TRIBOLIUM INFORMATION BULLETIN

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California State College, San Bernardino

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Number 15

March, 1972

Foreword

This issue of Tribolium Bulletin reflects the fact that this newsletter is serving a real need to investigators dealing with flour beetles and other coleoptera. Despite the fact that it can be obtained only on a subscription basis, some 20 research notes are being included in this issue. In view of the scarcity of research funds in most institutions, this also suggests that Triboliumists are managing to obtain funds for their research or are succeeding in doing research in spite of the lack of funds.

It is noteworthy that in the last issue of Evolutionary Biology there are two consecutive articles dealing with ecological genetics. The first deals with Droso pheta species, and the second with Tribolium. Tribolium ecological genetics is coming of age! The Clarendon Press, Oxford, has also published the first volume of an extended monograph by the editor. The Biology of Tribolium, which should provide further stimulus to research on flour beetles.

This issue of TIB has been made possible by the conscientious efforts of Pat Cavataio and Diane Marks.

NOTICE

Tribolumists may be interested in two reviews which have appeared recently:

1. King, C. E. and Dawson, P. S. 1972. Population Biology and the Tribolium model. In Dobzhansky, Th., Hecht, M. K. and Steere, W. C., Eds. Evolutionary Biology 5:133-227.

2. Sokoloff, A. 1972. The Biology of Tribolium with special emphasis on genetic aspects. Oxford University Press.

Stock Lists

BALTIMORE, MARYLAND
THE JOHN HOPKINS UNIVERSITY, DEPARTMENT OF CHEMISTRY

Known to have the following stocks:

I. Wild type strains

Cathocerus cornutus pearl
Latheticus oryzae +/+
Tribolium anaphe +/+ (Ho)
Tribolium brevicornis +/+
Tribolium destructor +/+
Tribolium madens +/+
Tenebrio molitor +/+

II. Mutant

Tribolium confusum melanotic stink glands (*msg*)

(Ed.)

BERKELEY, CALIFORNIA
UNIVERSITY OF CALIFORNIA, LAWRENCE RADIATION LABORATORY

I. Wild type strains

Tribolium confusum	U. of Calif., Berkeley
Tribolium brevicornis	U. of Calif., Berkeley

II. Mutant

Tribolium confusum - isolated from the wild type stock

(Ed.)

BRIDGEPORT, CONNECTICUT
UNIVERSITY OF BRIDGEPORT, DEPARTMENT OF BIOLOGY

Tribolium confusum

Wild type strains derived from Dr. Fraenkel's laboratory at the University of Illinois.

(Ed.)

BURLINGTON, NORTH CAROLINA
CAROLINA BIOLOGICAL SUPPLY COMPANY

Tribolium castaneum

1. black	Chicago
2. jet	
3. pearl	
4. wild	McGill

Tribolium confusum

1. wild	Carolina

(Ed.)

Stock Lists

CARBONDALE, ILLINOIS
SOUTHERN ILLINOIS UNIVERSITY, DEPARTMENT OF ZOOLOGY

I. Base populations

1. Purdue + foundation
2. Purdue s foundation (sooty)
3. Purdue b foundation (black)

II. Mutant

1. paddle (pd)
2. spotted (sp)
3. ring, spotted (rg sp)
4. pygmy, red, paddle (py r pd)
5. pygmy (py)
6. red (r)
7. pygmy, red (py r)
8. pygmy, paddle, spotted (py pd sp)
9. pearl (p)
10. pearl, pegleg (p pg)
11. white (w)
12. microcephalic, jet, maroon (mc j m)
13. ruby, light ocular diaphragm (rb lod)
14. Short antenna (Sa)
15. chestnut (c)
16. Short antenna, squint (Sa c)
17. antennapedia (ap)
18. squint (sq)

III. Selected populations

Black: a population subjected to twelve generations of natural selection in very dense larval conditions. Origin from Purdue Black Foundation. Four sublines present.

Early: a population subjected to selection for a short larval period. Origin in Purdue Wild Foundation.

High Chaetae: a population subjected to nine generations of selection for increased pregenital chaetae number. Origin from Purdue Black Foundation.

Late: a population subjected to selection for a long larval period. Origin in Purdue Wild Foundation.

Low Chaetae: a population subjected to nine generations of selection for decreased pregenital chaetae number. Origin from Purdue Black Foundation.

Pearl: a population subjected to twelve generations of natural selection in very dense larval conditions. Origin from Purdue Black Foundation. Five sublines present.

Purdue: a population subjected to twelve generations of natural selection in very dense larval conditions. Origin from Purdue Wild Foundation. Five sublines present.

D. C. Englert

CARLISLE, PENNSYLVANIA
DICKINSON COLLEGE, DEPARTMENT OF BIOLOGY

Tribolium confusum

I. Wild type strains

1. Six strains started from females caputred in a feed bin in New York City, 1955.

2. Three strains, one each from T. Park, Chicago; J. Stanley, Montreal; S. Smith, Sault Ste. Marie, Canada.

3. One strain consisting of several above strains mixed together about three years ago.

4. One strain started with individuals taken from (1) above, which has been freed of eye mutations.

NOTE: Some of the wild strains listed in (1) and (2) are known to be carrying pearl-like mutations.

II. Mutant

1. Black--Sault Ste. Marie (1956)
2. Ebony--Chicago (1957)
3. Eyespot--sex-linked--from a wild strain in (I.1) above (1959)
4. Rough--from strain (II.1) above (1957)
5. Split--from a wild strain in (I.1) above (1956)
6. Striped--sex-linked--from (II.1) above (1957)
7. One strain each of Striped/black and split/black

Oryzaephilus surinamensis

One strain started from insects captured in New York City, 1955.

(Ed.)

CHARLOTTESVILLE, VIRGINIA
UNIVERSITY OF VIRGINIA, DEPARTMENT OF BIOLOGY

Tribolium castaneum

A. Wild type strains

1. Chicago	University of Chicago
2. McGill	Carolina Biological
3. Purdue University Foundation	via Stony Brook
4. Synthetic +/+	San Bernardino

B. Mutant strains

1. McGill black	University of Chicago via Stony Brook

CHICAGO, ILLINOIS
UNIVERSITY OF CHICAGO, DEPARTMENT OF ZOOLOGY

Tribolium castaneum

"Chicago"--a wild type strain.
"paddle"--a sex-linked recessive antennal mutant.
"pearl"--an autosomal recessive eye mutant.
"Chicago black"--an autosomal semi-dominant body color mutant.

Tribolium confusum

"Chicago"--a wild type strain.
"ebony"--an autosomal recessive body color mutant.

Latheticus oryzae

"Chicago"--a wild type strain.
"pearl"--an autosomal recessive eye mutant.

(Known to have a number of inbred strains)

(Ed.)

COLLEGE PARK, MARYLAND
UNIVERSITY OF MARYLAND, DEPARTMENT OF ZOOLOGY

I. Wild type strains.

A. Tribolium castaneum

1. Chicago (via Sokoloff)	Berkeley, 1964
2. University del Valle-1	Cali, Colomiba, 1964
3. University of Maryland-2*	

*Formerly listed as Tribolium confusum in March, 1966, Tribolium Information Bulletin-9 and earlier issues. Whether the error occurred through original misidentification or an originally mixed species culture is not known.

Inbred strains.

4. E 2 (originally from Edinburgh, via Boylan)	Manitoba, 1964

B. Tribolium confusum

1. So. Illinois University-1 — Carbondale, Illinois, 1962

Inbred strains

2. CFI-11 — Berkeley, California, 1965

II. Mutant

1. T. confusum — Berkeley, California, 1959
2. Ebony ($e^{L\&H}$)

(Ed.)

CORAL GABLES, FLORIDA
UNIVERSITY OF MIAMI, DEPARTMENT OF BIOLOGY

I. Wild type strains

1. Tribolium confusum — Chicago
2. Tribolium castaneum — Chicago

II. Mutant

1. Tribolium castaneum - "jet" — Chicago
2. Tribolium castaneum - pearl type, origin in local stocks
3. Tribolium castaneum - jet x pearl
4. Tribolium confusum - "ebony"

(Ed.)

CORVALLIS, OREGON
OREGON STATE UNIVERSITY, DEPARTMENT OF ZOOLOGY

I. Wild type strains

A. Tribolium castaneum

1. Berkeley — Berkeley, 1966
2. Chicago — Urbana, 1966
3. del Valle — Maryland, 1966
4. Oregon — Urbana, 1967
5. Vivarium — Urbana, 1967

B. Tribolium confusum

1.	Berkeley	Berkeley, 1966
2.	Chicago	Urbana, 1966
3.	Kansas	Kansas, 1966
4.	Oklahoma	Urbana, 1966
5.	Oregon	Urbana, 1967

II. Mutant Strains

A. Tribolium castaneum

1.	sa-2 (+/s)	Berkeley, 1966
2.	dve, pd	Berkeley, 1967
3.	fas-3a	Berkeley, 1967
4.	b, mc, p	Berkeley, 1966
5.	bal, c (+/s)	Berkeley, 1966
6.	pd	Urbana, 1966
7.	Be	Berkeley, 1966
8.	mc	Berkeley, 1967
9.	aa (+/p)	Berkeley, 1967
10.	ctp, ju	Berkeley, 1966
11.	Mo	Berkeley, 1966
12.	b^D	Berkeley, 1966
13.	ap^D, s	Berkeley, 1966
14.	j	Berkeley, 1966
15.	p, s, ap^D	Berkeley, 1966
16.	Fta, c	Berkeley, 1966
17.	ser, py, r	Berkeley, 1967
18.	Spa (+/c)	Berkeley, 1966
19.	r^D, s	Berkeley, 1967
20.	sq	Berkeley, 1967
21.	h	Urbana, 1967
22.	sh^s	Berkeley, 1967
23.	p, lod	Berkeley, 1967
24.	Sa-2, s	Berkeley, 1967
25.	r^u	Urbana, 1968

B. Tribolium confusum

1.	sh, b	Berkeley, 1966
2.	msg^{AS}	Berkeley, 1967
3.	we	Berkeley, 1966
4.	dj, p, lod	Berkeley, 1966
5.	thu^s, e	Berkeley, 1966
6.	dj	Berkeley, 1966
7.	e	Urbana, 1966
8.	thu	Berkeley, 1966
9.	p	Berkeley, 1966
10.	p, lod	Berkeley, 1966
11.	b^u	Urbana, 1967
12.	thu^u	Berkeley, 1966
13.	ble^u	Urbana, 1967
14.	r^u	Urbana, 1968
15.	dep	Urbana, 1969
16.	sh^c	Corvallis, 1970

P. S. Dawson

DAVIS, CALIFORNIA
UNIVERSITY OF CALIFORNIA, DEPARTMENT OF ANIMAL HUSBANDRY

I. Wild type strains (T. castaneum)

BC1	T. castaneum	Berkeley, 1967
DCI	T. castaneum	Davis, 1969

II. Mutant strains

BC2	T. castaneum, sooty	Berkeley, 1967
BC114	T. castaneum, sooty, inbred from strain 14a	Berkeley, 1967
SCp	T. castaneum, pearl eye	San Bernardino, 1969

III. Selected strains (all derived from BC1)

6-14 BC1-2, lines 1-8, 10, selected for large 21-day pupa for 23-36 generations.
15 BC1-2, line 9 selected for 48 generations; average 21-day pupa weight 6-10 mg.
16-18 BC1-2L, lines 1-3, selected for small 21-day pupa for 30 generations.

IV. Wild type strains (T. confusum)

BF1	T. confusum	Berkeley, 1967
DF1	T. confusum	Davis, 1967
DF3	T. confusum	Davis, 1969

V. Mutant strains

SFp	(pearl eyes)	San Bernardino, 1969

G. A. E. Gall

EAST LANSING, MICHIGAN
MICHIGAN STATE UNIVERSITY, BIOLOGY RESEARCH CENTER

Tribolium castaneum

I. Wild type strain

1. McGill — Chicago via Berkeley, 1964

II. Mutant strains

1. paddle — Chicago via Berkeley,
2. spotted — Berkeley,

(Ed.)

EAST LANSING MICHIGAN
MICHIGAN STATE UNIVERSITY, DEPARTMENT OF ZOOLOGY

Tribolium confusum

I. Wild type strain

1. Chicago wild, Chi +/+ — Berkeley, 1964

II. Mutant strains

1. ruby eyespot (rus) — Berkeley, 1964
2. melanotic stink glands (msg^{Ho}) — Berkeley, 1964
3. light ocular diaphragm, pearl (lod p) — Berkeley, 1964
4. black, melanotic stink glands, ruby eyespot (b msg rus) — Berkeley, 1964
5. black, ruby eyespot (b rus) — Berkeley, 1964
6. McGill black, light ocular diaphragm, pearl (McGill b lod p) — Berkeley, 1964

Tribolium castaneum

Wild type strain
black strain

(Ed.)

HAMPTON, IOWA
FARMERS HYBRID COMPANY

I. Wild type strain

1. Chicago — via Berkeley, 1965

II. Mutant strains

1. r py
2. j mc
3. Be/+

(Ed.)

HUMACAO, PUERTO RICO
UNIVERSITY OF PUERTO RICO, COLLEGE OF HUMACAO
DEPARTMENT OF BIOLOGY

Tribolium castaneum

I. Wild type strain

1. Chicago

II. Mutant strains

1. paddle
2. pearl
3. Microcephalic
4. Bar eye, sooty
5. Short antennae (Sa-2)

(Ed.)

HUNTSVILLE, TEXAS
SAM HOUSTON STATE UNIVERSITY
DEPARTMENT OF BIOLOGY

Tribolium castaneum

I. Wild type strain
Purdue + Foundation

II. Mutant strains

1.	light ocular diaphragm, lod^D	Carbondale, Illinois, 1961
2.	maroon, m	Purdue + Foundation
3.	peach, r^{ph}	Carbondale, Illinois, 1961
4.	pink, p^{pk}	Chazy, New York
5.	pink, ivory, p^{pk}, i	Chazy, New York & Purdue + Foundation
6.	ruby, rb	
7.	ruby, jet, microcephalic, rb j mc	
8.	ruby, jet rb j	
9.	ruby, maroon, rb m	
10.	ruby, peach, rb p^{ph}	

A. A. Dewees

IMMACULATA, PENNSYLVANIA
IMMACULATA COLLEGE, CANCER RESEARCH UNIT

I. Wild type strains

1.	Alphitobius diaperinus	PIL
2.	Alphitobius laevigatus	PIL
3.	Gnathocerus cornutus	PIL
4.	Gnathocerus maxillosus	PIL
5.	Latheticus oryzae	Berkeley
6.	Tenebrio molitor	PIL
7.	Tenebrio obscurus	PIL
8.	Tribolium anaphae	Berkeley
9.	Tribolium brevicornis	Berkeley
10.	Tribolium castaneum	Berkeley
11.	Tribolium confusum	Berkeley
12.	Tribolium destructor	Berkeley
13.	Tribolium madens	Berkeley

II. Mutant Strain

1. Tribolium confusum melanotic stink glands (msg)

Note: The insect strains formerly maintained by one of us (S.K.L.) at the John Hopkins University, Chemistry Department, in Baltimore, Md., have been transferred to Immaculata College.

(Ed.)

IRVINE, CALIFORNIA
UNIVERSITY OF CALIFORNIA, DEPARTMENT OF ORGANISMIC BIOLOGY

Tenebrio molitor

(Ed.)

ITHACA, NEW YORK
CORNELL UNIVERSITY, DEPARTMENT OF ANIMAL SCIENCE

Tribolium castaneum

The Purdue Foundation wild type obtained form the Population Genetics Institute in April, 1965.

(Ed.)

ITHACA, NEW YORK
CORNELL UNIVERSITY, DEPARTMENT OF ENTOMOLOGY AND LIMNOLOGY

I. Wild type strains

1. Tribolium confusum from Dr. H. Ducoff, University of Illinois.
2. Tribolium confusum infected with Nosema whitei.

(Dr. L. V. Knutson, same department, is said to have a wild type strain of T. confusum. Whether this strain is the same as that listed above is not known. Ed.)

JAMAICA, NEW YORK
ST. JOHN'S UNIVERSITY, DEPARTMENT OF BIOLOGY

Tenebrio molitor

(Ed.)

KENT, OHIO
KENT STATE UNIVERSITY, DEPARTMENT OF BIOLOGICAL SCIENCES

I. Wild type strains

A. Tribolium castaneum

Synthetic strain combined from Chicago wild type derived from Dr. Thomas Park and a strain obtained from Dr. Karl Schurr, Department of Biology, Bowling Green State University, Bowling Green, Ohio.

B. Tribolium confusum

Derived from stock maintained by Dr. L. V. Knutson, Department of Entomology, Cornell University, Ithaca, New York.

C. Oryzaephilus surinamensis--from infested flour.

(Ed.)

LAFAYETTE, INDIANA
PURDUE UNIVERSITY, POPULATION GENETICS INSTITUTE

Tribolium castaneum

I. Wild Type strains

A. Base populations for quantitative genetics studies:

1. Foundation + - wild type population formed from a broad genetic base and maintained with no artificial selection and minimum of inbreeding.

2. Foundation s - same genetic base as Foundation + but marked with sooty (s).

3. Foundation b - marked with (b) and unrelated to Foundation +, broad genetic base, no selection, minimum inbreeding.

4. Foundation p - marked with pearl (p) and unrelated to Foundation + and b, broad genetic base, no selection, minimum inbreeding.

B. Laboratory stocks:

5.	Arkansas	Fayetteville, 1954
6.	Brazil	Vicosa, 1958
7.	Capetown	South Africa, 1958
8.	Chicago	University of Chicago, 1954
9.	Carbondale	Illinois, 1958
10.	Colombia	South America, 1958
11.	Florida	Gainesville, 1958
12.	Georgia	Tipton, 1954
13.	Japan	Kyoto, 1958
14.	McGill	Montreal, Canada, 1958
15.	Minnesota	Minneapolis, 1958
16.	Texas	College Station, 1954
17.	Virginia	Blacksburg, 1954
18.-30.	Inbred lines with 10-50 generations of full sibbing.	

II. Mutant strains

31.	antennapedia, ap	Purdue Sa Stock, 1962
32.	Bar eye, Be	Berkeley, 1962
33.	black, b^D	Carbondale, Illinois, 1964
34.	chestnut, c	Purdue + Foundation, 1961
35.	cordovan, b^{cd}	Purdue + Foundation, 1962
36.	corn oil sensitive, cos	Purdue + Foundation, 1966
37.	ivory, i	Purdue + Foundation, 1961
38.	jet, j^E	Purdue + Foundation, 1961
39.	light ocular diaphragm, lod^D	Carbondale, Illinois, 1964
40.	maroon m	Purdue + Foundation, 1962
41.	paddle, pd	Chicago, 1955
42.	peach, r^{ph}	Carbondale, Illinois, 1964
43.	pearl, p	Chicago, 1955
44.	pearl, p^M	Malta via Pest Infest. Lab., 1966
45.	pearl, p^S	Fla. Inbred. (Purdue), 1963
46.	pygmy, py	Chazy, New York, 1960
47.	red, r	Chazy, New York, 1960
48.	red, r^s	Purdue + Foundation, 1964
49.	ring, rg	Purdue + Foundation, 1961
50.	rose, rs	Purdue + Foundation,

51.	ruby, rb	Carbondale, Illinois, 1964
52.	Short antenna, Sa	Purdue + Foundation, 1960
53.	short antenna, sa_3	Purdue + Foundation, 1966
54.	sooty, s	Purdue + Foundation, 1956
55.	squint, sq	Chazy, New York, 1960
56.	wine, r^w	Purdue + Foundation, 1963

(Ed.)

LARMIE, WYOMING
UNIVERSITY OF WYOMING, DEPARTMENT OF ZOOLOGY AND PHYSIOLOGY

Tribolium castaneum

I. Mutant strains

1. Fta c
2. Be s
3. pd py pte
4. sp
5. Spa s eju
6. p b
7. p lod
8. ap sq

(Ed.)

LAURINGBURG, NORTH CAROLINA
ST. ANDREWS COLLEGE

Tribolium confusum

A wild stock that is infected with Nosema whitei.

(Ed.)

LEXINGTON, KENTUCKY
AGRICULTURAL EXPERIMENT STATION
UNIVERSITY OF KENTUCKY

Tribolium castaneum

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

LOS ANGELES, CALIFORNIA
UNIVERSITY OF CALIFORNIA MEDICAL CENTER
DEPARTMENT OF MEDICAL MICROBIOLOGY

I. Wild type strain

1. Tribolium confusum Chicago via Berkeley

(Ed.)

MANHATTAN, KANSAS
DEPARTMENT OF ENTOMOLOGY
KANSAS STATE UNIVERSITY

LEPIDOPTERA

Phycitidae

Cadra cautella (Walk.), almond moth, from USDA, Manhattan, Kansas, 1971.
Plodia interpunctella (Hbn.), Indian-meal moth, Kansas.

Gelechiidae

Sitotroga cerealella (Oliv.), Angoumois grain moth, Kansas, about 1970.

A. Sitotroga cerealella (Oliv.), Red-eyed Angoumois grain moth, from stock cultures, 1967.

COLEOPTERA

Anobiidae

Lasioderma serricorne (F.), Cigarette bettle, Kansas, 1966.
Stegobium paniceum (L.), Drugstore beetle, from USDA, Richmond, Virginia, 1971.

Bostrichidae

Rhyzopertha dominica (F.), Lesser grain borer, Kansas.

Bruchidae

Callosobruchus maculatus (F.), Cowpea weevil, Kansas, 1971.

Cucujidae

Cryptolestes ferrugineus (Steph.), Rusty grain beetle, Kansas.
Cryptolestes pusillus (Schon.), Flat grain beetle, Kansas.
Oryzaephilus surinamensis (L.), Saw-toothed grain beetle, Kansas.
Oryzaephilus mercator (Fauv.), Merchant grain beetle, from USDA, Savannah, Georgia, 1964.

Curculionidae

Sitophilus granarius (L.), Granary weevil, Kansas.
Sitophilus oryzae (L.), Rice weevil, Kansas, 1955.
Sitophilus zeamais Mots., Maize weevil, from Stuttgart, Arkansas, 1955.
Sitophilus zeamais Mots., Maize weevil, from Veracruz, Mexico, 1964.

Dermestidae

Megatoma piceus (Oliv.), Black carpet beetle, Kansas.
Trogoderma inclusum LeC., Larger cabinet beetle, from USDA, Manhattan, Kansas.
Trogoderma sternale Jayne, Manhattan, Kansas, 1971.
Trogoderma variabile Ballion, Kansas.

Ostomatidae

Tenebroides mauritanicus (L.), Cadelle, Kansas.

Ptinidae

Gibbium psylloides (Czemp.), Spider beetle, Chicago, Ill., 1966.

Silvanidae

Ahasverus advena (Waltl.), Foreign grain beetle, Manhattan, Kansas, 1969.

Tenebrionidae

Palorus ratzeburgi (Wissm.), Small-eyed flour beetle, Kansas, 1965.
Tenebrio molitor L., Yellow mealworm, Kansas.
Tenebrio obscurus F., Dark mealworm, Manhattan, Kansas, 1971.
Tribolium castaneum (Hbst.), Red flour beetle, Kansas.
Tribolium confusum J. du V., Confused flour beetle, Kansas.

