahara, Nat. Inst. Agr.(, Japan
taC Tsukuba, Japan
taC2 Tsukuba, Japan
tsC Tsukuba, Japan
yC Taisha, Japan

C. maculatus
12 wild type strains from different localities in the world.
aQ U.S.A. (probably Louisiana).
bQ Burma
cQ Fresno Lab., USDA, Calif., U.S.A.
eQ Thailand
fQ Thailand
oQ Ohio, U.S.A.
rQ
tQ Tel Aviv, Israel (Dept. Plant Prot., Stored Prod. Res. Res. Lab.
kQ Kyoto, Japan
mQ Kansas State Univ., Manhattan, KS, U.S.A.
sQ Savannah Lab, USDA, georgia, U.S.A.

C. analis From United Kingdom
C. phaseoli From United Kingdom
Zabrotes subfaciatus From Africa
Acanthoscelides obtectus From California, U.S.A.
Hymenoptera
Braconidae
Heterospilus prosopidis from Hawaii, U.S.A.
Pteromalidae
Anisopteromalus calandrae, Japan
Chaetospila elegans from United Kingdom
Dinarmus basalis from India

K. Fujii

## PAKISTAN

LAHORE
University of the Punjab (New Campus)
Department of Zoology

Tribolium castaneum
- a) Pak Wild type strain
- b) CTC 12 Malathion resistant
- c) FSS II Multi organophosphorus susceptible

## PEOPLE'S REPUBLIC OF CHINA

Beijing
Beijing Agricultural University
Dept of Animal Science

Tribolium castaneum

Wild type strains
1. Base population for quantitative genetics, Guelph, 1987.
2. Inbreeding line--Beijing, 1987

Mutant strains: pygmy
1. Base population maintained with no artificial selection and minimum of inbreeding--Guelph, 1987
2. Inbreeding line--Beijing, 1987.

Lao Zhang

## POLAND.

International Centre of Ecology
Polish Academy of Sciences
05-092 Łomianki, Dziekanów Leśny near Warsaw
Poland

Stock list:

*T. confusum* Duval, strain: HV
*T. castaneum* Herbst, strain: cI

# SPAIN

MADRID
INSTITUTO NACIONAL DE INVESTIGACIONES AGRARIAS
DEPARTAMENTO DE GENETICA CUANTITATIVA Y MEJORA ANIMAL

## *Tribolium castaneum*

A. wild type strains

| | | |
|---|---|---|
| 1. Consejo | C.S.I.C. Madrid, Spain | 1964 |
| 2. Purdue | Purdue, USA. | 1964 |
| 3. Edinburgh 1 | Edinburgh, Scotland | 1970 |
| 4. Edinburgh 2 | Edinburgh, Scotland | 1970 |
| 5. Campanario | Campanario, Spain | 1973 |
| 6. Coronada | La Coronada, Spain | 1976 |
| 7. Andujar | Andujar, Spain | 1975 |
| 8. Jerez | Jerez, Spain | 1975 |
| 9. Osuna | Osuna, Spain | 1975 |
| 10. Carpio | Carpio, Spain | 1975 |
| 11. Jafo | Jafo, Israel | 1975 |
| 12. Beer-Sheba | Beer-Sheba, Israel | 1975 |

B. Mutant type strains

| | | |
|---|---|---|
| 13. Black Purdue | Purdue, USA, | 1964 |

C. Experimental lines

Originated from the "Consejo" strain and selected for egg laying performance through 42 generations

| | selected for | | Temperature (oC) |
|---|---|---|---|
| 14. AN-I | high performance at | | 33 |
| 15. AN-II | " | " | 33 |
| 16. AF-I | " | " | 28 |
| 17. AF-II | " | " | 28 |
| 18. AT-I | " | " | 38 |
| 19. AT-II | " | " | 38 |
| 20. BN-I | low performance at | | 33 |
| 21. BF-I | " | " | 28 |
| 22. BF-II | " | " | 28 |
| 23. BT-I | " | " | 38 |
| 24. BT-II | " | " | 38 |

25. RN-I* high cross performance at 33
26. SN-I* " " " " 33
27. RN-II " " " " 33
28. SN-II " " " " 33
29. RF-I " " " " 28
30. SF-I " " " " 28
31. RF-II " " " " 28
32. SF-II " " " " 28
33. RT-I " " " " 38
34. ST-I " " " " 38
35. RT-II high cross performance at 38
36. ST-II " " " "
37. CTD-I high performance at diff. levels of selection
38. CTD-II " " " " " "
39. DTD-I " " " " " " "
40. DTD-II " " " " " " "
41. ETD-I " " " " " " "
42. ETD-II " " " " " " "
43. FTD-I " " " " " " "
44. FTD-II " " " " " " "

D. mutants

45. antennapedia ap, VIII — Purdue, 1964
46. diferencial Df, IV — Purdue, 1964
47. fused antennal segments-2 fas-2 IV — Sokoloff, 1968
48. ivory i ? — Purdue, 1964
49. paddle, pd i — Purdue, 1964
50. pearl p II — Sokoloff, 1968
51. pegleg pg II — Purdue, 1968
52. pygmy py I — Purdue, 1968
53. rose rs I — Purdue, 1964
54. ruby rb ? — Purdue, 1964
55. short elytra sh VIII
56. squint sq VIII — Purdue, 1964
57. white w ? — Purdue, 1964

58. wine r I — Purdue, 1968
59. eye mutant ? — Madrid, 1967
60. maroon m V — Purdue, 1977
61. melanotic stink glands--like — Madrid, 1968
62. sooty s Iv — Sokoloff, 1977
63. chestnut c VII — Sokoloff, 1977
64. microcephalic mc V — Sokoloff, 1977
65. Microphthalmic Mo VI — Sokoloff, 1977
Pk
66. pink p II — Sokoloff, 1977
67. Bar eye Be IV — Sokoloff, 1977
68. prothoraxless ptl IX — Sokoloff, 1977
69. light ocular diaphragm lod III — Purdue, 1968
70. black B III — Sokoloff, 1977

*Tribolium confusum*

A. Wild type strains

71. Coronada La Coronada, Spain

B. Mutants

72. creased abdominal sternites cas II Sokoloff, 1968
73. ebony-2 e-2 II Sokoloff, 1968

Ma. C. Fuentes

REPUBLIQUE DU SENEGAL Bambey,

MINISTERE DE L'AGRICULTURE

Institut Sénégalais

De Recherches Agricoles

Centre National de la Recherche Agronomique

1. Stock list
*Tribolium Castaneum* (Wild type strains)
genetic origin Bambey (Senegal)

: Dr. Dogo SECK
Chef ISRA/CNBA

UNITED KINGDOM

University of Newcastle upon Tyne

United Kingdom,

Faculty of Agriculture and Biological Sciences,

Department of Agricultural and Environmental Science, University of Newcastle upon Tyne, NE1 7RU, UK.

| Species/Strains | Status | Derived from |
|---|---|---|
| I Wild type strains | | |
| A. *Tribolium castaneum* | | |
| 1. Ph-1 | malathion specific resistant | Dr. Freeman, NRI, UK |
| 2. FSS-II | malathion susceptible | Central Science Laboratory, Sand Hutton, York, UK. |
| B. *Tribolium confusum* | | |
| 1. *Tribolium confusum* | malathion susceptible | Central Science Laboratory, Sand Hutton, York, UK. |
| C. *Sitophilus granarius* | | |
| 1. 1022 A | lindane resistant | Central Science Laboratory, Sand Hutton, York, UK. |
| 2. *Sitophilus granarius* | lindane susceptible | Central Science Laboratory, Sand Hutton, York, UK. |
| D. *Sitophilus oryzae* (L.) | | |
| 1. *Sitophilus oryzae* (L.) | Susceptible | Central Science Laboratory, Sand Hutton, York, UK. |

PREPARED BY F.M. BUGHIO, A. RAUF AND R.M. WILKINS

A. Sokoloff. **A note from Justin Dixon.**

**Mr. Justin Dixon is Invertebrate Supply Unit Manager of the Central Science Laboratory, D.E.F.R.A.. Sand Hutton, York, England, YO41, 1LZ. Mr. Dixon informs me that the following changes have taken place in the Central Science Laboratory (CSL):**
**Mrs. Carol Trowe left the CSL. She was replaced by Mrs. Imogen Foster. In turn, Mrs Foster was succeeded by Mr. Justin Dixon.**
**Besides changes in staff, there has been a centralization of the CSL onto one site, so requests directed to the Librarian are to be sent to the same address for insect requests.**
**The price per culture has been changed to 75 pounds plus VAT for 50-100 adults. Depending on the genus and species, required postage and packing is charged depending on destination and method of delivery required. Appended to this note is a list of insects available at the CSL to external customers and general information. The Ministry of Agriculture, Fisheries and Food (MAFF) no longer exists. It is now called the Department for Environment, Food and Rural Affairs (D.E.F.R.A.).**

**For Invertebrate sales, direct inquiries to**

**Mr. Justin Dixon**
**Invertebrate Supply Unit Manager**
**Central Science Laboratory**
**DEFRA**
**Sand Hutton.**
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**Tel: +44 (0) 1904 46 26 35**
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**Tel: +44 1904 46 20 00 Ask for Information Center).**

**The CSL web site is also a good source for center information and has full contact details for all. Those with internet access: www.csl.gov.uk**

CENTRAL SCIEN
LABORATORY

# Insect Cultures

**The following species of insect are currently available**

## *Coleoptera*

| *Anobiidae* | | **Common name** |
|---|---|---|
| *Lasioderma serricorne* | (Fabricius) | Cigarette beetle |
| *Stegobium paniceum* | (L.) | Biscuit beetle |
| ***Bostrichidae*** | | |
| *Prostephanus truncatus* | Horn | Larger grain borer |
| *Rhyzopertha dominica* | (F.) | Lesser grain borer |
| ***Bruchidae*** | | |
| *Acanthoscelides obtectus* | (Say) | Dried bean beetle |
| *Callosobruchus maculatus* | (F.) | Southern Cowpea beetle |
| ***Cucujidae*** | | |
| *Cryptolestes capensis* | (Waltl) | |
| *C. ferrugineus* | (Stephens) | Rust red grain beetle |
| *C. pusilloides* | (Steel and Howe) | |
| *C. pusillus* | (Schönherr) | Flat grain beetle |
| *C. pusillus fuscus* | Lefkovitch | Flat grain beetle |
| *C. turcicus* | (Grouvelle) | Turkish grain beetle |
| *C. ugandae* | (Steel and Howe) | |
| ***Curculionidae*** | | |
| *Sitophilus granarius* | (L.) | Grain weevil |
| *S. oryzae* | (L.) | Rice weevil |
| *S. zeamais* | Motschulsky | Maize weevil |
| ***Dermestidae*** | | **Common Name** |
| *Anthrenocerus australis* | (Hope) | Australian carpet beetle |
| *Anthrenus flavipes* | Le Conte | Furniture carpet beetle |

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E-mail: science@csl.go

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# Coleoptera

## Tenebrionidae

| | | Common Name |
|---|---|---|
| *Tribolium anaphe* | Hint. | |
| *T. audax* | Halstead | American flour beetle |
| *T. brevicornis* | LeC. | |
| *T. castaneum* | (Herbst) | Rust red flour beetle |
| *T. confusum* | Jacquelin du Val | Confused flour beetle |
| *T. destructor* | Uyttenboogaart | Dark flour beetle |
| *T. freemani* | Hinton | |
| *T. madens* | (Charp.) | Black flour beetle |

# Dictyoptera

## Blattellidae

| | | |
|---|---|---|
| *Blattella germanica* | L. | German cockroach |

## Blattidae

| | | |
|---|---|---|
| *Blatta orientalis* | L. | Oriental cockroach |
| *Periplaneta americana* | L. | American cockroach |
| *P. australasiae* | F. | Australian cockroach |

# Diptera

## Muscidae

| | | |
|---|---|---|
| *Musca domestica* | L. | House fly |

# Hymenoptera

## Formicidae

| | | |
|---|---|---|
| *Monomorium pharaonis* | (L.) | Pharoah's ant |

## Pteromalidae

| | | |
|---|---|---|
| *Anisopteromalus calandrae* | (Howard) | |
| *Lariophagus distinguendus* | (Förster) | |

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## Coleoptera

| Dermestidae | | Common Name |
|---|---|---|
| *Anthrenus picturatus hintoni* | Mroczkowski | |
| *A. sarnicus* | Mroczkowski | Guernsey carpet beetle |
| *A. verbasci* | (L.) | Varied carpet beetle |
| *Attagenus brunneus* | Faldermann | |
| *A. cyphonoides* | Reitter | |
| *A. insidiosus* | Halstead | |
| *A. pellio* | (L.) | Two-spot carpet beetle |
| *A. rufiventris* | Pic | |
| *A. smirnovi* | Zhantiev | |
| *A. unicolor* | (Brahm) | Black carpet beetle |
| *A. woodroffei* | Halstead, Green | |
| *A. fasciatus fasciatus* | (Thunberg) | |
| *Dermestes frischii* | Kug. | Hide beetle |
| *D. haemorrhoidalis* | Küster | Black larder beetle |
| *D. lardarius* | L. | Bacon beetle |
| *D. maculatus* | Degeer | Leather beetle |
| *D. peruvianus* | Laporte de Castelnau | Peruvian larder beetle |
| *Trogoderma angustum* | (Solier) | |
| *T. anthrenoides* | (Sharp) | |
| *T. glabrum* | (Herbst.) | |
| *T. granarium* | Everts | Khapra beetle |
| *T. grassmani* | Beal | |
| *T. particularis* | Pic. | |
| *T. inclusum* | LeConte | Large cabinet beetle |
| *T. irroratum* | Reitt. | |
| *T. ornatum* | (Say) | |
| *T. sternale plagifer* | Casey | |
| *T. variabile* | Ballion | Warehouse beetle |
| *T. varium* | (Mat. & Yoko) | |

### Mycetophagidae

| | | |
|---|---|---|
| *Typhaea stercorea* | (L.) | Hairy fungus beetle |

### Nitidulidae

| | | |
|---|---|---|
| *C. hemipterus* | (L.) | Dried fruit beetle |
| *Carpophilus dimidiatus* | (F.) | Corn sap beetle |

### Ptinidae

| | | |
|---|---|---|
| *Gibbium aequinoctiale* | Boieldieu | Hump beetle |
| *Mezium affine* | Boieldieu | |
| *M. americanum* | Laport | American spider beetle |

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E-mail: science@csl.gov

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# *Coleoptera*

## *Ptinidae*

| | | Common Name |
|---|---|---|
| *Niptus hololeucus* | Faldermann | |
| *Ptinus clavipes* | Panzer | Brown spider beetle |
| *P. exulans* | Erichson | |
| *P. pusillus* | Sturm | |
| *P. sexpunctatus* | Panzer | |
| *P.tectus* | Boieldieu | Australian spider beetle |
| *Pseudeurostus hilleri* | (Reitter) | |
| *Sphaericus gibboides* | (Boieldieu) | |
| *Stethomezium squamosum* | Hinton | African spider beetle |
| *Tipnus unicolor* | (Piller and Mitterpacher) | |
| *Trigonogenius globulus* | Solier | Globular flour beetle |

## *Silvanidae*

| | | |
|---|---|---|
| *Ahasverus advena* | Waltl | Foriegn grain beetle |
| *Oryzaephilus acuminatus* | Halstead | |
| *O. mercator* | (Fauvel) | Merchant grain beetle |
| *O. surinamensis* | (L.) | Saw-toothed grain beetle |

## *Tenebrionidae*

| | | |
|---|---|---|
| *Alphitobius diaperinus* | (Panzer) | Lesser mealworm |
| *Coelopalorus foveicollis* | (Blair) | |
| *Gnatocerus cornutus* | (F.) | Broad horned flour beetle |
| *G. maxillosus* | (F.) | Slender horned flour beetle |
| *Latheticus oryzae* | Waterhouse | Long headed flour beetle |
| *Palorus cerylonoides* | (Pascoe) | |
| *P. ficicola* | (Pascoe) | |
| *P. genalis* | Blair | |
| *P. ratzeburgii* | (Wissmann) | Small eyed flour beetle |
| *P. subdepressus* | (Wollaston) | Depressed flour beetle |
| *Sitophagus hololeptoides* | (Castelnau) | |
| *Tenebrio molitor* | L. | Yellow mealworm |
| *T. obscurus* | F. | Dark mealworm |

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# Lepidoptera

| | | Common name |
|---|---|---|
| **Gelechiidae** | | |
| *Sitotroga cereallella* | Olivier | Angoumois grain moth |
| **Pyralidae** | | |
| *Ephestia cautella* | Walker | Tropical warehouse moth |
| *E. elutella* | Hübner | Warehouse moth |
| *E. kuehniella* | Zeller | Mediterranean flour moth |
| *Galleria mellonella* | Linnaeus | Wax moth |
| *Plodia interpunctella* | Hübner | Indian meal moth |
| **Tineidae** | | |
| *Tinea pellionella* | Linnaeus | Case bearing clothes moth |
| *Tineola bisselliella* | Hummel | Webbing clothes moth |

# Psocoptera

| | | |
|---|---|---|
| **Liposcelidae** | | |
| *Liposcelis bostrychophilus* | Badonnel | Stored product psocid |
| *L. subfucus* | Broadhead | Outhouse psocid |
| **Trogiidae** | | |
| *Lepinotus patruelis* | Pearman | Black domestic psocid |
| *Trogium pulsatorium* | L. | Larger pale booklouse |

# Thysanura

| | | |
|---|---|---|
| **Lepismatidae** | | |
| *Lepisma saccharina* | L. | Silver fish |

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# Mite Cultures

**DEAD mites of the following species are available:**

## *Astigmata*

### *Acaridae*

*Acarus siro* L.

*Caloglyphus berlesei* (Michael)
*C. oudemansi* (Zachvatkin)
*C. redikorzevi* (Zachvatkin)

*Tyroborus lini* Oudemans

*Tyrophagus brevicrinatus* Robertson
*T. longior* (Gervais)
*T. neiswanderi* Johnston and Bruce
*T. perniciosus* Zachvatkin
*T. putrescentiae* (Schrank)

### *Carpoglyphidae*

*Carpoglyphus lactis* (L.)

### *Glycyphagidae*

*Blomia tropicalis* van Bronswijk et al.

*Glycyphagus domesticus* (De Geer)

*Lepidoglyphus destructor* (Schrank)

### *Pyroglyphidae*

*Dermatophagoides farinae* Hughes
*D. pteronyssinus* (Trouessart)

**DEAD mites of the following species MAY BE AVAILABLE commercially following further discussion on nature of work:**

## *Astigmata*

### *Acaridae*

*Acarus farris* (Oudemans)
*A. gracilis* Hughes

*Aleuroglyphus ovatus* (Troupeau)

*Rhizoglyphus callae* Oudemans
*R. robini* Claparède

*Suidasia medanensis* Oudemans

*Thyreophagus entomophagus* (Laboulbène)

*Tyrolichus casei* Oudemans

*Tyrophagus palmarum* Oudemans
*T. similis* Volgin
*T. tropicus* Robertson

### *Glycyphagidae*

*Austroglycyphagus geniculatus* (Vitzthum)

### *Pyroglyphidae*

*Dermatophagoides microcerus* Griffiths and Cunnington

**All the species listed may be available as live cultures following further discussion on nature of work**

# Invertebrate Supply Service

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- The Central Science Laboratory's Invertebrate Supply Unit maintains over 100 species of insect and 36 species of mite which are mainly pests of stored products and of public health importance.
- Cultures are maintained by highly trained specialist staff and are housed in custom-built computer- controlled constant environment rooms.
- Strict quality control systems are in place to ensure all cultures provided are of the highest quality. All cultures are regularly checked by qualified taxonomists and certificates of authenticity are provided with each culture purchased.
- Insects and mites can be provided at any stage of their life cycle. Specific ages can also be provided.
- Regular orders can be supplied under commercial contract
- Information on culturing requirements is included with each insect purchase.

## Availability

The majority of orders can be supplied within **3 days** .
However , if large numbers or specific ages of insects / mites are required please contact us direct and we will advise you of delivery time.

## Customs and quarantine regulations

Overseas customers are requested to include any necessary licences or documents with their request.

**For further information please contact:** **Mr Justin Dixon**
I.S.U. Manager
or visit the **Central Science Laboratory web site** which details further information on CSL and the services provided:

**Tel:** +44 (0)1904 46 26 35
**Fax:** +44 (0)1094 46 21 11
**www.csl.gov.uk** **e-mail:** isu@csl.gov.uk

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The Central Science Laboratory (CSL) is an executive agency of the Department for Environment, Food & Rural Affairs (DEFRA). CSL can provide experts and consultants from a wide variety of fields:

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# Insect and Mite Culture Order Form

**Name:** ..........................................................................

**Address:** ..........................................................................

..........................................................................

..........................................................................

**Tel no:** ............................ **Fax no:** ................................ **E-mail:** ................................

**Customer purchase order no:** ..............................................

**For new customers only:** How did you find out about CSL's invertebrate supply service? *(please tick appropriate box)*

| Advertisement in | Website | Conference/ Exhibition | Colleague | Other *(please specify)* |
|---|---|---|---|---|
| ................................... ................................... ................................... *(please name journal/magazine)* | | ................................................ .. ................................................ .. ................................................ .. *(please give details)* | | ................................................ .. ................................................ ................................................ .... |

| Species | Quantity* | Adult/Larvae | Price* £ |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | **Subtotal** | |
| (Note: VAT is not payable for orders paid from outside UK) | | **VAT** | |
| | | **TOTAL** | |

* An **insect culture** contains **50-100 insects** and costs **£75.00 + VAT.**
Mite cultures can be supplied either **live** or **dead** (min. order 5g dead mite culture). Price **£400.00 + VAT.**
For quantities greater than the above, prices will be increased pro rata.
For special requirements please contact the Invertebrate Supply Unit for a quote.
Invoices will be sent on completion of order. Payments must be made in Sterling

**Date required:** ..................................

**Please send completed form to:**

Mr J Dixon
Central Science Laboratory
Sand Hutton
York Y041 1LZ
UK

**Telephone:** +44 (0)1904 46 26 35
**Fax:** +44 (0)1904 46 21 11
**E-mail:** j.dixon@csl.gov.uk

**ISU use only**

| Date received:.......................... | Date despatched:..................... | CSL order no:........................ |
|---|---|---|

SLOUGH, BUCKS, U.K.
TROPICAL DEVELOPMENT AND RESEARCH INSTITUTE (FORMERLY TPI)
STORAGE DEPARTMENT
OVERSEAS DEVELOPMENT ADMINISTRATION
PEST BIOLOGY AND INSPECTION SECTION

TROPICAL DEVELOPMENT AND RESEARCH INSTITUTE (TDRI)

The Tropical Development and Research Institute (TDRI) was formed 1 April, 1983, following the amalgamation of the Tropical Products Institute and the Centre for Overseas Pest Research. The Director of the Institute is Dr. Malcolm Thain who was formerly Director of the Tropical Products Institute.

The Institute, part of the Overseas Development Administration and funded from the aid programme, will provide technical assistance to developing countries. The budget will total over eight million pounds in the financial year 1983/84.

TDRI will continue to work on post-harvest technology and pest and vector management for the benefit of developing countries, by controlling the pests harmful to agriculture, stored products and public health, and by improved processing, storage and marketing of agricultural fisheries products.

The main emphasis of its work in scientific research and development, marketing, information, advice and training will centre on the improvement of food supplies in accordance with the major objectives of the British overseas aid programme. Work will also continue on certain non-food crops of particular importance to developing countries. These activities will be carried out, as at present, in the UK and overseas in countries throughout the developing world.

Since post harvest technology and pest and vector management are broad and varied subjects, TDRIwill concentrate its activities in those areas where it has a comparative advantage in terms of experience, knowledge and cost-effectiveness. Close cooperation will continue with government organizations, universities and industry in developing countries, the UK and other industrialized countries, and with multilateral and bilateral aid agencies.

