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# TRIBOLIUM INFORMATION BULLETIN

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**CELEBRATING OUR $42^{ND}$ 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 42.**

## ANNOUNCEMENT I

## FOR SALE

1. 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 (includes postage, handling and insurance).

2. A few copies of Sokoloff's The Genetics of Tribolium and other Related Species in paper back. $40 (includes postage, handling and insurance).

3. Incomplete sets of Tribolium Information Bulletin at $5/volume plus mailing costs. List of volumes and index of contents available on request.

## SPECIAL ANNOUNCEMENT

I am happy to announce the completion of an autobiographical book by A. Sokoloff entitled Letters from My Mentors Prof. Theodosius Dobzhansky and the Rev. E.L.Yeats which will become available for sale in the near future. Its tentative price has not been established, but it will be around $35 including postage and insurance. If you wish to reserve a copy please use the enclosed purchase order.

## Announcement II

At long last we have received permit for the importation of three 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 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 remains open for discussion and it will be open for one more year.

As usual, the Editor reminds subscribers that the very existence of the TB 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 call for contribution reach your hands. This includes not only research notes, but also revision of personnel in your lab, stock lists, and lists of current papers you have published in the last year.

## Announcement IV. Tribolium News Exchange.

Margaret Bloch Qazi has retired from the function of providing an informal forum to exchange ideas, techniques and suggestions about Tribolium. I consider this source necessary and important, especially to graduate students and recently graduated Ph.D.'s who are looking for advice. Hence, this Directory is being incorporated with the TIB. If you wish to serve in this function or to withdraw your name from the list send me a postcard.

A. Sokoloff, Ed.

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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

25. PERMIT NO.

### PERMIT

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


**ISU use only**

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

# STOCK LISTS

RIVER FOREST, ILLINOIS
ROSARY COLLEGE
DEPARTMENT OF NATURAL SCIENCES

I. Wild type strains
 A. Tribolium castaneum
  1. "Chicago" (originally from Thomas Park)
  2. "Brazil" (originally from Rio de Janeiro; also known as cI)
  3. "Arkansas" (originally from Michael Wade)
 B. Tribolium confusum
  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. Tribolium castaneum
  1. "Chicago" black (derived from "Chicago")
 B. Tribolium confusum
  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.).

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 |

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, 1986 |
| 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 Bemadino |
| 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 metastema. 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., pea | ? | 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) [Eggs obtained from Carolina Biological Supply] | Tobacco Hornworm |
| **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>*

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$^{Ho}$ ($R^{Ho}$) | 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

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)

<u>Tribolium castaneum</u>

<u>Wild type strains</u>

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 | |

T. confusum

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

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)

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 <u>Tribolium anaphe</u>, <u>T. audax</u> and <u>T. destructor</u> 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

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

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**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

| NAME | SYMBOL | LINKAGE GROUP |
|---|---|---|
| 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 Munez del Castillo

## DENMARK

LYNGBY
STATENS SKADEDYRLABORATORIUM
(DANISH PEST INFESTATION LABORATORY)

*Anthrenus coscorus*
*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. Oryzaephilus surinamensis | Freiburg |
| 2. Tribolium castaneum | San Bernardino |
| 3. T. confusum | San Bernardino |

Mutant strains (All from San Bernardino)

A. Tribolium castaneum
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. Tribolium confusum
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--Acanthoscelides obtectus (Say)

Cucujidae--Cryptolestes turcicus Grouv. Munich, 1966

Ptinidae

| | |
|---|---|
| Gibbium psylloides (Czemp) | Regensburg, 1960 |
| Ptinus tectus (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)

# 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 | – | " |

<u>Tribolium confusum</u>

| | | |
|---|---|---|
| 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 entomophilus* (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 Lomianki, Dziekanów Lesny near Warsaw
Poland

Stock list:

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

[illegible]
[illegible]

# 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. |

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.
York, England YO41 1 LZ
Email: j.dixon@csl.gov.uk
Tel: +44 (0) 1904 46 26 35
fax : +44 1904 46 21 11
Web: http://www.csl.gov.uk

Requests addressed to the librarian should now be sent to the:

Information Centre
Central Science Laboratory
DEFRA
Sand Hutton, York, England YO41 1LZ
e-mail: Science@csl.gov.uk
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 SCIENCE 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 |

Sand Hutton York
YO41 1LZ U.K.
Tel: +44 (0)1904 462000
Fax: +44 (0)1904 462111
Website: www.csl.gov.uk
E-mail: science@csl.gov.uk

CENTRAL SCIENCI
LABORATORY

# *Coleoptera*

## *Tenebrionidae*

| | | Common Name |
|---|---|---|
| *Tribolium anaphe* | Hint. | American flour beetle |
| *T. audax* | Halstead | |
| *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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CENTRAL SCIENCE LABORATORY

# 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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LABORATORY

## *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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CENTRAL SCIENCE LABORATORY

# Lepidoptera

| Gelechiidae | | Common name |
|---|---|---|
| *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

CENTRAL SCIENCE LABORATORY

- 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
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CENTRAL SCIEN
LABORATORY

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:

**Agriculture and Environment R&D:**

Acarology • analytical chemistry • behavioural biology • biochemistry • biotechnology • entomology • information services • microbiology • nematology • ornithology • pest management • plant pathology • statistics • survey techniques • virology.

**Food R&D**

Authenticity testing • chemical analysis • allergy • microbiology • FAPAS • FEPAS

Our services are specialised, high value, high quality business to business offerings. For further information please contact:


| | | |
|---|---|---|
| CSL | | |
| Sand Hutton | **Tel:** | +44 (0) 1904 46 20 00 |
| York | **Fax:** | +44 (0) 1094 46 21 11 |
| Y041 1LZ, UK | **e-mail:** | science@csl.gov.uk |

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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)* |
|---|---|---|---|---|
| ..................................<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 35
**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:**......................... |

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 01-242 5412)

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

| | |
|---|---|
| **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. Corcyra cephalonica — a. Ex-MAFF
2. Ephestia cautella — a. Ex-MAFF; b. Ethiopia
3. Ephestia elutella — a. Ex-MAFF

Gellechiidae:

1. Sitotroga cerealella — 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

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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.*

A. Sokoloff
Biology Department
California State University
San Bernardino, California 92407.

*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.

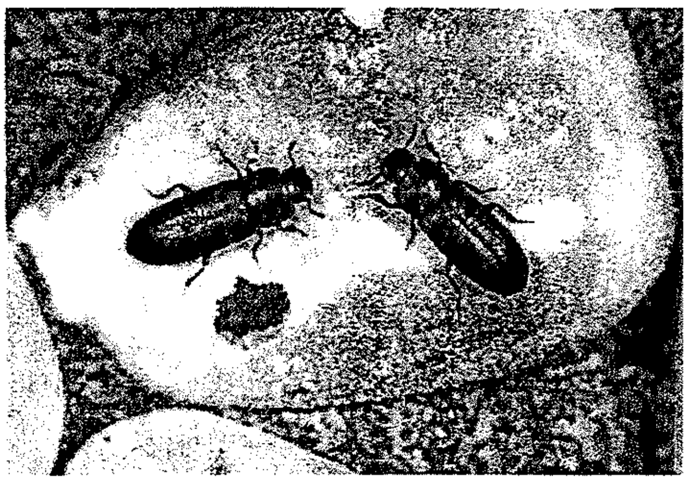
# R.W. BEEMAN'S TRIBOLIUM HOME PAGE

# 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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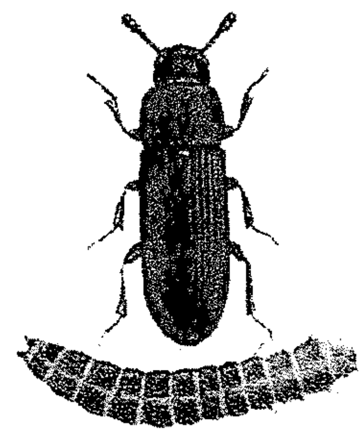
## Index





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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.)

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**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 ~~[illegible]~~ **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 the of 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.

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**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.

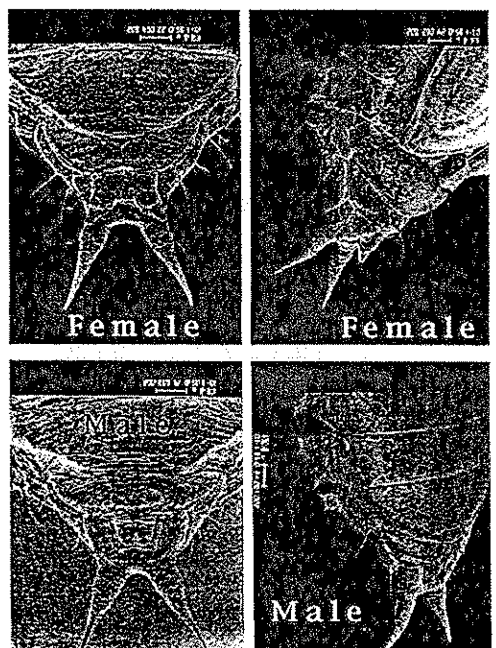
Manipulating tools: A small natural bristle brush can be used to move the pupae on the "plate".

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.).

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## 2. Adults

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

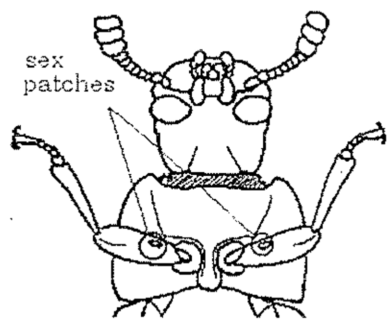
Ice bucket: Any container which can hold crushed ice can be used to precool adult beetles. The small styrofoam boxes or buckets which are used for picnics or fishing are perfect for this..