R. B. Mills

MIDLAND, MICHIGAN
THE DOW CHEMICAL COMPANY, BIOPRODUCTS DEPARTMENT

Tribolium confusum

Wild strain maintained in laboratory more than 20 years.

(Ed.)

MOSCOW, IDAHO
UNIVERSITY OF IDAHO, DEPARTMENT OF ENTOMOLOGY

A. Tribolium castaneum - large and small selections, sooty marked, obtained from Berkeley last October.

B. Tribolium madens from the Boise Valley area, Idaho, started in November, 1967.

C. Tribolium confusum - probably of local origin, held under weekly subculturing for about three years.

D. Tribolium castaneum - of local origin, subcultured largely at weekly intervals for about five years, started from a very few individuals surviving neglect of cultures previously, somewhat sporadically, maintained for several years in the laboratory.

(Ed.)

MUNCIE, INDIANA
BALL STATE UNIVERSITY, DEPARTMENT OF PHYSIOLOGY AND HEALTH SCIENCE

Tribolium castaneum, large stock, from Purdue University.

Tribolium castaneum, foundation stock, from Purdue University.

NATICK, MASSACHUSETTS
U.S. ARMY NATICK LABORATORIES, PIONEERING RESEARCH DIVISION

I. Wild type strains

Anagasta kuhniella	USDA Lab., Georgia, 1969
Anthrenus flavipes	USDA Lab., Georgia, 1967
Attagenus megatoma	USDA Lab., Georgia, 1956
Cadre cautella	USDA Lab., Georgia, 1969
Dermestes maculatus	USDA Lab., Georgia, 1968
Lasioderma serricorne	USDA Lab., Georgia, 1968

Oryzaephilus surinamensis	USDA Lab., Georgia, 1968
Plodia interpunctella	USDA Lab., Georgia, 1964
Rhyzopertha dominica	USDA Lab., Georgia, 1969
Sitophilus oryzae	USDA Lab., Georgia, 1968
Sitotroga cerealella	USDA Lab., Georgia, 1969
Tenebroides mauritanicus	USDA Lab., Georgia, 1968
Tribolium castaneum	USDA Lab., Georgia, 1956
Tenebroides molitor	Univ. New Hampshire, Durham, 1965
Tineola bisselliella	Univ. New Hampshire, Durham, 1965
Trogoderma parabile	Natick, 1968

II. Mutant

Tribolium confusum - Ebony strain A. Sokoloff, 1968

J. J. Pratt, Jr.

NORMAN, OKLAHOMA
DEPARTMENT OF ZOOLOGY
UNIVERSITY OF OKLAHOMA

I. Coleoptera

A. Tribolium castaneum (Tenebrionidae)

1. Wild type, Chicago University of Chicago

B. Tribolium confusum (Tenebrionidae)

1. Wild type Chicago University of Chicago

(Ed.)

NORTHRIDGE, CALIFORNIA
SAN FERNANDO VALLEY STATE COLLEGE, DEPARTMENT OF BIOLOGY

Tenebrio molitor infested with gregarines.

(Ed.)

NOTRE DAME, INDIANA
UNIVERSITY OF NOTRE DAME, DEPARTMENT OF BIOLOGY

I. Wild type strains

1.	CFI-11	Berkeley, 1965
2.	CFI-22	Berkeley, 1965
3.	CFI-11 x CFI-22	Berkeley, 1965
*4.	ND-11	Park, Univ. of Chicago, 1954

*Since 1956, maintained at the Air Force Weapons Laboratory, Kirtland, A. F. B., New Mexico.

(Ed.)

PITTSBURGH, PENNSYLVANIA
DUQUESNE UNIVERSITY, DEPARTMENT OF BIOLOGICAL SCIENCES

I. Wild type strains

1. Tribolium confusum (Chicago) used as interned host for Hymenolepis diminuta. Via Sokoloff

(Ed.)

POCATELLO, IDAHO
IDAHO STATE UNIVERSITY, DEPARTMENT OF BIOLOGY

I. Wild type strains

Tribolium castaneum--Synthetic strain marked with sooty from Berkeley.

Tribolium confusum--Synthetic strain from Berkeley.

(Ed.)

RICHLAND, WASHINGTON
BATTELLE-NORTHWEST, BIOLOGY DEPARTMENT

I. Wild type strains

1. Tribolium confusum Duval (Chicago Standard) — Univ. of Chicago
2. Tribolium castaneum Herbst (Brazil cI) — Univ. of Chicago

II. Mutant strain

1. Tribolium castaneum Herbst (Sooty) — Univ. of Calif., Berkeley

(Ed.)

RIVERSIDE, CALIFORNIA
UNIVERSITY OF CALIFORNIA, DEPARTMENT OF ENTOMOLOGY

A. Cryptolestes turcicus — PIL via Berkeley
B. Gnathocerus cornutus — PIL via Berkeley
C. Tribolium anaphe — PIL via Berkeley
D. Tribolium destructor — PIL via Berkeley
E. Tribolium madens — PIL via Berkeley
F. Tribolium brevicornis — California

(Ed.)

SALT LAKE CITY, UTAH
UNIVERSITY OF UTAH, DEPARTMENT OF ZOOLOGY AND ENTOMOLOGY

I. Wild type strains

1. Tribolium confusum — Park, Chicago, 1962
2. Tribolium castaneum — J. Laurie, Utah, 1962
3. Tenebrio molitor — W. P. Larsen, via S. Muliak, Utah, 1961
4. Oryzaephilus sp. — wild, Utah, 1962

II. Mutant strain

1. melanotic stink glands

(Ed.)

SAN BERNARDINO, CALIFORNIA
CALIFORNIA STATE COLLEGE, NATURAL SCIENCES DIVISION

I. Wild type strains

A. Tribolium castaneum
1. Arkansas — Bell, 1970
2. Brazil — ex Park via Howard Erdman, 1963

3.	Capetown	Bell, 1970
4.	Chicago	Park, 1955
5.	Columbia	Bell, 1970
6.	Consejo	Spain, 1968
7.	Davis	Davis, Calif., 1961
8.	Georgia	Bell, 1970
9.	Florida	Bell, 1970
10.	Japan	Bell, 1970
11.	McGill	Stanely, 1958
12.	Sacramento	1961
13.	Texas	1958
14.	Veracruz, Mexico	1963
15.	Virginia	1958

B. Tribolium confusum

1.	Chicago	Park, 1955
2.	Davis	1961
3.	McGill	Stanley, 1958
4.	New York	1961
5.	Pennsylvania	McDonald, 1963
6.	Sacramento	1961
7.	San Bernardino	1968

C. Tribolium audax

1.	PIL	Slough, 1971

D. Tribolium anaphe

1.	PIL	Slough, 1963

E. Tribolium brevicornis

1.	Riverside	Calif., 1965

F. Tribolium destructor

1.	PIL	Slough, 1963

G. Tribolium madens

1.	PIL	Slough, 1963
2.	PIL	Slough, 1971

H. Latheticus oryzae

1.	Kansas	1970
2.	Savannah	Georgia, 1970
3.	Tifton	Georgia, 1970

I. Oryzaephilus surinamensis

1.	Synthetic from Cold Spring, Harbor, N.Y. and Oakland, Calif. populations.	1968
2.	San Bernardino	1968

J. Cryptolestes turcicus

1.	PIL	Slough, 1963

K. Stegobium paniceum — San Bernardino, 1969

L. Trogoderma inclusum — USDA Lab., Fresno, 1968

II. Synthetic strains

A. Tribolium castaneum

1. Berkeley. Synthetic strain from six different laboratory strains marked with sooty. Prepared in 1958.

2. Berkeley. Synthetic strain from seven laboratory strains not marked with body color genes. Prepared in 1964.

B. Tribolium confusum

1. Berkeley. Synthetic strain form six wild type laboratory strains not marked with body color genes. Prepared in 1958.

III. Inbred lines

A. Tribolium castaneum

1. Started 1971 from synthetic strain now in the 9th generation of brother-sister mating and not marked with sooty.

B. Tribolium confusum

1. Started October, 1958, from the Berkeley synthetic strain (now in 90-99 generation of brother-sister mating, not marked with body color genes).

a. CFI-1
b. CFI-2
c. CFI-5
d. CFI-8
e. CFI-11
f. CFI-12

2. Started in 1964 from the Berkeley synthetic strain, (now in 56-58 generation of brother-sister mating, not marked with body color genes.)

a. CFI-13
b. CFI-14
c. CFI-15
d. CFI-23
e. CFI-24

IV. Mutants

A. Tribolium castaneum

Chromosome I

1. paddle (pd) — Park, 1955
2. paddle-1 (pd-1) — Berkeley, 1965

3.	red (r)	Chazy, New York, 1959
4.	red (r^{flo})	Berkeley, 1962
5.	red (r^{D})	Berkeley, 1963
6.	pygmy (py)	Chazy, New York, 1959
7.	spotted (sp)	Chazy, New York, 1959
8.	divergent elytra (dve)	Chazy, New York, 1959
9.	truncated elytra (te)	Chazy, New York, 1959
10.	platinum eye (pte)	Berkeley, 1965
11.	pokey (pok) (as heterozygotes)	Berkeley, 1962
12.	red modifier (r^{Mr})	Berkeley, 1961
13.	serrate (ser)	Berkeley, 1963
14.	pte pd	
15.	py pd	
16.	sp pd	
17.	py r pd	
18.	py r	
19.	te r	
20.	sp r	
21.	r pd	
22.	py r^{Mr}	
23.	pte py pd	
24.	r te Mr	
25.	sp dve py pd	
26.	ser py r	
27.	te-1	

Chromosome II

28.	pearl (p)	Park, 1955
29.	pink (p^{Pk})	Chazy, New York, 1959
30.	pegleg (pg)	Chazy, New York, 1959
31.	p pg	

Chromosome III

32.	aureate (au)	Berkeley, 1965
33.	McGill black (mcGb)	Stanley, 1964
34.	Chicago black (Cb)	Park, 1955
35.	Synthetic (McGb/Cb)	Chazy, New York, 1958
36.	black (b^{S-1}) (Brazil background)	Berkeley, 1963
37.	black (b^{S}) (Chicago background)	Chazy, New York, 1960
38.	light ocular diaphragm (lod) (pearl background)	Dewees, 1971
39.	light ocular diaphragm (lod^{d})	Berkeley, 1964
40.	melanotic stink glands (msg)	Purdue, 1964
41.	scar (sc)	PIL, 1965
42.	tawny (b^{t})	

Chromosome IV

39.	cut prothorax (ctp)	Berkeley, 1962
40.	elongated juvenile urogomphi (eju)	Berkeley, 1965
41.	fused antennal segments-2 (fas-2)	Berkeley,
42.	incomplete mesosternum (ims)	Berkeley, 1962
43.	juvenile urogomphi (ju)	Berkeley, 1962
44.	reduced juvenile urogomphi (rju)	Berkeley, 1963
45.	Spatulate (Spa)	Berkeley, 1964
46.	deformed legs (dfl)	Chazy, New York, 1959
47.	sternites incomplete (sti)	Berkeley, 1963
48.	fas-2s	
49.	mahogany (my)	

Chromosome V

50.	jet (j)	Park, 1955
51.	microcephalic (mc)	Chazy, New York, 1959
52.	fused antennal segments-3 (fas-3) (=agg)	Berkeley, 1961
53.	fused antennal segments-3a (fas-3a)	Berkeley, 1963
54.	j spl mc	
55.	maroon (m)	Eddleman, 1970

Chromosome VI

56.	Microphthalmic (Mo)	Chazy, New York, 1959

Chromosome VII

57.	Short antenna (Sa)	
58.	Short antenna (Sa-1) (=Gn)	Berkeley, 1959
59.	Short antenna (Sa-2) (=Ds)	Berkeley, 1962
60.	Short antenna (Sa-3) (=Cua)	Chazy, New York, 1959
61.	short antenna (sa) (=ca)	1961
62.	chestnut (c) (ex Eddleman)	Berkeley, 1962
63.	blistered elytra (ble)	Berkeley, 1962
64.	short antenna (sa-2) (=vg)	Berkeley, 1962
65.	Fused tarsi and antennae (Fta)	
66.	Fta ble	
67.	sa c	
68.	Fta c	
69.	Sa c	
70.	Fta ca c	
71.	ble c	

Stock Lists

Chromosome VIII

72. antennapedia (*ap*^{D}) Berkeley, 1962
73. antennapedia (*ap*^{S}) (=*fas-6*) Berkeley, 1963
74. squint (*sq*) Chazy, 1959

Chromosome IX

75. missing abdominal sternites (*mas*) Berkeley, 1964
76. prothoraxless (*ptl*) Chazy, New York, 1959
77. prothoraxless-1 (*ptl-1*) Berkeley, 1965
78. partially pointed abdominal sternites (*ppas*) Berkeley, 1963

Chromosome X

79. abbreviated appendages (*aa*) Cold Spring Harbor, N. Y., 1961
80. abbreviated appendages-1 (*aa-1*) (=*cspl*) Chazy, New York, 1960

Multichromosomal

Note: The Roman numerals indicated the linkage groups involved. The symbol ? means the linkage group for that gene has not been established.

81. *py pd*; *p* I, II
82. *sp*; *p* I, II
83. *py*; *b* I, III
84. *py r*; *lod* I, III
85. *sp*; *j* I, V
86. *pd*; *Mo* I, VI
87. *sp*; *p*; *j* I, II, V
88. *p*; *lod* II, III
89. *p*; *b* II, III
90. *p*; *b*; *Mo* II, III, VI
91. *p*; *b*; *mc* II, III, V
92. *p*; *mc* II, V
93. *b*; *Mo* III, VI
94. *j*; *Mo* V, VI
95. *ju ctp c* IV, VII
96. *Mo*; *sa* VI, VII
97. *b* (*p*) *apt* III, (II),?
98. *mc apt* V, ?
99. *apt j* V, ?
100. *Mo* (*c*) *mas* VI, (VII), IX
101. (*p*) *b mas* (II), III ?
102. *p Bamp*/+ II, III ?
103. *Bamp*/+*ap*^{D} III ?, IX
104. *Bamp*/+ *ptl*^{Hoy} III ?, IX
105. *b max* III, ?

Stock Lists

106. j max V, ?
107. au Npp IV, ?
108. ap Npp VIII, ?
109. Be au IV
110. Fta ppas VII, ?
111. mc ppas V, IX
112. fas-3a ptl^{Hoy} III, IX
113. b ap^{s} III, VIII
114. au ctp IV
115. j ppas V, IX
116. pp^{k} V, IX
117. rb m ?; V

Unassigned (but possibly in II)

118.	creased abdominal sternites (cas)	Berkeley, 1963
119.	abnormal abdominal sternites (aas)	Berkeley, 1965
120.	akimbo (akb)	Berkeley, 1964
121.	alate prothorax (apt)	Berkeley, 1964
122.	antennae and tarsi fused (atf)	Berkeley, 1961
123.	ballooned (bal)	Berkeley, 1963
124.	banjo (bj)	Chazy, New York, 1960
125.	bead (bd)	Bell, 1967
126.	bent tibia (bt)	Berkeley, 1961
127.	Blunt abdominal and metathoracic projections (Bamp) (possibly in III)	Berkeley, 1965
128.	bowed femur (bf)	Berkeley, 1963
129.	bowleg	Bell, 1967
130.	bumpy (by)	Bell, 1966
131.	Charcoal (Chr)	Berkeley, 1966
132.	deflected epimera (dep)	Berkeley, 1964
133.	deformed femur (dff)	Berkeley, 1964
134.	deformed tibia (dft)	Berkeley, 1964
135.	dented	Bell, 1967
136.	diminutive appendages (dim)	Berkeley, 1966
137.	elbowed antennae-1 (elb-1)	Berkeley, 1964
138.	elongated elytra (ele)	Berkeley, 1964
139.	elytra and tarsi affected (eta)	Berkeley, 1963
140.	extra urogomphi (eu) (black)	Chazy, New York, 1960
141.	fused antennal segments-1 (fas-1)	Chazy, New York, 1959
142.	Fused antennal segments-4 (Fas-4)	Berkeley, 1963
143.	Fused antennal segments-5 (Fas-5)	Berkeley, 1963
144.	jagged antecoxal piece (jac)	Berkeley, 1964
145.	knobby prothorax (knp)	Berkeley, 1966
146.	lopped median groove (lmg)	Berkeley, 1964
147.	maxillopedia (max)	Berkeley, 1965
148.	minature appendages (ma^{D} r)	Bell, 1967
149.	Multi-urogomphi (Mu)	Bell, 1966
150.	Nonpunctate prothorax (Npp)	Berkeley, 1965
151.	padded prothorax (pdp)	Berkeley, 1965

Stock Lists

152.	pectinate antennae (pec)	Berkeley, 1964
153.	reduced gin traps (rgt)	Berkeley, 1965
154.	reduced pleurosternal suture (rps)	Berkeley, 1965
155.	reduced tarsi and antennae (rta)	Berkeley, 1966
156.	rough (ro)	Berkeley, 1964
157.	ruby (rby)	Berkeley, 1962
158.	rugose elytra (rue)	Berkeley, 1966
159.	scalloped prothorax (scp)	Berkeley, 1965
160.	short median abdominal projection (smp)	Berkeley, 1966
161.	short split spinasternum (sss)	Berkeley, 1965
162.	split (sp)	1963
163.	split-back (sb)	Bell, 1966
164.	stumpy (stu)	Berkeley, 1965
165.	Tetra urogomphi (Tu)	Berkeley, 1965
166.	tiny (ti) (=ty)	1962
167.	umbilicus (umb)	Berkeley, 1964

B. Tribolium confusum

Chromosome I

1.	Striped (St)	McDonald, 1961
2.	eyespot (es)	McDonald, 1961
3.	light eyespot (es^{lt})	Berkeley, 1963
4.	red (r)	Berkeley, 1962
5.	antennae and elytra reduced (aer)	Berkeley, 1962
6.	labiopedia (lp)	Berkeley, 1962
7.	pointed abdominal segments (pas)	Berkeley, 1963
8.	thickened elytral tips (tet)	Berkeley, 1963
9.	lethal-1 (l_1) (in heterozygotes)	Berkeley, 1962
10.	crumpled (cru)	Berkeley, 1964
11.	prothoraxless-like (ptll)	Berkeley, 1964
12.	St es	
13.	es lp	
14.	es lp (synthetic background)	
15.	es^{lt} lp	
16.	St es lp	
17.	alate prothorax (apt)	Berkeley, 1965

Chromosome II

18.	pearl (p)	PIL, via Stanley, 1960
19.	pearl (p^S)	Berkeley, 1962
20.	ebony-2 (e_2)	PIL, via Stanley, 1960
21.	creased abdominal sternites (cas)	Berkeley, 1963
22.	dirty pearl eye (dpe) (=fro)	Berkeley, 1963
23.	e_2p	PIL, via Stanley, 1960
24.	p cas	

Chromosome III

25.	Yugoslavian black (=b^z)	Yugoslavia, 1969

Stock Lists

26.	McGill black (McGb) (=b^{Ho})	Stanley, 1960
27.	black-3 (b-3)	Berkeley, 1964
28.	ruby spot (rus)	Chazy, New York, 1960
29.	melanotic stink glands (msg)	Berkeley, 1962
30.	rus msg	
31.	b rus	
32.	b msg	

Chromosome IV

33.	thumbed (thu)	Berkeley, 1963
34.	thumbed^{s} (thu^{s}) (=rspP. S. D.)	Berkeley, 1963

Chromosome V

35.	ebony (e)	Park, via Stanley, 1960
36.	ebony ($e^{L\&H}$)	Berkeley, 1959
37.	synthetic ($e/e^{L\&H}$)	Berkeley, 1961
38.	blistered elytra (ble)	Chazy, New York, 1960
39.	e ble	

Chromosome VI

40.	disjoined (dj)	Berkeley, 1963

Unassigned (but possibly in III)

41.	light ocular diaphragm (lod) (pearl)	Berkeley, 1961

Multichromosomal

42.	p; lod	
43.	p; rus	
44.	b; sp	
45.	rus; sp	
46.	rus; ble	
47.	b (;) lod; p	
48.	b twa	
49.	ems dt msg	
50.	jac dt b	
51.	McGill b p	
52.	bent femur (btf)	Berkeley, 1964
53.	bent tibia (btt)	Berkeley, 1962
54.	black-3 (b-3)	Berkeley, 1964
55.	crumpled elytra (cru)	Berkeley, 1964
56.	creased abdominal sternites (cas-1)	1963
57.	deflected epimera (dep)	Berkeley, 1964
58.	deformed legs (dfl)	Berkeley, 1965
59.	elongated elytra (ele)	Berkeley, 1963
60.	fused antennal segments-1 (fas-1)	Berkeley, 1962
61.	fused antennal segments-2 (fas-2)	Berkeley, 1963

62.	incomplete meso-metathoracic suture (ims)	Berkeley, 1965
63.	imcomplete metathoracic projections (imp)	Berkeley, 1964
64.	knobby prothorax (knp)	Berkeley, 1964
65.	legless (lgl)	Berkeley, 1966
66.	medial abdominal groove (mag)	Berkeley, 1964
67.	nude (nd)	Berkeley, 1964
68.	pockets (poc)	Berkeley, 1965
69.	prosternumless (psl)	Berkeley, 1966
70.	Reduced eye (Re)	Berkeley, 1965
71.	rough (ro) (black)	McDonald, 1960
72.	ruby (rby)	Berkeley, 1962
73.	scar (sc) (=engraved metasternum)	Berkeley, 1962
74.	separated epimera (sep)	Berkeley, 1964
75.	short elytra (sh)	Berkeley, 1961
76.	split (sp)	Berkeley, 1961
77.	sternites incomplete (sti)	Berkeley, 1963
78.	stilted legs (stl)	Berkeley, 1962
79.	stunted (stt)	Berkeley, 1966
80.	tiny (ty)	Berkeley, 1961
81.	twisted abdomen (twa)	Berkeley, 1965
82.	umbilicus (umb) (=dent)	Berkeley, 1962
83.	warped elytra (we)	Berkeley, 1962
84.	wingless (wgl)	Berkeley, 1965

C. Tribolium anaphe

None

D. Tribolium audax

None

E. Tribolium brevicornis

1. creased abdominal sternites (cas)
2. split (spl)
3. fused antennal segments (fas)

F. Tribolium destructor

None

G. Tribolium madens

1.	fused antennal segments-1 (fas-1)	Berkeley, 1964
2.	split (spl)	Berkeley, 1964
3.	bent tibia (btt)	Berkeley, 1964

H. Latheticus oryzae

None

I. Oryzaephilus surinamensis

None

J. Cryptolestes turcicus

Chromosome I

1. red (r) PIL, 1963

K. Stegobium paniceum

None

A. Sokoloff

SANTA FE, NEW MEXICO
SANTA FE PREPARATORY SCHOOL

I. Wild type strain
A. Tribolium castaneum — Chicago via Berkeley
B. Tribolium confusum — McGill via Berkeley

(Ed.)