Requests from developing country govenments qualifying for British aid will be channelled through the Overseas Development Administration, which may commission TDRI to carry out the work if it lies within the scope of its terms of reference, and if resources are available. In addition, TDRI may, subject to the claims on its resources commissioned by ODA, accept contracts for relevant work on behalf of developing countries from multilateral aid agencies and other organizations.

TDRI is based in London, although relocation to a new site outside the central London area is under consideration. It currently employs over 450 staff.

Requests for information, advice, investigations or training should be sent to:

The Director
Tropical Development and Research Institute
56-62 Gray's Inn Road
London WC1X 8LU
England (Telephone 01-[illegible])

All stocks are maintained at 27 degrees centigrade and 70% R.H. The stocks listed below are those currently maintained for ongoing research projects. Other storage pest species are kept in culture from time to time for training or short research projects.

I. Wild type strains

A. Coleoptera

Bostrichidae

1. Prostephanus truncatus -- Mexico, Tanzania

Bruchidae

1. Acanthoscelides obtectus -- Swaziland; Turkey
2. Callosobruchus analis -- MAFF Lab., Slough; Indonesia
3. Callosobruchus chinensis -- Nepal; Kenya
4. Callosobruchus maculatus -- Brazil, 2 strains; Nigeria, 2 strains; Oman; Senegal; Sierra leone; Turkey; Upper Volta; Yemen.
5. Caryedon serratus -- Unknown
6. Zabrotes subfasciatus -- Uganda (collected from cowpeas and bred on cowpeas); Colombia.

Curculionidae

1. Sitophilus oryzae -- Peru (pulse-feeding strain breeding on split peas)
2. S. zeamais -- Mexico

B. Lepidoptera

Galleriinae: Corcyra cephalonica -- Malawi

Gellechiidae: Sitotroga cerealella -- Sudan

Phycitinae: Ephestia cautella -- Brazil

CHEMICAL CONTROL SECTION

(stocks of some major beetles pests are maintained, under selection pressure with insecticide where necessary, in order to enable the FAO recommended methods for the detection and measurement of resistance to be carried out. Incoming strains from abroad are screened and the methods are demonstrated in training programs.)

Wild type strains

Coleoptera

Bostrichidae

Prostephanus truncatus--Strains tested for phosphine resistance: Botswana; Indonesia; Mali (8 strains) Nepal; Nigeria; Pakistan (2 strains) Singapore; Sri Lanka (4 strains); Tunisia; Zimbabwe.

Bruchidae

Acanthoscelides obtectus -- Ethiopia
Callosobruchus chinensis -- India

Curculionidae

Sitophilus oryzae -- Insecticide-susceptible strain (reference strain) -- via MAFF Lab, Slough
S. oryzae -- Malathion and lindane resistant strain (A.76) -- via MAFF Lab., Slough.

Tenebrionidae

Tribolium castaneum -- Multiple insecticide-resistant strain (CTC 12) -- australia
T. castaneum -- Malathion-specific resistant strains (Kano C) -- Nigeria
T. castaneum -- Insecticide-susceptible strain (reference strain) -- MAFF Lab, Slough

Dr. P. F. Prevett
Deputy Head of Department

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I. Wild type strains

A. Coleoptera

Anobiidae

1. Lasioderma serricorne — a. Unknown
2. Stegobium paniceum — a. ex-MAFF

Bostrichidae

1. Dinoderus distinctus — a. Tanzania
2. D. minutus — a. Indonesia
3. D. porcellus — a. Togo
4. Prostephanus truncatus — a. Costa Rica
   b. Mexico (3 strains)
   c. Nigeria
   d. Tanzania (4 strains)
   e. Togo
   f. Kenya
5. Rhyzopertha dominica — a. Ex-MAFF
   b. Angola*
   c. Kenya (3 strains)***
   d. Mali *
   e. Morocco *
   f. Nepal*
   g. Sri Lanka

Bruchidae

1. Acanthoscelides obtectus -- a. Colombia (2 strains)
   b. Uganda
   c. Zimbabwe
2. Callosobruchus analis -- a. MAFF Lab.
3. Callosobruchus chinensis -- a. Indonesia
4. Callosobruchus maculatus -- a. Uganda
5. Caryedon serratus — a. India
6. Zabrotes subfasciatus -- b. Uganda

## Stock Lists

| | |
|---|---|
| **Curculionidae** | |
| 1. *Sitophilus oryzae* | |
| i. Normal strains | a. Ex-MAFF |
| | b. India |
| | c. Morocco |
| | d. Zimbabwe |
| ii. Pulse-feeding | a. Burma |
| 2. *S. zeamais* -- | a. Ex-MAFF |
| | b. India |
| **Dermestidae** | |
| 1. *Dermestes ater* | a. Ex-MAFF |
| 2. *D. maculatus* | a. Jamaica |
| 3. *Trogoderma granarium* | a. India |
| | b. Sudan |
| **Histeridae** | |
| 1. *Teretriosoma nigrescens* | a. Mexico |
| **Lophocateridae** | |
| 1. *Lophocateres pusillus* | a. Philippines |
| **Silvanidae** | |
| 1. *Ahasverus advena* | a. Ex-MAFF |
| 2. *Oryzaephilus sp.* | a. Kenya (4 strains) |
| 3. *Oryzaephilus surinamensis* | a. Ex-MAFF |
| **Tenebrionida** | |
| 1. *T. castaneum* | a. Ex-MAFF |
| | b. Botswana‡ |
| | c. Indonesia (2 strains) |
| | d. Kenya ‡ |
| | e. Mali‡ |
| | f. Mozambique |
| | g. Pakistan‡ |
| | h. Philippines + |
| | i. Sri Lanka |
| | j. Thailand (3 strains)‡‡‡+ |
| | k. Zimbabwe (2 strains)‡ |
| 2. *Latheticus oryzae* | a. Ex-MAFF |
| 3. *Gnatocerus cornutus* | a. Ex-MAFF |
| 4. *Palorus subdepressus* | a. Ex-MAFF |

Key
‡ Number of strains which have to date been found to be Phosphine resistant.
+ Malathion resistance noted.
‡ Pirimiphos methyl resistance noted.

B. Lepidoptera

Pyralidae

1. <u>Corcyra cephalonica</u> a. Ex-MAFF
2. <u>Ephestia cautella</u> a. Ex-MAFF
   b. Ethiopia
3. <u>Ephestia elutella</u> a. Ex-MAFF

Gellechiidae:

1. <u>Sitotroga cerealella</u> a. Sudan

CHEMICAL CONTROL SECTION

(stocks of some major beetles pests are maintained, under selection pressure with insecticide where necessary, in order to enable the FAO recommended methods for the detection and measurement of resistance to be carried out. Incoming strains from abroad are screened and the methods are demonstrated in training programs.)

Wild type strains

Coleoptera

Bostrichidae

Prostephanus truncatus--Strains tested for phosphine resistance: Botswana; Indonesia; Mali (8 strains) Nepal; Nigeria; Pakistan (2 strains) Singapore; Sri Lanka (4 strains); Tunisia; Zimbabwe.

Bruchidae

<u>Acanthoscelides obtectus</u> -- Ethiopia
<u>Callosobruchus chinensis</u> -- India

Curculionidae

<u>Sitophilus oryzae</u> -- Insecticide-susceptible strain (reference strain) -- via MAFF Lab, Slough
<u>S. oryzae</u> -- Malathion and lindane resistant strain (A.76) -- via MAFF Lab., Slough.

Tenebrionidae

<u>Tribolium castaneum</u> -- Multiple insecticide-resistant strain (CTC 12) -- australia
<u>T. castaneum</u> -- Malathion-specific resistant strains (Kano C) -- Nigeria
<u>T. castaneum</u> -- Insecticide-susceptible strain (reference strain) -- MAFF Lab, Slough

Dr. Chris P. Haines

## YUGOSLAVIA

INSTITUTE FOR BIOLOGICAL RESEARCH
"SINIŠA STANKOVIĆ"
UNIVERSITY OF BELGRADE
DEPARTMENT OF INSECT PHYSIOLOGY & BIOCHEMISTRY

1. *Morimus funereus*, L. (Cerambycidae - Coleoptera), wild type, Fruška Gora & Derdap, Serbia (geographic origin)

2. *Cerambyx cerdo*, L. (Cerambycidae - Coleoptera), wild type, Fruška Gora, Serbia

3. *Tenebrio molitor*, L. (Tenebrionidae - Coleoptera), wild type, Fruška Gora, Serbia

4. *Lymantria dispar*, L. (Lymantriidae - Lepidoptera), wild type, Despotovac, Serbia

*Dr. Zlatko Prolic, Ph. D.*

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*R.W. Beeman's Tribolium Home Page

For those who are not aware that Tribolium has a Home Page prepared by R.W. Beeman and accessible at the address http://bru.usgmrl.ksu.edu/beeman/tribolium it is included in this issue of the Tribolium Information Bulletin. It was last edited August `3, 1998, and it contains information on techniques on how to handle beetles in the laboratory as well as an up-to-date description of mutants and their linkage relationships, something which was also available from their extensive stock lists published in the TIB. On behalf of its readers, the Editor thanks Dr. Beeman and his group for their efforts in making the Home Page as current as possible.

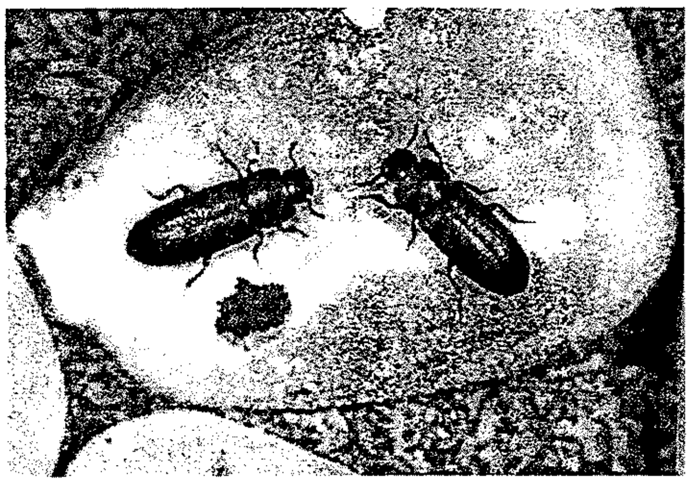
# R.W. BEEMAN'S TRIBOLIUM HOME PAGE

# Welcome to the *Tribolium* Home Page

**This site contains data and articles about the genetics of the red flour beetle, *Tribolium castaneum*, and related species. Work being done in Dr. Beeman's laboratory involves both standard and molecular approaches.**

- Standard Genetics
  - **Beetle Handling**
  - **Linkage Maps**
  - **Mutants**
- **Medea: Maternal-Effect Selfish Genes**
- **Insecticide Resistance in *Tribolium***

- Download these Web Pages for local use on your PC.



To Dr. Beeman's Page
To Biological Research Unit

Send comments or questions to
beeman@usgmrl.ksu.edu
haas@usgmrl.ksu.edu

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*Last Edited: August 13, 1998*

# BEETLE WRANGLING TIPS

**(An Introduction to the Care and Handling of *Tribolium castaneum* )**

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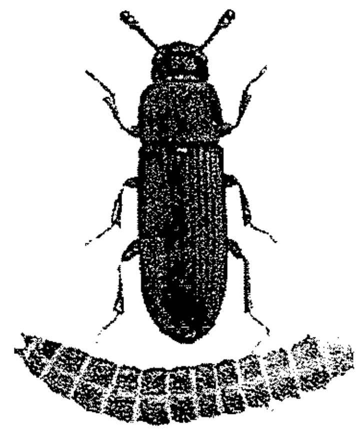
## Index





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## A. Subculturing

**1. Paper transfer**- The use of paper strips to transfer adult beetles from an older stock jar to a new one is the quickest and easiest method. Paper strips approximately 5" X 1" are used for sub culturing pint and quart jars. In a bottle with many beetles on the surface of the flour, put the paper strip into the mass of beetles,and wait for them to cover the bottom 1/4 - 1/3 of the strip. (If the jar has fewer adults on top, tilt the jar slightly to one side. Adults will gather in the low side, where you can collect them on the paper strip.)Then quickly but **carefully** withdraw the strip from the first jar and insert it into the jar of new flour. Shake the paper strip and tap it against the sides of the jar to remove the beetles. Repeat the process until the desired number of beetles is transferred. Discard that paper strip and use a fresh one for the next jar you subculture.

Smaller 5" X 3/4" paper strips are used for sub culturing square bottles or vials. The smaller strips may be cut even narrower for easier insertion into the smaller containers. Alternately, a 3/4" strip can be "bowed" along the narrow edge with the fingers to provide easier insertion into the vial and a more effectively shaped paper strip surface for collecting a smaller population of beetles which are being tilted to one side of the curved surface of a vial (or corner of a bottle)to concentrate them.

(Note: Use one clean strip of paper for each culture jar sub cultured.It's best not to lay the strip down on any surface while sub culturing a jar because of the possibility of a stray egg, larva or adult clinging to it, and being introduced into your jar as a contaminant. )

Use paper transfer whenever possible...it helps prevent transfer of disease via equipment if disease is a problem, and minimizes the possibility of contamination from a stray egg or small larva left in the sieve or pan.It also selects for the healthiest, most vigorous beetles (with the exception of stocks of beetles with short /defective legs that have difficulty climbing a paper strip.

It's a good idea to spot check each stock sub cultured at the time of each subculture. Just place an extra 10 beetles in a petri dish, cool on ice, and inspect the beetles for proper phenotype. Discard the beetles used for spot check. (If your stock is very small, and every beetle counts,save them, but be very conscientious of good "ot;t;;**sterile technique.**"(i.e., "bang" each petri dish lid and bottom on the tabletop before each use to dislodge any stray eggs or larvae.)

TOP

**2. Scoop or spoon transfer**- For Dch-3, and other mutants with very short / defective legs, use a small scoop or plastic spoon to collect adults from one jar or bottle and transfer to another."Sterilize" the scoop or spoon by rapping against the table top several times on both sides. Tilt the bottle so adults move to one side to concentrate them for scooping. Scoop carefully to prevent mashing any beetles against the side of the container. Avoid scooping flour as much as possible. (You just want to collect ~~feet ect etc~~ **live, healthy** adults.) Again,it's a good idea to spot check each stock as you subculture it. Place about 10 adults in a "sterilized" petri dish as mentioned above.

TOP

**3. Sieving transfer** ("Sterile technique")-When paper or scoop transfers are not possible, sieve and select live beetles for subculture by using the following protocol:

**Bang** sieves, receiving pans, and aluminum sorting pans firmly and thoroughly on wastebasket lid immediately before **and** immediately after use. Bang the plastic transfer funnel lip sharply on the tabletop or wastebasket lid several times.

**Inspect** banged equipment visually for presence of clinging larvae or adults. If larvae are stuck in the sieve, try to dislodge by additional banging. If this fails, **gently** poke at them with a brush to encourage them to go on through or withdraw, whichever is the shorter route to getting out. Be careful not to damage them while they are caught in the sieve.If they bleed onto the sieve, their blood and body fluids will corrode the screen.

**"Squeegee" sterilize brushes** between thumbnail and index finger before using each time.

Always sieve into a receiving pan, never onto the table top! **Sieve**any flour which contains larvae as **quickly** as possible, with**continuous**agitation dump siftings **immediately** into sorting pan to minimize the opportunity for larvae to try to crawl through screen and get stuck.For those caught in screen, dislodge first by banging sieve against receiving pan (first up-side-down, then right-side-up). Dislodge any remaining larvae by poking or "tickling" through screen gently with brush. Don't use ~~see~~ **lateral** brushing action to dislodge stuck larvae --- rough treatment can squash larvae, and hemolymph from injured larvae can corrode screen of sieve!!

After sieving diseased stocks, wipe down the sieve and receiving pan with alcohol and dry completely ( place on a heat source such as a scope light source, or top of hot incubator, to evaporate excess moisture and solvent)

TOP

**4. Pan sorting (after sieving)**

**a. Adults** - Count or sort the beetles collected in the aluminum pan by brushing adults into a petri dish with a small to medium sized brush.If your sample has a very large number of adults in it, flying beetles can be a problem. (Beetles seem to get more excited and want to fly away when crowded, or when conditions are hot and humid.) You can minimize the problem by first putting all the collected beetles in one or more petri dishes and place lids on the dishes. Then return smaller portions of beetles to the aluminum pan for sorting a bit at a time.

**b. Pupae** - If collecting pupae from a jar with a spoon, you can exclude many adults by tilting the jar to one side. Adults will move to the low side, and you can scoop from the center (Be sure to"sterilize"the spoon first by wiping off and rapping it against the table top several times on both sides!). Sieve, then brush adults and larvae into one petri dish, and brush pupae into another dish.

**Note**: Sorting adults, pupae, or larvae with a brush is easier if accumulations of exuvia (castoff skins) are first removed. One method to remove them is by **gently** blowing them out of the pan, using a side-to-side and near-to-far sweeping motion with your breath, blowing them into a waste basket. It usually takes 3 to four "sweepings"to get most of the exuvia out. (Be careful to blow gently enough that only exuvia, and some dead adults are blown out --not the live adults, pupae and larvae. Dead beetles and exuvia are lighter than live ones and careful blowing helps to separate them.).

Another way of separating pupae from adults and larvae is to sift the whole jar, place the adults, larvae and pupae (the siftings), into a petri dish or other clean container, then work with small amounts of the siftings.For each lot, blow off the skins, then shake down the adults and pupae,leaving the **larvae**. Pour the adults and pupae onto a petri dish lid in a covered sieve receiving pan, and let the **adults** run off,leaving mostly **pupae**. Exuvia can also be removed by vacuuming the siftings from a quart jar before placing in the aluminum sorting pan.

TOP

**5. Use of topping** - Topping (coarsely ground wheat) is used to give beetles traction on the flour so they can right themselves if they fall onto their backs (while many beetles in a container can help each other get up, a lone beetle can get stranded on its back and starve to death!).
Use topping if:

**a. Population density is low** due to disease or mutation.

**b.** Adults have impaired ability to right themselves due to a mutation affecting leg size or shape. For instance, it is wise to use topping with stocks of Dch-3 since they can't get around as well as beetles with normal sized and shaped front legs, and since they have lower fertility than other strains.

TOP

**6. Subculturing schedule** - If using a 30°C incubator temperature, subculture heavily used stocks weekly.Other stocks may be subcultured every other week or monthly.

**7. Diseased stocks** - Diseased stocks should be subcultured every two days to dilute the disease organisms. **Transfer only live beetles!** Dead or moribund beetles should be discarded.

TOP

# B. TROUBLE SHOOTING

## If a stock is not producing progeny, check the following:

1. Are there any adults still alive? If there are live adults, check to see if they are all males (some disease seems to plug up and kill the females first).
2. Is there evidence of disease......dead, dried, and sometimes darkened, larvae and pupae? ("Licorice stick" is a good description of the dead larvae's appearance. Dead pupae appear discolored and mummified, and are often chewed on by the adults.)
3. Are there mites in with the adults, or clinging to the adults? To differentiate between grain mites, psocids, and parasitic mites, you can look at this web page to see what grain mites and psocids look like.

- Parasitic mites tend to hang all over the adults, sometimes to the point of giving them a frosted look, and also hide under the wings and elytra. They seem to prefer female beetles, possibly as a way of being near eggs which they may feed on.
- A permanent or long term cure is possible. Follow this link to view the section on parasitic mites in the "Disease & Mites" part of this guide.

TOP

# C. TROUBLE PREVENTION

1. Keep all containers of beetles or culture flour closed or covered when not being used or worked with.
2. Bang pans and sieves up-side-down vigorously against wastebasket lid before and after each use to remove any remaining eggs or small larvae.
3. Wipe off and rap spoons and scoops against table top before each use.
4. "Squeegee" sterilize brushes before each use.
5. If beetle adults, larvae or pupae are found on the table top as a result of sieving, discard unless you saw it fall and are **100%** certain of its origin! (It helps to begin with a spotless working surface and floor.This helps increase the probability of an **accurate** recovery of a dropped or spilled beetle. It does not insure against accidently picking up a "fly-in" in place of the intended beetle!).
6. Don't house beetles in airtight containers, and don't push corks tightly into mouths of vials. Insects need fresh air!

TOP

# D. Disease & Mites

Eggs may also be collected on Gold Medal flour (or other equally fine flour), and a new stock begun from the debris-free eggs. Allow the adults to lay eggs on the fine flour for 24 hour periods of time. Each day, collect the eggs by double sieving. This method involves using two sizes of sieves,a #25 and a #50, stacked one on top of the other . The #25 is placed on top, with the #50 between the #25 and the receiving pan. Adults remain on the #25 sieve and can be placed temporarily in a covered, sterilized petri dish. The eggs will be retained on the #50 sieve, and can then be transfered to a clean petri dish. (Alternately, if the two sieves being used are warped and difficult to separate after sifting, egg collection can be done in two separate siftings: separate the adults from the flour using only the #25 sieve first, then sieve out the eggs using only the #50 sieve. ) All extraneous material (frass, debris) can then be removed from the collected eggs using a small brush. Put cleaned eggs in jar or bottle of fresh flour for development. This works for ridding a stock of **mites** as well as **disease**.

**Parasitic mites** can easily retard or destroy an otherwise healthy stock. The mites hang all over the adults, sometimes to the point of giving them a frosted look. They seem to prefer females. A permanent or long term cure can be achieved, with a lot of work.

1. Initially, a subset of adults needs to be cleaned. This means putting them on ice and removing the mites with a vacuum probe or aspirator. Mites are persistent, and can also hide (safely) under the elytra.
2. When the beetles are recovered, put them in fine flour with topping for egg collection.
3. Collect the eggs 1-3 days later (depending on the number of adults ovipositing).
4. Now come the hardest part. Put the eggs on some dark paper or other good-contrast surface, under the microscope. With an insect pin and a small vial of ethanol, remove EVERYTHING that is not a plump, healthy egg. Dip the head of the pin in the ethanol, and then blot up the trash. Swish and repeat.
5. Be careful of mites that are feeding on the eggs, as they swell up almost egg-size, and the egg wraps around them as it is depleted. Also look for loose mites roving the surface. Roll the eggs over.
6. Put the now "sterile" eggs in new flour. Keep infested cultures and healthy cultures separate. Disinfect your equipment.

TOP

## E. Developmental Rates of *Tribolium castaneum*

| **Rearing Temperature** | **30°C** | **34°C** |
|---|---|---|
| **Egg** | 3 days | 2 days |
| **Larva** | 20 days | 15 days |
| **Pupa** | 4 days | 3 days |
| **Reproductive Maturation** | 5 days | 4 days |
| **Total time egg to egg** | 32 days | 24 days |

(The reproductive lifetime is 3-4 months for females and 4-6 months for males. Isolated males have been known to live for up to a year)

Note: At 22°C, development is much slower.

TOP

## F. Sexing *Tribolium*

Separating the sexes is necessary in order to run a number of genetics tests. Both adults and pupae can be sexed. If the intended cross must be a virgin cross, it is necessary to sex the beetles as pupae to insure no previous mating has taken place. Following are some materials and methods which have worked well in our laboratory, plus suggested alternate materials you might use.

TOP

1. **Pupae** (Sexing beetles as pupae rather than as adults is easiest since pupae move very little compared to the adults,and do not need to be immobilized by cooling them on ice.)

**a. Materials** (Microscope, light source, working surface, manipulating tools)

Microscope: A stereoscope is needed to sex the pupae. You will want to be able to magnify the pupae by at least 20 - 30X.A zoom lens stereoscope is very handy.

Light source: A good light source will reduce eyestrain if you are going to be looking at many pupae. The best is a fiberoptics light system. It is both a cooler light source than conventional lights,and those on gooseneck pipes can be aimed at exactly the area you need to focus on. We use a fiber optics light with two light pipes. If you use a standard light, be careful not to overheat your pupae by having the light source too close to them.