<u>Ice block:</u> 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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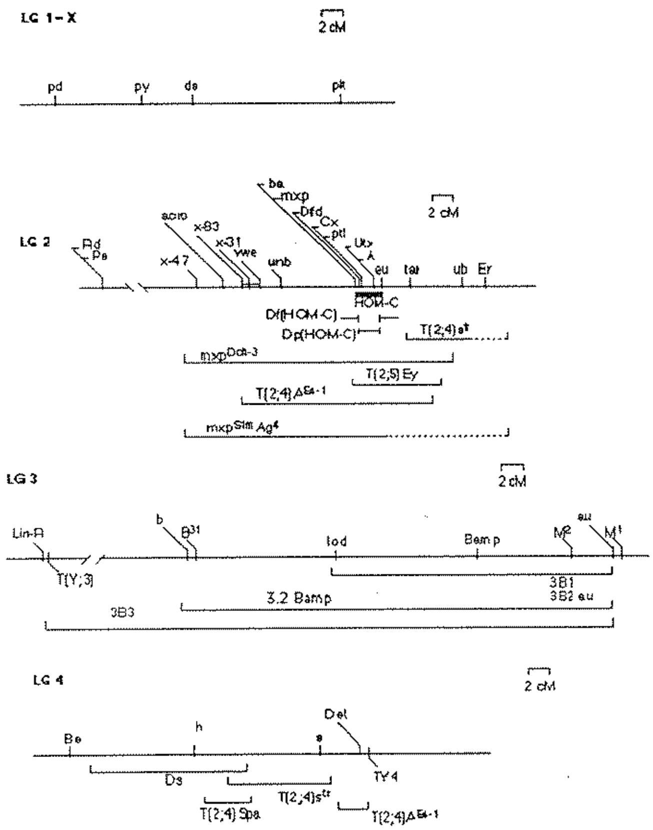
*Last Edited: August 13, 1998*

# *Tribolium castaneum* chromosomes 1-4

Select a Linkage Group:

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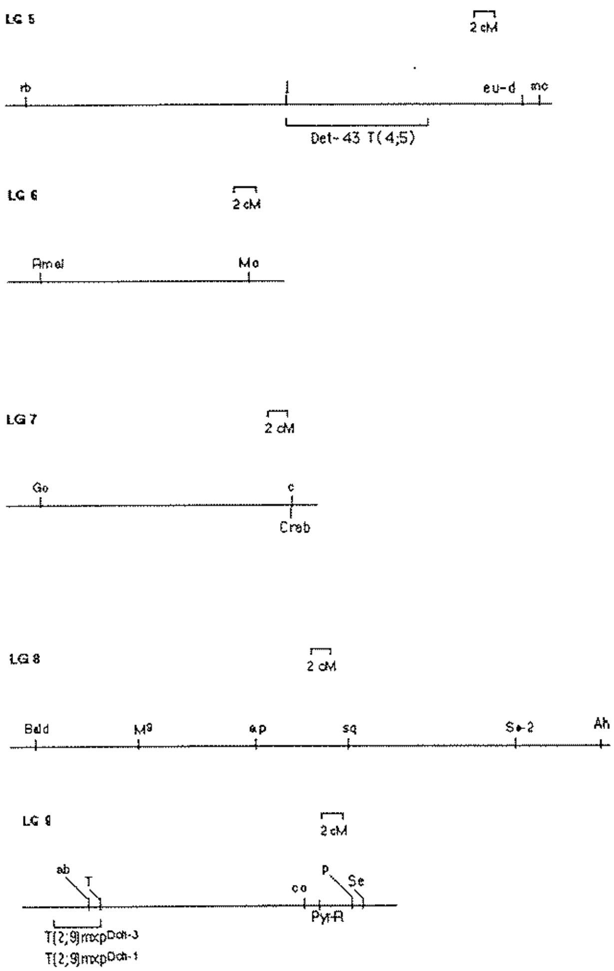
*Last Edited: August 13, 1998*

# *Tribolium castaneum* chromosomes 5-9

Select a Linkage Group:

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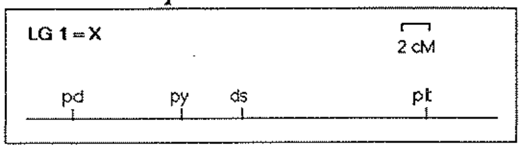
*Last Edited: August 13, 1998*

# *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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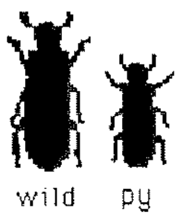
*Last Edited: August 13, 1998*

# 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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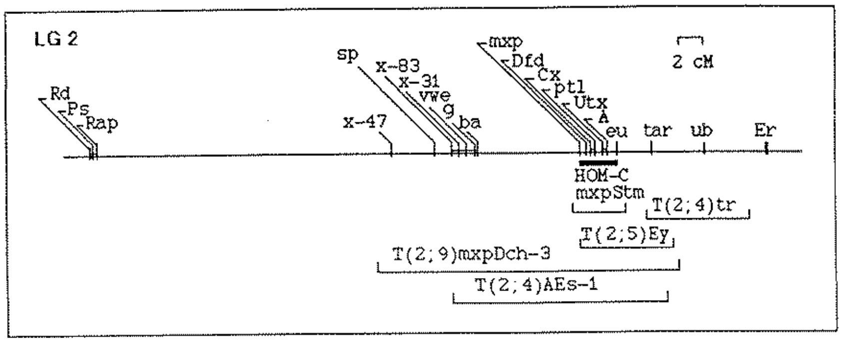
*Last Edited: August 13, 1998*

# *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.

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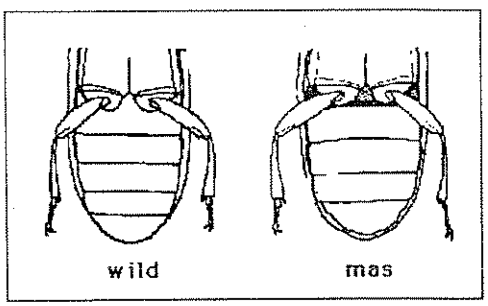
## mas (missing abdominal sternite)

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

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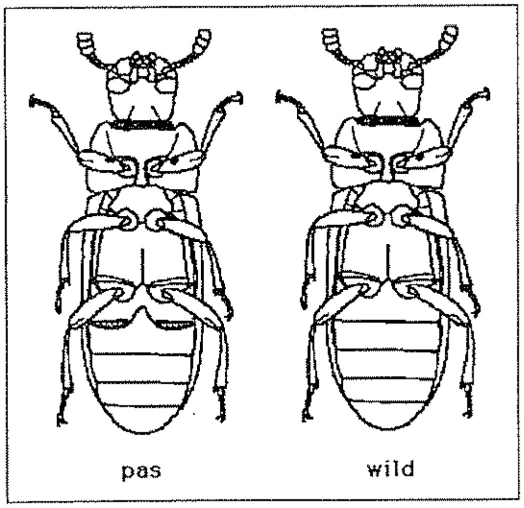
## pas (pointed abdominal sternite)

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

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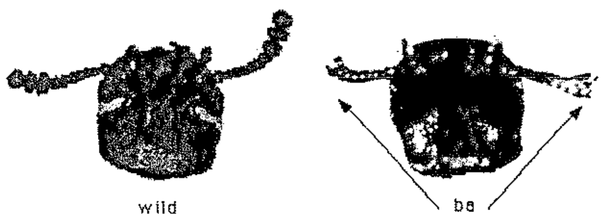
*Last Edited: August 13, 1998*

# 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.

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*Last Edited: August 13, 1998*

# Cx (Cephalothorax)

LG 2

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## Cx

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

wild Cx

(pupa)

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## 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 ).

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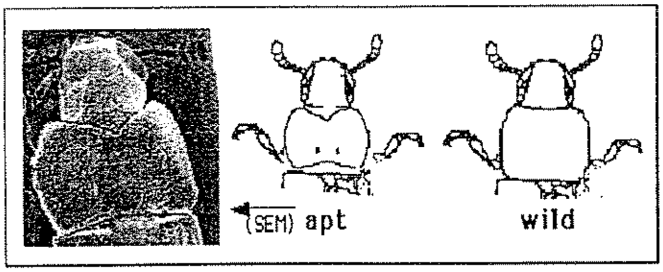
## apt

- **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).

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*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)

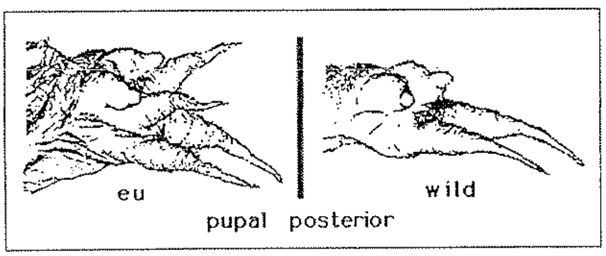
LG 2

---

## 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*

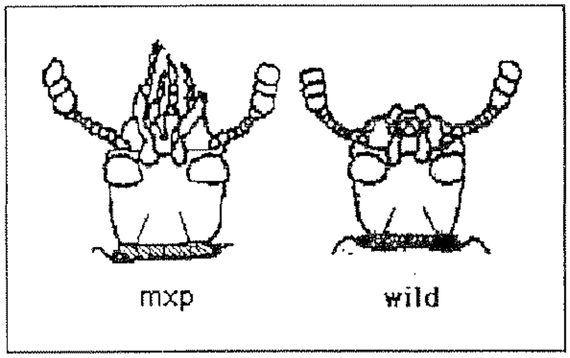
# mxp (maxillopedia)

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.




---

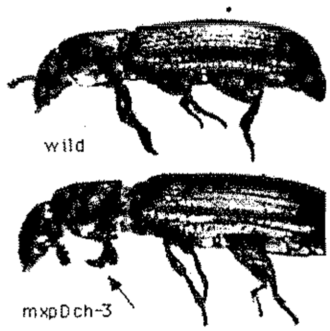
## Dch-1 (Dachshund)

- **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)

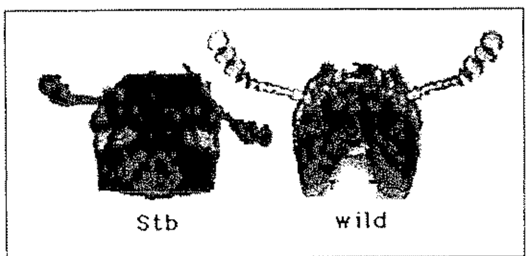
- **Structure affected:** Prothorax.
- **Linkage Group:** T(2;9)
- **Origin:** Radiation-induced.
- **Description:** GOF. Prothoracic legs are dramatically reduced. Remainder of prothorax is reduced to a lesser extent, presumably via a homeotic transformation toward labial or maxillary segment. Effect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

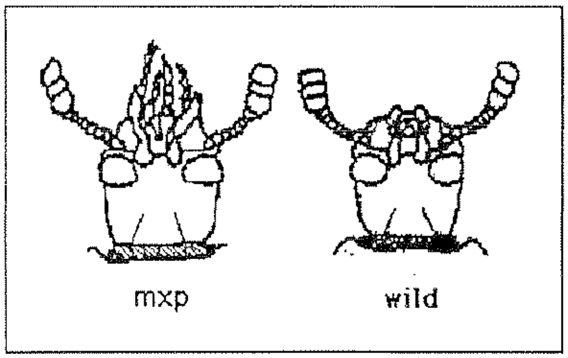

# mxp (maxillopedia)

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.




