TRIBOLIUM INFORMATION BULLETIN

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EDITOR: ALEXANDER SOKOLOFF

PROFESSOR EMERITUS

BIOLOGY DEPARTMENT

CALIFORNIA STATE UNIVERSITY

SAN BERNARDINO, CA 92407

TELEPHONE (909) 880-5305. EXT 5407

NOTE

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From the Editor's desk:

I have received preliminary announcements of the following meetings:

1. CAF INTERNATIONAL CONFERENCE ON CONTROLLED ATMOSPHERE AND FUMIGATION IN STORED PRODUCTS

   NICOSIA, CYPRUS, April 21-26, 1996.

   For further information contact:

   Dr. Andreas Varnava
   Secretary of the Organizing Committee
   Cyprus grain Commission
   P.O. BOX 1777
   Nicosia, Cyprus

* * *

2,

2. XX INTERNATIONAL CONGRESS OF ENTOMOLOGY

Apis mellifera ligustica Spinola
Francesco Stelluti 1625
XX I.C.E. - FIRENZE 1996

Firenze, Italy, August 25 - 31, 1996

SECOND ANNOUNCEMENT

IMPORTANT DATES

Abstract receipt deadline	January 31, 1996
Early Registration	January 31, 1996
Hotel Reservation	April 30, 1996
Registration	July 15, 1996 (Thereafter on-site registration only)

Organizing Secretariat

O.I.C. srl
Via A. La Marmora, 24
50121 Firenze, Italy
Tel. +39/55/50.00.631
Fax +39/55/50.01.912

Scientific Secretariat

Prof. Augusto Vigna Taglianti
Dip. Biologia Animale e dell'Uomo (Zoologia)
Viale dell'Università, 32
00185 Roma, Italy
Tel. +39/6/49.91.47.42 or 44.57.120
Fax +39/6/49.58.259

STOCK LISTS

Stock Lists

BURLINGTON, NORTH CAROLINA
CAROLINA BIOLOGICAL SUPPLY COMPANY

Tribolium castaneum

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

Tribolium confusum

1. Wild

(Ed.).

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

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

L. Stevens

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

Tribolium castaneum

I. Wild type strains

1. Purdue + Foundation

II. Mutant strains

1. antennapedia (ap)

D.C. Englert

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

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

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

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

Michael J. Wade Norman T. Johnson

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. castaneum - Chicago black-- Sokoloff
T. castaneum - dark sooty (Sokoloff)
T. castaneum - Charcoal--Sokoloff

Earl R. Rich

Stock Lists

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

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

(Ed.).

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

Tribolium castaneum

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

Tribolium confusum

Chicago	Park 1955
black	via San Bernardino
pearl	via San Bernardino

Tribolium madens via San Bernardino

Tribolium brevicornis via San Bernardino

(Ed.).

LAFAYETTE, INDIANA 47907
PURDUE UNIVERSITY
ANIMAL SCIENCES DEPARTMENT

Tribolium castaneum

I. Wild type strains

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

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

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

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

W.M. MUIR

LEXINGTON, KENTUCKY
UNIVERSITY OF KENTUCKY
AGRICULTURAL EXPERIMENT STATION

I. Base populations

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

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

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

4. C Davis, 1976

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

(Ed.).

MANHATTAN, KANSAS
KANSAS STATE UNIVERSITY
DEPARTMENT OF ENTOMOLOGY

LEPIDOPTERA

Phycitidae: Cadra cautella and Plodia interpunctella

Gelechiidae: wild and red eyed strains.

Pyralidae: Corcyra cephalonica

COLEOPTERA

Anobiidae: Lasioderma serricorne and Stegobium paniceum

Bostrichidae: Rhyzopertha dominica

Bruchidae: Callosobruchus maculatus

Cucujidae; Cryptolestes ferrugineus, C. pusillus,

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

Dermestidae: Trogoderma inclusum, Attagenus megatoma

Ostomatidae: Tenebroides mauritanicus

Ptinidae: Gibbium psylloides

Silvanidae: Ahasverus advena, Oryzaephilus surinamensis, O. mercator

Tenebrionidae:

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

Valerie Wright

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

Tribolium castaneum

I. Insecticide-resitant strains

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

II. Mutant strains

(see next pages)