SAVANNAH, GEORGIA
STORED PRODUCT INSECTS RESEARCH AND DEVELOPMENT LABORATORY

I. Wild type strains

A. Lepidoptera

1. Cadra cautella — USDA, Tifton, Ga., 1964
2. Ephestia elutella — Richmond, Virginia,
3. Plodia interpunctella
4. Sitotroga cerealla — Tifton, Georgia, 1962
5. Tineola bisselliella — Savannah, Georgia, 1962

B. Coleoptera

1. Anthrenus flavipes
2. Attagenus megatoma
3. Cryptolestes pusillus — Madison, Wisconsin, 1967
4. Dermestes maculatus
5. Lasioderma serricorne
6. Oryzaephilus mercator
7. Oryzaephilus surinamensis — Manhattan, Kansas, 1964
8. Rhyzopertha dominica
9. Sitophilus granarius — Manhattan, Kansas, 1966
10. Sitophilus oryzae
11. Sitophilus zea mais — Estill, S. C., 1961
12. Tenebriodes mauritanicus — Canada, 1960
13. Tenebrio molitor
14. Tribolium castaneum — Manhattan, Kansas, 1960
15. Tribolium confusum — Madison, Wisconsin, 1967
16. Trogoderma glabrum — Madison, Wisconsin, 1967
17. Trogoderma inclusum

II. Mutant strain

A. Tribolium confusum-black — Savannah, Georgia, 1967

(Ed.)

SOUTH LANCASTER, MASSACHUSETTS
ATLANTIC UNION COLLEGE, BIOLOGY DEPARTMENT

Tribolium castaneum

I. Wild type strains
1. Brazil (C-1)
2. Chicago
3. McGill
4. Sacramento
5. Texas
6. Veracruz, Mexico
7. Virginia

II. Mutant strains
1. red (r^D)
2. red (r)
3. red (r^{Ho})
4. red modifier (M^r)
5. McGill black ($McGb$)
6. Chicago black (Cb)
7. black (B^S-1), Brazil black
8. sooty (s)
9. jet (j)
10. chestnut (c^S)

(Ed.)

SOUTH ORANGE, NEW JERSEY
SETON HALL UNIVERSITY, DEPARTMENT OF BIOLOGY

I. Wild type strains

A. Laboratory strains
1. Tribolium castaneum - McGill — Montreal, Canada via University of California
2. Tribolium castaneum - Seton Hall — South Orange, New Jersey
3. Tribolium castaneum - inbred - 10 generations
4. Tribolium confusum — Fordham University

B. Base Populations for quantitative studies (Tribolium castaneum)
1. Foundation b - marked with black (b) body color - obtained via Purdue University, Lafayette, Indiana.
2. Foundation p - marked with pearl (p) eye color - obtained via Purdue University, Lafayette, Indiana.

II. Mutant Strains

A. Tribolium castaneum

1.	McGill black	via University of California
2.	paddle	via Calif. State College
3.	pearl	via University of California
4.	pygmy	via University of California
5.	red^{HO}	via Calif. State College
6.	Short antennael (Sa)	Purdue + Foundation, 1960
7.	white	via Calif. State College

R. F. Costantino

(Ed.)

STATE COLLEGE, MISSISSIPPI
USDA, ARS, BOLL WEEVIL RESEARCH LABORATORY

Anthonomus grandis

A. Wild type strains

1.	A & M	College Station, Texas
2.	Oktibbeha	State College, Miss.
3.	Thurberia	Tucson, Ariz.
4.	Iguala	Iguala, Mexico

B. Mutant strains

1.	yellow (y)	A & M strain
2.	slate (e)	Acala, Mexico
3.	ebony (e)	A & M strain
4.	pearl (p)	A & M strain

C. Insecticide resistant

1.	Endrin Resistant ca. 20 g/weevil	Auburn University

W. Ivey

(Ed.)

STONY BROOK, NEW YORK
STATE UNIVERSITY OF NEW YORK, DIVISION OF BIOLOGICAL SCIENCES

Tribolium castaneum

I. Wild type

1.	UPF Foundation	Purdue University
2.	CS-4	University of California

II. Mutants

1.	Sooty (s)	
2.	paddle (pd)	University of Chicago

3. pearl (p) — University of Chicago
4. McGill black (McGb) University of Chicago Stock — University of California
5. McGill black (McGb) with UPF genetic background obtained by backcrossing to UPF for nine generations. — University of Kansas

Tribolium confusum

I. Wild type
1. Chicago (Sonleitner) — University of Chicago
2. New York — University of Chicago

II. Mutants
1. McGill black (McGb) — University of California
2. ebony (e) — University of Chicago

Robert R. Sokal

ST. BERNARD, ALABAMA
ST. BERNARD ABBEY

I. Wild Type strains

A. Tribolium castaneum
1. Chicago — via San Bernardino

B. Tribolium confusum
1. New York — via San Bernardino

II. Mutant strains

A. Tribolium castaneum

1. McGill black — via San Bernardino
2. jet — via San Bernardino
3. Sooty — via San Bernardino
4. Chicago black — via San Bernardino

B. Tribolium confusum
1. pearl — via San Bernardino
2. McGill black — via San Bernardino
3. Ebony (Smith) — via San Bernardino

ST. PAUL, MINNESOTA
UNIVERSITY OF MINNESOTA, DEPARTMENT OF ENTOMOLOGY,
FISHERIES AND WILD LIFE

Tribolium confusum	St. Paul, Minn.,
Sitophilus oryzae (large strain)	Manhattan, Kansas, 1960
Sitophilus granarius	St. Paul, Minn.,
Oryzaephilus surinamensis	Savannah, 1963
Trogoderma parabile	St. Paul, Minn., 1965
Rhysopertha dominica	Manhattan, Kansas, 1963
Plodia interpunctella	St. Paul, Minn., 1963
Attagenus megatoma	Kansas, 1971

Ernesto De Las Casas

ST. PAUL, MINNESOTA
UNIVERSITY OF MINNESOTA

Tribolium castaneum

A. Inbreds
   1. CSI-5 — Univ. of Calif. Berkeley, 1963
   2. CSI-10 — Univ. of Calif. Berkeley, 1963

B. Segregating populations (marked with sooty)
   1. Random bred (no selection) since 1963 from a single cross.
   2. Random bred with selection for pupa weight.

(Ed.)

ST. PAUL, MINNESOTA
UNIERSITY OF MINNESOTA, DEPARTMENT OF ANIMAL SCIENCE

A. Inbreds
   1. CSI-10 — University of California, Berkeley
   2. E 1 — Institute of Animal Genetics, Edinburgh
   3. E 2 — Institute of Animal Genetics, Edinburgh

B. Purdue Foundation, p

C. Segregating population selected for pupa weight, synthesized by crossing CSI-10 and E 2 lines.

(Ed.)

SYCAMORE, ILLINOIS
DE KALB AGRICULTURAL ASSOCIATION, INC.

Dr. R. R. Shrode has moved to the University of Tennessee; fate of the Tribolium stocks is not know.

(Ed.)

TEMPE, ARIZONA
ARIZONA STATE UNIVERSITY, DEPARTMENT OF ZOOLOGY

I. Synthetic strains

A. Tribolium castaneum
1. Berkeley, 1964 — via San Bernardino

B. Tribolium confusum
1. Berkeley, 1958 — via San Bernardino

II. Mutant strains

A. Tribolium castaneum
1. melanotic stink glands (msg), Berkeley, 1964 — via San Bernardino

B. Tribolium confusum
1. melanotic stink glands (msg), Berkeley, 1962 — via San Bernardino

Harry E. Wistrand

TIFTON, GEORGIA
ABRAHAM BALDWIN AGRICULTURAL COLLEGE

Tribolium castaneum

A. Wild type strain
1. Chicago

B. Mutant strains
1. black
2. squint

(All derived from stocks maintained at Berkeley. Ed.)

URBANA, ILLINOIS
UNIVERSITY OF ILLINOIS, DEPARTMENT OF ZOOLOGY

I. Wild type strains

A. Tribolium castaneum
1. Berkeley — Berkeley, 1966
2. Chicago — Urbana, 1966
3. Carbondale — Maryland, 1966
4. del Valle — Maryland, 1966
5. Kansas — Kansas, 1966

B. Tribolium confusum
1. Berkeley — Berkeley, 1966

2.	Chicago	Urbana, 1966
3.	Kansas	Kansas, 1966
4.	Maryland	Maryland, 1966
5.	Minnesota	Minnesota, 1966
6.	Oklahoma	Urbana, 1966

II. Inbred lines

A. Tribolium castaneum

1.	CSI-2	Berkeley, 1966
2.	CSI-3	Berkeley, 1966
3.	CSI-5	Berkeley, 1966
4.	CSI-10	Berkeley, 1966
5.	CSI-12	Berkeley, 1966
6.	CSI-14	Berkeley, 1966
7.	CSI-15	Berkeley, 1966
8.	CSI-16	Berkeley, 1966
9.	CSI-22	Berkeley, 1966

B. Tribolium confusum

1.	CFI-1	Berkeley, 1966
2.	CFI-2	Berkeley, 1966
3.	CFI-3	Berkeley, 1966
4.	CFI-5	Berkeley, 1966
5.	CFI-7	Berkeley, 1966
6.	CFI-8	Berkeley, 1966
7.	CFI-11	Berkeley, 1966
8.	CFI-12	Berkeley, 1966
9.	CFI-13	Berkeley, 1966
10.	CFI-14	Berkeley, 1966
11.	CFI-15	Berkeley, 1966
12.	CFI-16	Berkeley, 1966
13.	CFI-18	Berkeley, 1966
14.	CFI-19	Berkeley, 1966
15.	CFI-20	Berkeley, 1966
16.	CFI-21	Berkeley, 1966
17.	CFI-22	Berkeley, 1966
18.	CFI-23	Berkeley, 1966
19.	CFI-24	Berkeley, 1966

III. Mutant strains

A. Tribolium castaneum

1.	sa-2 (+/s)	Berkeley, 1966
2.	i	Purdue, 1967
3.	w	Purdue, 1967
4.	b, mc, p	Berkeley, 1966
5.	bal, s	Berkeley, 1966
6.	pd	Urbana, 1966
7.	Be	Berkeley, 1966
8.	mc	Berkeley, 1967
9.	aa (+/p)	Berkeley, 1967

10.	r^{Ho}	Berkeley, 1966
11.	Mo	Berkeley, 1966
12.	b	Berkeley, 1966
13.	ap^{D}, s	Berkeley, 1966
14.	j	Berkeley, 1966
15.	r (+/py)	Berkeley, 1966
16.	Fta/+, c	Berkeley, 1966
17.	c	Berkeley, 1966
18.	Spa/+, +/c	Berkeley, 1966
19.	p	Berkeley, 1967
20.	sq	Berkeley, 1967
21.	msg	Berkeley, 1967
22.	sh^{s}	Berkeley, 1967
23.	p, lod	Berkeley, 1967
24.	Sa-2, s	Berkeley, 1967
25.	rg	Berkeley, 1967
26.	fas-3a	Berkeley, 1967
27.	r^{D}, s	Berkeley, 1967
28.	dve, pd	Berkeley, 1967
29.	h	Urbana, 1967
30.	rs	Purdue, 1967
31.	rb	Purdue, 1967
32.	j, m	Purdue, 1967
33.	ctp, ju	Berkeley, 1967

(Ed.)

URBANA, ILLINOIS
UNIVERSITY OF ILLINOIS, DEPARTMENT OF PHYSIOLOGY AND BIOLPHYSICS

Tribolium confusum

A.	Wild type	G. Fraendel, 1960
B.	McGill black	A. Sokoloff, 1966

Also available:

Nemeritis canescens (Ichneumon.)

From University of Cambridge Zoology Department. Carried on Anagasta kuehniella.

(Ed.)

WASHIGTON, D. C.
THE CATHOLIC UNIVERSITY OF AMERICA, DEPARTMENT OF BIOLOGY

R. H. Arnett moved to Purdue University; fate of Tribolium stocks at

the above institution is not known. (Ed.)

AUSTRALIA

BRISBANE, QUEENSLAND
DEPARTMENT OF PRIMARY INDUSTRIES, ENTOMOLOGY LABORATORY

COLEOPTERA

A. Tribolium castaneum
   1. Wild type strains
   2. Black mutant (reoccurrence of b)
   3. Lindane resistant

B. Sitophilus oryzae
   1. Wild type strains
   2. DDT resistant (single semi-dominant sex-linked factor)
   3. Lindane and dieldrin resistant (single and multi-factor strains.)
   4. Black strain

C. Sitophilus zeamais--wild type

D. Sitophilus granarius--wild type

E. Oryzaephilus surinamensis
   1. Wild type strains
   2. Lindane resistant strains (impure)

F. Lasioderma serricorne--wild type

G. Rhizopertha dominica--wild type

H. Mezium americanum--wild type

LEPIDOPTERA

A. Cadra cautella--wild type

B. Phthorimaea operculella
   1. DDT-endrin resistant
   2. Red-eyed mutant (single autosomal recessive)

HYMENOPTERA

A. Microchelomus sp.--wild type

(Ed.)

BELGIUM

GEMBLOUX
INSTITUT AGRONOMIQUE DE L'ETAT, ZOOLOGIE GENERALE

Tenebrio molitor

F strain--selected for small weight since 1950.
G strain--selected for large weight since 1950.

(Ed.)

LOUVAIN
F. A. JANSSENS MEMORIAL LABORATORY FOR GENETICS
AGRICULTURAL INSTITUTE OF THE UNIVERSITY

Tenebrio molitor

Wild type — Belgium

Tribolium confusum

Two inbred and a wild type — Berkeley, 1965

(Ed.)

BRAZIL

CAMPINAS, SÃO PAULO
INSTITUTE AGRONOMICO, SECAO DE ENTOMOLOGIA

Anobiidae

Lasioderma serricorne (F)--Campinas, SP--wild type.

Bostrichidae

Rhizopertha dominica (F)--Campinas, SP--wild type.

Bruchidae

Acanthoscelides obsoletus (Say)--Campinas, SP--wild type.

Curculionidae

Sitophilus oryzae (L.)--Campinas, SP--wild type

Silvanidae (Cucujidae)

Oryzaephilus surinamensis (L.)--Campinas, SP--wild type.

Tenebrionidae

Tribolium castaneum (Herbst.)--Campinas, SP--wild type.

(Ed.)

CANADA

BURNLEY, VICTORIA
VICTORIAN PLANT RESEARCH INSTITUTE, DEPARTMENT OF AGRICULTURE

COLEOPTERA

A. *Tribolium castaneum*
   1. Wild type strains
   2. Malathion specific resistant strain

B. *Tribolium confusum*

   1. Wild type strains
   2. Malathion specific strain

C. *Oryzaephilus surinamensis*
   1. Wild type strain
   2. Malathion resistant strain

D. *Gnathocerus cornutus* wild type strain

E. *Cryptolestes ferrugineus* wild type strain

F. *Sitophilus oryzae* wild type strain

G. *Sitophilus zeamais* wild type strain

H. *Sitophilus granarius* wild type strain

I. *Rhyzopertha dominica* wild type strain

LEPIDOPTERA

A. *Plodia interpunctella* wild type strain

EDMONTON, ALBERTA
UNIVERSITY OF ALBERTA, DEPARTMENT OF ANIMAL SCIENCE

A.	Brazil	Purdue, 1965
B.	Capetown	Purdue, 1965
C.	Chicago	Chicago, 1965
D.	Consejo	Madrid, 1965
E.	Japan	Kyoto and Purdue, 1965
F.	Kano	Scotland, 1965
G.	Kenya	Scotland, 1965
H.	Kingston	Scotland, 1965
I.	Lisbon	Portugal, 1965
J.	Purdue Foundation +	Manitoba, 1963
K.	Scotland	Edinburgh, 1965
L.	Seychelles	Scotland, 1965
M.	Surrey	England, 1965
N.	Veracruz	Berkeley, 1965

(Ed.)

GUELPH, ONTARIO
UNIVERSITY OF GUELPH, DEPARTMENT OF ANIMAL & POULTRY SCIENCE

Tribolium castaneum

A. 1. Purdue Foundation (+)

2. Purdue Foundation s

3. Purdue Foundation b

4. Purdue McNary Small

5. Purdue Burris I and II

B. Selected lines from Purdue Foundation (+) stock. 17 lines - comprised of a control and four degrees of inbreeding x high vs. low selection for pupa weight x 2 environments (wet and dry) in which selections were made.

GUELPH, ONTARIO
UNIVERSITY OF GUELPH, DEPARTMENT OF ZOOLOGY

A. Sitophilus granarius (L)
1. GG strain, dark, heavy and symbiotic
2. MW strain, paler, lighter and aposymbiotic
3. Two new strains as yet unclassified

B. Sitophilus oryzae (L.)--small rice weevil

C. Sitophilus zea-mais (Mots.)--large rice weevil

(Ed.)

MONTREAL, P. Q.
MCGILL UNIVERSITY, DEPARTMENT OF BIOLOGY

Tribolium castaneum

1.	Berkeley CSI-3F	Sokoloff, 1970
2.	Berkeley CS-synthetic, sooty	Sokoloff, 1970
3.	Berkeley CS-synthetic, pygmy	Sokoloff, 1970
4.	McGill black	Sokoloff, 1970
5.	Chicago black	Sokoloff, 1970
6.	Purdue Foundation	Scheinberg, 1967

OTTAWA, ONTARIO
ANIMAL GENETICS SECTION, ANIMAL RESEARCH INSTITUTE
CENTRAL EXPERIMENTAL FARM

Tribolium castaneum

Purdue Foundation

RSILW - A population selected for high larval weight for 10 generations restricting developmental time and pupal weight (derived from Purdue Foundation).

RSIDT - A population selected for short developmental time for 10 generations restricting larval weight and pupal weight (derived from Purdue Foundation).

RSIPW - A population selected for short developmental time for 10 generations restricting larval weight and developmental time (derived from Purdue Foundation).

TSLW - A populations selected for high larval weight for 10 generations (derived from Purdue Foundation).

TSDT - A population selected for short developmental time for 10 generations (derived from Purdue Foundation).

TSPW - A population selected for high pupal weight for 10 generations (derived from Purdue Foundation).

(Ed.)

QUEBEC, P. Q.
UNIVERSITE LAVAL, DEPARTMENT OF BIOCHEMISTRY

Tribolium confusum Duval

Strain: Laval
Origin: Quebec City

A. Lemonde

QUEBEC, P. Q.
UNIVERSITE LAVAL, DEPARTMENT OF BIOLOGY

Tribolium confusum Duval

Strain: Laval
Origin: Quebec City

L. Huot

VANCOUVER, B. C.
UNIVERSITY OF BRITISH COLUMBIA, DEPARTMENT OF POULTRY SCIENCE

I. Wild type strains

A. *Tribolium confusum* inbred lines

1.	CFI-2a	Berkeley, 1965
2.	CFI-3	Berkeley, 1965
3.	CFI-5	Berkeley, 1965
4.	CFI-7	Berkeley, 1965
5.	CFI-8b	Berkeley, 1965

II. Mutant strains

A. *Tribolium confusum*

1.	eyespot (*es*); chromosome I	Berkeley, 1965
2.	red (*r*); chromosome I	Berkeley, 1965
3.	dirty pearl eye (*dpe*); chromosome IV	Berkeley, 1965
4.	ebony-2 (e_2); chromosome II	Berkeley, 1965
5.	pearl riboflavinless (*pr*); chromosome II	Berkeley, 1965
6.	pearl slough (*p*); chromosome II	Berkeley, 1965
7.	ruby spot (*rus*); chromosome III	Berkeley, 1965
8.	light ocular diaphragm (*lod*); chromosome III	Berkeley, 1965
9.	*p*; *dre*; *cas*; multichromosomal	Berkeley, 1965
10.	*r s*; *b*; multichromosomal	Berkeley, 1965
11.	*St*; *b*; multichromosomal	Berkeley, 1965

B. *Tribolium castaneum*

1.	red (*r*); chromosome I	Berkeley, 1965
2.	pearl (*p*); chromosome I	Purdue, 1967
3.	pearl riboflavinless (*pr*) (formerly "ivory")	Berkeley, 1965
4.	pink (*ppk*); chromosome II	
5.	light ocular diaphragm (*p* background); chromosome III	Berkeley, 1965
6.	jet H. L. E.; chromosome V	Berkeley, 1967
7.	Chestnut (*c*); chromosome VII	Berkeley, 1965
8.	*s*; r^D; multichromosomal	Berkeley, 1965

VANCOUVER, B. C.
UNIVERSITY OF BRITISH COLUMBIA, POULTRY SCIENCE GENETICS LABORATORY

Tribolium confusum

Wild type
1. U.B.C. wild type - - Vancouver, B. C.

Mutants
1. Riboflavinless, pearl-eye (p^r)

C. W. Roberts

WINNIPEG, MANITOBA
CANADA DEPARTMENT OF AGRICULTURE, RESEARCH STATION

I. Wild type strains

A. Coleoptera

1.	Acanthoscelides obtectus (Say) Bruchidae	Winnipeg
2.	Alphitobius diaperinus Panzer Tenebrionidae	Saskatchewan
3.	Cryptolestes ferrugineus (Steph.) Cucujidae	Manitoba
4.	Cryptolestes ferrugineus (Steph.) Cucujidae	PIL United Kingdom
5.	Cryptolestes ferrugineus (Steph.) Cucujidae	Australia
6.	Cryptolestes turcicus (Grouv.) Cucujidae	Ontario
7.	Cryptolestes turcicus (Grouv.) Cucujidae	PIL United Kingdom
8.	Cynaeus angustus Leconte Tenebrionidae	Manitoba
9.	Oryzaephilus mercator (Fauvel) Silvanidae	Ontario
10.	Oryzaephilus surinamensis (L.) Silvanidae	Manitoba
11.	Rhyzopertha dominica (Fab.) Bostrichidae	Australia
12.	Sitophilus granarius (L.) Curculionidae	Manitoba
13.	Sitophilus oryzae (L.) Curculionidae	Montreal
14.	Sitophilus zea-mais Motschulsky Curculionidae	Japan

15. Stegobium paniceum (L.)
Anobiidae — Winnipeg
16. Tenebroides mauritanicus (L.)
Ostomidae — Manitoba
17. Tenebrio molitor (L.)
Tenebrionidae — Manitoba
18. Tribolium castaneum (Herbst)
Tenebrionidae — Manitoba
19. Tribolium confusum (DuVal)
20. Tribolium madens
Charp. Tenebrionidae — Manitoba
21. Trogoderma variabile
Ballion Dermestidae — Alberta

B. Lepidoptera
1. Plodia interpunctella (Hbn.)
Phycitidae — Winnipeg

II. Mutant strain

A. Coleoptera
1. Tribolium confusum DuVal — Winnipeg, Manitoba, 1963

L. B. Smith

DENMARK

LYNGBY
STATENS SKADEDYRLABORATORIUM
(DANISH PEST INFESTATION LABORATORY)

Alphitobius diaperinus
Anobium punctatum
Anthrenus museorum
Anthrenus vorax
Attagenus alfieri
Attagenus piceus
Dermestes frichii
Hylotrupes bajulus
Lasioderma serricorne
Oryzaephilus mercator
Oryzaephilus surinamensis
Rhizopertha dominica
Sitophilus granarius

Sitophilus oryzae
Stegobium (Sitodrepa) paniceum
Tenebrio molitor
Tenebrioides mauritanicus
Thylodrias contractus
Tribolium confusum
Tribolium destructor
Trogoderma granarium

EASTERN NIGERIA

PORT HARCOURT
THE NIGERIAN STORED PRODUCTS RESEARCH INSTITUTE

I. Wild type strains

1.	Dermestes maculatus De Geer	Port Harcourt Strain, 1966
2.	Oryzaephilus mercator Fauv.	Port Harcourt Strain, 1966
3.	Sitophilus zea-mais Motschulsky	Kano Strain, 1965 (Ex Kano Lab. Stock) November, 1965
4.	Tribolium castaneum Hbst.	Kano Strain, 1965 (Ex Kano Lab. Stock) October, 1965
5.	Tribolium confusum DuVal.	Kano Strain, 1965 (Ex Kano Lab. Stock) December, 1965
6.	Trogoderma granarium Everts	Kano Strain, 1965 (Ex Kano Lab. Stock) November, 1965

(Ed.)