---

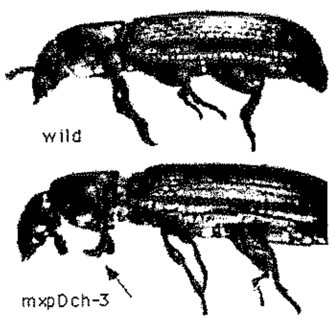
## Dch-1 (Dachshund)

- **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)

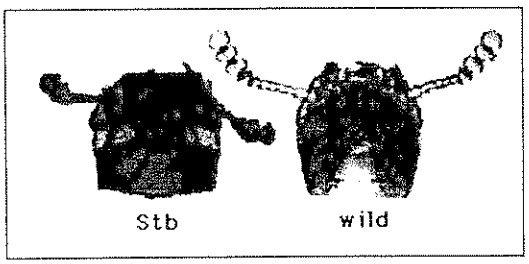
- **Structure affected:** Prothorax.
- **Linkage Group:** T(2;9)
- **Origin:** Radiation-induced.
- **Description:** GOF. Prothoracic legs are dramatically reduced. Remainder of prothorax is reduced to a lesser extent, presumably via a homeotic transformation toward labial or maxillary segment. Effect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

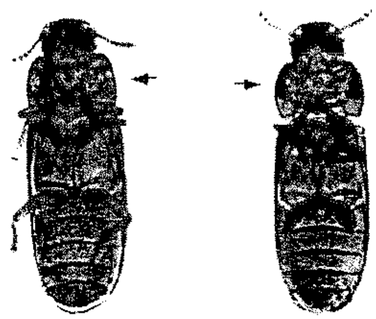
- **Structure affected:** Dorsal pronotum (T1)
- **Linkage Group:** 2
- **Origin:** Spontaneous mutant found in the Ga-1 (wild-type) stock
- **Description:**
  - Dorsal protonum has anterior midline dip, bilateral shallow dents, and enlarged anterio-lateral margins.
  - This dominant is homozygous viable.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



wild tar

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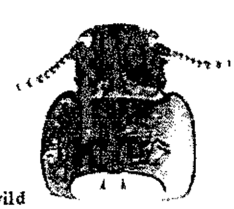
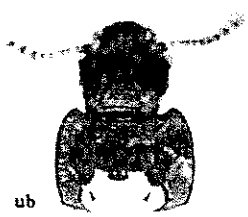
*Last Edited: August 13, 1998*

# 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).



wild



ub

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*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

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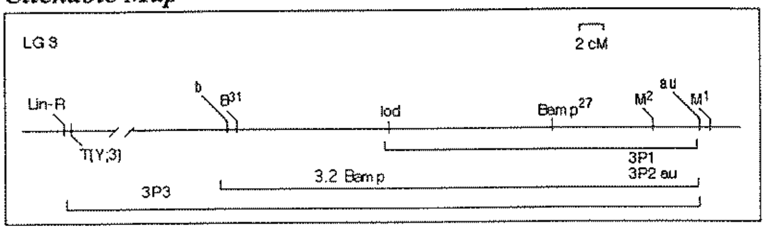
*Last Edited: August 13, 1998*


# *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

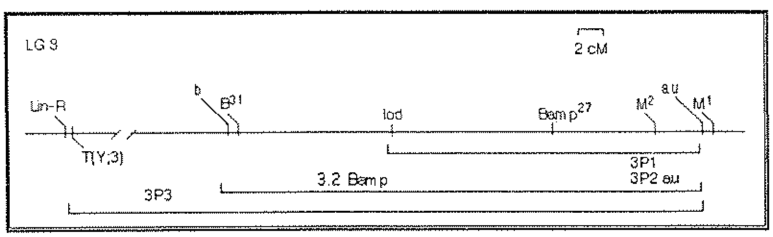
LG 3

## Description/notes

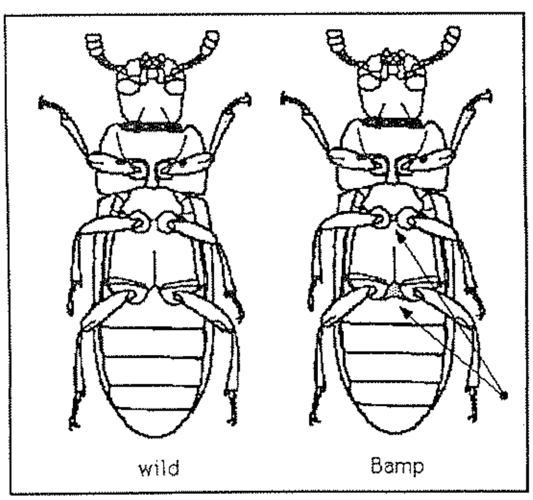
These crossover suppressors were made by irradiating the dominant LG 3 marker Bamp-27 (Click here to go to the Bamp-27 page, or see picture at bottom).

- **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.

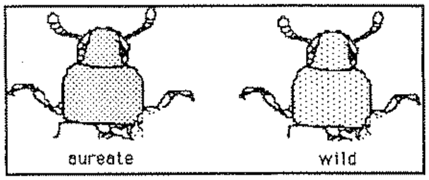
LG 3 linkage map




Bamp-27 phenotype (dominant)



au phenotype (recessive)

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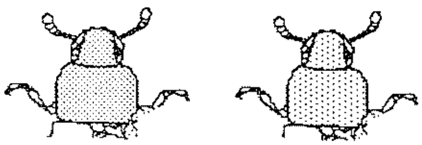
*Last Edited: August 13, 1998*


# 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*

# 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*

HOME Maps

# A (Abdominal)

LG 2

---

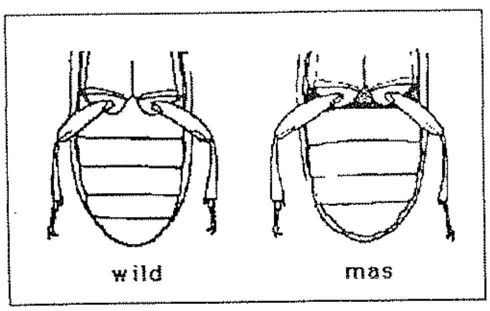
## ES-1 (Extra sclerite)

- **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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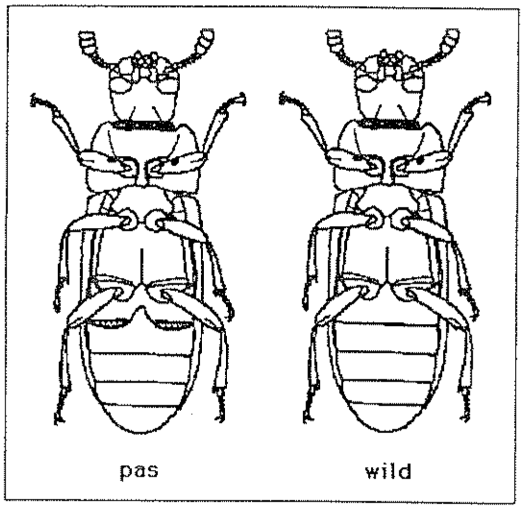
## pas (pointed abdominal sternite)

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

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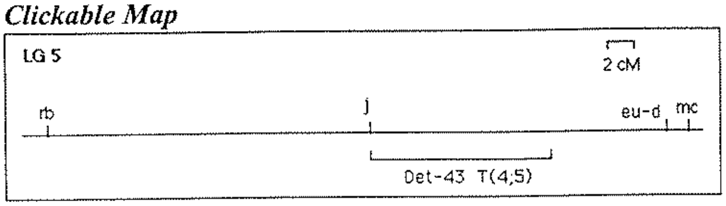
*Last Edited: August 13, 1998*

# *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)

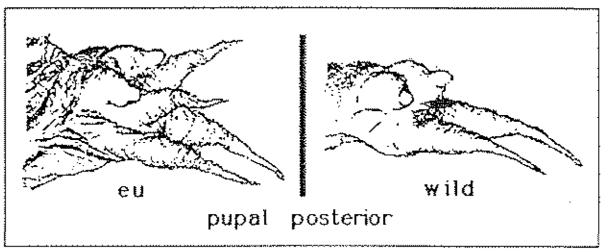
LG 2

---

## 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.

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### 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*

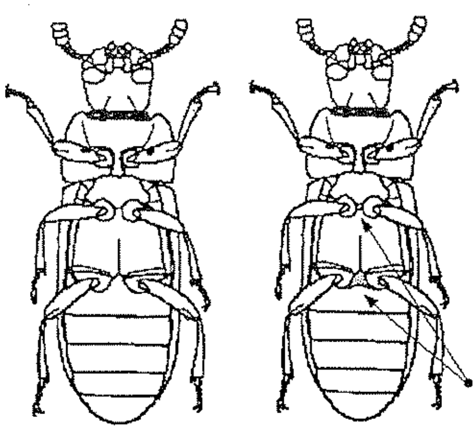

# Bamp-27 (Blunt abdominal and metathoracic projections)

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*

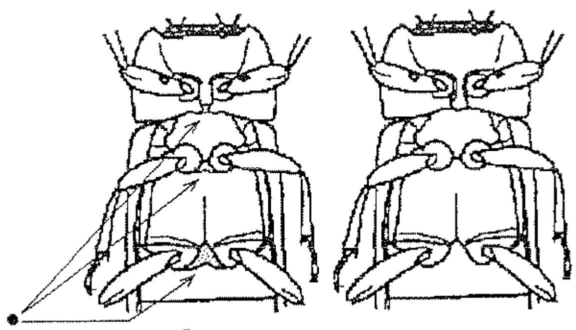
# Bamp-31 (Blunt abdominal and metathoracic projections)

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

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## 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.

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*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.

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*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)

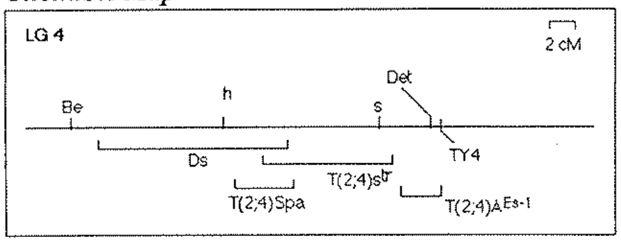
- **Structure affected:** None
- **Linkage Group:** T(Y;3)
- **Origin:** gamma-induced on a Ga-1 chromosome
- **Description:**
  - Translocation between LG3 and the Y chromosome
  - Mutant always carried by males.
  - Translocation demonstrated cytologically.

---

*Last Edited: August 13, 1998*

# *Tribolium castaneum* Linkage Group 4

***Clickable Map***



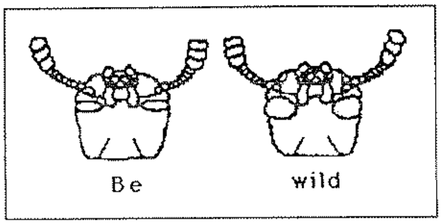

| Mutant | Name/note |
|---|---|
| Be | Bar eye |
| h | hazel eye |
| s | sooty |
| Det-43 | Divergent elytral tips |
| T(Y;4) | Translocation |
| Ds | Displaced sternellum |
| T(2;4)Spa | Spatulate |
| T(2;4) tr | tremblor |
| T(2;4)AEs-1 | Eyeless |

---

*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*

# 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*

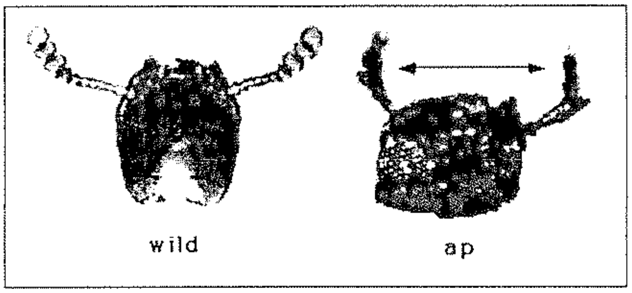

# ap (antennapedia)

LG 8

---

## ap (antennapedia)

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




---

## F (Fused funicle)

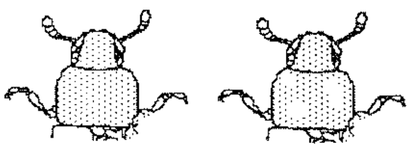
- **Structure affected:** Antennae.
- **Linkage Group:** 8
- **Origin:** Ff originated from an experiment in which Ds (Lg4) was irradiated with gamma rays.
- **Description:**
  - May be a dominant ap allele.
  - Dominance confirmed in a outcross to Ga-1. Penetrance is ~100%.
  - Characteristic phenotype - 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.