Working surface: A small plate of a non-static generating material (approx. 3" x 4") is very handy for separating the sexes. We use a 3" x 4" piece of styrofoam backed posterboard.This has a thickness of about 1/4" which makes it easy to pick up,is light weight, and has a smooth surface to work on. We have chosen a deep blue color, since that color provides a good contrast to the color of the pupae. Any dark color will do. Light colors should be avoided because they cause a glare from the lights.

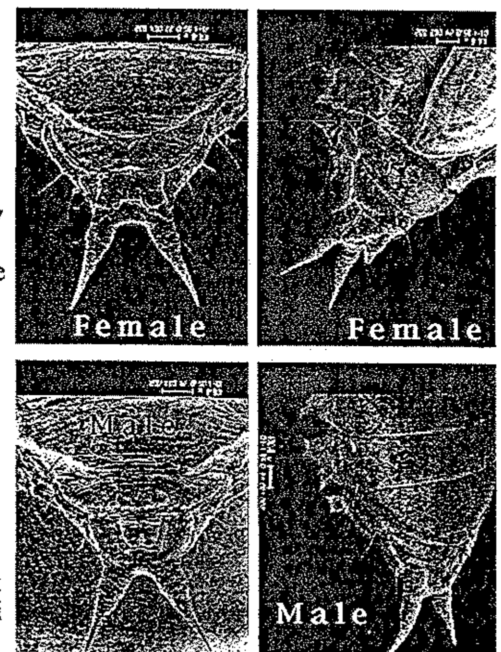
Manipulating tools: A small natural bristle brush can be used to move the pupae on the "plate".

Alternately, a commercial or a homemade vacuum probe can be used to manipulate the pupae.We use a version available through the Jensen Tool catalog, which is hooked up to the vacuum system in our building. (The same probe could also be connected to small electrical vacuum pump). A much simpler version can be made from a plastic drinking straw, a 2-foot piece of flexible rubber tubing (approx. 1/8" internal diameter), and a plastic pipette tip.In this case, the vacuum is supplied by the user's mouth.

Other: **Plastic petri dishes or other small containers**can be used to temporarily hold the pupae both before and after sexing.These same containers, or small bottles or vials which contain about 1"of flour can be used to hold the pupae until they eclose to adulthood.Any container used for this purpose should have a lid which would keep the wandering adults from escaping. (The lid also needs to have small air holes placed in the top if it is a very tight fitting lid. Petri dish lids do not need air holes.)A **plastic funnel** is handy for pouring pupae or adults from a sorting pan into a bottle or jar.

- TOP

**b. Methods**




1. Tilt dish and tap some onto the sexing plate.
2. Using a small brush or vacuum probe, line up the pupae in a horizontal line about half way down the plate (have them all facing the same direction, i.e. all heads up or all heads down).
3. As you look at each pupa under the microscope to determine the sex, brush one sex into a new line above the original line, and the other sex into a new line below the original line. When this process is done, you should have two new lines in place of the old one; one with males and one with females. Use the diagrams at right to identify males and females.(Tip: Ignore the two pointed structures at the very end of the pupa - these are the urogomphi, not the genital papillae. The female papillae, which are much larger than those of the male, are two finger-like structures just anterior to the pointed urogomphi. The male papillae are enough smaller that they look like just fingertips rather than fingers.).
4. Double check your work. To do this, it is important to brush one of the sexes off of the plate into a petri dish or other container while you double check the other sex. (Pupae can't walk, but they can roll or squirm, and if you leave both sexes on the plate while double checking them, one could squirm into the wrong line or group, undoing your careful sexing!) Look at each pupae again to verify its sex, placing missexed pupae in the correct group. You might want to check your pupae a third time just to be sure while you're getting the hang of it.
5. Label your containers and place each sex in a separate container with flour to allow them to eclose to adulthood. (You can use them for crosses once the adults have darkened to brown.).

TOP

**2. Adults**

**a. Materials** (ice bucket, ice block)

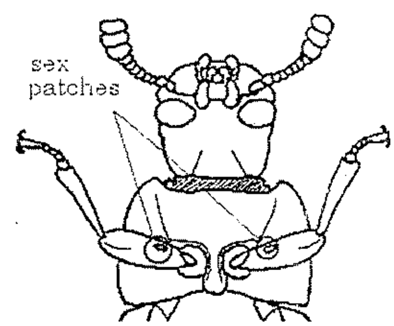
Ice bucket: Any container which can hold crushed ice can be used to precool adult beetles. The small styrofoam boxes or buckets which are used for picnics or fishing are perfect for this..

Ice block: This is used to keep the beetles immobile while you are looking at them under the microscope. We use small, flat plastic tissue culture bottles which we fill with water about 1/4"at a time until they are mostly full. (Don't fill any container completely full because it will crack or burst when frozen!) Any low-profile container which can hold crushed ice could be used; for instance, a large petri dish full of crushed ice. The pre-cooled beetles are then placed in a smaller, low-profile container (such as a smaller petri dish lid), and this smaller container of beetles is placed on the larger low-profile container filled with ice. You should be able to place this assemblage under your stereoscope.The beetles should remain immobile long enough for you to be able to sex them. (Tip: The ice eventually melts, allowing the beetles to "wake up", so you will want to limit the number of beetles you sex at onetime to a number compatible with the "staying power" of your cooling equipment.).

TOP

**b. Methods**

1. Collect adults from stock (using methods mentioned above in Wrangling Tips) and place in a covered petri dish or other container for temporary holding. Put the container of beetles on the crushed ice in the ice bucket to precool them before putting them on the ice block.
2. Tap a small number of adults from the petri dish into a smaller flat container on the ice block.
3. 
4. Line up the adults as with the pupae above, and separate them into two new lines according to sex. Use the diagram at right to distinguish between males and females. The males have a small patch of short bristles on the inside of the first pair of legs, about 1/3 the distance out from the bases. If the patches have picked up flour, they will appear like two domes of flour or flour paste, and will be fairly easy to see. If they have not yet picked up flour, they will appear as slightly darker, textured spots on the legs. (Changing the angle of light or changing the position of the beetle can help make the patches more visible if you are having trouble seeing them.)




Male RFB

5. Recheck the sexes while still on the ice block.
6. Brush each sex into a separate petri dish or other covered holding container until all the beetles are sexed.
7. (Reminder: Work with only a small number of beetles at a time. This will allow you to do the sorting and rechecking before the ice block starts to melt and the beetles wake up and try to walk off!)
8. Use the beetles for your crosses. If they are sexed as adults, they are usually used right away rather than being held in flour like the pupae mentioned above. If you do place them in containers for use later, remember that the females are probably already fertilized and will be producing offspring in their jar.

TOP

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*Last Edited: August 13, 1998*

# Linkage Groups

- LG 1-4 (large image)
- LG 5-9 (large image)

- LG 1 = X
- LG 2
- LG 3
- LG 4
- LG 5
- LG 6
- LG 7
- LG 8
- LG 9

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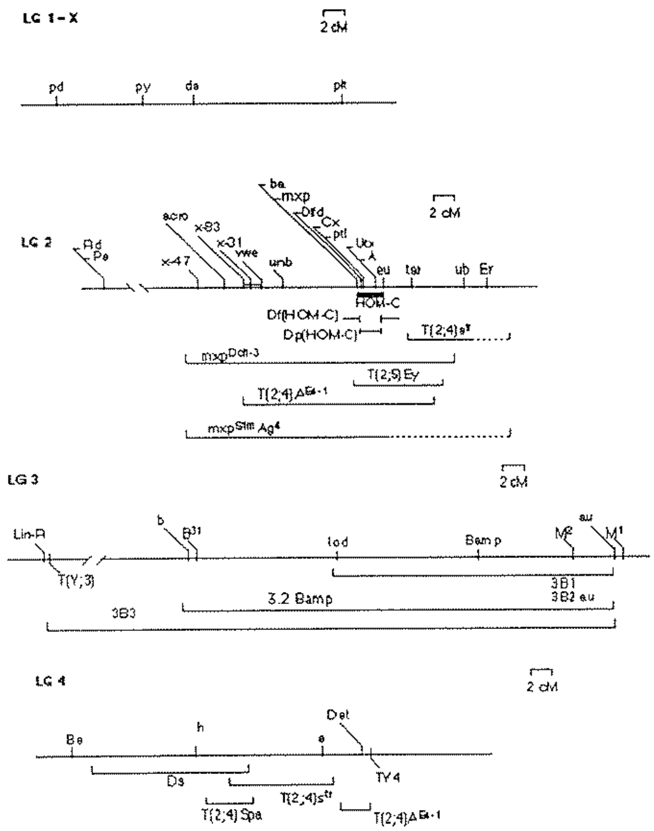
*Last Edited: August 13, 1998*

# *Tribolium castaneum* chromosomes 1-4

Select a Linkage Group:

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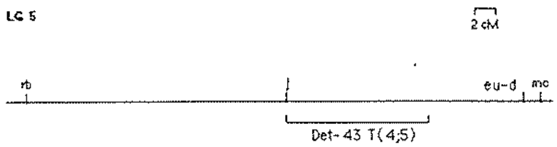
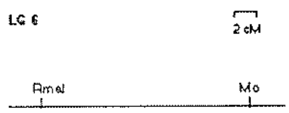
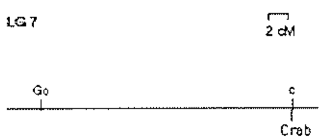
*Last Edited: August 13, 1998*

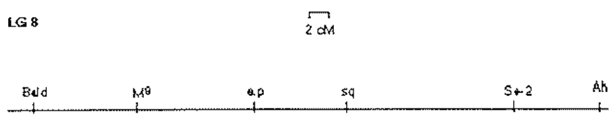

# *Tribolium castaneum* chromosomes 5-9

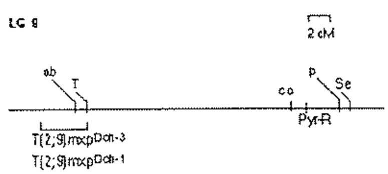
Select a Linkage Group:

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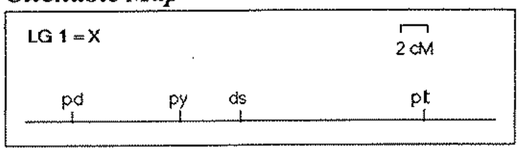
*Last Edited: August 13, 1998*

# *Tribolium castaneum* Linkage Group 1

***Clickable Map***




| Mutant | Name/note |
|---|---|
| ds | displaced sternellum |
| pd | paddle |
| plt | platinum eye |
| py | pygmy |

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*Last Edited: August 13, 1998*

# ds-X (displaced sternellum, X-linked)

- **Structure affected:** Sternellum on ventral prothorax and elytra
- **Linkage Group:** 1 = X
- **Origin:** Spontaneous, from Stm,Cx5/Ey; s/s stock
- **Description:** The sternellum is shortened and slightly displaced outward from the body. Elytra are short, exposing the dorsal tip of the abdomen.

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*Last Edited: August 13, 1998*

# pd (paddle)

- **Structure affected:** Antennae.
- **Linkage Group:** 1 = X
- **Origin:**
- **Description:** Antennal segments are fused, giving antenna a "canoe paddle" appearance.

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*Last Edited: August 13, 1998*

# plt (platinum eye)

- **Structure affected:** eye
- **Linkage Group:** 1 = X
- **Origin:** spont.
- **Description:** white-eye

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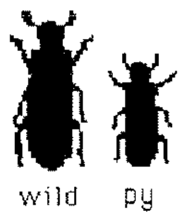
*Last Edited: August 13, 1998*

# py (pygmy)

- **Structure affected:** global
- **Linkage Group:** 1 = X
- **Origin:** spontaneous
- **Description:** Body mass reduced by one-half. All proportions normal.

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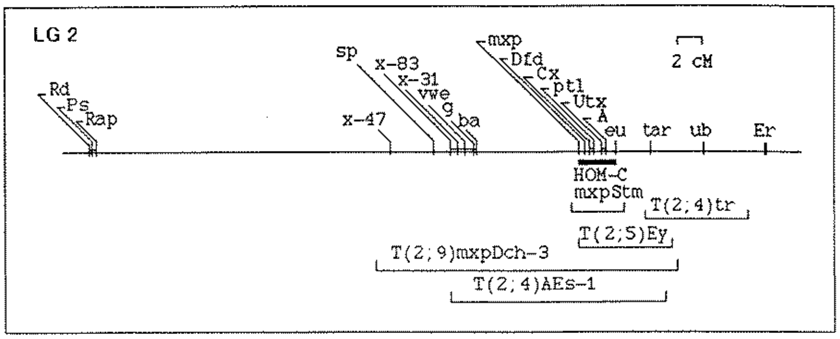
*Last Edited: August 13, 1998*

# *Tribolium castaneum* Linkage Group 2

*Clickable Map*




| Mutant | Name/note |
|---|---|
| A | Abdominal |
| ba | broken antenna |
| Cx | Cephalothorax |
| Dfd | Deformed |
| Er | Eyes reduced |
| eu | extra urogomphi |
| glossy | glossy cuticle |
| mxp | maxillopedia |
| mxpStm | Stumpy |
| Ps | Pinched sternellum |
| ptl | prothoraxless |
| Rap | Recurved anterior pronotum |
| Rd | Reindeer |
| sp | shoulder pads |
| T(2;4) AEs-1 | Extra sclerite |
| T(2;4) tr | tremblor |
| T(2;5)Ey | Eyeless |
| T(2;9) mxpDch-3 | Dachsund |
| tar | tar |
| ub | unbuckled |

| | |
|---|---|
| **Utx** | Ultrathorax |
| **vwe** | vestigial wings and elytra |
| **x-31** | lethal |
| **x-47** | lethal |
| **x-83** | lethal |

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*Last Edited: August 13, 1998*

# A (Abdominal)

LG 2

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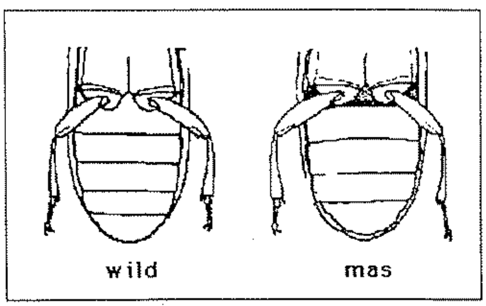
## ES-1 (Extra sclerite)

- **Structure affected:** Ventral abdominal segment 2.
- **Linkage Group:** T(2;4)
- **Origin:**
- **Description:**
  - Homeotic transformation of ventral part of abdominal segment 2 (normally forming the socket of the coxae of the third pair of legs) towards segment 3.
  - Excellent crossover suppressor and balancer (second only to Ey in usefulness).
  - No crossover suppr. between HOM-C and Rd.
  - Ag/Es1 spontaneously generates viable Df(HOM-C) gametes at a frequency of 1/1000 when outcrossed (see Ag).
  - Generated euD when outcrossed (BB, p. 32).
  - Translocation demonstrated cytologically, both cis and trans with Spa.

---

## mas (missing abdominal sternite)

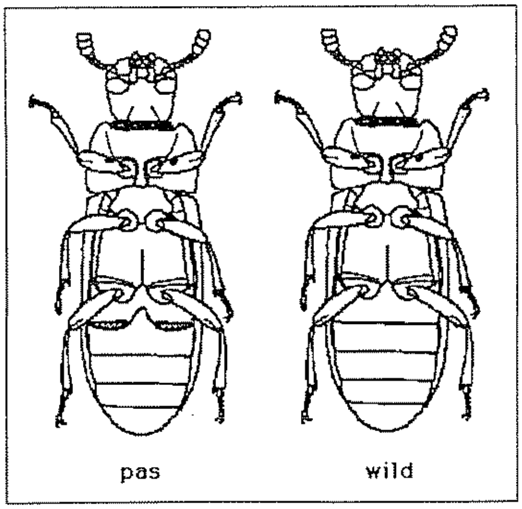
- **Structure affected:** 3rd abdominal sclerite
- **Linkage Group:** 2
- **Origin:** spontaneous
- **Description:** mas is an abdominal 3 to abdominal 2 transformation.




---

## pas (pointed abdominal sternite)

- **Structure affected:** 4th abdominal sclerite
- **Linkage Group:** 2
- **Origin:** spontaneous
- **Description:** pas is an abdominal 4 to abdominal 3 transformation.

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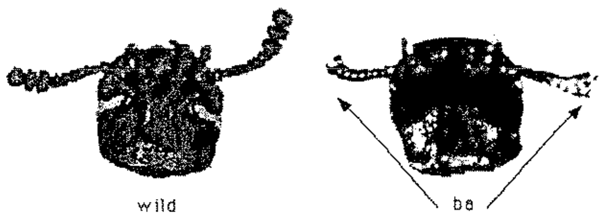
*Last Edited: August 13, 1998*


# ba (broken antenna)

- **Structure affected:** Antennae.
- **Linkage Group:** 2
- **Origin:** Ethylmethanesulfonate-induced.
- **Description:** Antennae appear defective in hemolymph supply. They fail to sclerotize normally after adult eclosion, then become melanotic and brittle, and break off as the adult ages.




---

*Last Edited: August 13, 1998*

# Cx (Cephalothorax)

LG 2

---

## Cx

- **Structure affected:** Labium and prothorax.
- **Linkage Group:** 2
- **Origin:** Gamma radiation-induced.
- **Description:** Complex homeotic transformations of labium and prothorax.

wild Cx

(pupa)

---

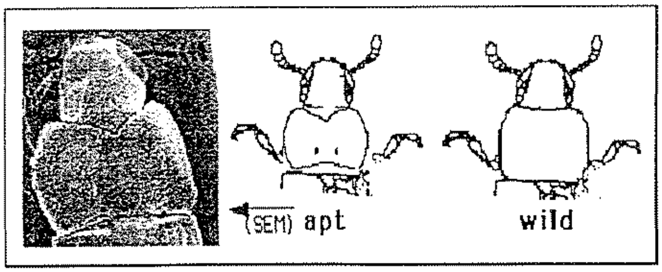
## Ag

- **Structure affected:** Antenna.
- **Linkage Group:** 2
- **Origin:** G, GA-1.
- **Description:** A galea-like projection is found on the basal segment (scape) of the antenna. (Ag/Es1 spontaneously generates viable Df(HOM-C) gametes at a frequency of 1/1000 when outcrossed. These uncover Cx, ptl, Utx and A, but complement mxp and eu ).

---

## apt

- **Structure affected:** dorsal pronotum.
- **Linkage Group:** 2
- **Origin:** spontaneous; A. Sokoloff, Berkeley, CA.
- **Description:** The dorsal pronotum is taking on characteristics of the dorsum of the next most posterior segment, the mesothorax (T2). In its strongest expression, the anterior margin of the pronotum has a large midline indentation, and the posterior midline is beginning to look like the T2 scutellum (the little roundly triangular structure just posterior to the pronotum).




---

*Last Edited: August 13, 1998*

# Dfd (Deformed)

- **Structure affected:** No gene-specific mutants known. Identified as molecular homolog of Drosophila Deformed gene.
- **Linkage Group:** 2
- **Origin:**
- **Description:**

---

*Last Edited: August 13, 1998*

# Er (Eyes reduced)

- **Structure affected:** Eyes and surrounding head capsule
- **Linkage Group:** 2
- **Origin:** Gamma irradiation of Ag mutant
- **Description:**
  - First recovered as an Mc on an Ag chromosome. The two genes later segregated away from each other.
  - The male first recovered was F1 of Ag/Es.
  - Head is reduced posterior to the genal shelf. Most of the dorsal component of the eye is missing. Ventral expression of eye is more complete, though somewhat reduced due to a reduction of that portion of the head capsule itself. **In contrast to Ey, Er most often has good bilateral expression of the ventral eye.**

---

*Last Edited: August 13, 1998*

# eu (extra urigomphi)

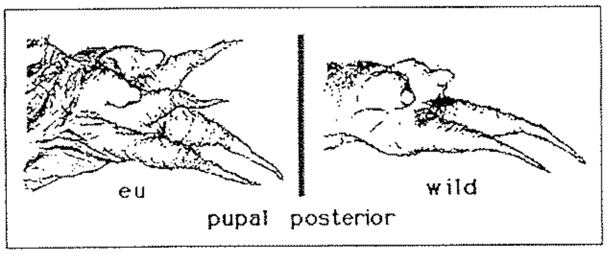
LG 2

---

## Description/Notes

### eu (extra urigomphi)

- **Structure affected:** urogomphi (paired "horns" at posterior tip of abdomen of larvae and pupae).
- **Linkage Group:** 2
- **Origin:** Spontaneous.
- **Description:** Supernumerary pair of urogomphi develop via homeotic transformation of abdominal segment 9 toward 10.




---

### euD (dominant allele)

- **Structure affected:** Posterior abdominal segments (A10 & A11)
- **Linkage Group:** T(2; 5)
- **Origin:** Gamma irradiation of Rd,mas,p males, Beeman Lab, USGMRL, Manhattan, KS
- **Description:**
  - Translocation: T(2;5), confirmed cytologically
  - Male sterile
  - extra urogomphi (unilaterally or bilaterally), found in larvae and pupae
  - Genital papillae of male and female pupae are abnormal
  - Male aedaegus non-rotated, rendering males functionally sterile
  - Female ovipositors with split lateral sclerite, causing dorsal-ventral flattening of ovipositor
  - euD/eu beetles have reiterated genital papillae in the females, and lack an aedaegus in males
  - Appears to be hyper-mutator stock

---

*Last Edited: August 13, 1998*

# g (glossy)

- **Structure affected:** cuticle, global
- **Linkage Group:** 2
- **Origin:** EMS mutagenesis of sooty. Dch3 /Ey chromosome extraction (Dch3/unb)
- **Description:**
  - Color has been found to be "light pumpkin", compared to wild-type.
  - The exterior surface, with the exception of elytra, has a higher reflectivity than normal, due to a reduction of the "surface microsculpture" between the setiferous pits.
  - The elytra are sometimes divergent (usually not).
  - T1 epimera tend to be slightly incomplete, not quite extending as far under the sternellum as with wild-type.
  - Ventral sclerites also have an imperfect T1-T2 juncture at the T2 coxae.

---

*Last Edited: August 13, 1998*

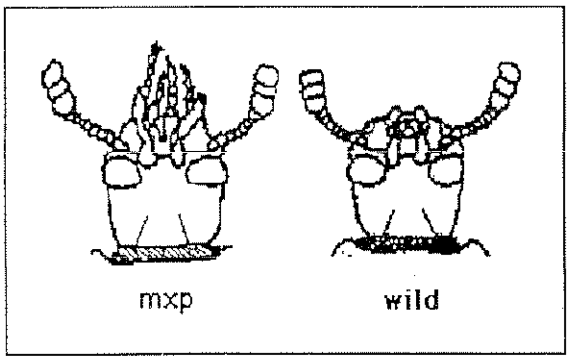
# mxp (maxillopedia)

LG 2

---

## mxp (maxillopedia)

- **Structure affected:** maxillary & labial palps
- **Linkage Group:** 2
- **Origin:** spontaneous
- **Description:** mxp/mxp causes transformation of the labial and maxillary palps into legs.




---

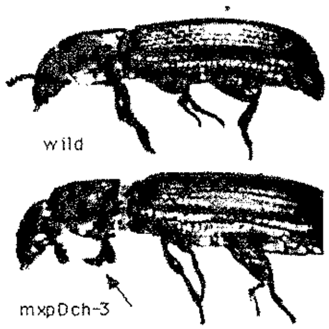
## Dch-1 (Dachshund)

- **Structure affected:** Antennae and legs.
- **Linkage Group:** T(2;9)
- **Origin:** Radiation-induced.
- **Description:** Dominant, gain-of-function (GOF). Antennae & legs shorter than normal (partially transformed towards palp) in heterozygotes. Dch-1/Dch-3 heteroallelic adults have complete and dramatic transformation of legs into palps.