R. W. Beeman Laboratory August 12, 1994 Manhattan, Kansas

Mutant	Full Name or description	Link. Group	Stocks	Source
1S65	Crossover supressor	2;9	1S65/mas,p	Manhattan
3P1	crossover supressor	3	3P1/au14	Purdue
3P2	crossover supressor	3	3P2/au14, 3P2/X(ab-2s)	Purdue
A(Ag1),Stm	abdominal (fr. Ag), cis Stm	2	A(Ag1), Stm /ptlD60	Manhattan
A(Ag2)	abdominal (from Ag)	2	A(Ag2)/Ey	Manhattan
A(mc)	abdominal (from mc)	2	A(mc),p/Stm,Cx5	Manhattan
A10	Abdominal 10	2	A10 / Ey	Manhattan
A10	Abdominal 10	2	A10,mxpA10/Utx1,mxp,apt	Manhattan
A10,mxpA10	Abdominal 10, mxp fr. A10	2	A10,mxpA10/Utx1,mxp,apt	Manhattan
A12	Abdominal 12	2	A12/Ey	Manhattan
A15, Stm	Abdominal 15, Stm cis	2	A15,Stm/Ey	Manhattan
A20 Rdiel	Dieldrin resistant	2	A20 Rdiel	Unknown
A4	Abdominal 4	2	A4/Stm,Cx5	Manhattan
A8	Abdominal 8	2	A8/Stm,Cx5	Manhattan
ab	antenna bifurcada	9	ab,pas30,p	Bogota, Colombia
ab	antenna bifurcada	9	ub,ab	Bogota, Colombia
ab	antenna bifurcada	9	ab/ab	Bogota, Colombia
ab	antenna bifurcada	9	ue,ab,msg,p,mxp,apt,pas30	Bogota, Colombia
AD100,Stm,Cx5	Notched gena,Stm,Cx5 (cis)	2	AD100,Stm,Cx5/Es1	Manhattan
Ag	Antennagalea	2	Ag/Es1	Manhattan
Ag	Antennagalea	2	Ag/mxpNG	Manhattan
Ag+RptlD1	Ag revertant-dominant ptl	2	Ag+RptlD1/Es1	Manhattan
Ag2, Stm	Antennagalea 2, Stm (cis)	2	Ag2,Stm/Ey	Manhattan
Ag5, Stm	Antennagalea 5, Stm (cis)	2	Ag5,Stm/Es1	Manhattan
AgPin	Antennagalea (Pinhead)	2	AgPin/Stm,Cx5	Manhattan
Ah	Arrowhead	8	Ah	Purdue
ap	antennapedia	8	b, ap	San Bernadino
ap	antennapedia	8	Bald,ap,sq1/ap,sq1	San Bernadino
ap	antennapedia	8	Bald,ap,sq2/ap,sq2	San Bernadino
ap	antennapedia	8	MMS (s.c,ap,au,mas)	San Bernadino
ap(psi)	ap(pleurosternal sutures incompl.	8	ap(psi)	Manhattan
Apl	Antennapalpus	2	Apl, apt, ub	Manhattan
Apl	Antennapalpus	2	Apl,apt,mas,pas	Manhattan
Apl	Antennapalpus	2	Apl/Apl	Manhattan
apt	alate prothorax	2	apt, mas, p	Manhattan
apt	alate prothorax	2	apt, pas	San Bernadino
apt	alate prothorax	2	b, apt, sa, c	San Bernadino
apt	alate prothorax	2	ba,mxp,apt,pas30	San Bernadino
apt	alate prothorax	2	Quad(mxp,apt,mas,pas	San Bernadino
apt	alate prothorax	2	quint	San Bernadino
apt	alate prothorax	2	s,h,b(t),mxp,apt,pas30	San Bernadino
apt	alate prothorax	2	s,h,j2,mxp,apt,pas30	San Bernadino
apt	alate prothorax	2	Utx1,mxp,apt/mxpX9,Es1	San Bernadino
apt	alate prothorax	2	s,j,b(t),mxp,apt,pas30,h	San Bernadino
au	aureate	3	au	San Bernadino
au	aureate	3	b(t),p,lod,au,msg	San Bernadino
au	aureate	3	au,lod isoline (JS)	San Bernadino
au	aureate	3	mas, p,au	San Bernadino
au	aureate	3	MMS (s.c,ap,au,mas)	San Bernadino
au14	aureate 14, lethal	3	3P1/au14, 3P2/au14	Purdue
b	black body color	3	b	San Bernadino
b	black body color	3	b, ap	San Bernadino
b	black body color	3	b, apt, sa, c	San Bernadino
b(ST)	black, dominant	3	Chr/b(ST)	Manhattan
b(t)	tawny body color	3	b(t)	San Bernadino
b(t)	tawny body color	3	b(t),p,lod,au,msg	San Bernadino
b(t)	tawny body color	3	s,h,b(t),mxp,apt,pas30	San Bernadino
b(t)	tawny body color	3	s,j,b(t),mxp,apt,pas30,h	San Bernadino
ba	broken antennae	2	ba, pas30	Manhattan
ba	broken antennae	2	ba, pas30	Manhattan
Bald	Bald (reduced setiferous pits)	8	Bald	Manhattan
Bald	Bald (reduced setiferous pits)	8	Bald,ap,sq1/ap,sq1	Manhattan

Stock Lists

R. W. Beeman Laboratory August 12, 1994 Manhattan, Kansas

Bald	Bald (reduced setiferous pits)	8	Bald,ap,sq2/ap,sq2	Manhattan
Bamp14	Blunt anterior metastern. projection '	3	Bamp14	Manhattan
Bamp27	Blunt anterior metastern. projection :	3	Bamp27	Manhattan
Bamp27,au	Blunt anterior metastern. projection 2	3	Bamp27,au/au	Manhattan
Bamp29	Blunt anterior metastern. projection :	3	Bamp29	Manhattan
Bamp31	Blunt anterior metastern. projection :	3	Bamp31/+	Manhattan
Bamp31	Blunt anterior metastern. projection :	3	Bamp31/Chr	Manhattan
Bamp58	Blunt anterior metastern. projection !	3	Bamp58	Manhattan
BampSp	Blunt anterior metastern. projection f	3	BampSp	Manhattan
Be	Bar eye	4	Be	San Bernadino
Be	Bar eye	4	Be, s	San Bernadino
box	box (abdominal)	2	box / Es	Manhattan
c	chestnut eye	7	b, apt, sa, c	San Bernadino
c	chestnut eye	7	sa,c	San Bernadino
c	chestnut eye	7	MMS (s.c,ap,au,mas)	San Bernadino
Cg	Cleft gular (sutures)	?	Cg	Manhattan
Chr	Charcoal body color	3	Bamp31/Chr	San Bernadino
Chr	Charcoal body color	3	Chr	San Bernadino
Chr	Charcoal body color	3	Chr/b(ST)	San Bernadino
ChrE	Charcoal (Elytra indented)	3	ChrE	Manhattan
co	cola body color	9	co,p	Manhattan
co	cola body color	9	Se,co	Manhattan
co	cola body color	9	Se,co,p	Manhattan
Crab	Crab (warped legs)	7	Crab	Manhattan
Crab	Crab (warped legs)	7	Crab,s	Manhattan
Crab	Crab (warped legs)	7	Crab/PL4	Manhattan
CTC 12 Rabon R	Rabon resistant	?	CTC 12 Rabon R	Australia
Cv	Cross-veined elytra	?	Cv	Purdue
Cx20	Cephalothorax 20	2	Cx20/Es1	Manhattan
Cx6	Cephalothorax 6	2	Cx6/Es1	Manhattan
Dch1	Dachshund 1	2;9	Dch1/Es1	San Bernadino
Dch13,Stm	Dachshund 13, Stm (cis)	2	Dch13,Stm/Es1	Manhattan
Dch4	Dachshund 4	2	Dch4 / Es	Manhattan
Det43	Divergent elytral tips	4;5	Det43,h,s/Es,h,s	Manhattan
Det43	Divergent elytral tips	4;5	Det43/Es1	Manhattan
Df(Dch1)	Deficiency (from Dch1)	2	Df(Dch1)/Ey	Manhattan
Df(Lu)/Df(Lu)	Deficiency (from Lu)	2?	Df(Lu)/Df(Lu)	Manhattan
Df1-3/Ey	Deficiency	2	Df1-3/Ey	Manhattan
Df1-5/Ey	Deficiency	2	Df1-5/Ey	Manhattan
Dp	Duplication (from Dch1)	2	Dp/Es1/A10	Manhattan
Dp	Duplication (from Dch1)	2	Dp/Es1/Df(Dch)	Manhattan
Dp	Duplication (from Dch1)	2	Dp/Es1/Df1-3	Manhattan
Dp	Duplication (from Dch1)	2	Dp/Es1/pas30	Manhattan
Dp	Duplication (from Dch1)	2	Dp/Ey/Ey	Manhattan
Dp	Duplication (from Dch1)	2	Dp/Stm,ptlD57/pas30	Manhattan
DpLu	Duplication (from Lu)	2	DpLu/Ey	Manhattan
DpSpa	Duplication (from Spa)	2	DpSpa/Es1/pas30	Manhattan
Ds	Displaced sternellum	4	Ds/Spa (no Medea)	Manhattan
ds(euD)	displaced sternellum (from euD)	?	ds(euD)	Manhattan
ds-X	displaced sternellum, x-linked	4?;X	ds-X	Manhattan
dve(mas,pas)	divergent elytra (from mas,pas stock	?	dve(mas,pas)	Manhattan
Em,A16s	Enlarged mentum, abdominal (cis)	2	Em,A16s/Stb	Manhattan
Er	Eye reduced	2	Er	Manhattan
Er	Eye reduced	2	Er,quint	Manhattan
Er	Eye reduced	2	Er,ub	Manhattan
Es	Extra sclerite (abdominal)	2;4	AD100,Stm,Cx5/Es1	Manhattan
Es	Extra sclerite (abdominal)	2;4	Ag+RptlD1/Es1	Manhattan
Es	Extra sclerite (abdominal)	2;4	Ag/Es1	Manhattan
Es	Extra sclerite (abdominal)	2;4	Ag5,Stm/Es1	Manhattan
Es	Extra sclerite (abdominal)	2;4	box / Es	Manhattan
Es	Extra sclerite (abdominal)	2;4	Cx20/Es1	Manhattan
Es	Extra sclerite (abdominal)	2;4	Cx6/Es1	Manhattan
Es	Extra sclerite (abdominal)	2;4	Dch1/Es1	Manhattan