wild Bald

---

*Last Edited: August 13, 1998*

# Se-2 (Short elytra 2)

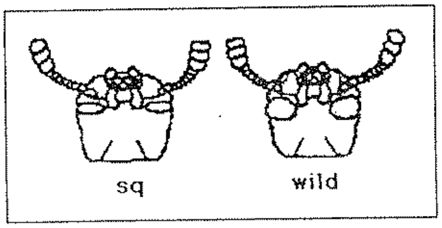
- **Structure affected:** Elytra
- **Linkage Group:** 8
- **Origin:** From ab stock, Scott Thomson, (while working in Beeman lab)
- **Description:**
  - Elytral tips are divergent, exposing wings and membranous dorsal abdomen.
  - Enough wing surface is usually exposed to cause the wings to no longer 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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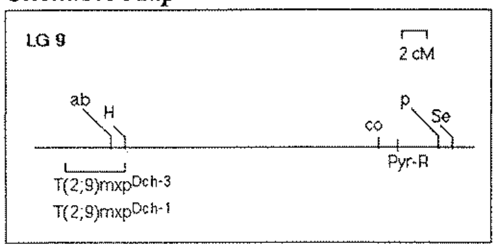
*Last Edited: August 13, 1998*

# *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

---

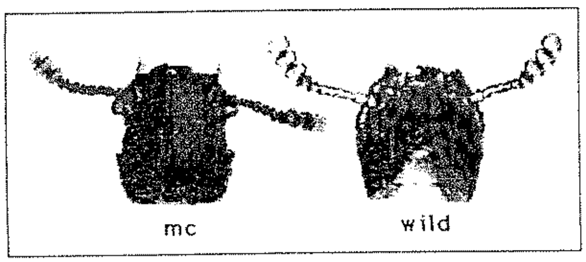
*Last Edited: August 13, 1998*

# 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.




## 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)

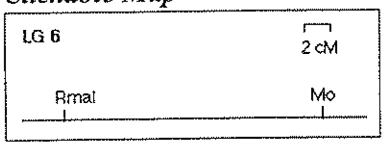
- **Structure affected:** Eyes
- **Linkage Group:** 5
- **Origin:** Alexander Sokoloff lab, Berkeley, CA
- **Description:** Reddish eye color.

---

*Last Edited: August 13, 1998*

# *Tribolium castaneum* Linkage Group 6

***Clickable Map***



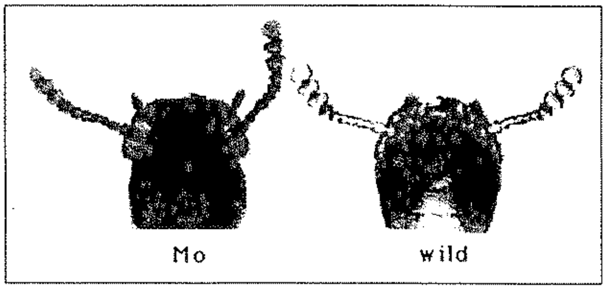

| **Mutant** | **Name/note** |
|---|---|
| Mo | Micro-opthalmic |
| Rmal | Resistance to malathion |

---

*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)

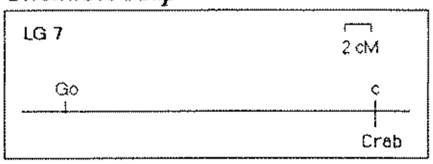
- **Linkage Group:** 9
- **Origin:** spontaneous
- **Description:** resistant to alpha-cyano synthetic pyrethroids.

---

*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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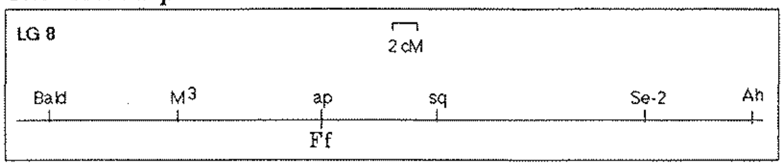
*Last Edited: August 13, 1998*

# *Tribolium castaneum* Linkage Group 8

***Clickable Map***




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

---

*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 subtle posterior rounding.
  - Closely linked to p (pearl eye)

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*Last Edited: August 13, 1998*

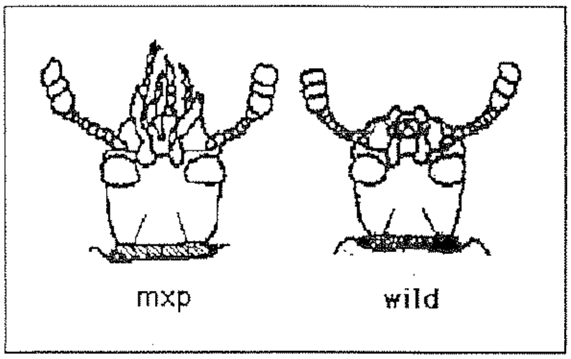

# mxp (maxillopedia)

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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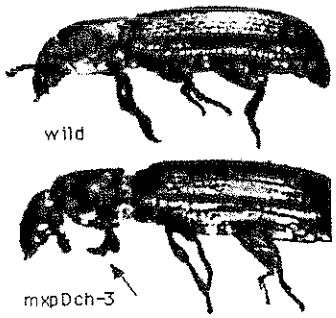
## Dch-1 (Dachshund)

- **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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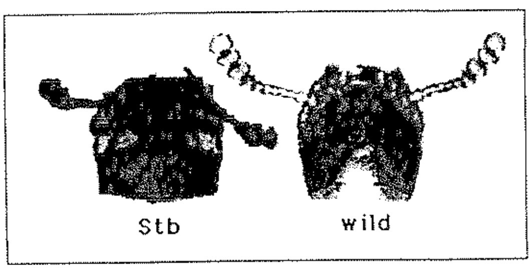
## Stb (Stubby)

- **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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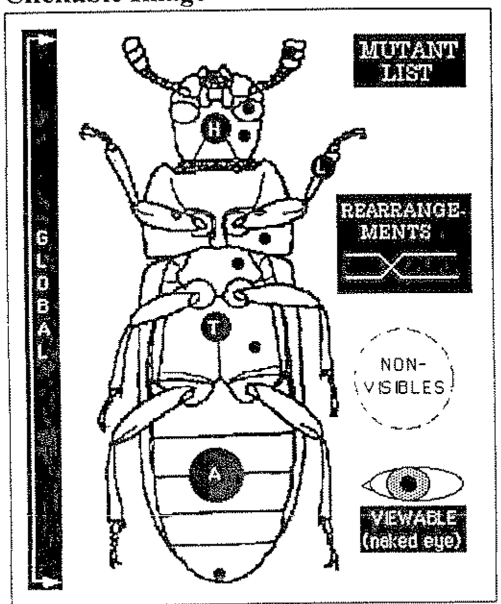
*Last Edited: August 13, 1998*

# 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 |

*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) |

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*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) |

---

*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 |

*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) |

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# Abdomen-genital

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

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HOME Maps

# 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 |

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# "Invisible" mutants

## Rearrangements (no marker)

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

## Hybrid Incompatibility

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

## 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 |

## MEDEA (maternal effect)

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

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# 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 |

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# 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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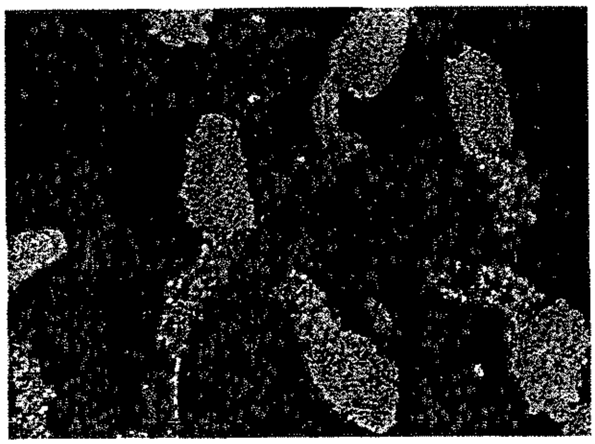
# Medea

### 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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# TRIBOLIUM INFORMATION BULLETIN 42

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B. Tribolium

A. Tenebrio and other Tenebrionidae and other insects except Tribolium.

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# Research Notes

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*Histological characterization of the reproductive accessory complex of Tribolium confusum (Coleoptera: Tenebronidae)

Introduction

Male reproductive accessory glands in insects produce secretions that assist in copulation, are used to make spermatophores that encase sperm, and/or assist in delivery of sperm directly into the female beetle (see the review by Kaulenas, 1992).

The male reproductive accessory glands have been characterized in several of the species within the family Tenebrionidae, where the standard arrangement of these glands is as follows: one pair of long thin relatively transparent tubular accessory glands (TAGs), which contain a single cell type, and one pair of shorter plumper glands, which contain multiple cell types (named according to shape). These glands include bean-shaped accessory glands (BAGs) found in Tenebrio molitor (Dailey, et al., 1980), rod-shaped accessory glands (RAGs) found in Tribolium anaphe (Hafeez and Gardiner, 1964; Nowaczewski and Grimnes, 1996), Tribolium freemani (Rummel and Grimnes, 1991), and Tribolium castaneum (Murad and Ahmad, 1977) and pear-shaped accessory glands (PAGs) found in Tribolium brevicornis (O'Dell, et al., 1990; Sevener, et al., 1992).

In this study, we will examine Tribolium confusum and investigate the cell types found in the accessory gland complex by using a histological study. These data will broaden our understanding of accessory glands in the genus Tribolium, especially within the confusum species group.

Materials and Methods

Colonies of T. confusum were maintained at 30°C on a 19:1 mixture of whole-wheat flour: brewers yeast. The adult beetles were dissected in phosphate-buffered saline (PBS). For the whole mount study, glands were stained in 0.3% Oil Red O (ORO) in 70% ethanol then destained and stored in 30% ethanol. For the histological study, 8-10 day adult glands were fixed in 10% formalin, dehydrated to xylene, embedded in Paraplast and sectioned at 6 μm. Sections were stained with hematoxylin and eosin (Kiernan, 1990), Mallory's Trichrome (Gray, 1964) or Periodic acid-Schiff's (PAS) to detect glycoproteins (Harleco kit via Fisher Scientific).

Results and Discussion

The reproductive accessory gland complex in T. confusum is standard for the genus Tribolium. There is a pair of long thin tubular glands of a uniform cell type (TAGs) and a pair of rod-shaped accessory glands (RAGs), which, in T. confusum, contain six distinct cell types (figure 1). The diagrams are arranged with dorsal views on the left side of the complex and ventral views on the right. All diagrams place the anterior of the gland toward the top. The RAG halves have been separated for clarity. Normally the glands would be attached to each other near the ejaculatory duct. The seminal vesicles and TAGs are attached to the glands on the ventral posterior side of the RAGs.

The whole mount Oil Red O staining of the glands differentiates four distinctive cell types, which contain varying degrees of non-polar materials (figure 2). The dark red ORO-positive areas (highly non-polar) were located in two parts of the gland. One area was in the middle of the gland (cell type 2) and two areas were located near the posterior end (cell types 5 and 6). One area (type 3) stained light red and was located directly under cell type 2. The anterior half of the gland (type 1) stained salmon. Type 4 cells failed to take up stain and remained white.

Analysis of the slides stained with hematoxylin and eosin showed two different areas of staining (figure 3). A small eosinophilic area (magenta) was located near the middle of the gland and appeared to contain cell types 2 and 3. The rest of the gland, and the TAGs, stained uniformly purple.