---

## Dch-3 (Dachshund)

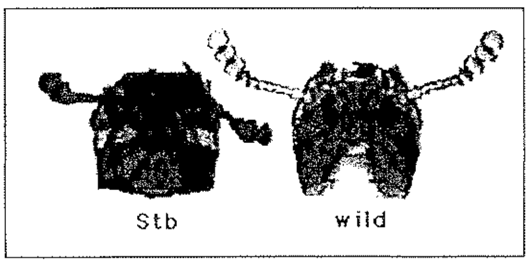
- **Structure affected:** Prothorax.
- **Linkage Group:** T(2;9)
- **Origin:** Radiation-induced.
- **Description:** GOF. Prothoracic legs are dramatically reduced. Remainder of prothorax is reduced to a lesser extent, presumably via a homeotic transformation toward labial or maxillary segment. Effect restricted to prothorax. Antennae are normal.




---

## Stb (Stubby)

- **Structure affected:** Antennae.
- **Linkage Group:** 2
- **Origin:** EMS, GA-1
- **Description:** GOF. Funicle of antennae reduced via homeotic transformation towards palp. Sometimes behaves as an X-linked trait (upon outcrossing) but loses this property upon inbreeding, only to regenerate the property again upon outcrossing.




---

## Stm (Stumpy)

- **Structure affected:** Antennae.
- **Linkage Group:** 2
- **Origin:** Ethylmethane sulfonate.
- **Description:** GOF. Club and funicle of antennae reduced.
  - Near-lethal with lethal mxp alleles
  - Complements viable mxp.
  - Homozygous stock is fertile.
  - Other stocks balanced with Stm are only slightly leaky.
  - Lab-S RFLP matches Stm RFLP in a clone from the A gene, so Stm probably is a Lab-S chromosome.
  - No translocation found cytologically by Giovani Mocelin.

---

*Last Edited: August 13, 1998*

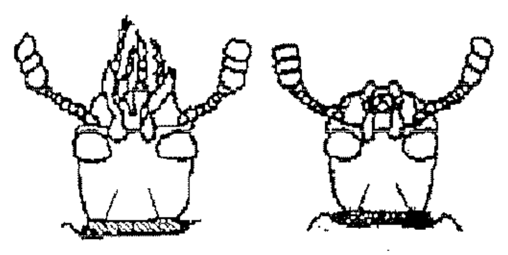
# mxp (maxillopedia)

LG 2

---

## mxp (maxillopedia)

- **Structure affected:** maxillary & labial palps
- **Linkage Group:** 2
- **Origin:** spontaneous
- **Description:** mxp/mxp causes transformation of the labial and maxillary palps into legs.




---

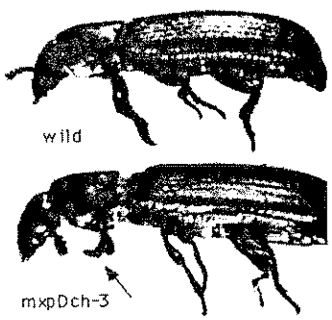
## Dch-1 (Dachshund)

- **Structure affected:** Antennae and legs.
- **Linkage Group:** T(2;9)
- **Origin:** Radiation-induced.
- **Description:** Dominant, gain-of-function (GOF). Antennae & legs shorter than normal (partially transformed towards palp) in heterozygotes. Dch-1/Dch-3 heteroallelic adults have complete and dramatic transformation of legs into palps.

---

## Dch-3 (Dachshund)

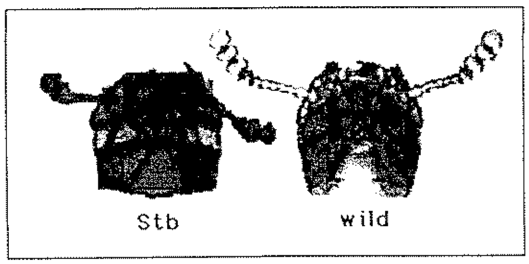
- **Structure affected:** Prothorax.
- **Linkage Group:** T(2;9)
- **Origin:** Radiation-induced.
- **Description:** GOF. Prothoracic legs are dramatically reduced. Remainder of prothorax is reduced to a lesser extent, presumably via a homeotic transformation toward labial or maxillary segment. Effect restricted to prothorax. Antennae are normal.




---

## Stb (Stubby)

- **Structure affected:** Antennae.
- **Linkage Group:** 2
- **Origin:** EMS, GA-1
- **Description:** GOF. Funicle of antennae reduced via homeotic transformation towards palp. Sometimes behaves as an X-linked trait (upon outcrossing) but loses this property upon inbreeding, only to regenerate the property again upon outcrossing.




---

## Stm (Stumpy)

- **Structure affected:** Antennae.
- **Linkage Group:** 2
- **Origin:** Ethylmethane sulfonate.
- **Description:** GOF. Club and funicle of antennae reduced.
  - Near-lethal with lethal mxp alleles
  - Complements viable mxp.
  - Homozygous stock is fertile.
  - Other stocks balanced with Stm are only slightly leaky.
  - Lab-S RFLP matches Stm RFLP in a clone from the A gene, so Stm probably is a Lab-S chromosome.
  - No translocation found cytologically by Giovani Mocelin.

---

*Last Edited: August 13, 1998*

# Ps (Pinched sternellum)

- **Structure affected:** T1 sternellum and dorsum, T3 antecoxal sutures, basal segments of legs, antennae and maxillary palps.
- **Linkage Group:** 2
- **Origin:** Reversion of Skl1 / Stm balanced mutants
- **Description:**
  - The original beetle was Ps and Stm.
  - Setae are commonly found on coxae, as are setae and spikes on the antennal scape and maxillary palps.
  - Pronotum has dorsal dents and bulges, and both a dorsal and a ventral anterior midline dip.
  - T3 antecoxal sutures are disrupted about 2/3 the way out from midline.

---

*Last Edited: August 13, 1998*

# ptl (prothoraxless)

- **Structure affected:** prothorax
- **Linkage Group:** 2
- **Origin:** spontaneous
- **Description:** pronotum is reduced in size, and prothoracic legs are stunted and malformed.

---

*Last Edited: August 13, 1998*

# Rap (Recurved anterior pronotum)

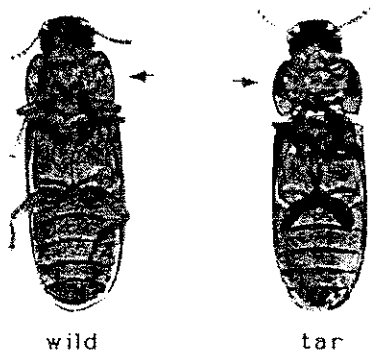
- **Structure affected:** Dorsal pronotum (T1)
- **Linkage Group:** 2
- **Origin:** Spontaneous mutant found in the Ga-1 (wild-type) stock
- **Description:**
  - Dorsal protonum has anterior midline dip, bilateral shallow dents, and enlarged anterio-lateral margins.
  - This dominant is homozygous viable. The phenotype very strong in homozygotes, but easily recognizable in heterozygotes.

---

*Last Edited: August 13, 1998*


# tar

- **Structure affected:** anterior quinone glands
- **Linkage Group:** 2
- **Origin:** EMS
- **Description:** The anterior stink glands are darkly pigmented, usually a red-brown to purple-brown rather than the normal clear yellow, and seem incapable of secretion. Posterior stink glands are not affected.

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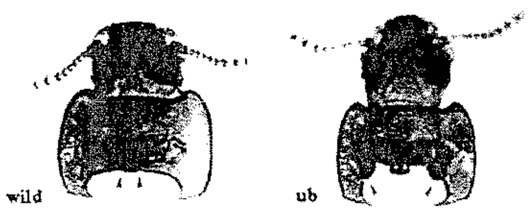
*Last Edited: August 13, 1998*

# ub (unbuckled)

- **Structure affected:** Prothorax, appendages.
- **Linkage Group:** 2
- **Origin:** Beeman Lab, USGMRL, Manhattan, KS. Spontaneous mutant recovered from F2 of ab X pas30,p cross.
- **Description:**
  - T1 epimera deflected ventro-posteriorly.
  - T2 metepimera are displaced from the plane of surrounding sclerites ("flaps").
  - Antenna, legs, gemale genital stylii, and mouthparts are more slender than those of wild-type.
  - Genital papillae of female pupae have a small, round sclerotization at the ventral midline anterior margin. Expression ranges from a barely visible dot to an enlarged structure taking up the full middle third of the papillar base. These larger ones usually have a darker sclerotized center. (Larvae have not been seen with these dots).




*Last Edited: August 13, 1998*

# Utx (Ultrathorax)

- **Structure affected:** Elytra, mesothorax (T2)
- **Linkage Group:** 2
- **Origin:** EMS mutagenesis using Lab-S or GA-1 wild-type strains.
- **Description:**
  - Dominant with warped elytra (gain-of-function, based on dosage analysis) and protruding T2 epimera ("flaps").
  - Recessive A1 to T3 transformation (loss-of-func?) seen in homozygous embryos.
  - Utx1 acts as a lethal only in the Utx1/Es1 bal. stock. Using Stm, Ey or mxpNG-1 as balancer, apparent Utx1 homozygotes are generated. These have "membranous antecoxae" (recessive) phenotype in addition to warped elytra and flaps. We cannot reconcile this phenomenon with the lethal embryo (A1 to T3) phenotype seen in the Utx1/Es1 stock. Utx1 derived from "homozygous" stock regains lethality when placed opposite Es1!
  - Recombination with apt, but not A.

---

*Last Edited: August 13, 1998*

# vwe (vestigial wings and elytra)

- **Structure affected:** wings & elytra
- **Linkage Group:** 2
- **Origin:** EMS
- **Description:** Wings & elytra of pupae are extremely reduced & vestigial. Pupae unable to eclose. Occasional adult escapers with well-differentiated (but miniature) wings & elytra.


---

*Last Edited: August 13, 1998*

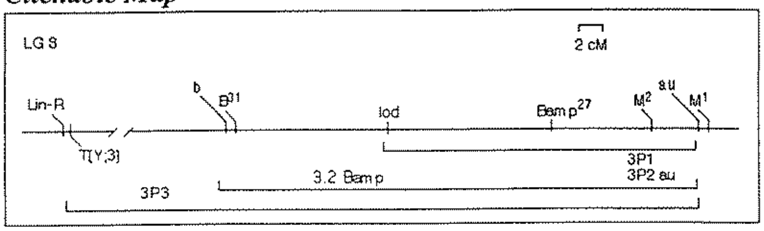
**This is a lethal mutation lacking a visible phenotype**

---

*Last Edited: August 13, 1998*

# *Tribolium castaneum* Linkage Group 3

*Clickable Map*




| Mutant | Name |
|---|---|
| 3.2 Bamp | (3P2 based crossover suppressor w/ 40+ cM range) |
| 3P1 | (Bamp-27 based crossover suppressor w/ 30 cM range) |
| 3P2 | (Bamp-27 based crossover suppressor w/ 30 cM range, and recessive au) |
| 3P3 | (Bamp-27 based crossover suppressor w/ 45+ cM range) |
| au | aureate |
| b | black body - b itself is incompletely recessive, but other alleles are completely resessive. |
| Bamp-27 | Blunt abdominal and metathoracic points |
| Bamp-31 | Blunt abdominal and metathoracic points |
| Lin-R | Lindane resistance |
| lod | light ocular diaphragm |
| $M^1$ | Medea |
| $M^2$ | Medea |
| T(Y;3) | Translocation |

---

*Last Edited: August 13, 1998*

# 3B. . . family of Bamp-27 based LG 3 crossover suppressors

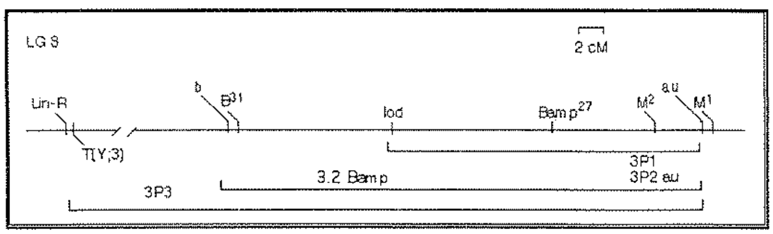
LG 3

## Description/notes

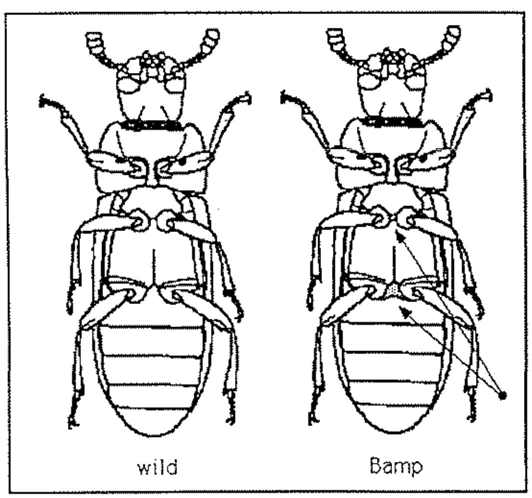
These crossover suppressors were made by irradiating the dominant LG 3 marker Bamp-27 (Click here to go to the Bamp-27 page, or see picture at bottom).

- **3P1** has the dominant Bamp phenotype, and covers approximately 30 cM (See map below).
- **3P2** is essentialy 3P1, with a new or recombined recessive au mutation attached (Click here to go to the au page, or see picture at bottom).
- **3P3** is one of the largest crossover suppressors available in *Tribolium*, covering approximately 15% of the genome. It allows approximately 1% single or double recombinants along most of its length. It has only the dominant Bamp phenotype (See map below)
- **3.2 Bamp** is a radiation-extended 3P2 crossover suppressor. Therefore it has the dominant Bamp and the recessive au. It covers about 40 cM. In the presence of 3.2, M1 and b recombine 2%, apparently at the b end of the 3.2 Bamp CS.

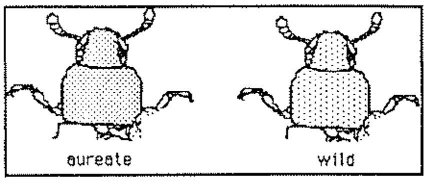
LG 3 linkage map




Bamp-27 phenotype (dominant)



au phenotype (recessive)

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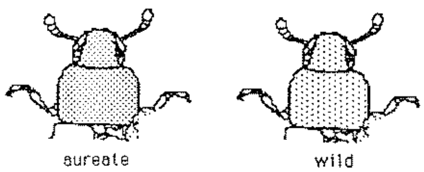
*Last Edited: August 13, 1998*

# au (aureate)

- **Structure affected:** entire surface of cuticle
- **Linkage Group:** 3
- **Origin:** spontaneous
- **Description:** setae (hairs) on general body surface are 2-3 times as dense as normal, giving a frosted or hairy appearance.

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*Last Edited: August 13, 1998*

# b (black)

- **Structure affected:** cuticle
- **Linkage Group:** 3
- **Origin:** spontaneous
- **Description:** black body color.

---

*Last Edited: August 13, 1998*

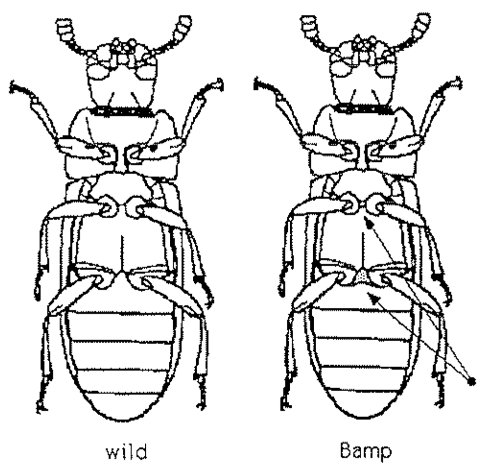
# Bamp-27 (Blunt abdominal and metathoracic projections)

LG 3

---

### Bamp-27 (Blunt abdominal and metathoracic projections)

- **Structure affected:**
- **Linkage Group:** 3
- **Origin:** Gamma irradiation of Ga-1
- **Description:**
  - The anterior midline projection of the T3 (third thoracic) sternum, which usually forms a firm junction with the posterior midline of the T2 sternum at the T2 legs, lacks its usual point, leaving a small gap at the T2-T3 juncture.
  - The anterior midline projection of the A3 (third abdominal) sternum, which usually forms a firm junction with the posterior midline of the T3 sternum at the T3 legs, has a reduced point, leaving a noticable gap at the T3-A3 juncture.
  - This was the irradiated chromosome for the 33B . . . family of LG 3 crossover suppresors.
  - Very fertile.
  - No translocations found by cytology.

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*Last Edited: August 13, 1998*

# Bamp-31 (Blunt abdominal and metathoracic projections)

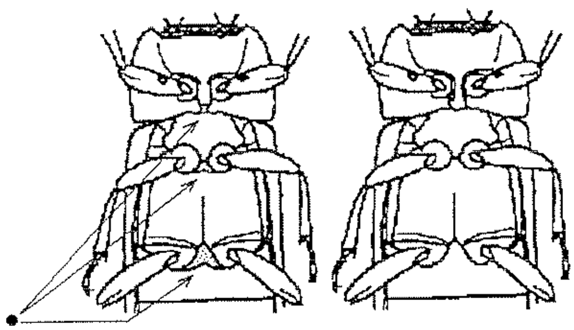
LG 3

---

## Bamp-31 (Blunt abdominal and metathoracic projections)

Blunt abdominal and metathoracic points

- **Structure affected:** T1 Sternellum and A3 point.
- **Linkage Group:** 3
- **Origin:** ChrE (lethal)
- **Description:**
  - The most obvious and easily identified feature of Bamp31 is its shortened, narrowed T1 sternellum. The blunted abdominal and metathoracic projections are more subtile than that found in other Bamp alleles. This allele also commonly has disrupted gular sutures and divergent, "rumpled" elytra.



Bamp wild

---

*Last Edited: August 13, 1998*

# Insecticide Resistance

---

## Lin-R (Lindane resistance)

- **Linkage Group:** 3
- **Origin:** spontaneous
- **Description:** resistant to lindane and cyclodiene insecticides because of a mutation in the GABA(A) receptor.

---

## Rmal (Malathion resistance)

- **Linkage Group:** 6
- **Origin:** spontaneous
- **Description:** resistant to malathion and phenthoate insecticides because of a modification in a carboxylesterase enzyme.

---

## Pyr-R (Pyrethroid resistance)

- **Linkage Group:** 9
- **Origin:** spontaneous
- **Description:** resistant to alpha-cyano synthetic pyrethroids.

---

*Last Edited: August 13, 1998*

# lod (light ocular diaphragm)

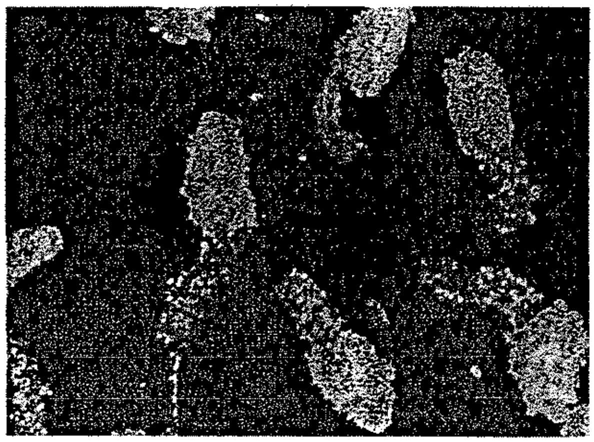
- **Structure affected:**
- **Linkage Group:** 3
- **Origin:** Spontaneous
- **Description:** Ocular diaphragm (ring around outer perimeter of eye) is unpigmented rather than the normal black pigmentation. Can only be recognized in mutant eye color background, such as pearl, ruby, etc.

---

*Last Edited: August 13, 1998*

# Medea

**MEDEA is an acronym for Maternal-Effect Dominant Embryonic Arrest**



**Medea-killed larvae**

---

**Medea** factors all share several characteristics:

- They breed true through the female line.
- They segregate in the male.

When a heterozygous Medea female (M/+) is crossed to a wild type male (+/+), the M gene and its homolog segregate normally. However, all progeny that do not inherit the Medea allele die at or shortly after egg hatch. The lethality is maternal, but the "rescue" is zygotic. The rescuing M allele can be inherited from either parent.

There have been four well-studied Medea factors. Of these, two (M-1 and M-4) are currently maintained at the Tribolium Stock Center. Almost all M strains in the field carry M-4. Of these, about a third also carry M-1. M-4 is the only Medea factor present in North American and European strains, being found in about half of them. Australian and Indian strains are almost devoid of Medea factors. South American, Asian, and African strains often have 2 or more M factors.

---

## $M^1$ (Medea)

- **Linkage Group:** 3
- **Description:** The first and most-studied Meda factor.

---

# $M^2$ (Medea)

- **Linkage Group:** 3
- **Description:** This Medea factor faded away and is no longer detectable.

---

# $M^3$ (Medea)

- **Linkage Group:** 8
- **Description:** This Medea factor faded away and is no longer detectable.

---

# $M^4$ (Medea)

- **Linkage Group:** Unknown
- **Description:** This Medea has an interesting distribution within the United States.

---

*Last Edited: August 13, 1998*

# T(Y;3)

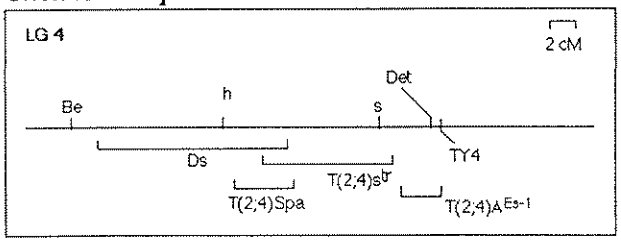
- **Structure affected:** None
- **Linkage Group:** T(Y;3)
- **Origin:** gamma-induced on a Ga-1 chromosome
- **Description:**
  - Translocation between LG3 and the Y chromosome
  - Mutant always carried by males.
  - Translocation demonstrated cytologically.

---

*Last Edited: August 13, 1998*

# *Tribolium castaneum* Linkage Group 4

***Clickable Map***



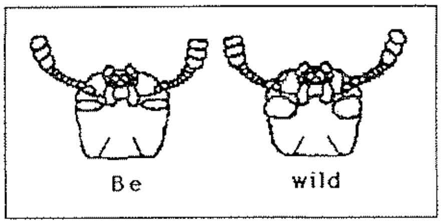

| Mutant | Name/note |
|---|---|
| Be | Bar eye |
| h | hazel eye |
| s | sooty |
| Det-43 | Divergent elytral tips |
| T(Y;4) | Translocation |
| Ds | Displaced sternellum |
| T(2;4)Spa | Spatulate |
| T(2;4) tr | tremblor |
| T(2;4)AEs-1 | Eyeless |

---

*Last Edited: August 13, 1998*

# Be (Bar eye)

- **Structure affected:** eye
- **Linkage Group:** 4
- **Origin:** Sponteneous, dominant. A. Sokoloff, Berkeley, CA.
- **Description:** The number of facets in the eye is reduced to a bar shape, similar to squint (sq).

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*Last Edited: August 13, 1998*

# h (hazel)

- **Structure affected:** eye color
- **Linkage Group:** 4
- **Origin:** spontaneous
- **Description:** hazel or tan eye color, allelic with "white"

---

*Last Edited: August 13, 1998*

# s (sooty)

- **Structure affected:** cuticle
- **Linkage Group:** 4
- **Origin:** spontaneous
- **Description:** cuticle is dark blackish brown, instead of the normal rust-red.

---

*Last Edited: August 13, 1998*

# Det-43 (Divergent elytral tips)

- **Structure affected:** Elytra
- **Linkage Group:** T(4; 5)
- **Origin:** Gamma-induced on a GA-1 chromosome, Beeman Lab, US Grain Marketing Research Lab., Manhattan, KS.
- **Description:**
  - Elytra are divergent at the tips and have a characteristic "knob and bend" at about 2/3 their length at the lateral margins. This characteristic is fully penetrant.
  - It is a T(4;5) translocation.