Es	Extra sclerite (abdominal)	2;4	Dch13,Stm/Es1	Manhattan
Es	Extra sclerite (abdominal)	2;4	Det43/Es	Manhattan
Es	Extra sclerite (abdominal)	2;4	Dp/Es1/A10	Manhattan
Es	Extra sclerite (abdominal)	2;4	Dp/Es1/Df(Dch)	Manhattan
Es	Extra sclerite (abdominal)	2;4	Dp/Es1/Df1-3	Manhattan
Es	Extra sclerite (abdominal)	2;4	Dp/Es1/pas30	Manhattan
Es	Extra sclerite (abdominal)	2;4	DpSpa/Es1/pas30	Manhattan
Es	Extra sclerite (abdominal)	2;4	Es/tr	Manhattan
Es	Extra sclerite (abdominal)	2;4	Ey/Es1	Manhattan
Es	Extra sclerite (abdominal)	2;4	g/Es	Manhattan
Es	Extra sclerite (abdominal)	2;4	lp69/Es1	Manhattan
Es	Extra sclerite (abdominal)	2;4	Spa/Es1	Manhattan
Es	Extra sclerite (abdominal)	2;4	Stb,Df(mas)/Es	Manhattan
Es	Extra sclerite (abdominal)	2;4	Stb/Es1	Manhattan
Es	Extra sclerite (abdominal)	2;4	Stbd/Es1	Manhattan
Es	Extra sclerite (abdominal)	2;4	Stm+RSptlD/Es1	Manhattan
Es	Extra sclerite (abdominal)	2;4	Stm,Ag4/Es	Manhattan
Es	Extra sclerite (abdominal)	2;4	Stm,Cx5/Es1	Manhattan
Es	Extra sclerite (abdominal)	2;4	Stm,Ns/Es1	Manhattan
Es	Extra sclerite (abdominal)	2;4	Stm-Es1/+NDJ	Manhattan
Es	Extra sclerite (abdominal)	2;4	Stm-Skl4-Es/+ NDJ	Manhattan
Es	Extra sclerite (abdominal)	2;4	StmR1/Es1	Manhattan
Es	Extra sclerite (abdominal)	2;4	StmR2/Es1	Manhattan
Es	Extra sclerite (abdominal)	2;4	StmR5/Es1	Manhattan
Es	Extra sclerite (abdominal)	2;4	StmR6/Es1	Manhattan
Es	Extra sclerite (abdominal)	2;4	Utx1,mxp,apt/mxpX9,Es1	Manhattan
Es	Extra sclerite (abdominal)	2;4	Utx1/Es	Manhattan
Es	Extra sclerite (abdominal)	2;4	vwe/Es	Manhattan
Es(Skl6)	Extra sclerite (from Skl6)	2	Es(Skl6)	Manhattan
Es1+R1/Stm	Extra sclerite revertant 1	2	Es1+R1/Stm	Manhattan
Es1+R9/Ey	Extra sclerite revertant 9	2	Es1+R9/Ey	Manhattan
Es2/Ey	Extra sclerite 2	2	Es2/Ey	Manhattan
Es3/Ey	Extra sclerite 3	2	Es3/Ey	Manhattan
eu	extra urogomphi	2	eu	San Bernadino
eu	extra urogomphi	2	eu, apt, mas	San Bernadino
eu	extra urogomphi	2	eu, mas	San Bernadino
eu	extra urogomphi	2	eu, mas, pas	San Bernadino
euD	Extra urogomphi (Abd B)	2	euD	Manhattan
Ey	eyeless	2;5	A(Ag2)/Ey	Manhattan
Ey	eyeless	2;5	A10 / Ey	Manhattan
Ey	eyeless	2;5	A12/Ey	Manhattan
Ey	eyeless	2;5	A15,Stm/Ey	Manhattan
Ey	eyeless	2;5	Ag2,Stm/Ey	Manhattan
Ey	eyeless	2;5	Dch3 / Ey	Manhattan
Ey	eyeless	2;5	Df(Dch1)/Ey	Manhattan
Ey	eyeless	2;5	Df(Lu)/Df(Lu)	Manhattan
Ey	eyeless	2;5	Df1-3/Ey	Manhattan
Ey	eyeless	2;5	DpLu/Ey	Manhattan
Ey	eyeless	2;5	Ey/Es1	Manhattan
Ey	eyeless	2;5	Lu,Skl6/Ey	Manhattan
Ey	eyeless	2;5	ptlD16,Stm/Ey	Manhattan
Ey	eyeless	2;5	Mcs1R1/Ey	Manhattan
Ey	eyeless	2;5	Mcs1R2/Ey	Manhattan
Ey	eyeless	2;5	Mcs1R5/Ey	Manhattan
Ey	eyeless	2;5	mxpD1,Skl6/Ey	Manhattan
Ey	eyeless	2;5	mxpX9,Es1/Ey	Manhattan
Ey	eyeless	2;5	Df1-5/Ey	Manhattan
Ey	eyeless	2;5	ptlD57,Stm/Ey	Manhattan
Ey	eyeless	2;5	ptlD60/Ey	Manhattan
Ey	eyeless	2;5	Skl4/Ey	Manhattan
Ey	eyeless	2;5	Skl4R1/Ey	Manhattan

R. W. Beeman Laboratory August 12, 1994 Manhattan, Kansas

Ey	eyeless	2;5	Skl4R2/Ey	Manhattan
Ey	eyeless	2;5	Stm,Cx5/Ey,A14	Manhattan
Ey	eyeless	2;5	Stm,Cx5/Ey; s/s	Manhattan
Ey,A14	Eyeless, Abdominal 14 (cis)	2	Stm,Cx5/Ey,A14	Manhattan
Ey-Lethal-Free	lethal free from Eyless	NA	Ey-Lethal-Free	Manhattan
fs(sa)	short antennae, female sterile	?	fs(sa)	Manhattan
Fta	Fused tarsi and antennae	?	Fta	San Bernadino
g	glossy	2	g	Manhattan
g	glossy	2	g/Dch3	Manhattan
g	glossy	2	g/Es	Manhattan
Ga-1	Georgia 1, wild type	NA	Ga-1	Georgia
Ga-1	Georgia 1, wild type	NA	Ga-9s	Georgia
Gi	Giant (body size)	NA	Gi	San Bernadino
Go	Goliath (body size)	7	Go	Manhattan
h	hazel eye	4	Det43/Es	San Bernadino
h	hazel eye	4	h, s	San Bernadino
h	hazel eye	4	s,h,b(t),mxp,apt,pas30	San Bernadino
h	hazel eye	4	s,h,j2,mxp,apt,pas30	San Bernadino
Hw	Hairy wing	2	Hw/Es,mxpX9	Manhattan
Hw	Hairy wing	2	Hw/Stm,Cx5	Manhattan
is	incomplete sternellum	?	is	Manhattan
j1	jet, body color	5	j,mc	San Bernadino
j1	jet, body color	5	rb,j	San Bernadino
j1	jet, body color	5	s,j,b(t),mxp,apt,pas30,h	San Bernadino
j2	jet, body color	5	j2	Cedar Rapids
j2	jet, body color	5	s,h,j2,mxp,apt,pas30	Cedar Rapids
ju	juvenile urogomphi	4?	ju,ptl	Manhattan
Lab-S Rusty	Lab strain, rusty, wild-type	NA	Lab-S Rusty	Manhattan
LF-3 (JS)	Lethal free	3	LF-3 (JS)	Purdue
lod	light optical diaphragm	3	au,lod isoline (JS)	San Bernadino
lod	light optical diaphragm	3	b(t),p,lod,au,msg	San Bernadino
lp69	labiopedia 69	2	lp69/Es1	Manhattan
lp69	labiopedia 69	2	lp69/Utx1,mxp,apt	Manhattan
Lu	Lucifer (dorsal head horns)	2	Lu / Stm,Cx5	Manhattan
Lu	Lucifer (dorsal head horns)	2	Lu,Skl6/Ey	Manhattan
Lu	Lucifer (dorsal head horns)	2	Lu,Skl6/Stb	Manhattan
Lu	Lucifer (dorsal head horns)	2	Lu/Stbd	Manhattan
m.l. 9.14	(Male linked)	2	9.14 (male linked)	Manhattan
M1	Medea 1	3	M1 - iso 3B1 (G)	Manhattan
M1	Medea 1	3	M1 isoline (JS)	Manhattan
M1	Medea 1	3	M1,au,M3	Manhattan
M1	Medea 1	3	M1,au,p,lod	Manhattan
M1	Medea 1	3	M1,b	Manhattan
M1	Medea 1	3	M1/M1, Bamp27	Manhattan
M3	Medea 3	3	M3,au	Manhattan
M3	Medea 3	3	M1,au,M3	Manhattan
mas	missing abdominal sternite	2	1S65/mas,p	San Bernadino
mas	missing abdominal sternite	2	apt, mas, p	San Bernadino
mas	missing abdominal sternite	2	mas	San Bernadino
mas	missing abdominal sternite	2	mas, p,au	San Bernadino
mas	missing abdominal sternite	2	mas, pas	San Bernadino
mas	missing abdominal sternite	2	ptl, mas, pas	San Bernadino
mas	missing abdominal sternite	2	Quad(mxp,apt,mas,pas	San Bernadino
mas	missing abdominal sternite	2	quint	San Bernadino
mas	missing abdominal sternite	2	MMS (s,c,mas,ap,au)	San Bernadino
mas2	missing abdominal sternite 2	2 ?	mas2	Manhattan
mc	microcephalic	5	j,mc	San Bernadino
mc	microcephalic	5	mc,rb,j	San Bernadino
mc	microcephalic	5	mc,j	San Bernadino
mc(eg)	microcephalic (eye growth)	5	mc(eg),p,lod	San Bernadino
Mc-2,Utx1	Microcephalic-2,Ultrathorax(cis)	2	Mc-2,Utx1/mxpNG	Manhattan
Mcs1	Miscadestral sclerite	2	Mcs1/Stm	Manhattan
Mcs1R1	Miscadestral sclerite, revertant 1	2	Mcs1R1/Ey	Manhattan

Mcs1R2	Miscadestral sclerite, revertant 2	2	Mcs1R2/Ey	Manhattan
Mcs1R4	Miscadestral sclerite, revertant 4	2	Mcs1R4/mxpNG	Manhattan
Mcs1R5	Miscadestral sclerite, revertant 5	2	Mcs1R5/Ey	Manhattan
Mo	Micro opthalmic	6	Mo	San Bernadino
msg	melanotic stink gland	?	b(t),p,lod,au,msg	San Bernadino
msg	melanotic stink gland	?	msg, pas	San Bernadino
msg	melanotic stink gland	?	ue,ab,msg,p,mxp,apt,pas30	San Bernadino
mt	melanotic tumors	?	mt	San Bernadino
mxp	maxillopedia	2	ba,mxp,apt,pas30	San Bernadino
mxp	maxillopedia	2	mxp, apt	San Bernadino
mxp	maxillopedia	2	mxp, apt, pas30	San Bernadino
mxp	maxillopedia	2	mxp, mas	San Bernadino
mxp	maxillopedia	2	ptl, mxp	San Bernadino
mxp	maxillopedia	2	A10,mxpA10/Utx1,mxp,apt	San Bernadino
mxp	maxillopedia	2	Quad(mxp,apt,mas,pas	San Bernadino
mxp	maxillopedia	2	quint	San Bernadino
mxp	maxillopedia	2	s,h,b(t),mxp,apt,pas30	San Bernadino
mxp	maxillopedia	2	s,h,j2,mxp,apt,pas30	San Bernadino
mxp	maxillopedia	2	s,j,b(t),mxp,apt,pas30,h	San Bernadino
mxp	maxillopedia	2	Utx1,mxp,apt/mxpX9,Es1	San Bernadino
mxp(Dch3)	maxillopedia dauchshund 3	2	X-31 pearl s.l./Dch3	Manhattan
mxp(Dch3)	maxillopedia dauchshund 3	2	X-31/Dch3	Manhattan
mxp(Dch3)	maxillopedia dauchshund 3	2	Dch3 / Ey	Manhattan
mxp(Dch3)	maxillopedia dauchshund 3	2	Dch3/X(ab-1s)	Manhattan
mxp(Dch3)	maxillopedia dauchshund 3	2	g/Dch3	Manhattan
mxp(Df1-3)	maxillopedia (from deficiency)	2	mxp(Df1-3)/Es	Manhattan
mxp170	maxillopedia 170, lethal	2	mxp170/Es1	Manhattan
mxp19	maxillopedia 19, lethal	2	mxp19/Es1	Manhattan
mxp8	maxillopedia 8, lethal	2	mxp8/Es1	Manhattan
mxpD1,Skl6/Ey	Maxillopedia, dom. 1, Skl6 (cis)	2	mxpD1,Skl6/Ey	Manhattan
mxpNG	maxillopedia, Notched Gena, lethal	2	mxpNG/Es1	Manhattan
mxpNG	maxillopedia, Notched gena	2	Ag/mxpNG	Manhattan
mxpNG	maxillopedia, Notched gena	2	Mc-2,Utx1/mxpNG	Manhattan
mxpNG	maxillopedia, Notched gena	2	Mcs1R4/mxpNG	Manhattan
mxpX9, Es	lethal maxillopedia, Es (cis)	2;4	Utx1,mxp,apt/mxpX9,Es1	Manhattan
mxpX9, Es	lethal maxillopedia, Es (cis)	2;4	mxpX9,Es1/Ey	Manhattan
mxpX9, Es	lethal maxillopedia, Es (cis)	2;4	Hw/Es,mxpX9	Manhattan
mxpX9,Es1/Ey	maxillopedia X9, lethal, Es (cis)	2;4	mxpX9,Es1/Ey	Manhattan
NDG-2 (#59)	Wild-type	NA	NDG-2 (#59)	Manitoba
p	pearl eye	9	1S65/mas,p	San Bernadino
p	pearl eye	9	ab,pas30,p	San Bernadino
p	pearl eye	9	apt, mas, p	San Bernadino
p	pearl eye	9	mas, p,au	San Bernadino
p	pearl eye	9	Se,co,p	San Bernadino
p	pearl eye	9	Se,p	San Bernadino
pas	pointed abdominal sternite	2	apt, pas	San Bernadino
pas	pointed abdominal sternite	2	ptl, mas, pas	San Bernadino
pas	pointed abdominal sternite	2	mas, pas	San Bernadino
pas	pointed abdominal sternite	2	Quad(mxp,apt,mas,pas	San Bernadino
pas	pointed abdominal sternite	2	quint	San Bernadino
pas30	pointed abdominal sternite 30	2	ab,pas30,p	Manhattan
pas30	pointed abdominal sternite 30	2	ba,mxp,apt,pas30	Manhattan
pas30	pointed abdominal sternite 30	2	s,h,b(t),mxp,apt,pas30	Manhattan
pas30	pointed abdominal sternite 30	2	s,h,j2,mxp,apt,pas30	Manhattan
pas30	pointed abdominal sternite 30	2	s,j,b(t),mxp,apt,pas30,h	Manhattan
pas30	pointed abdominal sternite 30	2	ub,pas30	Manhattan
pas30	pointed abdominal sternite 30	2	ue,ab,msg,p,mxp,apt,pas30	Manhattan
pd	paddle antenna	X	py, pd, plt	San Bernadino
PL4	Pseudo Linker 4	7;2	Crab/PL4	Manhattan
plt	platinum eye	X	py, pd, plt	San Bernadino
pnk (NDG-2)	pink eye, from NDG-2	?	pnk (NDG-2)	Manhattan
Ps	Pinched sternellum	2	Ps	San Bernadino
ptl	prothoraxless	2	ju,ptl	San Bernadino

R. W. Beeman Laboratory August 12, 1994 Manhattan, Kansas

ptl	prothoraxless	2	ptl	San Bernadino
ptl	prothoraxless	2	ptl, mas, pas	San Bernadino
ptl	prothoraxless	2	ptl, mxp	San Bernadino
ptlD16,Stm	Dom. prothoraxless 16, Stm (cis)	2	ptlD16,Stm/Ey	Manhattan
ptlD2	Dom. prothoraxless 2	2	ptlD2/Stb	Manhattan
ptlD26Y	Dom. prothoraxless 26, Y-linked	2;Y	ptlD26Y	Manhattan
ptlD57,Stm	Dom. prothoraxless 57, Stm (cis)	2	ptlD57,Stm/Ey	Manhattan
ptlD60	dominant prothoraxless 60	2	A(Ag1), Stm /ptlD60	Manhattan
ptlD60	dominant prothoraxless 60	2	ptlD60/Ey	Manhattan
py	pygmy	X	py, pd, plt	San Bernadino
py	pygmy	X	py, ser	San Bernadino
Pyr-R	Pyrethroid resistant	9	co,Pyr-R	Peter Collins
QTC 279 (Pyr-R)	Pyrethroid resistant	9?	QTC 279 (Pyr-R)	Peter Collins
Rap	Recurved anterior pronotum	2	Rap	Manhattan
rb	ruby eye	5	mc,rb,j	San Bernadino
rb	ruby eye	5	rb,j	San Bernadino
Rd	Reindeer, homozygous viable	2	Rd/Rd	Dawson
Rd	Reindeer, homozygous viable	2	Rd, mas, p	Dawson
Rd	Reindeer, homozygous viable	2	Rd,mc,p	Dawson
Rd	Reindeer, homozygous viable	2	Rd,pas30	Dawson
Rd(CS)	Reindeer, crossover suppressor	2	Ps/Rd(CS)	Manhattan
Rdiel BC9 Lab-S	Dieldrin resistant from Lab-S	NA	Rdiel BC9 Lab-S	Unknown
Rmal-2 (Cogburn)	Malation resistant	NA	Rmal-2 (Cogburn)	Texas
Russell 1 BC4s	spontaneous sooty ?	NA	Russell 1 BC4s	Russell, KS
Russell 2 BC4s	spontaneous sooty ?	NA	Russell 2 BC4s	Russell, KS
s	sooty	4	Crab,s	San Bernadino
s	sooty	4	s	San Bernadino
s	sooty	4	Det43,h,s/Es,h,s	San Bernadino
s	sooty	4	h, s	San Bernadino
s	sooty	4	s,h,b(t),mxp,apt,pas30	San Bernadino
s	sooty	4	s,h,j2,mxp,apt,pas30	San Bernadino
s	sooty	4	s,j,b(t),mxp,apt,pas30,h	San Bernadino
s	sooty	4	Be, s	San Bernadino
s	sooty	4	Ga-9s	San Bernadino
s	sooty	4	MMS (s.c.ap,au,mas)	San Bernadino
sa	short antenna	?	b, apt, sa, c	San Bernadino
sa	short antenna	?	sa,c	San Bernadino
Sa-8	Short antenna-8	?	Sa-8	Manhattan
sa-X	short antenna, X-linked	X	sa-X	Manhattan
Se	Short elytra	9	Se	Manhattan
Se	Short elytra	9	Se,co,p	Manhattan
Se	Short elytra	9	Se,p	Manhattan
se 46	short elytra 46	?	se 46	Purdue
Se-2	Short elytra 2	8	Se-2	Manhattan
Se12	Short elytra 12	?	Se12	Purdue
ser	serrate antenna	X	py, ser	San Bernadino
Skl2s	Socketless spontaneous 2	2	Skl2s/Stm,Cx5	Manhattan
Skl4/Ey	Socketless 4	2	Skl4/Ey	Manhattan
Skl4R1	Socketless 4, revertant 1	2	Skl4R1/Ey	Manhattan
Skl4R2	Socketless 4, revertant 2	2	Skl4R2/Ey	Manhattan
Skl4R3	Socketless 4, revertant 3	2	Skl4R3/Stm,Cx5	Manhattan
Skl6	Socketless 6	2	Skl6/Stm,Cx5	Manhattan
Skl6R1	Socketless 6, revertant 1	2	Skl6R1/Stm,Cx5	Manhattan
small	small body size	?	small	Purdue
sp	shoulder pads	2	sp/Dch3	Manhattan
sp	shoulder pads	2	sp/Stm,Ag4	Manhattan
Spa	Spatulate antennae	2;4	Ds/Spa (no Medea)	San Bernadino
Spa	Spatulate antennae	2;4	Spa/Es1	San Bernadino
sq (Tiw-2)	squint (from Tiw-1)	?	sq (Tiw-2)	India
sq-B	squint (from Burma)	?	sq-B	Burma
sq1	squint eye 1	8	Bald,ap;sq1/ap,sq1	San Bernadino
sq1	squint eye 1	8	sq1	San Bernadino

sq2	squint eye 2	8	ap,sq2	Manhattan
sq2	squint eye 2	8	Bald,ap,sq2/ap,sq2	Manhattan
Stb	Stubby antennae	2;X	Em,A16s/Stb	Manhattan
Stb	Stubby antennae	2;X	Lu,Skl6/Stb	Manhattan
Stb	Stubby antennae	2;X	Stb/Es	Manhattan
Stb,Df(mas)	Stubby, deficiency in mas	2	Stb,Df(mas)/Es	Manhattan
Stbd	Stuboid (short antennae)	2	Lu/Stbd	Manhattan
Stbd	Stuboid (short antennae)	2	Stbd/Es	Manhattan
Stm	Stumpy	2	Stm/Stm	Manhattan
Stm+RSptlD	Stm spontan. revert. ptl	2	Stm+RSptlD/Es1	Manhattan
Stm,Ag4	Stm, Antennagalea 4	2	X-83/Stm,Ag4	Manhattan
Stm,Ag4	Stm, Antennagalea 4	2	X-47/Stm,Ag4	Manhattan
Stm,Ag4	Stm, Antennagalea 4	2	vwe/Stm,Ag4	Manhattan
Stm,Ag4	Stm, Antennagalea 4	2	sp/Stm,Ag4	Manhattan
Stm,Ag4	Stm, Antennagalea 4	2	g/Stm,Ag4	Manhattan
Stm,Ag4	Stm, Antennagalea 4	2	X-31/Stm,Ag4	Manhattan
Stm,Cx5	Stm, Cephalothorax 5, cis	2	A4/Stm,Cx5	Manhattan
Stm,Cx5	Stm, Cephalothorax 5, cis	2	A8/Stm,Cx5	Manhattan
Stm,Cx5	Stm, Cephalothorax 5, cis	2	AgPln/Stm,Cx5	Manhattan
Stm,Cx5	Stm, Cephalothorax 5, cis	2	Lu / Stm,Cx5	Manhattan
Stm,Cx5	Stm, Cephalothorax 5, cis	2	Skl2s/Stm,Cx5	Manhattan
Stm,Cx5	Stm, Cephalothorax 5, cis	2	AD100,Stm,Cx5/Es1	Manhattan
Stm,Cx5	Stm, Cephalothorax 5, cis	2	AD100,Stm,Cx5/Es1	Manhattan
Stm,Cx5	Stm, Cephalothorax 5, cis	2	Skl2s/Stm,Cx5	Manhattan
Stm,Cx5	Stm, Cephalothorax 5, cis	2	Skl4R3/Stm,Cx5	Manhattan
Stm,Cx5	Stm, Cephalothorax 5, cis	2	Skl6/Stm,Cx5	Manhattan
Stm,Cx5	Stm, Cephalothorax 5, cis	2	Skl6R1/Stm,Cx5	Manhattan
Stm,Cx5	Stm, Cephalothorax 5, cis	2	Stm,Cx5/Es1	Manhattan
Stm,Cx5	Stm, Cephalothorax 5, cis	2	Stm,Cx5/Ey,A14	Manhattan
Stm,Cx5	Stm, Cephalothorax 5, cis	2	Stm,Cx5/Ey; s/s	Manhattan
Stm,Ns	Stm, Narrow sternellum (cis)	2	Stm,Ns/Es1	Manhattan
Stm-Es1/+NDJ	Non-disjunction	?	Stm-Es1/+NDJ	Manhattan
Stm-Skl4-Es/+ NDJ	Non-disjunction	?	Stm-Skl4-Es/+ NDJ	Manhattan
Stm-Skl6/+NDJ	Non-disjunction	?	Stm-Skl6/+NDJ	Manhattan
StmR1	Stm revertant 1	2	StmR1/Es1	Manhattan
StmR2	Stm revertant 2	2	StmR2/Es1	Manhattan
StmR5	Stm revertant 5	2	StmR5/Es1	Manhattan
StmR6	Stm revertant 6	2	StmR6/Es1	Manhattan
T(Y;3)	Translocation Y-3	Y;3	T(Y;3)	Manhattan
T(Y;4)	Translocation Y-4	Y;4	T(Y;4)	Manhattan
T. brevicornis	Tribolium brevicornis	NA	T. brevicornis	Manhattan
T. confusum (apt,mas,sti)	T.c. with apt, mas, sti	?	T. confusum (apt,mas,sti)	San Bernadino
T. confusum (b,au,lod,p)	T.c. with b,au,lod,p	?	T. confusum (b,au,lod,p)	San Bernadino
T. confusum (PRC)	Tribolium confusum	NA	T. confusum (PRC)	P.R. China
T. freemani	Tribolium freemani	NA	T. freemani	Japan
T. madans	Tribolium madans	NA	T. madans	Manhattan
tar	anterior melanotic stink glands	2	tar	Manhattan
tib	tibialess (from ab)	9?	tib	Manhattan
Tiw-1	?	NA	Tiw-1	India
Tiw-1 (iso 43)	Tiw-1 isoline	NA	Tiw-1 (iso 43)	India
Tiw-1(iso 43) pink	pink eye from Tiw-1	NA	Tiw-1(iso 43) pink	India
tr	tremblor	2;4	Es/tr	Manhattan
tr	tremblor	2;4	tr	Manhattan
ub	unbuckled T1 epimera	2	Ey,ub/Es,ub	Manhattan
ub	unbuckled	2	ub	Manhattan
ub	unbuckled	2	ub, ab	Manhattan
ub	unbuckled	2	ub,g	Manhattan
ub	unbuckled	2	ub,pas30	Manhattan
ub	unbuckled	2	Quint(ub,mxp,apt,mas,pas)	Manhattan
ue	unsclerotized elytra	?	ue	Manhattan
ue	unsclerotized elytra	?	ue,ab,msg,p,mxp,apt,pas30	Manhattan
Utx(New)	Ultrathorax (New)	2	Utx(New)	Manhattan
Utx1	Ultrathorax	2	A10,mxpA10/Utx1,mxp,apt	Manhattan

Utx1	Ultrathorax	2	lp69/Utx1,mxp,apt	Manhattan
Utx1	Ultrathorax	2	Utx1,mxp,apt/mxpX9,Es1	Manhattan
Utx1	Ultrathorax	2	Utx1/Es	Manhattan
Utx1	Ultrathorax	2	Utx1/Utx1	Manhattan
Utx2,Stm	Ultrathorax 2, Stm (cls)	2	Utx2,Stm/Es1	Manhattan
vwe	vestigial wings and elytra	2	vwe/Dch3	Manhattan
vwe	vestigial wings and elytra	2	vwe/Es1	Manhattan
vwe	vestigial wings and elytra	2	vwe/Stm,Ag4	Manhattan
w	white eye	4	w	San Bernadino
X(ab-1s)	Lethal revertant from ab	9	Dch3/X(ab-1s)	Manhattan
X(ab-2s)	lethal revertant from ab stock	3	3P2/X(ab-2s)	Manhattan
X-31	lethal 31	2	X-31/Dch3	Manhattan
X-31 pearl s.l.	lethal 31 with pearl	2	X-31 pearl s.l./Dch3	Manhattan
X-47	lethal 47	2	X-47/Stm,Ag4	Manhattan
X-83	Lethal 83	2	X-83/Stm,Ag4	Manhattan

SUE HAAS.

Stock Lists

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
39. r^D --red	Berkeley
54. pd, r--paddle, red	
55. py, r, M^r --pygmy, red, red modifier	
59. r, sp--red spotted	
61. pd, pte--paddle, platinum eye	

Autosomal

63. p--pearl II New York 1976
64. p^{Pk} --pink II Chazy, 1959
65. p pearl II Park 1955
66. p^{S} pearl II
76. au--aureate III
78. b--black III
81. b^{S-1} -- 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
98. b^{t} --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
136. j^{AS} --jet V
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
180. ap^{S} --antennapedia VIII Berkeley 1962
186. sq^{D} --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. <u>Tribolium confusum</u>

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. <u>Tribolium destructor</u>

VII. <u>Tribolium freemani</u>

VIII. <u>Tribolium madens</u>

A. Sokoloff

SAVANNAH, GEORGIA
STORED-PRODUCT INSECTS RESEARCH AND DEVELOPMENT LABORATORY

I. Wild type strains

A. Lepidoptera

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

b. Coleoptera

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

II. Mutant strains. None

Richard T. Arbogast, Laboratory Director.

South Orange, New Jersey
Seton Hall University
Department of Biology

T. castaneum

Wild Type Strains

Seton Hall-1

McGill, via California State

Synthetic Strains

Pearl Foundation, via Purdue University

Black Foundation, via Purdue University

Mutant Strains

Paddle (pd) via Cal State U., S.B.

Red (R^{Ho} ^{ho}) Via Cal State U., S.B.

White (w) Via Cal State U., S.B.

short antenna (ca) Via Oregon State

Short antenna (Sa) Via Purdue University

Tribolium confusum Via Carolina Biological Supply

Eliot Krause

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)	"
Oryzaephilus mercator (Fauvel)	
Cryptolestes pusillus (Schoenherr)	Manhattan Ka. 1967
Cryptolestes ferrugineus (Stephens)	Unknown

Silvanidae

Ahasverus advena Waltl.	Minnesota

Tenebrionidae	
Cyaneus angustus (LeConte)	Winnipeg; Minnesota
Tribolium castaneum (Herbst)	Corvallis, Ore
Tribolium confusum duVal	Unknown
Tenebrio molitor	Carolina Biological, 1984
Anobiidae	
Lasioderma serricorne (Fab.)	Savannah, Ga.
Bostrichidae	
Rhizopertha dominica (F.)	Manhattan, Ka.
Prostephanus truncatus (Horn)	Unknown
Curculionidae	
Sitophilus granarius (L.)	Unknown
S. oryzae (L.)	"
B. Lepidoptera	
Pyralidae	
Anagasta kuehniella (Zeller)	Savannah, Ga.
Gelechiidae	
Sitotroga cerealella (Oliver)	Savannah, Ga.

(Ed.)

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

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

Bhadriraju Subramanyam, Ph. D.

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

Coleoptera

Anobiidae
Stegobi_um paniceum (L.)

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

Bostrichidae
Rhyzopertha dominica (F.)

Bruchidae
Acanthoscelides obtectus (Say)

Cleridae
Necrobia rufipes (Deg.)

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

Curculionidae
Sitophilus granarius (L.)
S. zeamais Motschulsky

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

Ostomidae
Gibbium psylloides (Czemp.)

Silvanidae
Ahasverus advena (Waltl.)
Oryzaephilus surinamensis

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

T. madens (Charpentier)

M. Nakashima

AUSTRALIA

Burnley, Victoria
Victoria Plant Research Institute
Department of Agriculture

COLEOPTERA

Tribolium castaneum

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

Tribolium confusum

Wild type strains
Malathion specific strain

Oryzaephilus surinamensis

Wild type strain
Malathion resistant strain

Oryzaephilus mercator

Alphitobius diaperinus

Cryptolestes ferrugineus

Gnathocerus cornutus

Gnathocerus maxillosus

Latheticus oryzae

Rhyzopertha dominica

Sitophilus granarius

Sitophilus oryzae

Sitophilus zeamais

Tenebroides mauritanicus

LEPIDOPTERA

Ephestia cautella

Ephestia figulella

Galleria mellonella

Plodia interpunctella

P. Williams

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

Coleoptera

Oryzaephilus surinamensis

Wild type strains

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

Rhyzopertha dominica

Wild type strains

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

Sitophilus oryzae

Wild type strains

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

Tribolium castaneum

Wild type strains

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

Lepidoptera

Ephestia cautella Wild Queensland

Patrick J. Collins, Senior Entomologist

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

STOCKLIST

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

SPECIES	ORIGIN
The following *Tribolium castaneum* mutant strains were received in November, 1985 from Dr. Sokoloff's laboratory at California State University.	
21. Culture S38	red eye
22. Culture S351	red eye, pygmy, fused antennal segments
23. Culture S156	microphthalmic
24. Culture S136	jet (dark body)
25. Culture S113	sooty (dark body)
26. Culture S63	pearl eye
27. Culture S165	chestnut eye
28. Culture S148	maroon eye
29. Culture S38	paddle (antennae fused, flattened)
30. *T. castaneum*	abbreviated appendages (aa), missing abdominal *sternites* (mas)
31. *T. castaneum*	Rio Desago Malathion resistance
The following mutant strains of *Tribolium castaneum* have had no linkage analysis:	
32. malathion-specific resistance	
33. black body and pearl eyes	
The following mutant strains of *Tribolium confusum* have had no linkage analysis.	
34. red eyes	
35. black body	

36.	*Tribolium confusum*	Winnipeg, MB	1994
37.	*Tribolium madens*		
38.	*Trogoderma variabile*		
39.	*Typhaea stercorea*	Manitoba	1991
	LEPIDOPTERA		
1.	*Plodia interpunctella*	Winnipeg, MB	1990
2.	*Sitotroga cerealella*	Kansas	1982

Dr. Noel D.G. White
Section Head

COLOMBIA

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

Tribolium castaneum

I. Wild type strains

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

II. Domestic mutants

Mutant strains discovered in Colombia

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

III. Imported mutants from Tribolium Stock Center, 1985

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

Fernando Nunez del Castillo

DENMARK

LYNGBY
STATENS SKADEDYRLABORATORIUM
(DANISH PEST INFESTATION LABORATORY)

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

K. Arevad and H. Mourier

FRANCE

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

A. Wild type strains

1. Sitophilus granarius L.

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

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

B. Selected lines of Sitophilus oryzae

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

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

Stock Lists

GERMANY

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

Wild type strains

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

Mutant strains (All from San Bernardino)

A. Tribolium castaneum

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

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

weird eggs (wd)

B. Tribolium confusum

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

K. Sander

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

Coleoptera

Bruchidae--Acanthoscelides obtectus (Say)

Cucujidae--Cryptolestes turcicus Grouv. