TRIBOLIUM INFORMATION BULLETIN

Volume 32

1992

EDITOR: A. SOKOLOFF

PROFESSOR EMERITUS

BIOLOGY DEPARTMENT

CALIFORNIA STATE UNIVERSITY, SAN BERNARDINO, CA 92407

NOTE

TIB is not an official publication. Information appearing in the bulletin is refereed, but it should not be used for publication without the consent of the author. Unless an asterisk or the note "Reference authorized" accompanies the article. permission to quote from the bulletin must be obtained from the author(s) who are solely responsible for the contents of the articles.

ACKNOWLEDGEMENTS

The editor is indebted to BARBARA SOKOLOFF AND ELAINE SOKOLOFF for assistance in the preparation and distribution of TIB 32.

TRIBOLIUM INFORMATION BULLETIN

Number 32

July, 1992

Note..... ii

Acknowledgements..... iii

Stock Lists..... 1-57

Research, Teaching and Technical Notes..... 59-111

Respiratory metabolism of Tribolium castaneum Hbst. and T. confusum Duval in two phenotypic groups. Pawel Bijok..... 61

Relationships among proteins in male accessory reproductive gland complexes of several Tribolium species as analyzed by an enzyme-linked immunoabsorbant assay (ELISA). Lisa M. Clayton, Fred Vander Jagt, Terry L. White and Karin A. Grimnes..... 68

Synergism of Datura Metel Linn. leaf and seed extractions with methacrifos on Tribolium castaneum (Hbst.) M. Khalequzzaman and M. Nurul Islam..... 72

Quinone secretions of flour beetles, Tribolium: Problems and prospects. K.A.M.S.H. Mondal.... 79

Dietary efficiency of common spices in Tribolium anaphe Hinton (Coleoptera: Tenebrionidae). A.M. Saleh Reza, Mahbub Hasan, S.M. Rahman and A.R. Khan..... 90

Histological and histochemical evidence for an additional cell type in the male accessory reproductive glands of Tribolium brevicornis (Coleoptera: Tenebrionidae). Jeffrey D. Sevener, Nakeisha N. Dennard and Karin A. Grimnes..... 93

Mitochondrial DNA restriction analyses in species of Tribolium. A. Tous, J.A. Castro and C. Ramon..... 96

Developmental rates of *Tribolium* species.
A. Sokoloff..... 103

Hybridization between *T. castaneum* and *T. freemani* -- a possible exception.
Darice Henry-Ford and Alexander Sokoloff..... 104

Tribolium simulation of the effect of heat stress on laying hens performance.
Zhang Lao, Wang Xinmou, Lan Rong and Liu Wei.. 106

The simulation of sire genetic evaluation using *Tribolium castaneum* for the comparison of two statistical methods. Zhang Lao, Wang Xibin, Zhang Qineng, Wang Yachun and Liu Wei..... 107

The use of Fumagillin and bleach rinses to control *Nosema* infection in *Tribolium*.
Michael J. Wade..... 111

Current Bibliography..... 113-141

1. Anatomy and Histology..... 115

2. Behavior..... 116

3. Cytology and Electron Microscopy..... 117

4. Insect Tissue Culture and Embryology..... 118

5. Ecology and Population Ecology..... 119-122

6. General..... 123

7. Genetics and Population Genetics..... 124-125

8. Insecticides and Insecticide Resistance... 126-129

9. Irradiation and Use of Isotopes..... 130

10. Nutrition..... 131

11. Parasites and Symbionts of Coleoptera..... 132

12. Pests..... 133-134

13. Physiology and Biochemistry..... 135

14. Space and Aerial Ecology..... 136

15. Speciation..... 137

16. Statistical Methods and Mathematical Models 138

17. Taxonomic Studies..... 139

18. Techniques..... 140

19. Teratology..... 141

Directory - Geographical..... 143-172

Directory - Personal..... 173-193

STOCK LISTS

STOCK LISTS

BERKELEY, CALIFORNIA
UNIVERSITY OF CALIFORNIA
DONNER LABORATORY AND LAWRENCE RADIATION LABORATORY

Tribolium confusum

1. "+" - a wild type strain derived from Genetics Department, University of California, Berkeley.

2. Black - an autosomal semi-dominant body color mutant. From 1.

3. Miniature - an autosomal recessive body size mutant. From 1.

4. Short elytra - an autosomal dominant elytron-size mutant. Low viability in adults, indicating a recessive lethal gene.

5. Blistered elytra - an autosomal recessive mutant. Low viability.

Tribolium brevicornis.

Wild type derived from Genetics Department, University of California, Berkeley.

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

Tribolium confusum

1. Wild

(Ed.).

BURLINGTON, VERMONT 05401
UNIVERSITY OF VERMONT
DEPARTMENT OF ZOOLOGY

Tribolium castaneum

STEVENS/GOODNIGHT LAB

Tribolium confusum

bI
bII
bIII
bIV
b-Chicago b/b
b-Chicago
b-Circle
b-yugo-Illinois b/b
b-yugo-Illinois +/+
bSM
b-yugo-Kentucky
b-McGill
b-Thailand
b-Nigeria
b-Pakistan

Tribolium castaneum

cI
cSM-+/+
cSM-b/b
cIV-a
c-Brazil
c-Costa Rica
c-Thailand
c-Spain
c-Israel

Oryzaephyllus surnamensis

Stock Lists

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

Tribolium castaneum

I. Wild type strains

1. Purdue + Foundation

II. Mutant strains

1. antennapedia (ap)
2. antennapedia, black (ap, b)
3. Chicago black (b) via San Bernardino
4. weird (wd) via San Bernardino

D.C. Englert

CARLISLE, PENNSYLVANIA
DICKINSON COLLEGE
DEPARTMENT OF BIOLOGY

I. Wild type strains (T. confusum)

1. Six strains started from females captured 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 (T. confusum).

1. Black -Sault Ste Marie (1956)
2. Ebony - Chicago (1957)
3. Eyespot - sex-linked - from a I.1 strain 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- from insects found in NYC, 1955.

Dan McDonald

CHARLOTTESVILLE, VIRGINIA
UNIVERSITY OF VIRGINIA
DEPARTMENT OF BIOLOGY

Tribolium castaneum

I. Wild type strains

1. Chicago	University of Chicago
2. Purdue University Foundation	via Stony Brook
3. Synthetic	San Bernardino

II. Mutant strains

1. McGill black	University of Chicago

(Ed.).

CHICAGO, ILLINOIS
UNIVERSITY OF CHICAGO
DEPARTMENT OF BIOLOGY

I. Wild type strains

A. Tribolium castaneum

1. "Chicago" (originally from Thomas Park)
2. Brazil (also known as cI)--(originally from Rio de Janeiro)
3. cIVa--an inbred strain (derived from Chicago)

B. Tribolium confusum

1. "Chicago" (originally from Thomas Park)
2. bI an inbred strain derived from the Chicago strain)
3. bII (same)
4. bIII (same)
5. bIV (same)

C. Tribolium madens

D. Latheticus oryzae

(Ed.)

Stock Lists

CHICAGO, ILLINOIS
UNIVERSITY OF ILLINOIS AT CHICAGO CIRCLE
DEPARTMENT OF BIOLOGICAL SCIENCES

I. Wild type strains

A. Oryzaephilus surinamensis

B. Tribolium castaneum

1. "Chicago" (originally from Thomas Park)
2. "Brazil" (also known as cI) originally from Rio de Janeiro)
3. cIVa (an inbred strain derived from "Chicago"

C. Tribolium confusum

1. "Chicago" (originally from Thomas Park)
2. "Circle" (Collected in Chicago)
3. bI (derived from "Chicago")
4. bII (derived from "Chicago")
5. bIII (derived from "Chicago")
6. bIV (derived from "Chicago")

D. B. Mertz

CORAL GABLES, FLORIDA
UNIVERSITY OF MIAMI
DEPARTMENT OF BIOLOGY

I. wild type strains

1. Tribolium confusum (Chicago) Chicago
2. T. castaneum (Chicago) Chicago

II. Mutant

T. confusum - ebony--Sokoloff Sokoloff
T. castaneum - jet - from Chicago wild
T. cataneum - Chicago black-- Sokoloff
T. castaneum - sooty (Sokoloff)
T. castaneum - dark sooty (Sokoloff)
T. castaneum - Charcoal--Sokoloff
T. castaneum - tawny/pearl--Sokoloff

Earl R. Rich

CORVALLIS, OREGON
OREGON STATE UNIVERSITY
DEPARTMENT OF ZOOLOGY

I. Wild type strains

A. Tribolium castaneum
1. Oregon (synthetic)

B. Tribolium confusum
1. Oregon synthetic

II. Mutant strains

A. Tribolium castaneum

1. aa, mc, j
   D
2. ap , s
3. apt, b
4. b,mc,p
5. bb
6. Be
7. dve,pd
8. Fta
   c
9. h
   c
10. mc , s
11. nd, s
12. p, lod
13. Rd, s
14. sa-2, +/s
15. Sa-2, s
16. ser, py, r
17. Spa
18. wd, s

Tribolium confusum
   u
1. b
2. b,spl
      u
3. ble
4. dep
5. dj
   c
6. e
      AS
7. msg
   u
8. r
9. thu
        u
10. thu

Peter S. Dawson

DENTON, TEXAS
TEXAS WOMAN'S UNIVERSITY
DEPARTMENT OF BIOLOGY

I. Wild type strains and origin

A. Tribolium castaneum (Brazil cI)
B. Tribolium confusum (Chicago Standard)

(Ed.).

FLUSHING, NEW YORK 11367
QUEENS COLLEGE OF THE CITY UNIVERSITY OF NEW YORK
DEPARTMENT OF BIOLOGY

Tribolium castaneum wild type, Purdue University

(Ed.).

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

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

(Ed.).

Stock Lists

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

Tribolium castaneum

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

Tribolium confusum

Chicago	Park 1955
black	via San Bernardino
pearl	via San Bernardino

Tribolium madens via San Bernardino

Tribolium brevicornis via San Bernardino

(Ed.).

LAFAYETTE, INDIANA 47907
PURDUE UNIVERSITY
ANIMAL SCIENCES DEPARTMENT

Tribolium castaneum

I. Wild type strains

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

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

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

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

A.E. Bell.

LAURINGBURG, NORTH CAROLINA
ST. ANDREWS COLLEGE

Tribolium confusum-- Wild type stock infected with Nosema whitei

(Ed.).

LEXINGTON, KENTUCKY
UNIVERSITY OF KENTUCKY
AGRICULTURAL EXPERIMENT STATION

I. Base populations

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

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

1. MRS-1	Minnesota, 1970
2. MRS-2	Minnesota, 1970
3. P	Purdue, 1976
4. C	Davis, 1976

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

(Ed.).

MADISON, WISCONSIN
UNIVERSITY OF WISCONSIN

Xyleborus ferrugineus

I. Wild type strain WIS-1 from Costa Rica

II. "Germfree" strain WIS-2, derived from WIS-1.

NOTE: This insect in the wild exists in obligatory symbiosis

with filamentous fungi, yeasts and bacteria. The insect reproduces by arrhenotokous parthenogenesis with unfertilized (haploid n=7) eggs yielding male progeny, and fertilized (diploid, n=14) eggs yielding female progeny. Females can be kept alive for 9-12 months and will retain fertility over most of their life. Thus many experiments can be conducted with a given individual. The insect only decodes its larval genome into the phenotype if given a non-7-sterol. Imaginal phenotypic characteristics are decoded onlly when a dietary 7-sterol is provided to the larva. No other insects are known to provide this combination of attributes to researchers in the areas of cell determination versus differentiation, and other aspects of organismal development.

A new stock line can be started from a single virgin female by allowing her to produce male progeny which whe will tend until they are adults, then will mate with a son, and then will produce mostly diploid female progeny which can be used to continue the created line.

(Reproduced from an earlier issue of TIB, Ed.).

MANHATTAN, KANSAS
KANSAS STATE UNIVERSITY
DEPARTMENT OF ENTOMOLOGY

LEPIDOPTERA

Phycitidae: Cadra cautella and Plodia interpunctella

Gelechiidae: wild and red eyed strains.

Pyralidae: Corcyra cephalonica

COLEOPTERA

Anobiidae: Lasioderma serricorne and Stegobium paniceum

Bostrichidae: Rhyzopertha dominica

Bruchidae: Callosobruchus maculatus

Cucujidae; Cryptolestes ferrugineus, C. pusillus,

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

Dermestidae: Trogoderma inclusum, Attagenus megatoma

Ostomatidae: Tenebroides mauritanicus

Ptinidae: Gibbium psylloides

Silvanidae: Ahasverus advena, Oryzaephilus surinamensis, O. mercator

Tenebrionidae:

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

Valerie Wright

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

Tribolium castaneum

I. Insecticide-resitant strains

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

II. Mutant strains

1. au, lod, p--aureate, light ocular diaphragm, pearl (III,III,II) from San Bernardino, 1981
2. sa, c--short antenna, chestnut (VII, VII) "
3. pd, py, pte--paddle, pygmy, platinum eye (I, I, I) "
4. mc, j--microcephalic, jet (V,V) "
5. Dch--Dachs (II) "
6. rb--ruby (V) "
7. mas--missing abdominal sternites (II) "
8. s--sooty (IV) "
9. sq-like (squint-like VIII?) "
10. mxp--maxillopedia (II) "
11. Mo--Microphthalmic (VI) "

Stock Lists

12. fas3a--fused antennal segments (V) "
13. p-- pearl (II) "
14. B, ap--black, antennapedia (III, VIII) "
15. b, apt--black, alate prothorax (III, II) "
16. h, s--hazel, sooty (IV, IV) "
17. b--black (III) "
18. t b --tawny (III) "
19. Chr--Charcoal (III) "
20. d b --dusky (III) New mutant, Manhattan, 1983
21. Rmal--Resistance to malathion (VI) "
22. Rd-- Reindeer (II)
23. Be, s --Bar eye, sooty (IV, IV)
24. Fta--Fused tarsi and antennae (VII)
25. Sa--Short antennae (VII)
26. Spa, s--Spatulate, sooty (IV,IV)
27. mas, au, s, rb, Rmal+, ap (multimarker strain).

R.W. Beeman

SAN BERNARDINO, CALIFORNIA
CALIFORNIA STATE UNIVERSITY
BIOLOGY DEPARTMENT

I. Tribolium anaphe
1. Wild
2. Splprps (I)

II. Tribolium audax

III. Tribolium brevicornis

1. Wild Riverside, 1969
2. Wild Idaho 1975
3. Wild San Bernardino, 1977
4. spl

IV. Tribolium castaneum

A. Wild type strains

1. Chicago Park, 1955
2. Consejo Spain, a968
4. Davis Davis, Ca, 1961
6. Florida Bell, 1970
8. McGill Stanley, 1958
10. PIL ?
12. Sacramento 1961
14. Texas 1958
16. Veracruz Mexico, 1963

17. Virginia
19. Synthetic 1 (has s) Prepared 1958
20. Synthetic 2 (no body color) Prepared 1958
23. New York UPF 1976
24. San Bernardino 1976
25. CS-4 (from New York) 1976

B. Mutants

1. Sex-linked

26. dve--divergent elytra Chazy, 1959
30. pd--paddle Park, 1955
34. pte Berkeley, 1965
36. py--pygmy Chazy, 1959
38. r--red Chazy, 1959
D
39. r --red Berkeley
54. pd, r--paddle, red
r
55. py, r, M --pygmy, red, red modifier
59. r, sp--red spotted
61. pd, pte--paddle, platinum eye

Autosomal

63. p--pearl II New York 1976
Pk
64. p --pink II Chazy, 1959
65. p pearl II Park 1955
S
66. p pearl II
76. au--aureate III
78. b--black III
S-1
81. b -- black, Brazil
82. b--black Chicago 1955
84. b--black McGill 1959
85. b--black McGill via New York, 1976
86. b--black NASA 1959
88. b--black synthetic (Chicago/McGill)
90. Chr--Charcoal III
91. lod p--light ocular diaphragm, pearl III,II
94. msg--melanotic stink glands III
96. mt--mottled III
t
98. b --tawny III
105. fas-2--fused antennal segments-2 IV
107. ap, ju--antennapedia, juvenile urogomphi
113. s--sooty (Berkeley synthetic background) IV
114. s--sooty (New York) IV
135. j--jet V
AS
136. j --jet V

Stock Lists

139. mc--microcephalic V Chazy, 1959
140. mc-1 microcephalic-1 (eyeless) V Hayward 1967
143. fas-3a fused antennal segments 3a V Berkeley, 1963
148. m--maroon V Purdue 1970
150. rb--ruby V Berkeley, 1962
156. Mo--Microphthalmic VI Chazy, 1959
162. sa=ca--short antenna VII Cold Sprg. Hbr. 1960
165. c--chetnut VII Purdue, 1962
168. ju-7--juvenile urogomphi VII-IV Purdue
170. ble--blistered elytra VII Berkeley 1962
173. c, Rd VII,II Corvallis 1975
S
180. ap --antennapedia VIII Berkeley 1962
D
186. sq --squint VIII Chazy 1959
189. apt--alate prothorax IX Berkeley 1963
192. ptl--prothoraxless IX Chazy 1959
194. ppas--partially pointed abdominal sternites Berk. 1963
196. mas--missing abdominal sternites II Berkeley 1964
228. Dch--Dachs II San Bernardino 1976
230. fas-1--fused antennal segments-1 Chazy 1959
233. imp--incomplete mesothoracic projections
238. mxp--maxillopedia II berkeley 1965
240. Npp--Non-punctate prothorax, a phenodeviant
245. pec--pectinate
252. sc--scar Purdue
259. w--white Purdue
261. fas-8--fused antennal segments-8
271. Gi--Giant PIL
278. la--long abdomen PIL
280. Veracruz small
288. fas-9 fused antennal segments-9 San Bernardino, 1975
295. pd,p--paddle, pearl I, II
296. pd,p,b--paddle, pearl black I, II, III
297. sp,p--spotted, pearl I, II
299. py,i,p--pygmy, ivory, pearl I, II, II
301. p, au, lod--pearl, aureate, light ocular diaphragm II, III, III.
302. p, au, mc--pearl, aureate, microcephalic II, III, V
303. p,b--pearl, black (II, III)
304. p,au,lod,msg--pearl, aureate, light ocular diaphragm, melanotic stink glands (II, III, III, III)
306. p,b,pe--pearl, black, pointed elytra (II, III,?)
308. p,mc--pearl, microcephalic II, V
310. p,s--pearl, sooty II, IV
312. p,j,Npp--pearl, jet, Non-punctate prothorax II, V
313. p,apt,Mo--pearl, alate prothorax, Microphthalmic II, II, VI.
315. p,mas--pearl, missing abdominal segments II, II
316. p, knp--pearl, knobby prothorax II, II
317. p,aa--pearl, abbreviated appendages II, V
322. p,Fas-4,b--pearl, Fused antennal segments-4, black II, ?, III
415. mxp,s--maxillopedia, sooty II, IV

416. au, s--aureate, sooty III,IV
417. h, s--hazel, sooty III, IV
428. c, Npp--chestnut, Nonpunctate prothorax VII, ?
430. au,Npp--aureate, Nonpunctate prothorax III, ?
436. au,mc--aureate, microcephalic III, V
442. Df,s,Mo--Deformed, sooty, Microphthalmic ?, IV, VI
444. i,lod,Mo--ivory, light ocular diaphragm, Microphthalmic II, III, VI
445. i,ppas-ivory, partially pointed abdom. sternites II, ?
448. Chr,ap--Charcoal, antennapedia III, VIII
450. au,ble--aureate, blistered elytra III, VII
ELL Pk
454. p /p II
462. mas, mc--missing abdominal segments, microcephalic II,V
469. i,lod--ivory, light ocular diaphragm II,III
470. lod,rb--light ocular diaphragm, ruby III, ?
473. fas-6--fused antennal segments-6

V. Tribolium confusum

Wild type strains

1. Chicago	Park, 1955
2. Chicago	via Sokal, 1975
3. McGill	via McDonald
4. McGill	Stanley, 1958
5. New York	1961
6. Sacramento	
7. San Bernardino	1968
8. Yugoslavia	1975

Synthetic strains

1. Berkeley

Mutant strains

apt--alate prothorax I
apt,fas-2--alate prothorax, fused antennal segments-2
b-black III
b,cas,p--black, creased abdominal segments, pearl
b,lod,p--black, light ocular diaphragm, pearl
b,p--black, pearl
b,rus--black, ruby spot
b,rus,spl--black, ruby spot, split
b,twa--black, twisted abdomen
b-2--black-2
b-2/b McGill--synthetic black
bZ,rZ--black Zagreb, red Zagreb
(black strains from Carlisle, Pa., Chicago, Donner lab, Georgia, McGill, Sault Ste. Marie, Winnipeg and Yugoslavia)
b-Chicago/b McGill--synthetic black
b-Mcgill,fas--black, fused antennal segments
b-Mcgill,p--black, pearl

b-SSM,spl--black, split
ble--blistered elytra V
ble,e--blistered elytra, ebony V,V
car,p--carmine, pearl
cas--creased abdominal segments II
cla-claret
cru--crumpled I
dpe--dirty pearl eye II
dj--disjoined VI
dt--dent (see umb--umbilicus)
dt,p--dent, pearl
e--ebony V Chicago, 1955
(other ebony alleles)
e,fas-3--ebony, fused antennal segments-3 V, ?
e-2--ebony-2 (not allelic with e) II
e-2,fas-1--ebony, fused antennal segments-1
ele--elongated elytra
ele,fas-2--elongated elytra, fused antennal segments-2
es--eyespot I
es,fas-1--eyespot, fused antennal segments-1
es,fas,msg--eyespot, fused antennal segments melanotic stink glands I, ?, III
es,fas,sti--eyespot, fused antennal segments, sternites incomplete
eu,fas-2--extra urogomphi, fused antennal segments-2
fas-2--fused antennal segments-2 II
fas-2,lod,msg,p--fused antennal segments-2, light ocular diaphragm, melanotic stink glands, pearl II,III,III,II
fas-2,lod,p--fused antennal segments-2, light ocular diaphragm pearl II,III,II
fas-2,msg--fused antennal segments-2, melanotic stink glands II,III
fas-3--fused antennal segments-3
fro--frosted
lod,rus--light ocular diaphragm, ruby spot
msg--melanotic stink glands III
msg,rus--melanotic stink glands, ruby spot III,III
msg,twa--melanotic stink glands, twisted abdomen III,?
ov-like--overshot-like
p-pearl II
p-Slough-pearl
R
p --pearl riboflavinless II
r-red I
r,sh--red, short elytra
U
r --red
Z
r --red from Zagreb
rby--ruby
rus--ruby spot III
sh--short elytra (Berkeley)
sh,sp,twa--short elytra, split, twisted abdomen
sp--split III

sp-1--split-1
twa--twisted abdomen
thu--thumbed IV
S
thu --an allele of thu, IV
thu, Xl--thumbed, Extra large
umb--umbilicus

VI. Tribolium destructor

VII. Tribolium freemani

VIII. Tribolium madens

A. Sokoloff

South Orange, New Jersey 07079
Seton Hall University
Department of Biology

Tribolium castaneum

Wild Type Strains:	
McGill Wild	via California State
Synthetic Strains:	
Pearl Foundation	via Purdue University
Black Foundation	via Purdue University
Mutant Strains:	
Black	via Chicago
Red^{HO}	via California State
Short antennae (Sa)	via Purdue University
Short antennae (ca)	via Oregon State
White	via California State

Tribolium confusum

Wild Type Strains:	
Wild Type	via Carolina Biological Supply

Eliot Krause

SAVANNAH, GEORGIA
STORED-PRODUCT INSECTS RESEARCH AND DEVELOPMENT LABORATORY

I. Wild type strains

A. Lepidoptera

1. Anagasta kuehniella (Zeller)	N.C. State, Raleigh, N.C.
2. Cadra cautella (Walker)	Tifton, Ga.
3. C. figulilella (Gregson)	Unknown
4. Ephestia elutella (Hubner)	Richmond, Va.
5. Plodia interpunctella (Hubner)	Modesto, Ca.
6. Sitotroga cerealella (Olivier)	Manhattan, Ka
7. Tineola bisselliella (Hummel)	Savannah, Ga.; Ottawa, Can., and Durham, N.H.

b. Coleoptera

1. Anthrenus flavipes LeConte	Savannah, and Durham
2. Attagenus megatoma (Fab.)	CSMA strains
3. Callosobruchus maculatus (Fab.)	Fresno, ca.
4. Cathartus quadricollis (Guerin-Meneville)	Unknown
5. Cryptolestes pusillus (Schonherr)	Tifton, Ga.
6. Dermestes maculatus De Geer	Madison, Wis.
7. Gibbium psylloides (Czenpinski)	Unknown
8. Lasioderma serricorne (Fab.)	Unknown
9. Oryzaephilus mercator (Fauvel)	Unknown
10. Oryzaephilus surinamensis (L.)	Manhattan, Kan.
11. Rhyzopertha dominica Fab.)	Unknown
12. Sitophilus granarius (L.)	Manhattan, Kan.
13. S. oryzae (L.)	Ark., Calif., Kan., La. Minn. and Tex.
14. S. zeamais Motchulsky	Estill, S.C.

15. *Stegobium paniceum* (L.)	Madison, Wis.
16. *Tenebrio molitor* (L.)	Manhattan, Ka, Durham, N.H.
17. *Tenebroides mauritanicus* (L.)	Savannah, Ga.
18. *Tribolium castaneum* (Herbst)	Unknown
19. *Tribolium confusum* duVal	Manhattan, Kan.
20. *Tribolium madens* Charpentier	Tifton, Ga.
21. *Trogoderma glabrum* (Herbst)	Madison, wis., Riverside, Ca.
22. *T. inclusum* LeConte	Madison; Riverside
23. *T. variabile* Ballion	Fresno, Riverside, Ca.

II. mutant strains

A. *Plodia interpunctella*

1. Scaleless (scl)	Savannah, Ga.
2. Melanic (m)	"

B. *Tribolium castaneum.*

1. Black mutant	Ocilla, Ga.
2. Black mutant	Savannah, Ga.

C. *Tribolium confusum*

1. Fused antennal segments	Savannah, Ga.
2. Short elytra	"
3. Crumpled elytra	"
4. Blade elytra	"
5. Umbilicus	"
6. Red eye pupae	

New mutants

1. peg-leg (pl)--autosomal recessive with appendages extremely reduced in length. Savannah

2. separated elytra (sep)--elytra divergent from proximal end. Savannah

3. creased elytra (cr)--elytra creased and distal portion divergent. Savannah.

R. Davis

STORRS, CONNECTICUT 06268
COLLEGE OF LIBERAL ARTS AND SCIENCES
THE BIOLOGICAL SCIENCES GROUP

1. Tribolium brevicornis (two vials)

2. Tribolium castaneum

a. Chicago
b. Veracruz
c. Berkeley synthetic, marked with s.
d. Chicago black, b.
e. mc, p (microcephalic, pearl
f. pygmy
g. Davis Low Body Weight
h. Davis High Body Weight

3. Tribolium confusum

a. Chicago
b. Yugoslavia
c. Inbred (Group L CFI-B, culture 8d; Generation 123)
d. b,p (black, pearl
e. dj, e (disjoined, ebony)
f. sh (short elytra

(Ed.).

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

I. Wild type strains

A. Coleoptera strains

Dermestidae

Attagenus megatoma (F.)	Madison, Wis., 1975 Savannah, Ga., 1974.
Trogoderma variabile Ballion	Field collected, Mn., 1972.

Cucujidae

Oryzaephilus surinamensis (L)	Savannah, Georgia, 1975.
Oryzaephilus mercator (Fauvel)	Savannah, Georgia, 1984.
Cryptolestes pusillus (Schoenherr)	Manhattan Ka. 1967.
Cryptolestes ferrugineus (Stephens)	Unknown

Stock Lists

Silvanidae

Ahasverus advena Waltl.	Field collected, Mn., 1984

Tenebrionidae

Cyaneus angustus (LeConte)	Winnipeg; 1974.
Tribolium castaneum (Herbst) -	Field collected, Mn., 1977 Corvallis, Ore. 1976.
Tribolium confusum duVal	Unknown *
Tenebrio molitor	Carolina Biological, 1984

Anobiidae

Lasioderma serricorne (Fab.)	Savannah, ga., 1975
Stegobium paniceum	Unknown *

Bostrichidae

Rhizopertha dominica (F.)	Manhattan, Ka.
Prostephanus truncatus (Horn)	Unknown *

Curculionidae

Sitophilus granarius (L.)	Unknown *
S. oryzae (L.)	Inknown *

B. Lepidoptera

Pyralidae

Plodia interpunctella (Hubner)	Manhattan, Ka., 1972

Gelechiidae

Sitotroga cerealella (Oliver)	Savannah, Ga., 1975

KRISTEN BERG

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

Coleoptera

Anobiidae

Stegobiium paniceum (L.)

Anthribidae

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

Bostrichidae

Rhyzopertha dominica (F.)

Bruchidae

Acanthoscelides obtectus (Say)

Cleridae

Necrobia rufipes (Deg.)

Cucujidae

Ahasverus advena (Waltl)

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

Curculionidae

Sitophilus granarius (L.)
S. zeamais Motschulsky

Dermestidae

Anthrenus flavipes LeC. Weak culture
Anthrenus verbasci (Linnaeus)

Dermestes maculatus De Geer

Trogoderma variabile Ballion

Ostomidae

Gibbium psylloides (Czemp.)

Silvanidae

Ahasverus advena (Waltl.)

Oryzaephilus surinamensis

Tenebrionidae

Alphitobius diaperinus (Panz.)

Gnathocerus maxillosus (F.)

Palorus ratzeburgi (Wissm.)

Tribolium brevicornis (LeConte)
T. castaneum (Herbst)
T. confusum Duv.
T. destructor Uytt.--weak culture, may be diseased.
T. madens (Charpentier)

M. Nakashima

AUSTRALIA

Burnley, Victoria
Plant Research Institute
Department of Agriculture and Rural Affairs

COLEOPTERA

Tribolium castaneum

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

Tribolium confusum

Wild type strains
Malathion specific strain

Oryzaephilus surinamensis

Wild type strain
Malathion resistant strain
Fenitrothion resistant strain

Oryzaephilus mercator

Alphitobius diaperinus

Cryptolestes ferrugineus

Gnathocerus cornutus

Gnathocerus maxillosus

Latheticus oryzae

Rhyzopertha dominica

Sitophilus granarius

Sitophilus oryzae

Sitophilus zeamais

Tenebroides mauritanicus

LEPIDOPTERA

Ephestia cautella

Ephestia figulella

Galleria mellonella

Plodia interpunctella

P. Williams
(No change--Ed).

Queensland Department of Primary Industries, Entomology Branch,
Indooroopilly, Queensland,
Australia

Coleoptera

	TYPE	ORIGIN
Carpophilus dimidiatus	Wild	Queensland
Dermestes maculatus	Wild	Queensland
Lasioderma serricorne	Wild	Queensland
Necrobia rufipes	Wild	Queensland

Oryzaephilus surinamensis

VOS 48	insecticide susceptible	Victoria
QOS 42	fenitrothion resistant	Queensland
ZOS 73	fenitrothion resistant	Queensland

Stock Lists

	Type	Origin
Rhyzopertha dominica		
QRD 14	Insecticide susceptible	Queensland
QRD 2	multi-resistant	Queensland
QRD 63	multi-resistant	Queensland
Sitophilus oryzae		
LS 2	insecticide susceptible	Queensland
QSO 56	multi-resistant	Queensland
CSO 231	multi-resistant	W. Australia
Tribolium castaneum		
Wild type strains		
QTC 4	insecticide susceptible	Queensland
QTC 279	pyrethroid insecticide resistant	Queensland
QTC 285	multi-resistant, composite strain	Queensland
CTC 12	non-specific malathion resistant	Queensland
QTC 34	malathion soecific-resistant	Queensland
Mutant strains		
TC 65	pearl p	
TC 86	black b	
TC 179	antennapedia ap	
TC 113	sooty s	
TC 136	jet j	
TC 156	microphthalmic Mo	
TC 165	chestnut c	

LEPIDOPTERA

Ephestia cautella Wild Queensland
Plodia interpunctella Wild New South Wales

Graham White, Senior Entomologist.

Stock Lists

GEMBLOUX
INSTITUT AGRONOMIQUE DE L'ETAT
ZOOLOGIE GENRALE

No updated list has been received (Ed.).

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

No updated list has been received (Ed.).

BRAZIL

CAMPINAS, SAO PAULO
INSTITUTO AGRONOMICO, SECAO DE ENTOMOLOGIA

No updated list has been received (Ed.).

PIRACICABA, STATE OF SAO PAULO
CENTRO DE ENERGIA NUCLEAR NA AGRICULTURA
DEPARTMENT OF RADIOENTOMOLOGY

No updated list has been received (Ed.).

CANADA

GUelph, Ontario.
University of Guelph
Dept. of Animal and Poultry Science

1. Wild type strains

Tribolium castaneum — Purdue, 1960
Base population for quantitative genetics

2. Mutant strains

pygmy py — Purdue, 1960
Base populations maintained with no artificial selection and minimum of inbreeding.

Zhang Lao

Winnipeg, Manitoba R3T 2M9
Research Station, CDA
195 Dafoe Rd.