GIZA
PLANT PROTECTION DEPARTMENT, MINISTRY OF AGRICULTURE

I. Wild type strains

1.	Bruchus rufimanus	Egypt, U.A.R.
2.	Corcyra cephalonica	Egypt, U.A.R.
3.	Ephestia kühniella	Egypt, U.A.R.
4.	Latheticus oryzae	Egypt, U.A.R.
5.	Rhizopertha dominica	Egypt, U.A.R.
6.	Silvanus surinamensis	Egypt, U.A.R.
7.	Sitophilus granarius	Egypt, U.A.R.
8.	Sitophilus oryzae	Egypt, U.A.R.
9.	Tribolium castaneum	Egypt, U.A.R.
10.	Tribolium confusum	Egypt, U.A.R.

Stock Lists

Note: Dr. M. A. Hafeez is at present in London. Fate of above stocks is unknown.

(Ed.)

FRANCE

LYON, RHÔNE
LABORATORIRE DE ZOOLOGIE GÉNÉRALE, FACULTÉ DES SCIENCES

Tribolium castaneum

Wild type strain from Alès, France.

(Ed.)

VILLEURBANNE (LYON) RHÔNE
INSTITUT NATIONAL DES SCIENCES APPLIQUÉES, LABORATOIRE DE BIOLOGIE

A.	Acanthoscelides obsoletus--wild type	France
B.	Blabera fusca	
C.	Clitumnus extradentatus	
D.	Galleria mellonella	Saint Cyr au Mont d'Or
E.	Oryzaephilus surinamensis--from imported dried apricots	
F.	Periplaneta americana	
G.	Pseudococcus citri	Antibes
H.	Sitophilus granarius	Infestation Control Laboratory, Surbiton
I.	Sitophilus oryzae	P.I.L., Slough
J.	Sitophilus sasakii--wild type	Lyon
K.	Stegobium paniceum	P.I.L., Slough
L.	Tenebrio molitor	
M.	Tenebrio obscurus	P.I.L., Slough
N.	Tribolium castaneum--wild type	Alès

(Ed.)

GERMANY

MUNICH
BAYER, LANDESANSTALT FÜR BODENKULTUR
PFLANZENBAU U. PFLANZENSCHUTZ

Coleoptera

Cucjidae

Cryptolestes turcicus (Grouv.) Munich, 1966

Stock Lists

Curculionidae

Sitophilus granarius (L.)	Munich, 1966
Sitophilus zea-mais (Motsch.)	1966

Ptinidae

Gibbium psylloides (Czemp.)	Regensburg, 1960

Silvanidae

Oryzaephilus mercator (Fauv.)	Munich, 1966
Oryzaephilus surinamensis (L.)	Munich, 1959

Tenebrionidae

Gnathocerus cornutus (F.)	Munich, 1966
Tribolium confusum (Duv.)	Munich, 1960
Tribolium destructor (Uyttenb.)	Munich, 1957

Lepidoptera

Phyticidae

Anagasta Kuehniella (Zell.)	Munich, 1966

(Ed.)

GREAT BRITAIN

BIRMINGHAM, ENGLAND
THE UNIVERSITY OF BIRMINGHAM
DEPARTMENT OF ZOOLOGY AND COMPARATIVE PHYSIOLOGY

Tenebrio molitor
Tenebrio obscurus
Blaps sp.
Tribolium sp.

(Ed.)

DUNDEE, ANGUS
UNIVERSITY OF DUNDEE, DEPARTMENT OF NATURAL HISTORY

Only the stock unique to this laboratory is listed.

Wild stock

1. Tribolium castaneum - Kenya. Collected in December, 1967, from stored maize in the Nairobi district.

(Ed.)

DUNDEE
DUNDEE UNIVERSITY
DEPT. OF BIOLOGICAL SCIENCES

	Origin
Tribolium castaneum	Slough
T. confusum	
T. madens	
T. destructor	
T. brevicornis	
T. castaneum - M.S.G.	Sokoloff
T. castaneum - M.S.G.	Slough
T. confusum - Black mutant	Slough
T. confusum - Pearl Eye	Slough
Eppestion cautella	Slough
Gnathocerus maxillosus	Slough
G. cernutus - Slough, New Zealand	Egypt
Latheticus oryzae - Normal and Dark	Slough
Sitophilus zeamais	Slough

F. L. Waterhouse

EDINBURGH
UNIVERSITY OF ENDINBURGH, INSTITUTE OF ANIMAL GENETICS

Tribolium castaneum

A. Wild type strain

1. Chicago wild type

Stock Lists

B. Mutant strains

1. Microphthalmic (Mo)
2. microcephalic, pearl (mc, p)
3. Bar eye, sooty (Be s/+s)
4. squint (sq)

Stocks obtained from Berkeley, California.

(Ed.)

EDINBURGH, SCOTLAND
DEPARTMENT OF AGRICULTURE AND FISHERIES FOR SCOTLAND
AGRICULTURAL SCIENTIFIC SERVICES, EAST CRAIGS

Tribolium castaneum Herbst.

Wild type strain of unknown origin, collected from imported foodstuffs.

Tribolium confusum J. duV.

Wild type strain of unknown origin, collected from imported foodstuffs.

(Ed.)

LONDON
QUEEN ELIZABETH COLLEGE, DEPARTMENT OF BIOLOGY

Bruchus pectinicornis
Latheticus oryzae
Sitophilus granarius
Tenebrio molitor
Tribolium anaphe
Tribolium castaneum
Tribolium madens
Trogoderma

All insects are derived from the Pest Infestation Laboratory, Slough, Bucks.

(Ed.)

NEWCASTLE UPON TYNE
THE UNIVERSITY OF NEWCASTLE UPON TYNE, SCHOOL OF AGRICULTURE

Tribolium castaneum

A. Wild type

1. pearl (p)
2. black (b), tawny (b^t)
3. antennapedia (ap)
4. paddle (pd)
5. red (r)

Stock Lists

Tribolium confusum

A. Wild type
   1. ebony (e^2)
   2. pearl (p)

All stocks derived from cultures at the Insectary of the Pest Infestation Control Laboratory, Slough, Bucks.

(Ed.)

SLOUGH, BUCKS *
MINISTRY OF AGRICULTURE, FISHERIES & FOOD
THE INSECTARY OF THE PEST INFESTATION CONTROL LABORATORY

The object of this insectary is to provide constant supplies of storage insects and for this purpose the species listed are bred in controlled conditions. On request insects are sent, without charge, to educational bodies. To industrial organizations insects will be provided if commercial firms are unable to supply them. The insects are maintained in constant temperature rooms at a relative humidity of 70%, except in the case of cockroaches where the relative humidity is 50%. As far as possible insects are bred free from disease. All new stocks pass through quarantine precautions before acceptance into the insectary.

Some Tenebrionid species harbour eugregarines, and thus are a ready source of these micro-organisms which are believed to be harmless. The latter, however, can be eliminated easily if beetles free from eugregarines are required. Eugregarines may also be present in other insects.

Incorporated into the list is the name of the country from which the stock bred in this laboratory originated. However, it is only recently that records of this information have been kept, and since many species have been maintained in culture for over twenty years they are of unknown origin. Some species, such as Attahenus fasciatus, were sent to us from entomologists working abroad; but other species, such as Ephestia cautella, were obtained from infested produce brought to this country, so that there is only circumstantial evidence that produce and pests originated in the same country. In the latter case the name of the country is bracketed.

Limited stocks of the following species are cultured and may be available in small quantities at certain times of the year: Endrosis sarcitrella (L.), Hofmannophila pseudospretella (Staint.), Thylodrias contractus Mots., Tribolium audax Halstead.

* NOTE CHANGE IN ADDRESS FOR SLOUGH, BUCKS.

ORDER Family (-subfamily) Genus (sub genus), species.	COMMON NAME	COUNTRY OF ORIGIN OF STOCK	CULTURE MEDIUM	REARING TEMPERATURE °C
Cucujidae				
Cryptolestes capenis (Waltl)			10	25
Cryptolestes ferrugineus (Steph.)	Rust-red grain beetle		10	30
Cryptolestes pusilloides (Steel & Howe)		(Canada)	10	25
Cryptolestes pusillus (Schon.)	Flat grain beetle		10	25
Cryptolestes turcicus (Grouv.)			10	25
Cryptolestes ugandae (Steel & Howe)		(E. Africa)	10	25
Curculionidae				
Sitophilus granarius (L.)	Grain weevil	(Russia)	1	25
Sitophilus oryzae (L.)	Rice weevil	Britain	1	25
Sitophilus zeamais Motsch.	Maize weevil		1	25
Dermestidae				
Anthrenocerus australis (Hope)	Australian carpet	(Britain)	20	25
Anthrenus (Anthrenus) flavipes LeC. (=vorax Waterh.)	Furniture carpet beetle		20	30
Anthrenus (Nathrenus) verbasci (L.)	Varied carpet beetle	Britain	20	20
Anthrenus (Anthrenodes) sarnicus Mroczkowski			35	20
Anthrenus (Florilinus) olgae Kalik			20	20
Attagenus sp? (alfieri of Hinton 1945)		Kenya	17	25
Attagenus fasciatus (Thunberg) (=gloriosae (Fabrioius)		Botswana	18	25
Attagenus unicolor Brahm (=megatoma (F.) & piceus (Ol.) nec. Thb.)	Black carpet beetle		20	30
Attagenus pellio (L.)	Fur beetle	Britain	20	20
Dermestes ater Deg.	Black larder beetle	Britain	21a	25
Dermestes frischii Kug.	Hide beetle	(Nigeria)	21a	25
Dermestes haemorrhoidalis Kuster		Britain	21a	25
Dermestes lardarius L.	Bacon beetle	Britain	21a	25
Dermestes maculatus Deg.	Leather beetle		21a	25

ORDER Family (-subfamily) Genus (sub genus), species.	COMMON NAME	COUNTRY OF ORIGIN OF STOCK	CULTURE MEDIUM	REARING TEMPERATURE °C
Gelechiidae				
Sitotroga cerealella (Oliv.)	Angoumois grain moth		1	25
Tineidae				
Tinea columberiella Wocke	Case bearing clothes moth		20	25
Tinea flavescentella Haworth		Britain	20	25
Tineola bisselliella (Humm.)	Common clothes moth		20	25
Tenea Pellionella (L.)			20	25
COLEOPTERA				
Anobiidae				
Lasioderma serricorne (F.)	Cigarette beetle		6	25
Stegobium paniceum (L.)	Biscuit beetle		6	25
Antribidae				
Araecerus fasciculatus (Deg.)			39	25
Bostrichidae				
Rhyzopertha dominica (F.)	Lesser grain borer		1	30
Bruchidae				
Acanthoscelides obtectus (Say)	Dried Bean beetle	W. Africa	27	30
Callosobruchus analis (F.)			29	30
Callosobruchus chinensis (L.)	Cowpea weevil		29	25
Callosobruchus maculatus (F.)		Sierra Leone	29	30
Callosobruchus rhodesianus (Pic)			29	30
Caryedon serratus (Oliv.) (=gonagra (F.))	Groundnut seed beetle		26a	30
Zabrotes subfasciatus (Boh.)			28	30
Cerylonidae				
Murmidius ovalis (Beck)		Ceylon	13	25
Cleridae				
Necrobia rufipes (Deg.)	Copra beetle		22	30
Necrobia ruficollis (F.)			40	25

I. Wild type strains

ORDER Family (-subfamily) Genus (sub genus), species.	COMMON NAME	COUNTRY OF ORIGIN OF STOCK	CULTURE MEDIUM	REARING TEMPERATURE °C.
DICTYOPTERA				
Blattidae				
Blatta orientalis L.	Oriental cockraoch		18a	27
Blattella germanica (L.)	German cockroach		18a	27
Periplaneta americana (L.)	American cockroach		18a	27
Periplaneta australasiae (F.)	Australian cockroach		18a	27
DIPTERA				
Muscidae				
Musca domestica L.	Housefly	Britain	25	27
HYMENOPTERA				
Formicidae				
Monomorium pharaonis (L.)	Pharaoh's ant	Britain	33	27
Braconidae				
Bracon hebetor Say		America	31	25
LEPIDOPTERA				
Pyralidae - Pyralinae				
Pyralis farinalis (L.)	Meal Moth		5	25
Pyralidae - Phycitinae				
Ephestia (Anagasta) Kuehniella (Zell.)	Mediterranean flour moth	Britain	8a	25
		Britain	8a	25
Ephestia (Cadra) cautella (Walk.)	Tropical warehouse moth	(S. Africa)	8a	25
Ephestia (Ephestia) elutella (Hubn.)	Warehouse moth	Britain	8a	25
Ephestia (Cadra) calidella (Guen.)		Cyprus	34a	30
Ephestia (Cadra) figulilella Gregs.		Cyprus	34a	30
Plodia interpunctella (Hubn.)	Indian meal moth	Britain	8a	25
Pyralidae - Galleriae				
Achroia grisella (F.)	Lesser wax moth		16a	25
Galleria mellonella (L.)	Honeycomb moth		16a	25
Paralipsa gularis (Zell.)			26	25

ORDER Family (-subfamily) Genus (sub genus), species.	COMMON NAME	COUNTRY OF ORIGIN OF STOCK	CULTURE MEDIUM	REARING TEMPERATURE °C
Dermestes peruvianus Castelnau		Britain	21a	25
Trogoderma anthrenoides (Sharp)		U.S.A.	2	30
Trogoderma glabrum (Herbst)		U.S.A.	2	30
Trogoderma granarium Everts	Khapra beetle	(Britain)	2	30
Trogoderma grassmanii Beal		U.S.A.	18	30
Trogoderma inclusum LeC.	Larger cabinet beetle		10	25
Trogoderma irroratum Reitt.		Egypt	2	30
Trogoderma variabile Ballion (=parabile Beal)		U.S.A.	2	30
Trogoderma simplex Jayne		U.S.A.	18	30
Trogoderma sternale plagifer Casey		New Mexico	32	30
Mycetophagidae				
Typhaea stercorea (L.)	Hairy grain beetle	Nigeria	4	25
Nitidulidae				
Carpophilus dimidiatus (F.)	Corn-sap beetle		14	25
Carpophilus hemipterus (L.)	Dried fruit beetle		15	25
Carpophilus marginellus			23a	25
Trogossitidae				
Lophocateres pusillus (Klug.)	Siamese grain beetle		11	30
Tenebroides mauritanicus (L.)	The Cadelle	Pakistan	12	30
Ptinidae				
Gibbium psylloides (Czemp)	Hump spider beetle	Britain	17a	20
Mezium affine Boield.		Britain	17a	20
Mezium americanum Lap.	American spider beetle		17a	20
Niptus hololeucus (Fald.)	Golden spider beetle	Britain	17a	20
Pseudeurostus hilleri (Reitt.)		Britain	17a	20
Ptinus clavipes Panz.	Brown spider beetle	Britain	17a	20
Ptinus pusillus Sturm.			17a	20
Ptinus sexpunctatus Panz.			17a	20
Ptinus tectus Boield	Australian spider beetle		19a	25
Stethomezium squamosum Hint.	African spider beetle	Britain	17a	20
Tipnus unicolor (P. & M.)		Kenya	17a	20
Trigonogenius globulus Sol.	Globular spider beetle	Ireland	17a	20
Trigonogenius particularis Pic		Kenya	18a	25

ORDER Family (-subfamily) Genus (sub genus), species.	COMMON NAME	COUNTRY OF ORIGIN OF STOCK	CULTURE MEDIUM	REARING TEMPERATURE °C
Silvanidae				
Ahasveras advena (Waltl)	Foreign grain beetle	(West Africa)	10	25
Cathartus quadricollis (Guer.)	Square-necked grain beetle	W. Africa	10	25
Oryzaephilus mercator (Fauv.)	Merchant grain beetle		10	25
Oryzaephilus surinamemsis	Saw-toothed grain beetle		10	25
Tenebrionidae				
Alphitobius diaperinus (Panz.)	Lesser mealworm		7	25
Alphitobius laeviagatus (F.)	Black fungus beetle		7	25
Alphitobius viator Muls. & God.		Sierra Leone	7	25
Alphitophagus bifasciatus (Say)	Two-banded fungus beetle	Britain	5	25
Gnathocerus cornutus (F.)	Broad-horned flour beetle		17	25
Gnathocerus maxillosus (F.)	Slender horned flour beetle		6	25
Latheticus oryzae Waterh.	Long headed flour beetle		6	30
Palorus laesicollis (Fairm.)		Kenya	24	25
Palorus ratzeburgii (Wissm.)	Small-eyed flour beetle		6	25
Palorus subdepressus (Woll.)	Depressed flour beetle	Turkey	7	25
Tenebrio molitor L.	Yellow mealworm		10a	25
Tenebrio obscurus F.	Dark mealworm		10a	25
Tribolium anaphe Hint.		Nigeria	17	25
Tribolium brevicornis LeC.		U.S.A.	23	25
Tribolium castaneum (Herbst)	Rust-red flour beetle	Britain	23	25
Tribolium confusum Duv.	Confused flour beetle		23	25
Tribolium destructor Uytt.	Dark flour beetle	(Holland)	17	25
Tribolium madens (Charp.)	Black Flour beetle	(Yugoslavia)	17	25
Languriidae				
Pharaxonotha kirschi (Reitt.)			6a	25

The letter "a" after a number indicates that drinking water is added to the culture either in the form of damp blotting paper or as a corked tube of water containing a wick of blotting paper.

CULTURE MEDIA

No.	Food	Weight Ratio (Ounces)
1.	Wheat	
2.	Wheat + wheatfeed	7:3
3.	Wheat + wheatfeed + glycerol	7:3:1
4.	Wheat + wheatfeed + glycerol on a damp pad of cotton wool	7:3:1
5.	Wheat + wheatfeed on a damp pad	7:3:1
6.	Wheatfeed + yeast	10:1
7.	Wheatfeed + yeast on a damp pad	10:1
8.	Wheatfeed + yeast + glycerol	10:1:3
9.	Wheatfeed + yeast + glycerol on a damp pad	10:1:3
10.	Wheatfeed + rolled oats + yeast	5:5:1
11.	Wheatfeed + rolled oats + yeast + groundnuts	5:5:1:1
12.	Wheatfeed + rolled oats + yeast + groundnuts + cork	5:5:1:1
13.	Wheatfeed + rolled oats on a damp pad	2:1
14.	Rolled oats + yeast	10:1
15.	Rolled oats + yeast + dates	6:1:6
16.	Wheatfeed + rolled oats + yeast + glycerine + honey + brood comb	5:5:1:2:2:2
17.	Wheatfeed + fishmeal + yeast	8:4:1
18.	Wheatfeed + rolled oats + fishmeal + yeast	5:5:2:1
19.	Fishmeal + yeast	16:1
20.	Fishmeal + yeast + flannel	16:1
21.	Fishmeal + yeast + bacon ends	16:1
22.	Fishmeal + yeast + bacon ends + cheese	16:1
23.	Wholemeal flour + yeast	12:1
24.	Wheatfeed + rolled oats + flour + yeast	3:3:3:1
25.	Wheatfeed + grassmeal + yeast + shortex	20:10:1:2
26.	Groundnuts	
27.	Haricot beans	
28.	Butter beans	
29.	Cowpeas + dried green peas	1:1
30.	Liver + sugar and water	
31.	Moth culture (Sub-family Phycitinae)	
32.	Fishmeal + Yeast + dried cockroaches	
33.	Liver, swiss roll and honey	
34.	Wheatfeed + glucose + yeast	5:2:1
35.	Wheatfeed + fishmeal + yeast + cholesterol	8:8:1:1
36.	Crushed dog biscuit + yeast	20:1
37.	Bread and butter	
38.	Sweet biscuits	
39.	Maize	
40.	Wood sawdust + bones	

I. Resistant strains

A. Tribolium castaneum (Tenebrionidae)

1. DDT resistant	South Africa, 1960
2. Non-specific resistant	Australia, 1968
3. Lindane specific resistant	Zambia, 1970
4. Malathion specific resistant	Nigeria, 1963
5. Insecticide susceptible	Unknown, 1970

II. Mutants

MUTANT STOCKS	MUTATION	COUNTRY OF ORIGIN OF STOCK	MEDIA	TEMP.
Bostrichidae				
Rhyzopertha dominica (F.)	Black		1	30
Bruchidae				
Callosobruchus maculatus (F.)	Giant		29	30
Cucujidae				
Cryptolestes pusillus (Schön)	Black	Trinidad	10	30
Dermestidae				
Dermestes maculatus Deg.	Black/ Brown	Australia	21	25
Nitidulidae				
Carpophilus dimidiatus (F.)	Pearl-eyed		10	25
Silvanidae				
Ahasveras advena (Waltl)	Black	Britain	10	25
Oryzaephilus surinamensis (L.)	Small	Burma	10	25
Tenebrionidae				
Latheticus oryzae Waterh.	Dark		6	30

MUTANT STOCKS	MUTATION	COUNTRY OF ORIGIN OF STOCK	MEDIA	TEMP.
Tribolium confusum Duv.	Black		23	25
T. confusum	Pearl-eyed	Malta	23	25
T. confusum	Pearl-eyed	Britain	23	25
T. confusum	Pearl-eyed		23	25
T. confusum	Black and Pearl-eyed		23	25

(Ed.)

SLOUGH, BUCKS, U.K.
TROPICAL STORED PRODUCTS CENTRE, MINISTRY OF OVERSEAS DEVELOPMENT

I. Wild type strains

COLEOPTERA

Anobiidae

Lasioderma serricorne	Cyprus, 1964

Silvanidae

Oryzaephilus surinamensis	Crete, 1964
Oryzaephilus surinamensis	Cyprus, 1964
Oryzaephilus surinamensis (bicornis)	Crete, 1964
Oryzaephilus surinamensis (Small)	Far East, 1967

LEPIDOPTERA

Phycitidae

Cadra cautella	Cyprus, 1964
Cadra cautella	Rhodesia, 1965
Cadra figulilella	Cyprus, 1967
Plodia interpunctella	South Africa, 1965
Plodia interpunctella	N. Nigeria, 1965

(Ed.)

Stock Lists

INDIA

GORAKHPUR, U. P.
UNIVERSITY OF GORAKHPUR, DEPARTMENT OF ZOOLOGY

Wild type strain

1. Tribolium castaneum from local godowns.

(Ed.)

HISSAR, HARAYANA
PUNJAB AGRICULTURAL UNIVERSITY, DEPARTMENT OF GENETICS

I. Wild type strains (Tribolium castaneum)

1. IZT I
2. MAD I
3. PAU I
4. PAU II
5. Chicago wild — via Sokoloff, Berkeley
6. Brazil — via Sokoloff, Berkeley
7. Inbred lines in 8th. generation of full sibbing.

II. Mutant strains (Tribolium castaneum)

S-8	Py	via Sokoloff, Berkeley
S-12	P	via Sokoloff, Berkeley
S-20	Me	via Sokoloff, Berkeley
S-24	Squint	via Sokoloff, Berkeley
S-26	sa	via Sokoloff, Berkeley
S-28	mc	via Sokoloff, Berkeley
S-35	py r	via Sokoloff, Berkeley
S-53	jet	via Sokoloff, Berkeley
S-71	sa	via Sokoloff, Berkeley
S-74	ju	via Sokoloff, Berkeley
S-81	Bes	via Sokoloff, Berkeley
S-90	Py r Mr	via Sokoloff, Berkeley
S-100	b Mo	via Sokoloff, Berkeley
S-154	Be Fta	via Sokoloff, Berkeley
S-248	Fta c ca	via Sokoloff, Berkeley
S-253	lod p	via Sokoloff, Berkeley
S-304	Msg	via Sokoloff, Berkeley
S-313	ser py r	via Sokoloff, Berkeley
S-325	Fta	via Sokoloff, Berkeley
S-333	Spa	via Sokoloff, Berkeley
S-341	r	via Sokoloff, Berkeley
S-346	Fms-3	via Sokoloff, Berkeley
S-483	pd	via Sokoloff, Berkeley

(Ed.)

Stock Lists

BAHAUDU SHAH TAFAR MARJ, NEW DELHI-1
MAULANA AZAD MEDICAL COLLEGE, DEPARTMENT OF BIOCHEMISTRY

T. castaneum

Wild strain of local origin

(Ed.)

JABALPUR, MADHYA PRADESH
J.N. AGRICULTURAL UNIVERSITY
COLLEGE OF VETERINARY SCIENCE & A.H.
DEPARTMENT OF ANIMAL BREEDING & GENETICS

1. Random Stocks: R-1, R-2, R-3, R-4, R-5, R-6, R-7, R-8, R-9, R-10.
PAU-1 (HSR-Wild).

2. Inbred Lines: I-1, I-2, I-3, I-4, I-5, I-6, I-7, I-8, I-9, I-10.

These stocks have been inbred for 19 generations.

3. Mutant stocks: S-1 Chi-wild
S-8 py
S-10 p
S-12 Chi b/b, Chi +/b, Chi +/+
S-53 jet
S-100 b Mo
S-248 Fta c Ca
S-304 msg
S-313 ser py r
S-333 Spa
S-341 r

ISRAEL

TEL AVIV, ISRAEL
TEL AVIV UNIVERSITY, DEPARTMENT OF ZOOLOGY

I. Wild type strains

Tribolium castaneum
++ (Purdue) strain

Tribolium confusum
++ (Chicago) strain

Both obtained from Dr. Robert R. Sokal's laboratory, Stony Brook, N. Y., U.S.A.

II. Mutant strains

Tribolium castaneum
1. Black (bb)

2. Pearl (P)
3. Sooty (ss)

Tribolium confusum
1. (McGill) Black (bb)

All mutants obtained from Dr. Robert R. Sokal's laboratory, Stony Brook, N. Y., U.S.A.

ITALY

PAVIA
UNIVERSITY PAVIA, CENTRO DE GENETICA

1. Tribolium confusum Duval, wild strain obtained from Professor A. Kock, Biological Institut, Regenesburg.
2. id. id., strain of recent colonization from speciments collected in Pavia; small, difficult colony.

(Ed.)

JAPAN

KYOTO
KYOTO UNIVERSITY, FACULTY OF AGRICULTURE
ENTOMOLOGICAL LABORATORY

Bruchidae:

Calosobruchus chinensis: 11 wild strains from Kyoto, Syuzenzi and other localities in Japan. A black body colored mutant derived from wild Syuzenzi strain.

Callosobruchus maculatus: Strains from:
Fresno Laboratory, U.S.D.A., California
Louisiana, U. S. A.
Burma
Hong Kong
Thailand
Israel

Zabrotes bifasciatus — Hong Kong

Curculionidae:

Sitophilus zeamais — Kyoto
Sitophilus oryzae — Kyoto and Nepal

Tenebrionidae:

Tribolium castaneum	Kyoto
Tribolium confusum	Osaka

(Ed.)

MISIMA, SIZUOKA-KEN
NATIONAL INSTITUTE OF GENETICS

No stock list available.

(Ed.)

MIYAZAKI
MIYAZAKI UNIVERSITY, DEPARTMENT OF BIOLOGY

Alphitobius diaperinus--wild type strains
Callosobruchus chinensis--Kyoto strains
Martianus dermestoides--wild type strains
Palorus ratzeburgi--wild type strains
Sitophilus oryzae --wild type strains
Sitophilus zeamais--wild type strains
Tenebrio obscurus--wild type strains
Tribolium castaneum--wild type strains
Tribolium confusum--wild type strains

(Ed.)

MEXICO

CHAMPINGO
CAMPO EXPERIMENTAL "EL HORNO"

Tribolium castaneum
Tribolium confusum

Both cultures have long been maintained in our rearing chambers. Their source is unknown.

(Ed.)

NEW ZEALAND

NELSON
DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH
ENTOMOLOGY DIVISION

Stegobium paniceum--from infested rat food pellets at Otago University, Dunedin

Oryzaephilus surinamensis--from infested rat food pellets at Otago University, Dunedin
Gnathocerus cornutus--from infested rat food pellets at Otago University, Dunedin
Sitophilus oryzae--from spaghetti in galleys of overseas ships at Port Nelson
Sitophilus zeamais--from rice in galleys of overseas ships at Port Nelson

(Ed.)

PRIVATE BAG, HAMITON
RUAKURA AGRICULTURAL RESEARCH CENTRE, DEPARTMENT OF AGRICULTURE

Tribolium castaneum

1. Wild type strains derived from imported strain from Edinburgh.
2. Mutant strain carrying the chromosome II mutant pearl (p) and obtained from Tribolium Stock Center, Berkeley, California.

A. R. Quartermain

PRIVATE BAG, PALMERSTON NORTH
DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH
GRASSLAND DIVISION

Tribolium castaneum

1. Heavy and light population resulting from 18 generations of selection for increased and decreased pupal weight.

2. Strong, moderate and weak populations resulting from 20 generations of within-family selection for increased pupal weight at three selection intensities.

(Ed.)

PORTUGAL

LISBON
LABORATORIO DA DEFESA FITOSSANITÁRIA DOS PRODUTOS ARMAZENADOS
MINISTERIO DA ECONOMIA

The laboratory maintains the following cultures in the breeding room at 25° - 27° C and 65 - 70% R. H. The origin of the culture, the year of commencement and the culture media are given for each insect species.

Acanthoscelides obtectus (Say)--white bean Coimbra, 1968

Anagasta kuhniella (Zell.)--bran and glycerine	Carcavelos, 1968
Cadra cautella (Walk.)--decorticated almonds	Algarve, Portugal, 1969
Callosobruchus maculatus (F.)--California black eye	Alcobaca, 1968
Gnathocerus cornutus (F.)--whole-meal flour and yeast	Portugal, 1969
Lasioderma serricorne (F.)--bran and dried yeast	Lisboa, 1964
Oryzaephilus surinamensis (L.)--broken wheat	Portugal, 1960
Plodia interpunctella (Hübn.)--bran and glycerine	Carcavelos, 1968
Rhyzopertha dominica (F.)--wheat	S. Tomé, W. Africa, 1969
Sitophilus granarius (L.)--wheat	Portugal, 1969
Sitophilus oryzae	Portugal. 1969
Sitotroga cerealella (Oliv.)--barley	Portugal, 1968
Tenebroides mauritanicus (L.)--broken maize, bran and dried yeast	Portugal, 1967
Tribolium castaneum (Herbst)--flour	Bissau (Guiné), 1957
Zabrotes subfasciatus--white bean	Lisboa, 1968

(Ed.)

SPAIN

MADRID
INSTITUTO NACIONAL DE INVESTIGACIONES AGRONOMICAS
LABORATORIO DE GENETICA DE POBLACIONES

Tribolium castaneum

A. Wild type strains

1.	Consejo	CSIC, Madrid, Spain, 1964
2.	Purdue	Purdue, USA, 1964
3.	Edinburgh 1	Edinburgh, Scotland, 1970
4.	Edinburgh 2	Edinburgh, Scotland, 1970

B. Mutant type strains

5.	Black Purdue	Purdue, USA, 1964

C. Experimental lines

Originated from the "Consejo" strain and selected for egg laying performance through 40 generations.

		Selected for		Temperature
6.	AN - I	high performance	at	33° C
7.	AN - II	high performance	at	33° C
8.	AF - I	high performance	at	28° C
9.	AF - II	high performance	at	28° C
10.	AT - I	high performance	at	38° C
11.	AT - II	high performance	at	38° C
12.	BN - I	low performance	at	33° C
13.	BN - II	low performance	at	33° C

		Selected for		Temperature
14.	BF - I	low performance	at	28° C
15.	BF - II	low performance	at	28 C
16.	BT - I	low performance	at	38° C
17.	BT - II	low performance	at	38° C
18.	RN - I*	high cross performance	at	33° C
19.	SN - I*	high cross performance	at	33° C
20.	RN - II	high cross performance	at	33° C
21.	SN - II	high cross performance	at	33° C
22.	RF - I	high cross performance	at	28° C
23.	SF - I	high cross performance	at	28° C
24.	RF - II	high cross performance	at	28° C
25.	SF - II	high cross performance	at	28° C
26.	RT - I	high cross performance	at	38° C
27.	ST - I	high cross performance	at	38° C
28.	RT - II	high cross performance	at	38° C
29.	ST - II	high cross performance	at	38° C

* R & S corresponding lines were selected through a reciprocal recurrent selection.

30-62. Inbred lines with 22 generations of full sibbing.

D. Mutants

		Source and date
63.	antennapedia ap, VIII	Purdue 1964 and Sokoloff 1968
64.	Bar eye Be, IV	Purdue 1964
65.	black b, III	Sokoloff 1964
66.	chicago black cb, III	Sokoloff 1968
67.	chestnut c VII	Purdue 1964
68.	cordoban cd, III	Purdue 1964
69.	Diferencial Df, IV	Purdue 1968
70.	fused antennal segm.-2 fas-2, IV	Sokoloff 1968
71.	ivory i, ?	Purdue 1964
72.	jet j, V	Purdue 1964 and Sokoloff 1968
73.	juvenile urogomphi ju, IV	Purdue 1968
74.	light ocular diaph. lod, III	Purdue 1968
75.	maroon m, V	Purude 1964
76.	microcephalic mc, V	Purdue 1964
77.	Microphthalmic Mo, VI	Sokoloff 1968
78.	miniature appendaged D. ma^D	Purdue 1968
79.	paddle pd, I	Purdue 1964 and Sokoloff 1968
80.	pearl p, II	Purdue 1964 and Sokoloff 1968
81.	pegleg pg, II	Purdue 1968
82.	pink ppk, II	Purdue 1968
83.	pygmy py, I	Purdue 1964 and Sokoloff 1968
84.	red r, I	Purdue 1964
85.	ring rg, I	Purdue 1964
86.	rose rs, I	Purdue 1964
87.	ruby rb, V	Purdue 1964

88.	Short antenna Sa, VII	Purdue 1964
89.	short elytra sh, VIII	Purdue 1968
90.	sooty s, IV	Purdue 1964
91.	spotted sp, I	Purdue 1964
92.	squint sq, VIII	Purdue 1964
93.	white w, ?	Purdue 1964
94.	wine rW, I	Purdue 1968
95.	Eye mutant, ?	Madrid 1967
96.	Elytra mutant, ?	Madrid 1967
97.	Melanotic stink gland-like ?	Madrid 1968

Tribolium confusum

98.	black b, III	Sokoloff 1968
99.	blistered elytra ble, V	Sokoloff 1968
100.	creased abdominal sternites cas, II	Sokoloff 1968
101.	ebony e, V	Sokoloff 1968
102.	ebony-2 e_2, II	Sokoloff 1968
103.	red r, I	Sokoloff 1968
104.	ruby spot rus, III	Sokoloff 1968

F. Orozco

YUGOSLAVIA

ZAGREB, KAČIĆEVA 9
INSTITUTE FOR PLANT PROTECTION
AGRICULTURAL FACULTY

I. Wild type strain

LEPIDOPTERA

Gelechiidae
Sitotroga cerealella (Oliv.)

Phycitidae
Anagasta kuhniella Zell.

COLEOPTERA

Bostrichidae
Rhizopertha dominica (F.)

Bruchidae
Acanthoscelides obtectus (Say)

Cucujidae
Cryptolestes spp. (Species not yet identified, but ferrugineus and pusillus are present)

Curculionidae
Sitophilus zeamais Motsch.

Sitophilus oryzae (L.)
Sitophilus granarius (L.)

Dermestidae
Attagenus megatoma (F.)
Attagenus piceus (Oliv.)
Trogoderma granarium Everts

Ostomatidae
Tenebrioides mauritanicus (L.)

Ptinidae
Mezium spp. (species not yet identified)

Silvanidae
Oryzaephilus surinamensis (L.)
Oryzaephilus surinamensis (L.) v. bicornis
Oryzaephilus mercator (Fauv.)

Tenebrionidae
Gnathocerus cornutus (F.)
Palorus spp. (species not yet identified but ratzeburgi and subdepressus are present)
Tenebrio molitor L.
Tribolium castaneum (Herbst)
Tribolium confusum Duv.

All insects are originated from storehouses and mills from Croatia, Yugoslavia. They are reared in a lab under constant circumstances during 3-4 years. Only species Trogoderma granarium is of unknown origin, collected from imported foodstuffs. This species is not found in Yugostavia yet.

II. Mutants

Tribolium confusum

Chromosome III
Yugoslavian black (=bz)--Yugoslavia 1969 (report of A. Sokoloff, TIB 13)

Zlatko Korunić

NOTES - RESEARCH

BAIRD, C. J. and H. S. Ducoff
Department of Physiology and Biophysics
University of Illinois
Urbana, Illinois

*Techniques Developed for Hemocyte Studied on Tenebrio molitor larvae

An improved staining procedure for Tenebrio hemocytes:

Published methods for preparing stained hemolymph smears from Tenebrio molitor larvae are sketchy and yield unsatisfactory results. A procedure originally developed for Drosophila hemocytes by Nappi and Stream (1969) has been modified in this laboratory for use on larval T. molitor hemocytes and gives uniformly good, reproducible results: Anesthetize a larva with CO_2 for 5 minutes, (CO_2 generated from dry ice should be warmed to room temperature before use), amputate the posterior pair of legs, collect a drop of hemolymph at the edge of a 22 x 22 mm coverslip, and make a smear on a 1"x 3" slide. After thoroughly air drying the smear, tilt the slide at a 60° angle, fix with 15 drops of absolute methanol, and air dry again.

Place the slide on a level staining rack, flood the smear with 1-2 ml of Giemsa stain (Harleco) diluted 1:10 with demineralized water, and stain for 15 minutes. While the slide is still horizontal, thoroughly wash it with demineralized water for 5 minutes, then drain--do not air dry. Immediately differentiate the stained smear in acetone for 1 1/2 minutes, dehydrate the slide in an acetone:xylene series (30:70, 2 minutes; 5:95, 2 minutes; and two changes of xylene, 15 minutes), and mount with a suitable permanent mounting media (e.g.--Permount).

The permanent preservation of hemocyte wet-mounts:

Sometimes it is desirable to preserve a hemocyte wet-mount. A modification of the quick-freeze method of Conger and Fairchild (1953) has been developed for this purpose and gives excellent results with larval T. molitor hemocyte wet-mounts: Anesthetize and amputate a Tenebrio larva as outlined above. Collect a drop of hemolymph 2 1/2 mm in diameter in the center of an 11 x 11 mm coverslip (These are easily made from 22 x 22 mm coverslips, which are too large for use here, by using a diamond marking pencil) and gently lower the coverslip onto a 1" x 3" albumin coated slide. The wet-mount can now be easily examined under phase contrast. Generally, there is an even monolayer of cells in the preparation which nicely maintain their three dimensional shape.

To preserve the wet-mount, carefully set the slide on a flat cake of dry ice until it becomes thoroughly frozen (at least 30 seconds). While the slide is still flat on the dry ice, flick the coverslip off with a razor blade; then immediately fix the slide by immersing it in cold absolute methanol for one minute (2, 30-second changes) and air dry. The slide may now be stained and mounted as described above but with one significant change: Differentiate the smear in acetone for 5 minutes instead of 1 1/2 minutes.

A technique for collecting relatively large volumes of Tenebrio hemolymph:

For certain types of experimental studies, relatively large volumes of hemolymph may be required. A procedure has been developed in this laboratory which has permitted the collection of milliliter volumes of larval Tenebrio hemolymph which takes advantage of a fortuitous property of the CO_2 used for anesthesia--its anticoagulant activity. This is exploited as follows: Larvae are anesthetized with CO_2 for at least 10 minutes and amputated as mentioned above. The hemolymph is collected in capillary tubes previously flushed with humidified CO_2 and pooled in a vessel under humidified CO_2. Using this procedure, a milliliter of hemolymph can be collected in about an hour with no tanning or clotting. The hemocytes remain in surprisingly good condition with only the cystocytes showing some deterioration, but some slight clumping of the hemocytes does occur.

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*Preliminary Observations on the X-ray Response of T. brevicornis

The large size and slow development time make T. brevicornis attractive as a tool in various types of physiological investigation. A surprisingly great resistance to starvation has been reported (Sokoloff, 1971). We have kept a population of 78 females and 73 male adults at 30°C and approximately 50% relative humidity in flour-yeast medium in groups of 5 of 1 sex, and have had no deaths in 12 months.

Comparison of the response of T. brevicornis with that of T. castaneum and of T. confusum to X-irradiation is of considerable interest. Most of our strains of T. confusum exhibit an LD_{50} between 5,000 and 7,500 R for young adults, and the LD_{50} for our T. castaneum strain is about 12,000 R. In both of these species, for all strains tested, the period of acute mortality begins 8-10 days after irradiation and continues for about 2 1/2 weeks at 30°. This is true for doses in the midlethal range and for doses up to at least 60,000 R (Ducoff et al., 1971). Radiosensitivity, as indicated by the fraction dying withing 5 weeks after a given dose, increases progressively

with age at irradiation, but the time course of mortality is not altered.

Groups of T. brevicornis young adults were exposed to a graded series of X-ray doses between 5 and 15 kR in one experiment and between 4,700 and 7,900 R in a second. In both experiments there were very few deaths during the first 3 weeks; median survival time of decedents was between 6 and 7 weeks; and there were no deaths of irradiated T. brevicornis after 13 weeks. Thus, survival time of irradiated adults of T. brevicornis is more than twice that of T. confusum or of T. castaneum. This does not denote greater radioresistance, however; allowing an appropriately long observation period (13 weeks) the LD_{50} of T. brevicornis is less than 6,000 R. These results, coupled with the previously cited findings of Sokoloff indicate that reduced food intake does not contribute to lethality of irradiated Tribolium. These results also suggest that cell turnover in T. brevicornis proceeds much more slowly than in other Tribolium species.

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*Pleiotropic effects of the "midget" (mi) mutant in Tribolium castaneum

Tribolium has become recognized as excellent material for model experiments in the biological testing of quantitative genetic theory. Polygenic traits which have been useful for this purpose include fecundity, hatchability, larval weight, pupation time, pupal weight, adult emergence time, adult weight and biomass (Bell, 1969). Recent theoretical concern regarding the importance and possible influence of major genes in an assumed polygenic model gives added interest to the study of gene mutations with major effects on supposedly polygenic traits. The "corn oil sensitive" mutant, cos, of T. castaneum is an excellent example of a single major gene acting in an otherwise polygenic genotype by environment interaction model (Constantino, et. al., 1967). The "midget" (mi) mutant of T. castaneum (Bell and Shideler, 1971) is a major gene whose pleitropic effects on several polygenic traits will be summarized in this report.

MATERIALS AND METHODS

"Midget" was discovered in a sub-population of the Purdue "pearl"

Notes - Research

Foundation which was under selection for 13-day larval weight. It is sex-linked in its inheritance and was initially reported as recessive to its normal allele in regards to its primary effect, reduced larval growth. The action of mi on other polygenic traits was contrasted with its normal allele in both homozygous and heterozygous states by mating purebred and reciprocal crosses between the "midget" pearl stock (mi, P) and the normal pearl ($+^{mi}$, p) population in which mi was discovered. Thus the various genotypes under study should have a similar background genome. Yet in isolating and reproducing the mi stock, genetic drift may have resulted in genetic differentiation at some loci.

In the first phase of this study, 25 random single pair matings were used to measure fecundity and hatchability for mi and $+^{mi}$ females mated to both kinds of males. In the second phase, other traits were measured in offspring from the same mating design used in phase 1 except three mass matings of 3 males by 3 females were used.

In phase 1, a 24-hour egg collection was taken in 2 g of standard medium from each mating. The eggs were counted, placed in sterile medium and cultured for one week at 33°C and 70% R. H. At that time, the larvae were screened from each collection and counted. Hatchability was calculated on a per mating basis as the ratio of number of larvae to initial number of eggs. Similar egg collection and culturing procedures were used to investigate the other traits, except the egg collections were cultured for 13 days. At that time a random sample of 16 larvae per mating were individually weighed, then placed in individual creamers containing .1 g of medium for additional observations. Beginning on day 15, the creamers were checked at 12 hour intervals to determine time to pupation. The pupae were then observed every 12 hours to determine adult emergence time. Pupae and adults were weighed 12 hours after they were observed. All weights and ages are expressed in decamicrograms (10 μg) and days, respectively.

The data were analyzed by analysis of variance and the Student-Neuman-Keuls procedure was used for mean separation tests provided a significant effect was indicated by analysis of variance.

RESULTS

Analysis of variance indicated significant ($P < .001$) differences among the four mating types for egg number with the mi females laying less eggs regardless of the males to which they were mated. However, no significant ($P > .25$) differences were detected among the mating types for either actual hatchability or the arcsin square root of hatchability. The agreement for the actual and transformed hatchability analyses was expected since most of the hatchability values were in the .4 to .7 range. The means their standard errors and significant differences are presented in Table 1.

Table 1. Means ± standard errors for egg number and hatchability for the four types of matings. Means with different superscripts are significantly ($P < .05$) different.

Mating Number	Mates by strain		Mean performance by trait	
	Male	Female	Egg numbers	Hatchability
1	pearl	pearl	$20.8^{1} \pm 1.3$	0.74 ± 0.06
2	midget	pearl	$19.2^{1} \pm 1.1$	0.62 ± 0.05
3	pearl	midget	$13.4^{2} \pm 1.0$	0.74 ± 0.05
4	midget	midget	$13.7^{2} \pm 0.9$	0.68 ± 0.04

Variation for each trait observed in phase 2 was analyzed on a within sex of offspring basis. Significant ($P < .01$) differences among genotypes for all traits studies were found. The mean values for the various genotypes are listed by trait in Table 2. In the hemizygous male, it is evident that mi reduces 13-day larval weight by over 100%. Pupal and adult weights also were inhibited, but to a lesser degree. Developmental rate as measured by pupation time and time to adult emergence was significantly reduced by the mi allele.

Table 2. Effect of the midget gene on various polygenic traits Means with different superscripts within each sex are significantly ($P < .05$) different.

Genotype by sex	Means ± standard errors by traits				
	Larval Weight	Pupatation Time	Pupal Weight	Emergence Time	Adult Weight
Males					
$+^{mi}/_{Y}$	$236^{1} \pm 10$	$16.6^{1} \pm .1$	$257^{1} \pm 5$	$21.0^{1} \pm .1$	$216^{1} \pm 4$
$mi/_{Y}$	$98^{2} \pm 6$	$17.9^{2} \pm .2$	$160^{2} \pm 3$	$22.5^{2} \pm .2$	$145^{2} \pm 3$
Females					
$+^{mi}/+^{mi}$	$223^{1} \pm 12$	$16.9^{1} \pm .2$	$270^{1} \pm 5$	$21.4^{1} \pm .2$	$228^{1} \pm 4$
$+^{mi}/mi$	$222^{1} \pm 11$	$16.8^{1} \pm .2$	$242^{2} \pm 7$	$21.3^{1} \pm .2$	$208^{2} \pm 6$
mi/mi	$81^{2} \pm 10$	$18.6^{2} \pm .4$	$162^{3} \pm 5$	$23.2^{2} \pm .4$	$145^{3} \pm 5$

The contrast between +mi/+mi and mi/mi genotypes in females followed closely the pattern observed in males. The female genotypes provided an opportunity to determine the degree of dominance manifested at the mi locus. In regards to 13-day larval weight and the two measures of developmental rate, the +mi/mi genotype did not differ from +mi/+mi and suggested complete dominance for the wild type allele. However, the heterozygote was intermediate for pupal and adult weights to suggest only partial dominance for gene action on these characters.

In conclusion, it is apparent that the mi gene locus has pleiotropic effects (at least at the secondary level) on several manifestations of growth and development. Also, the degree of dominance was found to vary with the scale chosen for measuring the action at this locus.

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The effects of "re-used" media on fecundity and larval weight of Tribolium

It is well known that highly conditioned media significantly influence the ecology of Tribolium cultures (Park, 1936). A question remains as to whether surplus or "once-used" media from quantitative studies, where by design the amount of medium per culture is optimum or in excess of any limiting factor, could be used again in subsequent experiments without detrimental effects on the trait under study. The present study investigates the effect of "re-used" media (not as highly conditioned as that used by Park) on fecundity and larval weight in T. castaneum.

MATERIALS AND METHODS

The genetic material used here represented our three heterogenous ramdomly mating foundation populations, "pearl", "black" and "+". The effects of standard, once-used and twice-used media were investigated. The standard medium is whole wheat flour enriched with 5% dried brewers yeast. Once-used medium was obtained by thoroughly mixing the "used"

medium collected by a vacuum system specially designed to separate beetles at any developmental stage from their culturing medium. The contents of the vacuum at this time had been collected from the following kinds of matings with approximate proportions: 1) single pair inbred pupal matings and their offspring after 28 days (60%), 2) single pair matings, 24 and 48-hour egg collections cultured for 13 days (20%), 3) 13-day larvae to pupation cultures (15%) and 4) mating creamers used to acclimate parents (5%). The matings indicated were made on standard media, approximatley 20 offspring resulted per mating and approximately 15% of the matings were sterile. Twice-used medium was obtained from mass matings of approximately 15 parents on 6 g of once-used medium for 28 days. These yielded about 60 offspring per mass mating.

Two independent replications of a 3 X 3 factorial design consisting of the 9 treatment combinations of media type by populations were conducted. Each replication was initiated with 90 males and 90 females randomly chosen from each population. Parents were ramdomly placed in their respective treatment media as pupae and at 10 days most emergence 30 ramdom single pair matings per treatment combination were made. A 24 hour egg collection in 2 g of the respective treatment medium was taken and cultured for 13 days at 33°C and 70% relative humidity. At that time all larvae were counted and a group weight on 15 ramdomly chosen larvae was taken in decamicrograms (10 µg). The number of larvae per mating and mean larval weights were analyzed by analysis of variance with a model including a ramdom effect due to replications, the fixed effects of populations and media types, their interactions and a ramdom residual (within) component to estimate error. Within medium types product moment correlation coefficients of larval number and average larval weight were calculated. The Student-Neuman-Keuls Procedure was used for mean separation tests provided a significant effect was indicated by analysis of variance.

RESULTS AND DISCUSSION

Analyses of variance (Table 1) indicate all main effects, except populations for larval number, were significant ($P < .01$). Means for both traits on standard medium were significantly greater than once-used media which were significantly greater than twice-used media (Table 2). The significant population differences for larval weight were ranked "pearl">"+">"black". Significant two-factor interactions indicate the effects of medium were not consistent over the 2 replications for larval number and larval weight; in addition for larval weight the effects of populations were not consistant over the 2 replications.

Notes - Research

In conclusion, it is apparent that even slightly conditioned once-used medium has a marked deterimental effect on fecundity and larval weight in T. castaneum.

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Toxicity of some metabolic inhibitors in Tenebrionid larvae

As a preliminary study for examination of metabolic pathways involved in repair of radiation injury, the toxicity of various metabolic inhibitors was determined for Tribolium castaneum larvae and Tenebrio molitor larvae. Larvae were raised in 96% autoclaved enriched white flour plus 4% brewers yeast (F-Y medium) at 30°C and 70-80% RH.

T. castaneum larvae were allowed to ingest media containing the various metabolic inhibitors. For preparation of test media, 1% mixtures of the inhibitors were made by adding 3 grams of inhibitor to 297 grams of F-Y medium and the mixtures were ground in a ball mill overnight. Three serial dilutions were then prepared, giving additional concentrations of .1%, .01%, and .001% for most inhibitors. In the case of caffeine 10% and 5% mixtures were also made up; in the case of ethidium bromide, the highest concentration made was .5%. Twenty 10-12 day old T. castaneum larvae were initially placed in 2 cm vials containing different concentrations of each test medium. After four days, 10 of the 20 larvae were removed from the test medium and returned to a vial of standard FY medium. The remaining larvae were kept on the test medium for the full extent of the experiment (40 days). Thus for each inhibitor, the maximum concentration that was sublethal could be determined for both short term and long term exposure. The data are shown in Table I.

The metabolic inhibitors, dissolved in autoclaved insect ringer, were injected into CO_2-anesthetized T. molitor larvae. A 30 gauge hypodermic needle, attached to a polypropylene micrometer syringe, was inserted between the 4th and 5th segments and directed anteriorly; a volume of 3 ml was injected in each case. The maximum concentrations found to be sublethal were .5% KCN, .2% solium azide; .1% sodium arsenate, 2.0% caffeine, and .5% ethidium bromide.

TABLE I

Ingested Toxicity Determinations for T. castaneum Larvae

Chemical	Sublethal Concentration (4 day exposure)	Sublethal Concentration (40 day exposure)
caffeine	5.0%	1.0%
acriflavin	1.0%*	1.0%
ethidium bromide	0.5%*	0.5%
crystal violet	0.1%	0.01%
lead acetate	0.01%	0.001%
rotenone	0.01%	0.001%
potassium cyanide	1.0%*	1.0%
sodium azide	.01%	0.001%
sodium arsenate	.01%	0.001%

*highest concentration prepared

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Photic effects on the fecundity of Tribolium castaneum, a preliminary report

Light plays a major role in the biology of many organisms including certain members of the family Tenebrionidae. The mealworm Tenebrio molitor, and the flour beetles Tribolium castaneum and Tribolium confusum are photo-negative in the larval and adult forms (Cloudsley-Thompson, 1953; Good 1936; and Stermer, 1959). In a 24-hour cycle of 12hr-light and 12hr-dark, locomotor activity of Tenebrio occurs exclusively during the dark period (Fondacaro and Butz, 1970). However, when populations of Tenebrio molitor and Tribolium confusum are placed under conditions of constant darkness, temperature, and humidity, their physical activities become arhythmic, (Cloudsley-Thompson 1953; Park and Noskin, 1947). In view of the numerous reports

Egg numbers were significantly lower in continuous light for each day of treatment. Also, the number of eggs was significantly lower for Day 1 than for Days 2 and 3 under both photic conditions. Clearly, continuous light creates at least an initial sub-optimal environment for egg production in T. castaneum. This photo-negative response may be analogous to that found in Tenebrio by Cloudsley - Thompson where the photo-negative response disappears a short time after exposure to bright light. If a similar response is occurring here, one might expect a decrease in this effect over days with a subsequent increase in the biological activity of egg production. It appears in Table 1 that such was the case. The difference between egg numbers in "light" and "dark" declined on successive days (5.25, 4.74, and 3.45) and egg production in the former seems to be converging toward the more optimal rate observed in "dark".

In summary then, this investigation indicates that light is an important factor in the biological activity of Tribolium with respect to egg production. Hence, this environmental factor should be taken into consideration when investigating this or other traits possibly influenced by differential activity among experimental groups.

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*The effects of yeast on growth in Tribolium castaneum

It has been shown that yeast supplementation enhances growth and

survival in Tribolium confusum. (Bushnell, 1938; Bushnell and Lund, 1939; Charbonneau and Lemonde, 1960). Sokoloff et al. (1966) found that productivity of T. castaneum and T. confusum was increased by the addition of yeast. Wilson (personal communication), trying to find a suitable stress environment for T. castaneum, collected eggs from a population maintained on a standard medium of 95 % whole wheat flour with the bran removed and 5% brewer's yeast. Larvae from these eggs were grown on this medium and a flour medium without the added yeast. He found no difference between the thirteen day weights of the larvae grown on the two media (Table I). The present study deals with a test of these two types of media throughout the entire life cycle and over three successive generations in T. castaneum.

Three populations were tested: the Purdue Pearl Foundation, the Purdue Black Foundation, and the Purdue Plus Foundation. Each population was divided into two groups: one grown on the standard flour medium and the other on the unsupplemented flour. Twenty-five single pair matings per group were placed in 3/4 ounce glass creamers with one gram of medium type and placed in the control chamber at 91°F. and 70% relative humidity. On the third day, each mating was put in one gram of fine medium for a twenty-four hour egg collection. After the egg collection, the eggs were put in two grams of medium and placed in the control chamber. Fourteen day larval weights were obtained for groups of ten individuals from twenty families. The unit of measurement was tens of micrograms. Larvae were then placed in two grams of their respective medium to pupate. Between seventeen and twenty-three days, the pupae were sexed and weighed. All pupae of one sex within a treatment-population group were placed in a single creamer and held for parents of the next generation. Selection and mating of potential parents were random. A second replication was started two weeks after the first. Family means were adjusted for differential numbers of males and females by adding one unit to the mean for every male over five males or by subtracting one unit for every female over five.

Although egg production on the yeast supplemented media was higher (Tables II and III), there was little difference in hatchability, which varied from 74% to 88% for the three populations on flour in the two replications and from 75% to 89% for the three populations on the media. The three populations showed a higher fourteen day larvae weight when grown on the flour alone, (Table IV). This difference was significant $F > F_{.01}$, as was the effect of successive generations, again $F > F_{.01}$. There appeared to be no difference in the proportion of larvae that pupated nor in the pupal weights, (Table V), but it was noted that the larvae on the flour took longer to pupate. Pupation time on the standard medium was seventeen to twenty-one days while the time needed on the flour was nineteen to twenty-three days.

The results of the above experiment were significantly different from Wilson's orignial study. There was a difference in the design of the two studies. In the original, eggs were collected on a normal diet, while in the latter, larvae that were grown on flour came from eggs that were collected on unsupplemented flour. Because of this, it was decided to rerun the preliminary study.

Mass matings of Purdue Plus Foundation were made in plastic populations boxes, one half on the standard medium and the other on the unsupplemented flour. Five hundred eggs from each box were divided into groups of twenty-five and placed in twenty creamers of standard medium: another five hundred eggs were similarly divided and placed in flour. Thirteen day larval weights were obtained for the first ten creamers in each treatment group, and fourteen day weights were obtained for the last ten in each group. The larvae were not held for pupation.

The results of the replication of Wilson's original study show that there is a significant difference in thirteen and fourteen day larval weights for the larvae from eggs laid on standard medium and grown on flour, and the larvae from eggs laid and grown on media, but this difference is not as great as that between the larvae from eggs laid and grown on flour, and the larvae from eggs laid and grown on media (Table VI).

It seems evident that when eggs are collected on yeast supplemented flour and the larvae are grown on unsupplemented flour, there is a carry-over effect that significantly increases growth as compared to the growth, on unsupplemented flour, of larvae hatched from eggs collected on unsupplemented flour.

Table I. Preliminary nutrition experiment, 13-day larvae weights on the Purdue Plus Foundation Stock and 19-day pupae weights taken on the same larvae that were weighted.

	100% Flour				95% Flour-5% Yeast			
Group	Larvae		Pupae		Larvae		Pupae	
	#	Average Weight	#	Average Weight	#	Average Weight	#	Average Weight
1	24	118	23	213	25	117	19	239
2	30	122	30	222	24	116	21	233
3	25	107	23	211	24	118	23	220
4	21	113	19	221	24	120	24	228
5	24	116	24	222	23	121	22	231
6	23	125	19	221	19	124	18	231
7	31	120	30	214	21	118	19	226
8	29	123	28	221	24	116	20	226
9	25	115	21	221	28	117	24	229
10	24	114	22	213	18	111	16	214
$\bar{x}$	26	118	24	218	23	118	21	228

Table II. Nutrition experiment using Purdue Pearl Foundation, Purdue Black Foundation, and Purdue Plus Foundation Stocks. The number of eggs and larvae for Replication I.

		Flour		Media	
Population	Generation	# Eggs	# Larvae	# Eggs	# Larvae
Pearl	1	518	446	668	522
	2	376	310	499	373
	3	448	388	628	472
Black	1	526	464	718	560
	2	401	319	461	372
	3	489	386	611	505
Plus	1	606	481	593	487
	2	434	329	624	501
	3	401	295	557	435

Table III. Nutrition experiment using Purdue Pearl, Black, and Plus Foundation Stocks. The number of eggs and larvae for Replication II.

		Flour		Media	
Population	Generation	Eggs	# Larvae	# Eggs	# Larvae
Pearl	1	520	441	617	493
	2	404	323	631	523
	3	465	406	656	536
Black	1	425	345	613	475
	2	553	442	618	525
	3	498	390	645	573
Plus	1	513	431	525	456
	2	387	330	594	466
	3	406	330	550	452

Table IV. Nutrition experiment using Purdue Pearl Black and Plus Foundation Stocks. The number of individuals weighed and the average 14-day larvae weight.

			Rep 1		Rep 2	
Pop	Gen		no. indiv.	ave. weight	no. indiv.	ave. weight
Pearl	1	flour	200	202	200	204
		media	200	281	200	288
	2	flour	195	147	199	171
		media	191	300	200	290
	3	flour	200	155	200	172
		media	200	286	200	285
Black	1	flour	200	136	181	151
		media	200	198	200	211
	2	flour	196	102	200	211
		media	163*	200	200	213
	3	flour	200	107	200	119
		media	200	192	200	191
Plus	1	flour	200	162	200	157
		media	200	227	200	230
	2	flour	195	122	199	123
		media	200	215	200	229
	3	flour	193	110	196	130
		media	200	216	200	219

Table V. Nutrition experiment using Purdue Pearl, Black and Plus Foundation Stocks. The number of individuals weighed and the average 17 to 23-day pupae weight.

Pearl	1	flour	200	260	200	252
		media	200	272	194	270
	2	flour	193	267	197	261
		media	190	287	200	274
	3	flour	196	264	198	261
		media	199	283	200	272
Black	1	flour	200	248	200	228
		media	199	236	199	235
	2	flour	192	253	185	248
		media	163*	242	200	244
	3	flour	198	246	200	237
		media	200	248	199	251
Plus	1	flour	198	224	199	213
		media	196	221	200	220
	2	flour	188	231	199	224
		media	200	227	200	232
	3	flour	189	229	195	223
		media	199	230	200	228

* only 17 families represented.

Table VI. Replication of preliminary nutrition experiment, comparing the effects of the environment on which the parents are mated and the environment on which the larvae are grown for 13-day and 14-day larvae weights on the Purdue Plus Foundation.

			Eggs Laid on: Flour		Media	
			13 day	14 day	13 day	14 day
Larvae grown on	flour	no. of ind.	213	201	219	220
		ave. wt.	89	126	115	170
	media	no. of ind.	223	214	200	216
		ave. wt.	132	212	128	202

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Simultaneous changes of phenotypic variance and selection differentials in a selection experiment with Tribolium castaneum.

Pupal weight was selected upward and downward for seven generations with different degrees of inbreeding. It was noted that the phenotypic variance generally decreased with selection (Table 1). A reduction in phenotypic variance can be caused by two things, an increased uniformity of genetic make-up or a refinement of the micro-environment. Since the dry environment at 40% relative humidity (R.H.) and the wet environment at 70% R. H. were well controlled, the reduction in phenotypic variance was more probably due to increased genetic homogeneity of the selected population than to systematic shifts in the environment. However, on the contrary, it would appear that the phenotypic variance has also decreased on the control line. Therefore, considerations are limited to the phenotypic rather than the genetic or environmental levels.

If the weights are normally distributed, and an equal proportion is selected in each generations, then a reduction in phenotypic variance should be accompanied by a corresponding reduction in the selection differential. However, it was found that the signs of the regressions of the selection differential on generation mean (Table 2) are positive for all except two of the selected lines and two of the control lines. Allowing for the expectation of essentally no directional selection in the control line, this trend suggests that both downward and upward selection in the control line, this trend suggest that both downward and upward selection were accompanied by an increase in the selection differential.

Further investigations revealed that the increase of the selection differential occurring simultaneously with a reduction in phenotypic variance may be interpreted by the distribution of the family means of the selected lines. It was found that the estimated parameters for the degree of kurtosis (β_2) was significantly less than 3 for all lines after seven generations of selection (Table 3). Such deviations from normality imply that the distributions are platykurtic or more flat-topped than the normal curve. In such a distribution the frequencies at the "shoulder" regions are higher than expected in a normal distribution (Fig. 1). Such changes in the distribution allow for a trend toward reduced phenotypic variance accompanied by an increase in the selection differential.

Table 2. The regression coefficients of selection differential on generation mean.

Direction of selection	Degree of inbreeding	Replication I Dry	Replication I Wet	Replication II Dry	Replication II Wet
Downward	Full sib	0.2088	0.1671	0.0587	0.1509
	Half sib	0.0069	0.0774	-0.3579	-0.0372
	Double first cousin	0.2362	0.1059	0.4151	0.1512
	Minimal inbreeding	0.5579	0.2508	0.2180	0.0408
Upward	Full sib	0.6252	0.1064	0.2895	0.1334
	Half sib	0.2744	0.2353	0.4129	0.1711
	Double first cousin	0.3278	0.2100	0.1216	0.2442
	Minimal inbreeding	0.1381	0.1049	0.1736	0.1004
Control		-0.3695	0.0099	-0.2742	0.7361

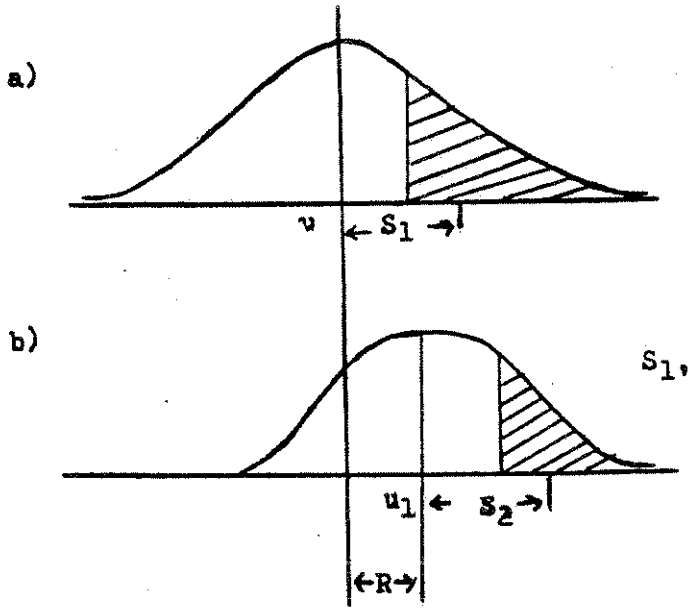
Table 3. β_2* estimated from generation seven of each selected line.

Direction of selection	Degree of inbreeding	Replication I Dry	Replication I Wet	Replication II Dry	Replication II Wet
Downward	Full sib	0.5088	0.1488	0.2046	0.2383
	Half sib	0.1459	0.1726	0.1743	0.2053
	Double first cousin	0.2067	0.1719	0.1392	0.1309
	Minimal inbreeding	0.2658	0.1400	0.1476	0.2368

Direction of selection	Degree of inbreeding	Replication I Dry	Replication I Wet	Replication II Dry	Replication II Wet
Upward	Full sib	0.1805	0.1942	0.2101	0.1581
	Half sib	0.1878	0.1829	0.2365	0.2395
	Double first cousin	0.1248	0.2068	0.1388	0.1669
	Minimal inbreeding	0.2046	0.1796	0.1951	0.2256
Control		0.0770	0.1206	0.0855	0.1043

$^{*}\beta_2 = \mu_4 / \mu_2^2$

Fig. 1. The possible effect of platykurtosis on selection differential. a) a normal distribution with greater variance but smaller selection differential, b) a platykurtic distribution with lower variance but a larger selection differential.



R: the response to previous selection

S_1, S_2: the selection differentials, $S_2 > S_1$

Table 1. Average phenotypic standard deviation of different lines over replications and environments.

Direction of selection	Degree of inbreeding	Generation 1	2	3	4	5	6	7
Downward	Full sib	128	118	113	119	98	129	69
	Half sib	135	116	120	113	122	86	94
	Double first cousin	121	135	119	125	122	98	76
	Minimal inbreeding	144	150	87	109	110	99	96
Up-ward	Full sib	149	140	149	127	107	109	111
	Half sib	139	140	122	103	111	107	118
	Double first cousin	156	121	116	133	114	104	113
	Minimal inbreeding	146	119	107	108	98	101	100
Control*		152	128	134	121	121	110	94

*Random selection with minimal inbreeding.

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*A study of the effects of irradiation on the developmental stages of T. brevicornis

INTRODUCTION

Mice, guinea pigs, and rabbits have been examined after irradiation with gamma rays (Zirkle, 1954). The life spans of rats and wasps were reduced when the young of each species were treated with x-rays. It has been postulated that radiation reduces the life span by inducing somatic mutations (Lamb and Smith, 1964). Such somatic mutations can often be seen in malformations which produce lethal effects.