Slides stained with Mallory's Trichrome showed six distinctive colors (figure 4). Cell type 1 at the anterior end of the gland stained yellow, while cell type 2 stained light orange and was located in the middle of the gland. A red area was located under cell type 2 and corresponded to cell type 3. Cell type 4, which was underneath and on the edge of cell types 2 and 3, stained blue. Cell type 5 stained gray and was located at the posterior end of the gland. Cell type 6 occurred as patches of dark orange, which were variable in size but were located on both the dorsal and ventral sides of the gland. The TAGs were uniformly stained orange with Mallory's Trichrome. Even though we were unable to correlate specific coloration with cellular content, the diverse colors seen with Mallory's Trichrome are useful because the secretory plug also shows these characteristic colors of cellular secretions. This phenomenon will allow us to map the pathway between cellular production and final destination in the spermatophore.

Periodic acid-Schiff stains cells purple when they contain carbohydrates or carbohydrate-containing macromolecules. Cell type 3, located directly under cell type 2, stained purple and thus contains a carbohydrate or carbohydrate-containing macromolecule. Since cell type 3 also stained positive for ORO, the PAS-positive material could be a glycolipid or a non-polar glycoprotein. The TAGs were a uniform pink/purple, which is not indicative of carbohydrate moieties.

## Conclusion

Through our investigation of T. confusum, we have identified six distinctively different cell types in the rod-shaped reproductive accessory glands and a uniform cell type in the tubular accessory glands. This finding is consistent with other species in the genus Tribolium. In general, five or six cell types are seen in the multiple cell type glands in the species characterized thus far. When whole glands are stained with ORO, there are one or two areas of ORO-positive cells. A single cell type stains positive for PAS in each species, indicating the presence of carbohydrate moieties (T. freemani has yet to be tested).

The cell type pattern in T. confusum is similar to the pattern seen in T. anaphe (as determined by Nowaczewski and Grimnes, 1996). Both species have a major ORO-positive cell type in the middle of the gland and another ORO cell type at the posterior end. There is a PAS-positive cell type in both species, which is located in the same region of the gland. Based on external morphological characteristics, T. confusum and T. anaphe have both been assigned to the confusum species group. In this study, T. confusum reproductive accessory glands matched T. anaphe glands more closely in shape and cellular diversity than any of the Tribolium species (from other species groups) investigated to date. Therefore, our study supports the assignment of these species to the same group. We plan to extend our research to more members of the confusum species group in order to verify our conclusions.

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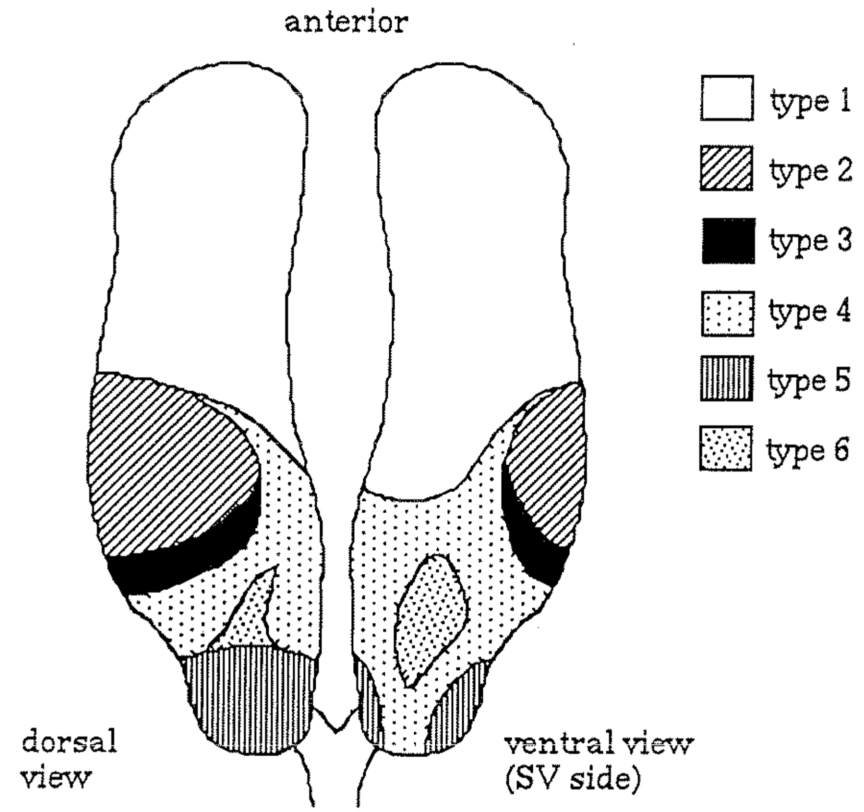



Figure 1. Cell type locations in the RAG of T. confusum (TAGs and SVs omitted for clarity)

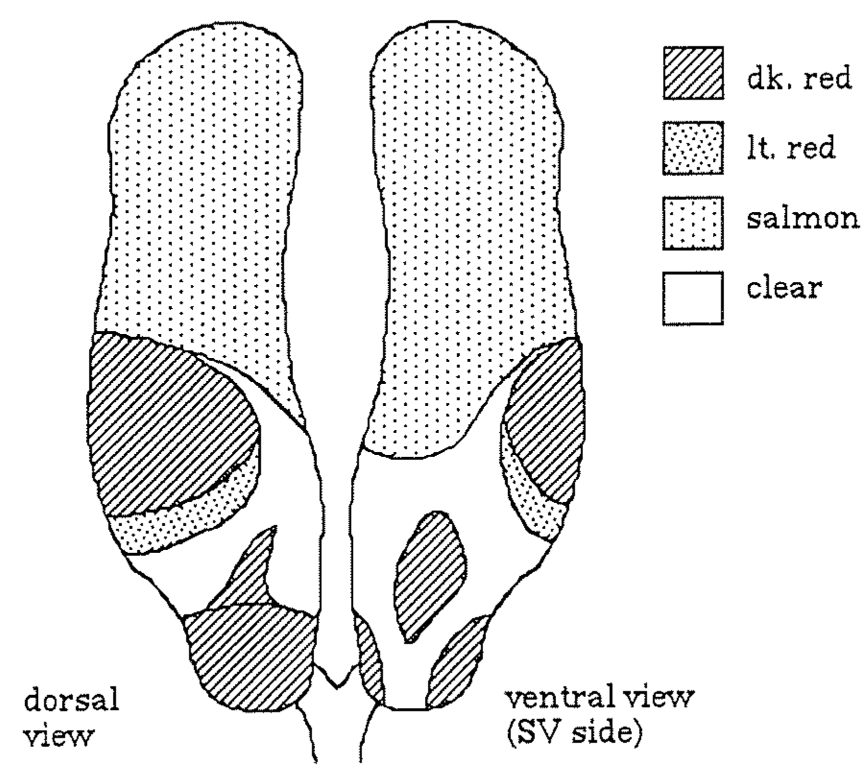



Figure 2. Oil Red O staining of T. confusum RAG

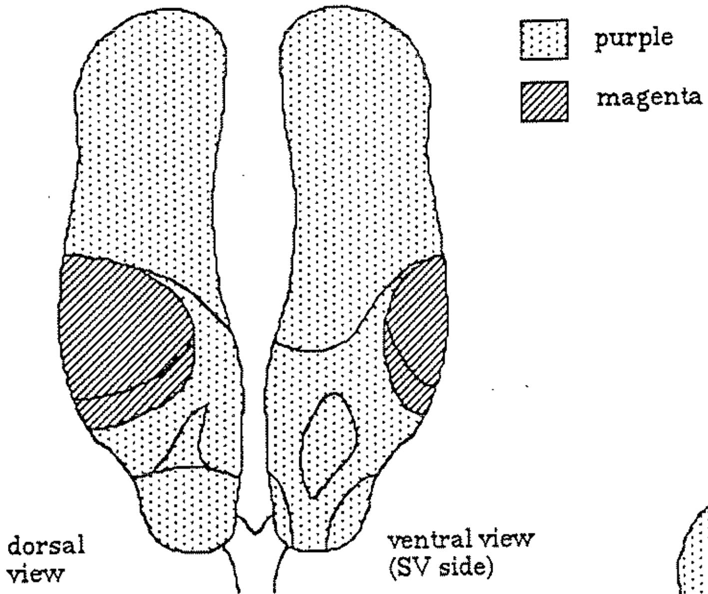



Figure 3. H and E staining of T. confusum RAG

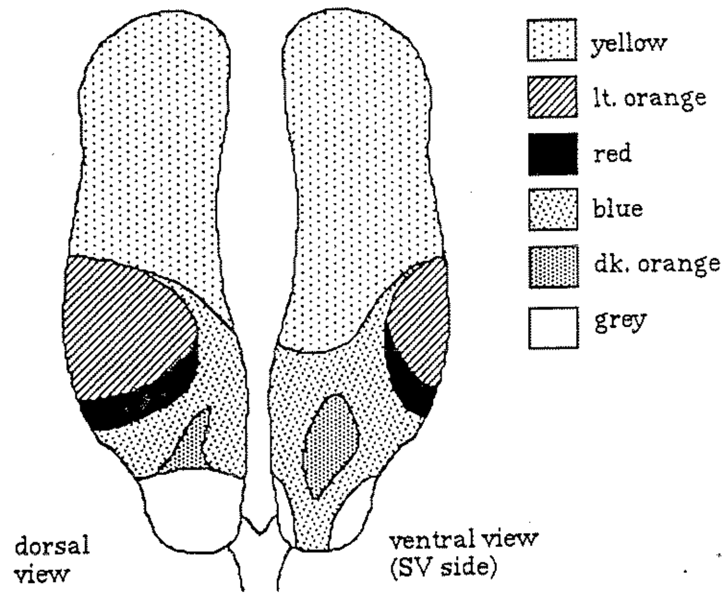
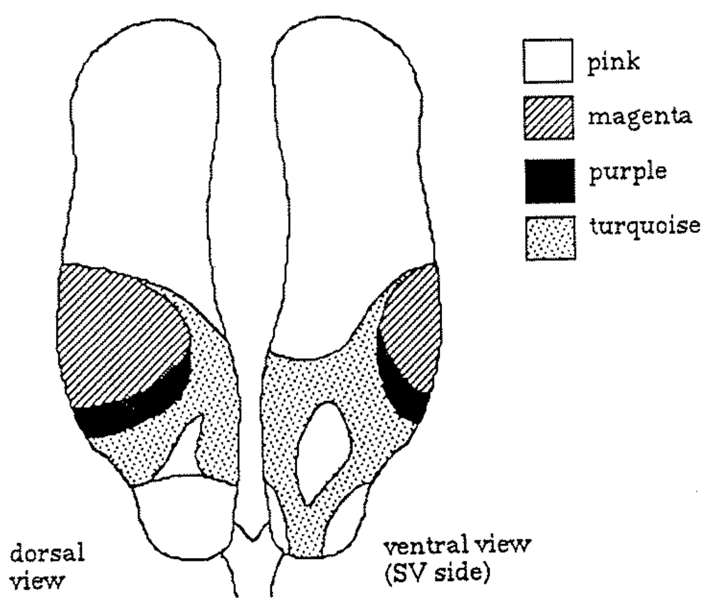



Figure 4. Mallory's Trichrome staining of T. confusum RAG




Figue 5. PAS staining of T. confusum RAG

Sokoloff, A. Emeritus Professor, Biology Department, California State University, San Bernardino, California 92407. Walkingsticks, Part III.

Biological information on a Northern California walking stick.

In 1937 Laura M. Henry, a biologist at Stanford University, provided the following information on Timema. californicum a small walking stick found from the San Francisco Bay region to Humboldt County on the North and South from Monterey to Fresno counties. All specimens were found in the Chaparral area. The species was recorded by Essig, Ferris and Hebard from fir, madrone, deciduous oaks, redwood, manzanita, pitcher sage, ceanothus, and Garrya elliptica, plants which grow in the chaparral. T. californicum apparently feeds on the tender shoots of these chaparral species. The following are excerpts of her findings They are included here as an introduction to my paper.