All cultures are laboratory cultures maintained over several years. Geographic origins are not complete

Species	Origin
Cryptolestes ferrugineus	
C. turcicus	
Oryzaephilus mercator	
O. surinamensis	
Prostephanus truncatus	Mexico City, Mexico 1977
Rhyzopertha dominica	
Sitophilus granarius	
S. oryzae	
S. oryzae	Minnesota, USA 1982
Stegobium paniceum	
Tribolium audax	
T. castaneum	
T. confusum	

R.N. Sinha

CHINA

Beijing, People's Republic of China
Beijing Agricultural University
Department of Animal Science

Tribolium castaneum

Wild type strains:

1. Base populations	**Guelph, 1987**
2. Inbreeding Line (full sib mating)	**Beijing, 1988**
3. Wu Line (local line)	**Beijing, 1988**
4. R Line	**Beijing, 1990**
5. H Line (selected for heavier pupa wt.)	**Beijing, 1991**
6. L line (selected for highter pupa wt.)	**Beijing, 1991**

Mutant Strains:

1. Base population maintained with no artificial selection and minimum of inbreeding	**Guelph, 1987**
2. Inbreeding Line (full sib mating)	**Beijing, 1988**

L. Zhang

Stock Lists

BOGOTA, COLOMBIA
UNIVERSIDAD NACIONAL DE COLOMBIA
DEPARTAMENTO DE BIOLOGIA
APDO. AEREO #23227

I. Tribolium castaneum

Wild type strains

1. Apulo	Cundinamarca, Col. 1982
2. Bogota	Inst. Publ. Health, 1978
3. Bucaramanga	Trichogramma lab., 1981
4. Cartagena	Cartagena, Col. 1980
5. Abbc	Synthetic, 1982
6. bbc	Synthetic, 1982

Mutant strains (originals)

N	
7. antennapedia, (ap -VIII (1981)	Bogota, 1981
8. bifurcated antenna, ab-II (1979)	Bogota, 1979
9. black, b-III	Bogota, 1983
10. charcoal, chr-III	Bogota, 1981
11. chestnut eyes, oc- ?-	Bogota, 1984
12. disjuncted elytra, es- ?	Bogota. 1982
13. fused antennameres, af- ?	Bogota, 1980
14. glass legs, pv-?-	Bogota, 1980
15. ivory eyes, omf-I	Bogota, 1981
16. light eyes, op -?-	Bogota, 1985
17. miniature appendaged ma-I-	Bogota, 1981
18. narrow eye (oje) -?-	Bogota, 1980
19. red eyes or- ?-	Bogota, 1980
20. scars, ca -sc?-	Bogota, 1984
21. white eye, obl -IV-	Bogota, 1982

II. Gnathocerus cornutus

1.Wild strain.	Apulo, (Cund.) Colombia

III. Oryzaephilus surinamensis

1. Wild strain	Chocolate from U.S.A.

Fernando Nunez del Castillo

(For original Spanish names of these mutants, see TIB 24, Ed.).

Stock Lists

DENMARK

LYNGBY
STATENS SKADEDYRLABORATORIUM
(DANISH PEST INFESTATION LABORATORY)

Alphitobius diaperinus
Anobius punctatus
Anthrenus museorum
A. vorax
Attagenus alfieri
A. piceus
Dermestes frischi
Hylotrupes bajulus
Lasioderma serricorne
Oryzaephilus mercator
O. surinamensis
Rhizopertha dominica
Sitophilus granarius
S. oryzae
Stegobium (Sitodrepa) paniceum
Tenebrio molitor
Tenebroides mauritanicus
Thylodrias contractus
Tribolium confusum
T. destructor
Trogoderma granarium

(Ed.).

FRANCE

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

A. Wild type strains

1. Sitophilus granarius L.

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

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

B. Selected lines of Sitophilus oryzae

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

3. RR strain (fast development) 88,000+5000 ovarian symbiotes)

P. Nardon

GERMANY

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

Wild type strains

1.	Oryzaephilus surinamensis	Freiburg
2.	Tribolium castaneum	San Bernardino
3.	T. confusum	San Bernardino

Mutant strains (All from San Bernardino)

A. Tribolium castaneum
4. alate prothorax (apt)
5. Bar eye (Be)
6. black (Brazil background)
7. black (Chicago background)
8. Dachs (Dch)
9. Fused tarsi and antennae (Fta)
10. Microphthalmic (Mo)
11. nude (nd)
12. pygmy (py)

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

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

K. Sander

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

Coleoptera

Bruchidae--*Acanthoscelides obtectus* (Say)	
Cucujidae--*Cryptolestes turcicus* Grouv.	Munich, 1966
Ptinidae	
Gibbium psylloides (Czemp)	Regensburg, 1960
Ptinus tectus (Boi.)	Munich, 1972
Silvanidae	
Oryzaephilus mercator (Fauv.)	Munich, 1966
O. surinamensis (L)	? 1971

Munich (cont'd)

Tenebrionidae

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

Lepidoptera

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

E. Naton.

INSTITUT FUR FLUGMEDIZIN DER DFVLR
GODESBERGER ALLEE 70
5300 BONN 2

I. Wild type strains derived from crop imports from Africa and Far East, selected against rough anomalies

A. *Tribolium castaneum*, not inbred.
B-1. *T. confusum*, not inbred
B-2. *T. confusum*, inbred by 12 single-pair passages

II. C. *T. castaneum*, a highly inbred strain (C-1) from Prof. Bell, Purdue University, which showed more than 505 different anomalies during first generations in our laboratory.
C-1. *T. castaneum*, wild type strain.
C-2. *T. castaneum*, mixed mutations strain.

W. Briegleb

Stock Lists

INDIA

NEW DELHI 110012
INDIAN AGRICULTURAL RESEARCH INSTITUTE
DIVISION OF ENTOMOLOGY

STRAIN	RESISTANCE RATIO	LAB GENE-RATION	REARING MEDIUM
1. T. CASTANEUM MALATHION RESISTANT	>200X	42	COMMON WHEAT FLOUR CHARGED WITH TECH. MALATHION
2. T. CASTANEUM LINDANE RESISTANT	>100X	112	COMMON WHEAT FLOUR CHARGED WITH TECH. LINDANE
3. T. CASTANEUM DDT RESISTANT	>100X	137	COMMON WHEAT FLOUR CHARGED WITH TECH DDT
4. T. CASTANEUM PIRIMIPHOS METHYL RESISTANT	>18X	31	COMMON WHEAT FLOUR CHARGED WITH TECH PIRIMIPHOS METHYL
5. T. CASTANEUM PHOSPHINE RESISTANT	>6.27X	43	COMMON WHEAT FLOUR
6. SUSCEPTIBLE T.CASTANEUM	-	149	COMMON WHEAT FLOUR
7. T. CASTANEUM BLACK	-	65	"
8. SUSCEPTIBLE T. CONFUSUM	-	23	"
9. T. CONFUSUM NIGRAT - MELANIC MUTANT	-	23	"

J. D. SAXENA
SENIOR SCIENTIST

TEL AVIV, ISRAEL
TEL AVIV UNIVERSITY
DEPARTMENT OF ZOOLOGY

A. Tribolium castaneum

1. Wild type strains

Berkeley--via Tribolium Stock Center, San Bernardino
McGill--via Tribolium Stock Center (TSC).
3 strains collected from different stored products, in Israel.

2. Mutant strains

Visible mutants
Chicago b via Stony Brook, N.Y.
eu++ (extra urogomphi, normal body color)
eu b (extra urogomphi, black body color)
p--pearl. From TSC
mc--microcephalic. Originated as a single mutant in p.
pd--paddle--From TSC.
pd b--paddle, black
py,r--pygmy, red from TSC.

electrophoretic mutants

bEs (slow esterase, b)--selected from b.
bPs (Acph-1 slow, est-1 null, b) selected from eu b.
FF (fast Acid phosphatase, + body color). Selected from eu+.

B. Tribolium confusum

Wild type strains
Chicago +--from TSC.
Israel

Mutant strains
McGill b--via Stony Brook
msg melanotic stink glands (prothoracic)--from TSC.
msg (strong)--from TSC
p (pearl) from TSC.
XL (extra large) from TSC

c. T. brevicornis

Riverside + via TSC.

David Wool

Stock Lists

JAPAN

TSUKUBA
STORED-PRODUCT ENTOMOLOGY LABORATORY
NATIONAL FOOD RESEARCH INSTITUTE
KANNONDAI 1-2-1,
TSUKUBA, IBARAKI 305

PSOCOPTERA

Liposcelidae

1. Liposcelis bostrychophilus Badonel — Wild
2. Liposcelis entomophilus (Enderlein) — Wild

Trogiidae

3. Lepinotus reticulatus Enderlein — Wild

COLEOPTERA

Silvanidae

4. Oryzaephilus surinamensis (L.) — Wild

Cucujidae

5. Cryptolestes turcicus (Grouvelle) — Wild
6. Cryptolestes pusilloides (Steel and Howe) — Wild (Okayama)

Tenebrionidae

7. Alphitobius diaperinus (Panzer) — Wild
8. Gnathocerus cornutus (Fabricius) — Wild
9. Latheticus oryzae Waterhouse — Wild
10. Palorus ratzeburgi (Wissmann) — Wild
11. Tribolium castaneum (Herbst) — Wild
12. Tribolium confusum Jacquelin du Val — Wild
13. Tribolium freemani Hinton — Wild
14. Tenebrio molitor L. — Wild
15. Tenebrio obscurus Fabricius — Wild

Anobiidae

16. Lasioderma serricorne (Fabricius) — Wild
17. Stegobium paniceum (L.) — Wild

Ptinidae

18. Gibbium equinoctiale Boieldieu — Wild

Bostrichidae

19. Rhyzopertha dominica (Fabricius) — Wild
20. Dinoderus minutus (Fabricius) — Wild

Curculionidae

21. Sitophilus oryzae (L.) — Wild
22. S. zeamais Motschulsky — Wild

LEPIDOPTERA

Phycitidae

23. *Ephestia elutella* (Hubner)	Wild
24-1. *Ephestia cautella* (Walker)	Wild
24-2.	brbr (brown wing)
25-1. *E. kuhniella* (Zeller)	Wild
Mutant:	
25-2 aa (Red, Misima)	
25-3 bb (black wing mutant	
25-4 wawa (white eyes	
26.1 *Plodia interpunctella* (Hubner)	Wild

Gelechiidae

27. *Sitotroga cerealella* (Olivier)	Wild

HYMENOPTERA

Ichneumonidae

28. Ventris canescens (Gravenhorst)	Wild

O. Imura
T. Kotaki

Note: Dr. H. Nakakita"s list in TIB 24 also includes the following information on Tribolium stocks:

Wild type strains and geographic origin

Tribolium audax H.....derived from Dr. D.G.H. Halstead, Slough
T. castaneum (H.) Japan
T. castaneum (H.)
TCP.A (PH3-resistant)--derived from Dr. R.G.Winks, Stored Grain Research Lab, Division of Entomology, CSIRO
CTC4 (PH3-susceptible)--derived from R.G. Winks
T. confusum.....Japan
T. freemani..... captured in Japan (contaminated imported corn from Brazil).

H. Nakakita

Stock Lists

OKAYAMA
LABORATORY OF APPLIED ENTOMOLOGY
COLLEGE OF AGRICULTURE
OKAYAMA UNIVERSITY

1. Wild type strains

COLEOPTERA

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

HYMENOPTERA

1.	*Anisopteromalus calandrae*	Okayama
2.	*Chaetospila elegans*	Okayama
	Lariophagus distinguendus	Okayama

Toshiharu Yoshida

INSTITUTE OF BIOLOGICAL SCIENCES
UNIVERSITY OF TSUKUBA
TSUKUBA, IBARAKI 305 JAPAN

COLEOPTERA
Bruchidae
Callosobruchus chinensis
13 strains from various localities in Japan and abroad.
1 black colored mutant derived from Shuzenji strain.
cC Mainland China
fC Fukushima, Japan
hC Hirosaki, Japan
h C Hirosaki, Japan
1
jC Kyoto, Japan, 1936
mC Morioka, Japan
nC Niigata, Japan, 1964
pC Punjab, India
sC Shuzenji black mutant
bl
tC Tokyo (Nishigahara, Nat. Inst. Agr.), Japan
t C Tsukuba, Japan
a
t C Tsukuba, Japan
a 2
t C Tsukuba, Japan
s
yC Taisha, Japan

Callosobruchus maculatus
12 strains from various localities in the world
aQ U.S.A. (prob. Louisiana)
bQ Burma
cQ Fresno Lab., USDA, Calif. U.S.A.
eQ
fQ Thailand
gQ
iQ U.S.A. (dr. Mitchell's lab)
kQ Kyoto, Japan
mQ Kansas State Univ., Manhattan, KS, U.S.A.
rQ
sQ Savannah Lab., U.S.D.A., Georgia, U.S.A.
tQ Tel Aviv, Isr. (Dept. Plant Prot., Stored Prod. Res. Lab.)
yQ England (Dr. Creland's lab)
Zabrotes subfasciatus Africa
Callosobruchus analis United Kingdom
Callosobruchus phaseoli United Kingdom
Acanthoscelides obtectus California, U.S.A.

Curculionidae
Sitophilus zeamais National Food Research Institute (Japan)
Sitophilus oryzae " " " " "

Stock Lists

HYMENOPTERA

Braconidae

Heterospilus prosopidis	Hawaii, U.S.A.

Pteromalidae

Anisopteromalus calandrae	Japan
Chaetospila elegans	United Kingdom
Dinarmus basalis	India

Koichi Fujii

Spain

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

Tribolium castaneum

A. Wild type strains

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

B. Mutant strains

13.	Black Purdue	Purdue, U.S.A.	1964

c. Experimental lines
Originated from the "Consejo" strain and selected for egg laying performance through 42 generations

		Selected for	Temperature (0C)
14.	AN-I	high performance at	33
15.	AN-II	" "	33
16.	AF-I	" "	28
17.	AF-II	" "	28
18.	AT-I	" "	38
19.	AT-II	" "	38
20.	BN-I	low performance at	33
21.	BF-I	" "	28
22.	BFII	" "	28
23.	BT-I	" "	38
24.	BT-II	" "	38
25.	RN-I*	high cross performance at	33
26.	SN*-I	" "	33
27.	RN-II	" "	33
28.	SN-II	" "	33
29.	RF-I	" "	28
30.	SF-I	" "	28
31.	RF-II	" "	28
32.	SF-II	" "	28
33.	RT-I	" "	38
34.	ST-I	" "	38
35.	RT-II	" "	38

Stock Lists

36. ST-II " " 38
37. CTD-I high performance at diff. levels of selection
38. CTD-II " " " " "
39. DTD-I " " " " "
40. DTD-II " " " " "
41. ETD-I " " " " "
42. ETD-II " " " " "
43. FTD-I " " " " "
44. FTD-II " " " " "

d. Mutants

45.	antennapedia a, VIII	Purdue,	1964
46.	diferencial Df, IV	Purdue.	1964
47.	fused antennal segments-2 fas-2 IV	Sokoloff,	1968
48.	ivory I ?	Purdue.	1964
49.	paddle, pd I	Purdue,	1964
50.	pearl p II	SOKOLOFF,	1968
51.	pegleg pg II	Purdue,	1968
52.	pygmy py I	Purdue,	1964
53.	rose rs	Purdue,	1964
54.	ruby rb ?	Purdue,	1964
55.	short elytra sh VIII		
56.	squint sq VIII	Purdue.	1964
57.	white w ? w	Purdue	
58.	wine r I	Purdue,	1968
59.	eye mutant ?	Madrid,	1967
60.	maroon m ?	Purdue,	1977
61.	melanotic stink glands-like	Madrid,	1968
62.	sooty s IV	Sokoloff,	1977
63.	chestnut c VII	Sokoloff,	1977
64.	microcephalic mc V	Sokoloff,	1977
65.	Microphthalmic Mo VI Pk	Sokoloff,	1977
66.	pink p II	Sokoloff	
67.	Bar eye Be IV	Sokoloff,	1977
68.	prothoraxless ptl IX	Sokoloff,	1977
69.	light ocular diaphragm lod III	Purdue,	1968
70.	black b III	Sokoloff	1977

Tribolium confusum

A. Wild type strains

71. Coronada — La Coronada, Spain

B. Mutants

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

Ma. C. Fuentes

MEXICO

INstituto Nacional de Investigaciones Agricolas
Centro de Investigaciones Agricolas del Norte Centro
Pabellon, Aguascalientes, Zacatecas

Prostephanus truncatus--wild type strain

M.C. Mario Ramirez Martinez

POLAND

POLISH ACADEMY OF SCIENCES, INSTITUTE OF ECOLOGY,
DZIEKANOW LESNY, 05092, LOMIANKI, POLAND

Acanthoscelides obtectus Say--Wild type, Poland

Tribolium castaneum Hbst.

Wild strain from San Bernardino via Freiburg
cI genetic strain from Chicago
cII " " " "
cIII " " " "
cIV " " " "
sooty (s) from San Bernardino via Freiburg
pearl (p) " " " " "
pygmy, paddle, platinum (py,pd,ptl) from San Bernardino via Chicago

Tribolium confusum

Wild strain from San Bernardino via Freiburg
bI genetic strain from Chicago
bII " " " "
bIII " " " "
ebony-2 e-2 from San Bernardino via Freiburg

Tadeusz Prus

PEOPLE'S REPUBLIC OF CHINA
BEIJING
BEIJING AGRICULTURAL UNIVERSITY
DEPARTMENT OF ANIMAL SCIENCE

Tribolium castaneum

Wild type strains

1. Base populations for quantitative studies Guelph, 1957.
2. Inbreeding line (full sib-mating) Beijing, 1988
3. Wu line (local line Beijing, 1988

Mutant strains: py

1. Base population maintained with no artificial selection and minimum of inbreeding
2. Inbreeding line (full sib mating) Beijing 1988

Zhang Lao

UNITED KINGDOM

ADAS CENTRAL SCIENCE LABORATORY
MINISTRY OF AGRICULTURE, FISHERIES AND FOOD
LONDON ROAD
SLOUGH, BERKS, U.K.
SL3 7HJ TEL (0753) 34626 Fax (0753 824058

Insects mentioned below are bred in controlled environmental conditions and, as far as possible, free from disease. All new stocks pass through a quarantine procedure before acceptance into the main insectaries. This list was last updated in November 1988. The country of origin and year of receipt at this laboratory are shown against strains, where this information is known. For some of the older strains, such information is not known. Please note thatz some strains do not have a name, especially if only one strain of a species is held. Where more than five strains of a species are held, full details are not given. (However, full details of all mutant strains held are given). Please write to me for further details on any aspect of this list and with any requests for specimens. The latter will be met where sufficient are available, but a charge may have to be made.

Monica O'Donnell (Mrs.)

Species	Strain	Country of origin	Year received at Lab.
COLEOPTERA			
Alasverus advena (Waltl)	Insectary	W. Africa	1956
Alphitobius diaperinus (Panz)	Insectary		
	Goose's foot	Britain	1983
	Droxford	Britain	1984
	35	Britain	1987
Anthrenocerus australis (Hope)	Insectary	Britain	1933
Anthrenus flavipes (LeC.)	Insectary		
A. picturatus Hintoni (Mroczkowski)	Insectary	U.S.S.R.	
A. garnicus (Mroczkowski)	Insectary		
A. verbasci (L.)	Insectary	Britain	1951

Attagenus brunneus Falderman	Insectary	Spain	
A. cyphonoides Reitter		U.S.S.R.	1976
A. fasciatus cinnamomeus (Roth)	Insectary	Botswana	1965
A. fasciatus fasciatus (Thunberg)	Insectary	Botswana	1972
A. insidiosus Halstead	Insectary	Kenya	
A. pellio (L.)	Insectary	Britain	
A. rufiventris Pic	Insectary	Botswana	1970
A. smirnovi Zhantier	Insectary	Kenya	1962
A. unicolor japonicus Reitter	Insectary	Japan	1956
A. unicolor japonicus Reitter (Synonym A. unicolor canadensis Casey	Insectary	N. U.S.A.	1980
A. unicolor simulans Solsky	Insectary	U.S.S.R.	1976
A. unicolor unicolor (Brahm) (=megatoma (F.) =piceus (Olivier)			
A. woodroffi	Finland		1965
Halstead & Green	Sweden		1978
Carpophilus dimidiatus (F.)	Insectary	U.S.A.	
C. hemipterus (L.)	Insectary		
Coelopalorus foveicollis (Blair)	Trinidad		
Cryptolestes capensis (Waltl)	Insectary		
C. ferrugineus (Steph.)	9 strains from 2 countries held, many differing in their susceptibility to pesticides		
C. pusilloides (Steel and Howe)	Canada		
C. pusillus (Scho.)			
C. pusillus fuscus Lefkovitch	Trinidad		
C. turcicus (Grouv.)			
C. ugandae Steel and Howe		E. Africa	1954
Dermestes ater Deg.		Britain	1953
D. frischii Kug.		Nigeria	
D. haemorrhoidalis Kuster		Britain	
D. lardarius		Britain	
D. maculatus Deg.		Bangladesh	1975
D. peruvianus Castelnau		Britain	1961
Gibbium aequinoctiale (Boield.)		Britain	1937

Gnatocerus cornutus (F.)			
G. maxillosus (F.)			
Lasioderma serricorne (F.)	Insectary		
Latheticus oryzae Waterh.	Insectary		
Mezium affine Boield.	Insectary	Britain	
M. americanum (Lap.)	Insectary		
Niptus hololeucus (Fald.	Insectary		
Oryzaephilus acuminatus Halstead	Insectary		
O. mercator (Fuv.)	Insectary		
	Senegal	Senegal	1979
	O-871	Cyprus	1979
O. surinamensis (L.)	52 strains from 11 countries held, many differing in their susceptibility to pesticides		
Palorus ratzeburgi (Wissm.)	Insectary		
Palorus subdepressus (Woll.)			
Pseudeurostus hilleri (Reitt.)	Insectary	Britain	1940
Ptinus clavipes Panz.		Britain	1954
P. exulans Er.		Britain	
P. pusillus Sturm	Insectary		
P. sexpunctatus Panz.	Insectary		
P. tectus Boield.	Insectary A		
	Insectary B	Britain	1960
	Wild	Britain	1975
Rhyzopertha dominica (F.)	8 strains from 5 countries held, many differing in their susceptibility to pesticides		
Sitophagus hololeptoides (Cast.)	Insectary	Trinidad	1972
Sitophilus granarius (L.)	15 strains from 5 countries held, many differing in their susceptibility to pesticides		
S. oryzae (L.)	7 strains from 6 countries held, many differing in their susceptibility to pesticides		
S. zeamais Motsch.	Insectary		
	153	Guatemala	1972
	912	Kuwait	1972
	US	USA	1976
	PS-60	Britain	1984

Sphaericus gibboides (Boield.)	Insectary	Britain	1976
Stegobium paniceum (L.)	Insectary		
Stethomezium squamosum Hint.	Insectary	Britain	
Tenebrio molitor L.	Insectary		
T. molitor F.	Insectary		
Tipnus unicolor (P. & M.)	Insectary	Kenya	
Tribolium anaphe Hint.	Insectary	Nigeria	
T. audax Halstead	Insectary	Canada	
T. brevicornis LeC	Insectary	USA	
T. castaneum (Herbst)	7 strains from 5 countries held, many differing in their susceptibility to pesdticides		
T. confusum J. du V.	Insectary		
	W-44		
	PS-108	Britain	1983
T. destructor Uytt.	Ethiopia	Ethiopia	1968
	Denmark	Denmark	1968
T. freemani Hinton	Insectary	Japan	1980
T. madens (Charp.)	Insectary	Yugoslavia	
Trigonogenius globulus Sol.	Insectary	Ireland	
T. particularis Pic	Insectary	Kenya	
Trogoderma angustum (Solier)	Insectary	Germany	1975
T. anthrenoides (Sharp)	Insectary	USA	
T. glabrum (Herbst)	Insectary	USA	
T. granarium Everts	11 strains from 7 countries held.		
T. grassmanii Beal	Insectary	USA	1976
T. inclusum LeC	Insectary		
T. irroratum Reitt.	Insectary	Egypt	
T. sternale plagifer Casey	Insectary	USA	
T. varium Matsumura and Yohoyama	Insectary	Korea	1970
T. variabile Ballion	Insectary	USA	
Typhaea stercorea (L.)	Somerset	Britain	
	Datchet	Britain	1980

DICTYOPTERA

Blatta orientalis L.	Insectary		
	W. Middlesex	Britain	1986
Blattella germanica (L.)			
Periplaneta americana (L.)			

DIPTERA

Musca domestica L.	6 strains from 2 countries held, several other strains also held, but on a short term basis		

HYMENOPTERA

Monomorium pharaonis (L.)		Britain	1953

LEPIDOPTERA

Endrosis sarcitrella (L.)	Reading	Britain	1986
Ephestia cautella (Walker)	Insectary	Cyprus	1969
E. elutella (Hubner)	Insectary		
	Milwall 8F	Britain	1969
E. Kuehniella Zell.	Insectary	Britain	1949
	Southampton	Britain	1953
	Harlescott	Britain	1982
	Rhydymwyn	Britain	1988
Galleria mellonella (L.)	Insectary A		
	Insectary B	USA	
Plodia interpunctella Hubner	9 strains from 9 countries held		
Sitotroga cerealella (Oliv.)	A68	Nepal	1972
	S623	USA	1972

PSOCOPTERA

Lepinotus patruelis Pearman		Britain	
Liposcelis Bostrychophilus *L. subfuscus* (Broadhead)		Britain	1949
Trogium pulsatorium		Britain	

MUTANT STOCKS

Species	Mutation	Strain/s mutation/s arose in	Country of origin
COLEOPTERA			
Carpophilus dimidiatus (F.)	Pearl eye		
Cryptolestes turcicus (Grouv.)	Red eye		
Dermestes maculatus Deg.	Pearl-eye		
	Black/Brown		Australia
Lasioderma serricorne (F.)	Black		USA
Oryzaephilus mercator (Fauv)	Pearl eye (pe) X	O-779	Pacific Isles
O. surinamensis (L.)	Clear eye (cc)	00757	
	Dark body (dd)	484 Square	India
	Speckled eye	484 Diamond	India
	L.O.D. (ss,ll)	484 Diamond	India
	Transparent eye (tt)	01061	Britain
	Clear eye, dark body (cc, dd)		
	Speckled eye, dark body (ss,dd)		
	Transparent eye, dark body (tt, dd)		
Rhyzopertha dominica (F.	Black		
Tribolium castaneum (Herbst)	Black		
LEPIDOPTERA			
Ephestia cautella (Walker)	Yellow eye	Florida	USA
	Black eye	Insectary	Cyprus
	Diapause	x Florida	USA
Ephestia elutella (Hubner)	White eye		
Sitotroga cerealella (oliv.)	Pearl eye	A68	Nepal
	Red eye	A68	Nepal

Monica O'Donnell (Mrs.)

Grain Technology Dept.
Natural Resources Institute (NRI)
Central Ave.
Chatham Maritime
Chatham
Kent ME4 4TB
UK

Below is a list of Tribolium species held by Grain Technology Dept of NRI, Chatham UK. All strains are wildtype but with differing susceptibility to insecticides and fumigants.

CULTURE NO	TRIBOLIUM SPP	COUNTRY OF ORIGIN	DATE OF ENTRY	COMMENTS
MAFF REF (1)	Tribolium castaneum	MAFF	June '91	MAFF Slough UK
(2)	Tribolium Spp.	Indonesia (Jakarta, ((Bulog Jaya))	Sept '91	
(3)	Tribolium Spp.	Sudan	Sept '91	Collected from Canadian wheat flour
(4)	Tribolium Spp.	Mozambique (Matola)	Nov '91	Found in ware-house of Ancreda, at Matola, just outside Maputo. Found on white maize - food aid from Mexico. Fumigation history was not given, - probably fumigated.
(6)	Tribolium Spp.	Zimbabwe (concession)	Aug '91	Found at commercial and communial farms, insects taken off white maize. Fumigation using Methyl Bromide carried out by Grain Marketing board, although thought not to be fully successful.
(7)	Tribolium Spp.	Thailand	July '91	

(9)	Tribolium castaneum.	Philippines (Munoz)	4/12/91	From private rice mill at Munoz. No history of fumigation, or contact insecticides
(10)	Tribolium castaneum.	Philippines (Cabantuan)	6/12/91	Taken off local paddy milled rice from NFA stores at Carbanatuan. PH_3 used on milled rice-carried out by NFA. Contact insecticides used:- a) Acetellic b) Permethrion
(11)	Tribolium castaneum	Parkistan	June '87	From Karachi No resistance to Methyl Bromide. 88% MORT/PH_3
(14)	Tribolium castaneum	Indonesia	June '87	From Cilacap, Bulog-Jaya. GBB II/unit 2/08 No resistance to Methyl Bromide. 100% mort-PH_3
(28)	Tribolium castaneum	Pakistan	March '87	100% resistance to PH_3, No resistance to Methyl Bromide at d.d.*
(33)	Tribolium castaneum	MAFF	Jan '87	
(39)	Tribolium castaneum	Philippines	Feb '88	No resistance to Methyl Bromide at d.d.*100% mort to PH_3 From Naphire, Lab strain
(40)	Tribolium	Philippines	Feb '88	From Naphire - Lab strain. Resistant to Malathion at 0.5% d.d.* Susceptible to Pirimiphos methyl. 100% mort' to PH_3. No resistance to Methyl Bromide at d.d.*

* Discriminating Dose

Stock Lists

(42)	Tribolium	India	June '88	From the food corp-ortation Godown, Cochin. 7% mortality to PH_3. No resistance to Methyl Bromide at d.d.
(48)	Tribolium castaneum	Sri Lanka	July '89	Sample n° 01, collected from Pakistan boiled-rice stored at store n° 6 Food Dept, store complex on 7.7.89 - Naraheripita.
(50)	Tribolium castaneum	Botswana	July '89	From USA, ex Botswana. Found on food aid sorghum
(54)	Tribolium castaneum	Kenya	March '89	From combined warehouses. 100% mortality to PH_3. 64% mortality to Pinimiphos methyl at d.d.*
(55)	Tribolium castaneum	Zimbabwe	March '89	From GMB, Zimbabwe
(58)	Tribolium castaneum	Kenya	March '89	From port transit shed, Mombasa. 92% mort' to Pirimiphos methyl, at d.d.* 1% mort' to Malathion, at d.d.* No resistance to Methyl Bromide at d.d.*
(59)	Tribolium castaneum	Mali	March '89	50% mortality to PH_3 at d.d. No resistance to M. Bromide
(67A)	Tribolium castaneum	Ex Thailand	Dec '89	Found on rice from Thailand, shipped to W. Africa - insects ex Dakar after fumigation. Insects fumigated on Quayside (4.5 - 6g 1 tonne PH_3) for 48 hrs.

				Malathion susceptible at 0.5% d.d. - 85% mortality no resistance to Methyl Bromide
(67B)	Tribolium castaneum	Ex Thailand	Dec '89	Found on rice from Thailand, shipped to W. Africa. Insects ex Dakar before fumigation. No resistance to M. Bromide
(69)	Tribolium castaneum	Ex Thailand	Dec '89	Found on rice from Thailand, shipped to W. Africa. Insects, ex Dakar. Possible PH_3 resistance
(70)	Tribolium castaneum	Ex Indonesia	Feb '91	Taken from Bulog rice store - Budran. No resistance to Methyl Bromide.
(71)	Tribolium Spp.	Zambia	Dec '90	From Lusaka
(72)	Tribolium Spp.	Thailand	Sept '91	From Chiang Rai barley store
(73)	Tribolium castaneum	Zambia	Sept '91	
(74)	Tribolium castaneum	Zimbabwe	21/11/91	From Nandi. Fumigated in Zimbabwe using Methyl Bromide. - 4.4 g/t
(75)	Tribolium castaneum	Zimbabwe	22/10/91	From Gurve, from intake of communal origin
(76)	Tribolium castaneum	Zimbabwe	15/11/91	Collected from Aspindale. Fumigated with Methyl Bromide. - 4.4 g/t

(77)	Tribolium castaneum	Zimbabwe	13/11/91	Collected from Gowive, collected from incoming maize of communal origin
(78)	Tribolium castaneum	Pest Biology		Laboratory reference Susceptible to Pirimiphos Methyl at d.d.* No resistance to M. Bromide

D P Rees

Post Harvest Pests and Quality Section

G229 Ex3810

SLOUGH, BERKS., U.K.
OVERSEAS DEVELOPMENT NATURAL RESOURCES INSTITUTE, SLOUGH DEPT.
OVERSEAS DEVELOPMENT ADMINISTRATION

PEST BIOLOGY AND INSPECTION SECTION

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

1. Wild type strains
   A. COLEOPTERA

	Bruchidae	
1.	Acanthoscelides obtectus	a. Swaziland
		b. Colombia (6 strains)
		c. Turkey
		d. Colombia-CIAT
2.	Callosobruchus analis	a. ex MAFF Lab., Slough
3.	C. chinensis	a. Kenya
		b. Indonesia
4.	C. maculatus	a. Brazil
		b. Yemen, A.R.
		c. Nigeria
		d. Uganda
		e. Indonesia
5.	C. rhodesianus	a. Zimbabwe
6.	Caryedon serratus	a. unknown
		b. India
	Cucujidae	
7.	Cryptolestes ferrugineus	a. unknown
	Bostrichidae	
8.	Dinoderus distinctus	a. Tanzania
9.	D. minutus	a. Indonesia
10.	D. porcellus	a. Togo
	Tenbrionidae	
11.	Gnatocerus maxillosus	a. Tanzania
	Anobiidae	
12.	Lasioderma serricorne	a. unknown
	Lophocateridae	
13.	Lophocateres pusillus	a. Philippines
	Bostrichidae	
14.	Prostephanus truncatus	a. Mexico
		b. Tanzania (2 strains)
		c. Togo
		d. Costa Rica
15.	Rhyzopertha dominica	a. ex MAFF Lab. Slough

Curculionidae	b. Mali
16. *Sitophilus oryzae*	
i. Normal strains	a. Indonesia
	B. Tanzania
ii. Pulse-feeding strains	a. Burma (2 strains)
	b. Peru
	c. Trinidad (2 strains)
17. *S. zeamais*	a. Tanzania
	b. Indonesia
	c. Mexico (2 strains)
	d. Ex MAFF Lab. Slough
Histeridae	
18. *Tretriosoma nigrescens*	a. Mexico
	b. Costa Rica
Tenebrionidae	
19. *Tribolium castaneum*	a. Tanzania
	b. Unknown
	c. Mali
Bruchidae	
20. *Zabrotes subfasciatus*	a. Colombia (4 strains)
	b. Uganda

B. LEPIDOPTERA

Galleriinae	
1. *Corcyra cephalonica*	a. Malawi
Phycitinae	
2. *Ephestia cautella*	a. Ethiopia
	b. MAFF Lab. Slough
3. *E. elutella*	a. Unknown
4. *Plodia interpunctella*	a. Unknown
Gelechiidae	
5. *Sitotroga cerealella*	a. Sudan

CHEMICAL CONTROL SECTION

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

Wild type strains

A. COLEOPTERA

Cucujidae	
21. *Cryptolestes* sp.	a. Ethiopia
Dermestidae	
22. *Dermestes ater*	a. Ex MAFF Lab. Slough
23. *D. frischii*	a. Ex MAFF Lab. Slough
24. *D. maculatus*	a. Malawi
25. *D. carnivorus*	a. Indonesia
Curculionidae	
26. *Sitophilus oryzae*	
Insecticide-susceptible reference strain	a. Ex MAFF Lab. Slough
Malathion- and lindane-resistant strain (A76)	b. Ex MAFF Lab. Slough
Strains tested for phosphine resistance	c. Bhutan
	d. Nepal
	e. Pakistan (2 strains)
	f. Tunisia
	g. Brazil
	h. Tanzania
	i. Philippines
	j. Morocco
27. *S. granarius*	a. U.K.
	b. Cyprus
28. *S. zeamais*	a. Unknown
Strains tested for phosphine resistance	b. Ghana
	c. Zimbabwe
	d. Burma
	e. Thailand
Tenebrionidae	
Tribolium castaneum	
Multiple insecticide-resistant strain (CTC 12)	a. Australia
Malathion-specific resistant strain (Kana C)	b. Nigeria
Insecticide-susceptible reference strain	c. Ex MAFF Lab. Slough
Phosphine resistant strains	d. Nepal
	e. Pakistan (8 strains)
	f. Sri Lanka

g. Ethiopia (2 strains)
h. Liberia
i. Mali (5 strains)
j. Zimbabwe (2 strains
k. Ghana
l. Philippines (2 ")
m. India (7 strains)
n. Tunisia
o. Uganda
p. Indonesia (6 strains)
q. Cyprus (3 strains)
r. Tanzania
s. Brazil

Bostrichidae

30. Prostephanus truncatus — As pest biology
Dinoderus sp. — a. Jamaica
Rhyzopertha dominica
Phosphine resistant strains — a. Nepal
b. Pakistan (2 strains)
c. Sri Lanka (2 strains)
d. Mali
e. Indonesia
f. Ethiopia
g. Morocco
h. Brazil

Silvanidae

33. Oryzaephilus surinamensis — a. Sri Lanka
Phosphine resistant strains — b. Ethiopia

Histeridae

34. Teretriosoma nigrescens — As Pest Biology

Dr. Chris P. Haines

RESEARCH, TEACHING AND TECHNICAL NOTES

Notes-Research, Teaching and Technical

Paweł BIJOK

Laboratory of Ecophysiology of Invertebrates
Institute of Ecology, Polish Academy of Sciences,
Dziekanów Leśny (near Warsaw), 05-092 Łomianki, Poland

* RESPIRATORY METABOLISM OF *TRIBOLIUM CASTANEUM* HBST. AND *T. CONFUSUM* DUVAL IN TWO PHENOTYPIC GROUPS.