---

*Last Edited: August 13, 1998*

# T(Y;4)

- **Structure affected:** None
- **Linkage Group:** T(Y; 4)
- **Origin:** gamma-induced on a Ga-1 chromosome
- **Description:**
  - Translocation between LG4 and the Y chromosome
  - Translocation demonstrated cytologically.

---

*Last Edited: August 13, 1998*

# Ds (displaced sternellum)

- **Structure affected:** T1 (prothoracic) sternellum, elytra, global
- **Linkage Group:** 4
- **Origin:** Spontaneous, from Peter Dawson's lab, Oregon State Univ.
- **Description:**
    - Sternellum is shortened and displaced outwardly from the body wall.
    - The elytra are slightly shortened.
    - Length of appendages and of the overall body are slightly reduced.
    - Reduces the recombination frequency between h and s from around 17% to 7.7%.
    - No evidence of chromosome translocation detected in tests for pseudolinkagae or upon cytological exam.
    - Most likely associated with an inversion with one breakpoint between h and s and the other breakpoint on the opposite side of h.

---

*Last Edited: August 13, 1998*

# Spa (Spatulate antenna)

- **Structure affected:** Antenna
- **Linkage Group:** T(2; 4)
- **Origin:** Alexander Sokoloff lab, Berkeley, CA
- **Description:** Antennal club and funicle fusion, giving antenna a shortened look.

---

*Last Edited: August 13, 1998*

# tr (tremblor)

- **Structure affected:** None (behavior affected)
- **Linkage Group:** T(2; 4)
- **Origin:** EMS mutagenesis of sooty
- **Description:**
  - Translocation: t(2;4)
  - Originally, adults had a tremorous gait. This trait has lessened with time.
  - The stock remains balanced with Es, but while balanced with Ey, viable homozygotes were recovered which are sooty colored.

---

*Last Edited: August 13, 1998*

# A (Abdominal)

LG 2

---

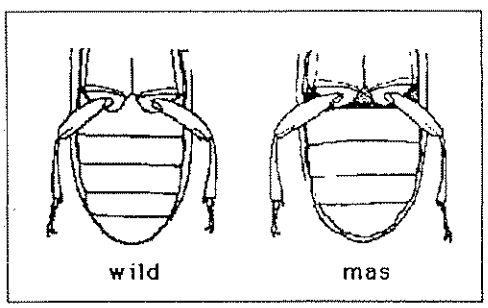
## ES-1 (Extra sclerite)

- **Structure affected:** Ventral abdominal segment 2.
- **Linkage Group:** T(2;4)
- **Origin:**
- **Description:**
  - Homeotic transformation of ventral part of abdominal segment 2 (normally forming the socket of the coxae of the third pair of legs) towards segment 3.
  - Excellent crossover suppressor and balancer (second only to Ey in usefulness).
  - No crossover suppr. between HOM-C and Rd.
  - Ag/Es1 spontaneously generates viable Df(HOM-C) gametes at a frequency of 1/1000 when outcrossed (see Ag).
  - Generated euD when outcrossed (BB, p. 32).
  - Translocation demonstrated cytologically, both cis and trans with Spa.

---

## mas (missing abdominal sternite)

- **Structure affected:** 3rd abdominal sclerite
- **Linkage Group:** 2
- **Origin:** spontaneous
- **Description:** mas is an abdominal 3 to abdominal 2 transformation.

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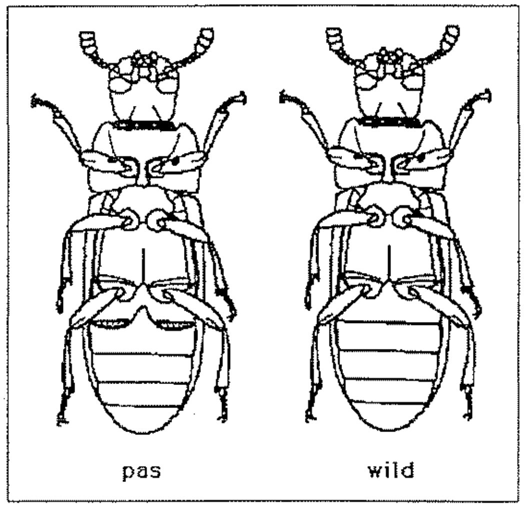
## pas (pointed abdominal sternite)

- **Structure affected:** 4th abdominal sclerite
- **Linkage Group:** 2
- **Origin:** spontaneous
- **Description:** pas is an abdominal 4 to abdominal 3 transformation.

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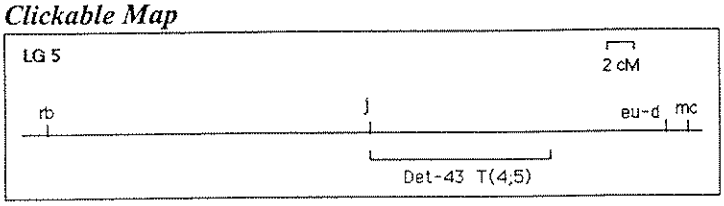
*Last Edited: August 13, 1998*

# *Tribolium castaneum* Linkage Group 5

***Clickable Map***




| Mutant | Name/note |
|---|---|
| Det-43 | Divergent elytral tips |
| eu-D | extra urogomphi |
| j | jet |
| mc | microcephalic |
| T(2;5) Ey | Eyeless |
| rb | ruby |

---

*Last Edited: August 13, 1998*

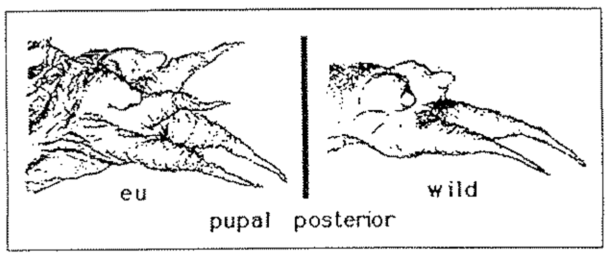
# eu (extra urigomphi)

LG 2

## Description/Notes

### eu (extra urigomphi)

- **Structure affected:** urogomphi (paired "horns" at posterior tip of abdomen of larvae and pupae).
- **Linkage Group:** 2
- **Origin:** Spontaneous.
- **Description:** Supernumerary pair of urogomphi develop via homeotic transformation of abdominal segment 9 toward 10.




### euD (dominant allele)

- **Structure affected:** Posterior abdominal segments (A10 & A11)
- **Linkage Group:** T(2; 5)
- **Origin:** Gamma irradiation of Rd,mas,p males, Beeman Lab, USGMRL, Manhattan, KS
- **Description:**
  - Translocation: T(2;5), confirmed cytologically
  - Male sterile
  - extra urogomphi (unilaterally or bilaterally), found in larvae and pupae
  - Genital papillae of male and female pupae are abnormal
  - Male aedaegus non-rotated, rendering males functionally sterile
  - Female ovipositors with split lateral sclerite, causing dorsal-ventral flattening of ovipositor
  - euD/eu beetles have reiterated genital papillae in the females, and lack an aedaegus in males
  - Appears to be hyper-mutator stock

*Last Edited: August 13, 1998*

# j (jet body)

- **Structure affected:** Cuticle, global
- **Linkage Group:** 5
- **Origin:** Alexander Sokoloff lab, Berkeley, CA
- **Description:** Jet-black body color

---

*Last Edited: August 13, 1998*

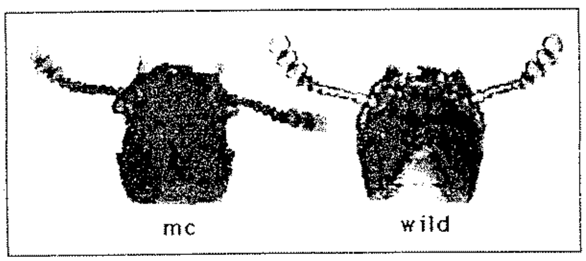
# mc (microcephalic)

LG 5

---

## mc (microcephalic)

- **Structure affected:** eyes and head
- **Linkage Group:** 5
- **Origin:** spontaneous (from Sokoloff)
- **Description:**
  - Width of head is reduced posterior to genal shelf.
  - Eyes are variably reduced, ranging from slight reduction in eye size and number of facets, to complete reduction with no facets. Not bilaterally uniform.
  - One strain occasionally has an "eye-growth" which appears on a sclerotized encroachment into the anterior edge of the eye. The growth ranges from very small and fine, and often appears segmented in its largest and strongest expression.

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## Ey (Eyeless)

- **Structure affected:** eyes and head
- **Linkage Group:** T(2; 5)
- **Origin:** Gamma irradiatin of GA-1 (wild-type).
- **Description:**
  - Dominant allele of mc on LG 5, with a similar range of expression (see mc). Ey is a T(2;5).
  - The lethality seems to be associated with LG 2, since Dp(2)/Ey/Ey is viable (where Dp is derived from mxpDch/Es1).
  - Ey is a good HOM-C balancer, (good crossover suppression, fertile, fully penetrant, heterozygotes extremely viable, homozygous lethal). Only one recombinant (out of ca. 2000) has been observed, placing Ey closer to the mxp-apt region than to the A region.

---

*Last Edited: August 13, 1998*

# rb (ruby eyes)

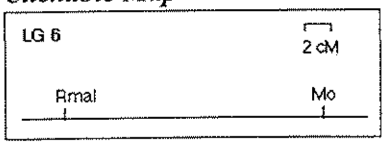
- **Structure affected:** Eyes
- **Linkage Group:** 5
- **Origin:** Alexander Sokoloff lab, Berkeley, CA
- **Description:** Reddish eye color.

---

*Last Edited: August 13, 1998*

# *Tribolium castaneum* Linkage Group 6

*Clickable Map*



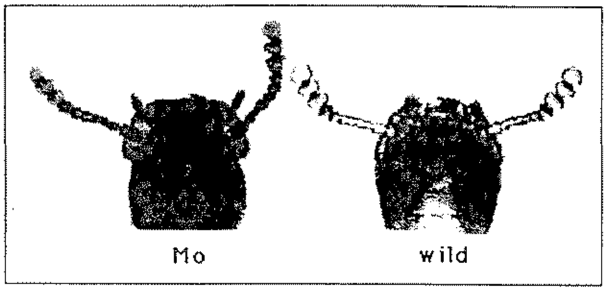

| Mutant | Name/note |
|---|---|
| Mo | Micro-opthalmic |
| Rmal | Resistance to malathion |

---

*Last Edited: August 13, 1998*

# Mo (Micro-opthalmic)

- **Structure affected:** Head and eye
- **Linkage Group:** 6
- **Origin:** Alexander Sokoloff, Univ. California at Berkeley
- **Description:** Width of head capsule reduced behind genal shelf. Dorsal component of eye is reduced or missing. Good bilateral expression.

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*Last Edited: August 13, 1998*

# Insecticide Resistance

---

## Lin-R (Lindane resistance)

- **Linkage Group:** 3
- **Origin:** spontaneous
- **Description:** resistant to lindane and cyclodiene insecticides because of a mutation in the GABA(A) receptor.

---

## Rmal (Malathion resistance)

- **Linkage Group:** 6
- **Origin:** spontaneous
- **Description:** resistant to malathion and phenthoate insecticides because of a modification in a carboxylesterase enzyme.

---

## Pyr-R (Pyrethroid resistance)

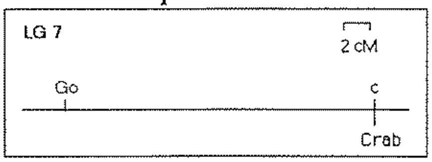
- **Linkage Group:** 9
- **Origin:** spontaneous
- **Description:** resistant to alpha-cyano synthetic pyrethroids.

---

*Last Edited: August 13, 1998*

# *Tribolium castaneum* Linkage Group 7

***Clickable Map***




| Mutant | Name/note |
|---|---|
| c | chestnut eye |
| Crab | Crab legs |
| Go | Goliath |

---

*Last Edited: August 13, 1998*

# c (chestnut eye)

- **Structure affected:** Eye
- **Linkage Group:** 7
- **Origin:** Alexander Sokoloff, University of California at Berkeley
- **Description:** Red-brown colored eye

---

*Last Edited: August 13, 1998*

# Crab

- **Structure affected:** legs
- **Linkage Group:** 7
- **Origin:** EMS mutagenesis, 1986 (Beeman lab, Manhattan, KS)
- **Description:**
  - Tibia shortened, thickened, and bowed, giving them a crab-like look.
  - Male "sex patches" on T1 femur occasionally found on T1 tibia.
  - Linked to c, (chestnut eye color) (0%)

---

*Last Edited: August 13, 1998*

# Go (Goliath)

- **Structure affected:** Body size, global
- **Linkage Group:** 7
- **Origin:** Gamma-induced in Stm/Es. Beeman Lab., USGMRL, Manhattan, KS
- **Description:** Overall body size is increased. Beetles tend to be 1/3 to 1/2 again as large as wild type siblings.

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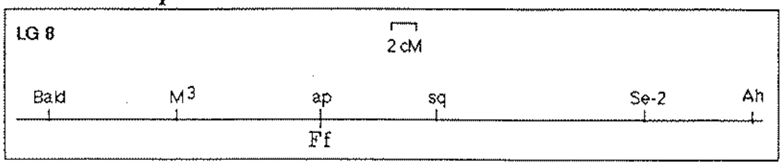
*Last Edited: August 13, 1998*

# *Tribolium castaneum* Linkage Group 8

***Clickable Map***




| Mutant | Name/note |
|---|---|
| Ah | Arrowhead |
| ap | antennapedia |
| Ff | Fused funicle |
| Bald | Bald |
| $M^3$ | Medea |
| Se-2 | Split elytra |
| sq | squint |

---

*Last Edited: August 13, 1998*

# Ah (Arrowhead)

- **Structure affected:** Eye and head.
- **Linkage Group:** 8
- **Origin:** Giovani Mocelin at Jeff Stuart's Lab, Purdue University
- **Description:**
    - This mutant looks like a moderate version of Ey, with extreme expression of all eye facets missing found only rarely.
    - Ah first showed up when males from isogenic line M1/M1 (from Big IV/I/II) were irradiated and crossed to MMS females.
    - It maps on LG8 in this order: Bald-ap-sq-Ah, about 25 cM from sq (it may be very near Se-2).
    - The original Ah was a female.
    - They appear to be homozygous viable.

---

*Last Edited: August 13, 1998*

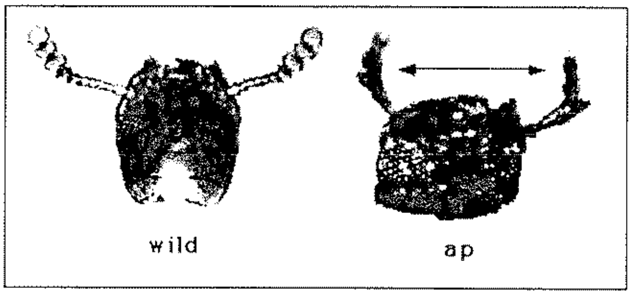

# ap (antennapedia)

LG 8

---

## ap (antennapedia)

- **Structure affected:** Antennae.
- **Linkage Group:** 8
- **Origin:** Spontaneous.
- **Description:** Homeotic transformation of antenna to leg.

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## F (Fused funicle)

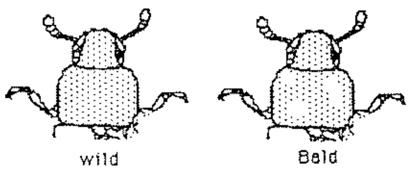
- **Structure affected:** Antennae.
- **Linkage Group:** 8
- **Origin:** Ff originated from an experiment in which Ds (Lg4) was irradiated with gamma rays.
- **Description:**
  - May be a dominant ap allele.
  - Dominance confirmed in a outcross to Ga-1. Penetrance is ~100%.
  - Characteristic phenotype - normal club, funnicle with fusion to usually 4-5 segments. The distal 1-2 segments are enlarged to a size intermediate between that of a funnicle and club segment, giving the club an enlarged 4-segment look usually.

---

*Last Edited: August 13, 1998*

# Bald

- **Structure affected:** Entire cuticle.
- **Linkage Group:** 8
- **Origin:** EMS, Lab-S or Ga-13.
- **Description:** Patches of setae (cuticular hairs) missing over entire surface of adult body. Gives overall glossy appearance to cuticle.

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*Last Edited: August 13, 1998*

# Se-2 (Short elytra 2)

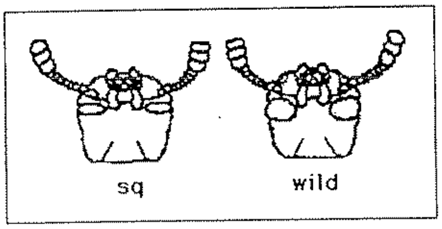
- **Structure affected:** Elytra
- **Linkage Group:** 8
- **Origin:** From ab stock, Scott Thomson, (while working in Beeman lab)
- **Description:**
  - Elytral tips are divergent, exposing wings and membranous dorsal abdomen.
  - Enough wing surface is usually exposed to cause the wings to no longer be neatly folded underneath. Wings are often rumpled, giving the beetle a "cotton-tail" look.
  - Elytra are rarely "short".

---

*Last Edited: August 13, 1998*

# sq (squint)

- **Structure affected:** eye
- **Linkage Group:** 8
- **Origin:** Sponteneous recessive, A. Sokoloff, Berkeley, CA.
- **Description:** The number of facets in the eye is reduced, giving the eye a "squinty" look.

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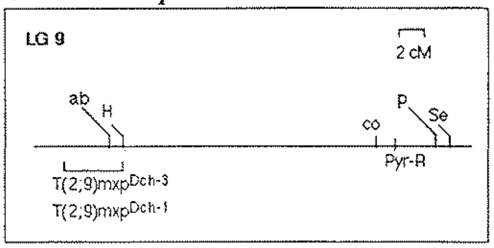
*Last Edited: August 13, 1998*

# *Tribolium castaneum* Linkage Group 9

*Clickable Map*




| Mutant | Name/note |
|---|---|
| ab | antenna bifurcata |
| co | cola body |
| p | pearl eye |
| Pyr-R | Pyrethroid resistance |
| Se | Split elytra |
| T(2;9) mxpDch-1 | Dachsund |
| T(2;9) mxpDch-3 | Dachsund |
| H | H factor |

---

*Last Edited: August 13, 1998*

# ab (antenna bifurcata)

- **Structure affected:** Antennae and trochanter of legs
- **Linkage Group:** 9
- **Origin:** Colombia
- **Description:**
  - The antennae are branched, usually at the pedicel (second segment out from head). Size of the branch varies from a small projection, up to 1/3 the length of the antenna. The projection sometimes appears to be segmented.
  - Spikes on the trochanter usually appear at basal edge and vary in size. Some appear segmented. Less commonly found than branches on antennae.
  - Male sterile.

---

*Last Edited: August 13, 1998*

# co (cola body)

- **Structure affected:** cuticle
- **Linkage Group:** 9
- **Origin:** spontaneous
- **Description:** dark brown body color

---

*Last Edited: August 13, 1998*

# p (pearl eye)

- **Structure affected:** Eyes
- **Linkage Group:** 9
- **Origin:** Alexander Sokoloff, University of California at Berkeley
- **Description:** White colored eye

---

*Last Edited: August 13, 1998*

# Insecticide Resistance

---

## Lin-R (Lindane resistance)

- **Linkage Group:** 3
- **Origin:** spontaneous
- **Description:** resistant to lindane and cyclodiene insecticides because of a mutation in the GABA(A) receptor.

---

## Rmal (Malathion resistance)

- **Linkage Group:** 6
- **Origin:** spontaneous
- **Description:** resistant to malathion and phenthoate insecticides because of a modification in a carboxylesterase enzyme.

---

## Pyr-R (Pyrethroid resistance)

- **Linkage Group:** 9
- **Origin:** spontaneous
- **Description:** resistant to alpha-cyano synthetic pyrethroids.

---

*Last Edited: August 13, 1998*

# Se (Short elytra)

- **Structure affected:** Elytra
- **Linkage Group:** 9
- **Origin:** Spontaneous, from Ey/Stm X Rd,mas,p (Beeman lab, Manhattan, KS).
- **Description:**
  - Expression is variable, ranging from very short elytra noticably rounded posteriorly, to almost normal length with a subtile posterior rounding.
  - Closely linked to p (pearl eye)

---

*Last Edited: August 13, 1998*

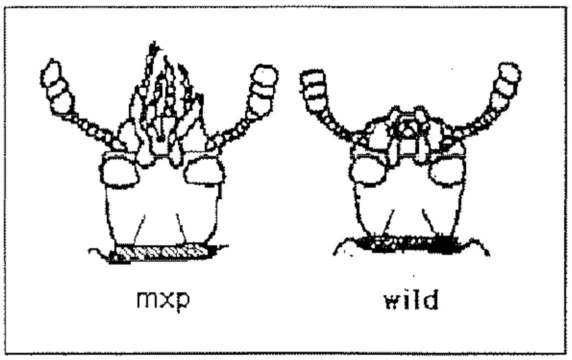
# mxp (maxillopedia)

LG 2

---

## mxp (maxillopedia)

- **Structure affected:** maxillary & labial palps
- **Linkage Group:** 2
- **Origin:** spontaneous
- **Description:** mxp/mxp causes transformation of the labial and maxillary palps into legs.

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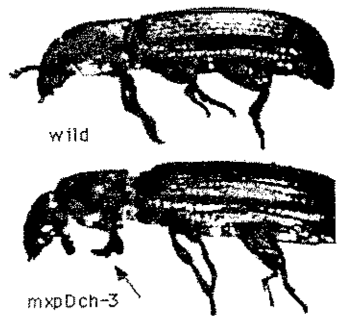
## Dch-1 (Dachshund)

- **Structure affected:** Antennae and legs.
- **Linkage Group:** T(2;9)
- **Origin:** Radiation-induced.
- **Description:** Dominant, gain-of-function (GOF). Antennae & legs shorter than normal (partially transformed towards palp) in heterozygotes. Dch-1/Dch-3 heteroallelic adults have complete and dramatic transformation of legs into palps.

---

## Dch-3 (Dachshund)

- **Structure affected:** Prothorax.
- **Linkage Group:** T(2;9)
- **Origin:** Radiation-induced.
- **Description:** GOF. Prothoracic legs are dramatically reduced. Remainder of prothorax is reduced to a lesser extent, presumably via a homeotic transformation toward labial or maxillary segment. Effect restricted to prothorax. Antennae are normal.

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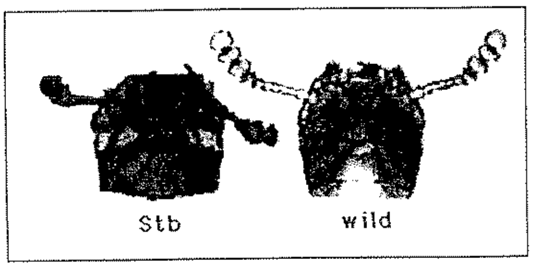
## Stb (Stubby)

- **Structure affected:** Antennae.
- **Linkage Group:** 2
- **Origin:** EMS, GA-1
- **Description:** GOF. Funicle of antennae reduced via homeotic transformation towards palp. Sometimes behaves as an X-linked trait (upon outcrossing) but loses this property upon inbreeding, only to regenerate the property again upon outcrossing.

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## Stm (Stumpy)

- **Structure affected:** Antennae.
- **Linkage Group:** 2
- **Origin:** Ethylmethane sulfonate.
- **Description:** GOF. Club and funicle of antennae reduced.
  - Near-lethal with lethal mxp alleles
  - Complements viable mxp.
  - Homozygous stock is fertile.
  - Other stocks balanced with Stm are only slightly leaky.
  - Lab-S RFLP matches Stm RFLP in a clone from the A gene, so Stm probably is a Lab-S chromosome.
  - No translocation found cytologically by Giovani Mocelin.