"On May 29$^{th}$ Henry made a trip to Loma Linda Mountain and collected 67 specimens off the Garrya elliptica and brought them to the lab. They were kept alive and fed the tender hairs on the backs of the leaves and the new spring growths of Garrya. The specimens died during the course of two weeks, and Henry recorded three cases of cannibalistic tendencies. In a second trip to Loma Prieta she collected thirty nine specimens. Eighteen were collected from Manzanita and the rest from Garrya. In the lab, the walking sticks fed most successfully on Manzanita leaves and spring bark. The plant material in the cages was kept alive by placing them in vials of water and corked with paper toweling. Since she observed that the insects drank water from these vials, she concluded that in nature, when the chaparral is dry during the summer the insects must obtain water from dew and fog which collects on the leaves. Other investigators have found that the Timema can be collected as early as May 18, and mating takes place during June and July. The insects were numerous and over sixty were caught in two hours by beating the Garrya elliptica or Manzanita by picking the insects that had fallen on the ground. By August 1 the insects had disappeared.

"Timema females were green with light yellow lines completely around the body. The thorax and abdomen had irregular patterns of green with yellow markings. Their appendages were yellow to rose brown, and the eyes were yellow. The males had the same green color, but the appendages were rose to brown, the base having the deepest color. The eyes were blackish. The intensity of color may vary with each specimen. Five males were found to be yellow-green on their ventral sides and the dorsal side was yellow brown. The female insects were much larger than the male: the adult females were 21-25 mm while the male adults were 16-17 mm in length.

(Henry does not give complete information of the number of molts during the life cycle. She states that the specimens she collected were in the last two instars. The last molt into the adult form was June 10$^{th}$, when one male molted during the night.)

"Mating

A few days after reaching maturity the males and females of Timema were found copulating. The male crawled upon the back of the female, placed his forelegs on her mesothorax, the middle legs on the metathorax and the hind legs about one third of the way down the abdomen. The female carried the male about in this manner throughout the mating and egg-laying season of six to eight weeks. The male retained this position by hanging on with his tarsal claws. If the members of a pair were forced to separate, they soon joined each other again. The adult female feeds a great deal. But the male leaves the female's back to feed only occasionally.

"Copulation takes place during the early part of June. The male slides down the back of the female. The trilobed clasper is placed under the genital plate and the bilobed clasper at the base of the plate on the ventral side. The abdomen of the female is bent to the right and slightly upward. The position is held for several hours. Copulation takes place several times during the egg-laying period and at irregular intervals. During the copulation the female moves about the plants.

"Egg laying.

The first eggs generally appeared about seven days after the first copulation (in one case the appearance of the egg was 5 days after the first copulation). The eggs ware extruded between the valvulae and held in the cup-like cerci. A fluid is secreted about the egg from the genitalic organs, while it is carefully turned and patted by the cerci. The egg is held by its collar with the tip of the valvulae. The turning and coating continues for five to ten minutes; when completed, the valvulae release the egg and it is held in the cerci until the coating is dry and has hardened. When the egg is dry the female may drop it to the ground, but in the majority of cases it is carefully placed on some object. The females deposited many eggs in the folds of the paper toweling which corked the vials, others were placed in the bottom of the cages. Often the female would carry the egg about in search of a proper place to place it.

"The whole process of laying a single egg takes from 12-15 minutes. As soon as one egg is deposited another may be extruded. The number of eggs laid between copulations varied a great deal. Some days only one might be laid, on others five to ten, while often no eggs were laid in a given day.

"As far as is known, copulation takes place at intervals of two to five days during the egg-laying period which lasts approximately 45 days.

"Eggs.

"The length of the egg is 1 ½- 2 mm. and the width 1mm. There is a small micropyle at one end and a hard collar like at the other. The shell is very tough and hard, but not brittle. The eggs vary in color from tan to brown, resembling the ground upon which they are normally deposited. When the eggs are first laid and not completely dry, they sometimes pick up debris which helps to cover and protect them.

"Timema californica is a spring and early summer form. The insect presumably passes the late summer and winter in the egg stage and emerges sometime in the spring when the growth of leaves is developing, Circumstances point to the fact that the span of life is short and that there is only one generation per year.

"Defense

"The tergite of the prothorax is shield-shaped and at each anterior-lateral angle is a darkly pigmented spot which marks the opening of the odoriferous gland. If the insect is suddenly disturbed, a fluid is exuded from this gland. It is not entirely disagreeable but is rather strong. Each odoriferous gland consists of a large reservoir and a gland that extends almost the entire length of the prothorax, just under the hypodermal layer. The gland is pear shaped and deeply grooved. The wall of the gland proper consist of cells with very large nuclei. The reservoir is irregular and lies between the gland and the body wall. The cells of this structure are large and have small nuclei. The gland and reservoir are placed among the body muscles, but there are no muscles attached to them, they being held in place by the ligaments of the prothorax. The salivary gland of the same side of the body lies in close contact under the odoriferous gland.

"Parasites

"Two cases of parasitism were found, both involving adult females. A dead female was found with a parasitic round worm extruded from the body. In the other case, an immature stage of a mite was found clinging to the thorax, apparently feeding on the walking stick".

This concludes the salient points of her paper. Other points about a species of walkingstick found in Southern California (regeneration and details about their eggs and birth ) can be found in Sokoloff, TIB 40, 2000 and TIB 41, 2001.

Introduction.

Of the 200 eggs collected in the winter in the year 2000, only six survived to the adult stage. Many of the hatchlings had attempted to hatch, but died while they were trying to emerge from the egg case, or they failed to emerge from the egg case because their legs were stuck within the egg case. Others died for various reasons even before they became adults, so eventually only four walking sticks remained alive and seemed to be ready to start reproducing after reaching the adult stage. Adults are difficult to sex because their genitalia are not exposed to the outside. Judging from their size, I concluded that two must be males and the other two females. (One of the males had the left foreleg missing, but it walked well on the remaining five legs). I had not seen the insects trying to copulate, but I decided to place the larger insects (presumably the females) in two separate cages. That left the two males, and these were separated and each joined to the females cages in their cages. In cage number 1 the male had only five legs, but the presumed female had six legs. In the other, cage # 2, both insects had complete sets of walking appendages. I had hoped that the insect with the missing leg would molt once more and regenerate the missing leg, but that was not to be because, according to their size and color, the insects had reached the adult stage.

My daughter Alexandra was visiting, and per chance she saw the insects in copula, so I knew that the pairing of the insects was correct, i.e. that each of the two cages contained a pair of insects of different sex. I had read that the male mounted the female and remained joined to her for a long time, but my daily visits to feed the animals and give them water always found the walking sticks separated. I had decided to record the date when the eggs from each of the females were laid, record the number of eggs they laid, when the next generation of walking sticks began to hatch from the eggs, and record when the period of hatching ends.

External morphology.

Walking sticks have a pair of antennae which, before the last molt, consist of 11 segments. In the immature walking sticks, the first segment is roundish while the second is trapezoidal in shape. The next 8 segments are variable in shape and bear two or three bristles; the last is the longest, having an oval–ovate shape. This shape of the antennal segments is retained in most of the instars. In the last instar the proximal two segments are enlarged and flattened in shape, and attached to the distal surface of the second segment arises a threadlike structure about 15 mm long and subdivided into 25 or 26 segments of variable size. (See Figure 2).

Examination under the dissecting microscope showed that the second segment of the left antenna and the distal portions of the antenna of the male in cage 1 were damaged. The tarsi of two legs of this male and the tarsi of one of the legs of the female in the same cage were missing. They may have broken off when the two insects were transferred from one cage to another cage,

Lateral to the middle of the top of the head, slightly behind each eye, is a sharp horn.

Each of the eyes is shaped like half a sphere. Near the middle of an eye one can see a cluster of about 50 bright ommatidia but this is the reflection of the light from a lamp: If the head is rotated, the bright cluster will move in the direction of the lamp. The eyes are compound eyes consisting of <u>many</u> ommatidia. Their numbers are difficult to estimate with a dissecting microscope. A guess would be that there are about 1000 facets in each eye. Each of the eyes has a broad black streak in the equator of the eye. This streak has four thinner branches which run up- and rearward at a 45 degree angle and four branches which run at a 45 degree angle in the down and rearward direction.

The mouth parts consist of a labrum or upper lip, a pair each of mandibles and maxillae, a labium and a hypopharynx. Lateral to the mouth parts are two bright black spots which mark the opening of the stink glands, and lateral to these are the salivary glands.

MORTALITY OF WALKINGSTICKS.

In walking sticks mortality at birth is high. When the insect is ready to come out of the egg-shell it exerts some pressure on the cap, with the result that the cap opens and falls off, or it may remain attached to the egg shell. There is another, membranous and translucent, cap which must be opened before the ypung walking stick can come out from the egg shell. However, the hatchling may have its legs stuck on the yolk inside the shell, forcing the hatchling to free itself from the egg shell. Sometimes only the anterior half of the young walking stick comes out of the egg shell. After great exertion, the hatchling

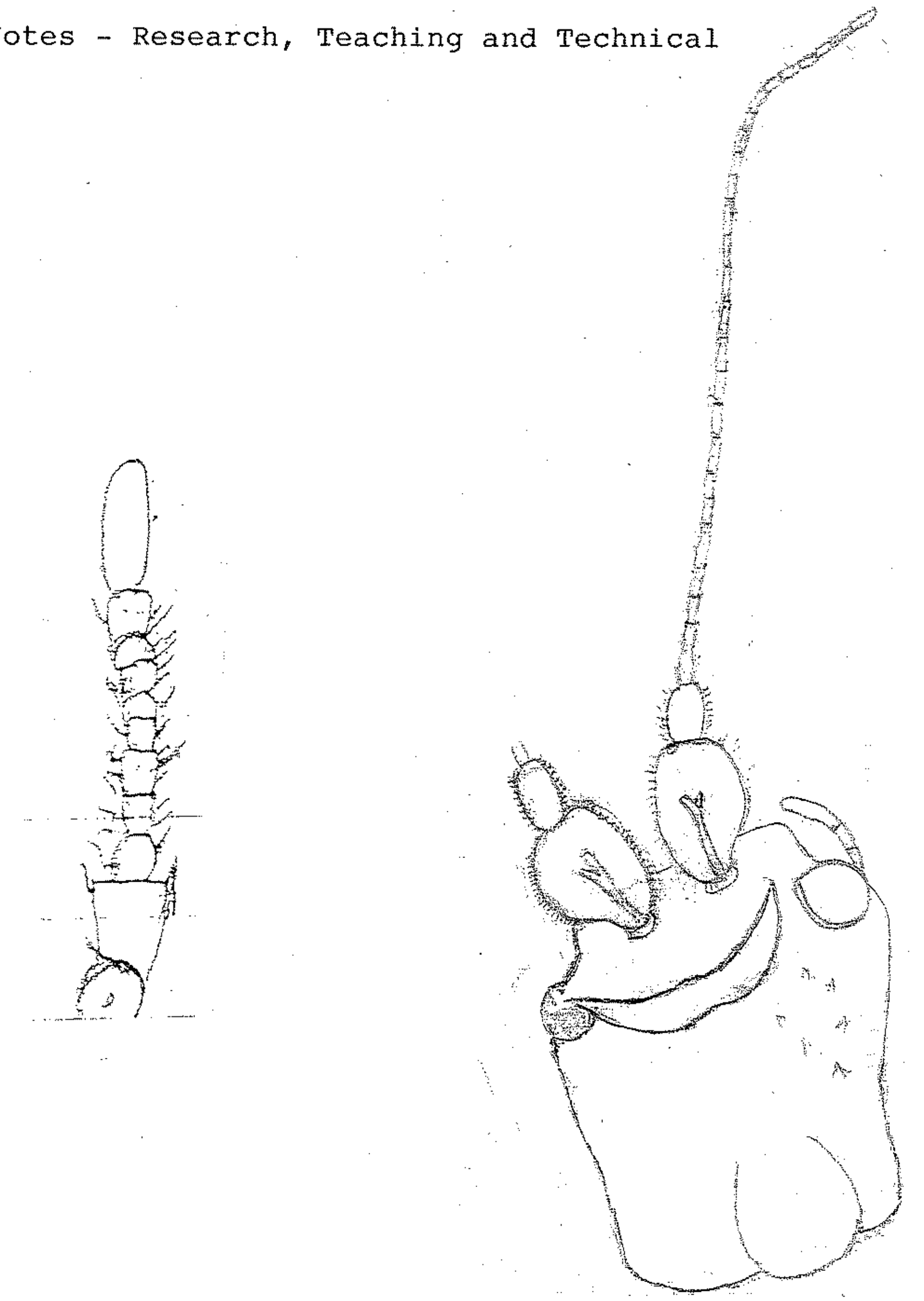


Figure 2.Left, dorsal view of an antenna in immature walking sticks. Here the antenna consists of 11 segments. The two basal segments are broad; segments 3-10 are smaller than the basal segments, the terminal segment is longer than the intermediate and basal ones.

Right, dorsal sketch of the head showing the right antenna in a mature walking stick. The basal segment is pear-shaped and large. The second is much smaller and oval. The remaining 25 or 26 segments are much smaller and elongated forming a whip-like structure. Other structures shown are the end of a maxillary palp, the eye, the horns spine-like structures.

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BEHAVIORAL PECULIARITIES OF WALKINGSTICKS

1. A young walking stick will bend its abdomen up and towards its head, apparently trying to scare the thing that has disturbed it, just as a scorpion bends its tail forward in self-defense.
2. The young walking sticks will also lift their forelegs for an additional way to scare away an undesirable predator.
3. The walking sticks of any age will sway their bodies from side to side if you blow air into their cage.
4. The first two instars are greyish, but the third and fourth instars develop a green exoskeleton. The fifth instar will also be green and it will have white spots surrounding the dorsal hairs. After the last molt the exoskeleton maintains a tan or light brown color. The moulted skeleton has a pink color.
5. At rest, all the instars place their forelegs extended forward and parallel to the head as if to protect the head, the eyes and the antennae
6. .When I remove the adult walking sticks from their cages and place them on the table while I remove their fecal pellets and /or harvest the eggs laid during the last 24 hours, they generally stay on the table without moving. When they move, they do so stealthily trying not to attract my attention. One of the walking sticks of this study, a male, managed to walk away while I was occupied with other matters and I was not able to find it again. After returning the female into its cage, she lived without a partner. It apparently had been inseminated, and continued to lay high numbers of eggs. (See next section for details and Tables I and II).

7. . When I put a drop of water between the bases of the antennae or put a drop or several drops of water on the table, they drank the droplet(s). It took about a minute or two pick up and swallow the water with their mouth parts until all the water disappeared into their mouths. It is not that they did not have water to drink, because I supplied enough water every day by saturating a piece of water absorbing paper, or by placing drops of water on the rose leaves (to mimic dew drops) or in a plastic cup. But when I take them out of their cages they seem to have learned that water is coming to them.

## TAXONOMIC POSITION OF THE PRESENT WALKING STICKS

Using the key provided by Borror, Triplehorn and Johnson (1992) the walking sticks I have raised, with 5 segments in their tarsi, belong to the family Heteronemiidae. Pending the identification by a taxonomist, I believe we are dealing with a member of the genus Diapheromera.

## REGENERATIVE ABILITY

In the first paper in this series of articles I mentioned that these insects can regenerate lost appendages as mentioned in the literature. I gave some examples of regeneration in my own starting colony and produced some illustrations.(Sokoloff, 2000) However, this ability apparently is not constant. As I indicated, one of the males in the egg producing experiment lost one of its front legs in the $4^{th}$ or $5^{th}$ instar and at the last molt it had not regenerated the missing leg.

In the juvenile progeny there is only one that has regenerated its leg, albeit imperfectly. However, in the period during which the two females were egg layers a total of more than 2000 eggs were collected (see next section of the paper). If time permits, I plan to study regenerative ability with this abundant material.

### Fecundity of females.

Between July 9 and November 3. 2002, I collected the eggs the two females had laid and recorded their number. During the collection of the eggs I never saw the walking sticks in copula. My daughter saw them copulating, The raw data for the daily collection of the eggs for nearly 4 months is given in Table 1. A total of 826 eggs were collected from female A who was in a cage with a male during her entire egg laying period. The total number of eggs laid by female B was 1079. It must be remembered that the male kept with the female from the beginning of her egg-laying period, escaped on September 9, so female B was left without a mate for the remaining egg-laying period, while the male in cage 1 remained with the female throughout the experiment.

The temperature dropped to the 60's and 70's in late October, and at night to the lower 60's and upper 50's. The collecting continued for seven days into November. During this period the female A did not lay any eggs. Female B laid an average of 4.5 eggs during this period.

Figure 2 illustrates the number of eggs plotted every five days. It can be seen that Female A (shown in red) was about a day late in starting its oviposition compared with B (shown in green) and the overall egg production was higher by the B female than the A female.

The figures obtained are comparable to those give by Bedford (1978) in his review of Phasmatodea he cites the observation of Favrelle (1938) that P. longiscaphus produced 236 eggs per female. N. sparaxes produced 60-287 eggs during a 19-120 day oviposition period (Gangrade, 1951). T. californica produced 60-80 eggs, while C. tessulatus produced 300-900 eggs over 5 months (Hadlington and Hoscke, 1959), P. bioculatum produced 85-100 eggs (Leigh, 1909). C. morosus an average of 739 eggs (Basden, 1955); and E. Goliath produced an average of 198 eggs (Bedford, !968) whereas

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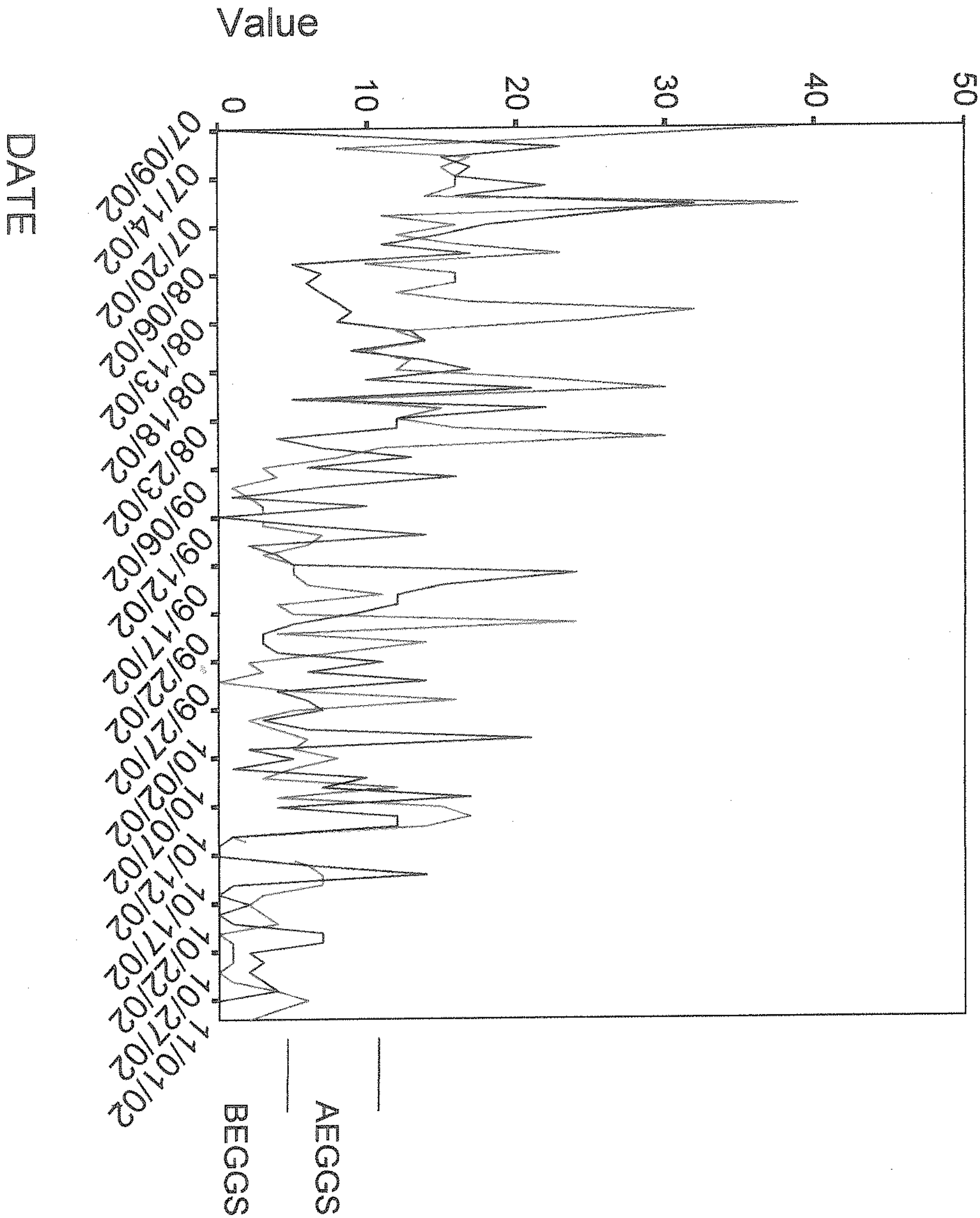
Walkingstick eggs laid by two females, July 9 to November 3, 2002

| Date | Female A | Female B |
|---|---|---|
| 7/9/00 | 0 | 39 |
| 10 | 12 | 24 |
| 11 | 23 | 8 |
| 12 | 17 | 17 |
| 13 | 16 | 15 |
| 14-15 | 31 | 32 |
| 16 | 16 | 14 |
| 17-18 | 32 | 39 |
| 19 | 25 | 11 |
| 20 | 18 | 16 |
| 21 | 15 | 12 |
| | | |
| 8/1-2 | 22 | 40 |
| 3 | 11 | 16 |
| 4 | 17 | 23 |
| 5 | 7 | 10 |
| 6 | 7 | 16 |
| 7-8 | 6 | 16 |
| 9-10 | 7 | 12 |
| 11 | 8 | 17 |
| 12 | 9 | 32 |
| 13 | 8 | 25 |
| 14 | 13 | 12 |
| 15 | 14 | 14 |
| 16 | 9 | 10 |
| 17 | 14 | 13 |
| 18 | 17 | 12 |
| 19 | 10 | 22 |
| 20 | 21 | 30 |
| 21 | 5 | 7 |
| 22 | 22 | 15 |
| 23 | 12 | 12 |
| 24 | 12 | 16 |
| 25 | 4 | 30 |
| | | |
| 8/26-9/3 | 68 | 85 |
| | | |
| 9/4 | 7 | 11 |
| 5 | 13 | 8 |
| 6 | 6 | 3 |
| 7 | 16 | 4 |
| 9/8-9 | 7 | 1 |
| 10 | 1 | 2 |
| 11 | 10 | 3 |
| 12 | 0 | 3 |
| | | |
| 13 | 6 | 7 |
| 14 | 14 | 6 |
| 15 | 2 | 3 |
| 16 | 4 | 5 |
| 17 | 5 | 6 |
| 18 | 8 | 5 |

| | | |
|---|---|---|
| 19 | 15 | 6 |
| 20 | 12 | 11 |
| 21 | 12 | 4 |
| 15 | 9 | 5 |
| 16 | 5 | 3 |
| 17 | 3 | 5 |
| 18 | 3 | 5 |
| 19 | 4 | 6 |
| 20 | 11 | 11 |
| 21 | 6 | 4 |
| 22 | 14 | 5 |
| 23 | 5 | 24 |
| 24 | 3 | 4 |
| 25 | 3 | 14 |
| 26 | 4 | 8 |
| 27 | 11 | 2 |
| 28 | 6 | 3 |
| 29 | 14 | 0 |
| 30 | 4 | 5 |
| 10/1 | 6 | 16 |
| 2 | 7 | 5 |
| 3 | 3 | 2 |
| 4 | 6 | 4 |
| 5 | 21 | 6 |
| 6 | 2 | 5 |
| 7 | 5 | 8 |
| 8 | 1 | 5 |
| 9 | 10 | 3 |
| 10 | 7 | 12 |
| 11 | 17 | 4 |
| 12 | 4 | 15 |
| 13 | 12 | 17 |
| 14 | 12 | 14 |
| 15 | 1 | 1 |
| 16 | - | - |
| 17 | - | - |
| 18 | 3 | 6 |
| 19 | 14 | 7 |
| 20 | 1 | 7 |
| 21 | 0 | 3 |
| 22 | 2 | 2 |
| 23 | 0 | 3 |
| 24 | 1 | 4 |
| 25 | 7 | 0 |
| 26 | 7 | 1 |
| 27 | 2 | 1 |
| 28 | 3 | 1 |
| 29 | 2 | 0 |
| 30 | 3 | 1 |
| 31 | 4 | 4 |
| 11/1 | 0 | 6 |
| 2 | 0 | 4 |
| 3 | 0 | 2 |

| | | |
|---|---|---|
| Total | 826 | 1079 |


Value
0
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DATE
07/09/02
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08/06/02
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08/18/02
08/23/02
09/06/02
09/12/02
09/17/02
09/22/02
09/27/02
10/02/02
10/07/02
10/12/02
10/17/02
10/22/02
10/27/02
11/01/02
AEGGS
BEGGS

APPENDIX.

This is an essay I wrote prior to writing the short paper that precedes this Appendix. It is actually the story of the walking stick that I refer to as WS-2 or walking stick number 2. I strongly believe that this walking stick and its tribulations; my acting like a nurse to it when it lost its legs from one side of its body my discovery after its death that this poor creature had been laying eggs before it died got me interested me in finding out whether the eggs were fertilized or not, all were factors in glancing at the vial that contained its eggs, with the the discovery that in the same vial there were first instar walking sticks some of which had died because of lack of water and others which were dying of thirst but moving actively within the vial. All this led me to learn more about walking sticks with the material that I had on hand.

Walking stick number 2 (WS-2) outlived number1 (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 movements. 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 of the leg: the femur extends from the trochanter to the joint between femur and tibia. A pair of spines protect the femoral-tibial joint. There are 3 dorsal 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 trsus 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 poximal 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 moult its exoskeleton once more and attempt to regenerate its legs, but it died without doing so.

While it was alive, I decided to collect the fecal pellets it produced to see if contained cysts of parasites. 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. Both oval and irregularly shaped fecular droppings ended up in a screw-cap vial.

Sokoloff, A.2002. Evolutionists, Alert!

In case Triboliumists are not aware of recent developments, I wish to draw your attention to an article in Scientific American, published in November, 2002, by Joachim Adis, Oliver Zompro, Esther Moombolah-Goagoses and Eugene Marais, Gladiators: A new order of insect. Pp. 60-65.

Zompro, a doctoral student at the Max Plant Institute, received some bits of amber which had captured some insect larvae. They looked completely different from any Zompro had seen before. On a visit to Judith A. Marshall, a curator at the Natural History Museum in London, Zompro was shown an insect found in Tanzania. It was the dried up exo-skeleton of an adult male, but no one could identify what it was. Later, Zompro received a fossilized adult male from amber in a private collection. He was struck at how much it resembled the exoskeleton he had seen in London. Zompro's adviser suggested he examine other collections. In the Berlin Natural History Museum he found a female insect preserved in alcohol that looked like the bug in amber. Further examination led to the conclusion that it was a new insect, closely related to preying mantis and walking sticks. After other comparisons with present day insects, they concluded that it was unlike any existing insect, and they called it Mantophasmatodea because it looks like a hybrid between a preying mantis and a walking stick. The common name of these insects is gladiator.

For other details see the article and these other references:

Klaus-Dieter Klass, Oliver Zompro, Niels P. Kristensen and Joachim Adis. Mantophasmatodea: A new insect order with extant members in the Afrotropics. Science 236:1456-1459.

Zompro, O., J. Adis and W. Weitschat. A review of the order Mantophasmatodea (Insecta) Zoologischer Anzeiger 241 (in press).

Zompro maintains a Web site on the new order at www.mantophasmatodea

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## RESEARCH HIGHLIGHTS AND TECHNOLOGY TRANSFER FOR 2001-2002

**Male and Female Red Flour Beetles Respond Differently to Pheromone Traps.** The red flour beetle is a major pest of food processing facilities and warehouses, but the pheromone lure used for the monitoring of this insect is widely perceived as not very effective. We are investigating how red flour beetle adults behave around pheromone traps by asking: over what range are insects attracted, what is the probability of capture, and how is insect response to traps influenced by the use of different combinations of attractant (pheromone, food oil, or pheromone + food oil combinations)? Results to date indicate that females are more likely to be captured in traps with the pheromone and food oil combination, but males are more likely to be captured in traps with pheromone alone. However, even when looking at only the best attractant for a given sex, only 25% of individuals released 25 cm from the trap were captured. Further experiments will be performed to determine how mating status, starvation level, and air movement influence responsiveness to the traps. With this information we will be better able to implement and interpret monitoring programs.
(Jim Campbell, 785-776-2717, email: campbell@gmprc.ksu.edu)

**Update on the Area-Wide Integrated Pest Management (IPM) Project.** For the past 4 years, an area-wide IPM project for stored grain was developed and tested in 20 grain elevators in Kansas and Oklahoma. During this study, we have taken thousands of grain samples in concrete elevator silos. We found that there is little correlation between the need to fumigate because of the presence of large numbers of insects and whether or not the grain is actually fumigated. Fumigations tended to be based on past experience or were calendar-based. True integrated pest management requires insect sampling, risk benefit analysis and, often, the use of multiple control tactics. In the study, moving grain samples, probe trap, and vacuum probe samples were compared. We found that the best sampling method for estimating insect density without moving the grain was the vacuum sampler. In new grain, insect densities were highest in the top half of the grain mass and decreased with depth. Sampling the top 12 meters instead of the entire 30 meters greatly reduced sampling time.
(Paul Flinn, telephone: 785-776-2707, email: flinn@gmprc.ksu.edu)

**Wheat Germ Agglutinin May Be Potent Synergist for Biopesticides.** The protein called agglutinin that is found in low concentrations in wheat germ can bind to carbohydrate structures and is toxic when fed to insects. This protein apparently causes destabilization of the lining of the insect's midgut when it binds to the carbohydrate called chitin that is a vital component of the digestive membrane. We are investigating use of wheat germ agglutinin as a synergist that can be combined with other potential insecticides, such as compounds that inhibit the digestive enzymes in insects, to increase their overall potency. This work is in its very early stages and various combinations of proteins are being tested to identify the most effective cocktails for controlling stored-product insect pests in grains.
(Karl Kramer, telephone: 785-776-2711, email: kramer@gmprc.ksu.edu)

**Outside Populations May Be an Important Source of Infestation for Food Processing and Storage Facilities.** The distribution and movement patterns of warehouse beetle and Indianmeal moth outside of food processing and storage facilities were investigated. Both species were present in high numbers around food processing plants in Kansas. Monitoring pest populations inside and outside of facilities during a fumigation indicated that even if populations inside the facility were suppressed, the trap capture immediately outside the facility remained high. Mark-recapture studies outside showed that warehouse beetle flew up to 508 m and Indianmeal moth flew up to 276 m before capture. Mark-recapture studies were also performed to measure movement into and out of the facility. These findings indicate that insects marked outside the facility can be recaptured inside. These results suggest that insect movement from outside of food processing and storage facilities can have a significant impact on infestation and population resurgence after treatment. This research was done in collaboration with Mike Mullen (GMPRC) and Terry Arbogast (USDA, ARS, Gainesville, FL).
(Jim Campbell, telephone: 785-776-2717, email: campbell@gmprc.ksu.edu)

**New Insecticide to Control Stored-Grain Pests.** The insecticide, ethiprole, is part of a new class of insecticides with low mammalian toxicity that have very specific effects on insects. Tests were conducted in which ethiprole alone and in combination with other insecticides was evaluated as a residual protectant of stored corn and wheat. All treatments involving ethiprole successfully suppressed the development of insect progeny of the major internal and external feeders of both commodities for 6 months, regardless of the temperature at which the treated commodities were stored. Data from this project will be useful for predicting the residual efficacy of ethiprole on stored grain and will provide support for registration.
(Frank Arthur, telephone: 785-776-2783, email: arthur@gmprc.ksu.edu)

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

Sokoloff, A. Biology Department , California State University, San Bernardino, CA 92407.
*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 one more year.

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Sokoloff, A. and Lerner, I.M. 1967. Laboratory ecology and mutual predation of Tribolium species.AmerNat.101:261-276.

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.

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# 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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| | |
|---|---|
| Tautz, Diethard (Professor) | Evolution and development; Segmentation in Drosophila, Tribolium and zebrafisch. |
| Schroeder, Reinhard (Postdoc) | Head- and terminal gap genes; antibodies, antisense, CALI technique. |
| Wolff, Christian (Postdoc) | Function of Tribolium upstream elements in Drosophila. |
| Klingler, Martin (Res. Associate) | Embryonic lethal mutations in Tribolium affecting segmentation, appendage formation; transposon-mediated transformation; evolution of enhancer elements. |
| Berghammer, Andreas (Ph.D. stud.) | Transformation of Tribolium |
| Bucher, Gregor (Ph.D. student) | Tribolium gap-gene mutants |
| Maderspacher, Florian (Ph.D. st.) | Triblium pair-rule mutants |

Martin Klingler

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The University of Newcastle upon Tyne, School of Agriculture

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1. Name: **Abdul Rahman Dhuyo**

Degree held: M.Sc. (Agri. Entomology)

Field of work: Biological control of *Prostephnus* and *Tribolium* species.

2. Name: **Abdur Rauf**

Degree held: M.Sc. (Agri. Entomology)

Field of work: Enzymatic mechanism of resistance to insecticides in *Tribolium* and *Sitophilus* species.

3. Name: **Fazalullah.M Bughio**

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