INTRODUCTION

The bioenergetic and population investigations of *Tribolium* beetles (Prus 1976 and Bijok 1986), as well as other store-product insects (Howe 1961), showed that individuals of the same population can differ strongly in respect of the number of larval instars, development time and body weight.

Two clearly different phenotypic groups can be distinguished within populations of two allied species: *Tribolium castaneum* and *T. confusum*. So called 6-instar individuals which develop faster but has lower weight and 7-instar ones which develop longer but their bodies become heavier. The differences between phenotypic groups within both species are very similar to that which occurs between two species. That differences are probably the effect of different life strategies accomplished by the species.

Further investigations were concerned with analyzing differences between 6- and 7-instar individuals as well as between the two *Tribolium* species in many life parameters, e.g. fecundity, weight and hatchability of eggs (Prus and Prus 1987, Prus et al. 1989), reproductive effort (Prus et al. 1988) and dependence between embryonic and postembryonic development (Bijok in press).

The phenotypic diversity can be explained as the way of fitting the species to changeable environment and can be interpreted in terms of life-history theory (Imura 1990, Sibly and Calow 1989, Møller et al. 1989).

The purpose to perform the present investigation was to compare the two *Tribolium* species according to their level of metabolism and to find out whether the instar-group diversity affects this factor and has an influence on the way of energy management in individuals belonging to different phenotypic groups.

MATERIAL AND METHODS

Two strains of two species: cI - *T. castaneum* and bIV - *T. confusum* both from the group of genetic strains, developed at the Chicago University (Park et al. 1961) were used in this investigation.

Cultures were kept in standard condition of 29°C, 75%

relative humidity, in culture medium consisting of 95% of wheat flour and 5% of baker's yeast (by weight). Before the experiments the culture medium was conditioned in incubators to obtain adequate temperature and humidity.

Newly hatched larvae (no more than two hours old) were placed in respiration chambers with an amount of 1g of culture medium. On the 4-th day of life the respiration chambers were connected with constant pressure volumetric microrespirometers (Klekowski 1975). Chambers were darkened with pieces of aluminum foil to run respiration measurements in standard light conditions. Second arms of respirometers were connected with compensation chambers, also filled with the same quantity of culture medium. Respirometers were placed in water bath and after 1 hour of thermoadaptation measurements of oxygen uptake were run for about 5 hours. Thereafter the chambers were disconnected from respirometers. Animals were separated from medium by sifting through fine mesh, placed into chamber with a fresh portion of medium and left in incubator until the next respirometric session. Oxygen consumption was examined every two days to the moment of eclosion. Newly emerged pupae were weighed on CAHN electrobalance with 1 µg accuracy and their sex was determined according to methods described by Sokoloff (1972). Newly eclosed adults were mated into pairs and placed together in chambers to let them develop their reproductive activity. Males were separated from females and placed in other chambers only for the time of respiration measurements. In order to separate the individuals correctly males were marked with nitrocellulose paint on their elytra after their eclosion. After measurements eggs laid by female were separated from medium by sifting through a fine mesh and their number was determined. Males and females were placed together back into chambers. Oxygen consumption measurements of adult insects were run every 3 days - this is the standard period for reproduction assay for *Tribolium* (Park at al. 1961). Distinguishing between 6- and 7-instar individuals was performed on the basis of weight and time of pupae emerging (Bijok 1989).

RESULTS AND DISCUSSION

The course of changes of respiration rate during development of two *Tribolium* species (Fig. 1) can be divided into three periods characteristic for holometabolic insects: 1) The period of fast increase of respiratory metabolism during larval. development Oxygen consumption in the last phase of larval development exceeds value of 20 µl/h in *T. castaneum* and 25 µl/h in *T. confusum*.

2) Decrease of this value in pupae illustrated by U-shaped curve (Edwards 1953). The value reaches its minimum generally in the middle of pupal stage - about 1 µl/h in *T. castaneum* and below 2 µl/h in *T. confusum*.

3) An increase in young adult individuals which leads to more or less stable state at the level depending on sex and species.

A very characteristic phenomenon in the first period is a

sudden decrease of respiration level in the middle of larval stage. This decrease was observed in both species and in all phenotypic groups. The minima referring to two phenotypic groups are displaced one from another in time by the period which corresponds to the difference between time of larval development of these groups. It suggests that this phenomenon is not a chance caused for example by accidental change of culture conditions but is a regularity in development cycle of this species. Similar phenomenon was observed in these species by Klekowski et al. (1967) and Bijok (1989). It may be a symptom of a temporary decline in larval development, the reason of which should be found in the live-history of the species.

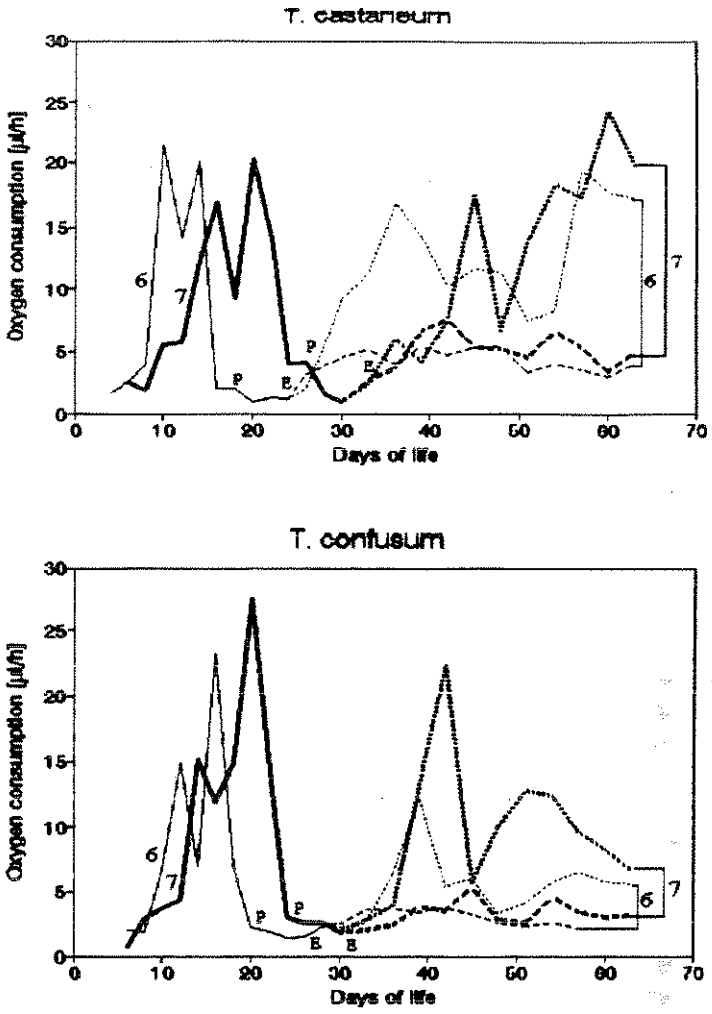


Figure 1.
Oxygen consumption during development of two *Tribolium* species, their two phenotypic groups and sexes.
6, 7 - phenotypic groups
P - pupation
E - eclosion

The relationship between body weight and oxygen consumption in growing larvae (L-II - L-VII) is presented in form of points on log-log scale and regression lines of multiplicative type: $QO_2=aW^b$ drawn on graphs (Fig. 2). In *T. castaneum* we can conceivably see the difference in localization of points representing 6- and 7-instar individuals on graph. Points of 6-instar individuals generally lay somehow above that representing 7-instar ones. Regression lines are almost parallel but there is a apparent distance between them. In *T. confusum* such a distinction is quite impossible and regression lines for 6- and 7-instar individuals are almost overlapping.

The parameters of regression lines of presented data are

shown in Tab. I. In all cases the correlation coefficient is high (over 0.95). There are slight differences between species in *b*-parameter (slope) of regression lines. Such difference is not observed comparing data obtained by Klekowski et al. 1967) and Bijok (1989). The difference exists also between instar groups in *T. castaneum*: in 6-instar group the "b" - value (90.91) is higher than in 7-instar group (0.86).

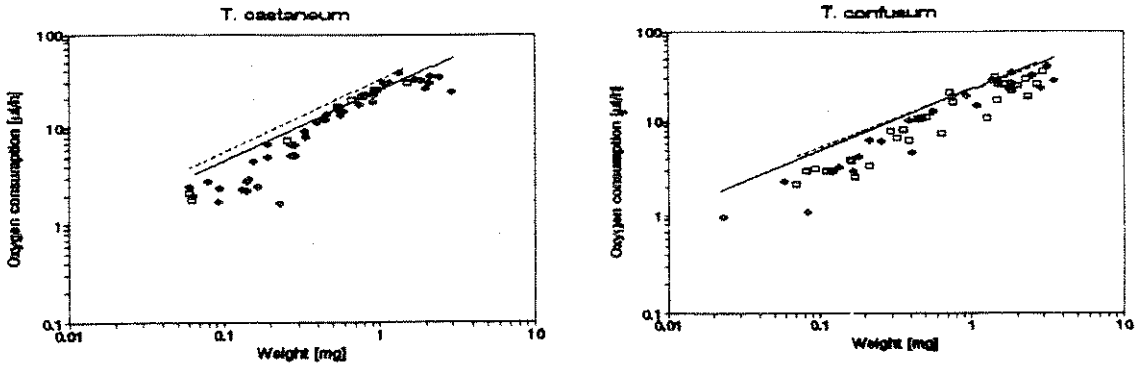


Figure 2
Correlation between body weight and oxygen consumption in growing larvae of two *Tribolium* species and their two phenotypic groups. Regression lines: dashed - 6-instar group, continuous - 7-instar group, □ - 6-instar indivs., + - 7-instar indivs.

The *a*-parameter (intercept) in regression equation is generally somehow higher than that presented in papers referenced above. Nevertheless, the same tendency of higher "a" - value in *T. castaneum* than in *T. confusum* is observed. Similar difference is observed between 6-instar group (25.60) and 7-instar group (19.90) of *T. castaneum*. In *T. confusum* such

Table I
Correlation coefficient and parameters of regression equation of weight-respiration rate dependence: $QO_2=aW^b$ in two phenotypic groups of *T. castaneum* and *T. confusum*.

parameter	*T. castaneum*		*T. confusum*	
	6	7	6	7
a	25.60	19.90	14.93	15.88
b	0.91	0.86	0.71	0.78
R	0.99	0.96	0.95	0.96

difference is not apparent.

Adult life is characterized by very changeable level of respiratory metabolism in these species. Oxygen consumption rises

progressively since eclosion as reproductive activity increases. The value reaches an average level which in females is more or less similar to that of older larvae but is about 3 times higher than that of adult males. This is quite obvious because of high production of eggs by females which reaches during one day about 17-20% of their body weight (Bijok 1989). Metabolism of particular individuals - especially females - shows high fluctuations which are present even when the data were averaged. It may be a result of any incontinuities in activity of organisms, e.g. production processes.

To evaluate and compare the efficiency of energy management in adult reproducing females the mean oxygen consumption by a female calculated per one egg laid by it, was presented in Fig. 3. The second half of presented period shows more stable results of the ratio than the first one which is a period of developing reproduction activity by newly eclosed females. Judging from that second half of presented period we can find out that 6-instar females of *T. castaneum* require more oxygen (and so that energy) to produce one egg than 7-instar ones. In *T. confusum* such difference is not observed. The interspecies difference of this ratio is not evident either.

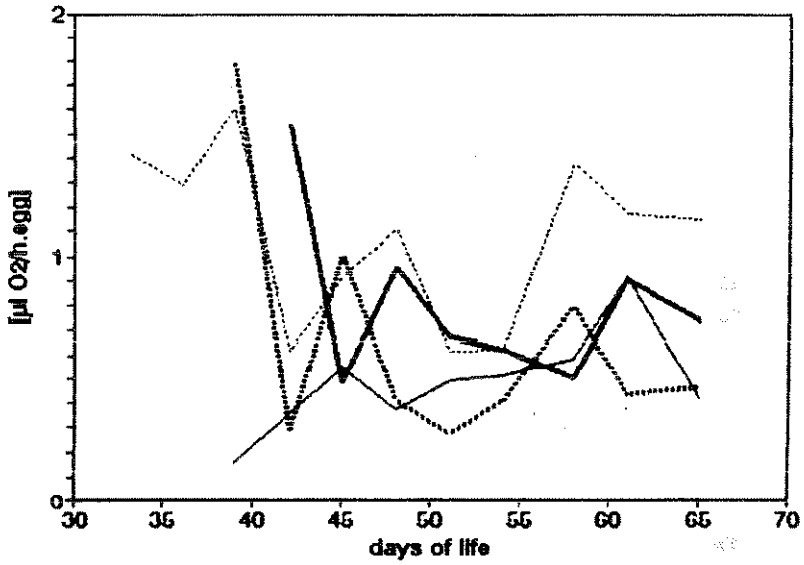


Figure 3
Oxygen consumption calculated per one lied egg in females of two *Tribolium* species and their two phenotypic groups.

Analyzing the obtained results we can state that the described species differ in respect of respiratory metabolism. The *a*-parameter of regression equation gives good evaluation of energy expenditure per biomass unit in an organism. (the *b*-parameter gives rather an idea of type of dependence in the metabolism on body weight or surface - Zeuthen 1970). Both these parameters are much higher in *T. castaneum*. It shows generally higher metabolic activity of this species and suggests less economic way of energy management than in *T. confusum*. It

supports the hypothesis about different life strategies represented by these two species. Tending by *T. castaneum* to faster development and shortening of time necessary to begin reproduction gives prevalence in colonizing new habitats. But is at the cost of less economic energy management what have its result in lower response to shortage of food or generally - deterioration of the habitat. On the other hand, higher metabolism of this species improves its locomotoric activity which gives better chance to migrate and find new habitats for colonization. Dawson (1977) reported that *T. castaneum* can fly whereas in *T. confusum* this ability was not observrd.

We deal in this case with a rather complex case of trade-off between some parameters of fitness.

We can find quite similar regularity observing two instar groups of *T. castaneum*. The 6-instar group shows higher metabolic activity both in immature stages (higher *a*-parameter of regression equation) and in reproduction period (higher O_2 expenditure per production of egg) than the 7-instar group. This also indicates a difference in energy management between groups of this species. The phenotypic groups existing within *T. castaneum* species shows similar diversity as occurs between presented species what have obviously quite similar consequences in their responses to environmental factors. It is a good support for the conception that the existence of two phenotypic groups makes the population fit better to changeable life conditions.

CONCLUSIONS

1. In all examined species and phenotypic groups a decline in respiratory metabolism occurs in the middle of larval development.

2. *T. castaneum* shows higher level of metabolism then *T. confusum* which in larval stage is indicated by a higher *a*-parameter of regression line of weight-respiration rate dependance: $QO_2=aW^b$, and in adult females by higher oxygen consumption per one laid egg.

3. Similarly, in *T. castaneum* 6-instar individuals shows higher level of metabolism than 7-instar ones.

4. In *T. confusum* such regularity is not observed.

5. The observed differences indicates different ways of life strategy in the two species and support the conception that the existence of two phenotypic groups makes the population fit better to changeable life conditions.

REFERENCES

1. Bijok P. 1986 - On heterogeneity in bIV strain of *Tribolium confusum* Duval - Ekol. pol 34:87-93.

2. Bijok P. 1989 - Energy budget and production efficiency of *Tribolium confusum* Duval in the developmental cycle - Ekol. pol 37:109-133.

3. Bijok P. in press - Relationship between time of embryonic development and postembryonic development time and weight in two species of *Tribolium* beetles - Ekol. pol 0:00-00.

4. Dawson P. S. 1977 - Life history strategy and evolutionary history of *Tribolium* flour beetle - Evolution, 31:227-229.

5. Edwards G. A. 1953 - Respiratory metabolism. In: Insect physiology. K. D. Roeder (Ed.) - John Wiley and Sons Inc., New York, 96-146.

6. Howe R. W. 1961 - Developmental time and weight in *Tribolium castaneum* - Tribolium Inf. Bull, San Bernardino, USA. 4:21-22.

7. Imura O. 1990 - Life histories of stoed-product insects. In: Bruchids and Legumes: Economics, Ecology and Coevolution. K. Fujii et al. (eds.) - Kluwer Academic Publishers Netherlands 257-269.

8. Klekowski R. Z. 1975 - Constant presure volumetric microrespirometer for terrestrial invertebrates. In: Methods for ecological bioenegretics. W. Grodziński, R. Z. Klekowski, A. Duncan (Eds.). I.B.P. Handbook No 24 - Blackwell Sci. Publ., Oxford, London, Edinburgh, Melbourne, 212-225

9. Klekowski R. Z., Prus T., Żyromska-Rudzka H. 1967 - Elements of energy budget of *Tribolium castaneum* (Hbst.) in its developmental cycle. In: Secondary productivity of terrestrial ecosystems. K. Petrusewicy (Ed.) - Państwowe Wydawnictwo Naukowe, Warszawa - Kraków, 2:859-879.

10. Møller H., Smith R. H. and Sibly R. M. 1989 - Evolutionary demography of bruchid beetle. I. Quantitative genetical analysis of the female life history. - Functional Ecology 3:679-681.

11. Park T., Mertz D.B., Petrusewicz K. 1961 - Genetic strains of *Tribolium*: Their primary characteristics. - Physiol. Zool. 34:62-80

12. Prus T. 1976 - On heterogeneity in cI strain of *Tribolium castaneum* Hbst - Tribolium Inf. Bull, San Bernardino, USA. 19:97-104.

13. Prus T., Bijok P., Prus M. 1989 - Autecological features of strains: *Tribolium castaneum* Hbst cI and *T. confusum* Duval bIV. - Ekol. pol. 37:97-107.

14. Prus T., Prus M. 1987 - Phenotypic differentiation of *Tribolium castaneum* Hbst. cI strain. - Tribolium Inf. Bull, San Bernardino, USA. 27:89-95.

15. Prus M., Prus T., Bijok P. 1988 - Comparative study of reproductive effort in two species of *Tribolium*. - Tribolium Inf. Bull, San Bernardino, USA. 28:76-81.

16. Sibly R. M. and Calow p. 1989 - A life-cycle theory of responses to stress. - Biological Journal of the Linnean Society 37:101-116.

17. Sokoloff A. 1972 - The biology of *Tribolium* with special emphasis on genetic aspects. Vol. I - Oxford University Press, 300 pp.

18. Zeuthen E. 1970 - Rate of living as related to body size in organisms - Pol. Arch. Hydrobiol., 17:21-30.

Clayton, Lisa M., Fred Vander Jagt, Terry L.White, and Karin A. Grimnes
Dept of Biology
Alma College
Alma, Michigan USA 48801

* Relationships Among Proteins in Male Accessory Reproductive Gland Complexes of Several Tribolium Species as Analyzed by an Enzyme-linked Immunoabsorbant Assay (ELISA)

Introduction

The development of monoclonal antibody (MoAb) technology has greatly extended the utility of antibodies in many areas of research. However, the specificity of MoAbs (reactions against a single structural feature or epitope) remains their greatest limitation. Possession of a shared epitope does not guarantee common identity or ancestry among proteins. Even so, the power of MoAbs coupled with ELISA technology permits development of a rapid screening system to detect proteins worthy of further investigation. We report the use of such an ELISA system to examine cross-reactivity among proteins of Tribolium reproductive accessory gland complexes.

Several authors have reported on the biochemical or structural similarities among reproductive accessory gland complexes within insects (Chen,1984; Happ,1984). In beetles of the family Tenebrionidae, each species thus far examined appears to possess two pairs of paired accessory glands (Murad and Ahmad,1977; Srivastava,1953). One pair is elongated, and relatively transparent (the tubular accessory glands or TAGs). The second pair of glands appears opaque with an elongated epithelial layer of secretory cells, and its form is more variable among species. The second gland has been identified as bean-shaped (BAG) in T. molitor (Happ,1984), as pear-shaped (PAG) in Tribolium brevicornis (O'Dell, et. al.,1990) or as rod-shaped (RAG) in Tribolium castaneum and Tribolium freemani (Rummel and Grimnes, 1991).

Despite structural similarities among the accessory reproductive glands of Tribolium species and T. molitor, questions of functional significance and protein relatedness remain. In this study, a panel of monoclonal antibodies originally developed against the accessory glands of Tenebrio molitor was used to screen for epitopes common to the family Tenebrionidae.

Materials and Methods

In addition to Tenebrio molitor, three Tribolium species groups were studied: the castaneum group (T. castaneum, Tribolium madens), the confusum group (T. confusum, Tribolium anaphe) and the brevicornis group (T. brevicornis). Stocks were obtained from Dr. Sokoloff (San Bernardino, Ca.) and colonies were raised on a 19:1 mixture of whole wheat flour and Brewer's yeast at a constant temperature of 32°C. Methods for Tenebrio rearing and spermatophore collection have been described elsewhere (Grimnes and Happ,1986)

Reproductive complexes from male adult beetles were dissected in phosphate-buffered saline (PBS) and homogenized in ELISA coating buffer at an approximate protein concentration of 1 ug/ml (Voller, et. al.,1979). Entire complexes were not used for T. molitor; its larger size permitted individual gland analysis. Homogenate binding occurred overnight at 4°C in ELISA plates (Corning). The primary antibody source was either supernatant fluid from hybridoma cultures or diluted ascites fluid. The second antibody was peroxidase labelled anti-mouse IgG

(obtained from Fisher Company). All rinses contained 0.5% Tween 20. After color development with ABTS, plate absorbances were read on a Molecular Devices Vmax microplate reader attached to a Macintosh computer. Each assay was repeated at least three times.

Because background readings and absolute absorbance values differed between assays, all absorbances were expressed as the degree to which the response exceeded background (ie. 2x, 4x, 6x, 8x, and 10x or greater). This allowed a direct comparison between any two species' response to the same antibody. A numerical estimate of cumulative differences (labelled a dissimilarity index) was generated by assigning each response difference of 2x between species a score of 1 (or 4x=2, 6x=3, 8x=4, 10x=5). By this system, responses similar in intensity were given low scores, higher scores indicate a difference in antibody binding at many wells.

Additional complexes from T. confusum, T. madens and T. anaphe were dissected and stained with 0.3% Oil Red O (ORO) in 70% ethanol and subsequently destained and stored in 30% ethanol for detection of lipid-containing cells and comparison of general morphological features.

Results and Discussion

The accessory gland complexes of T. confusum, T. madens and T. anaphe were basically similar to both T. castaneum and T. confusum, and therefore follow the pattern characteristic of the genus. Accordingly, the opaque accessory glands of these species are identified as rod-shaped accessory glands (RAGs).

A total of 27 monoclonal antibodies were screened to compare cross-reactivity among the five Tribolium species and T. molitor accessory gland proteins. Although 15 of the 27 MoAbs reacted (to some degree) with each species tested, the combination of reacting antibodies was not always the same. Dissimilarity indices for the Tribolium species and the tissues of T. molitor are presented in Table 1. The data indicate that the Tribolium accessory gland complex shares more cross-reactive epitopes with the bean-shaped accessory gland of T. molitor than with the product of the BAG, the spermatophore. Cross-reactivity with TAG proteins appeared moderate. Species traditionally placed together in the same species-group possessed similar indices when compared to T. molitor.

Dissimilarity indices generated by all pair-wise comparisons of the five Tribolium species in the study are displayed in Figure 1. As indicated by the higher values, T. brevicornis remains distinct from the other species, a position often ascribed to it on traditional characteristics (Hinton,1948). In contrast to studies on total body soluble protein (Castro and Ramon,1991) or electrophoretic enzyme analysis (Wool,1982), data from this study indicate no close relationship between T. confusum and T. brevicornis, at least in terms of accessory gland proteins.

Although cross-reactivity sen with monoclonal antibodies is specific to the shared structural feature, the ELISA provides no data concerning the nature of the actual proteins bearing the epitope. Preliminary immunohistochemical localization studies indicate at least one monoclonal antibody binds to the tubular accessory glands of both T. molitor and T. brevicornis. Western immunoblot analysis is currently underway to determine the precise nature of cross-reactivity seen in the ELISAs reported here.

Literature cited

Castro, J.A. and C. Ramon. 1991. The systematics of Tribolium investigated by means of the isoelectric focusing (IEF). Tribolium Information Bulletin, 31: 61-69.

Chen, P.S. 1984. The functional morphology and biochemistry of insect male accessory glands and their secretions. Ann. Rev. Ent. 29: 233-255.

Grimnes, K.A. and G.M. Happ. 1986. A monoclonal antibody against a structural protein in the spermatophore of Tenebrio molitor (Coleoptera). Insect Biochem. 16: 635-643.

Happ, G. M. 1984. Structure and development of male accessory glands in insects. In Insect Ultrastructure (Edited by King, R. C. and Akai, H.), Vol. 2, pp. 365-396. Plenum Press, New York.

Hinton, H. E. 1948. A synopsis of the genus Tribolium Macleay, with some remarks on the evolution of its species-groups (Coleoptera:Tenebrionidae). Bull. Ent. Res. 39: 13-55.

Murad, H. and I. Ahmad. 1977. Histomorphology of the male reproductive organ of the red flour beetle, Tribolium castaneum L. (Coleoptera:Tenebrionidae). J. Anim. Morphol. Physiol. 24: 35-41.

O'Dell, M., L. Paulus and K. Grimnes. 1990. Preliminary characterization of the male accessory glands in Tribolium brevicornis (Coleoptera: Tenebrionidae). Tribolium Information Bulletin, 30: 55-57.

Paulus, L. and K. A. Grimnes. 1989. The reproductive accessory gland complex of Tribolium brevicornis (Coleoptera). American Zoologist, 29: 109A.

Rummel, R.L. and K.A. Grimnes. 1991. Preliminary comparison of the reproductive accessory glands in two, species of Tribolium and their hybrids. Tribolium Information Bulletin, 31:79-82.

Srivastava, U. S. 1953. On the post-embryonic development of the male genital organs (external and internal) of Tribolium castaneum Herbst (Coleoptera: Tenebrionidae) Indian J. Ent. 15: 352-361.

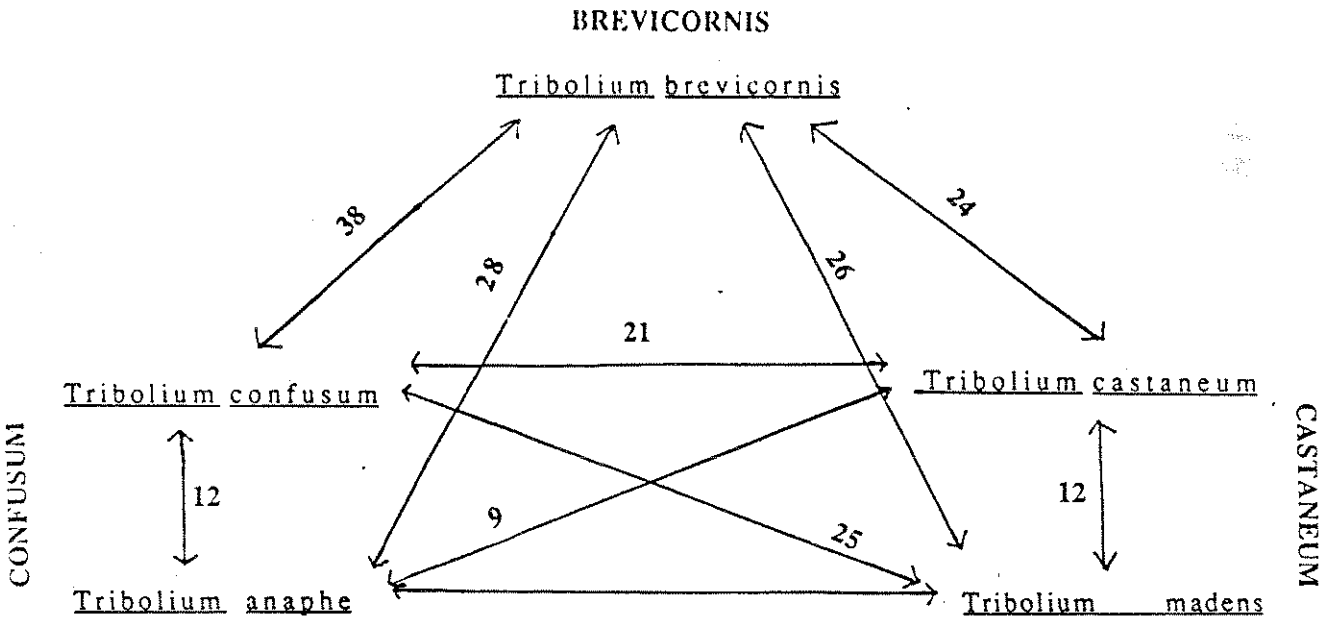
Voller, A., D.C. Bidwell and A. Bartlett. 1979. The enzyme linked immunoabsorbant assay (ELISA). In A Guide with Abstracts of Microplate Applications. Dynatech Laboratories, Borough House, Guernsey, Great Britain.

Wool, D. 1982. Critical examination of the postulated cladistic relationships among species of flour beetles (Genus Tribolium, Tenebrionidae, Coleoptera). Biochem. Genet. 20: 333-349.

Table 1. Dissimilarity indices between Tribolium species accessory gland complexes and Tenebrio molitor tissues as determined by ELISA.

Tribolium species	Tenebrio molitor tissues TAG	spermatophore	BAG
T. brevicornis	28	48	38
T. castaneum	49	60	19
T. madens	48	68	22
T. confusum	54	75	28
T. anaphe	52	70	20

Figure 1. Dissimilarity indices among species in the genes Tribolium as determined by ELISA.



Tribolium Inf. Bull, California Univ.

M. Khalequzzaman[1] and M. Nurul Islam
Crop Protection Laboratory
Department of Zoology
University of Rajshahi, Rajshahi-6205
Bangladesh

#SYNERGISM OF *DATURA METEL* LINN. LEAF AND SEED EXTRACTIONS WITH METHACRIFOS ON *TRIBOLIUM CASTANEUM* (HBST.)

Derivatives of some plants have had temporary to restricted use in pest control, or have been considered items of regional interest (Saxena ***et al.***, 1983). The chemistry and biological activity of these plants have recently been studied. But even after a long history of pest control potential, these plants have not been fully utilized for insect control. Renewed interest in botanical insect control agents is motivated by three major objectives : to encourage traditional use of simple formulations of locally available plant materials by farmers who cannot afford commercial insecticides; to identify sources of new botanical insecticides for commercial extraction; and to elucidate the chemical structure of active principles botanical insect control agents extracted on large scale may also be used to replace or supplement the activity of existing synthetic insecticides against refractory pests.

Datura Linn. (Solanaceae), a genus of herbaceous plant regarded as being highly poisonous, and from the remotest antiquity, have been used both medicinally and criminally. This promising attribute led to evaluate the potential use of ***D. metel*** leaf and seed extractions with insecticide combinedly treated on ***Tribolium castaneum*** (Hbst.).

The standard strain of ***T. castaneum*** FSS-II was collected from the Crop Protection Laboratory, Department of Agricultural and Environmental Science, University of Newcastle upon Tyne, England. The strain was reared and cultured in the Department of Zoology, Rajshahi University.

The leaves and seeds of white Dhutura plant, ***D. metel*** were collected and dried in an oven at 60°C for 36 hours and were powdered in a mortar and pestle separately. Extraction of the leaves and seeds were done in a Soxhlet Apparatus. The powdered materials were put into the thimble of the Soxhlet and extractions were done serially with petrolium spirit, ethyl acetate, acetone and methanol. Thus four extractions from leaf and another four from seeds were obtained. The extracted liquid was dried in a Rotary Vacuum Evaporator and then weighed and again dissolved in the same solvent according to the proportion of dry-weight in leaf and seed. This was taken as the highest dose. The other doses were made by serial dilution.

The insecticide used was methacrifos [methyl (E)-3-(dimethoxyphosphino-

---

[1] For correspondence

thioyloxy)-2-methylacrylate, commercially available as Damfin 950 EC of Ciba-Geigy]. This insecticide was diluted in the distilled water to have the required dose.

During laboratory trials the lowest dose both for extraction and insecticide on *T. castaneum* adults were determined and the mortality rates were recorded. Then the lowest dose of an extraction and insecticide were combined and tested on the same stage of the insect. Thus four combined doses were made each for leaf and seed extraction.

For each dose 1 ml liquid was dropped on a petridish (90 mm) and dried. Four plastic rings (30 mm) were placed inside the petridish and 10 adult beetles were released in each ring. Thus within the petridish each ring served as a replication. The mortality was recorded after 12 and 24 hours of treatment.