---

*Last Edited: August 13, 1998*

# H (Hybrid incompatability factor)

- **Structure affected:**
- **Linkage Group:** 9
- **Origin:** Tiw-1 strain (India)
- **Description:** There are three kinds of strains involved in this type of hybrid incompatibility, namely H strains, neutral strains and non-permissive (NP) strains. When an H male is crossed to a neutral female, F1 hybrids are viable. However, when an H male is crossed to an NP female at 25 C, the progeny all die as larvae. Incompatibility is less severe at 32 C. Crosses between neutral and NP strains are fully compatible.

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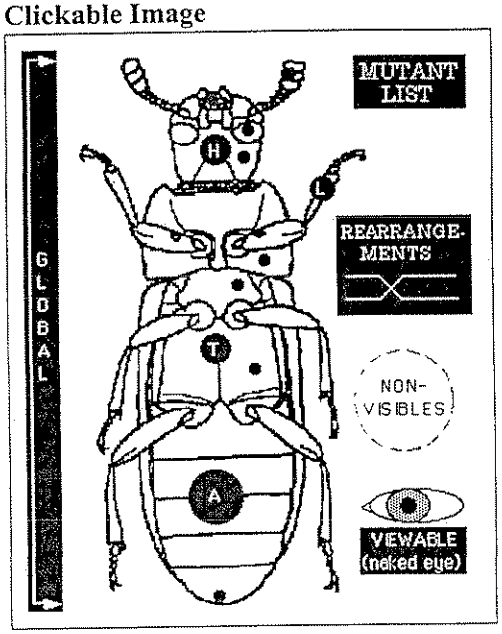
*Last Edited: August 13, 1998*

# Mutants by Region Affected

**Clickable Image**






- Whole Mutant List
- Head
    - Antennna
    - Eyes
    - Shape
    - Mouthparts
- Thorax
    - T1
    - T2 (not elytra)
    - T3
    - Elytra
    - Legs
- Abdomen-general
- Abdomen-genital region
- Elytra
- Gross (naked eye/hand lens)
- Legs
- "Invisible" (lethals; resistance; Medea)
- Rearrangements
- Global

---

*Last Edited: August 13, 1998*

# Mutant List in Alphabetical Order

| Mutant | Name/note | Linkage Group |
|---|---|---|
| 3.2 Bamp | 3P2 based crossover suppressor w/ 40+ cM range. | LG 3 |
| 3P1 | Bamp-27 based crossover suppressor w/ 30 cM range. | LG 3 |
| 3P2 | Bamp-27 based crossover suppressor w/ 30 cM range, and recessive au. | LG 3 |
| 3P3 | Bamp-27 based crossover suppressor w/ 45+ cM range. | LG 3 |
| A | Abdominal | LG 2 |
| ab | antenna bifurcata | LG 9 |
| Ah | Arrowhead | LG 8 |
| ap | antennapedia | LG 8 |
| au | aureate | LG 3 |
| b | black body - b itself is incompletely recessive, but other alleles are completely resessive | LG 3 |
| ba | broken antenna | LG 2 |
| Bald | Bald | LG 8 |
| Bamp-27 | Blunt abdominal and metathoracic points | LG 3 |
| Bamp-31 | Blunt abdominal and metathoracic points | LG 3 |
| Be | Bar eye | LG 4 |
| c | chestnut | LG 7 |
| co | cola body | LG 9 |
| Crab | Crab legs | LG 7 |
| Cx | Cephalothorax | LG 2 |
| Det-43 | Divergent elytral tips | T(4; 5) |
| ds | displaced sternellum | LG 1 = X |
| Ds | Displaced sternellum | LG 4 |
| Er | Eyes reduced | LG 2 |
| eu | extra urigomphi | LG 2 |
| eu-D | extra urigomphi | T(2; 5) |
| glossy | glossy cuticle | LG 2 |
| Go | Goliath | LG 7 |
| h | hazel | LG 4 |
| H | Hybrid incompatability factor | LG 9 |
| j | jet body | LG 5 |
| Lin-R | Lindane resistance | LG 3 |
| lod | light ocular diaphragm | LG 3 |
| $M^1$ | Medea factor | LG 3 |

| | | |
|---|---|---|
| **$M^2$** | Medea factor | LG 3 |
| **$M^4$** | Medea factor | unknown |
| **$M^9$** | Medea factor | LG 8 |
| **mc** | microcephalic | LG 5 |
| **Mo** | Micro-opthalmic | LG 6 |
| **mxp** | maxillopedia | LG 2 |
| **mxpStb** | Stubby | LG 2 |
| **mxpStm** | Stumpy | LG 2 |
| **p** | pearl | LG 9 |
| **pd** | paddle | LG 1 = X |
| **plt** | platinum | LG 1 = X |
| **Ps** | Pinched sternellum | LG 2 |
| **ptl** | prothoraxless | LG 2 |
| **py** | pygmy | LG 1 = X |
| **Pyr-R** | Pyrethroid resistance | LG 9 |
| **rb** | ruby | LG 5 |
| **Rd** | Reindeer | LG 2 |
| **Rmal** | Resistance to malathion | LG 6 |
| **s** | sooty body | LG 4 |
| **Se** | Split elytra | LG 9 |
| **Se-2** | Split elytra | LG 8 |
| **sp** | shoulder pads | LG 2 |
| **Spa** | Spatulate | T(2; 4) |
| **sq** | squint | LG 8 |
| **T(2;4) AEs-1** | Extra sclerite | T(2; 4) |
| **T(2;4) tr** | tremblor | T(2; 4) |
| **T(2;5)Ey** | Eyeless | LG 5 |
| **T(2;9) mxpDch-1** | Dachsund | T(2; 9) |
| **T(2;9) mxpDch-3** | Dachsund | T(2; 9) |
| **T(Y;3)** | translocation | LG 3 |
| **T(Y;4)** | translocation | LG 4 |
| **tar** | tar | LG 2 |
| **ub** | unbuckled | LG 2 |
| **Utx** | Ultrathorax | LG 2 |
| **vwe** | vestigial wings and elytra | LG 2 |

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*Last Edited: August 13, 1998*

# Head

| Mutant | Name/note | Linkage Group |
|---|---|---|
| ab | antenna bifurcata | LG 9 |
| Ah | Arrowhead | LG 8 |
| ap | antennapedia | LG 8 |
| ba | broken antenna | LG 2 |
| Be | Bar eye | LG 4 |
| c | chestnut | LG 7 |
| Er | Eyes reduced | LG 2 |
| Ff | Fused funicle | LG 8 |
| h | hazel | LG 4 |
| lod | light ocular diaphragm | LG 3 |
| mc | microcephalic | LG 5 |
| Mo | Micro-opthalmic | LG 6 |
| mxp | maxillopedia | LG 2 |
| mxpStb | Stubby | LG 2 |
| mxpStm | Stumpy | LG 2 |
| p | pearl | LG 9 |
| pd | paddle | LG 1 = X |
| plt | platinum | LG 1 = X |
| Ps | Pinched sternellum | LG 2 |
| rb | ruby | LG 5 |
| Rd | Reindeer | LG 2 |
| sp | shoulder pads | LG 2 |
| Spa | Spatulate | T(2; 4) |
| sq | squint | LG 8 |
| T(2;5)Ey | Eyeless | LG 5 |
| T(2;9) mxpDch-1 | Dachsund | T(2; 9) |

*Last Edited: August 13, 1998*

# Head-antennae

| Mutant | Name/note | Linkage Group |
|---|---|---|
| **ab** | antenna bifurcata | LG 9 |
| **ap** | antennapedia | LG 8 |
| **ba** | broken antenna | LG 2 |
| **Ff** | Fused funicle | LG 8 |
| **pd** | paddle | LG 1 = X |
| **mxpStb** | Stubby | LG 2 |
| **mxpStm** | Stumpy | LG 2 |
| **Rd** | Reindeer | LG 2 |
| **Spa** | Spatulate | T(2; 4) |
| **T(2;9) mxpDch-1** | Dachsund | T(2; 9) |

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*Last Edited: August 13, 1998*

# Head-eyes

| Mutant | Name/note | Linkage Group |
|---|---|---|
| **Ah** | Arrowhead | LG 8 |
| **Be** | Bar eye | LG 4 |
| **c** | chestnut | LG 7 |
| **Er** | Eyes reduced | LG 2 |
| **h** | hazel | LG 4 |
| **lod** | light ocular diaphragm | LG 3 |
| **mc** | microcephalic | LG 5 |
| **Mo** | Micro-opthalmic | LG 6 |
| **p** | pearl | LG 9 |
| **plt** | platinum | LG 1 = X |
| **rb** | ruby | LG 5 |
| **sq** | squint | LG 8 |
| **T(2;5)Ey** | Eyeless | T(2; 5) |

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*Last Edited: August 13, 1998*

# Head-shape

| Mutant | Name/note | Linkage Group |
|---|---|---|
| Ah | Arrowhead | LG 8 |
| Bamp-31 | Blunt abdominal and metathoracic points | LG 3 |
| Cx | Cephalothorax | LG 2 |
| Er | Eyes reduced | LG 2 |
| mc | microcephalic | LG 5 |
| Mo | Micro-opthalmic | LG 6 |
| T(2;5)Ey | Eyeless | LG 5 |

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*Last Edited: August 13, 1998*

# Head-mouthparts

| Mutant | Name/note | Linkage Group |
|---|---|---|
| **mxp** | maxillopedia | LG 2 |
| **Ps** | Pinched sternellum | LG 2 |
| **sp** | shoulder pads | LG 2 |

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*Last Edited: August 13, 1998*

# Thorax

| Mutant | Name/note | Linkage Group |
|---|---|---|
| **3.2 Bamp** | 3P2 based crossover suppressor w/ 40+ cM range. | LG 3 |
| **3P1** | Bamp-27 based crossover suppressor w/ 30 cM range. | LG 3 |
| **3P2** | Bamp-27 based crossover suppressor w/ 30 cM range, and recessive au. | LG 3 |
| **3P3** | Bamp-27 based crossover suppressor w/ 45+ cM range. | LG 3 |
| **acro** | acromegaly | LG 2 |
| **ap** | antennapedia | LG 8 |
| **apt** | alate prothorax | LG 2 |
| **Bamp-27** | Blunt abdominal and metathoracic points | LG 3 |
| **Bamp-31** | Blunt abdominal and metathoracic points | LG 3 |
| **Cx** | Cephalothorax | LG 2 |
| **Det-43** | Divergent elytral tips | T(4; 5) |
| **Ds** | Displaced sternellum | LG 4 |
| **ds** | displaced sternellum | LG 1 = X |
| **mxp** | maxillopedia | LG 2 |
| **Ps** | Pinched sternellum | LG 2 |
| **ptl** | prothoraxless | LG 2 |
| **Rap** | Recurved anterior pronotum | LG 2 |
| **Se** | Split elytra | LG 9 |
| **sp** | shoulder pads | LG 2 |
| **tar** | tar | LG 2 |
| **ub** | unbuckled | LG 2 |
| **Utx** | Ultrathorax | LG 2 |
| **vwe** | vestigial wings and elytra | LG 2 |

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*Last Edited: August 13, 1998*

# Thorax-T1

| Mutant | Name/note | Linkage Group |
|---|---|---|
| apt | alate prothorax | LG 2 |
| Bamp-31 | Blunt abdominal and metathoracic points | LG 3 |
| Cx | Cephalothorax | LG 2 |
| ds | displaced sternellum | LG 1 = X |
| Ds | Displaced sternellum | LG 4 |
| mxp | maxillopedia | LG 2 |
| Ps | Pinched sternellum | LG 2 |
| ptl | prothoraxless | LG 2 |
| Rap | Recurved anterior pronotum | LG 2 |
| sp | shoulder pads | LG 2 |
| tar | tar | LG 2 |
| ub | unbuckled | LG 2 |

*Last Edited: August 13, 1998*

# Thorax-T2

| Mutant | Name/note | Linkage Group |
|---|---|---|
| 3.2 Bamp | 3P2 based crossover suppressor w/ 40+ cM range. | LG 3 |
| 3P1 | Bamp-27 based crossover suppressor w/ 30 cM range. | LG 3 |
| 3P2 | Bamp-27 based crossover suppressor w/ 30 cM range, and recessive au. | LG 3 |
| 3P3 | Bamp-27 based crossover suppressor w/ 45+ cM range. | LG 3 |
| acro | acromegaly | LG 2 |
| ap | antennapedia | LG 8 |
| Bamp-27 | Blunt abdominal and metathoracic points | LG 3 |
| Det-43 | Divergent elytral tips | T(4; 5) |
| ds | displaced sternellum | LG 1 = X |
| Ds | Displaced sternellum | LG 4 |
| Se | Split elytra | LG 9 |
| Se-2 | Split elytra | LG 8 |
| Utx | Ultrathorax | LG 2 |
| vwe | vestigial wings and elytra | LG 2 |

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*Last Edited: August 13, 1998*

# Thorax-T3

| Mutant | Name/note | Linkage Group |
|---|---|---|
| 3.2 Bamp | 3P2 based crossover suppressor w/ 40+ cM range. | LG 3 |
| 3P1 | Bamp-27 based crossover suppressor w/ 30 cM range. | LG 3 |
| 3P2 | Bamp-27 based crossover suppressor w/ 30 cM range, and recessive au. | LG 3 |
| 3P3 | Bamp-27 based crossover suppressor w/ 45+ cM range. | LG 3 |
| Bamp-27 | Blunt abdominal and metathoracic points | LG 3 |
| Bamp-31 | Blunt abdominal and metathoracic points | LG 3 |
| Ps | Pinched sternellum | LG 2 |
| vwe | vestigial wings and elytra | LG 2 |

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*Last Edited: August 13, 1998*

# Elytra

| Mutant | Name/note | Linkage Group |
|---|---|---|
| Det-43 | Divergent elytral tips | T(4; 5) |
| Ds | Displaced sternellum | LG 4 |
| Se | Split elytra | LG 9 |
| Se-2 | Split elytra | LG 8 |
| sp | shoulder pads | LG 2 |
| Utx | Ultrathorax | LG 2 |
| vwe | vestigial wings and elytra | LG 2 |

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*Last Edited: August 13, 1998*

# Legs

| Mutant | Name/note | Linkage Group |
|---|---|---|
| **ab** | antenna bifurcata | LG 9 |
| **Crab** | Crab legs | LG 7 |
| **Rd** | Reindeer | LG 2 |
| **T(2;9) mxpDch-1** | Dachsund | T(2; 9) |
| **T(2;9) mxpDch-3** | Dachsund | T(2; 9) |

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*Last Edited: August 13, 1998*

# Abdomen-general

| Mutant | Name/note | Linkage Group |
|---|---|---|
| 3.2 Bamp | 3P2 based crossover suppressor w/ 40+ cM range. | LG 3 |
| 3P1 | Bamp-27 based crossover suppressor w/ 30 cM range. | LG 3 |
| 3P2 | Bamp-27 based crossover suppressor w/ 30 cM range, and recessive au. | LG 3 |
| 3P3 | Bamp-27 based crossover suppressor w/ 45+ cM range. | LG 3 |
| A | Abdominal | LG 2 |
| Bamp-27 | Blunt abdominal and metathoracic points | LG 3 |
| sp | shoulder pads | LG 2 |
| T(2;4) AEs-1 | Extra sclerite | T(2; 4) |

*Last Edited: August 13, 1998*

# Abdomen-genital

| Mutant | Name/note | Linkage Group |
|---|---|---|
| **A** | Abdominal | LG 2 |
| **eu** | extra urigomphi | LG 2 |
| **eu-D** | extra urigomphi | T(2; 5) |

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*Last Edited: August 13, 1998*

# Gross (naked eye; hand lens)

| Mutant | Name/note | Linkage Group |
|---|---|---|
| A | Abdominal | LG 2 |
| b | black body - b itself is incompletely recessive, but other alleles are completely resessive. | LG 3 |
| Be | Bar eye | LG 4 |
| co | cola body | LG 9 |
| Crab | Crab legs | LG 7 |
| Det-43 | Divergent elytral tips | T(4; 5) |
| Go | Goliath | LG 7 |
| h | hazel | LG 4 |
| Mo | Micro-opthalmic | LG 6 |
| p | pearl | LG 9 |
| plt | platinum | LG 1 = X |
| Ps | Pinched sternellum | LG 2 |
| py | pygmy | LG 1 = X |
| rb | ruby | LG 5 |
| Rd | Reindeer | LG 2 |
| s | sooty body | LG 4 |
| j | jet body | LG 5 |
| Se-2 | Split elytra | LG 8 |
| sp | shoulder pads | LG 2 |
| T(2;9) mxpDch-3 | Dachsund | T(2; 9) |
| vwe | vestigial wings and elytra | LG 2 |

*Last Edited: August 13, 1998*

# "Invisible" mutants

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## Rearrangements (no marker)

| Mutant | Linkage Group |
|---|---|
| T(Y;3) | LG 3 |
| T(Y;4) | LG 4 |

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## Hybrid Incompatibility

| Mutant | Name/note | Linkage Group |
|---|---|---|
| H | Hybrid incompatability factor | LG 9 |

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## Insecticide Resistance

| Mutant | Name/note | Linkage Group |
|---|---|---|
| Lin-R | Lindane resistance | LG 3 |
| Pyr-R | Pyrethroid resistance | LG 9 |
| Rmal | Resistance to malathion | LG 6 |

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## MEDEA (maternal effect)

| Mutant | Linkage Group |
|---|---|
| $M^1$ | LG 3 |
| $M^2$ | LG 3 |
| $M^3$ | LG 8 |
| $M^4$ | |

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*Last Edited: August 13, 1998*

HOME Maps

# Rearrangements

| Mutant | Name/note | Linkage Group |
|---|---|---|
| 3.2 Bamp | 3P2 based crossover suppressor w/ 40+ cM range. | LG 3 |
| 3P1 | Bamp-27 based crossover suppressor w/ 30 cM range. | LG 3 |
| 3P2 | Bamp-27 based crossover suppressor w/ 30 cM range, and recessive au. | LG 3 |
| 3P3 | Bamp-27 based crossover suppressor w/ 45+ cM range. | LG 3 |
| A | Abdominal | LG 2 |
| Bamp-27 | Blunt abdominal and metathoracic points | LG 3 |
| Bamp-31 | Blunt abdominal and metathoracic points | LG 3 |
| Cx | Cephalothorax | LG 2 |
| Det-43 | Divergent elytral tips | T(4; 5) |
| eu-D | extra urigomphi | LG 5 |
| mxpStm | Stumpy | LG 2 |
| Spa | Spatulate | T(2; 4) |
| T(2;4) AEs-1 | Extra sclerite | T(2; 4) |
| T(2;4) tr | tremblor | T(2; 4) |
| T(2;5)Ey | Eyeless | T(2; 5) |
| T(2;9) mxpDch-1 | Dachsund | T(2; 9) |
| T(2;9) mxpDch-3 | Dachsund | T(2; 9) |
| T(Y;3) | Translocation | LG 3 |
| T(Y;4) | Translocation | LG 4 |

*Last Edited: August 13, 1998*

# Global

| Mutant | Name/note | Linkage Group |
|---|---|---|
| **au** | aureate | LG 3 |
| **b** | black body | LG 3 |
| **Bald** | Bald | LG 8 |
| **co** | cola body | LG 9 |
| **ds** | displaced sternellum | LG 1 = X |
| **glossy** | glossy cuticle | LG 2 |
| **Go** | Goliath | LG 7 |
| **j** | jet body | LG 5 |
| **py** | pygmy | LG 1 = X |
| **s** | sooty body | LG 4 |
| **sp** | shoulder pads | LG 2 |

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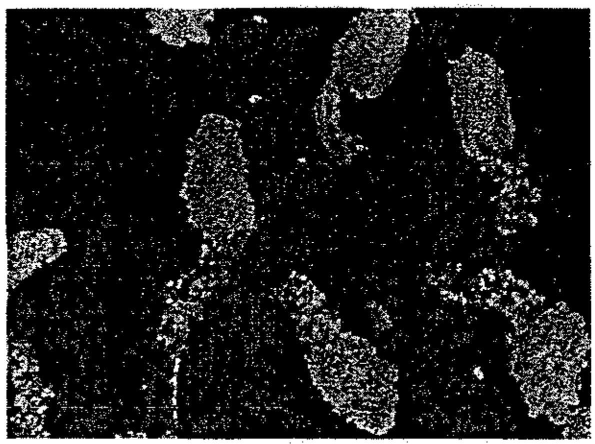
*Last Edited: August 13, 1998*

# Medea

**MEDEA is an acronym for Maternal-Effect Dominant Embryonic Arrest**



**Medea-killed larvae**

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**Medea** factors all share several characteristics:

- They breed true through the female line.
- They segregate in the male.

When a heterozygous Medea female (M/+) is crossed to a wild type male (+/+), the M gene and its homolog segregate normally. However, all progeny that do not inherit the Medea allele die at or shortly after egg hatch. The lethality is maternal, but the "rescue" is zygotic. The rescuing M allele can be inherited from either parent.

There have been four well-studied Medea factors. Of these, two (M-1 and M-4) are currently maintained at the Tribolium Stock Center. Almost all M strains in the field carry M-4. Of these, about a third also carry M-1. M-4 is the only Medea factor present in North American and European strains, being found in about half of them. Australian and Indian strains are almost devoid of Medea factors. South American, Asian, and African strains often have 2 or more M factors.

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## $M^1$ (Medea)

- **Linkage Group:** 3
- **Description:** The first and most-studied Meda factor.

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## $M^2$ (Medea)

- **Linkage Group:** 3
- **Description:** This Medea factor faded away and is no longer detectable.

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## $M^3$ (Medea)

- **Linkage Group:** 8
- **Description:** This Medea factor faded away and is no longer detectable.

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## $M^4$ (Medea)

- **Linkage Group:** Unknown
- **Description:** This Medea has an interesting distribution within the United States.

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*Last Edited: August 13, 1998*

# TRIBOLIUM INFORMATION BULLETIN 41

## Bibliography

Tenebrio and other Tenebrionidae, 1998-2000. Key to subjects.

# BIBLIOGRAPHY

_Tenebrio_ and other Tenebrionidae, 1993-1999. Key to Subjects.

1. Anatomy, Histology and Morphology
2. Behavior and Behavioral Ecology and Evolutionary Ecology
3. Cytology and Fine Structure
4. Tissue Culture, Embryology and Development
5. Ecology and Population Biology
6. General
7. Genetics and Animal Breeding
8. Insecticides, Insecticide Resistance, Attractant and Repellents
9. Irradiation and Use of Isotopes
10. Nutrition
11. Parasitology and Symbiosis
12. Pests
13. Biochemistry, Physiology and Molecular Biology
14. Space and Aerial Ecology
15. Speciation and Evolutionary Biology
16. Statistical Methods and Mathematical Models
17. Taxonomy
18. Technique
19. Teratology

# A. Bibliography for Tenebrionidae, 2000-2001

# BIBLIOGRAPHY

Note: These are the subjects into which the bibliography has been broken down. If the font is normal, there were no papers cited either in Biosis, CAB, or Agricola. If there are papers in any of the categories listed, the heading will appear larger (Font size 14), and the letters and the numbers of the title will be enhanced by the bold key. Thus, in the table below, the title of the first category is printed in a normal font size 12 letters or numbers, while the second category is in bold letters and numbers, the font size is 14. After that, the entries in each table in each category is given in normal letters, in size 12.