This experiment is primarily concerned with the immediate lethal effects in the flour beetle Tribolium brevicornis, rather than prolonged studies, simply because of the time factor. The selection of T. brevicornis was primarily based on the size of the beetle as compared to the related species T. confusum and T. castaneum which are smaller in size. Although all three species were available, the choice of T. brevicornis was partially due to the lack of previous investigation of this species.

The effects of ionizing radiation on insects vary according to the order, genus, species, developmental stage, and criteria employed (O'Brien and Wolfe, 1964). No systematic investigation of the beetle T. brevicornis has appeared in radiation literature. Insects, having complete metamorphosis, offer a unique opportunity to study the irradiation of different developmental stages, which cannot easily be done with mammals, because their embryos are usually hard to control and observe (Yang, 1968a.). Growth from the egg to the imago involves a complex metamorphosis, accompanied by a series of larval stages and a pupal instar (Yang, 1968b.). One might consider the larva a free-living embryo, since specific groups of larval tissue form the adult organs (Yang and Ducoff, 1969). These tissues are referred to as "imaginal discs". The degree of damage in the imaginal discs probably accounts for the lethal or non-lethal malformations in the developing adult.

The size of the T. brevicornis offers a beetle that is readily observable, and yet small enough to eliminate problems of uneven irradiation (Yang, Frigerio, and Sampson, 1969). In the experiment, eggs (1-24 hours), early larvae and late larvae (differentiated strictly by size and coloration), and pupae, were irradiated at a single level of 1000 Rads, chosen because the value was intermediate between the lethal doses of each stage.

MATERIALS AND METHODS

The T. brevicornis used in this study were obtained from the stocks of A. Sokoloff. The beetles were kept in a whole wheat flour and yeast media which had been run through the fine sifter. Approximately fifteen grams were placed in plastic creamers with cardboard lids. There were five creamers each of irradiated eggs, early larvae, late larvae, and pupae. One control creamer was established for the early larvae, late larvae, and pupae. Since it was expected that the egg stage is the most sensitive to

radiation, five controls were used rather than one as for the other stages.

Each creamer housed twenty individuals of the particular developmental stages. Therefore, there was a total of one-hundred irradiated of each stage, twenty control for the early larvae, late larvae, and pupae, and one-hundred control eggs. The organisms all remained at room temperature the same length of time before being stored at 32°C.

Initially, the adult beetles were separated from the larvae and pupae with a camel's hair brush after the flour had been sifted away. The larvae and pupae were removed to separate containers. The adults were placed in fresh flour for egg collections. Four days were required for a sufficient number of eggs (1-24 hours) to be laid. This was probably the result of the stock beetles being stored in old flour. When they were transported to fresh flour, they were busy eating and not laying eggs. The eggs were collected by sifting the flour media through the coarse sifter to remove the adults, and through the fine sifter to separate the eggs from the flour. The residue in the fine sifter was placed on black construction paper, and examined under a dissecting scope for eggs, which were placed in a covered petri dish until irradiation.

The larvae were distinguished by size and color. The smaller and lighter being early, and the larger and darker being late larvae. The lighter colored pupae were selected.

Irradiation was done one stage at a time. When the irradiation was occuring, the controls were left out at room temperature. A source of Cs^{137} was used in the experiment, and its deterioration was taken into account. The specimens received 18,800 Rads/hour for three minutes and twelve seconds or approximately 1,000 Rads.

Weekly observations were made on the development of the stages, and the number of emerged adults was recorded. Any progeny were removed to a new creamer to prevent any confusuion resulting from their presence. The adults were counted after sifting the flour off of them.

Larvae and pupae were considered dead when there was a lack of movement, as well as a dry and dark colored appearance. The adults were assumed dead when there was no movement in response to tactile stimuli, and the color of the beetles changed to a very dull, deep brown. Here it should be noted that the flour beetle often plays opossum, especially when it is young.

RESULTS

Generally, the irradiated stages were slower to emerge than the controls. After a few weeks, the irradiated stages caught up with the controls. The adults that died in the controls were generally well-formed adults. However, the deaths that occured in the irradiated specimens were of underdeveloped or malformed adults. The elytra were often not completely formed and posterior regions were dried and shriveled in appearance. Below, the percentages are recorded for the different stages of development of the irradiated and the controls.

Stage	Group	Dates of count: 10-29	11-4	11-12	11-22	11-30
		Percentages				
*eggs	control		larval	larval	77%	75%
	irradiated		trails	trails	14%	14%
early larvae	control	pupae have	15%	70%	85%	stable
	irradiated	formed	6%	49%	81%	
late larvae	control	pupae have	0%	90%	95%	stable
	irradiated	formed	3%	89%	95%	
pupae	control	60%	90%	95%	stable	stable
	irradiated	46%	89%	90%		

* It should be noted that the percentages here are of larvae, since the adults had not yet emerged. However, the other stages are in terms of emerged adults.

The greatest effect of radiation was exhibited by the eggs (1-24 hours). There was approximately a 60% decrease in emergence of larvae between the irradiated eggs and the controls.

In the early larval stage, the emerged adults from the control eggs outnumbered the emerged adults from the irradiated group during the three weeks post-irradiation. However, by the fourth week, the adults in each group were within 5% of each other.

In the case of the late larvae, the percents of adults were equivalent in each sample. In changing from the late larva to the pupa, a period of great somatic cell growth occurs. From this, it was expected that the effects of radiation would be greater than was observed. The variation in the experimental results from the anticipated results could be explained by the possibility of insufficient dosage.

The results indicate that the eggs were the most highly susceptible to the effects of 1000 Rads. Acording to the results, the late larvae exhibited the greatest resistance to the given dosage. The other stages were intermediate between the eggs and the late larvae. The pupal stages differed initally by nearly 15%. Here again the control pupae emerged sooner than the irradiated, but the irradiated pupae eventually approached the number of controls. The pupae possess protective cases which may be less permeable to irradiation than soft skin layers.

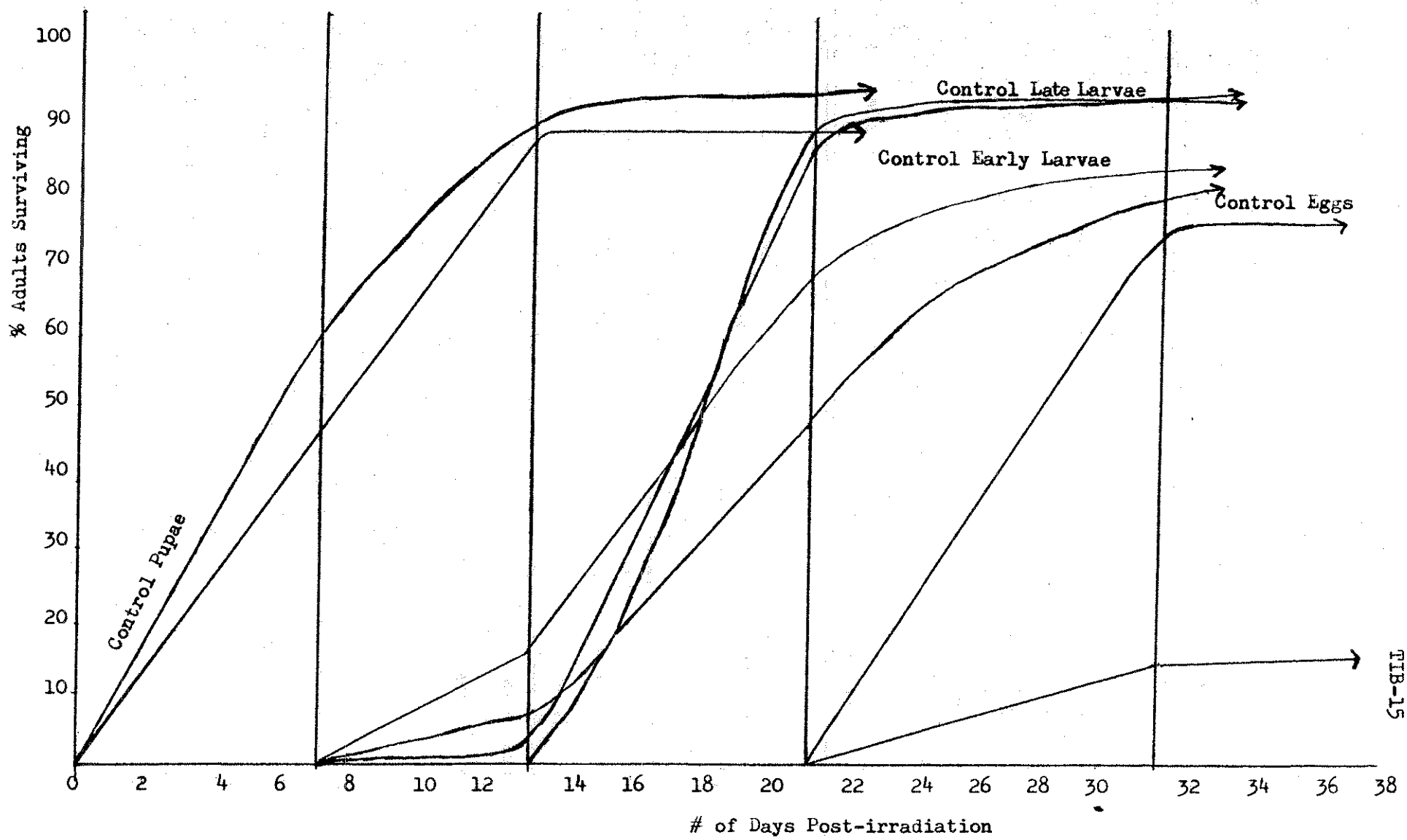
Generally, the developmental stages were progressively more viable from the egg to the pupa. In embryogenesis, the first few weeks are more critical to the survival of the embryo than later periods of development. Perhaps this would account for the decreased viability of the egg.

DISCUSSION

Since no previous experiments have been done with T. brevicornis and

Adults vs Days Post-irradiation

*Note: Adults have not yet developed from the egg stage, so the egg results are in larvae.



the effects of irradiation, the literature surveyed dealt mainly with related species of Tribolium. Closely related species will have comparable rates of cell division and sequences of development, so differences at specific stages would provide a bases for special features of differentiation (Erdman, 1966b).

T. confusum and T. castaneum have been studied and compared for radiosensitivity (Erdman 1965). T. castaneum was found to have greater variability (Erdman, 1966a). Although the two species had similar biology, they differed radiologically (Erdman, 1963). T. confusum was proved to be more sensitive to radiation exposure than T. castaneum (Erdman, 1966b). From this research, it can be seen that various species of Tribolium have different radiosensitivities, and thus, the information on T. castaneum and T. confusum must be regarded with this in mind when it is being applied to work with T. brevicornis.

The results of Sokoloff (1966) and Erdman (1966b), are consistent with the results obtained in this experiment regarding the sensitivity of the egg stage. Erdman (1966b) observed that the 1 - 3 hour eggs were most radiosensitive, which he explained by the fact that this is a highly mitotic period. Since the nucleus is rapidly dividing and undifferentiated, this would be the weakest link in the life cycle. Tilton (1966) found in his studies that after the eggs were irradiated with 13.2 krads, they hatched, but after three weeks, all larvae were dead. After exposing eggs to gamma irradiation, an extended larval stage was noted (Yang, 1968a).

Yang and Ducoff (1969) and Erdman (1965) determined that there was decreased resistance in the larval stage after fifteen days. Mortality during the larval stage was rare, but mortality between pupation and a time shortly after eclosion was frequent (Yang and Ducoff, 1969). As the dosage was increased from 3.0 to 5.0 kR, the number of deaths at pupation and during the pupal period was increased (Yang and Ducoff, 1969). Yang (1968c) found that the radiosensitivity of the adult increases as the dose given at the larval stage increased.

In the pupal stages, increased radiation decreased the number of individuals that emerged to adults (Erdman, 1966c). The sensitivity of pupae decreased as they reached adulthood (Erdman, 1965).

In each stage, many studies noted numerous and varied types of malformations in the adult. Some individuals failed to metamorphosize completely (Erdman, 1966c). Although the head and thorax developed, the elytra and abdomen remained pupal-like (Erdman, 1966c). Beck (1963) and Ducoff (1963) studied the deformity of the adult wing after irradiation during the pupal stage and during the larval stage. They found that the wing abnormality of the adult is a consequence of irradiation of the larva. Severity of wing deformity was a function of the dose. Sokoloff (1966) observed blistered elytra, deformed forelegs, split elytra and pink eyes mutations in descendants of irradiated adults.

The differences in sensitivities in eggs, larvae, and pupae indicate the differences in dividing and non-dividing cells (Erdman, 1966b). In the insect egg, which is a closed system, any delay in hatching would reflect a growth delay of the embryo. This hatching delay was found to be proportional to the radiation level (Yang and Sacher 1969).

The lethality of the individuals showed no differences dependent on sex (Erdman, 1966c). However, a pronounced effect of age was demonstrated on radiosensitivity (Yang and Ducoff, 1969). In eggs and pupae, the sensitivity was an inverse function of age (Yang and Ducoff, 1969).

The causes of mortality remain essentially unknown. It is known that the irradiated individuals feed after exposure, so starvation is not a cause of death (Erdman, 1966c). Erdman (1966c) believes that mortality is the result of a chemical aberration in the cytoplasm, but concedes that nuclear and cytoplasmic effects are hard to separate. Generally, more data is required to determine what the actual causes of death are.

For more concrete data on T. brevicornis, numerous other experiments should be completed. Further study could be done at different levels of radiation for the different developmental stages to determine death rates and lethal effects. Studies can be performed with conditioning doses in the developmental stages to determine if life spans are increased. The data in this experiment have not even touched on adult irradiation, and effects on the progeny. The discussion of new studies to be done with T. brevicornis and irradiation could go on indefinitely. It is obvious that this field is open to a great deal of research.

CONCLUSION

From this study of T. brevicornis irradiation, it can be concluded that the egg (1 - 24 hours) is the most sensitive stage to irradiation. This sensitivity is probably a result of the rapid cell division that is occurring at this stage. The late larval stage proved to be the least sensitive, which is not consistent with other studies. However, since T. brevicornis is a relatively new experimental species, further research must be done to show decisively the resistance of the late larvae. Possibly, the late larvae were not close enough to pupation to show increased cell division, but were intermediate between the rapid growth of early larvae and the pupal stage. This would account for the increased resistance of late larva. The sensitivity of the early larvae and pupae were inbetween the egg and late larvae sensitivities.

The radiosensitivity appeared to be the consequence of cellular growth occuring in the particular developmental stage. Periods of great cell growth had high sensitivities, whereas periods of little cell growth had high resistance. At times, the radiation appeared to halt certain parts of metamorphosis, and incomplete individuals resulted.

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*Observations on the life history of Tribolium brevicornis

The time lapse from the initial egg stage to the adult is important for any study on a particular organism. In a developmental study the length of time of the life cycle is necessary data.

In Tribolium brevicornis, a larger beetle than T. castaneum and T. confusum, a longer life cycle would be anticipated, strickly because of the size factor.

T. brevicornis eggs were collected from one to twenty-four hours old and twenty eggs were placed in fifteen grams of whole wheat flour and yeast in plastic creamers with cardboard lids. One hundred eggs in all were transferred to five creamers. The environmental conditions of the eggs were a temperature of 32°C. and humidity of 20-25%. Weekly checks were made on the progress of the developing eggs until the first pupae were noted, then checks were made every other day.

The following chart indicates the results obtained in the study.

		Creamer				
Days	Stage	A	B	C	D	E
7	eggs	20	20	20	20	20
13	larval trails were present in each creamer					
21	larval trails were present in each creamer					
31	larvae	17	16	18	15	11
39	larvae	16	16	18	14	11
45	pupae were present in all creamers					
52	adults	1	0	0	0	0
54	adults	2	2	0	0	1
56	adults	0	0	0	3	1
59	adults	7	11	7	7	6*
61	adults	2	1	6	3	3
63	adults	4	2	5	1	1
Total	adults	16	16	18	14	12
Percentage		80%	80%	90%	70%	60%

*At 59 days the greatest number of adults emerged.

From the initial one hundred eggs, seventy-six adults emerged or 76% of the eggs reached adulthood, in fifty-two to sixty-three days. Thus, the life cycle of Tribolium brevicornis was completed in approximately sixty days or two months.

The greatest decrease in the number of individuals occurred between the egg and larval stages, indicating that this was the most susceptible period in the life cycle of T. brevicornis.

Notes - Research

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*Homosexual behavior related to a melanic mutant in Tribolium castaneum

In the course of arena observations on sex behavior it was convenient to use beetles which could be easily distinguished. For observations on the frequency and duration of mountings the standard procedure in this laboratory is to use males of one phenotype (such as a melanic mutant form) with wild type females and to repeat the observations using the reverse configuration.

When jet males were used it was grossly obvious that most of the mountings were of males although the sex ratio was unity. In the reverse situation the mountings by wild type males were about half on males and half on females. In an experimental situation with 10 males and 10 females one would expect 53% of the mountings to be heterosexual. The existence of homosexual mountings has been well known to Tribolium workers for decades. Taylor and Sokoloff (1971) indicated a low frequency of homosexual mountings. Sinnock (1970) reported a slight proponderance of homosexual mountings in a brief observation series using Chicago black beetles.

On the basis of this preliminary information we carried out an extensive series of observations of mountings. Here 10 males and 10 females were observed for 5 minute periods in an arena 10 cm in diameter. In the case of jet males 2,897 mountings were observed - 2,178 of these were homosexual. The approximate 99% confidence interval for the proportion is from 71.3 to 78.5. Of 899 mountings by wild type males 401 were homosexual. The approximate 99% confidence interval for the proportion homosexual is from 40.6 to 49.5. Recall that the proportion expected if mounting is indiscriminant is 45%.

In a preliminary check on the genetics of the phenomenon we made use of a stock of jet-pearl beetles which had been isolated from the original stocks for 5 years. To date 393 mountings have been observed by the jet-pearl males and 67% of these have been homosexual. On the basis of this information our tentative interpretation is that either jet has a sex behavior manifestation or there is a closely associated gene responsible for this remarkable behavior. At this point it would seem very desirable for such observations to be extended to other allelic series.

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Notes - Research

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*Effect of PTC on survival of Tribolium castaneum adults

The effect of different concentrations (0.5, 1.0, 2.0, 4.0, and 50%) of the phenyl-thio-carbamide old) was studied. Normal medium (95% whole wheat flour and 5% dried yeast) was used as control. The adults were left in the medium for seven days.

Table I. Survival of T. castaneum adults on medium supplemented with PTC

PTC %	No. of adults	% dead after 7 days
0.0	285	0.0
0.5	93	7.5
1.0	100	9.0
2.0	115	23.5
4.0	97	16.5
50.0	183	34.7

In examining the percentage of dead adults (Table I.) it is obvious that PTC has a disturbing effect on T. castaneum beetles. Increasing the concentration on PTC increased the percentage of dead adults. It has been also observed that the beetles were highly cannibalistic in the presence of PTC where different parts of the dead adults were found missing. This cannibalistic tendency increased by increasing concentration of PTC. Since for a given treatment all beetles were reared together, it is not clear whether the main cause of death was due to the direct toxic effect of PTC or the increase in cannibalism.

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*Choice between normal and PTC supplemented media by adults of Tribolium castaneum

A simple Y-shape maze (6.5 cm = lenght of each of the three arms and

2.5 cm in diameter with 5 cm high and one cm central funnel) made of glass was used to test the preference of adults of T. castaneum for normal medium (95% whole wheat flour and 5% dried yeast) or normal medium supplemented with various concentrations of phenyl-thio-carbamide (PTC) (0.0, 0.5, 1.0, 2.0, and 4.0). All adults were sixteen-weeks old. The beetles remained in the maize for 6 days and the experiment was run at room temperature (about 22° C.). The results of the preference reported in Table I are based on the total of two replicates for concentrations 0.5 to 5% PTC and three replicates for the control.

Table I. PTC preference of Tribolium castaneum adults

PTC %	Number of Beetles				Percentages		
	normal	PTC	Source	Total	normal	PTC	Source
0.0	286	254	155	695	41.2	36.6	22.3
0.5	31	52	16	99	31.3	52.5	16.2
1.5	57	27	15	99	57.6	27.3	15.15
2.0	47	39	12	98	48.0	39.8	12.24
4.0	82	9	5	96	85.4	9.38	5.21

The difference between the number of beetles that went to the right (286) or the left arm (245) of the maze was not significant for 0% PTC. However, supplementing the medium by 0.5% of PTC seems to attract more beetles than the normal medium. This tendency was reversed by increasing the amount of PTC in the media.

The number of beetles that remained at the source end of the maze tend to decrease by increasing the amount of PTC from zero to 4%.

To the best of our knowledge this is the first observation on a probably olfactory effect of PTC. However, a preliminary test on six human families with a total of 40 members indicates that although nine individuals could not taste PTC, all of them could smell it.

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Observing growth and development of Tribolium castaneum larvae without handling

Newly hatched larvae grown singly in a thin layer of flour carpeting the bottom of a small dish, such as a syracuse dish, appear to grow and develop normally. Under these conditions, the larva cannot burrow into

the flour out of sight. Thus it may be observed at will, as frequently as necessary, without the necessity of handling. This is a distinct advantage because Mertz (1970, Ecology, 51:989-998) has shown that excessive handling tends to slow development.

The accompanying table shows the developmental data on thirty larvae that hatched within a one hour period beginning at 4:30 P.M. on day 0 and kept in an incubator at 29°C and 70% relative humidity in stone-ground whole wheat flour with 5% brewers yeast added. On each of the following days, observations were made in the morning and evening. The presence of an exuvium indicated that a moult had occurred; tracks in the flour indicated acitivity. The exuviae could be removed and the tracks obliterated with a small brush. If necessary, additional flour was added from time to time. When these larvae reached the pupal stage, 19 were identified as males and 11 as females. A chi-square goodness of fit test showed that this deviation from a 1:1 sex ratio was non-significant ($.5 > P > .1$).

Although the larvae were raised under uniform conditions there was a variation in the total number of larval instars. In most cases there were seven but 5 males and 1 female pupated after only six larval instars. A Fisher's exact test applied to these data shows that the observed difference in the frequency of occurrence of such individuals among the two sexes is non-significant, the one-tailed probability being P=.26. Those individuals with only 6 larval instars tend to have a shorter overall developmental period. If only those individuals with 7 instars are considered, there is no difference in the developmental periods of males and females, the average hatching-to-emerge time being 28.7 days for the 10 females and 28.5 days for 13 males. (One male - No. 21 - was not included in this calculation because it behaved in a peculiar fashion. Towards the end of the 7th stadium it entered a quiescent pre-pupal period. After 2 days it became active again for several days before entering the pre-pupal period a second time, emerging as an adult after 32 days.) This variation in the number of larval instars even under uniform conditions may be largely responsible for the bimodal distribution of emergence times described by many authors including Sokal and Sonleitner (1968, Ecol. Monogr. 38:345-379).