The mortality rate was tested using chi-square based on an expected mortality for the sum of two individual effects as given by Mather (1940) :

$$\chi^2 = \frac{(N_C X_S X_A - X_C N_S N_A)^2 \, N_S N_A}{X_S X_A N_C \{ N_S N_A \, (N_S N_A - X_S X_A) + N_C N_A X_A Y_S + N_C N_S X_S Y_A \}}$$

where, N_S, N_A and N_C are the total number of insects used in the treatments of toxicant (insecticide), test material (extraction) and their combined doses respectively. X_S, X_A and X_C represent the total number of insects surviving in treatments of toxicant (insecticide), test material (extraction) and their combined doses respectively. Y_X, Y_A and Y_C represent the number of insects killed in toxicant (insecticide), test material (extraction) and their combined doses respectively. Significant chi-square result indicates observed mortality and combined chemicals is greater than expected and synergism is occurring. The combined effects in adult mortality were classified on the criteria for synergism (Hewlett, 1960) as described by Benz (1971).

Results are shown in table 1. Plant extractions showed a synergistic action on methacrifos killing significantly higher number of *T. castaneum* adults in comparison with the mortality due to individual action of chemicals (Figures 1 & 2).

D. metel contains an alkaloid - scopolamine in all parts of the plant. The seeds contain much scopolamine, a trace of hyosciamine and 12% of a fixed oil (Pradisth and Santos, 1939). Khaleque *et al.* (1965, 1968, 1974) isolated scopolamine, hyoscyamine, fastusine, fastusinine, daturanolone acid, fastusic acid, ß sterol from the leaf and seed of Dhutura.

According to Hewlett (1968) and Metcalf (1967) synergist inhibit the enzymes responsible for toxicant degradation. Othaki *et al.* (1968) and Othaki and Williams (1970) showed that the insect body contains enzymes for the degradation of hormones like the maulting hormone (MH), which may be a mode of action of plant extractions. Another possible explanation was advanced by Leuschner (1974) and Walker and Thompson (1973) who found that simultaneous application of MH and Juvenile Hormone (JH) caused an increase in MH activity. A hypothesis for the mode of action of MH and JH when applied together was that the MH activated to synthesis of RNA and JH simultaneously by induced a duplication of the DNA. This process causes such a severe disturbance in the insect that it leads to its death

because the DNA and RNA synthesis are mutually separated and perhaps, exclude each other (Du Praw, 1967).

The synergistic action of the plant extractions, used in the present investigation, is to some extent similar to the results of Dyte and Rowlands (1970) who reported higher mortality of ***T. castaneum*** adults in combined doses of insecticides (e.g., Fenitrothion, Bromoxon and Malaoxon) and synergists (Sesamex, SKF, 525A and PAOB-1) in comparison with the mortality due to individual action of the chemicals. This result is also similar to that of Ishaaya ***et al.*** (1983) who reported higher mortality of ***T. castaneum*** in combined doses of insecticide (e.g. ***trans*** and ***cis*** cypermethrin) and synergist (pyperonyl butoxide) in comparison with the mortality due to individual action of the chemicals. Mondal (1990) also observed the same results using insecticide (pirimiphos methyl) and synergist (methylquinone) on ***T. castaneum.***

The authors wish to express their gratitude to Dr. R.M. Wilkins, Department of Agriculture and Environmental Science, University of Newcastle upon Tyne, England for supplying beetles and to the Chairman, Department of Zoology, Rajshahi University for providing necessary laboratory facilities.

References

Benz, G. 1971. Synergism of micro-organisms and chemical insecticides. In - *Microbial control of Insects and Mites* (eds. H.D. Burges & H.W. Hussey). Academic Press, Lond. & N.Y. 145-163.

Du Praw, F.J. 1967. *Cell and Molecular Biology.* Academic Press, NY. USA.

Dyte, C.E. and Rowlands, D.G. 1970. The effects of some insecticide synergists on the potency and metabolism of Bromophos and Fenitrothion in ***Tribolium castaneum*** (Herbst) (coleoptera : Tenebrionidae). *J. Stored Prod. Res.* **6** : 1-18.

Hewlett, P.S. 1960. Joint action in insecticides. *Adv. pest control Res.* 3: 27-74.

Hewlett, P.S. 1968. Synergism and potentiation in insecticides. *Chem. Ind.* 1 : 701-706.

Ishaaya, I., Elsner, A., Ascher, K.R.S. and Casida, J.E. 1983. Synthetic pyrethroids: Toxicity and synergism on dietary exposure of ***Tribolium castaneum*** (Herbst) Larvae. *Pestic. Sci.* **14** : 367-372.

Khaleque, A., Roy, N., Miah, M.A.W and Amin, M.S. 1965. Investigation on ***Datura fastuosa*** Linn. (Solanaceae). I. Isolation of scopolamine, hyoscyamine and two new alkaloids. *Scientific Researches.* **2(1&2)**: 147-151.

Khaleque, A., Miah, M.A.W., Alam, M.N. and Amin. M.S. 1968. Investigation on ***Datura fastuosa*** Linn. (Solanaceae). **IV.** Isolation and characterization of daturanolone and fastusic acid. *Scientific Researches.* **5(1)** : 66-70.

Khaleque, A., Rahman, A.K.M.M., Khan, M.I., Amin, M.S. and Kiamuddin, M. 1974. Investigation on ***Datura fastuosa*** Linn. (Solanaceae). V. Isolation of fastusine, scopolamine and ß-sitosterol from the pericarp (fruit shell). *Bangladesh J. Sci. Ind. Res.* **9(1&2)** : 79-81.

Leuschner, K. 1974. Wirkung von Juvenil hormon - Analoga and phytoecdysonen any Entwicklug, Fortpflanzung, Paarungsverhalten and Eiparasiten der ostajrikanischen Kaffeewenzen ***Antestiopsis orbitalis bechnana*** Kirk. and ***Antestiopsis orbitalis ghesquirer*** Car. *Ph. D. thesis*, University of Gressin, FRG.

Mather, K. 1940. The design and significance of synergic action tests. *J. Hyg. Camb.* **40** : 513-531.

Metcalf, R.L. 1967. Mode of action of insecticide synergists. *A. Rev. Ent.* **12** : 229-256.

Mondal, K.A.M.S.H. 1990. Combined action of methylquinone, aggregation pheromone and pirimiphos-methyl on ***Tribolium castaneum*** larval mortality. *Pakistan J. Zool.* **22(3)** : 249-255.

Othaki, T., Milkma, R.D. and Williams, C.M. 1968. Dynamics of ecdysone secretion and action in the fleshfly, ***Sacrophaga peregrina***, *Biol. Bull. mar. biol. Lab., woods Hole.* **135** : 322-334.

Othaki, T. and Williams, C.M. 1970. Inactivation of ß-ecdysone and cyasterone by larvae of the fleshfly, ***Sacrophaga peregrina*** and pupae of the silkworm, ***Samia cynthia***, *Biol. Bull. mar. biol. lab. Woods Hole* **138** : 326-333.

Pradisth, C.S. and Santos, A.C. 1939. Isolation and separation of the main constituents of ***Datura alba*** Nees. *Rev. filipina med. farm.* 30-170.

Saxena, R.C., Epino, P.B., Cheng-Wen, T. and Puma, B.C. 1983. Neem, Chinaberry and custard apple antifeedant insecticidal effects of seed oils on leaf hopper and plant hopper pests of rice. *Proc. 2nd. Int. Neem Conf. Rauischholzhausen.* 403-412.

Walker, W.F. and Thompson, M.J. 1973. 22-25-Bisdeoxyecdysone : Pathological effects on the Mexican bean beetle and synergism with juvenile hormone compound. *J. econ. Ent.* **66** : 64-67.

Table 1. Mortality of adult *T. castaneum* treated in insecticide, Dhutura plant extractions and their combined doses.

Treatment	Dose of Extractions	N_S	Y_S	X_S	N_A	Y_A	X_A	N_C	Y_C	X_C	χ^2
LPS12	0.762	40	11	29	40	1	39	40	30	10	20.34***
LEA12	0.513	40	11	29	40	1	39	40	27	13	14.24***
LAC12	0.394	40	11	29	40	0	40	40	34	6	33.17***
LME12	2.799	40	11	29	40	2	38	40	39	1	42.03***
LPS24	0.726	40	20	20	40	2	38	40	40	0	18.54***
LEA24	0.513	40	20	20	40	2	38	40	29	11	3.29*
LAC24	0.394	40	20	20	40	0	40	40	40	0	20.00***
LME24	2.799	40	20	20	40	3	37	40	40	0	17.83***
SPS12	0.733	40	11	29	40	1	39	40	36	4	35.97***
SEA12	1.038	40	11	29	40	8	32	40	39	1	27.06***
SAC12	1.296	40	11	29	40	0	40	40	31	9	25.08***
SME12	1.485	40	11	29	40	7	33	40	31	9	12.32***
SPS24	0.753	40	20	20	40	3	37	40	40	0	17.83***
SEA24	1.038	40	20	20	40	13	27	40	40	0	11.61***
SAC24	1.296	40	20	20	40	1	39	40	39	1	17.33***
SME24	1.485	40	20	20	40	10	30	40	38	2	10.01**

Notes :

Dose of insecticide : 15.56^{-5} µg/sq. cm.
N_S = Number of insects used in insecticide
Y_S = Number of insects killed in insecticide
X_S = Number of insects surviving in insecticide
N_A = Number of insects used in extractions
Y_A = Number of insects killed in extractions
X_A = Number of insects surviving in extractions
N_C = Number of insects used in combined dose
Y_C = Number of insects killed in combined dose
X_C = Number of insects surviving in combined dose
LPS/SPS = Leaf/Seed extraction in petroleum spirit
LEA/SEA = Leaf/Seed extraction in ethyl acetate
LAC/SAC = Leaf/Seed extraction in acetone
LME/SME = Leaf/Seed extraction in methanol
12 & 24 indicate the duration of treatment in hours
* = P<0.05, ** = P<0.01, *** = P<0.001

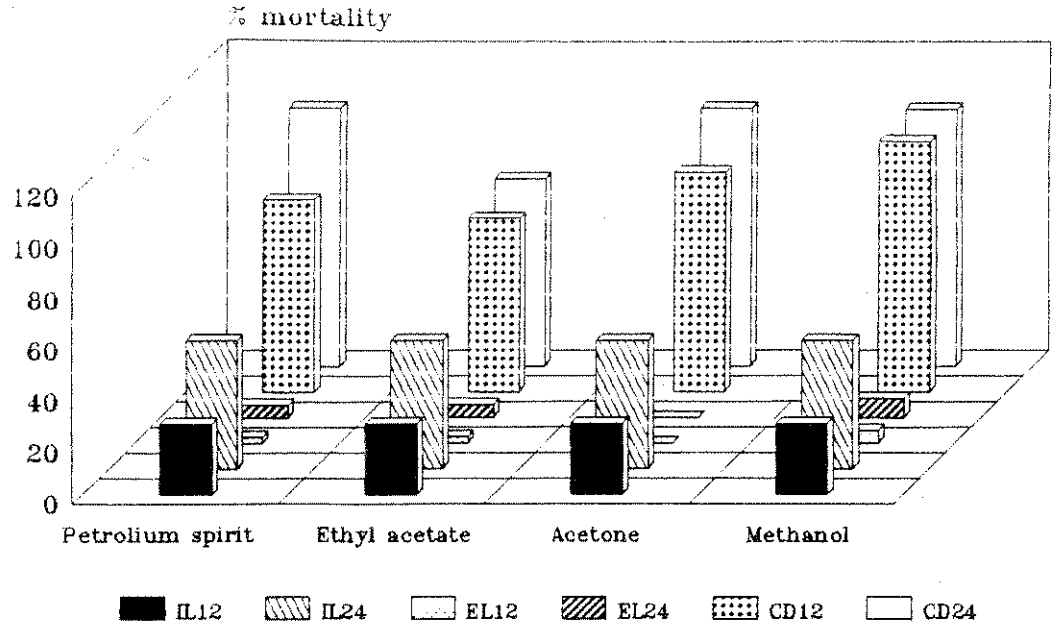


Figure 1 : Mortality percentage of *T. castaneum* adults in low doses of insecticide (IL), leaf extraction (EL) of Dhutura and their combined doses (CD) after 12 & 24 hours of treatment in extracts of different solvents.

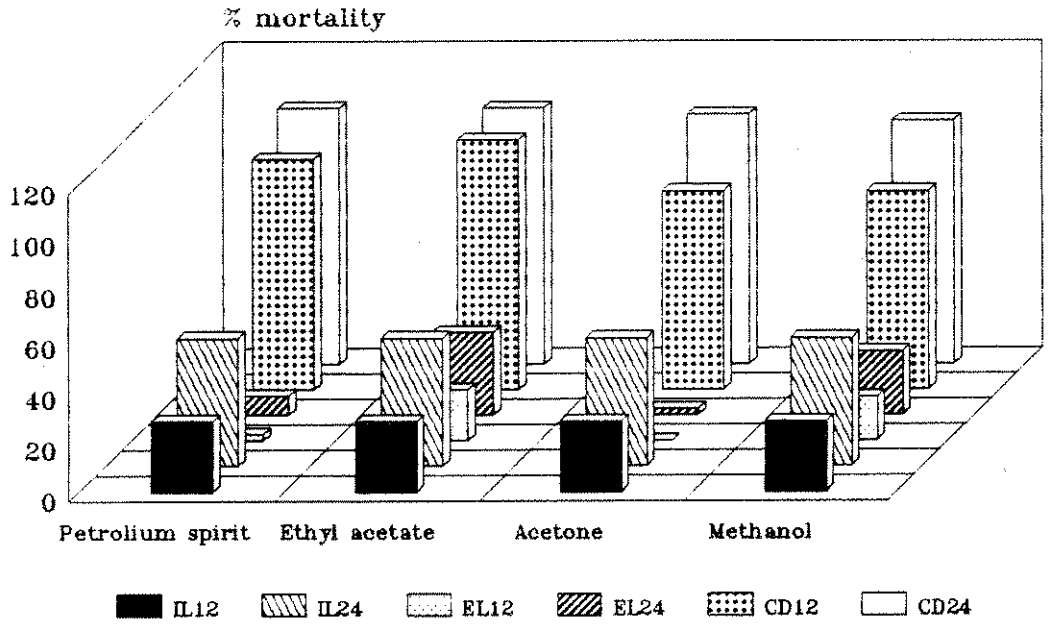


Figure 2 : Mortality percentage of *T. castaneum* adults in low doses of insecticide (IL), seed extraction (EL) of Dhutura and their combined doses (CD) after 12 & 24 hours of treatment in extracts of different solvents.

Sokoloff, A. 1974. *The Biology of Tribolium.* Oxford University Press, New york. Volume 2. 610 pp.

Sternburg, J.; Cheng, S.C.; Kearns, C.W. 1959. The release of a neuroactive agent by the American cockroach after exposure to DDT or electrical stimulation. *Journal of Economic Entomology* 52 : 1070-1076.

Sverdlov, E.; Wool, D. 1973. The effect of rearing *Tribolium castaneum* in used culture medium on the developmental time of the next generation. *Entomologia Experimentalis et Applicata* 16 : 550-556.

Taher, M.; Cutkomp, L.K. 1983. Effects of sublethal doses of DDT and three other insecticides on *Tribolium confusum* J. Duv. (Coleoptera: Tenebrionidae). *Journal of Stored Product Research* 19 : 43-50.

Tschinkel, W.R. 1969. Phenols and quinones from the defensive secretions of the tenebrionid beetle, *Zophobas rugipes*. *Journal of Insect Physiology* 15 : 191-200.

Tschinkel, W.R. 1975a. Comparative study of the chemical defensive system of Tenebrionid beetles. I. Chemistry of the secretions. *Journal of Insect Physiology* 21 : 753-783.

Tschinkel, W.R. 1975b. Comparative study of the chemical defensive system of Tenebrionid beetles. II. Defensive behaviour and ancillary structures. *Annals of the Entomological Society of America* 68 : 439-453.

Van Wyk, J.H.; Hodson, A.C.; Christensen, C.M. 1959. Microflora associated with the confused flour beetle, *Tribolium confusum*. *Annals of the Entomological Society of America* 52 : 452-463.

Wilbur, D.A.; Mills, R.B. 1978. Stored grain insects. In : Pfadt, R.E. (ed.) *Fundamentals of Applied Entomology*. 3rd edition. MacMillan Publishing Co. Inc. pp. 73-81.

Wirtz, R.A.; Taylor, S.L.; Semey, H.G. 1978a. Concentration of substituted p-benzoquinones and 1-pentadecene in the flour beetles *Tribolium confusum* J. Duval and *Tribolium castaneum* (Herbst). *Comparative Biochemistry and Physiology* B61 : 25-28.

Wirtz, R.A.; Taylor, S.L.; Semey, H.G. 1978b. Concentration of substituted p-benzoquinone and 1-pentadecene in the flour beetles *Tribolium madens* (Charp.) and *Tribolium brevicornis* (Lec.) (Coleoptera : Tenebrionidae). *Comparative Biochemistry and Physiology* C61 : 287-290.

Tribolium Inf. Bull, California Univ.

K.A.M.S.H. Mondal
Department of Zoology
Rajshahi University, Rajshahi-6205
Bangladesh

*QUINONE SECRETIONS OF FLOUR BEETLES, *TRIBOLIUM*: PROBLEMS AND PROSPECTS

ABSTRACT

The quinone secretions of flour beetles of the genus ***Tribolium*** is briefly reviewed. Toxicity of the quinones on both flour beetles and human beings is discussed and their possible role in the control of flour beetles is suggested.

INTRODUCTION

Flour beetles of the genus ***Tribolium*** are the major pests of stored products. The ability of both adults and larvae to exploit a wide variety of stored products has contributed to their status as major (Good, 1933, 1936). Flour beetles live in almost any kind of flour including whole-wheat flour, bleached and unbleached white flour, bran, rice flour, cornmeal, barley flour and oatmeal (Chittenden, 1896, 1897). Their presence in a stored product results in contamination and substantial economic damage due to loss of the product and a decrease in nutritional value (Wilbur and Mills, 1978).

Adult flour beetles infest and contaminate the flour giving a persistent and disagreeable odour, turning the flour pinkish (Chittenden, 1896; Engelhardt ***et al.***, 1965), adversely affecting the viscous and elastic properties of the flour and create a disgusting taste (Payne, 1925). This is because of the accumulation of the quinones given off by the adults and taken up by the flour (Ghent, 1963).

QUINONE SECRETIONS

Source of quinones

The flour beetles manufacture and store large quantities of quinones within their odoriferous glands (Roth, 1943; Roth and Eisner, 1962; Eisner and Meinwald, 1966). Two pairs of well developed odoriferous glands - one pair in the prothorax and the other in the abdomen, are the source in both sexes of adults of these quinoid secretions (Roth, 1943, 1945). The prothoracic glands are located on the anterolateral region of the thoracic cavity and are attached to and open at the anterior prothoracic margin. The abdominal glands open just posterior to the lateral processes of the lateral margin of the seventh abdominal sternite (Sokoloff, 1972).

In newly emerged adults the quinone secretion is from the thorax only. There is no detectable secretion of the quinones in larvae or in prepupae, but quinones may be detected in the thoracic glands of some very late pupae which are shortly to emerge, and in all adults one hour after emergence. The substance is definitely detected in the abdominal glands two hours after emergence of adults. The quinones appear at the same time in both male and female adults (Good, 1936; Roth, 1943).

Ejection of quinones

The thoracic glands may eject quinones independently of the abdomen and vice versa. In most cases the secretion appears to be given off from the thoracic glands more readily than from the abdominal ones. This is due to the absence of a closing mechanism for the thoracic reservoir. Sometimes the quinone secretions are given off readily from both the thoracic and abdominal glands (Roth, 1943).

The quinones are discharged under different conditions e.g. crowding, excitement (Engelhardt ***et al.***, 1965), agitation of the beetles (Ogden, 1969) and partial narcosis (Irwin ***et al.***, 1972). If a volume of flour medium is overloaded with a great number of adult beetles (more than 20/gm.) the agitation of such a large number of individuals in a relatively small volume will cause the rapid release of quinones. The accumulation of quinones in the flour is also due to a longer duration of occupation by the beetles (Mondal, 1983, 1985). There is another way in which quinones may get into the flour. When the beetles die they slowly release the quinones from their odoriferous glands. A large number of deaths in a culture both in a laboratory and warehouse may lead to the presence of quinones in the flour medium (Ogden, 1969).

Concentrations of the quinones are extremely low in newly emerged adults (less than 20 microgrammes per insect). The level increases with age until 20-30 days after adult emergence, after which time the concentrations are maintained for a long time. In adults 30 or more days after emergence, females contain higher levels of quinones than males of the same age. However, the level of quinones varies from 9.2 to 472 µg depending on the species of flour beetles (Sokoloff, 1974; Wirtz ***et al.***, 1978 a,b). The mutants *msg* in both *T. castaneum* and *T. confusum* greatly reduce and even eliminate the production of quinones (Sokoloff, 1974).

Table 1. Average amount of quinone contained in flour beetle's odoriferous glands (Sokoloff, 1974).

Species	Quinones/insect (µg)		
	Average	Minimum	Maximum
Tribolium castaneum	39.5	12.4	76.0
T. castaneum msg	1.3	0.2	3.6
T. confusum	33.1	9.2	53.0
T. confusum msg	2.4	0.0	5.5
T. anaphe	73.1	29.0	155.0
T. brevicornis	225.7	56.0	472.0
T. destructor	135.5	43.0	237.0
T. madens	197.0	60.0	307.0

Chemical Nature

The quinone secretions of the odoriferous glands have been analysed for ***Tribolium castaneum*** (Alexander and Barton, 1943; Loconti and Roth, 1953); ***T. confusum*** (Hackman ***et al.***, 1948; Engelhardt ***et al.***, 1965; Ladisch ***et al.***, 1967a); ***T. destructor*** (Tschinkel, 1975a); ***T. audax*** Hal. (Markarian ***et al.***, 1978); and ***T. madens*** Charp. (Markarian ***et al.***, 1978). The secretion comprises mainly ethylquinone (2-ethyl-1,4-benzoquinone) and methylquinone (2-methyl-1,4-benzoquinone) (Alexander and Barton, 1953). In addition to these two components, methoxyquinone, ethylhydroquinone and methylhydroquinone have been reported by Hackman ***et al.*** (1948). The quinone consists of 80-90% ethylquinone; 10-20% methylquinone and a trace of other components (Loconti and Roth, 1953; Markarian ***et al.***, 1978).

Role of Quinones

There has been much speculation concerning the role of the quinone secretions. They are thought to serve as defensive compounds (Roth and Eisner, 1962; Tschinkel, 1969, 1975b). They are toxic to many species of both bacteria and fungi (De Coursey ***et al.***, 1953; Ladisch, 1963; Ladisch ***et al.***, 1967b). Both fungi and bacteria have been found to be attractive to ***Tribolium*** (Van Wyk ***et al.***, 1959) as a food source (Sinha, 1966, 1968). While fungi and bacteria serve as a source of growth factors for flour beetles, the presence of too many of them may compete for the basic flour or grain substance. Thus it appears that part of the effect of quinone secretion may be to decrease the growth of fungi and, to a lesser extent, the growth of bacteria minimizing the competition for grains while still allowing to serve as a source of growth factors (Ogden, 1969).

PROBLEMS

Quinones are highly reactive and acutely toxic compounds. Quinones secreted by the flour beetles infesting the flour or grains in both warehouses and private houses are responsible for the following problems :

Effects on flour

Quinones turn the flour into a grey useless mass deleteriously affecting its viscous and elastic properties (Payne, 19250). It contaminates the flour giving a persistent and disagreeable odour, creating a disgusting taste and, thus making the infested flour unsuitable for human consumption (Chittenden, 1896).

Toxicity to human beings

Quinones are both acutely toxic, allergenic and even carcinogenic to human beings (Ladisch ***et al.***, 1967a). Poisoning by hydroquinone - quinone systems in man is characterized by jaundice, anemia, haemoglobinuria and cachexia. In mammals its toxicity may also cause respiratory depression, skin blanching and cyanosis before death. Respiratory impairment may be due to inadequate blood oxygen (Omaye ***et al.***, 1981). Also the quinone vapour from the infested flour is irritating to men resulting particularly in gastric disorders (Park, 1934). Moreover, it smells like an aldehyde and it irritates the mucous membrane of the nose, and in high concentrations it also irritates the eyes (Chapman, 1926).

PROSPECTS

Fortunately, quinone secretion is highly toxic to the flour beetles themselves (Palm, 1946). It is well known that the activities of the flour beetles result in the flour becoming contaminated with quinone secretions and that the population declines largely through reduction of the reproductive rate (Park, 1934, 138). As a result irrespective of initial population density, eventually an equilibrium is attained after the population of flour beetles becomes relatively constant (Chapman, 1928; Park, 1935, 1937; Roth, 1943). Thus, the quinone secretions may reduce the population of flour beetles adversely affecting the following biological aspects (Table 2).

Larval Growth

The quinones inhibit the larval development by reducing larval weight and lengthening the larval period (Park, 1934, 1938; Sverdlov and Wool, 1973; Mondal, 1986). This is due to their effects on the juvenile hormone. It may accelerate the secretion of the juvenile hormone in the larvae of the flour beetles. The other explanation may be that the quinones change the sulfhydryl-disulfide equilibrium of important digestive enzymes or membrane proteins of the microvilli of the midgut. Complexing with either enzymes or membrane proteins may have the effect of allowing less food to be assimilated (Rees and Beck, 1976).

Fecundity and Fertility

Long period of feeding on quinones contaminated flour affects the metabolism of adults particularly the physiological state of the female (Loschiavo, 1960, Taher and Cutkomp, 1983) which ultimately reduce both fecundity (Park, 1936a; Mondal and Port, 1985) and fertility in ***Tribolium*** (Park, 1936a; Mondal, 1987).

A population can bring about a compensation for increased mortality by increasing net reproduction. The multiplication or outbreak of insects is greatly influenced by both fecundity and fertility of the species (Khan, 1981). Both fecundity and fertility of ***Tribolium*** females are reduced by quinones which plays an important role in the reduction of the reproductive rate.

Adult Deformity

Quinone secretion is capable of producing various abnormalities in flour beetle populations, the effect varies with the developmental stages of the insects (Roth and Howland, 1941). Some insects surviving quinones suffer physiological effects other than death reflected in an impaired ability to develop properly (Loschiavo, 1960). The quinone affects critical periods in the development of the larvae or pupae resulting in gross abnormalities in the subsequent adult which may be mistaken for mutations (Sokoloff, 1972). These abnormalities include larvae with wing pads which fail to become adults; pupae which produce monstrous imagoes with legs reduced in size or altogether wanting; adults with the head greatly reduced, missing legs, antennae, mouthparts or elytral deformity (Chapman, 1926; Oosthuizen and Shepard, 1936; Park, 1936b; Roth and Howland, 1941; Sokoloff, 1972; Mondal, 1990a).

These deformed adults probably suffer latent effects which are responsible for this reduced fecundity (Mondal, 1985), fertility (Mondal, 1987) and adult life span (Ashford, 1970; Mondal, 1988; Mondal and Ali, 1989).

Table 2. Showing the effects of quinone on different life stages of flour beetles.

Life stage	Control	Quinone	Reference
Larval period (days)	20.0	27.1	Mondal, 1986
Larval weight (mg) (6th instar)	1.8	0.7	Mondal, 1986
Fecundity (Eggs/day/female)	9.1	4.4	Mondal, 1985
Hatching (%)	93.1	79.0	Mondal, 1987
Adult mortality (%) ♂	4.0	14.0	Mondal, 1988
♀	5.3	15.3	Mondal, 1988
Larval mortality (%)	2.4	10.0	Mondal, 1990b
Adult deformity (%) resulting from :			Roth and Howland, 1941
1st instar larvae	-	100.0	
Last instar larvae	-	77.0	
Prepupae	-	53.0	
Pupae	-	8.0	

Synergistic action

Quinones act as a synergistic (Hewlett, 1960, 1968) with insecticides against the flour beetles, killing significant higher numbers in comparison with the mortality due to individual action of the chemical (Table 3). The synergism may be achieved by applying either constant or variable doses of quinone in combination with constant or variable doses of insecticide (Mondal, 1990b).

The synergism happens following physical stress. Quinones may reduce the number of haemocytes which probably increases the susceptibility to the insecticides or it slows down the detoxification of insecticides in insects (Sternburg *et al.*, 1959; Davey, 1963).

Table 3. Synergistic effects of quinone with pirimiphos-methyl (insecticide) on *Tribolium castaneum* larval mortality (Mondal, 1990b).

Chemical doses (ppm)		Percentage mortality		
Pirimiphos-methyl (A)	Quinone (B)	Pirimiphosmethyl (A)	Quinone (B)	Combined (A + B)
1.0	200	15.5	8.9	38.9
1.0	2000	15.5	12.2	58.9
1.0	4000	15.5	13.3	55.5
1.0	8000	15.5	13.3	60.0
2.0	200	43.3	8.9	65.5
3.0	200	64.4	8.9	86.7
4.0	200	81.1	8.9	95.5

As Repellent

Naturally occurring quinones are repellent to flour beetles (Ghent, 1963). Among different components of quinones, both synthetic methylquinone and ethylquinone are repellent to both adults (Loconti and Roth, 1953; Ogden, 1969) and larvae (Mondal, 1983, 1985, 1989; Mondal and Port, 1984) of the flour beetles. Quinones have been found to be effective both in a vapour and contact phase which complies with the properties of a repellent (Slifer, 1954, Dethier *et al.*, 1960; Painter, 1967). In the case of contact action, the quinone acts upon receptors not normally sensitive to vapours, particularly gustatory receptors on the mouthparts and tarsi (Frings, 1946; Dethier, 1956). Both olfactory and gustatory effects cause directed avoiding reactions which are more or less immediate (Dethier, 1956) and also frequently control feeding (Painter, 1967).

CONCLUSIONS

Despite of being toxic to mammals, quinones may be exploited for the control of flour beetles in warehouses. Firstly, the most important method is to use them as a repellent. Treatment of bags of flour or other stored products with repellent quinone may prevent flour beetles from attacking and infesting the food. It may be used more widely in warehouses to direct insects to other areas where they can be killed by appropriate insecticides, chemosterilants or pathogens (Ginsburg, 1935; Painter, 1967). Secondly, the synergistic effect of quinone indicates its possible use to enhance the effectiveness of insecticides. A complete or almost complete elimination of the flour beetles from warehouses can be achieved even using a low concentration of insecticides in combination with quinones. Thus, quinone secretions may play a vital role in achieving the long-range goals of controlling flour beetle populations effectively and economically, reducing the use of insecticides. Unfortunately so far, no such endeavour has been made to use these quinones in control measures. In this regard scientists as well as the agrochemical industry should take the initiative to carry out both investigation and synthesis of these quinones commercially so that they may be available for large scale use. Moreover, the toxic and carcinogenic effect of quinones may be overcome if the synthesis of a non-toxic analogue of this compound is possible.

Otherwise, necessary care and precautions should be taken to avoid the vapour or direct contact with this compound. The safe and effective use of quinones should be of concern to everyone. To protect against unwanted exposure to quinones the following precautions and safety measures are suggested :

1) Stored flour in a warehouse should be inspected frequently at a regular interval to detect whether they have been infested by flour beetles.

2) Flour to be taken out of the warehouse for human consumption before being infested and contaminated with quinones. Under no circumstances, should the food grains be allowed to be heavily infested and contaminated with quinones.

3) Stored flour, which has become pinkish in colour should not be used for human consumption because the colour indicates the presence of quinones in the flour.

4) Both quinones and quinone-contaminated flour should be handled with care. It should not be brought into contact with the skin. Protective clothing including gloves should be used.

5) The quinone vapour should be avoided : a mask may be used.

6) People should be made aware of the toxic effects of the quinone secretion of flour beetles and that quinone-contaminated food is a threat to human health.

ACKNOWLEDGEMENT

The author is grateful to Dr. B.J. Selman, Department of Agriculture and Environmental Science, University of Newcastle upon Tyne, U.K. for critically reviewing the manuscript.

REFERENCES

Alexander, P.; Barton, D.H.R. 1943. The excretion of ethylquinone by the flour beetle. *Biochemical Journal* 37 : 463-465.

Ashford, R.W. 1970. Some relationships between the red flour beetles, *Tribolium castaneum* (Herbst) (Coleoptera, Tenebrionidae) and *Lymphotropha tribolii* Ashford (Neogregarinidae, Schizocystidae). *Acta Protozoologica* 7 : 513-529.

Chapman, R.N. 1926. Inhibiting the process of metamorphosis in the confused flour beetle (*Tribolium confusum* Duval). *Journal of Experimental Zoology* 45: 293-299.

Chapman, R.N. 1928. Quantitative analysis of environmental factors. *Ecology* 9 : 111-122.

Chittenden, F.H. 1896. Insects affecting cereals and other dry vegetable foods. *U.S. Department of Agricultural Division Entomological Bulletin* 44 : 112-131.

Chittenden, F.H. 1897. Some insects injurious to stored grain. *U.S. Department of Agricultural Division Entomological Bulletin* 45 : 11-12.

Davey, K.G. 1963. The release by enforced activity of the cardiac accelerator from the corpus cardiacum of *Periplaneta americana*. *Journal of Insect Physiology* 9 : 375-381.

DeCoursey, J.D.; Webster, A.P.; Taylor, W.W.; Leopold, R.S.; Kathan, R.H. 1953. An antibacterial agent from *Tribolium castaneum* (Herbst). *Annals of the Entomological Society of America* 46 : 386-392.

Dethier, V.G. 1956. Repellents. *Annual Review of Entomology* 1 : 181-202.

Dethier, V.G.; Browne, L.B.; Smith, C.N. 1960 The designation of chemicals in terms of the responses they elicit from insects. *Journal of Economic Entomology* 53 : 134-136.

Eisner, T.; Meinwald, J. 1966. Defensive secretions of Arthropods. *Science* 153 : 1341-1350.

Engelhardt, M.; Rapoport, H.; Sokoloff, A. 1965. Odorous secretions of normal and mutant *Tribolium confusum*. 150 : 632-633.

Frings, H. 1946. Gustatory threshold for sucrose and electrolytes for the cockroach, *Periplaneta americana* (Linn.) *Journal of Experimental Zoology* 102: 23-50.