1. Anatomy, Histology and Morphology

2. Behavior, Behavioral Ecology and Evolutionary Biology

3. Cytology and fine structure

4. Tissue culture, Embryology and Development

5. Ecology, Population Biology and Evolutionary Ecology

6. General

7. Genetics and Animal Breeding

8. Insecticides, Insecticide Resistance, Attractants, Antifeedants and Repellents, and Biological control.

9. Irradiation and Use of Isotopes

10. Nutrition

11. Parasitology and Symbiosis

12. Pests and Pest Control

13. Biochemistry, Physiology Molecular Biology and Pheromones

14. Space and Aerial Ecology

15. Speciation, Geographic Distribution and Evolutionary Biology

16. Statistical Methods

17. Taxonomy

18. Technique

19. Teratology

20. Allergy

Examples: 1 and 2 (below) are the names of topics. Under1 there were no papers. Under 2 there was one paper belonging to this title:

1. Anatomy, Histology and Morphology (The topics are in Normal Font 12, letters not shown in bold print).

**2. Behavior, Behavioral Ecology and Evolutionary Biology (Letters in bold, in size 14).**

2. Drnevich, J.M.;
Hayes, E.F.; Rutowski, R.L. 2000. Sperm precedence, mating interval, and a novel mechanism of paternity bias in a beetle (Tenebrio molitor L.).
In: Behavioral Ecology and Sociobiology 48: 447-451.

**(Note the difference in font and degree of boldness)**

**The actual listing of references for Tenebrionidae begins on next page.**

## Bibliography of Tenebrionidae (except Tribolium) for 2000-2001

1. Anatomy, Histology and Morphology

### 1. Behavior, Behavioral Ecology and Evolutionary Biology (Letters in bold, in size 14).

2. Drnevich, J.M.;
Hayes, E.F.; Rutowski, R.L. 2000. Sperm precedence, mating interval, and a novel mechanism of paternity bias in a beetle (Tenebrio molitor L.). In: Behavioral Ecology and Sociobiology 48: 447-451.

## 3. Cytology and Fine Structure

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## 5. Ecology, Population Ecology

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6. General (No references)

## 7. Genetics, Population genetics and Animal Breeding.

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8. Sosa, M.E.; Guerreiro, E.; Giordano, O.S.; Tonn, C.E. 2000. Bioactivity flavonoids against Tenebrio molitor (Coleoptera: Tenebrionidae) larvae.

## 9. Irradiation and Use of isotopes

## 10. Nutrition

10. Klasing, K.C.; Thacker, P.; Lopez, MA.; Calvert, C.C. 2000. Increasing the calcium content of mealworms (Tenebrio molitor) to improve their nutritional value for bone mineralization of growing chicks. In: Journal of Zoo and Wildlife Medicine 31:512-517.

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## 12. Pests.

12. Lonc, E.; Mazurkiewicz, M.; Doroszkiewicz, W.; Kolpa, A.; Manka, M. 2001. Microbial control of coleopteran larvae of Alphitobius diaperinus and Tenebrio molitor –grain pests. In Medycyna Weterynaryjna 57:259-262

## 13. Biochemistry, Physiology and Molecular Biology

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A. Sokoloff. An apology to the Subscribers to the TIB from the Editor.

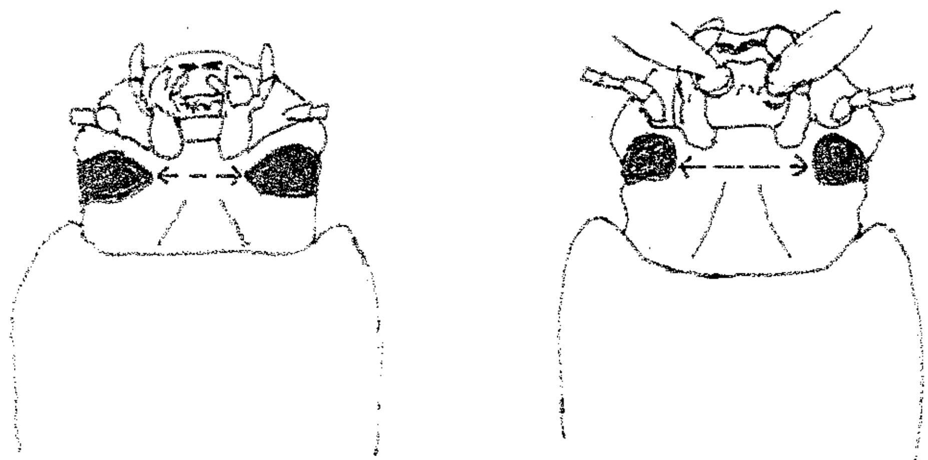
Dear Subscriber to TIB;

Tribolium Information Bulletin Volume 40, page 248, has a Figure representing the difference between the eyes of Tribolium castaneum (left) and Tribolium confusum (right). It was taken from the Front cover of Tribolium Volume 6, 1963 to show that in T. castaneum the distance between the two compound eyes is roughly about 1 eye width, while in T. confusum the distance is over two eye widths. It is the simplest criterion one can use to identify T. castaneum and T. confusum when they are grown together in the same medium. The two specimens actually were homeotic mutants discovered in these two species of Tribolium: antennapedia in T. castaneum and labiopedia in T. confusum by the author and editor, and the drawing was so striking, that I thought it would serve very well as an illustration for Mr. Abels letter he wished to published in TIB.
The drawing was quite clear when it was first published in 1963, but something happened during its duplication so it was printed with a big smudge covering most of the page. Neither I nor the staff at the Duplicating Center noticed the error and Volume 40 was distributed without correction. My apologies to Mr. Abels and the rest of the subscribers. I hope this will not happen again.
I'm sending each of the subscribers a copy of a drawing that highlights the eyes of the normal beetle. Please tape the drawing included over the illustration on page 248.

Sincerely yours,

Alexander Sokoloff

EDITOR'S APOLOGY TO SUBSCRIBERS OF TIB



A diagram representing the compound eyes in Tribolium castaneum (left) and Tribolium confusum (right). Note that in T. castaneum the distance between the two compound eyes is about one eye width (see the double headed arrow between the eyes) while in T. confusum the distance between the compound eyes is about two eye widths (note the double headed arrow between the compound eyes).

# Research Notes

**New Mutants (*Tribolium castaneum*)**: Richard W. Beeman and M. Susan Haas

*Split gula (Sg).* Spontaneous dominant found in the *Bar Eye (Be), sooty (s)* stock. The gula, pregula, submentum and mentum of these mutants is split medially and the labial palps are no longer "nested" between the maxillary palps. The two halves of the mentum appear to form basal structures proximal to the palps. This phenotype could be a transformation of labial identity to either maxillary or prothoraxic. *Sg* complements *alate prothorax (apt)* and *Cephalothorax (Cx)*. Tests are underway to determine complementation with *prothoraxless (ptl)*. Linkage testing is in progress to determine if *Sg* is linked to the HOM-C.

*Split ventral abdominal 7 (Sva7).* Spontaneous dominant found in the *A20 Rdiel* stock. As most strongly expressed, *Sva7* causes the normally sclerotized ventral A7 (seventh abdominal segment) to appear as a pair of oval plates. The posterior margin of this segment is often medially indented between the plates. This phenotype appears to be a A7 to A8 transformation. *Sva7* complements *pointed abdominal sternite (pas)* and *extra urogomphi (eu)*. Linkage testing is underway to determine if it is linked to the HOM-C.

Dev Genes Evol (2001) 211:89–95
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OPINION PAPER

M. Susan Haas · Susan J. Brown
Richard W. Beeman

# Pondering the procephalon: the segmental origin of the labrum

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**Abstract** With accumulating evidence for the appendicular nature of the labrum, the question of its actual segmental origin remains. Two existing insect head segmentation models, the linear and S-models, are reviewed, and a new model introduced. The L-/Bent-Y model proposes that the labrum is a fusion of the appendage endites of the intercalary segment and that the stomodeum is tightly integrated into this segment. This model appears to explain a wider variety of insect head segmentation phenomena. Embryological, histological, neurological and molecular evidence supporting the new model is reviewed.

**Keywords** Insect head · Intercalary · Labrum · Stomodeum · Segmentation

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>As Editor of the Tribolium Information Bulletin, I would like to reproduce
>two abstracts of articles recently published in Dev Genes Evol. (2001)
>211:89-95 and 96-102. Both of the articles were authored by M. Susan Haas,
>Susan J. Brown and Richard W. Beeman. The first article reviews the models
>available for insect head segmentation and proposes a third model. The
>second paper through the use of a homeotic gene Antennagalea-5) transforms
>both antennal and labral structures to resemble those of gnathal appendages
>in Tribolium castaneum. This suggests that the labrum is a fused structure
>derived from two pairs of appendage endites and is serially homologous to
>the gnathal appendages.
>I believe that such a finding merits wide distribution of information, and
>this information, should be included in the Tribolium Information Bulletin.
>I hope that as Editor in Chief of your journal you will agree with me and
>give your permission and let me include the abstracts in in Vol. 41 of the
>Newsletter I edit.
>With best personal regards, Alexander Sokoloff.
>

***********************************************
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SHORT COMMUNICATION

M. Susan Haas · Susan J. Brown
Richard W. Beeman

# Homeotic evidence for the appendicular origin of the labrum in *Tribolium castaneum*

Received: 8 June 2000 / Accepted: 14 November 2000 / Published online: 8 February 2001


**Abstract** The ontogeny of the insect labrum, or upper lip, has been debated for nearly a century. Recent molecular data suggest a segmental appendage origin of this structure. Here we report the first arthropod mutation associated with a homeotic transformation of the labrum. *Antennagalea-5* (*Ag*$^5$) transforms both antennal and labral structures to resemble those of gnathal appendages in *Tribolium castaneum*. This labral transformation suggests that the labrum is a fused structure composed of two pairs of appendage endites, and is serially homologous to the gnathal appendages.

**Keywords** Insect head · Homeotic transformation · Mandible · Labrum · Appendage

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>Susan J. Brown and Richard W. Beeman. The first article reviews the models
>available for insect head segmentation and proposes a third model. The
>second paper through the use of a homeotic gene Antennagalea-5) transforms
>both antennal and labral structures to resemble those of gnathal appendages
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**********************************************

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Sokoloff, A. Emeritus Professor, Biology Department, California State University, San Bernardino, California.

* Observations of Walking Sticks (Phasmidae).

NOTE: The first paper in this series Regeneration in walking sticks (Sokoloff, 2000) dealt with the growth of the sticks from the third instar to the adult stage and regeneration of the walking appendages. The present note deals with further observation of the adults, and some observations on the earlier stages of development.

Walking stick number 2 (WS-2) outlived number 1 (WS-1). Shortly after the death of WS-1, it molted. It had the normal number of legs except for the middle right leg, which failed to expand and formed into a coiled leg. Two weeks later WS-2 molted again, but the molted specimen had three normal left legs. The three right legs were missing beyond the trochanter. I placed the specimen in a plastic container which originally housed a lemon meringue cake. The top and bottom of the container were clear plastic. The cake originally rested on a disk-shaped base made of styrofoam. Its upper surface had two concentric elevated circles about ½" in width to prevent the cake from sliding. The styrofoam disk was soft, but sturdy enough one could drive dry sticks into it and thus create a more "natural" environment.

There were two sources of water: one was a small rectangle of blotting paper which was saturated with water every day. The second source was water injected between two rose plant leaves to give a dew effect.

It became evident that the WS would not be able to take care of itself. Every morning I would find it on its back,or side at the edge of the cage, between the styrofoam disc and the plastic cover of the cake container, lying helplessly. It would try to reach for some solid surface lying on the plastic box floor, for example rose leaves which served as its food. Usually the result was that it might drag itself to reach for the leaves, to anchor its claws on the leaf thorns, and contracting the muscles of the femur. If it managed to reach the leaves, it would try to get closer to them but the leaves would slip away. I helped it by anchoring the leaves with an open paper clip. I constructed an arbor of dry sticks and a few times I found it perched on one of the sticks. Most of the time, however, I would find it on the inner side of the plastic cover lying on its back. When it was hungry, the rose leaves would attract the WS, and I knew that it had been eating by the very characteristic way these insects eat along the edge of the leaf. Clearly, the presence of three legs, all on one side of the body, was not conducive to effective locomotion.

The WS had grown to a sizeable specimen: Its overall length was 8.5 cm. The antennae were 11mm; The horns on its head were about 1.5mm long. The segments of the legs had the following dimensions:

Left foreleg: coxa, 2 mm.; trochanter, 2mm.femur , 34 mm; tibia, 20mm. The tarsal segments had broken off. The proximal 5 mm. of the femur of the foreleg were free of spines and served to protect the head and its parts. The rest of the femur was thicker, about 1 1/2mm, with spines on the dorsal and ventral surface. The distal dorsal part of the femur bears a spine at the femoral tibial joint.

The middle leg: the femur extends from the trochanter to the joint between femur and tibia. A pair of spices protect the femoral-tibial joint. There are 3 prominent spines on the dorsal part of the femur. There are four rows of spines extending the length of this segment. The tibia bears 5 spines directed toward the "foot" of the leg, the first spine being the most prominent. The tarsus and claws were broken off.

The hind leg has a 30 mm femur and a 30mm tibia (the tarsus and claws had fallen off). The femur has 4 ridges with spines arranged along these ridges. There are two prominent bristles on the distal end of the femur, one on each side of the proximal end of the tibia. The tarsus of the hind and other legs consists of 5 segments and a pair of claws.

I was hoping the walking stick would molt its exoskeleton once more and attempt to regenerate its legs, but it died without doing so. The walking stick was on its 3rd or 4th instar when it was given to me in September, 2000. It died in June of 2001.

While it was alive, I decided to collect the fecal pellets it produced to see if they contained cysts of parasites or to add them to our insect collections. The droppings, feces or fecular pellets of walking sticks are black, and irregular in shape. Among them there were some that had an oval shape, but at the time I collected them I did not pay much attention to them (my vision was greatly reduced owing to the presence of cataracts, and I did not examine them either with a magnifying glass or with the dissecting microscope). In any case, both oval and irregularly shaped fecular droppings ended up in a screw-cap vial, the three legged stick insect ended up in the insect collection. I was sad because I expected the two walking sticks to reproduce so I could study these interesting insects.

A month later, returning to my study room one day, I saw movement in the vial containing fecal pellets. On closer examination, the movement was produced by walking insects that hatched. Most of the 20 specimens were dead, obviously because of lack of food and water, but four had hatched more recently and survived.

The mother may have been inseminated by the other stick insect before it died, or the development may have been possible because of parthenogenesis which is known to occur in these insects. In any case, besides the 20 eggs that hatched there were 200 eggs, which had not hatched, allowing further observations.

THE EGGS.

It has been reported that the eggs resemble plant seeds. They are dropped from the shrubs singly in autumn, rest on the ground all winter, hatching in early summer. The nymphs feed on leaves, and reach maturity in summer and early fall. At this time they resemble twigs upon which they rest (brown or green). The eggs I examined had thin and fragile shells and could easily be broken into when picked up with forceps.

The eggs roughly resemble a pickle jar in shape. The width is about half the length. The pickle jar is flat at one end so it will stand, but the base of the egg is rounded. The pickle jar has a neck and around the mouth the neck bears some elevations to allow the cap to close the jar tightly so the liquid will not spill out. The comparable end of the egg has some distinct elevations to close the exit of the egg firmly. The external surface of the cap of the egg has about 3 layers and the cap resembles a Gaucho hat. In an unopened egg, below the cap (Fig. 1) which is shiny black on its external surface, there are lines which suggest the presence of ridges resembling the ridges that are found on the outer part of the neck of the pickle jar. In the pickle jar there are spiral depressions of the metal cap fit to hermetically close the contents to twist the cap on the bottle or to remove the cap from the bottle. The cap of the egg has 3 spiral ridges which fit into corresponding spiral depressions matched in a similar fashion as in the pickle jar.

On the outside of the egg, about half way from the cap to the closed opposite end of the egg there is a kidney-shaped "scar" which may be the place where some attachment from the ovary attaches to the egg (Fig. 1)

Sometimes the hat-shaped cap can apparently yield to pressure so that the completely developed hatchling can walk out and leave the egg with the cap still attached to the egg's opening. Other times the cap of the egg is given such a strong shove from the inside of the egg that it detaches completely from the egg. Fig a and 1b show the concave side of the cap when the cap has been pushed gently from the inside by the hatchling. Figure 7 is a side view of the cap, 7a, and an inner side view with three levels of the cap (7b)

## EXTERNAL SURFACE OF THE EGG SHELL...

Another remarkable feature of the egg of a walking stick is the appearance of its outer surface. No two eggs are alike (Figs. 2a-b to 6a-b). In these sketches, are shown the front and the back of the egg, to maximize the effect. In a few of these figures we can see the attachment point of the egg to the attachment organ to the ovary. This place of attachment looks kidney-shaped as in Fig 1. My guess is that the rest of the egg shell and sometimes even the kidney-shaped attachment point is some substance that acts as a lubricant when the egg is laid, and when it hits the air water evaporates leaving some kind of design.

## BIRTH OF WALKING STICKS

The hatching from the egg, from my limited observation, occurs prior to sunrise. during the warmer days of summer. By this time one can tell whether the walking stick has emerged from the egg successfully or not. Birth is apparently a very hazardous event. The nymph may remove the cap successfully, but then it has wiggle back and forth to leave the shell. The head may appear, followed by the thorax. The walking appendages are long and fragile, and the external environment may not be suitable for the retention of moisture which may act as a lubricant to gradually free its appendages from the shell (the appendages reach all the way to the closed end of the shell (Fig. 8)

Judging from the individuals I have examined, there may be several mishaps during the birth of the walking sticks. In all these cases the cap has been popped off the shell:

1. The new hatchling may have its head and thorax out of the shell, but all six pairs of legs are stuck within the shell, and eventually the insect dies.

2. Any one or more of the legs may remain stuck within the shell, making it more and more difficult for the insect to emerge from the shell. Death eventually follows.
3. With further efforts, the hatchling may free its first and second pairs out of the shell, but it may be too exhausted to exert itself further, and dies attached itself to the shell.
4. The middle and hind legs may come out and one or both of the front legs still remain stuck

One or both of the legs may become free from the shell after further efforts, or one of the legs may be stuck to the shell until the first molt. If only one leg is stuck in the eggshell, the insect may carry it like a boot. Efforts may be successful in dropping the shell, in which case the leg may be recovered entirely, or may separate from the shell losing the tarsus or more proximal segments of the leg and later degenerated.

One thing is clear: one should not attempt to help any of these first instar walking sticks because the exoskeleton is very soft, and parts of the leg or the entire leg may separate from the body.

At this writing, only about one 15-20 percent of the eggs laid by the female hatched between the time they were laid and the present, and since the weather has turned cold in the evenings, there have been no more walking sticks being born. It will be interesting to see how many of the 150 eggs remaining will hatch next summer.

Sexing these insects is difficult because in the female the ovipositor is hidden by other structures. The two original walking sticks I received had similar structures at the tip of the abdomen. I did not see the process or frequency of egg-laying, The discovery of live first instar phasmids was the first indication that the larger walking stick had laid eggs was the presence of the 20 hatchlings of which only four were alive.

As I mentioned above, there were only about 200 eggs in the clutch, and of these about 20 had hatched, but 16 of them had died for lack of water. For the next 6 weeks the eggs hatched at the rate of 1 or 2 or none per day. Many of these died for various causes, but survivors included 6 which at this writing are in their third instar, 4 are now in their second and 2 are in their first instar. The third instars have complete sets of legs and have a green color. The others have brownish color and lack some of their legs as I indicated before. Their antennae are short. While the walking sticks are at rest, they hold their front legs forward, parallel to the to the small antennae. If one blows gently into their cage they begin to sway on their legs from side to side.

The hatching of new nymphs has ceased since the beginning of October when nights began to cool off. It will be interesting if any of the remaining eggs continue hatching from next summer to fall of 2002. It may be possible that these eggs were produced by parthenogenesis as it has been reported in the literature. Horn (1976) states that many walking sticks are parthenogenic (without mates). Females simply lay viable eggs that drop to the forest floor and may take a year or two to hatch.

Notes - Research

1

1a

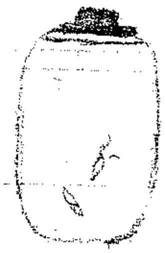
1b

2a

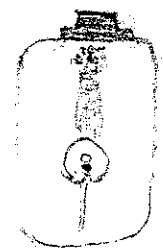
2b

3a

3b



4a



4b.

5a

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6a

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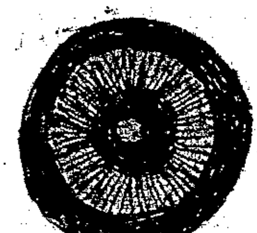
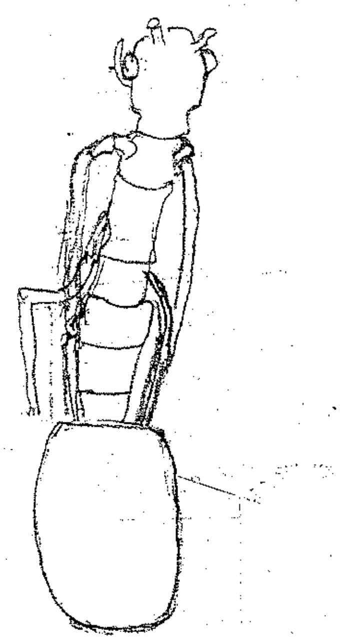
7a



7b



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**RESEARCH HIGHLIGHTS AND TECHNOLOGY TRANSFER FOR 2000-2001**

**Temperature and Relative Humidity Impact Efficacy of Diatomaceous Earth**. Diatomaceous earth (DE) is a reduced-risk low-toxicity natural product registered to control stored product insects. When red flour beetles and confused flour beetles are exposed to diatomaceous earth, mortality of both species increases with temperature and decreases with relative humidity. In addition, the confused flour beetle is more tolerant to DE than the red flour beetle, and longer exposure intervals may be required to eliminate populations of the confused flour beetle. Seasonal variation within a storage facility, the target pest species, and the presence of food material must be taken into account when using DE to control flour beetles in mills and food warehouses. (Athur, 776-2783)

**Transgenes inserted into beetles.** In 2000 we succeeded for the first time in producing genetically transformed beetles, using gene transfer vectors constructed in 1999. Foreign genes were inserted into the chromosome of the red flour beetle using mobile gene vectors ("transposons") derived from moths and flies. This new system can be used to insert DNA tags into target insect control genes, making it possible to identify, isolate and characterize such genes and to facilitate the incorporation of these genes into transgenic plants for insect control. The system could also be used to correct genetic defects and genetically engineer improvements in beneficial insect species. To demonstrate this possibility, we used the new system to introduce the tryptophan oxygenase gene (required for pigmentation) into tryptophan oxygenase-deficient, unpigmented red flour beetles, and showed that normal pigmentation was restored. (Beeman, 776-2710)

**Chitin synthase gene mapped in flour beetle.** The chitin synthase gene was mapped onto chromosome 5 of the red flour beetle. This accomplishment makes possible a mutational analysis of this important developmental gene, which will in turn allow us to identify the regions of the gene most critical for activity and most sensitive to inhibitors. (Kramer, 776-2711)

**Influence of food patch size on egg laying behavior investigated.**
The red flour beetle, *Tribolium castaneum,* is a major pest of flour mills and other food processing and storage facilities. The spatial configuration of food patches strongly influences the abundance and distribution of individuals in a landscape and this in turn impacts on where pest management needs to be targeted. We investigated how food patch size influences egg laying behavior and the fitness consequences of different egg laying decisions. Females adjusted the number of eggs that they laid in a given patch as a function of amount of flour present. Females visited multiple patches and the allocation of eggs among patches was influenced by the amount of flour in the patch. There was a good correlation between the number of eggs laid and the optimal number of eggs to maximize offspring survival to adulthood. Understanding patch use behavior will help

improve the management of pest populations in food processing and storage facilities. (Campbell, 776-2717)

**Nematodes may be effective against insects that infest grain and grain products.** Certain species of nematodes are lethal parasites of many species of insects. These nematodes are small (less then 1/16 inch) round worms that have the ability to seek out insects and kill them. They are also commercially available and initial results indicate that they may be effective against insects that infest grain and grain products. Initial data indicate that one of the nematodes (Steinernema carpocapsae) is very effective at attacking the larvae of Indianmeal moths and moderately effective at attacking red flour beetle adults. Further research is being conducted to determine how effective the nematodes will be at finding and killing insects in the structure of buildings and the influence of low relative humidity on efficacy. (Campbell, 776-2717)

**Responding to customer requests, a web site was developed for downloading stored product insect images (http://bru.usgmrl.ksu.edu/images).** The database contains over 130 images of 30 different stored product pests in easy-to-download jpeg files. This information will provide a valuable resource for researchers, educators, and the general public. (Oppert, 776-2780)

# EFFECT OF SELECTION ON HERITABILITY OF EGG NUMBER IN *Tribolium castaneum*

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## SUMMARY

In order to study the trend of heritability estimates in two-way selection, generation-wise estimates from sire, dam and sire + dam components were obtained. These estimates were regressed on the generation number to study time trend in heritability in selection experiment. All the linear regression coefficients in both the directions of selection were observed to be negative suggesting loss of additive genetic variance due to selection.

## INTRODUCTION

*Tribolium* has been extensively used as a model to investigate population genetic and animal breeding theory. The effect of selection on heritability estimates has been of considerable interest to research workers. Its importance further increases when different intensities of selection are applied in divergent selection. The trait 'egg production' in *Tribolium* is very sensitive to environmental conditions like egg production in poultry and milk yield in cattle. It is, therefore, the time trend in estimates of heritability for egg production at two different selection intensities in *Tribolium castaneum* was studied in the present investigation.

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## MATERIALS AND METHODS

*Tribolium castaneum* (Izatnagar strain) maintained for last several years as a closed population on random mating constituted the genetic material for this study. The procedure of *Tribolium* culture was the same as reported by Bhat and Bhat (1974). The cultures were maintained in B.O.D. incubator at 32 ± 0.5$^0$ C and 70 ± 5% R.H. throughout. On 5$^{th}$ day of adult life one male was allowed to mate with 3 females for 48 hours and on 7$^{th}$ day all the 4 adults from the mating vials were separated into 4 individual vials, each female in 1 vial. Egg production was recorded on 8$^{th}$, 9$^{th}$ and 10$^{th}$ day of adult life. Two hundred and seventy sire families, each consisting of 1 sire, 3 dams and 15 female progenies were formed. These sire families were further divided randomly into 9 groups each consisting of 30 sires, 90 dams and 450 female progenies. One of these groups was used as control. Two groups as replicates ($R_1$ and $R_2$) were used for each of the high selected lines 1 and 2. These groups were symbolised as : $HS_1$ – high selection line 1 where top 33.33% families were selected, $HS_2$ – high selection line 2 where top 50% families were selected, $LS_1$ – low selected line 1 where lowest 33.33% families were selected and $LS_2$ – low selected line 2 where lowest 50% families were selected and control – unselected line.

Thirty sire families were ranked on the basis of the total egg number (8$^{th}$ – 10$^{th}$ day) after adult emergence in each group. Selection was practised for high and low egg production using sire family means at intensity levels- (a) 33.33% and (b) 50% in each group. Next generation was regenerated in a way that the number of sires, dams and female progenies remained constant in each line and generation. Half-sib and full-sib matings were avoided.

Heritabilities in each group were calculated separately using variance component analysis (King and Henderson, 1954). The standard errors for heritability estimates were computed as per Dickerson (1960). Pooled estimates of heritability were obtained by weighting each estimate with the inverse of its variance following the method of Enfield *et al.* (1966). Linear regressions of heritability estimates on generation number were obtained according to Snedecor and Cochran (1967).

## RESULTS AND DISCUSSIONS

Generation-wise estimates of heritability are presented in Table – 1. The heritability for the selected trait in the control line ranged from 0.19 to 0.25, 0.30 to 0.47 and 0.27 to 0.33 from sire, dam and sire + dam components of variance respectively. The respective estimates pooled over generations were 0.21, 0.42 and 0.32. The estimates derived from dam components of variance were found to be consistently higher than those from sire components which are in agreement with the reports of Krause and Bell (1972) and Verma *et al.* (1980) and these suggested the involvement of non-additive genes and/or maternal effects in the inheritance of this trait. Linear regressions of heritability estimates on generation number (time trend in heritability estimates) are presented in Table – 2. In the control line the regression co-efficient indicated a non-significant decline of 0.0007 from the sire component, however, dam and sire + dam components showed non-significant increase of 0.0023 and 0.0004 respectively. These reflected that the control population remained genetically stable over generations and fluctuations were due to the chance factor.

The heritability for the selected trait '$8^{th} - 10^{th}$ day egg number' for the two high and the two low lines did not present any definite trend from generation to generation. The time trends in heritability were consistently negative in all the lines from all the three components of variance (Table-2). Eight out of 12 regression co-efficients were found to be significant. Bell and Burris (1973) observed a decline in heritability estimates at the end of four and eight generations of selection for $7^{th} - 11^{th}$ day egg number in *Tribolium castaneum.* Ruano *et al.* (1975) and Orozco (1976) reported significant negative regression co-efficients of the heritability estimates from daughter dam regression method on generation number for $7^{th} - 11^{th}$ day egg production to be $- 0.03 \pm 0.01$ and $- 0.0216 \pm 0.0063$ respectively in *Tribolium castaneum.* Nordskog *et al.* (1974) and Thiyagasundaram (1984) also observed decline in heritability estimates for egg number in poulty in selection experiments.

The present study revealed that the heritability estimates tended to decline as selection advanced which is in agreement with the findings of the research workers mentioned above. The decrease in heritability estimates during selection may be attributed to a loss of additive genetic variance.

## ACKNOWLEDGEMENT

The authors are thankful to the Vice-Chancellor, Birsa Agricultural University for providing necessary facilities for the study.

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Table – 1. Heritability estimates for the selected trait ($8^{th}$ – $10^{th}$ day egg number) in different lines and generations (Replicates pooled).

| | | LINES | | | | |
|---|---|---|---|---|---|---|
| Generations | Heritability | $HS_1$ | $HS_2$ | $LS_1$ | $LS_2$ | Control |
| $G_0$ | $h^2_S \pm$ S.E. | 0.21 ± 0.11 | 0.22 ± 0.11 | 0.24 ± 0.11 | 0.21 ± 0.11 | 0.19 ± 0.16 |
| | $h^2_D \pm$ S.E. | 0.41 ± 0.14 | 0.41 ± 0.14 | 0.29 ± 0.13 | 0.42 ± 0.14 | 0.47 ± 0.21 |
| | $h^2_{S+D} \pm$ S.E. | 0.31 ± 0.07 | 0.31 ± 0.07 | 0.27 ± 0.07 | 0.31 ± 0.07 | 0.33 ± 0.10 |
| $G_1$ | $h^2_S \pm$ S.E. | 0.09 ± 0.10 | 0.20 ± 0.11 | 0.22 ± 0.12 | 0.17 ± 0.09 | 0.21 ± 0.16 |
| | $h^2_D \pm$ S.E. | 0.64 ± 0.17 | 0.42 ± 0.14 | 0.52 ± 0.15 | 0.31 ± 0.13 | 0.42 ± 0.20 |
| | $h^2_{S+D} \pm$ S.E. | 0.37 ± 0.08 | 0.31 ± 0.07 | 0.37 ± 0.08 | 0.24 ± 0.06 | 0.32 ± 0.10 |
| $G_2$ | $h^2_S \pm$ S.E. | 0.15 ± 0.09 | 0.21 ± 0.10 | 0.19 ± 0.10 | 0.16 ± 0.10 | 0.25 ± 0.16 |
| | $h^2_D \pm$ S.E. | 0.22 ± 0.13 | 0.19 ± 0.12 | 0.30 ± 0.13 | 0.50 ± 0.15 | 0.30 ± 0.19 |
| | $h^2_{S+D} \pm$ S.E. | 0.18 ± 0.06 | 0.20 ± 0.06 | 0.25 ± 0.06 | 0.33 ± 0.07 | 0.27 ± 0.10 |
| $G_3$ | $h^2_S \pm$ S.E. | 0.15 ± 0.09 | 0.16 ± 0.09 | 0.21 ± 0.11 | 0.14 ± 0.09 | 0.21 ± 0.16 |
| | $h^2_D \pm$ S.E. | 0.25 ± 0.13 | 0.15 ± 0.12 | 0.43 ± 0.14 | 0.31 ± 0.13 | 0.44 ± 0.21 |
| | $h^2_{S+D} \pm$ S.E. | 0.20 ± 0.06 | 0.16 ± 0.05 | 0.32 ± 0.07 | 0.23 ± 0.06 | 0.33 ± 0.10 |
| $G_4$ | $h^2_S \pm$ S.E. | 0.13 ± 0.09 | 0.15 ± 0.09 | 0.16 ± 0.09 | 0.30 ± 0.10 | 0.23 ± 0.16 |
| | $h^2_D \pm$ S.E. | 0.27 ± 0.13 | 0.25 ± 0.13 | 0.27 ± 0.13 | 0.09 ± 0.10 | 0.41 ± 0.20 |
| | $h^2_{S+D} \pm$ S.E. | 0.20 ± 0.06 | 0.20 ± 0.06 | 0.22 ± 0.06 | 0.20 ± 0.06 | 0.32 ± 0.10 |

Continued…

Table-1. Continued

| | | | | | | |
|---|---|---|---|---|---|---|
| $G_5$ | $h^2_S \pm$ S.E. | 0.11 ± 0.08 | 0.16 ± 0.09 | 0.15 ± 0.09 | 0.12 ± 0.08 | 0.21 ± 0.16 |
| | $h^2_D \pm$ S.E. | 0.23 ± 0.13 | 0.20 ± 0.12 | 0.32 ± 0.13 | 0.19 ± 0.12 | 0.44 ± 0.20 |
| | $h^2_{S+D} \pm$ S.E. | 0.17 ± 0.05 | 0.18 ± 0.06 | 0.24 ± 0.06 | 0.16 ± 0.05 | 0.33 ± 0.10 |
| $G_6$ | $h^2_S \pm$ S.E. | 0.12 ± 0.08 | 0.14 ± 0.08 | 0.17 ± 0.09 | 0.14 ± 0.08 | 0.19 ± 0.16 |
| | $h^2_D \pm$ S.E. | 0.14 ± 0.12 | 0.14 ± 0.12 | 0.23 ± 0.12 | 0.14 ± 0.12 | 0.45 ± 0.21 |
| | $h^2_{S+D} \pm$ S.E. | 0.13 ± 0.05 | 0.14 ± 0.05 | 0.20 ± 0.06 | 0.14 ± 0.05 | 0.32 ± 0.10 |
| $G_7$ | $h^2_S \pm$ S.E. | 0.11 ± 0.08 | 0.12 ± 0.08 | 0.13 ± 0.09 | 0.16 ± 0.09 | 0.21 ± 0.16 |
| | $h^2_D \pm$ S.E. | 0.12 ± 0.12 | 0.13 ± 0.12 | 0.33 ± 0.13 | 0.20 ± 0.12 | 0.42 ± 0.20 |
| | $h^2_{S+D} \pm$ S.E. | 0.12 ± 0.05 | 0.13 ± 0.05 | 0.23 ± 0.06 | 0.18 ± 0.06 | 0.31 ± 0.10 |
| Overall | $h^2_S \pm$ S.E. | 0.13 ± 0.03 | 0.16 ± 0.03 | 0.18 ± 0.03 | 0.17 ± 0.03 | 0.21 ± 0.06 |
| | $h^2_D \pm$ S.E. | 0.26 ± 0.05 | 0.22 ± 0.04 | 0.33 ± 0.05 | 0.24 ± 0.04 | 0.42 ± 0.07 |
| | $h^2_{S+D} \pm$ S.E. | 0.19 ± 0.02 | 0.19 ± 0.02 | 0.26 ± 0.03 | 0.21 ± 0.02 | 0.32 ± 0.04 |

$h^2_S$, $h^2_D$ and $h^2_{S+D}$ are the heritability estimates from sire, dam and sire ± dam components respectively.

Table – 2. Linear regression of estimates of heritability on generation number for the selected trait in different lines (Replicate pooled).

| b ± S.E./LINES | $HS_1$ | $HS_2$ | $LS_1$ | $LS_2$ | Control |
|---|---|---|---|---|---|
| $h^2_S$ | – 0.0082 ± 0.0052 | – 0.0138** ± 0.002 | – 0.0142** ± 0.0025 | – 0.0055 ± 0.0092 | – 0.0007 ± 0.0033 |
| $h^2_D$ | – 0.0533* ± 0.0177 | – 0.0384* ± 0.0115 | – 0.0151 ± 0.0144 | – 0.0421* ± 0.016 | 0.0023 ± 0.0085 |
| $h^2_{S+D}$ | – 0.0305** ± 0.0074 | – 0.0254** ± 0.0055 | – 0.015 ± 0.0071 | – 0.0232* ± 0.0062 | 0.0004 ± 0.0033 |

*Significant at $P<0.05$; **Significant at $P<0.01$

Note - Technical

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## HOW TO MARK TRIBOLIUM ADULTS

We have to employ a very thin nylon fibre (0,1 mm.). We have to place a handle on it. One possibility is to bind the nylon fibre on a small brush, better without bristles, in a way that it remains firm (figure 1).

There are felt tip pens that once empty, it is very easy to extract its porous tip and then to introduce it again together with the nylon fibre, cutting a piece away if it is too long (figure 2).

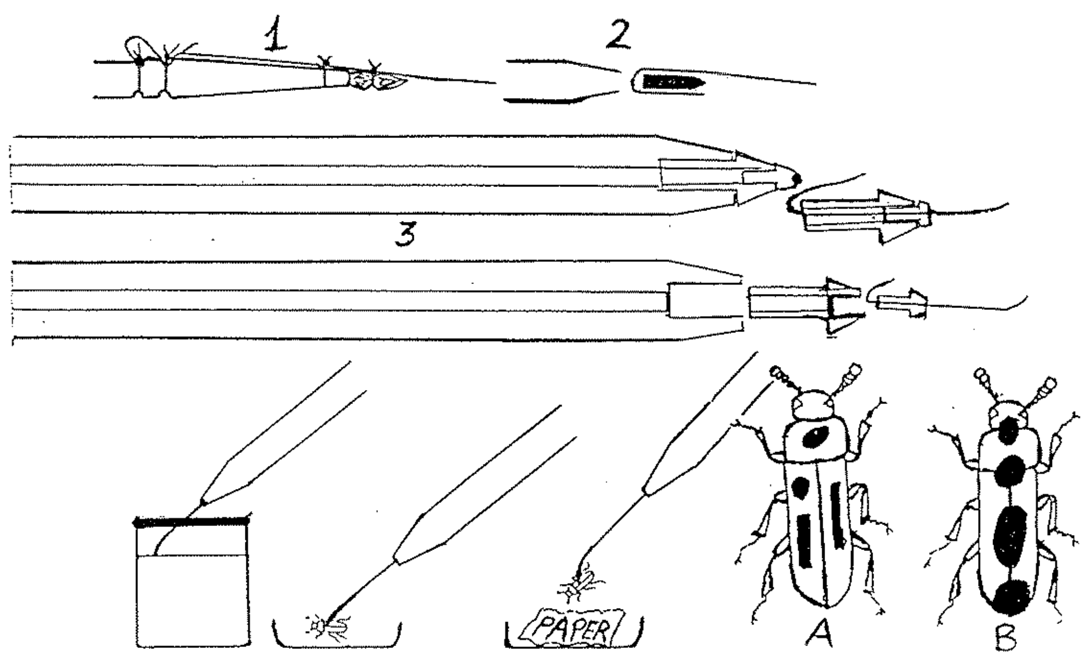
The ball-point pens have got a little but very hard ball that can be removed filing or cutting all around it with an old blade or scalpel: doing this under the binocular will be a great help. Then we have to remove the pipe with the ink. If it's necessary, we can wash with alcohol the support that has no longer the little ball in it, in order to introduce the nylon fibre in a way that it remains well firm (figure 3).

With the fibre we have to touch slightly the not toxic paint surface so that we take a minimal but sufficient quantity. The best way to do this is to take a little blob with a needle and place it horizontally on a smooth surface in order to get a thin coat where we can dip the fibre while the paint doesn't get dry.

The clean insects must be put on a smooth surface, and touching them with the fibre they will remain sticked on it so that we can transfer them to a Petri dish with flour and a piece of paper where they can grasp on in order to get free.

We can do it with or without the binocular. It will be very useful to immobilize with ice. It is important that the paint does not immobilize the head, the thorax or the elithres of the insects, marking like in A but not like in B.

Each time we mark an insect it is convenient to clean the fibre frequently with the thumb and the index finger of the left hand using or not a cleaning cloth or a thin piece of paper. It is important to avoid that the paint on the fibre gets dry.



OPEN FORUM

Note: This paper, published in 1996 in the Tribolium Information Bulletin 36:83-85 has been shortened and somewhat modified to fit a two-page requirement for the TIB On-Line

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*Interactions in Tribolium: Competition or predator-prey?

Population biologists have developed classification systems to define rigorously social interactions between lower organisms. Some interactions between associated populations are of benefit (+), other interactions are harmful (-), and others are neither beneficial nor harmful (0) .In commensalism of two species one benefits while the other is not harmed (+/0). In competition both species are harmed in some way (-/-). In predator-prey or parasite-host inter- actions one species benefits and the other is harmed (+/-) (one species serves as food for the other). We are concern- ed here only in the last two interactions.

As the reviews of King and Dawson (1972) and Sokoloff (1975) have summarized, the late Thomas Park and his students and collaborators studied interactions between Tribolium castaneum (CS ) and T. confusum (CF). He concluded that the interaction between these stored-product pests was competition: one of the species or the other was eliminated depending on the environmental conditions used. In the mid-sixties Park et al (1965) and Soko-loff and Lerner (1967) independently came to the conclusion that the interaction observed when these two species are placed in the same vial is a predator-prey interaction and not (as originally assumed by Park and his collaborators and others) a competition interaction. Sokoloff and Lerner thought that under certain conditions (such as rearing CS and CF in whole wheat flour enriched with brewer's yeast at 29° C and 70% R.H. the interaction is one of mutual predation because food is present in abundance and regularly renewed, and under these conditions CS is the winner.. Under the same conditions, but utilizing other media such as corn, CS was eliminated by CF. Again the amount of food is probably in excess , since once CS is eliminated CF experiences a threefold increase in population size. But here the possibil- ity that competition has occurred cannot be ruled out , because certain nutritional required nutri- ents are in limited supply in corn. Evidence that a shortage of these requirements causes CS to become a more ac- tive cannibal was obtained by Inouye and Lerner (1965).

At the time when these experiments were carried out neither Park et al (1965) nor Sokoloff and Lerner (1967) had any experimental basis to show that temperature may be a useful guide to resolve what kind of interaction (competition or predator-prey ) is prevailing in the experiment. Bowker (1978) showed in her measurements of energetics of populations of single and mixed species of CF and CS that when beetles are reared at 25° or 30° C predator-prey interactions predominate, while at 35°C competition interactions predominate. Unfortunately, her paper did not attract the attention of Triboliumists: Her paper is not cited by any of the papers on competition or other interaction studies in the last 20 years.

In my opinion, recent students of interactions in Tribolium species, judging from the contents and their titles and the temperatures at which the experiments have been carried out, have misidentified the type of interaction they are observing, perhaps because of an inadequate search of the available literature. To a certain extent reliance on the literature published and available in data bases leads to errors in interpretation such as those I have described here. I have made available the facilities of the Tribolium Information Bulletin as an open forum to discuss the topic. So far only one Triboliumist has shown interest, but the open forum will remain open for a couple of years.

Literature Cited

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The following is Dr. Charles Goodnight's opinion about the topic "Interactions in Tribolium: Competition or predator-prey" prepared for the Open Forum.

The interaction between Tribolium confusum and T. castaneum clearly has elements of both competition and predation. It is hard not to consider the eating of one species by another to be anything other than predation. However, when distinguishing between these two processes it is perhaps more important to consider whether the dynamics of the system are better modeled as competition or as predation. As an evolutionary biologist I will not embarrass myself by expressing an opinion on the ecological dynamics. From an evolutionary perspective the evolution of the interaction appears to be best considered to be one of competition (either T. confusum or T. castaneum surviving) at the individual, group and community level. I am doing this selection both on communities (both species transferred between generations) and on systems where only one of the species can evolve, with the other drawn from a stock population each generation. Those data are still very preliminary. As before I am finding no evidence of evolution by individual selection, however there is evidence that group or community selection is changing the outcome of competition.

Several years ago we published a study of the effect of coexistence on the interaction between T. castaneum and T. confusum (Goodnight and Craig, 1996). In this study we set up 10 two species communities and 10 pairs of single species populations. These lines were maintained for 18 generations using discrete generation husbandry (see Goodnight and Craig 1996 for details). The advantage of discrete generation husbandry is that the two communities coexist with neither species going extinct. Nevertheless they interact sufficiently that there is ample opportunity for co-evolution to occur. At the end of 18 generations we set up continuous "Park style" competition (Park, 1948). The two species communities were allowed to compete, and the single species populations were combined into two species communities for the first time. We set 15 replicates for each lineage. Under this continuous form of husbandry it is inevitable that one of the species will go extinct, although the last community had both species surviving for 1000 days.

The outcome of this experiment was that there was no evidence that the two species communities co-evolved, that is there was no significant amount in the treatment component in the outcome of competition. However, there was a huge variation among lineages within treatments in the outcome of the competitive interaction. From this we conclude that there was no consistent evolution of the outcome of competition by individual selection, but the outcome would evolve if group or community selection were imposed. Note that our design could not distinguish between a lack of evolution by individual selection and a balanced "red queen" situation in which the competitive ability of the two species was evolving, but the overall outcome was not changing.

I am currently testing the prediction that competitive outcome can evolve by group and community selection, but not individual selection in an experiment in which I am selecting for the outcome of competition (either T. confusum or T. castaneum surviving) at the individual, group and community level. I am doing this selection both on communities (both species transferred between generations) and on systems where only one of the species can evolve, with the other drawn from a stock population each generation. These data are still preliminary. As before, I am finding no evidence of

I am currently testing the prediction that competitive outcome can evolve by group and community selection, but not individual selection in an experiment in which I am selecting for the outcome of competition.

Although certainly not definitive, these experiments suggest to me that from an evolutionarly perspective the two species T. castaneum/T. confusumcommunities are behaving as competitive systems rather than predator-prey systems. The reason for this is that the predator-prey systems are directional, with one species (the predator) benefiting at the expense of the other species (the prey). It seems likely that I could have so a directional change due to individual selection in a directional system, but perhaps not in a competitive system. It is particularly telling that there is no change in the outcome of competition due to individual even when only one of the species is allowed to evolve (Goodnight unpublished data). In a predator-prey system I would suspect that either becoming a more efficieny predator or more resistant predation would be a reasonalble outcome. On the other hand, in a competitive system it is often argued that intraspecific competition should be as intense a selective force as interspecific competition. Thus, the failure of competitive outcome to evolve due to individual selection is perhaps less surprising.

## Literature Cited

Goodnight, C. J. and D.M. Craig. 1996. Theeffect of coexistence on competitiveoutcome in Tribolium castaneum and T. confusum. Evolution 50:1241-1250.

Park, T. 1948. Experimental studies of interspecies competition. I. Competition between populations of flour beetles, Tribolium confusum Duval and Tribolium castaneum Herbst, Ecological Monographs 18:265-305.

# GEOGRAPHICAL DIRECTORY

# GEOGRAPHICAL DIRECTORY

NOTE: An asterisk denotes the individual who, as far as known, has worked or is working on Coleoptera. The plus sign (+) before the geographical locality indicates there was no current contribution. Since the information was obtained from previous issues of TIB, there is no guarantee that the information is accurate.

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Marcé Lorenzen (transformation of Tribolium)
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