It can also be seen from the table that the so-called quiescent pre-pupal period is simply the last 2-2½ days of the ultimate larval stadium. Presumably during this period the internal reorganization of the individual is progressing. A similar quiescent period of much shorter duration (only a few hours) occurs immediately prior to each larval moult as the final development of the new exoskeleton proceeds.

No mortality occurred in this group of larvae because they were grown singly. When larvae are cultured together in this way, mortality does occur, only one out of the several in the same dish ultimately surviving. Although they tend to aggregate in the same portion of the dish, a larva dish, a larva tends to avoid other active larvae. On the other hand, if a larva is in a quiescent pre-moult or pre-pupal state, then an active larva does not hesitate to cannibalize the quiescent individual. I have observed an active large larva curled around a pre-pupa, chewing on it. Thus when several larvae are kept in the same dish, eventually all but one are cannibalized when they enter a quiescent period. This is a situation similar to that occurring with other highly cannibalistic insects as anyone who has

Notes - Research

Table I.

females

day (eggs hatched: 4:30 - 5:30 P. M. on day 0)

Indiv.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
1	-1	2**	--	--	--	3-	--	--	4-	--	5-	--	--	6-	--	--	7-	--	--	qq	qq	qP	--	--	--	--	--	--	A_y			
6	-1	2-	--	--	--	3-	--	-4	--	--	5-	--	--	6-	--	--	7-	--	--	-q	qq	qq	P-	--	--	--	--	--	--	A_y		
11	-1	2-	--	--	--	3-	--	--	--	4-	--	5-	--	-6_m	--	--	--	7-	--	--	qq	qq	P-	--	--	--	--	--	--	A_y		
13	-1	2-	--	--	--	3-	--	-4	--	--	5-	--	-6	--	--	--	7-	--	-q	qq	qq	P-	--	--	--	--	--	--	--	A^{m}_{b}		
20	-1	2-	--	--	-3	--	--	4-	--	-5	--	--	-6	--	--	--	7-	--	qq	qq	qP	--	--	--	--	--	--	--	--	A^{b}_{w}		
22	-1	2-	--	--	-3	--	--	4-	--	--	5-	--	--	--	6-	--	-q	7_m	--	--	--	qq	qq	qP	--	--	--	--	--	--	A_y	
23	-1	2-	--	--	--	3-	--	-4	--	--	5-	--	--	--	6-	--	--	7-	--	--	qq	qq	P-	--	--	--	--	--	--	A_b		
25	-1	2-	--	--	3-	--	--	4-	--	-q	5-	--	-6_m	--	--	--	7-	--	--	qq	qq	P-	--	--	--	--	--	--	A_y		
*26	-1	2-	--	--	--	3-	--	--	4-	--	5-	--	--	-6_m	--	--	--	--	-q	qq	qq	P_m	--	--	--	--	--	--	--	A^{b}_{y}	
28	-1	2-	--	--	-3	--	--	4-	--	-5_m	--	--	6_m	--	--	-7	--	--	--	qq	qq	qP	--	--	--	--	--	--	--	A^{y}_{w}	
29	-1	2-	--	--	--	3-	--	--	4-	--	-5_m	--	--	-q	6-	--	--	q7	--	--	--	qq	qq	P_m	--	--	--	--	--	--	--	

total number emerging as adults (7 larval instars): 1 4 2 3

(6 larval instars): 1

males

* 2	-1	2**	--	--	3-	--	-4	--	--	5-	--	--	6-	--	--	--	qq	qq	P-	--	--	--	--	--	A_y							
3	-1	2-	--	--	-3	--	-4_m	--	--	-5	--	--	6-	--	--	-7	--	--	qq	qq	qP	--	--	--	$-A^{b}_{y}$							
4	-1	2-	--	--	--	3-	$--^{m}$	-4	--	--	-5	--	--	-6	--	--	-7	--	-q	qq	-q	qq	qq	P-	--	--	--	--	--	Ab_y		
5	-1	2-	--	--	3-	--	-4	--	--	-5	--	--	6-	--	--	7_m	--	--	-q	qq	qP	--	--	--	--	--	--	--	A_w			
7	-1	2-	--	--	-3	--	$--^{m}$	4_m	--	--	-5	--	--	6-	--	--	7^{m}	--	--	--	qq	qq	P-	--	--	--	--	--	Ab_y			
8	-1	2-	--	--	3-	--	--	4-	--	-5	--	--	-6	--	--	--	7-	--	-q	qq	qq	P-	--	--	--	--	--	--	A_y			
9	-1	2-	--	--	3^{m}	--	-4	--	--	5-	--	--	6-	--	--	7-	--	--	-q	qq	qq	P-	--	--	--	--	--	--	Ab^{b}_{y}			
10	-1	2-	--	--	-3	--	--	-4	--	$-q^{m}$	5-	--	--	6-	--	--	7-	--	--	--	qq	qq	P-	--	--	--	--	--	--	$-A_y$		
12	-1	2-	--	--	--	3-	--	4-	--	--	5-	--	q6	--	--	--	7-	--	--	--	-q	qq	P_m	--	--	--	--	--	--	Ab^{b}_{w}		
14	-1	2-	--	--	3-	--	-4	--	--	5-	--	--	6-	--	--	-7	--	--	-q	qq	P-	--	--	--	--	--	--	--	A^{b}_{w}			
15	-1	2-	--	--	--	3-	--	-4	--	$--^{m}$	5-	--	--	6-	--	--	-q	7-	--	--	--	qq	qq	P-	--	--	--	--	--	Ab_y		
*16	-1	2-	--	--	-3	--	-4_m	--	--	--	5^{m}	--	--	6-	--	--	-q	qq	qq	P-	--	--	--	--	--	--	--	--	Ab^{r}_{y}			
*17	-1	2-	--	--	--	3-	$--^{m}$	-4	--	--	5-	--	--	6-	--	--	--	--	-q	qq	qP_m	--	--	--	--	--	--	--	--	A_b			
*18	-1	2-	--	--	3-	--	-4	--	--	-5	--	--	6-	--	--	--	qq	qP	--	--	--	--	--	--	--	--	--	--	A_b			
19	-1	2-	--	--	-3^{m}	--	--	4-	--	-5	--	--	-6	--	--	--	7-	--	--	qq	qq	P-	--	--	--	--	--	--	--	A_y		
21	-1	2-	--	--	-3	--	--	4-	--	--	5-	--	--	6-	--	--	q7	--	-q	qq	q-	--	--	q-	qq	qP_m	--	--	--	--	--	$-A_y$
24	-1	2-	--	--	-3	--	--	-4	--	--	-5	--	--	-6	--	--	-7	--	--	--	--	qq	qq	P-	--	--	--	--	--	Ab_y		
27	-1	2-	--	--	--	3-	--	-4	--	--	5-	--	--	6-	--	--	-7	--	--	-q	qq	qP	--	--	--	--	--	--	--	Ab_y		
*30	-1	2-	--	--	-3	--	--	4-	--	-5_m	--	--	-6_m	--	--	--	--	qq	qP	--	--	--	--	--	--	--	--	--	--	Ab^{r}_{w}		

total number emerging as adults (7 larval instars): 3 4 3 3 1

(6 larval instars): 2 1

Code: m - moulting, q - quiescent, for adults: w - white, y - yellow, b - bronze, r - red.
subscripts refer to the previous observation.

* having only 6 larval instars

** The first larval stadium lasted between 31 hours (midnight, day 1) and 41 hours (10 A.M., day 2)

tried to raise mantid nymphs will know. When a small larvae is killed, it apparently disappears because its body rapidly dries up to an almost invisible mote of dust, which if it is not wafted away by the slightest air current over the dish, will not be distinguished from a particle of dust or flour unless it is observed very closely under highly magnification.

This experimental technique should be useful in determining the effects of certain factors, such as temperature, humidity, quality of food, etc. on the developmental history of the flour beetle.

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*Tribolium as Human Food

A large percentage of the world's population is malnourished--malnourished primarily because most people are unable to obtain enough protein to meet their minimal requirements. Not only is the amount of protein per capita insufficient, but it is rapidly decreasing. Man clearly cannot afford to neglect any possible source of protein, and in my opinion one of the largest untapped sources of protein is being ignored--insects.

Although there are a number of insects that would appear to be excellent sources of protein and therefore of potential value as human food, Tribolium appears especially promising. Tribolium feeds on wholesome, nutritious, and inexpensive food, is exceedingly easy to rear, can readily be harvested at any desired stage of development, has a short life cycle and high reproductive potential, and has a high efficiency of food conversion--in fact much higher than most of man's usual meat animals; approximately 40% of the food consumed is converted into body weight.

Rather than suggesting we feed protein-deficient peoples intact recognizable insects, I am suggesting the preparation of an insect (in this case Tribolium) protein concentrate--the equivalent of fish protein concentrate now being manufactured on a limited basis. This concentrate could then be incorporated into flours, meals, breads, cakes, beverages, etc. For those squeamish about eating insects, the final product need only indicate that it is fortified with animal protein. Such a declaration might in fact serve to promote the sale of the product.

The ideal stage for harvesting Tribolium would be last instar larvae or pupae when they are their largest and before the development of phenolic defensive secretions.

Tribolium has a high fat content, and an incidental byproduct of the protein-extracting procedures might be a cooking oil, or at least an oil that might have applications in the food or other industries.

Although Tribolium would probably have its greatest usefulness as human food in an unrecognizable form as described above, there is no reason other than

prejudice to preclude its use in intact form. I have collected last instar larvae and prepared them by frying for a few minutes in a shallow layer of hot vegetable oil, draining on paper toweling, and then lightly salting. Prepared in this manner, my students have described them as tasting "like chicken," "like roasted sunflower seeds," "like pork cracklings," etc. I find their taste unique and very pleasant.

Palatability clearly has little to do with western man's prejudice against eating insects; properly prepared many of them are quite tasty. Only irrational prejudice--the roots of which are hard to find--prevents many people from experiencing this wholesome and nutritious food.

Whether we ever use Tribolium as a gourmet food or as a source of a protein concentrate that could be incorporated into other foods and utilized in the diets of protein-deficient peoples, will be largely dependent on the appropriate research being done. What is the protein content of Tribolium? (Most insects tested are high in protein.) What is the quality of the protein--that is, are all the amino acids essential to man present? What is the cost of producing one pound of Tribolium protein concentrate as compared to one pound of fish protein concentrate? What will be the marketability of the product? In my estimation, the potential of using Tribolium as a source of animal protein is clearly present. It is also clear that those nations best suited to conduct the necessary research, i.e., those with the greatest know-how in terms of modern food technology, are also those nations that are best fed and with the greatest prejudice against the eating of insects. With these facts in mind, it is questionable that Tribolium or any insect will ever be explored in the manner a hungry and protein-deficient world deserves.

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* A Recurrent Mutation

A single female pupa, having 3 urogomphi, was recovered from among thousands of pupae of a strain of McGill Black Tribolium castaneum which was undergoing selection for resistance to DDT. The pupae closely resembled the description of the "extra urogomphi" (eu) mutant described in 1960 by Lasley and Sokoloff, from the same source strain, and is perhaps identical to it (Sokoloff, personal communication).

The female was crossed to 2 wild type males of the same species (a strain that was derived from Purdue) and produced all normal F_1 progeny which was then mated to produce F_2. The resulting F_2 pupae yielded 103 males and 95 females with a normal phenotype, and 20 mutants (9.17%):

9 males with 3 or 4 urogomphi
10 females with 3 or 4 urogomphi
1 male with urogomphi fused into one

The ratio of normal to mutant phenotypes differs significantly from 3:1 (P 0.001).

The F_2 beetles with a normal phenotype were discarded. The 20 mutants were mated together and produced numerous offspring. In the larval stage the extra urogomphi were very clearly seen, but their expression varied from a fully developed set of 4 to 2 normal urogomphi and 2 other small, barely visible ones. The distribution of the number of urogomphi in the F_3 pupae is given in Table 1.

Table I. Distribution of F_3 pupae

	number of urogomphi in pupa			
	2 (normal)	3	4	5
males	74	41	106	0
females	62	26	98	4
Totals	136	67	204	4

Of the 411 pupae, 275 (67%) had extra urogomphi, although genetically all must have carried the trait. This may indicate poor penetrance, as suggested by Lasley and Sokoloff (1960).

In the pupae with 3 urogomphi, the extra ones sometimes vary in size. It is possible that in those with 3, the fourth has failed to grow large enough to be noticeable, due to low expressivity of the trait.

Only about 75% of the F_3 pupae survived to adulthood. The 300 adults were classified by body colour into 3 groups at the b locus: black (bb); wild type (++); hybrid (+b).

The result (Table 2) is rather interesting. Mutants appear in all colour classes. It may be noted that the adults with 2 urogomphi fitted the 1:2:1 ratio expected at the b locus, (p 0.05), while those phenotypically mutant did not (p 0.001). In those, there was an excess of hybrids above expectation.

Table II. Number of mutants in the different genotypes of F_3 adults

	(sexes pooled)		
No. of urogomphi	++	+b	bb
2 (normal type)	23	57	28
3, 4	30	128	34
Total	53	185	62

But this cannot be interpreted as resulting from linkage because, genetically, all F_3 adults must have been mutant. The proportion of phenotypically-mutant individuals was slightly higher in the +b group than in ++ or bb (0.608 versus 0.567 and 0.548 respectively) but these differences were not significant (P 0.05 by the test of proportions suggested by Snedecor, 1956).

We may reach the following conclusions:

1. The trait is recessive and is showing incomplete penetrance (60-70%) and incomplete expressivity.
2. The trait is not closely linked to the b locus, if linked at all.

Further investigations are currently under way.

Literature Cited

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Snedecor, G. W. 1956. Statistical Methods, Iowa State College Press.

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*A Search for Tryptophan Metabolites in Tribolium castaneum.

Materials

2-Chromatography jars 12½ x 12½ x 24 in.
Drummund micropipettes 5 microliter
Hair dryer
Ice bath
Konte's tissue grinder size 22
Millipore filters plain white 13mm. .45 micron
Separatory funnel
Soil sieve
Syringe 10cc
Ultra violet light (long wave)
Whatman #1 filter paper 23 x 57 cm

Standards, Solutions and Reagents

1 mg/ml solutions in 50% aqueous acetone of the following:

L-tryptophan
D,L kynurenine (Aldrich chem)
D,L 3-hydroxykynurenine (Calbiochem)
L N-formylkynurenine (Calbiochem)
a standard mixture of the above

Iso-propanol/Ammonia/Water solvent (IPrAm) 200/10/20 v/v/v
Butanol/Acedic acid/Water solvent (BuA) 4/1/5 v/v/v

Ehrlich's reagent: p-dimethylaminobenzaldehyde/acetone/conc. HCL 1/90/10 w/v/v

Ninhydrin: 0.3% w/v in acetone

Note: for a review of chromatography techniques see Block, Kurram, and Zweig (1958) and I.Smith (1958).

The ommochrome pathway of eye pigmentation is common to many arthropods. This enzymatic pathway begins with the indole-aminoacid tryptophan which is converted to formlykynurenine, kynurenine and 3-hydroxykynurinine before the final step to the structurally unidentified ommochromes. Mutants of Drosophila melanogaster and other species have been associated with enzyme deficiencies which allow the excessive accumulation of a particular tryptophan metabolite in the pathway.

Two types of experiments were performed on wild and mutant strains of Tribolium castaneum in an attempt to demonstrate the ommochrome pathway: 1) extraction of possible pathway intermediates from pupae and imagoes using paper chromatography, and 2) direct feeding of the intermediates to several mutant larvae types.

Procedures

All developmental stages used were cultured in a nutritive medium of white flour and yeast at 32° C. Relative humidity was maintained at approximately 70 per cent.

Extraction:

The soil sieve was used to remove all flour from beetles to be used for extraction. One tenth of a gram of pupae or adult whole bodies or heads was macerated in 2ml of cold 80% ethanol in the hand tissue grinder. An ice bath was used to keep the solution cold throughout the extraction process. Cell fragments and precipitated proteins were removed with the Millipore filter. The filtrate and 3 volumes of cold chloroform were well mixed in the separatory funnel and the chloroform layer discarded. The aqueous layer was centrifuged and refrigerated at 4°C until it was to be chromatographed.

Chromatography:

The unconcentrated extracts and standards were applied directly on the paper with care to prevent spots larger than 5 mm in diameter. Some 200 microliters of extract were applied in each instance. The hairdryer was used between applications to dry the spots.

Two-step descending chromatography with a two-solvent monodirectional system gave good separation and consistant Rf values with the standards. The atmosphere in the glass chamber was saturated with 25 ml of IPrAm solvent before the sheets were hung and the chromatogram developed. A total of 50 ml of solvent was placed in the glass trough with a pipette to prevent splashing.

The sheets were removed when the solvent front approached the end of the paper and allowed to dry under a hood for 15 minutes.

In the BuA solvent run, the lower aquoeus layer was used to equilibrate the atmosphere and the organic layer used as the moving phase. All other procedures were as in the first run. Depeloping times normally ran 22-26 hrs for IPrAm and 19-24 hrs for BuA.

All spots observed under U.V. light were outlined in pencil then each sheet was dipped in 20 ml of ninhydrin and any additional spots outlined. After drying, the sheets were dipped in fresh Ehrlich's reagent (20 ml per sheet).

The metabolite standards gave identifiable color reactions at the following sensitivities:

Tryptophan	<1.5 µgms
N-formylkynurenine	<1.5 µgms
Kynurenine	5.0 µgms
3-hydroxykynurenine	5.0 µgms

Separation was excellent with the exception of kynurenine and tryptophan which ran together slightly. Average Rf values were as follows:

N-formylkunurenine	.747
tryptophan	.565
kynurenine	.459
3-hydroxykynurenine	.361

Feeding Experiment:

Mutant larvae of various instar levels were placed in separate vials containing only one of the ommochrome intermediates. Five larvae per intermediate were tested, and five fasting controls used for each mutant strain used. At the end of three days, the white flour-yeast medium was added. At the end of 20 days all live individuals were examined under a dissecting scope and comparisons made with controls.

Results and Discussion

In addition to synthetic[a,b] and Virginia[a] wild types the following mutant species were tested in extraction and feeding experiments:

maroon $(m)^{a,c}$
peach $(r^{ph})^{a,c}$
pearl $(p)^{a,c}$
pink $(r^{pk})^{a,c}$
platinum $(pt)^{b,c}$
red modifier,pigmy $(rM^{r}py)^{a,b,c}$
red Ho $(r^{Ho})^{c}$
red modifier $(rM^{r})^{c}$
white (w)

a= pupae
b= imago
c= feeding experiment (i.e. larvae)

Chromatography:

Under U.V. light, the r^{ph} mutant displayed 2 spots which did not occur in any of the others. All pupae extracts gave three unidentified amino acid color reactions with ninhydrin except $rM^{r}py$ and r^{pk} which displayed only two.

Treatment of chromatograms with Ehrlich's reagent did not give any indication of intermediates other than tryptophan. Whole body extracts from w pupae gave slight tryptophan color reactions but pt heads yielded over 10 µgms of this intermediate. Imago extracts of all types did not give any color

reactions with Ehrlich's reagent unless heads alone were used. Even then, the amount of tryptophan found measured less than 1.5 µgms.

An extraction experiment of wild type pupae segregated by age according to the method of Ho (1961), did not indicate any decline in tryptophan through day six. Apparently, there is a decline in tryptophan titer shortly after the imagp emerges.

The results of the feeding experiments did not reveal observable differences between controls and larvae fed the metabolites.

The negative results of these experiments do not rule out the possibility of the ommochrome pathway in Tribolium. The extraction and chromatography methods used may not have been sensitive enough to identify metabolites other than tryptophan. The size of the eyes in this species is rather small and accumulations of metabolites would probably be small also.

The extraction procedures used here were performed on the cinnabar (cn) mutant of Drosophila melanogaster with negative results, although this mutant is known to accumulate kynurenine. The absence of kynurenine in this experiment indicates that possibly: 1) this procedure may not be useful on Drosophila due to interfering molecules, or 2) Tribolium has a much larger tryptophan pool than does the fruit fly.

Modifications of the extraction experiment which may give a greater sensitivity include; 1) the concentration of the extract by using more tissue or by using evaporation techniques, 2) concentrating the amount spotted by application of the complete extract, or 3) using another procedure entirely. This last suggestion may be the best considering the results with Drosophila.

The feeding experiment may have failed due to the possible inability for the larvae to assimilate the metabolites. Micro-injection of the intermediates directly into the eyes may eliminate this possibility.

Direct extraction of ommochrome pigments has not been performed on this

species. Anyone considering the continuation of this project might do well to practise his or her technique on Drosophila first. This species is readily available and extraction of intermediates has been performed by several workers.

This project was sponsored by Drs. Richard Goodman and Alexander Sokoloff. Miss Mary Corriea aided me in the pupal aging experiment.

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Maintenance Transfer of Stocks of Tribolium.

We maintain three replicates of eleven different stocks of Tribolium in pint fruit jars with perforated plastic liners in place of the regular metal liners. To sift these cultures is quite a chore. In many cases, we are interested in continuing the stock without census.

In a clean plastic dish pan we place the uncapped jar on its side and shake it enough to bring the medium to the level of the shoulder of the jar. We cover the dishpan with a piece of heavy clear plastic and leave it until enough adults to more than meet our needs have moved from the jar to the dishpan. The jar is then removed and capped.

The beetles in the dishpan are then tapped to one corner of the pan. Holding the pan on the corner with its outter lip projecting into a petri-dish the desired number of beetles are counted out. These are then immobilized in a freezer and examined under the microscope. If there is no signs of genetic contamination, they are placed in new medium and all other are discarded.

All equipment is then soaked in very hot water and an entirely different, clean set of equipment is used for the next culture.

(Note on the interaction between natural selection and stupidity! Using this time saving method without the microscopic examination in making several transfers of a culture of T. castaneum Sa/+ ch/ch obtained from Dr. A. E. Bell, Population Genetics Institute, Purdue University, resulted in the loss of the Sa gene. Apparently the +/+ ch/ch beetles crawled out of the medium first and also out of the dishpan first.)

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Sieves for Working With Small Cultures of Tribolium.

A Foley canning funnel and a number 32, screw type, radiator hose clamp along with a 3" x 3" piece of bolting cloth makes an excellent sieve for sorting small cultures of Tribolium. Except for the bolting cloth, this unit costs about eighty cents.

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*A technique for removing Tribolium larvae, pupae, and adults from small amounts of flour.

In order to facilitate transfers of Tribolium in small amounts of flour (1-10 g) from one container to another, an apparatus using an inexpensive two-piece nalgene (polyethylene) Büchner funnel was constructed.

The perforated plate of the upper or cup portion of the Büchner funnel was cut out and the rough edges smothed over the fine sandpaper. A piece of silk bolting cloth can be inserted between the upper and lower portions of the funnel, in the manner of two-piece sieve rings, and easily changed for different operations. The apparatus may be easily and quickly washed, due to its small size.

Unfortunately, nalgene cannot be autoclaved, so another method of sterilization (such as 95% ethanol) must be used. I have found the 55 mm size funnel (Van Waters and Rogers #30305) to be the most workable, as the cups are large enough for 10 g of flour and the funnel stems are only 14 mm in diameter. The funnel stems of the lower portion may be cut to any desired length.

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