Ghent, A.W. 1963. Studies of behaviour of the *Tribolium* flour beetles. I. Contrasting responses of *T. castaneum* and *T. confusum* to fresh and conditioned flours. *Ecology* 44 : 269-283.

Ginsburg, M. 1935. Protection from mosquito bites in outdoor gatherings. *Science* 82 : 490-491.

Good, N.E. 1933. Biology of the flour beetles, *Tribolium confusum* Dev. and *T. ferruginaeum* Fab. *Journal of Agricultural Research* 46 : 327-334.

Good, N.E. 1936. The flour beetle of the genus *Tribolium. Technical Bulletin, U.S. Department of Agriculture* 498 : 1-57.

Hackman, R.H.; Pryor, M.G.M.; Todd, A.R. 1948. The occurrence of phenolic substances in arthropods. *Biochemical Journal* 43 : 474-477.

Hewlett, P.S. 1960. Joint action in insecticides. *Advance in Pest Control Research* 3 : 27-74.

Hewlett, P.S. 1968. Synergism and potentiation in insecticides. *Chemistry and Industry* 1 : 701-706.

Irwin, D.G.; Smith, L.W.; Pratt, J.J. Jr. 1972. Effects of carbon dioxide and nitrogen on the secretion of parabenzoquinones by *Tribolium castaneum* Herbst. *Journal of Stored Product Research* 8 : 213-219.

Khan, A.R. 1981. ***The combined action of organophosphorous insecticides and microsporidians on Tribolium castaneum.*** Unpublished Ph. D. University of Newcastle upon Tyne, U.K. 146 pp.

Ladisch, R.K. 1963. Isolation and characterization of certain insect secretions. *Pennsylvania Academy of Science Proceeding* 37 : 127-136.

Ladisch, R.K.; Ladisch, S.K.; Howe, P.M. 1967a. Quinoid secretions in grain and flour beetles. *Nature* 215 : 939-940.

Ladisch, R.K.; Seuter, Sr. M.A.; Demer, C. 1967b. Antibacterial properties of ethylquinone. *Pennsylvania Academy of Science Proceeding* 41 : 94-96.

Loconti, J.D.; Roth, L.M. 1953. Composition of the odorous secretion of *Tribolium castaneum. Annals of the Entomological Society of America* 46 : 271-289.

Loschiavo, S.R. 1960. Effects of low doses of Ethylene Dibromide on some stages of the confused flour beetle, *Tribolium confusum. Journal of Economic Entomology* 53 : 762-767.

Markarian, H.; Florentine, G.J.; Pratt, J.J. 1978. Quinone production of some species of *Tribolium. Journal of Insect Physiology* 24 : 785-790.

Mondal, K.A.M.S.H. 1983. Response of *Tribolium castaneum* (Herbst) larvae to the different components of conditioned medium. *Tribolium Information Bulletin* 23 : 104-111.

Mondal, K.A.M.S.H. 1984. ***Effects of methylquinone, aggregation pheromone and pirimiphos-methyl on Tribolium castaneum Herbst larvae.*** Unpublished Ph. D. University of Newcastle upon Tyne. U.K. 259 pp.

Mondal, K.A.M.S.H. 1985. Response of *Tribolium castaneum* larvae to aggregation pheromone and quinones produced by adult conspecifics. *International Pest Control* 27 : 64-66.

Mondal, K.A.M.S.H. 1986. Effect of methylquinone, aggregation pheromone and pirimiphos-methyl on larval growth of *Tribolium castaneum* Herbst. *Bangladesh Journal of Zoology* 14 : 123-128.

Mondal, K.A.M.S.H. 1987. Effect of synthetic methylquinone, aggregation pheromone and pirimiphos-methyl on fertility of *Tribolium castaneum* Herbst. *University Journal of Zoology, Rajshahi University* 5 & 6 : 21-26.

Mondal, K.A.M.S.H. 1988. Effect of synthetic methylquinone, aggregation pheromone and pirimiphos-methyl on adult mortality in *Tribolium castaneum* Herbst. *Pakistan Journal of Zoology* 21 : 45-51.

Mondal, K.A.M.S.H. 1989. Response of *Tribolium confusum* larvae to synthetic methylquinone. *Bangladesh Journal of Zoology* 17 : 165-168.

Mondal, K.A.M.S.H. 1990a. Effect of synthetic quinone and pheromone on *Tribolium castaneum*. *Annals of Entomology* 8 : (in press).

Mondal, K.A.M.S.H. 1990b. Combined action of methylquinone, aggregation pheromone and pirimiphos-methyl on *Tribolium castaneum* larval mortality. *Pakistan Journal of Zoology* 22 : 249-255.

Mondal, K.A.M.S.H.; Port, G.R. 1984. Repellent effect of synthetic methylquinone on larvae of *Tribolium castaneum* (Herbst). *International Pest Control* 26 : 68-71.

Mondal, K.A.M.S.H.; Port, G.R. 1985. Effect of methylquinone, aggregation pheromone and pirimiphos-methyl on the fecundity of *Tribolium castaneum* Herbst (Coleoptera : Tenebrionidae). *Proceedings of Fifth National Zoological Conference of Bangladesh*, 45-53.

Mondal, K.A.M.S.H.; Ali, M.M. 1989. Effect of synthetic methylquinone on adult mortality in *Tribolium confusum* Duval. *Tribolium Information Bulletin* 29 : 81-84.

Ogden, J.C. 1969. Effects of components of conditioned medium on behaviour of *Tribolium confusum*. *Physiological Zoology* 42 : 266-274.

Omay, S.T.; Wirtz, R.A.; Fruin, J.T. 1981. Toxicity of substituted p-benzoquinones found in the secretion of tenebrionid flour beetles. *Proceedings of West. Pharmacological Society* 24 : 169-171.

Oosthuizen, M.J.; Shepard, H.H. 1936. Prothetely in larvae of the confused flour beetle (*Tribolium confusum* Jacq. Duv.). *Annals of the Entomological Society of America* 29 : 268-272.

Painter, R.R. 1967. Repellents. In : Kilgor, W.W.; Doutt, R.L. (eds.) *Pest Control*. Academy Press, New York and London, pp. 267-285.

Palm, N.B. 1946. Structure and physiology of the stink glands in *Tribolium destructor* Uytt (Col.). *Opuse Ent.* 11 : 119-132.

Park, T. 1934. Studies in population physiology. III. The effect of conditioned flour upon the productivity and population decline of *Tribolium confusum*. *Journal of Experimental Zoology* 68 : 167-182.

Park, T. 1935. Studies in population physiology. IV. Some physiological effects of conditioned flour upon *Tribolium confusum* Duval and its population. *Physiological Zoology* 8 : 91-115.

Park, T. 1936a. Studies in population physiology. VI. The effect of differentially conditioned flour upon the fecundity and fertility of *Tribolium confusum* Duval. *Journal of Experimental Zoology* 73 : 393-404.

Park, T. 1936b. A note on the occurrence of a pupal abnormality in the flour beetle *Tribolium confusum* Duval. *Journal of Washington Academy of Science* 26 : 543-545.

Park, T. 1937. Experimental studies of insect populations. *American Naturalist* 71: 21-33.

Park, T. 1938. Studies in population physiology. VIII. The effect of larval population density on the postembryonic development of *Tribolium confusum* Duval. *Journal of Experimental Zoology* 79 : 51-70.

Payne, N. 19250. Some effects of *Tribolium* on flour. *Journal of Economic Entomology* 18 : 737-743.

Rees, J.C.; Beck, S.D. 1976. Effects of Allelochemics on the black cutworm, *Agrotis ipsilon* : Effects of p-benzoquinone, Hydroquinone, and Duroquinone on larval growth, development and utilization of food. *Annals of the Entomological Society of America* 69 : 59-67.

Roth, L.M. 1943. Studies on the gaseous secretion of *Tribolium confusum* Duval. II. The odoriferous gland of *Tribolium confusum*. *Annals of the Entomological Society of America* 36 : 397-424.

Roth, L.M. 1945. The odoriferous glands in the tenebrionidae. *Annals of the Entomological Society of America* 38 : 77-87.

Roth, L.M.; Eisner, T. 1962. Chemical defense of Arthropods. *Annual Review of Entomology* 7 : 107-136.

Roth, L.M.; Howland, R.B. 1941. Studies on the gaseous secretion of *Tribolium confusum* Duval. I. Abnormalities produced in *Tribolium confusum* Duval by exposure to a secretion given off by the adults. *Annals of the Entomological Society of America* 34 : 151-175.

Sinha, R.N. 1966. Development and mortality of *Tribolium castaneum* and *T. confusum* on seed borne fungi. *Annals of the Entomological Society of America* 59 : 192-201.

Sinha, R.N. 1968. Adaptive significance of mycophagy in stored-product Arthropoda. *Evolution* 22 : 785-798.

Slifer, E.H. 1954. The reaction of a grasshopper to an odorous material held near one of its feet (Orthroptera : Acrididae). *Proceedings of the Royal Entomological Society of London (A)* 29 : 177-179.

Sokoloff, A. 1972. *The Biology of Tribolium*. Oxford University Press, New York. Volume 1. 300 pp.

DIETARY EFFICIENCY OF COMMON SPICES IN TRIBOLIUM ANAPHE HINTON (COLEOPTERA: TENEBRIONIDAE).

A.M.Saleh Reza, Mahbub Hasan*, S.M.Rahman and A.R.Khan
Department of Zoology, Rajshahi University
Rajshahi 6205, Bangladesh.

The present investigation determines the effect of commonly used spices on the growth and development of Tribolium anaphe. Spices had a deleterious effect on the beetle. However, addition of 5% yeast improved the dietary status of chilli, cardamon and cinnamon in T. anaphe.

Tribolium anaphe Hinton, originating in Ethiopia, has become a potential pest of stored products in recent years in various parts of the globe. Spices are important ingredients of our diet which are primarily used to add flavour and to remove unsolicited bad odour. As other stored commodities these are liable to pest infestations.

The growth and development of Tribolium on spices have been worked out by a few workers (Good, 1933; Punj, 1967; Pajni and Virk, 1978). However, no literature is available on the effect of spices on the growth and development in T. anaphe. This initiated the present investigation.

Various spices, e.g. Chilli (Capsicum annum), Clove (Syzygium aromaticum), Cardamon (Ammomum subulatum), Cinnamon (Cinnamomum zeyandicum), Coriander (Coriandrum sativum), Black pepper (Peper nigrum) and Cumin (Cuminum sativum) were procured from the local market, dried, crushed to powder and passed through a 60-mesh sieve. Eggs of T. anaphe were collected from a laboratory culture maintained on wholemeal flour. Neonate larvae (>24 hrs old), 50 for each food, were transferred to glass jars each containing 50 gms of food. Another set of experiment was made where each treatment contained 5% yeast. In addition, two samples of wheat flour with and without 5% yeast were kept as standard food. Larvae were observed for pupation. Freshly formed pupae were kept in Petridishes for adult emergence. The larval periods of T. anaphe on various spices were noted. After eclosion the pupal period and adult recovery (%) were recorded.

* To whom correspondence should be sent.

The growth index of the test insect in respect of various foods was computed by dividing adult emergence (%) by the total duration of pupal and larval periods. All the experiments were replicated thrice and performed in an incubator set at 30 °C.

Spices produced deleterious effects on the development of T. anaphe (Table 1). The development of the beetle was complete on chilli and cardamon with and without yeast. In the case of cinnamon the addition of yeast produced 13.20% adults and no adults emerged entirely on the spices. Somewhat similiar results were obtained by Punj (1967) and Pajni & Virk (1978).

Acknowledgements: The authors would like to extend sincere thanks to Dr Sayedur Rahman, Ex-Chairman, Dept. of Zoology, Rajshahi University, for providing required laboratory facilities, and to the Slough Laboratory, MAFF, England, for supplying the experimental beetles.

References

Good, N. E. 11933. Biology of the flour beetles T. confusum and T. ferrugineum. **J. Agric. Res.** 46: 327 - 334.

Punj, G. K. 1967. Dietary efficiency of natural foods for the growth and development of T. castaneum Hbst. and Corcyra cephalonica Staint. **Bull. Grain Technol.** 5 : 209 - 213.

Pajni, H. R. and **Virk, N.** 1978. Comparative dietary efficiency of common spices and oilseeds for the larval growth of Tribolium castaneum Herbst (Coleoptera:Tenebrionidae). **Entomon.** 3(1): 135 - 137.

Table 1 : Growth and development of *Tribolium anaphe* on different spices.

Food	Adult eclosion(%)	Total larval & pupal periods(days)	Growth index
Wholemeal	81.62	20.48	03.98
wholemeal + 5% yeast	87.24	19.31	04.52
Chilli	33.33	43.40	00.77
Chilli+ 5% yeast	71.33	31.37	02.27
Clove	-	-	-
Clove + 5% yeast	-	-	-
Cardamon	03.33	44.42	00.07
Cardamon + 5% yeast	04.16	44.35	00.09
Cinnamon	-	-	-
Cinnamon + 5% yeast	13.20	51.69	00.25
Coriander	-	-	-
Coriander + 5% yeast	-	-	-
Black pepper	-	-	-
Black pepper + 5% yeast	-	-	-
Cuminseed	-	-	-
Cuminseed + 5% yeast	-	-	-

- means larvae died before pupation

Sevener, Jeffrey D., Nakeisha N. Dennard and Karin A. Grimnes
Dept of Biology
Alma College
Alma, Michigan USA 48801

*Histological and Histochemical Evidence for an Additional Cell Type in the Male Accessory Reproductive Glands of Tribolium brevicornis (Coleoptera: Tenebrionidae)

Introduction

The structure of reproductive accessory gland complexes in the family Tenebrionidae have been described in earlier studies (Murad, et. al., 1977; Happ, 1984). Past studies of the male accessory gland complex of Tribolium brevicornis have shown that the complex consists of two pairs of paired glands; the tubular accessory glands (TAGs) and the pear-shaped accessory glands (PAGs) (O'Dell, et. al., 1990). Based on whole mount studies and histological investigation, four types of cells were identified in the PAGs. However, during recent reevaluation of these slides, a staining anomaly was noted. The purpose of this study was to further characterize the male accessory glands of T. brevicornis (with special emphasis on the anomalous cell type) via histological and histochemical studies.

Materials and Methods

Colonies of T. brevicornis were raised according to previously established guidelines (O'Dell, et. al., 1990). For histological studies, 8-10 day adult glands were dissected in phosphate-buffered saline, fixed in 3% gluteraldehyde, embedded in Paraplast and sectioned at 7 μm. Sections were stained in Mallory's trichrome (Pearse, 1968). For histochemical studies, the tissues were dissected in phosphate-buffered saline, fixed in 3% gluteraldehyde, embedded in Paraplast and sectioned at 6μm. Sections were stained in Periodic acid-Schiff's reagent (PAS) with counterstains of celestine blue and naphthol yellow (Pearse, 1968).

Results and Discussion

A ventral view of the reproductive accessory gland complex of T. brevicornis can been seen in Figure 1. Four cell types already recognized during the previous study and the new cell type (type 5) described here, have been included in the figure. Figures 2, 3, and 4 show the distribution of the newly identified cell type when the PAGs are viewed dorsally, medially, or laterally, respectively. As in a previous study, no evidence for more than one TAG cell type was seen.

Observation of slides stained with Mallory's trichrome show a variety of colors which can be used to track the progression of cell types throughout the gland. Cell type 1, which is located in the anterior cap of the PAGs, stained orange in Mallory's trichrome. Cell type 2, which lines the inner wall of the PAGs, stained light pink. Cell types 3 and 4 stained varying shades of red, with cell type 4 (the body of the PAGs) staining bright red and cell type 3 (near the ejaculatory duct) staining a rose color. Cell type 5 flanks cell types 1 and 4 and stains bright blue in Mallory's trichrome.

Periodic acid-Schiff's staining, which stains for carbohydrates and carbohydrate-containing macromolecules, shows distinctly different color

patterns in the five cell types. Cell type 1 stains golden, cell type 2 stains white (no coloration is seen). Cell types 3 and 4 stain tan and green, respectively. Cell type 5 is the only cell type to stain purple; a positive stain for carbohydrate presence. Positive carbohydrate staining was also detected in the secretory cells of the TAG, indicating that the TAG secretions might contain glycogen or glycoproteins. In addition, PAS positive material was detected in two other places in the accessory complex; the basement membrane of the seminal vesicles and the inner cuticular lining of the ejaculatory duct.

Conclusions

Up to eight cell types have been detected in the bean-shaped accessory glands of Tenebrio molitor (Dailey, et. al., 1980). Although there is no clear relationship between the cell types of T. molitor and the five cell types of the PAGs of T. brevicornis, several similarities can be noted. In both animals, possible lipid-containing and glycoprotein-containing cell types have been identified in similar areas of the glands, but the actual components which are being stained have yet to be identified. Eventually, we hope to extend these studies to more members of the family Tenebrionidae.

Literature Cited

Dailey, P.J., N.M. Gadzama, and G.M. Happ. 1980. Cytodifferentiation in the accessory glands of Tenebrio molitor. VI. A congruent map of cells and their secretions in the layered elastic product of the male bean-shaped gland. Journal of Morphology 166: 289-322.

Happ, G.M. 1984. Structure and development of male accessory glands in insects. In Insect Ultrastructure (Edited by King, R.C. and Akai, H.), Vol. 2, pp. 365-396. Plenum Press, New York.

Murad, H. and I. Ahmad. 1977. Histomorphology of the male reproductive organ of the red flour beetle, Tribolium castaneum L. (Coleoptera:Tenebrionidae). J. Anim. Morphol. Physiol. 24: 35-41.

O'Dell, M., L. Paulus, and K. Grimnes. 1990. Preliminary characterization of the male accessory reproductive glands of Tribolium brevicornis. (Coleoptera: Tenebrionidae). Tribolium Information Bulletin 30: 55-57.

Pearse, A.G.E. 1968. Histochemistry, theoretical and applied. Volume 1. J. and A. Church, Ltd., London.

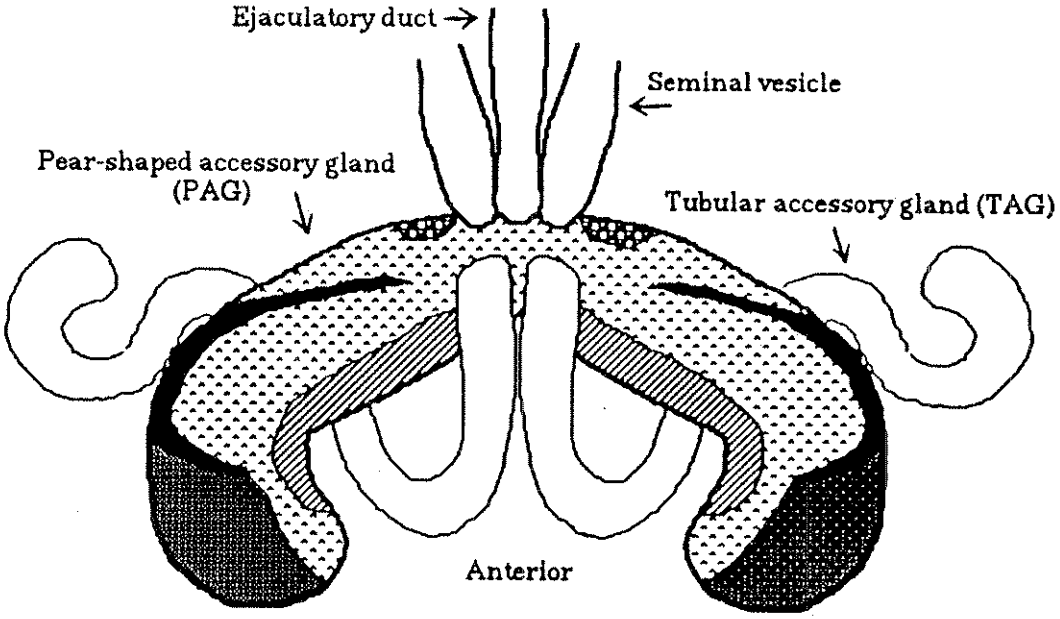


Figure 1. Ventral view of Tribolium brevicornis accessory complex

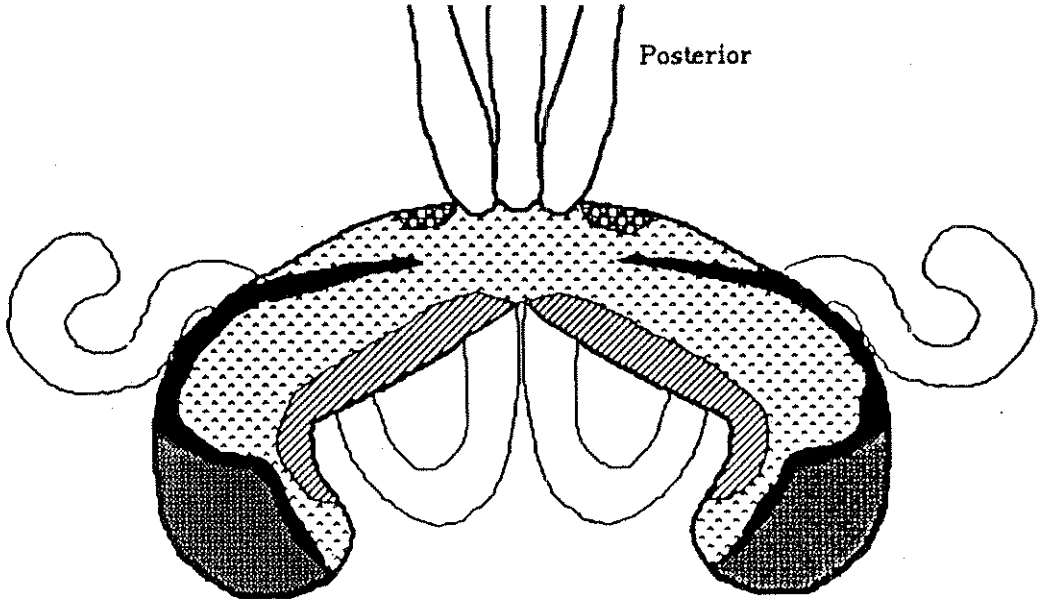
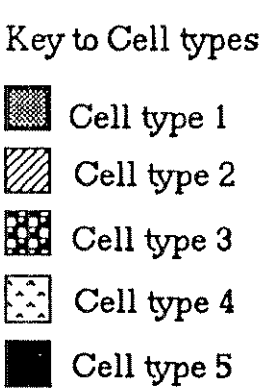


Figure 2. Dorsal view of Tribolium brevicornis accessory complex



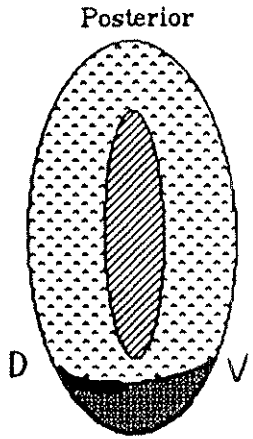


Figure 3. Medial view

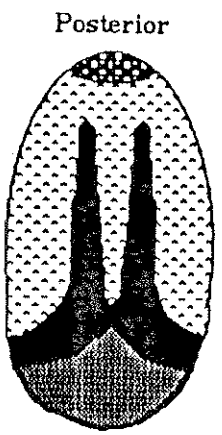


Figure 4. Lateral view

A. Tous, J.A. Castro and C. Ramon
Laboratori de Genètica
Departament de Biologia Fonamental
i Ciències de la Salut
Facultat de Ciències
Universitat de les Illes Balears
07071 Palma de Mallorca. SPAIN

*Mitochondrial DNA restriction analyses in species of *Tribolium*.

Introduction

In the last years, mtDNA analyses have become a powerful tool for evolution studies in animals. These analyses have given a major knowledge of the structure of populations, hybridizations, biogeography and phylogenetic relationships among species. Three kinds of changes determine the mtDNA variability: nucleotide substitutions, additions and deletions, and sequence rearrangements, although nucleotide substitutions appear to occur more frequently than other changes (Brown,1985).

The restriction endonucleases have been applied to the study of mtDNA of many organisms, such as human and ape populations (Cann *et al.*,1982), lizards (Brown and Wright,1979), rodents (Avise *et al.*,1983), *Drosophila* (Powell and Zuniga,1983). Nowadays, these techniques are predominant in phylogenetic research.

The flour beetles of the genus *Tribolium* have been studied under different points of view: morphological, physiological, ecological, ethological, cytogenetical, etc.(Sokoloff,1972). Curiously, we have not found mitochondrial DNA studies on *Tribolium* in the literature.

In this preliminary study we have investigated the mtDNA of six species of *Tribolium*, determining their mtDNA size by means of the fragments obtained after cutting with some restriction endonucleases.

Materials and Methods

Biological material

The species of *Tribolium* analyzed were: *T. brevicornis*; *T. confusum*; *T. castaneum*, *T. madens*, *T. audax* and *T. freemani*, obtained from the Lab of Prof. Sokoloff, San Bernardino, Univ. of California

Several isofemale lines (lines initiated from a single female) were established and examined. Because of its maternal inheritance, all individuals of an isofemale line share the same mtDNA.

MtDNA isolation and digestion

MtDNA was extracted according to the method of Latorre *et al.*(1986), which is a modification of the method employed by Coen *et al.*(1982). 12-20 individuals are gently homogenized in an Eppendorf tube containing 320µl of 10mM Tris; 60mM NaCl; 5% sucrose; 10mM EDTA; pH 7.8. Then, 400µl of 300mM Tris; 5% sucrose; 10mM EDTA; 1.25% SDS; 0.8% DEPC (freshly mixed) (pH 9.0) were added. The mixture was incubated at 65°C for 30 min., after which 120µl of 3M potassium acetate was added and the mixture was kept at -20°C for 12 min. After centrifugation for 10 min. in an Eppendorf centrifuge, the supernatant was added to 1 volume of 2-propanol and left standing at room temperature for 5 min., which was followed by a centrifugation for 5 min. The pellet was washed with 500µl of 70% ethanol and centrifuged for 2 min. The supernatant was discarded, and the pellet was resuspended in 250µl of destilled water with 0.25% DEPC (freshly mixed) and left at room temperature for 30 min. Then, 250µl of destilled water, 0.1 volume of 3M potassium acetate and two volumes of ethanol (-20°C) were added, and the mixture was kept at -20°C for 10 min. The DNA was then spun down for 5 min. in the Eppendorf centrifuge and washed with 70% ethanol. Residual ethanol was removed by drying the precipitate in a desiccator for 30 min., after which the DNA was dissolved in 40µl of TE buffer (10mM Tris; 1mM EDTA; pH 8.0).

Restriction endonuclease digestions of mtDNA were conducted using conditions recommended by the commercial firm (Boehringer Mannheim). Three restriction enzymes with hexanucleotide recognition sites (**EcoRI**, **PstI** and **BamHI**) and two with

tetranucleotide recognition sites (**HaeIII** and **HpaII**) were tested. The mtDNA was digested with the endonucleases in a final volume of 20µl, following the supplier's recommendations. RNase (2µg/ml) was added to the mixture. Restriction fragments were separated in 1% agarose gels, stained with ethidium bromide and visualized under UV illumination.

Measurement of restriction fragments

Bacteriophage λ DNA digested with HindIII, and λ DNA digested with HindIII+EcoRI were used as a molecular size markers. An additional size marker used was the *Drosophila azteca* mtDNA (16 kb) digested with HaeIII (that gives one fragment of 16000 bp) or with HpaII (that gives two fragments: 11230 bp and 4680 bp).

The relative mobilities of *Tribolium* mtDNA, λ DNA and *D. azteca* mtDNA fragments were measured from photographs of the gels, and the molecular sizes of *Tribolium* mtDNA estimated by plotting them on semilog-paper. Besides, the restriction fragment sizes were calculated by means of the ASIZE program proposed by Krawczak (1988). Fragments were assumed to be homologous if they had the same mobility in adjacent lines of a gel (Oveden *et al.*,1988).

Results and Discussion

The six species studied did not show any intraspecific variability, but a high variability among species. The restriction patterns of the six species were different from one another. Figure 1 shows the photograph with the HaeIII restriction patterns for all the species studied. As it can be seen, they are very different. HaeIII yields a lot of fragments in all species analyzed (from 2 fragments in *T. audax* to 13 in *T. brevicornis*). Three of the enzymes (HaeIII, HpaII and EcoRI) usually gave a lot of fragments whereas the other two enzymes used (BamHI and PstI) gave a minor number, and in some cases no bands were observed (Table 1).

The size of the fragments obtained after digestion is represented in Table 1. The mtDNA size for each species of *Tribolium* was estimated averaging all the different sizes obtained after digesting with the five enzymes used. The sizes may be

underestimated because fragments smaller than 500 base pairs could not be accurately resolved. Anomalous values were not included in the calculations. As it can be seen in Table 1, all species except *T. brevicornis* have a similar mtDNA size, which ranges from 17.000 bp to 18.200 bp. The mtDNA of *T. brevicornis* is the biggest, around 22400 bp, 4000 bp more than the others. Curiously, this species has a HaeIII fragment of 1100 bp highly repeated (about 8 times).

The genetic distance between the mtDNA of the species in pairwise comparisons may be estimated by the parameters **S** (probability that two DNAs share the same recognition sequence at a given site) and **d** (expected number of nucleotide substitutions per site). The **d** values between two species can be determined by the maximum likelihood method of Nei and Tajima (1981) (Nei,1987). From these values it can be constructed a dendrogram. Nevertheless, these analyses could not been carried out due to the fact that two comparisons, *T. madens -T. freemani* and *T. confusum - T. brevicornis* do not share any fragment in common (Table 1) and the results could be distorted. More restriction enzymes are needed to find common fragments.

This work was partly supported by the 1989 "Ciutat de Palma" Prize from the Palma de Mallorca city council to A. T.

Literature cited

Avise, J.C., Shapira, J.F., Daniel, S.W., Aquadro, C.F. and Lansman, R.A. (1983). Mitochondrial DNA differentiation during the speciation process in *Peromyscus. Mol. Biol. and Evol.* **1**: 38-56.

Brown, W.M. (1985). The mitochondrial genome of animals. In *Molecular Evolutionary Genetics* (ed. R.J. MacIntyre). New York, London: Plenum. pp. 95-130.

Brown, W.M. and Wright, J.W. (1979). Mitochondrial DNA analyses and the origin and relative age of parthenogenetic lizards (genus *Cnemidophorus*). *Science* **203**: 1247.

Cann, R.L., Brown, W.M. and Wilson, A.C. (1982). Evolution of human mitochondrial DNA: A preliminary report. In *Human Genetics, Part A: The Unfolding Genome*, Alan r. Liss, Inc.. pp. 157-165.

Coen, E.S., Thoday, J.N. and Dover, G. (1982). Rate of turnover of structural variants in the rDNA gene family of *Drosophila melanogaster. Nature* **295**: 564-568.

Krawczak, M. (1988). Algorithms for the restriction site mapping of DNA molecules. *Proc. Natl. Acad. Sci. U.S.A.* **85**: 7298-7301.

Latorre, A., Moya, A. and Ayala, F.J. (1986). Evolution of mitochondrial DNA in *Drosophila subobscura. Proc. Natl. Acad. Sci. U.S.A.*, **83**: 8649-8653.

Nei, M. (1987). *Molecular Evolutionary Genetics.* Columbia University Press, New York, 512 pp.

Nei, M. and Tajima, F. (1981). DNA polymorphism detectable by restriction endonucleases. *Genetics* **97**: 145-163.

Oveden, J.R.; White, R.W.G. and Sanger, A.C. (1988). Evolutionary relationships of *Gadopsis* spp. inferred from enzyme analysis of their mitochondrial DNA. *J. Fish Biol.* **32**: 137-148.

Powell, J.R. and Zuniga, M.C. (1983). A simplified procedure for studying mtDNA polymorphisms. *Biochem. Genet.* **21**: 1051-1055.

Sokoloff, A. (1972). *The Biology of Tribolium with Special Emphasis on Genetics Aspects.* Vol 1. Oxford University Press.

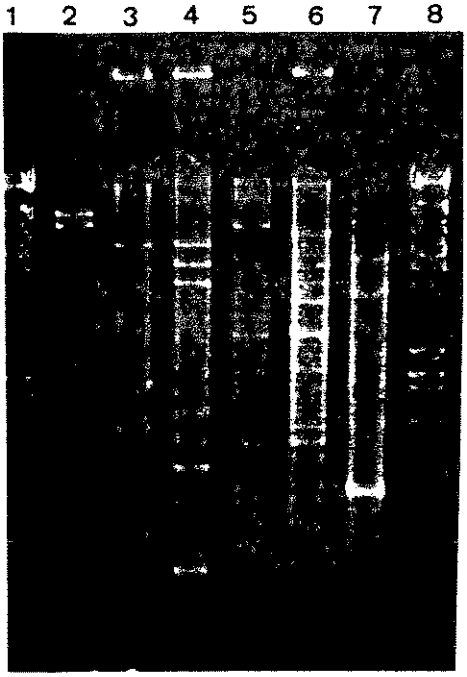


Figure 1. Photograph with the HaeIII restriction patterns for all species. Lanes 1 and 8: λ DNA marker. 2:*T. audax*; 3: *T. castaneum*; 4: *T. madens*; 5: *T. freemani*; 6: *T. confusum*; 7: *T. brevicornis*.

Table 1. Restriction fragments and mtDNA size of the six species of *Tribolium*

SPECIES	ENZYMES					
	HaeIII	HpaII	EcoRI	PstI	BamHI	MEAN SIZE
T. audax	10000 8000	9400 5000 2100 2000	3400 3100 3000 1900 1000		16000 2100	
	18000	18500	12400*	-	18100	18200
T. freemani	8000 2500 2100 2000 1400 1200		9700 6500 1100	16000 1650	14500 2100 1700	
	17200	?	17300	17650	18300	17600
T. castaneum	5700 2100 1900 1700 1600 1600 1300 850 800	7000 2200 2100 1700 1400 1000	7000 7000 2000 1100 900	16000 1900	16000 2100	
	17550	15400*	18000	17900	18100	17900
T. madens	5700 4700 3700 1750 1250 750X2	10400 5700 500 500	4400 3000 2900 1900 800	11000 5500	16000	
	18600	17100	13000*	16500	16000	17000
T. confusum	6700 3200 2500 1600 1450 900 700	4200 3500 2500 2000	3600 3100 2900 2900 2300 1200 1200			
	17050	12200*	17200	?	-	17100
T. brevicornis	4800 3300 2200 1900 1250 1100(x8)	9400 4900 3300 2100 1700 1100 600	7600 6000 1750 1000	16000 2200 1250 1100 1100		
	22250	23100	16350*	21650	-	22400

- : The enzyme did not cut
? : The restriction pattern could not be interpreted
* : Value that was not considered in the mean

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

* Developmental rates of Tribolium species.

Carreras et al. have given the following data on the duration of the developmental cycle of T. brevicornis, T. castaneum, T. confusum and T. madens when reared at room temperature (24 C) and 50% Relative Humidity.

STAGE	T. brevicornis	T. castaneum	T. confusum	T. madens
Egg	7.02	0.04		
Larva	41.65	0.39		
Pupa	12.15	0.07		
Total days	60.82	50.25	52.55	54.75

The following values for several species have been obtained in our laboratory at different temeratures and relative humidities

Species	Temp & R.h.	Total developmental period (days) (days)
T. brevicornis	32 60	60
T. destructor*	28 75	44
T. audax	32 70	43
T. madens	35 70	35.3

*T. destructor shows great mortality at higher temperatures.

In another experiment where T. audax and T. madens were reared at the same temperature and humidity (32 C. and 70% R.H.) we obtained the following data:

Stage	T. audax	T. madens
egg	7	9
larva	22	19
pupa	14	10
Total	43	36

The days elapsed before adults of these species became sexually mature were 50 for T. audax and 40 for T. madens.

Literature cited

Carreras, L., Alvarez-Fuster, A., Juan C. and Petitpierre, E. 1991. Tasa de desarrollo en Tribolium brevicornis (Coleoptera: Tenebrionidae) y su relacion con el tamano del genoma. X Bienal de la Real Sociedad Espanola de Historia Natural, Palma de mallorca 23-27, 1991, p.184.

Notes-Research, Teaching and Technical

Henry-Ford, Darice and Alexander Sokoloff
Biology Department
California State University
San Bernardino, California, 92407.

*Hybridization between T. castaneum and T. freemani--a possible exception.

Crosses between T. castaneum and T. freemani produce abundant progeny all of which are sterile (Nakakita et al. 1981). This indicates that they are closely related sibling species. Further evidence for this close relationship has been obtained by crossing sex-linked recessive, autosomal semi-dominant and autosomal dominant mutants with recessive lethal effects available in T. castaneum with T. freemani. The ratios among the hybrid progeny were similar to those obtained when T. castaneum mutants were crossed with T. castaneum normal beetles, attesting to the similar genetic endowment of the two species (Brownlee and Sokoloff, 1989). Further evidence for this has been obtained by crossing the mutant black of T. castaneum with a recently discovered in T. freemani. The F1 of these hybrid crosses were all black, indication the two black mutants were due to homologous genes (Spray and Sokoloff,1991).

One of the most notable differences between T. castaneum and T. freemani is the size of the adults: T. freemani males and females weigh two to three times more than the corresponding sex in T. castaneum, and when etherized beetles of comparable sex are placed side by side under the dissecting microscope it is evident that T. castaneum is roughly 2/3 the length of T. freemani. Within T. castaneum the wild type and the pygmy mutations differ in the same relative way: The wild type weighs roughly twice as much as the py beetles, and the overall length of the latter is roughly 2/3 the length of the former.

Brownlee and Sokoloff (1988) have shown that despite these differences in size T. castaneum py males are perfectly capable of producing hybrids when crossed with T. freemani females, and in the reciprocal cross py females can be inseminated by T. freemani males. Since the py gene is a sex linked semidominant one, the F1 female hybrids are somewhat reduced in size while the F1 male hybrids are all py. The other two sex-linked recessive mutants investigated separately from each other and from py in hybridization studies (pd and r) give distinct F1 ratios in reciprocal crosses as they would in single species crosses: r/r ♀ x + ♂ give black eyed females and red-eyed males in equal numbers, while the reciprocal cross r ♂ x black eyed females give black eyed males and females in equal proportions. Crosses involving the sex-linked antennal mutation, paddle (pd) give similar results as those obtained for the red eyed mutant.
Recently, however, we carried out reciprocal crosses between T. freemani and b; r py. b is a semidominant autosomal gene

modifying body color) and r and py are of course sex linked.

The results were interesting:
b r py male x T. freemani ♀ produced males and females phenotypically wild type. The reciprocal cross failed to produce even though the b r py females and their T. freemani were held together and transferred to fresh food for several months.

Next we tried crossing pd pte (both sex linked traits) x T. freemani reciprocally. We obtained F1 hybrids when the male was pd pte was the male, but in the reciprocal cross there were no progeny, even though the parents of both species were held together for several weeks.

Further studies are now in progress.

Literature cited

Brownlee, A. and Sokoloff, A. 1988. Transmission of Tribolium castaneum (Herbst) mutants to T. castaneum-T. freemani Hinton hybrids (Coleoptera:Tenebrionidae). J. stored Prod. Res. 24:145-140.

Nakakita, H., Imura, O. and Winks, r.g. 1981. Hybridization between T. freemani Hinton and Tribolium castaneum (Herbst), and some preliminary studies on the biology of T. freemani (Coleoptera:Tenebrionidae). Appl. Ent. Zool. 16:209-214.

Spray, S. and Sokoloff, A. 1991. Further identification of homologous genes in T. castaneum (Herbst) and T. freemani through hybridization. Tribolium Inf. Bull. 31: 88-92.

Zhang Lao, Wang Xinmou, Lan rong and Lu wei
Deaprtment of Animal Science
Beijing Agricultrual University
Beijing, P. R. China

TRIBOLIUM SIMULATION OF THE EFFECT OF HEAT STRESS ON LAYING HENS PERFORMANCE

ABSTRACT

The simulation of the effect of heat stress on laying hens performance was carried out by using the flour beetle (Tribolium castaneum Herbst) which has a short life cycle, high reproductive performance, and is easy to raise and control. The results showed that the offspring number of the tratment group R which mated at the temperature of 38 C was singnificantly smaller than that of control group C (32 C), and the pupal weight of R was heavier than that of C. The curve of the offspring number of R took an 'arched' before it began its downswing and never reached their standard peak due to the heat stress. The study also showed that different time legths of treatment had no equal effects on reproduction performance.

Zhang Lao, Wang Xibin, Zhang Qineng, Wang Yachun and Liu Wei
Department of Animal Science
Beijing Agricultrual University
Beijing, P.R.China

THE SIMULATION OF SIRE GENETIC EVALUATION USING TRIBOLIUM CASTANEUM FOR THE COMPARISON OF TWO STATISTICAL METHODS

ABSTRACT

The simulation of sire genetic evaluation by using Tribolium castaneum for the comparison of two statistical methods: Henderson's method 3 and REML for the estimation of variance and covariance components, and also the comparison of two selection methods. The same data set of pupal lenghth and pupal width in two generations was analysed by two methods. Results showed that heritabilities of two traits estimated by Henderson's methods 3 were lower than that estimated by REML and did not remain stable in two generations. The ranking of each family average of breeding value showed that the usual method may be used for sire evaluation when the heritabilities of selected traits are middle in heigh.

TECHNICAL NOTES

Notes-Research, Teaching and Technical

MICHAEL J. WADE

Department of Ecology and Evolution
The University of Chicago
1101 East 57th Street
Chicago, IL 60637

*The use of Fumagillin and bleach rinses to control Nosema infection in Tribolium

In longterm culture, flour beetles, Tribolium spp., can be subject to outbreaks of Nosema whitei, a microsporidian parasite. We have found that such outbreaks can be eliminated by adding the antibiotic fumagillin to the medium in very low doses. This antibiotic is used to control Nosema infection in honey bees. We employ the following procedure in treating a suspect culture and during experimental work. First, a 0.50% by weight "F-concentrate" is made by combining 189 g of whole wheat flour, 10 g of brewer's yeast, and 1 g of bicyclohexylammonium fumagillin (brand name, "FUMIDIL B", obtained from Mid-Continental Agrimarketing, Inc., Lenexa, KS 66215). The F-concentrate is stored in a freezer at 0° to -10° C. Second, a 200 g batch of rearing medium with 1 part in 10,000 by weight fumagillin is prepared by combining 3 g of F-concentrate with 197 g of standard flour-yeast medium (95% by weight whole wheat flour and 5% by weight dried brewer's yeast). Third, "washed" eggs or adult beetles are added to the fumagillin medium. Eggs are washed in a bleach solution consisting of 10% by volume chlorine bleach and 90% by volume distilled water following procedures outlined in Park (1948). Adults are also washed to remove adhering spores by shaking for three minutes in a test tube containing the bleach rinse. After the adults are rinsed, they are blotted on paper toweling and given approximately 30 minutes to recover before being added to the medium.

It is our experience over the past seven or eight years that these procedures will eliminate Nosema and other parasitic infections observed to cause larval and pupal mortality during longterm culture.

REFERENCES:

Park, T. 1948. Experimental studies of interspecies competition. I. Competition between populations of the flour beetles Tribolium confusum Duv. and Tribolium castaneum Herbst. **Ecol. Monogr. 18**:265-308.

CURRENT BIBLIOGRAPHY

Compiled

by

A. SOKOLOFF

BIBLIOGRAPHY

1. Anatomy and Histology

BREIDBACH, O. and MARX, J. 1990. Antennal sensory projections in the central nervous system of larval beetles Tenebrio molitor L. (Insecta: Coleoptera). Z. Angew. Zool. 77: 291-310.

BIBLIOGRAPHY

2. BEHAVIOR

FARRELL, G. 1990. An Investigation of the Flight Behavior of the Larger grain borer Prostephanus truncatus (Horn) (Coleoptera:Bostrichidae) in Response to Synthetic Pheromone. M.Sc. Thesis, University of Birmingham. 50 pp.

HETZ, M. and SLOBODCHIKOFF, C.N. 1990. Reproduction and the energy cost of defence in a Batesian mimicry complex. Oecologia 84:69-73.

KORONA, R. 1990. Travel costs and ideal free destribution of ovipositing female flour beetles, Tribolium confusum. Animal Behavior 40: 186-187.

KORONA, R. 1991. genetic basis of behavioral strategies. Dispersal of female flour beetles, Tribolium confusum, in a laboratory system. Oikos 62:265-270.

LEWIS, S.M. and AUSTAD, S.N. 1990. Sources of intraspecific variation in sperm precedence in red flour beetles. Amer. Nat. 135:351-359.

MORRILL, W.L., LESTER, D.G. and WRONA, A.E. 1990. Factors affecting efficacy of pitfall traps for beetles (Coleoptera: Carabidae and Tenebrionidae). J. entomol. Science. 25: 284-293.

TRUNG, V.Q., SINGH, K. and MAJUMDER, S.K. 1990. Olfactory behavior of red flour beetle Tribolium castaneum Herbst to male and female produced chemicals. Indian J. Entomol 51:397-400.

BIBLIOGRAPHY

3. CYTOLOGY AND ELECTRON MICROSCOPY

BIBLIOGRAPHY

4. INSECT TISSUE CULTURE AND EMBRYOLOGY

BIBLIOGRAPHY

5. ECOLOGY AND POPULATION ECOLOGY

AMBADKAR, P.M. and HOWLADER, A.J. 1990. Interspecific reactions between Lasioderma serricorne F. and Tribolium castaneum Herbst in combined cultures. H. Anim. Morphol. Physiol. 37:59-70.

BARKER, P.S. 1991. Note on the effect of low temperatures on the survival of adults and larvae of the American black flour beetle Tribolium audax. Phytoprotection 72: 77-80.

BEN-SHLOMO, R., MOTRO, U. and RITTE, U. 1991. The influence of the ability to disperse on generation length and population size in the flour beetle Tribolium castaneum. Ecological Entomology 16:279-282.

CHON, W.K., HONG, Y.S. and RYOO, M.I. 1991. A note on the Development of Tribolium castaneum (Coleoptera: Tenebrionidae) on brown rice Oryza sativa L. Korean J. Appl. Entomol. 30: 130-136.

DICK, K.M., REES, D.P., LAY, K.K. and OFOSU, A. 1989. Occurrence of larger grain borer, Prostephanus truncatus (Horn) in Ghana. FAO plant Protection Bulletin, 37:132.

GOODNIGHT, C.J. 1990. Experimental studies of community evolution. I. The response to selection at the community level. Evolution 44:1614-1624.

GOODNIGHT, C.J. 1990. experimental studies of community evolution. II. The ecological basis of the response to community selection. Evolution 44: 1625-1636.

GOODNIGHT, C.J. 1991. Intermixing ability in two species Tribolium communities. Am. Nat. 138:342-354.

HAGSTRUM, D.W. and MILLIKEN, G.A. 1991. Modeling differences in insect developmental times between constant and fluctuating temperatures. Ann. Entomol. Soc. Am. 84:369-379.

HASTINGS, A. and COSTANTINO, R.F. 1991. Oscillation in population numbers age-dependent cannibalism. J. Anim. Ecol. 60:471-482.

HETZ, M. and SLOBODCHIKOFF, C.N. 1990. Reproduction and the energy cost of defence in a Batesian mimicry complex. Oecologia 84:69-73.

HIGGINS, J.V. 1990. Age-structure and population dynamics in Tribolium flour beetles. Bull. Ecol. Soc. Am. 71:188.

BIBLIOGRAPHY

HOWARD, R.W. and FLINN, P.W. 1990. Larval trails of Cryptolestes ferrugineus (Coleoptera: Cucujidae) as kairomonal host-finding cues for the parasitoid Cephalonia waterstoni (Hymenoptera: Bethylidae). Ann. Entomol Soc. Am. 83:239-245.

JASIENSKI, M., KORZENIAK, U. and LOMNICKI, A. 1988. Ecology of kin and nonkin larval interactions in Tribolium beetles. Behav. Ecol. Sociobiol. 22:277-284.

KORONA, R. 1989. Ideal free distribution of unequal competitors can be determined by the form of competition. J. Theor. Biol. 138:347-352.

KORONA, r. 1989. Evolutionarily stable strategies in competition for resource intake rate maximization. I. The model. Behav. Ecol. Sociobiol. 25:193-199.

KORONA, R. 1989. Evolutionarily stable strategies in competition for resource intake rate maximization. II. Oviposition behavior in Tribolium confusum. Behav. Ecol. Sociobiol. 25:201-205.

KORONA, R. 1990. Travel costs and ideal free distribution of ovipositing female flour beetles, Tribolium confusum. Animal Behavior 40:186-187.

KORONA, R. and LOMNICKI, A. 1988. individual differences and survival during competition: a simple theoretical model and empirical evidence for flour beetles Tribolium castaneum (herbst). Functional Ecol. 2:331-334.

LI, L. and ARBOGAST, R.T. 1991. The effect of grain breakage on fecundity, development, survival, and population increase in maize of Tribolium castanewum Heerbst (Coleoptera: Tenebrionidae). J. stored Prod. Res. 27: 87-94.

LOMNICKI, A. 1980. Regulation of population density due to individual differences and patchy environment. Oikos 35:185-193.

LOMNICKI, A. 1988. Population Ecology of Individuals. Princeton University Press, Princeton.

LOMNICKI, A., and KRAWCZYK, J. 1980. Equal egg densities as a result of emigration in Tribolium castaneum. Ecol. 6:432-437.

LOMNICKI, A. and OMBACH, J. 1984. Resource partitioning within a single species population and population stability: a theoretical model. Theoretical Population Biology 25:21-28.

NADVORNAYA, L.S. 1990. Preimaginal stages of darkling beetle Diaclina testudinea Pill. Entomol. Rev. 69: 20-25.

OBENG-OFORI, D. and COAKER, T.H. 1990. Some factors affecting responses of four stored product beetles (Coleoptera: Tenebrionidae & Bostrichidae) to pheromones. Bull. ent. Res. 80: 433-441.

BIBLIOGRAPHY

QUINN, M.A., KEPNER, R.L., WALGENBACH, D.D., FOSTER, R.N., BOHLS, R.A., POOLER, P.D., REUTER, K.C. and SWAIN, J.L. 1990. Effect of habitat and perturbation on populations and community structure of darkling beetles (Coleoptera: Tenebrionidae) on mixed-grass rangeland. Environmental Entomol. 19:1746-1755.

REES, D.P., RODRIGUEZ, R., and HERRERA, F.J. 1990. Observations on the ecology of Teretriosoma nigrescens Lewis (Col. Histeridae) and its prey, Prostephanus truncatus (Horn) (Col.: Bostrichidae) in the Yucatan peninsula, Mexico. Tropical Sci. 30:153-165.

REES, D.P. 1991. The effect of Teretriosoma nigrescens Lewis (Coleoptera: Histeridae) on three species of storage Bostrichidae infesting shelled maize. J. stored Prod. Res. 27:83-86.

REES, d. 1991. Ecology and predatory ability of Teretriosoma nigrescens Lewis (Col.: Histeridae), a potential bio-control agent for Prostephanus truncatus (Horn) (Col.: Bostrichidae). Proc. 5th International Working Conference on Stored-Product Protection, Vol. II, 1281-1288.

REES, D. 1991. Report from project leader on traditional storage; Monitoring the distribution of Prostephanus truncatus and a predator Teretriosoma nigrescens. In WILKIN, R. Trapping Workshop Report. Proceedings of the Fifth International Working Conference on Stored-Product Protection, Vol. ii,1371-1377.

REES, D., RODRIGUEZ, R., HERRERA, F. AND OFOSU, A. 1991. Advances in monitoring Prostephanus truncatus (Horn) (Col.: Bostrichidae) and Teretriosoma nigrescens Lewis (Col.: Histeridae), populations. Proceedings of the Fifth International Working Conference on Stored-Product Protection Vol. III, 1417-1424.

SCHULTZE-WERNINGHAUS, G., ZACHGO, W, ROTERMUND, H., WIEWORDT, R. MERGET, R.,WAHL, R., BURO, W.G. and STRASSEN, R. 1990. Tribolium confusum confused flour beetle rice flour beetle an occupational allergen in bakers demonstration of IGE antibodies. 18th symposium of the Collegium Internationale Allergologicum on Cellular and Molecular Networks in Clinical Immunology and Allergy, Funchal, Madeira, N. Atlantic Ocean, September 22-26, 1990. Int. Arch. Allergy Appl. Immunol. 94:371-372.

SONLEITNER, F.J. and GUTHRIE, P.J. 1991. Factors affecting oviposition rate in the flour beetle Tribolium castaneum and the origin of the population regulating mechanism. Res. Pop. Ecol. 33:1-12.

BIBLIOGRAPHY

STEVENS, LORI and WICKLOW, D. 1992. Multi-species interactions affect reproductive incompatibility in Tribolium flour beetles. Am. Nat (In Press).

STEVENS, LORI. 1992. cannibalism in Beetles. In Cannibalism: Ecology and Evolution Among Diverse Taxa. (ed. M.A. Edgar and B.J.Crespie), Oxford University, Oxford (In Press).

SUBRAMANYAM, B. and HAREIN, P.K. 1990. Accuracies and sample sizes associated with estimating densities of adult beetles (Coleoptera) caught in probe traps in stored barley. J. econ. Entomol. 83: 1102-1109.

WADE, M.J. and GOODNIGHT, C.J. 1991. Wright's Shifting Balance Theory: An Experimental Study: Science 253:1015-1018.

WU, A. C. J. 1979. Life history traits correlated with emigration in flour beetle populations. Ph. D. Thesis, U. of Chicago.

BIBLIOGRAPHY

6. GENERAL

FRIENDSHIP, R. and COMPTON, J. 1991. Bag or bulk? A decision making check list. NRI Bulletin (45).

BIBLIOGRAPHY

7. GENETICS

ALVAREZ-FUSTER, A., JUAN, C. and PETITPIERRE, E. 1991. Genome size in Tribolium flour beetles, interspecific and intraspecific variationl. Genet. Res. 58:1-6.

BEEMAN, R.W. and STUART, J.J. 1990. A gene for lindane plus cyclodiene resistance in the red flour beetle (Coleoptera: Tenebrionidae). J. econ. Ent. 83:1745-1751.

BROWN, S.J., HENRY, J.K., BLACK, W.C. IV, and DENELL, R.E. 1990. molecular genetic manipulation of the red flour beetle: genome organization and cloning of a ribosomal protein gene. Insect Biochem. 20:185-193.

CAMPO, J.L. and RODRIGUEZ, M. 1990. Relative efficiency of selection methods to improve a ratio of two traits om Tribolium. Theoretical and Appl. Genetics 80:343-348.

CARRERAS, L., ALVAREZ-FUSTER, A., JUAN, C. y PETITPIERRE, E. 1991. Tasa de desarrollo en Tibolium brevicornis (Coleoptera:Tenebrionidae) y su relacion con el tamaño del genoma. X Bienal de la Real Sociedad Española de Historia Natural, Palma de Mallorca, 23-27 de Septiembre de 1991.

COGBURN, R.R. and BOLLICH, C.N. 1990. Heritability of resistance to stored-product insects in three hybrid populations of rice. Environmental Entomol. 19: 268-273.

DESHARNAIS, R.A., DENNIS, B. and COSTANTINO, R.F. 1990. Genetic analysis of a population of Tribolium. IX. Maximization of population size and the concept of a stochastic equilibrium. Genome 33:571-580.

DONAHAYE, E. 1990. Laboratory selection of resistance by the red flour beetle Tribolium castaneum Herbst to a carbon dioxide-enriched atmosphere. Phytoparasitica 18:299-308.

GARCIA, C and TORO, M.A. 1990. individual and g roup selection for productivity in Tribolium castaneum. Theoret. and Applied Genetics. 79:256-260.

GOODNIGHT, C.J. 1991. Intermixing ability in two-species communities of Tribolium flour beetles. Amer. Nat. 138:352-354.

GOODNIGHT, C.J. 1990. Experimental studies of community evolution. II. The ecological basis of the response to community selection. Evolution 44:1625-1636.

JUAN, C., GOSALVEZ, J., MEZZANOTTE, R., y PETITPIERRE, E. 1991. Analisis de las fracciones de ADN solubilizado y no solubilizado por digestion in situ de cromosomas de Tenebrio molitor con AluI y EcoRI. XXVI Jornadas de Genética Luso-Espanholas, Coimbra 3-5

BIBLIOGRAPHY

Octubre, 1991.

JUAN, C., VAZQUEZ, P., RUBIO, J.M., HEWITT, G.M. y PETITPIERRE, E. 1991. Presencia de ADNs altamente repetitivos en Tribolium (Coleoptera). XXVI Jornadas de Genética Luso-expanholas, Coimbra 3-5 Octubre, 1991

KORZENIAK, U. and JASIENSKI, M. 1990. Opportunity for non-random mating and components of offspring fitness in the flour beetle Tribolium confusum. Animal Behavior 40:408-409.

LEWIS, S.M. and AUSTAD, S.N. 1990. Sources of intraspecific variation in sperm precedence in red flour beetles. Amer. Nat. 135:351-359.

PETITPIERRE, E., JUAN, C., FUJIYAMA, S y CARRERAS, I. 1991. las especies genelas del complejo Chrisolina aurichalcea Mann. (Coleoptera, Chrysomelidae); divergencia genética y evolución. XXVI Jornadas de Genética Luso-Espanolas, Coimbra 3-5 Octubre 1991.

STEVENS, L. and WADE, M.J. 1990. Cytoplasmically inherited reproductive incompatibility in Tribolium flour beetles: the rate of spread and effect on population size. Genetics 124:367-372. (According to Stevens the title is "Partial reproductive incompatibility in Tribolium flour beetles: The rate of spread and effect on host fitness" (Ed.)

STUART, J.J., BROWN, S.J., BEEMAN R.W. and DENELL, R.E. 1991. A deficiency of the homeotic complex of the beetle Tribolium. Nature 350: 72-74.

WADE, M.J. 1990. Genetics-environment interactions for climate and competition in a natural population of flour beetles, Tribolium castaneum. Evolution 44:2004-2011.

WADE, M.J. 1991. Genetic variance for rate of population increase in natural populations of flour beetles Tribolium spp. Evolution 45:1574-1584.

WADE, M.J. 1991. Wright's shifting balance theory: an experimental study. Science 253: 1015-1018.

ZIRKLE, D.F., DAWSON, P.S., AND LAVIE, B. 1988. An experimental analysis of the genetic relationships among life-history traits and emigration behavior in Tribolium castaneum. Oikos 53:395-397.

BIBLIOGRAPHY

8. INSECTICIDES AND INSECTICIDE RESISTANCE

ALDRYHIM, Y.N. 1990. Efficacy of the amorphous silica dust, Dryacide against Tribolium confusum Duv. and Sitophilus granarius (L.) (Coleoptera: Tenebrionidae and Curculionidae). J. stored Prod. Res. 26: 207-210.

ARTHUR, F.H. and GILLENWATER, H.B. 1990. Evaluation of esfenvalerate aerosol for control of stored product insect pests. J. entomol. Sci. 25:261-267.

ARTHUR, F.H., THRONE, J.E., SIMONAITIS, R.A. and ZEHNER, J.M. 1990. Evaluation of chlorpyrifos-methyl and chlorpyrifos-methyl plus methoprene as protectants of stored corn: small bin tests. J. econ. Entomol. 83:1114-1121.

BEEMAN, R.W. and STUART, J. J. 1990. Gene for lindane + cyclodiene resistance in the red flour beetle (Coleoptera: Tenebrionidae). J. econ. Ent. 83:1745-1751.

BOLTER, C.J. and CHEFURKA, W. 1990. The effect of phospphine treatment on superoxide dismutase, catalase, and peroxidase in the Granary weevil, Sitophilus granarius. Pesticide biochem. and Physiol. 36:52-60.

CLABORN, D.M., TETRAULT, G.E. and ARTHUR, F.H. 1991. Effectiveness of three residual insecticide formulations to control red flour beetles (Coleoptera: Tenebrionidae) on painted and unpainted steel. J. Entomol. Sci. 26:395-400.

COLLINS, P.J. 1990. A new resistance to pyrethroids in Tribolium castaneum (Herbst). Pesticide Sci. 28:101-115.

CONWAY, J.A., MITCHELL, M.K., GUNAWAN, M. and FAISAL, Y. 1989. Cost benefit analysis of stock preservation systems. A comparison of CA and the use of conventional pesticides under operational conditions in Indonesia. pp. 228-236. In Fumigation and Controlled Atmosphere Storage of Grain. Champ, B.R., highley, E. and Banks, H.j. (Eds). ACIAR Proceedings, no. 25. Canberra: ACIAR.

CORK, A. 1990. Identification and Field Optimization of SELECTED insect Sex Pheromones for Use in Population Monitoring. Ph.D. Thesis, University of London. 292 pp.

DALES,----1991. the effect of carbon dioxide in a controlled atmosphere upon the development of stored products pests. Proceedings of the Fifth International Working Conference on stored-product Protection Vol. 2:785-786.

BIBLIOGRAPHY

DOBIE, P., DENDY, J.A., SHERMAN, C., PADGHAM, J., WOOD, A. and GATEHOUSE, A.M.R. 1990. New sources of resistance to Acanthoscelides obtectus (Say) and Zabrotes subfasciatus Boheman (Coleoptera: Bruchidae) in mature seeds of five species of Phaseolus. J. stored Prod. Res. 26:177-186.

DONAHAYE, E. 1990. Laboratory selection of resistance by the red flour beetle Tribolium castaneum Herbst to an atmosphere of low oxygen concentration. Phytoparasitica 18: 189-202.

GOLOB, P., BROADHEAD, P., and WRIGHT, M. 1991. Development of resistance to insecticides by populations of Prostephanus truncatus (Horn) (Coleoptera: Bostrichidae).Proceedings of the Fifth International Working Conference on Stored-Product Protection, Vol II, 999-1007.

GOLOB, P., BROADHEAD, P., and WRIGHT, M. 1991. Susceptibility of Teretriosoma nigrescens Lewis (Coleoptera: Histeridae) to insecticide. Proceedings of the Fifth International Working Conference on Stored-Product Protection Vol. II, 1259-1264

GRANT, J.A., PARKER, B.L. and SUHARTO, H. 1990. Controlled-release insecticides for stored grain pest control in Indonesia. I. Laboratory tests. ASEAN Food J. 5.:34-42.

HIRASHIMA, A., OYAMA, K. and Eto, M. 1990. Effect of insecticidal cyclic phosphorotionates on adenylate cyclase and phosphodiesterase. Pesticide Biochem. and Physiol. 39: 186-195.

IRSHAD, M. and GILLANI, W.A. 1990. Resistance in Tribolium castaneum (Coleoptera: Tenebrionidae) against malathion. Pak. J. Zool. 22: 257-262.

KHAN, S.U., KACEW, S. and AKHTAR, M.H. 1990. Bound 14C residues in stored wheat treated with (14C) deltamethrin and their bio-availability in rats. J. agric and Food Chem. 38:1077-1082.

KULKARNI, S.G., CHANDER, H. and BERRY, S.K. 1990. Effectiveness of sorbic acid to control rust red flour beetle Tribolium castaneum Herb. in wheat flour. J. Insect Sci. 3:204-206.

LEESCH, J.G., ARTHUR, F.H. and DAVIS, R. 1990. Three methods of aluminum phosphide application for the in-transit fumigation of grain aboard deep-draft bulk cargo ships. J. econ. Entomol. 83:1459=1467.

MATHEWS, W.A. 1990. The fate of chlorpyrifos-methyl in stored wheat: a comparison of a laboratory-scale experiment with a pilot-scale treatment. Pesticide Science 30:21-29.

MILLER, R.W. 1990. Use of ivermectin to control the lesser meal worm (coleoptera: Tenebrionidae) in a simulated poultry broiler house. Poultry Science 69:1281-1284.

BIBLIOGRAPHY

PRICE, N.R., HOPPE, T. and WATSON, H. 1991. methacrifos as a grain protectant: a comparison of the vapor effects of some organophosphorus insecticides used in grain protection. Pestic. Sci. 31: 1-8.

RAJENDRAN, S. 1990. The toxicity of phosphine methyl bromide, 1,1,1-trichloroethane and carbon dioxide alone and as mixtures to the pupae of red flour beetle, Tribolium castaneum (Herbst). Pesticide Sci. 29:75-83.

RIE, J. VAN, MCGAUGHEY, W.H., JOHNSON, D.E., BARNETT, B.D., MELLAERT, H. VAN. 1990. Mechanism of insect resistance to the microbial insecticide Bacillus thuringiensis. Science 247:72-74.

RISHA, E.M., EL-NAHAL, A.K.M. and SCHMIDT, G.H. 1990. Toxicity of vapors of Acorus calamus L. oil to the immature stages of some stored-product coleoptera. J. stored prod. Res. 26:133-137.

SHAKOORI, A.R. and SALEEM, M. A. 1991. comparative biochemical composition of a susceptible FSS II and two malathion resistant CTC 12 and Pakistan strains of Tribolium castaneum Herbst, Coleoptera Tenebrionidae. Pak. J. Zool. 23:1-10.

SUBRAMANYAM, B. and HAREIN, P.K. 1990. Status of malathion and pirimiphos-methyl resistance in adults of red flour beetle and sawtoothed grain beetle infesting farm-stored corn in Minnesota, U.S.A. J. Agric. Entomol 7:127-136.

Taylor, r.w.d. 1991. Field detection of resistance in beetle pests to contact insecticides. Proceedings of the Fifth International Working Conference on Stored-Product Protection, Vol. II, 1061-1064.

TAYLOR, R.W.D. 1991. Resistance to grain fumigants and future prospects for their use. Pesticide Outlook 2:22-24.

WALTER, C.M. and PRICE, N.R. 1989 (1990). The uptake and penetration of pirimiphos-methyl into susceptible and resistant strains of the rust red flour beetle Tribolium castaneum Herbst (Coleopter: Tenebrionidae). Comp. Biochem. Physiol. C Comp Pharmacol. Toxicol. 94:419-424.

WEINZIERL, R.A., and PORTER, R.P. 1990. Resistance of hairy fungus beetle (Coleoptera: Mycetophagidae) to pirimiphos methyl and malathion. J. econ. Entomol. 83:325-328.

WHITE, G.G. and LAMBKIN, T.A. 1990. Baseline responses to phosphine and resistance status of stored-grain beetle pests in Queensland, Australia. J. econ. Ent. 83:1738-1744.

WHITE, N.D.G. and SINHA, R.N. 1990. Effect of chorpyrifos-methyl on oat ecosystem in farm granaries. J. econ Entomol. 83:1128-1134.

BIBLIOGRAPHY

WHITE, N.D.G. and SINHA, R.N. 1990. Effects of sub-lethal exposures to malathion or chlorpyrifos-methyl on offspring production by some stored-product beetles. Can. Entomol. 122:1187-1192.

WILDE, G. 1990. Enhanced degradation of fonofos in soil from two southwest Kansas fields. J. econ. Entomol. 83: 1250-1253.

ZETTLER, J.L. 1991. Pesticide resistance in Tribolium castaneum and T. confusum (Coleoptera: Tenebrionidae) from flour mills in the United States. J. econ Ent.84:763-767.

ZETTLER, J.L. and CUPERUS, G. W. 1990. Pesticide resistance in Tribolium castaneum (Coleoptera: Tenebrionidae) and Rhyzopertha dominica (Coleoptera: Bostrichidae) in wheat. J. econ. Ent. 83: 1677-1681.

BIBLIOGRAPHY

9. IRRADIATION AND USE OF ISOTOPES

MEHTA, V.K. SETHI, G.R. and GARG, A.K. 1990. Effect of gamma radiation on the development of Tribolium castaneum Herbst after larval irradiation. J. Nucl. Agric. Biol. 19: 124-127.

MEHTA, V.K., SETHI, G.R. and GARG, A.K. 1990. Development of Tribolium castaneum Herbst larvae after gamma irradiation of eggs. J. Nucl. Agric. Biol. 19: 54-57.

UDEAAN, A.S. 1991. Studies on the basis of resistance in Tribolium castaneum Herbst to gamma HCH using carbon 14 labelled lindane. J. Nucl. Agric. Biol. 20:39-44.

BIBLIOGRAPHY

10. NUTRITION

BECKER, R. and HANNERS, G.D. 1990. Compositional and nutritional evaluation of quinoa whole grain flour and mill fractions. Lebensm-Wiss. Technol. 23: 441-444.

BECKER, R., WAGONER, P., HANNERS, G.D. and SAUNDERS, R.M. 1991. compositional, nutritional and functional evaluation of intermediate wheatgrass (Thinopyrum intermedium). J. Food Process. and Preserv. 15:63-77.

MULLEN, M.A. and HIGHLAND, H.A. 1990. Developmemt of six species of stored-product insects on multi-grain blend supplement. J. entomol. Sci. 25: 21-24.

VIA, S. 1991. Variation between strains of the flour beetle Tribolium castaneum in relative performance on five flours. Entomol. exp. et appl. 60:173-182.

BIBLIOGRAPHY

11. PARASITES AND SYMBIONTS OF COLEOPTERA

BIBLIOGRAPHY

12. PESTS

GOLOB, P. and HANKS, C. 1990. Protection of farm stored maize against infestation by Prostephanus truncatus (Horn) and Sitophilus species in Tanzania. J. stored Prod. Res. 26:187-198.

Haines, c.1991. Report from project leader on bagged grain; Trapping in developing countries (detection of pests in bulk grain); Detection of insects in rice stores (trapping techniques in developing countries). In: WILKIN, R. Trapping Workshop Report. Proceedings of the Fifth International Working Conference on Stored-Product Protection, Vol. II, 1371-1377.

HAINES, C., REES, D., RYDER,K., SISTYANTO, S. and CAHYANA, Y. 1991. brown-rice bait-bags for monitoring insect pest populations in b ag stacks of milled rice as an aid to pest control decision-making. Proceedings of the Fifth Internationa Conference on Stored-Product Protection, Vol II. 1351-1359.

Harris, a.h. And COX, J.R. 1991. development of meters for measuring phosphine concentrations in the field. Proceedings of the Fifth International Working Conference on Stored-Product Protection, Vol. II, 821-822.

JAVER, A., BORDEN, J.H., PIERCE, H.D. JR., and Pierce, A.M. 1990. Evaluation of pheromone-baited traps for monitoring of cucujid and tenebrionid beetles in stored grain. J. ECON entomol. 8a3:268-272.

MADRID, F.J., WHITE, N.D.G. and LOSCHIAVO, S.R. 1990. Insects in stored cereals, and their association with farming practices in southern Manitoba. Canad. Entomol. 122:515-523.

MULLEN, M.A. and HIGHLAND, H.A. 1990. Development of six species of stored-paroduct insects on multi-grain blend supplement. J. entomol. Sci. 25:21-24.

OBENG-OFORI, D. and COAKER, T. H. 1990. Some factors affecting

BIBLIOGRAPHY

responses of four stored product beetles (Coleoptera: Tenebrionidae & Bostrichidae) to pheromones. Bull. ent. Res. 80: 433-441.

REES, D.P. and WALKER, A.J. 1990. The effect of temperature and humidity on population growth of three Liposcelis species (Psocoptera: Liposcelidae) infesting stored products in tropical countries. Bull. Ent. Res. 80: 353-358.

SUBRAMANYAM, B. and HAREIN, P.K. 1990. Accuracies and sample sizes associated with estimating densities of adult beetles (Coleoptera) caught in probe traps in stored barley. J. econ. Ent. 83:1102-1109.

YUCEL, A. 1988. Investigation on determining flour beetles and their damages in meal factories and mills in southeastern Anatolia, Turkey. Bitki Koruma Bul 28:57-78.

BIBLIOGRAPHY

13. PHYSIOLOGY AND BIOCHEMISTRY

CORK, A. HALL, D.R., BLANEY, W.M. and SIMMONDS, M.S.J. 1991. Identification of a component of the female sex pheromone of Callosobruchus analis (Coleoptera: Bruchidae). Tetrahedron Letters 32: 129-132.

CORK, A., HALL, D.R., HODGES, R.J. and PICKETT, J.A. 1991. Identification of the major component of the male-produced aggregation pheromone of the larger grain borer, Prostephanus truncatus (HORN) (Coleoptera: Bostrichidae). J. Chem. Ecol. 17:789-803.

DENDY, J., DOBIE, P., SAIDI, J.A., SMITH, J. and URONU, B. 1991. Trials to assess the effectiveness of new synthetic pheromone mixtures for trapping Prostephanus truncatus (Horn) (Coleoptera: Bostrichidae) in maize stores. J. stored Prod. Res. 27:69-74.

HEBANOSKA, E., MALINSKI, E., LATOWSKA, A., DUBIS, E., PIHLAJA, K., OKSMAN, P., NAWROT, J. and SZAFRANEK, J. 1990. A comparison of cuticular hydrocarbons of larvae and beetles of the Tribolium destructor. Comparative Biochem. and Physiol.: B: Comparative Biocem. 96:815-819.

HINES, M.E., OSUALA, C.I. and NIELSEN, S.S. 1991. Isolation and partial characterization of a soybean cystatin cysteine proteinase inhibitor of coleopteran digestive proteolytic activity. J. Agric. Food Chem. 39: 1515-a520

HOWARD, R.W., and STANLEY-SAMUELSON, D.W. 1990. Phospholipid fatty acid composition and arachidonic acid metabolism in selected tissues of adult Tenebrio molitor (Coleoptera: Tenebrionidae). Annals. Ent. Soc. Amer. 83:975-981.

NICOLSON, S.; ISAACSON, L. 1990. Patch clamp of the basal membrane of beetle malpighian tubules: direct demonstration of potassium channels. J. Insect Physiol. 36: 877-884.

PASCUAL, N., MARCO, M.P. and Belles, X. 1990. Azadirachtin induced imaginal moult deficiencies in Tenebrio molitor L. (Coleoptera: Tenebrionidae). J. stored Prod. Res. 26:53-57.

RANGASWAMY, J.R. and SASIKALA, V.B. 1991. Sex pheromone properties of Z-2 nonenyl propionate isolated from virgin females of red flour beetle Tribolium castaneum (Coleoptera). Indian J. Exp. Biol. 29:263-266.

RANGASWAMY, J.R. and SASIKALA, V.B. 1991. Aggregation pheromone activity of compounds isolated from male red flour beetle Tribolium castaneum (Coleoptera: Tenebrionidae). Indian J. Exp. Biol. 29:52-55.

BIBLIOGRAPHY

14. SPACE AND AERIAL ECOLOGY

BIBLIOGRAPHY

15. SPECIATION

CREDLAND, P.F. and DENDY, J. 1991. Bruchids and legume seeds: adaptations and adaptability. Proceedinbgs of the Fifth International Working Conference of Stored-Product Protection, Vol I, 29-38.

GATEHOUSE, A.M.R., MINNEY, B.H.P., DOBIE, P. and HILDER, V. 1990. Biochemical resistance in bruchid attack in legume seeds: investigation and exploitation. pp.241-256. Om Bruchids and Legumes: Economics, Ecology and Co-evolution. Fujii, K. et al. (Eds,) The Hague: kluwer Academic Publishers.

BIBLIOGRAPHY

16. STATISTICAL METHODS AND MATHEMATICAL MODELS

PACK, S.E. and MORGAN, B.J.T. 1990. A MIXTURE MODEL FOR interval-censored time-to-response quantal assay data. Biometrics 46:749-758.

SUBRAMANYAN, B. and HAREIN, P.K. 1990. Accuracies and sample sizes associated with estimating densities of adult beetles (Coleoptera) caught in probe traps in stored barley. J. econ. Ent. 83:1102-1109.

BIBLIOGRAPHY

17. TAXONOMIC STUDIES.

HAINES, C.P., (ed.) 1991. Insects and Arachnids of Tropical Stored Products (A Training Manual). Chatham, UK: natural Resources Institute. 246 pp.

MACLACHLAN, W.B., and OLSON, C.A. 1990. A revision of the Trimytini of America North of Mexico. (Coleoptera: Tenebrionidae). The Coleopterists' Bull. 44:69-82.

MEDVEDEV, G.S. 1990. Review of darkling beetles of the genus Alcinoeta Strand (Coleoptera, Tenebrionidae). Entomol. Rev. 69: 15-19.

TRIPLEHORN, C.A. 1990. Review of the genus Corticeus (Coleoptera: Tenebrionidae) of America north of Mexico. Annals Ent. Soc. Amer. 83:287-306.

BIBLIOGRAPHY

18. TECHNIQUE

VIRKKI, N., MAZZELLA, C. AND DENTON, A. 1991. Silver staining of the coleopteran Xyp sex bivalent. Cytobios 67:45-63.

BIBLIOGRAPHY

19. TERATOLOGY

GEOGRAPHICAL DIRECTORY

GEOGRAPHICAL DIRECTORY

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

AUSTRALIA

+Brisbane, Queensland
Department of Primary Industries
Entomology Laboratory
Meirs Road, Indooroopilly

*Champ, B.R., B.Agr.Sc., Ph.D., D.I.C. Entomologist, storage pests, insecticide resistance. (7, 12)

Indooroopilly, Queensland, Australia
Queensland Department of Primary Industries
Entomology Branch

Bengston, M., M. Sc. Ph.d. Grain protectant insecticides
Collins, P. J., B.Sc., Ph.d. Insecticide resistance genetics, biochemistry, fitness, insecticide assay, resistance management, resistance monitoring, ecology.
White, G.G. B. Agr. Sc., Ph.D. Ecology, pest management

Melbourne, Victoria
Plant Research Institute
Department of Agriculture
Burnley, Victoria 3121

Braby, M.F. (8, 12, 18)
Williams, P., B.Sc., A.R.C.S., Ph.D., D.I.C., M.I. Biol. (8, 12, 18)

BANGLADESH

Rajshahi 6205
University of Rajshahi, Department of Zoology

Mahbub Hasan, M.D., Research Fellow
KHALEQUZZAMAN, M., Professor
KHAN, A.R.
Mondal, K.A.M. Shahadat Hossain, Ph. D.
RAHMAN, S.M.
SALEH REZA, A.M.

DIRECTORY - GEOGRAPHICAL

BELGIUM

Gembloux
Institut Agronomique de l'Etat
Zoologie Generale

Leclercq, Jean, Ph.D.

Ghent
Rijks Universiteit
Faculteit de Landbouwwetenschappen

Pelerents, C. (9)

+Louvain
F.A. Janssens Memorial Laboratory for Genetics
Agricultural Institute of the University
Heverlee, Louvain

*Lints, F.A., Ph.D. Premier Assistant U.C.S. Physiological genetics. (7)
Wattiaux, J.M., Ph.D. Charge de Recherches au F.N.R.S. Age effects. (13)

CANADA

Guelph, Ontario
Department of Animal and Poultry Science
Ontario Agriculture College
University of Guelph

Friars, G.W., Ph.D. Population genetics. (7)

+Cooperative Electron Microscopy:

Grinyer, I., Scientist. Department of Avian Pathology and Wildlife Diseases, University of Guelph. (4)

+Quebec
Universite Laval
Department de Biologie
Faculte des Sciences Pures

Benskin, J., Ph.D. Post-doctorat. Endocrinology. (13)
Chawla, S.S., Ph.D. Post-doctorat. Physiology. (13)
Corrivault, G.W., D.Sc. Professor. Histology (1)

DIRECTORY - GEOGRAPHICAL

Huot, L., D.Sc. Professor. Entomology and Physiology. (10, 13)
Perron, J.M., D.Sc. Professor. Entomology and physiology. (10, 13)

+Tunney's Pasture, Ottawa, Ontario
Department of National Health and Welfare
Food and Drug Directorate

Bray, D.F., Head. Biometrics Section. (16)

Saskatoon, Saskatchewan
University Campus
Research Station
Research Branch, Agriculture Canada

Davis, G.R.F., Ph.D. Insect nutrition and Biochemistry. (10, 13)

+Victoria, B.C.
Department of Forestry and Rural Development
Forest Research Laboratory

Atkins, M.D., Ph.D. Experimental Ecology. (5)
Chapman, J.A., Ph.D. Physiology and study of attractants. (Scolytid studies).
Edwards, D.K., Ph.D. Dispersal, survival and population dynamics. Periodic phenomena in insects. (5)
Mansingh, A., Ph.D. Nutritional Physiology. (10, 13)
McMullen, L.H., Ph.D. Douglas-fir beetle biology and control. Balsam Woolly Aphid, biology and life history. (12)
Morris, O.N., Ph.D. Insect Pathology. (13)
Sahota, T.S., Ph.D. Endocrinology. (13)
Sinha, R.N., Ph.D. Ecology. (5)
Smith, L.B., Ph.D. Ecology and Population dynamics. (5)
Watters, F.L., Ph.D. Insect control. (12)
Wellington, W.G., Ph.D. Experimental ecology. (5)

Winnipeg, Manitoba R3T 2M9
Agriculture Canada
Research Station
Stored Products Section
195 Dafoe Road

Loschiavo, S.R., Ph.D. Stored grain insect biology. Insect ethology and biology. (2, 5, 10, 12)
**Singh, N.B., Ph.D. Bioenergetics of storage insects, insect physiology. (12, 13)
Sinha, R.N., Ph.D. Ecology of granary insects, mites and fungi.

(5, 10, 12)
Smith, L.B., Ph.D. Stored product insect ecology, low temperature effects. (5, 7, 10, 12)
Watters, F.L., Ph.D. Storage pest control, behavior and control of stored product insects. (2, 8, 9, 12)

White, N.D.G., Ph.D.

* Research Associate
** Post-doctoral Fellow

CHINA, PEOPLE'S REPUBLIC OF

Beijing
Beijing Agricultural University
Department of Animal Science

Zhang, L. M.Sc. (7)
Zhang, Qineng B.Sc., Statistics
BAI, LIHUA, Technician
CHANG, CHUN. Graduate student

COLOMBIA

Bogota, D.E., Colombia, S.A.
Universidad Nacional
Depto. de Biologia
Apdo Aereo 23227

Nunez, F.

DENMARK

Lyngby
Statens Skadedyrlaboratorium

Borlund, H.P., Agronomist (Testing of insecticides).
Funder, J.V., Agronomist (Testing of insecticides).
Wichmand, H., Director.

EGYPT

Alexandria
Alexandria University
Faculty of Agriculture
Plant Protection Department

DIRECTORY - GEOGRAPHICAL

Khamis, Awatef E.

FRANCE

+Lyon, Rhone
Faculte des Sciences de Lyon
Laboratoire de Zoologie Generale
Section d'Entomonlogie Experimentale et de Genetique

David, J. Professeur. Nutrition and quant. genet. in Drosophila.

+Villeurbanne (Lyon) Rhone
Laboratoire de Biologie
Institut National des Sciences Appliquees

Laviolette, P. Professeur. Head of the department.

GERMANY

D 78 Freiburg i. Br.
Biologisches Institut I (Zoologie) der Universitat

Sander, Klaus, Dr. rer. nat. Ph.D.
Zissler, D. Dr. rer. nat.

Field of interest: 3, 4, 6, 7, 11

GREAT BRITAIN

+Glasgow, Scotland
Universtiy of Glasgow G12800
Department of Zoology

Crowson, R.A. (17) (Retired)

+Newcastle upon Tyne
The University of Newcastle upon Tyne, School of Agriculture

Bichard, M., Ph.D. Anima Genetics. (7)

Hughes, M.A., Ph.D. Genetics. (7)

Selman, B.J., Ph.D. Taxonomy of Coleoptera. Microbial parasites of Tribolium. (11, 17)

NORWICH, NR4 7TJ
University of East Anglia
School of Biological Sciences

Hewitt, G. M.

Juan, C.

Rubio, J. M.

Vazquez, P.

SLOUGH, BERKS.
ADAS Central Science Laboratory

Abraham, Mrs. L.	Hormones
Bell, Dr. C.H.	Non chemical control, fumigation, developmental biology
Cox, Dr. P.D.	Stored-product entomology
Edwards, Dr. J.P.	Hormones
Halstead, Dr. D.G.H.	Taxonomy, ecology, behavior (2, 5, 17) dynamics
Mills, Dr. K.A.	Fumigation, controlled atmospheres, genetics, mutants
Muggleton, Dr. J.	Insecticide resistance, population genetics
Price, Dr. N.R.	Insecticide biochemistry
Prickett, Dr. A.J.	Insecticides, resistance statistics (5, 7,
Spratt, Miss E.C.	Behavior, ecology.

CHATHAM, KENT, ME4 4TB, U.K.
Storage Department
Natural Resources Institute (NRI)
Central Ave.,
Chatham Maritime

Compton, J.A.F. B.Sc., MsC. Farm and village level storage management

Dick, K. B.Sc. PhD. Insect behavior and ecology (2,5) plant resistance

Donaldson, T. M.Phil. Farming systems, training, project management

Freeman, N. Biology and behavior of stored product pests.

Giles, P.H., B.Sc., D.I.C., Dip.Agric.Sci., M.I.Biol. Stored products technology. Biology and control of insect pests. (12)

Golob, P., B.Tech., Ph.D. Control of stored product pests, especially with insecticides. (8, 12, 18)

Gudrups, I. M.Sc. Biology and Behavior of stored products pests

Guy Poulter, R. B.Sc. PhD. F.I.F.S.T. Head of Department

Haines, C.P., B.Sc., Ph.D. Stored products entomology and acarology. Control by pheromones and natural predators. (2, 6, 12, 17)

Hodges, R.J., B.Sc., Ph.D. Stored products entomology. Control and inspection procedures using pheromones. (12)

McFarlane, J.A., B.Sc., D.I.C., M.I.Biol. Stored products technology. Biology and control of insect pests. (12)

Orchard, J. Ph. D. Biochemist, resistance of grains to insect attack.

Prevett, P.F., B.Sc., Ph.D., D.I.C., A.R.C.S., M.I. Biol. Deputy Head of Centre. Biology and control of storage insects. (6, 12, 17)

Rees, D.P. Post Harvest Pests and Quality Section.

INDIA

Coimbatore
Department of Entomology
Agricultural College and Research Institute

Balasubramanian M.

Sobramanian, T.R.

+Delhi
University of Delhi
Department of Zoology

Saxena, K.N., Senior Scientist (12, 13)

IRELAND

DIRECTORY - GEOGRAPHICAL

Dunsinea
Dublin County
Agricultural Institute

Cunningham, E.P.

Dublin
University College
Zoology Department

Ryan, Michael, Ph.D.

ISRAEL

Haifa
Institute of Evolution
University of Haifa

Lavie, B. Ph.D.

Jerusalem

Vision Research Laboratory
Hadassah University hospital

Yinon, U, Ph. D.

The Hebrew University of Jerusalem
Department of Genetics

Ritte, Uzi, Ph. D.

Tel-Aviv
Tel-Aviv University
Department of Zoology

Wool, David, Ph. D. (5, 7, 8)

Manheim, Ora. M.Sc. Technician

DIRECTORY - GEOGRAPHICAL

ITALY

Turin 10123
Universita di Torino
Via Academia Albertina

Robotti, C.A.

JAPAN

HIROSHIMA, HIGASHI-SENDA-MACHI, NAKA-KU 730
Hiroshima University
Faculty of Integrated Arts and Sciences
Department of Environmental Studies

Takahashi, F., Ph.D.

+INO, AGAWA-GUN KOCHI
Pref. Institute of Agricultural and Forest Science
Department of Entomology

Kiritani, K., D. Agr. Head, Population ecology (5)

MATSUMOTO CITY
Shinshu University
Faculty of Science
Department of Biology

Fujiyama, S.

OSAKA 530
Taijin Chemicals Ltd. Osaka
Ekimai Dai 1 Bldg.
3-1-700 Umeda, Chome, Kitoku

Masumune Yamamoto, Ph.D.

IBARAKI 305, TSUKUBA
University of Tsukuba
Institute of Biological Sciences

Fujii, Koichi, Professor, Ph. D. Population ecology of stored product insects

DIRECTORY - GEOGRAPHICAL

Nishimura, Kinya, Ph.D. Research Associate. Population ecology of parasitic wasps

IBARAKI 305
Kan -nondai, Tsukuba
National Food Research Institute
Stored Product Entomology Laboratory

Fujii, Hiroshi, Ph.D.

Imura, O. Ecology and Genetics

Mitsui, E. Ecology

Nakakita, H., Ph. D. Physiology and Fumigants

IBARAKI 305
Tsukuba Norindanchi, P.O. Box 5
National Institute of Animal Industry

Takebe, A., Ph.D.

+MISIMA, Shizuoka-ken
National Institute of Genetics

Yamada, Yukio, Ph. D. (7)

OKAYAMA
Okayama University
Faculty of Agriculture
Laboratory of Applied Entomology

Yoshida, T., Population ecology and biology of stored product insects (2,5,13)

YAMAGUCHI
Yamaguchi University
Biological Institute

Chiba, Yoshihiko

MEXICO

Mexico City 20, D. F.
Universidad Nacional Autonoma de Mexico, Instituto de Biologia
Departamento de Zoologia, Laboratorio de Entomologia

DIRECTORY - GEOGRAPHICAL

Ramos-Elorduy de Conconi, Julieta, Ph. D. (9)

NETHERLANDS

AMSTERDAM
Royal Tropical Institute
Department of Agricultural Research
Product Research Division
Entomology Section

Schulten, G.G.M., Ph.D. Entomologist, storage pests (12)

Klashorst, Van de, G., D.Sc. Assistant Entomologist, storage pests (12).

WAGENINGEN
Department of Genetics

Stam, P. (7,16)

NEW ZEALAND

AUCKLAND, Private Bag
Entomology Division
Department of Scientific and Industrial Research

Singh, Pritam, Ph. D. Rearing

Watt, J.C., Ph. D., Systematics (5, 17)

HAMILTON, Private Bag
Ruakura Agricultural Research Centre

Carter, A.H., M.A., ph. D., Leader of genetics section (7)

Clarke, J.H., m. Agr. Sci., Ph.D. Quantitative genetics and animal breeding (7).

Meyer, H.H. M.S. Ph.D. Quantitative genetics and animal breeding (7).

DIRECTORY - GEOGRAPHICAL

POLAND

30-060 KRAKOW
Institute of Environmental Biology
Jagiellonian University
M. Karasia 6.

Jasienski, M.

Korzeniak, U.

Korona, R.

Krawczyk, J.

Lomnicki, A.

Ombach, J.

WARSAW
Szkola Glowna Gospodarstwa Wiejskiego
Katedra Entomologii Stosowanej

Boczek, Jan Ph.D. (5,7,13)

05 092 Lomianki
Dziekanow Lesny near Warsaw
Institute of Ecology, Polish Academy of Sciences
Laboratory of Ecophysiology of Invertebrates
Tel. (48 22) 353046 Tlx 817378 Fax (48 22) 349100
Bijok, Pawel Ph.D. (5,7,13)

Prus, Miroslawa, Ph.D. (5,7,13)

Prus, Tadeusz,Assistant Professor, Laboratory head (5,7,13)

Macko, Anna, M. Sc. (5,7,13)

SPAIN

MADRID
Instituto Nacional de Investigationes Agronomicas
Laboratorio de Genetica de Poblaciones

*Barrera, Antonio; Prto. Agr. Population Genetics. (7)

Campo, Jose Luis; Dr. Ing. Agr. Population Genetics and Poultry Breeding. (7)

DIRECTORY - GEOGRAPHICAL

Carceles, Francisco; Prto. Agr. Poultry Breeding. (7)

*Diez-Barra, Rafael; Prto. Agr. Population Genetics. (7)

*Frias, Angel; Prto. Agr. Population Genetics. (7)

*Fuentes, Ma. Carmen; Dr. Ing. Agr. Population Genetics. (7)

*Jodar, Bartolome; Dr. Ing. Agr. Population Genetics. (7)

*Lopez-Fanjul, Carlos; Dr. Ing. Agr. and Ph.D. Popul. Genetics. (7)

*Orozco, Fernando; Dr. Ing. Agr. and Ph.D. Head of Department Population Genetics and Poultry Breeding. (7)

*Ruano, Ramiro G.; Dr. Veterinario. Population Genetics. (7)

*Silvela, Luis; Dr. Ing. Agr. and Ph.D. Population Genetics. (7)

*Tagarro, Ma. Pilar; Prto. Agr. Population Genetics. (7)

*Actually working with Tribolium.

+Madrid
Escuela Tecnica Superior de Ingenieros Agronomos
Catedra de Genetica

Espinos, A., Prof. Enc. Lab. Genetica General. (7)

Nuez, F., Prof. Enc. Lab. Mejora Genetica. (7)

PALMA DE MALLORCA 07071
Universitat de les Illes Balears
Departamento de Biologia Ambiental
Laboratorio de Genetica

Alvarez-Fuster, A.
Carreras, I.
Juan, C.
Petitpierre, E.

SWEDEN

S-223 62 LUND
Institute of Genetics
Solvegatan 29

Norsegaard, Rolf

DIRECTORY - GEOGRAPHICAL

UPPSALA
The Swedish University of Agricultural Sciences
Department of Plant and Forest Protection

Pettersson, Jan, Prof. of Agricultural Entomology

TAIWAN, REPUBLIC OF CHINA

WUFENG, TAIWAN
Plant Protection Center
Division of Entomology
189 Chung Cheng Road
Taichung Hsien, Taiwan 431

Hsieh, F.K. Ph.D. (12)

Hung, L.M. (Miss)

Kao, Suey-Sheng, Ph.D. (12)

Lin, T. (12)

TURKEY

ANKARA
Ankara Universitesi Zootekni Enstitusu Ziraat Fakultesi

Duzgunes, Orphan, Ph. D.

UNITED STATES

ARIZONA

TEMPE, Arizona
Arizona State University
Department of Zoology

Rasmussen, D. I., Ph.D. Associate Professor. Population Genetics
(7)

CALIFORNIA

+BERKELEY, CALIFORNIA 94720
University of California
Donner Radiation Laboratory

Graise, L.M.B.X.

Hayes, T.L., Ph.D. (4)

Yang, T.C.H., Ph.D., Radiation biophysics (9)

LOS ANGELES, California 90024
University of California Medical Center
Department of Medical Microbiology

Voge, Marietta (11)

NORTHRIDGE, California
San Fernando Valley State University
Department of Biology

Moore, Joseph, Ph.D. Associate Professor. (11)

SAN BERNARDINO, California 92407
California State University
School of Natural Sciences
Department of Biology

Brownlee, Aaron, M.S.

Henry-Ford, Darice, Student assistant

Mankau, Sarojam, Ph. D. (11)

Sokoloff, Alexander Ph. D. (5,7)

SANTA BARBARA, California 93103
Westmount College
995 La Paz Road

Percival, Frank

CONNECTICUT

+BRIDGEPORT, Connecticut
University of Bridgeport
Department of Biology

Raghuvir, N.N., Ph.D. Effects of ultraviolet on T. confusum

STORRS, CONNECTICUT
University of Connecticut
Department of Biology

Silander, John A., Ph.D.

FLORIDA

CORAL GABLES, Florida
University of Miami
Department of Biology
P.O. Box 249118

Rich, Earl R., Ph. D.

GAINESVILLE, Florida
U.S.D.A.
Biology Research Laboratory

Agee, H.R., Research Entomologist

Ashley, T.T., Asst. Prof., Univ. of Florida

Calkins, C.O., Research Entomologist

Callahan, P.S., Research Entomologist

Chambers, D.L., Research Entomologist-Laboratory Director

*Coffelt, J.A., Research Entomologist

Doolittle, R.E., Research Chemist

*Ferkovich, S.M., Research Entomologist

Greany, Ph.D., Asst. Prof., Univ. of Florida

*Hagstrum, D.W., Research Entomologist

Hamilton, E.W., Research Entomologist

Huettel, M.D., Asst. Prof., Univ of Florida

Leppla, N.C., Research Entomologist

*Marzke, F.O., Research Entomologist

Mayer, M.S., Research Entomologist

Mitchell, E.R., Research Entomologist

McLaughlin, J.R., Asst. Prof., Univ. of Florida

*Oberlander, H., Research Physiologist

Sharp, J.L., Asst. Prof., Univ. of Florida

Silhacek, D., Research Chemist

*Sower, L., Research Entomologist

Spencer, N.R., Research Entomologist

Stanley,J.M., Agricultural Engineer

Tingle, F.L., Research Entomologist

Tumlinson, J.H., Research Chemist

Turner, W.K., Agricultural Engineer

*Vick, K., Research Entomologist

Webb, J.C., Agricultural Engineer

*Working with stored products insects.

GEORGIA

DECATUR, Georgia
Agnes Scott College
Department of Biology

Wistrand, H. (5,7)

SAVANNAH, Georgia
U.S.D.A.
Stored Product Insects Research and Development Laboratory

Arbogast, Richard T., Ph.D. Population Dynamics of Stored-Product Insects.

Arthur, Franklin H. Ph. D. Insect pest management, Chemical Control, Insecticide Resistance

Baker, J.E., Ph.D. Physiology, Biochemistry, Nutrition, Ecology.

Brower, J.H., Ph.D. Biological control, Radiobiology, Genetics, Ecology.

Bruce, W.A., Ph.D. Acarology, Biological control, morphology.

Davis, Robert, Ph.D. Acarology, fumigation.

Halliday, W.R. Insecticide resistance, Toxicology, Insect Genetics.

Highland, H.A., Ph.D. Insect-resistant packaging.

Jay, E.G., Ph.D. Modified atmospheres.

Leesch, J.G., Ph.D. Fumigation.

Lum, P.T.M., Ph.D. Physiology, Biology.

Mullen, M.A., Ph.D. Insect resistant Packaging, Host Plant Resistance, Ecology, Biology

Simonaitis, R.A., Ph.D. Insecticide residues.

Su, H.C.F., Ph.D. Chemical constituents found in food stuffs.

Throne, J.E. Ecology and Population Dynamics, simulation modeling.

Zehner, J.M. Ph.D. Analytical Chemistry, Pesticide Residues.

Zettler, J.L., Ph.D. Pesticide Resistance, Insect Toxicology.

SAVANNAH, Georgia
Armstrong State College
Biology Department

Davenport, L.B., Jr., Ph.D. Head of Department.

IDAHO

+POCATELLO, Idaho
Idaho State University
Department of Biology

Minshall, G. Wayne (5)

ILLINOIS

CARBONDALE, Illinois 62901
Southern Illinois University at Carbondale

Department of Zoology

Englert, DuWayne C., Ph.D., Professor (5,6,7)

CHICAGO, Illinois
University of Illinois at Chicago Circle
Department of Biological Sciences

Goodnight, Charles J., Ph. D. Postdoctoral fellow

Mertz, David B., Ph.D. Professor. (5,7)

+CHICAGO, Illinois
University of Chicago
Department of Zoology

McCauley, David, Ph.D., Ecology, Population Ecology, Genetics and Phenotypic Variation (5,7)

Wade, Michael J., Ph.D. Ecology, Population Ecology, Genetics and Phenotypic Variation, Speciation (2, 5, 7)

URBANA, Illinois
University of Illinois
Department of Physiology and Biophysics

Ducoff, H.S., Ph.D., Professor, Radiation Biology, Experimental Gerontology (9,13)

Heath, M., Ph.D.; Physiological Ecology, Radiation Biology (5,9,13)

INDIANA

WEST LAFAYETTE, IN 47907
Purdue University
Department of Animal Sciences

Bell, A.E., Ph.D., Population and Quantitative Genetics (7)

Doolittle, D.P., Ph.D. Population and Quantitative Genetics (7)

Muir, W.M., Ph. D., Population and quantitative Genetics (7)

+MUNCIE, Indiana
Ball State University
Department of Physiology and Health Science

Henzlik, Raymond E., Ph.D. Radiation effects. (9)

+NOTRE DAME, Indiana
University of Notre Dame
Department of Biology

Ackerman, John. (5)

Bender, Harvey A., Ph.D. Genetics. (7)

Griffing, Thomas C., Ph.D. Ecology. (5)

IOWA

+AMES, Iowa
Iowa State University of Science and Technology
Department of Animal Science

*Freeman, A.D., Professor. (7)

KANSAS

MANHATTAN, Kansas
Kansas State University
Department of Entomology

Mills, Robert B., Ph.D. Associate Professor, Stored-product insects. (12)

Partida, Gregory J. Ph.D. Assistant Professor. (12)

Wright, Valerie, Ph. D.

MANHATTAN, Kansas 66502
U.S. grain Marketing Research Lab., ARS, USDA

Beeman, R. W., ph. D.

KENTUCKY

LEXINGTON, Kentucky
University of Kentucky
Department of Animal Science

Goodwill, Robert E., Ph.D., Population Genetics (7)

Green, Cynthia B., B.S., Graduate assistant
Department of Agronomy

Finkner, V.C.

Vian, W.E.

MARYLAND

+BELTSVILLE, Maryland
U.S.D.A.-A.R.S.
Animal Husbandry Research Division

Kinney, T.B., Jr., Ph.D., Population genetics (located at Lafayette, Indiana). (7)

Lepore, P.D., Ph.D. Biochemical genetics (7, 13)

Sarvella, P.A., PhD. Cytological genetics (4, 7)

Tindell, L.D., Ph.D. Population genetics (located at Athens, Ga.). (7)

MASSACHUSETTS

NORTON, Massachusetts
Wheaton College
Department of Biology

Keim, Barbara Howell (5)

+SOUTH LANCASTER, Massachusetts
Atlantic Union College
Department of Biology

Kissinger, D.G., Ph.D. Taxonomy, genetics and development of Curculionidae. (3,5,17)

DIRECTORY - GEOGRAPHICAL

MICHIGAN

ALMA, Michigan
Alma Collegete University
Biology Department

*Grimnes, Karen

MINNESOTA

ST. PAUL, Minnesota
University of Minnesota
Institute of Agriculture
Department of Entomology, Fisheries and Wildlife

Barak, A.V. Ph.D. Dermestid pheromones (2,5,7,12)

Dunkel, F.V. Ph.D. Insecticidal mode of action of food additives in stored grain insects and protozoan associates (1,3,4,11,13)

Harein, P.K., Ph.D. Stored product insect management; RPAR (5,12,13,18).

ST. PAUL, Minnesota
University of Minnesota
Department of Genetics and Cell Biology

Braskerud, Ove A. B.A. Associate Scientist (7)

Comstock, Ralph E. Ph.D. Professor (7)

Enfield, Franklin D. Professor (7)

MISSOURI

KIRKSVILLE, Missouri
N.E. Missouri State
Science Division

Bell, Max E., Ph.D. Ecology (5)

Hanks, David L., Ph.D. Microbiology (11)

Jay, Austin E., Ph.D. Physiology (13)

Shaddy, James H., Ph.D. Entomology (12)

DIRECTORY - GEOGRAPHICAL

MONTANA

BOZEMAN, Montana 59715
Montana State University
Animal and Range Sciences Department

Kress, D.D.

NEW JERSEY

MADISON, New Jersey
Fairleigh Dickinson University
Department of Biology

Huber, Ivan Ph.D. Population biology and systematics of cockroaches; Genetic control of the German cockroach. (1,5,7,17)

SOUTH ORANGE, New Jersey 07079
Seton Hall University
Department of Biology

Krause, Eliot Ph.D. Genetics and Population Genetics (7)

Kotin, Carol. Undergraduate. Behavioral Genetics

NEW YORK

ITHACA, New York
New York State College of Agriculture
Cornell University
Department of Animal Husbandry

Hogue, D.E., Ph.D. Nutrition (10)

Van Vleck, L.D.,Ph.D. Animal breeding (7)

+ITHACA, New York
New York State College of Agriculture
Cornell University

Knutson, Lloyd V., Ph.D.

Kramer, John P., Associate Professor. (11)

DIRECTORY - PERSONAL

+BENDER, H.A., University of Notre Dame, Notre Dame, Indiana. (7)

*Numbers in parenthesis indicate research specialties.

BENSKIN, J., Universite Laval, Quebec, Canada. (13)

BENSON, A.J., Southern Illinois University at Carbondale, Department of Zoology, Carbondale, Illinois. (6, 7)

BERNACKY, B.J., Purdue University, Department of Animal Sciences, West Lafayette, IN. (7)

BIJOK, Pawel, Inst. of Ecology, Dziekanow Lesny near Warsaw, 05-092 Lomianki, Poland

BINDRA, O.S., Department of Entomology, Punjab Agricultural University, Ludhiana, Punjab, India.

BLAKE, G.M., Pest Infestation Laboratory, Slough, Bucks, England. (13)

BLAKELY, W., Radiation biology; aging (9), University of Illinois at Urbana-Champaign. (9)

BOCZEK, J., Szkola Glowna Gospodarstwa Wiejskiego, Katedra Entomologii Stosowang, Warsaw, Poland.

BORLUNG, H.P., Statens Skadedyrlaboratorium Skovbrynet, Lyngby, Denmark. (8, 12)

+BOYER, JOHN F., Department of Biological Sciences, Union College, Schenectady, New York 12308

+BOYER, LESLIE S., Biological Sciences Department, California Polytechnic State, San Luis Obispo, California 93407.

BRINCKMAN, D., National Pest Control Association, 8150 Leesburg Pike, Suite 1100, Vienna VA 22180.

BROWER, J.H., Stored-Product Insects Research and Development Laboratory, Savannah, Georgia. (1, 9 12)

BROWN, A.W.A. Insecticide Research Institute, Michigan State University, E. Lansing, MI 48823.

BROWN, E.H., University of Illinois, Department of Genetics and Development, 515 Morrill Hall, Urbana, Illinois 61801.

BROWN, W.P., Marietta College, Marietta, Ohio 45750.

BRUCE, W.A., U.S. Department of Agricultural Research Service, Savannah, Georgia. (13)

DIRECTORY - PERSONAL

CALHOUN, R.E., Department of Biology, Queens College of the City University of New York, New York (Flushing) N.Y., 11367. (7, 15, 16)

CAMADRO, E.L., University Nacional de Mar Del Plata, Balcarce, Buenos Aires, Argentina. (7)

CAMPO, J.J., Instituto Nacional de Investigaciones Agronomicas, Madrid, Spain. (7)

CARBONELL, E., Instituto Nacional de Investigaciones Agronomicas, Madrid, Spain. (7)

CARCELES, F., Instituto Nacional de Investigaciones Agronomicas, Madrid, Spain. (7)

CARRERAS, I., Laboratorio de Genetica, Departamento de Biologia Ambiental, Universitat de les Illes Baleares, Palma de Mallorca 07071.

CHAHAL, B.S. Department of Entomolgy, Punjab Agricultural University, Punjab, Ludhiana -141004, India. (12)

+CHAMP, B.R., Department of Primary Industries, Entomology Laboratory, Meins Road, Indooroopilly, Brisbane, Queensland, Australia. (7, 11)

CHAPMAN, A.B., Department of Genetics, University of Wisconsin, Madison, Wisconsin.

CHAUDHARY, K.D., Universite Laval, Quebec, Canada. (10)

+CHAUDHRY, H.S., University of Gorakhpur, Gorakhpur, U.P., India. (3, 4, 13)

CHERKOVSKAYA, A., Ya. All-Union Grain and Grain Products Research Institute, Moscow, USSR.

CHIBA, Y. Biological Institute, Yamaguchi University, Yamaguchi, Japan.

CHITTY, J., Oregon State University, Dpartment of Zoology, Corvallis, Oregon. (2, 5, 7)

CLARKE, J.N., Ruakura Agricultural Research Centre, Private Bag, Hamilton, New Zealand. (7)

CLOVER, R., Cal State Long Beach, Biology Department, Long Beach, California 90804.

COHEN, E., Department of Zoology, Tel Aviv University, Israel. (12, 13)

CORRIVAULT, G.W., Department of Biology, Universite Laval,

Quebec, Canada. (10)

COSTANTINO, R.F., Department of Zoology, University of Rhode Island, Kingston, R.I., 02881. (7, 10).

+CRENSHAW, R.A., Zoology Department, University of Glasgow W2, U.K.

CROSSNER, K., Department of Biology, Seton Hall University, South Orange, New Jersey 07079.

CROWSON, R.A., University of Glasgow, Department of Zoology, Glasgow G12800, U.K..

+CUTLER, J.R., Agricultural Scientific Services, Department of Agriculture and Fisheries for Scotland Edinburgh, Scotland, Great Britain. (12)

DARMADJA, D., Fakultas, Kedoteran Hewan and Peternakan, Universitas Udayana, Denpasar, Bali, Indonesia. (7)

+DASGUPTA, J., Department of Biology, Jawaharlal Institute of Post-graduate Medical Education and Research, Pondicherry 605006, India.

+DAVENPORT, L.B., Armstrong State College, Savannah, Georgia.

+DAVID, J., Faculte des Sciences de Lyon, Lyon, Rhone, France. (7, 10)

DAVIS, G.R.F., Ph.D., Insect nutrition and biochemistry, Research Station, Research Branch, Agriculture Canada, University Campus Saskatoon, Saskatchewan. (3, 10)

DAWSON, P.S., Department of Zoology, Oregon State University, Corvallis, Oregon. (2, 5, 7)

DELGADO, M.A., Southern Illinois University at Carbondale, Department of Zoology, Carbondale, Illinois 62901. (5)

DEL SOLAR, E., Instituto de Ecologia, Universidad Austral de Chile, Casilla 57-D, Valdivia, Chile.

DETURCK, J.E., Cabrini College, King of Prussia Road, Radnor, PA 19087.

DEXTER, J., St. Anselm College, Department of Biology, St. Anselm Drive, Manchester, N.H. 03102.

DIEZ-BARRA, R., Instituto Nacional de Investigaciones Agronomicas, Madrid Spain (7).

DOOLITTLE, D.P., Ph.D., Department of Animal Sciences, Purdue University, West Lafayette, IN 47907

DIRECTORY - PERSONAL

DRICKAMER, L.C., Williams College, Thompson Biology Lab, Williamstown, MA. 01267.

DUCOFF, H.S., Ph.D., Department of Physiology and Biophysics and Bioengineering, University of Illinois, Urbana-Champaign, Illinois. (9, 13)

DUGGLEBY, W.F., State University of New York, Department of Biological Science, Buffalo, N.Y. 14214.

DUGUESCLIN, P.B., Victorian Plant Research Institute, Department of Agriculture, Burnley, Victoria, Australia. (6)

DUNKEL, F.V., University of Minnesota, Department of Entomology, Fisheries and Wildlife, St. Paul, Minnesota.

DYTE, C.E., Pest Infestation Control Laboratory, Slough, Bucks, England. (5, 7, 8)

EDONGALI, H., Al Fateh University, P.O. Box 13274, Tripoli, Libya.

ELORDUY DE CONCONI, J.R., Instituto de Biologia UNAM, Laboratorio de Biologia UNAM, apdo. Postal 70-153, Mexico 20, D.F.

+ENFIELD, F.D., Department of Animal Husbandry, University of St. Paul, Minnesota. (7)

ENGLERT, D.C., Department of Zoology, Southern Illinois University, Carbondale, Illinois. (5, 6, 7)

+ESPINOS, A., Escuela Tecnica Superior de Ingenieros Agronomos, Valencia, Spain. (7)

FAIRFULL, R.W., Department of Animal Science, University of Guelph, Guelph, Ontario, Canada. (7)

FAUSTINI, D.L. Ph.D. Philip Morris Research Center, P.O. Box 26583, Richmond VA, 23261.

FERNS, P.N., Department of Zoology, University College, Cardiff, Wales, U.K.

FINKNER, V.C., Department of Animal Sciences, University of Kentucky, Lexington, Kentucky.

FREEMAN, J.E.., Iowa State University of Science and Technology, Ames, Iowa. (7)

FREEMAN, J.A., Pest Infestation Laboratory, Slough, Bucks, England. (12)

DIRECTORY - PERSONAL

FRIARS, G.W., Ontario Agricultural College, Department of Poultry Science, Guelph, Ontario, Canada. (7)

FRIAS, A., Instituto Nacional de Investigaciones Agronomicas, Madrid, Spain.

FUENTES, Ma. C., Inst. Nacional de Investigaciones Agronomicas, Madrid, Spain. (7)

FUJII, H. Stored Product Entomology Laboratory, National Food Research Institute, Kan-nondai, Tsukuba, Ibaraki 305, Japan.

FUJII, K., University of Tsukuba, Institute of Biological Science, Sakura-Mura, Ibaraki, 300-31, Japan.

FUJIYAMA, S., department of Biology, Faculty of Science, Shinshu University, Matsumoto City, Japan

GALLEGO, A., Instituto Nacional de Investigaciones Agrarias, Dept. de Genetica, Avda. Puerta de Hierro, S/N, Madrid, Spain.

GALLEGO-DIAZ, J., Instituto Nacional de Investigaciones Agronomicas, Madrid, Spain. (7)

GERBER, G.H., Canada Department of Agriculture, Research Station, Winnipeg, Manitoba.

GERDY, J., Department of Biology, Benison University, Granville, Ohio 43023.

GINGRICH, J., U.S. Army Natick Laboratories, Natick, Massachusetts.

GOLD, P., Health Sciences; State University of New York, Buffalo, N.Y. 14214.

GOLEBIOWSKA, ZOFIA, Plant Protection Institute, Poznan, Poland.

GOLOB, P., Ministry of Overseas Development., Tropical Stored Products Centre (TPI) Slough, Berks., England. (8, 12, 18)

GOMEZ B.R., Instituto de Nutricion de Centro America y Panama. Guatemala, Guatemala, C.A.

GOODNIGHT, CHARLES J. Department of Zoology, University of Vermont, Burlington, Vermont 05405-0086.

GOODWILL, ROBERT, University of Kentucky, Lexington, Kentucky 40506. (7)

GOUGH, M.C., Ministry of Overseas Development, Troical Stored

Products Centre (TPI) Slough, Berks., England. (6, 18)

GREEN, C.B., University of Kentucky, College of Agriculture, Department of Animal Sciences, Lexington, Kentucky.

GRIFFING, T.C., University of Notre Dame, Notre Dame, Indiana. (5)

GRIMNES, KAREN, biology Department, Alma College, Alma, MI 48801

GRINYER, I., University of Guelph, Guelph, Ontario, Canada. (4)

GROSSMAN, M., Ph.D., Department of Dairy Science, University of Illinois, Urbana, Illinois. (7, 16)

+GRUNDMANN, A.W., University of Utah, Salt Lake City, Utah. (3)

GUTHRIE, P., Dept. of Biology Central State University, Edmond, Oklahoma 73034.

HAGSTRUM, D.W., Insect Attractants, Behavior and Basic Biology Research Laboratory, ARS, USDA, Gainesville, Florida. (5)

HAINES, C.P., Ministry of Overseas Development, Tropical Stored Products Centre (TPI) Slough, Berks., England. (2, 6, 12 17)

+HALL, D.W., Tropical Stored Products Centre, Slough, Bucks, England. (5, 12)

HALLIHAN, M., University of Chicago, Department of Biology, Chicago, Illinois 60637.

HALSTEAD, D.G.H., Pest Infestation Laboratory, Slough, Bucks., England. (5,12,17).

HAMALAINEN, M.K., Institute of Pest Investigation, Agricultural Research, Box 18, SF-01301 Vantaa 30, Finland

HANES, D., Facultad de Veterinaria, Catedra de Genetica, Cordoba, Spain.

HANKS, D.L., N.E. Missouri State College, Kirksville, Missouri, 63501. (11)

DIRECTORY - PERSONAL

HAREIN, P.K., University of Minnesota, Department of Entomology, Fisheries, and Wildlife, St. Paul, Minnesota. (5, 12, 13)

HARRIS, D.L. Department of Animal Sciences, Purdue University, Lafayette, Indiana 4797. (7)

HEATH, M., Ph.D., University of Illinois, Department of Physiology and Biophysics, Urbana, Illinois. (5, 13, 17)

HEWITT, G.M. school of Biological Sciences, University of East Anglia, Norwich NR4 7TJ, great Britain.

HOLM, E., University of Pretoria, Department of Entomology, Pretoria 0002, South Africa.

HOPKINS, T.L., Kansas State University, Department of Entomology, Manhattan, Kansas.

HOWE, R.W., Pest Infestation Laboratory, Slough, Bucks, England. (5, 12) (Emeritus)

HSIEH, F.K., Division of Entomology, Plant Protection Center, Taiwan.

HUBER, I., Ph.D., Department of Biology, Fairleigh Dickinson University, Madison, New Jersey. (1, 4, 7, 17 -- all of these with special reference to cockroaches.)

HUGHES, A.M., Pest Infestation Laboratory, Slough, Bucks, England.

HUOT, L., Universite Laval, Quebec, Canada. (10)

IMURA, O., National Food Research Institute, Stored Product Entomology Laboratory, Tsukuba, Japan

JASIENSKI, M. Institute of Environmental Biology, Jagiellonian University, M. Karasia 6, 30-060 Krakow, Poland

JAY, A.E., N.E. Missouri State College, Kirksville, Missouri 63501. (13)

JAY, E.G., U.S.D.A., A.R.S., Savannah, Georgia 31401.

JAYASINGH, D.B., Ministry of Industry and Communication, Storage and Infestation Division, 20 Hope Road, Kingston 10, Jamaica, W.I..

JILLSON, D.A., Ph.D., Visiting Assistant Professor, Population Biology Department of Zoology, University of Vermont, Burlington Vermont.

JOHANNSEN, I., Royal Agricultural College, Uppsala 7, Sweden.

DIRECTORY - PERSONAL

JOHNSON, G., Department of Biology Sciences California State University, Hayward, California.

JUAN, C. Laboratorio de Genetica, Departamento de Biologia Ambiental, Universitat de les Illes Balears, Palma de Mallorca 07071, Spain.

KALTHOFF, K., Ph.D., University of Texas, Department of Zoology, Austin, Texas 78712.

KANDASAMY, S., Tamil Nadu Agri. Univ., Dept. of Entomology, Madurai-625104 India.

KANGAS, D.E., N.E. Missouri State College, Kirksville, Missouri. (5)

KANNOWSKI, P.B., Ph.D., Pheromones and behavior, Institute for Ecological Studies, University of North Dakota, Grand Forks, North Dakota 58202. (2, 5, 13)

KATZ, F.F., Seton Hall University, South Orange, New Jersey. (11).

KELLY, R.P., St. Peter's College, Department of Biology, Kennedy Blvd., Jersey City, N.J. 7300.

KHALEQUZZAMAN, M. Ph. D. Zoology Department, Rajshahi University, Rajshahi, Bangladesh.

KHAN, A.R. Zoology Department, Rajshahi University, Rajshahi, Bangladesh.

KINKADE, M.L., N.E. Louisiana Univ., Dept. of Biology, Monroe, Louisiana 71209.

KIRITANI, K., Prefectural Institute of Agricultural and Forest Science, Oosone, Nangoku, Kochi, Japan (5, 12)

KISSINGER, D.G., Atlantic Union College, South Lancaster, Massachusetts. (3, 7, 17)

KORONA, R. Institute of Environmental Entomology, Jagiellonian University, M. Karasia 6, 30-060 Krakow, Poland (5)

KORZENIAK, U. Institute of Environmental Entomology, Jagiellonian University, M. Karasia, 30-060 Krakow, Poland (5)

KOTAKI, TOYOMI, Stored Product Entomology Laboratory, National Food Research Institute, Tsukuba, Ibaraki 305, Japan.

KRAWCZYK, J. INSTITUTE OF environmental Entomology, Jagiellonian University, M. Karasia 6, 30-060 Krakow, Poland (5)

DIRECTORY - PERSONAL

+KRAMER, J.P., Department of Parasitology, Cornell Univ., Ithaca, New York (11)

KRAMER, K.J., Department of Entomology, Kansas State University, Manhattan, Kansas.

KRAUSE, E., Seton Hall University, South Orange, New Jersey. (7)

KRESS, D.D, Animal and Range Sciences Department Montana State University, Bozeman, MT 59715.

KRICHER, V.C., Wheaton College, Norton, Massachusetts 02766.

KUMAR, S.A., University of Gorakhpur, Gorakhpur, India.

LANG, D., University of Illinois at Chicago Circle, Department of Biological Sciences, Chicago, Illinois.

LANGHOLFF, W.K., Purdue University, Department of Animal Sciences, West Lafayette, IN 47907. (7)

LAVIE, B., University of Haifa, Institute of Evolution, Haifa, Israel.

LECLERCQ, J., Zoologie Generale, Institut Agronomique de l'Etat, Gembloux, Belgium.

LEACH, C.E., Insect Attractants, Behavior and Basic Biology Research Laboratory, A.R.S., U.S.D.A., Gainesville, Florida 32601.

LEE, Y.J., University of Illinois, Department of Physiology and Biophysics, Urbana, Illinois. (9)

LEESCH, J.G., U.S. Department of Agriculture, Agricultural Research Service. Savannah, Georgia. (8, 13)

LEROI, B.R., Universite F. Rabelais, Avenue Monge, Parc Grandmont, 37200 Tours (France).

LEVAN, A., Institute of Genetics, Solvegatou 29, S-223 62 Lund, Sweden.

LINTS, F.A., Janssens Memorial Laboratory for Genetics. Heverlee, Louvain, Belgium.

LIPA, J.J., Institut Ochrony Roslin, Miezurina 20, Poznan, Poland 60-318.

LISTOV, M.V., S.M. Kirov Military Medical Academy, Leningrad, U.S.S.R.

DIRECTORY - PERSONAL

LOHS-SCHARDIN, M. Biologisches Institut I (Zoologie) der Universitat Freiburg i. Br. D 78 Germany.

LOMNICKI, A. institute of Environmental Biology, Jagiellonia University, M. Karasia 6, 30-060, Krakow, poland

LOOKJART, G.L., Kansas State University, Department of Entomology, Manhattan, Kansas.

+LOSCHIAVO, S.R., Canada Department of Agriculture, Research Station, Winnipeg, Manitoba, Canada. (5, 10, 12) (Ret.)

MANKAU, S.K., California State College at San Bernardino, San Bernardino, California 92407. (11)

MARGHAM, J.P., Liverpool Polytechnic, Department of Biology, Liverpool L33AF, England.

MARINI, L., Department of Biology, Faculty of Science, Gilan University, Rasht, Iran.

MATIN, A., Irradiation and Pest Control Research Institute, c/o Atomic Energy Center, Dacca, Bangladesh.

MAYES, P.A., Muscatine Community College, 152 Colorado Street, Muscatine, Iowa 52761.

MACCAULEY, D., Department of Zoology, University of Chicago, Chicago, Illinois 60037.

+MCDONALD, D.J., Dickinson College, Carlisle, Pennsylvania. (5, 7)

MCRAE, T.A., University of New England, Department of Animal Science, Armidale, New South Wales 2351. (5, 7, 10)

MEDLINGER, S., Tel-Aviv University, Department of Zoology, Tel Aviv, Israel.

MERTZ, D.B., University of Illinois, Chicago, Illinois 60680. (5)

MEYER, H.H., Ruakura Agricultural Research Centre, Private Bag, Hamilton, New Zealand.

MILES, D.A., Purdue University, Department of Animal Sciences, West Lafayette, IN 47907. (7)

MILLER, S.A. The School of the Ozarks, Biology Department, Point Lookout, Missouri 65726

+MILLS, R.B., Kansas State University, Manhattan Kansas. (5, 12)

+MINSHALL, G.W., Idaho State University, Pocatello, Idaho.

DIRECTORY - PERSONAL

MINVIELLE, F., Universite Laval, Zootechnie, Quebec, Canada.

MITSUI, E., National Food Research Institute, Stored Product Entomology Laboratory, Tsukuba, Japan.

MOCK, O.B., N.E., Missouri State College, Kirksville, Missouri 63501. (13)

MONDAL, K.A.M.S.H. Department of Zoology, University of Rajshahi, Rajshahi, Bangladesh.

MOORE, J., San Fernando Valley State College, Northridge, California. (11)

MORGAN, T.D., Kansas State University, Department of Entomology, Manhattan, Kansas.

MUIR, W.M., Department of Dairy Science, University of Illinois, Urbana, Illinois, 61801.

MULLEN, M.A., U.S. Department of Agriculture, Agricultural Research Service, Savannah, Georgia. (5, 12)

MURRAY, J.J., University of Virginia, Charlottesville, VA. (5, 7)

NAITO, M., Laboratory of Animal Breeding, Tokyo University, Tokyo, Japan.

NAKAKITA, H., National Tropical Agricultural Research Center Tsukuba, Ibaraki 305, Japan.

NAKANE, T., The National Science Museum, Veno Park, Tokyo, Japan.

NARDON, P., Institut National des Sciences Appliquees, Villeurbanne (Rhone), France.

+NATON, E., Bayer, Landesanstalt f. Bodenkultur, Pflanzenbau u. Pflanzenschutz, Pflanzenschutz, 8 Munich 38 Postfach, Germany. (5, 10, 12)

NEW, J.H., Minister of Overseas Development, Tropical Stored Products Centre (TPI) Slough Berks., England. (6, 12)

NORRIS, D.M., Department of Entomology, University of Wisconsin, Madison, Wisconsin 53706.

NORSEGAARD, r. Institute of Genetics, Solvegatan 29, S-233 62 Lund, Sweden.

NUNEZ, F., Dept. de Biologia, U.N., Apdo Aereo 23227, Bogota,

DIRECTORY - PERSONAL

D.E., Colombia, S.A..

O'BRIAN, D.M., Seton Hall University, South Orange, New Jersey 07079.

OKA, H., National Institute of Genetics, Misima City 411, Japan.

OKURA, E., Okayama University, Laboratory of Genetics, Okayama, Japan.

OLKOWSKI, W., John Muir Institute, 1307 Acton Street, Berkeley, California 94706.

OMBACH, J. Institute of Environmental Biology, Jagiellonian Univerisity, M. Karasia 6, 30-060, Krakow, Poland.

ORCHARD, J. Ph. D. Grain Technology Department, Natural Resources Institute (NRI), Central Avenue, Chatham Maritime, Chatham, Kent ME4 4TB, UK.

OROZCO, F., Inst. Nacional de Investigaciones, Departamento de Genetica, Avda. Puerta de Hierro, Madrid-3, Spain.

PARTIDA, G.J., Kansas State University, Manhattan, Kansas. (12)

PETERSON, L., Rio Hondo College, Biology Department, 3600 Workman Mill Road, Whittier, California 90608.

PELERENTS, C., Faculteit De Landbouwwetenschappe, Rijks Universiteit, Ghent, Belgium.

PERCIVAL, F., Westmount College, 995 La Paz Road, Santa Barbara, California 93103.

PEREIRA, C., Purdue Univeristy, Dept of Entomology, West Lafayette, In 47907

PETITPIERRE, E. Dept. of Genetics, Faculty of Sciences, departamento de Biologia Ambiental, Universitat de les Illes Baleares, Palma de Mallorca, 07071, Spain

PIERANTONI, ROGERO, Director, Laboratory of Biophysics and Cybernetics, National Research Center, Camugli, Italy.

POLESKI, D., St. Anselms College, Biology Department, St. Anselms Drive, Manchester, N.H. 03102.

POPOV, V.V., Institute of Applied Molecular Biology and Genetics, 23 Vuchetich St., Moscow, 125206, U.S.S.R..

POST, D., University of Wisconsin, Biology Department, Stevenspoint, Wisconsin 54481.

PRANATA, R.I., Seameo Regional Center for Tropical Biology,

Bogor, Indonesia.

PREVETT, P.F., Tropical Stored Products Centre, Slough, Bucks, England. (5, 12)

PRUS, T., Institute of Ecology, Dziekanow Lesny, 05-150 Lomianki, Poland.

PUGH, J.B., Southern Illinois University at Carbondale, Carbondale, Illinois.

QUINTANILHA, A., Laboratorio de Biologia, Universidade de Maputo, Maputo, Mozambique.

RABINDRA, R.J., Agricultural College and Research Institute, Coimbatore, India 641003.

RAHOO, G.M., Sind Agricultural College, Tandojam, Pakistan.

RAHMAN, S.M. Department of Zoology, Rajshahi University, Rajshahi, Bangladesh.

RAISBECK, B., U.S. Army Natick Laboratories, Natick, Mass.

RAMIREZ, M., Instituto de Biologia, UNAM, departamento de Zoologia, Apdo Postal 70-153, Mexico 20, D.F.

DIRECTORY - PERSONAL

RAMOS-ELORDUY DE CONCONI, J., Laboratorio de Entomologia, Departamento de Zoologia, Instituto de Biologia, Universidad Nacional de Mexico, Mexico 20, D.F., Mexico. (9,10)

RASMUSSEN, D.I., Department of Zoology, Arizona State University, Tempe, Arizona. (5)

REES, D.P. Grain Technology Department, Natural Resources Institute (NRI), Central Ave., Chatham Maritime, Chatham, Kent ME 4 4TB, Uk.

RESSEGUIE, L.M., Department of Biology, Beloit College, Beloit, Wisconsin 53511.

RICH, E.R., University of Miami, Department of Biology, P.O. Box 249118, Coral Gables, Florida 33124 (2, 5, 7, 9, 13).

RITTE, U., Department of Genetics, The Hebrew University of Jerusalem, Israel

+ROBINSON, R., Bibliography Center, Ealing, London, England.

ROBOTTI, C.A., Universita di Torino, Via Academia Albertina Turin 10123, Italy.

RODRIGUEZ, P., University of Texas, San Antonio, Texas 78285.

ROLLING, W.C., University of Caifornia, College of Agriculture, Department of Animal Husbandry, Davis, California 95616.

ROSEBERRY, D.A., N.E. Missouri, Kirksville, Missouri 63501. (5)

ROSELAND, C.R., Kansas State University, Department of Entomology, Manhattan, Kansas.

ROSS, M.H., Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061.

ROY, D., University of Kalnany, Distr of Nadga, W. Bengal, India 741235.

ROY, P., Bidhan Chandra Krishi Viswa Vidyals, Department of Agricultural Entomology, Kalyani 741235 (West Bengal), India.

ROZOK, M., Polish Acad. Science, Krakow, 26.1X.87, Poland.

RUANO, R.G., Instituto Nacional de Investigaciones Agronomicas, Madrid, Spain. (5, 7)

+RUMBALL, W., Department of Scientific and Industrial Research, Palmerston North, New Zealand. (5, 7)

DIRECTORY - PERSONAL

RYAN, M., Zoology Department, University College, Dublin, Ireland.

SANCHEZ-MONGE, E., Escuela Tecnica Superior de Ingenieros Agronomos, Madrid, Spain. (7)

SANDER, K., Biologisches Institut I (Zoologie) des Universitat. Freiburg, Germany. (3, 4, 6, 7, 11)

SAUER, D.B., Plant Pathology, U.S., Grain Marketing Research Laboratory, A.R.S., U.S.D.A., Manhattan, Kansas 66502.

SELLIN, L., Seton Hall University, South Orange, New Jersey 07079.

SELLS, G.D., N.E. Missouri State College, Kirksville, Missouri 63501. (13)

SHADDY, J.H., Northeastern Missouri State College, Kinsville, Missouri. (12)

SHELBY, C.E., Stored Products Research and Development Laboratory, Savannah, GA 31403.

SHRIVASTAVA, P.N., Agricultural University, Jabalpur, Madhya Pradesh, India. (7)

SILANDER, J., The University of Connecticut, Biological Sciences, Box U42, Storrs, Connecticut 06268.

SILVELA, L., Instituto Nacional de Invetigaciones Agronomicas, Madrid, Spain. (7)

SIMONAITIS, R.A., U.S. Department of Agriculture, Agricultural Research Service, Savannah, Georgia. (8, 13)

SINGH, N.B., Canada Deparment of Agriculture, Research Station, Winnipeg, Manitoba, Canada. (5, 12, 13)

SINGH, P., Department of Scientific and Industrial Research Entomology Division, Auckland, New Zealand. (5, 12)

SINGH, R.N., University of Gorakhpur, Department of Zoology, Gorakhpur, U.P., India. (2, 13)

SINHA, R.N., Canada Department of Agriculture, Research Station, Winnipeg, Manitoba, Canada. (5, 10, 11, 12, 13)

SLATER, J.V., S.U.N.Y., Department of Biology, New Paltz, NY 12561.

SMITH, P.D., University of Georgia, Athens, Georgia 30602.

SOBRAMANIAN, T.R., Department of Entomology, Agricultural

College and Research Institute, Coimbatore, India 641003.

SOKOLOFF, A., California State University San Bernardino, California. (2, 5, 7, 10, 11, 13, 19)

+SONLEITNER, F.J., University of Oklahoma, Department of Zoology, Norman, Oklahoma. (5, 16)

SOOMRO, B.A., Sind Agricultural College, Tandojam, Pakistan.

SPRATT, E.C., Pest Infestation Control Laboratory, Slough, Berks, England.

STAM, P., Department of Genetics. Wageningen (The Netherlands). (7, 16)

+STANLEY, M.S.M., George Mason College, Fairfax, Virginia. (3)

SU, H.C.F., U.S. Department of Agriculture, Agricultural Research Service, Savannah, Georgia. (13)

SVERDLOV, E., Tel Aviv University, Tel Aviv, Israel. (7)

TAGARRO, M.P., Instituto Nacional de Investigaciones Agronomicas, Madrid, Spain. (7)

TAKAHASHI, F., Hiroshima University, Faculty of Integrated Arts and Sciences, Higashi-Senda-Machi, Naka-Ku, Hiroshima 730, Japan.

TAKEBE, A., National Institute of Animal Industry, Tsukuba Norindanchi, P.O. Box 5, Ibaraki 305, Japan

THOMAS, I., Pest Infestation Laboratory, Slough, Bucks, England.

TORO, M.A., Instituto Nacional de Investigaciones Agrarias, Departamento do Genetica, Carretera de la Coruna KM. 7, Madrid-35, Spain.

+TSCHINKEL, W., Biology Department, University of Florida, Tallahassie, Florida.
13)

VATTI, K.V., Leningrad State University, Department of Genetics, Leningrad 199164, U.S.S.R..

VEA, E.V., Deparment of Entomolgy, Fisheries and Wildlife, University of Minnesota, St. Paul, Minnesota 55101. (7)

VIAN, W.E., University of Kentucky, College of Agriculture, Department of Animal Sciences, Lexington, Kentucky.

DIRECTORY - PERSONAL

VICK, K.W., Insect Attractants, Behavior and Basic Biology Research Laboratory, A.R.S, U.S.D.A., Gainesville, Florida 32601.

VILLENEUVE, J.L., Universite Laval, Quebec, Canada. (10)

VIRKKI, N., Agricultural Experiment Station, Department of Crop Protection, Rio Piedras, Puerto Rico 00928.

VOGE, M., Department of Medical Microbiology, University of California Medical Center, Los Angeles, California 90024.

VON DE KLASHORT, G., Koninklijk Institut Voor De Trupen, Amsterdam-Oost, The Netherlands.

WADE, M., Department of Zoology, University of Chicago, Chicago, Illinois 60637.

WANNA, S., M.S., Radiation biology; mathematical biology. University of Illinois at Urbana-Champaign. (9, 16)

WARTOMO, H., Fakultas Peternakan, Universitas Hadja Mada, Yogyakarata, Indonesia.

WASSERMAN, S.S., University of Virginia, Biology Department, Charlottesville, VA. 22901.

WATTERS, F.L., Canada Department of Agriculture, Winnipeg, Manitoba. (7, 12)

WATT, J.C., Entomology Division (17). D.S.I.R. Auckland, New Zealand. (17)

WEBLEY, D.J., Ministry of Overseas Development, Tropical Stored Products Centre (TPI) Slough, Berks., England. (8, 12)

WEIDNER, H., Zoologisches Institut und Zoologisches Museum der Universitat, Hamburg, Germany.

WEIJER, J., University of Alberta, Edmonton, Alberta, Canada. (9)

WELDMAN, H., Zoologisches Institute, Zoologisches Museum der Universitat, Hamburg, Germany.

WELSH, G., Donner Laboratory and Lawrence Radiation Laboratory, University of California, Berkeley, California. (9)

WELSH, J.F., Humboldt State University, Arcata, California 95521.

WILLIAMS, P., Department of Agriculture, Victorian Plant Research Institute, Burnley, Victoria, Australia.

(8, 12, 18)

WILSON, S.P., Purdue University, Population Genetics Institute, Lafayette, Indiana. (7)

WISTRAND, H., Agnes Scott College, Decatur, Georgia. (5, 7)

WOOL, D., Tel-Aviv University, Department of Zoology, Tel-Aviv, Israel. (5, 7)

WRIGHT, V.F., Department of Entomology, Kansas State University, Manhattan, Ks.

YAMAMOTO, Masumune, Ph.D., Taijin Chemicals Ltd. Osaka, ekimai Dai 1 bldg., 3-1-700 Umeda, 1 Chome, Kita-ku, Osaka 530, Japan.

YANG, T.C, University of California, Donner Radiation Laboratory, Berkeley, California. (9)

YAO, K., Central China College of Agriculture, Plant Protection Department, Wuhang, Hupei, China.

YEE, Y.J., University of Illinois, Department of Physiology and Biophysics, Urbana, Illinois.

YINON, U., Vision Research Laboratory, Hadassah University Hospital, Israel, Jerusalem.

YOSHIDA, T., Okayama University, Okayama, Japan. (5, 12)

YOUNG, A.M., Milwaukee Public Museum, 300 West Wells Street, Milwaukee, WI 53233.

ZEHNER, J.M., U.S. Department of Agriculture, Agricultural Research Service, Savannah, Georgia. (8, 13)

ZETTLER, J.L., U.S. Department of Agriculture, Agricultural Research Service, Savannah, Georgia. (8, 13)

ZISSLER, D., Biologisches Institut I (Zoologie) der Universitat Freiburg i. Br. Germany. (3, 4, 6, 7, 11)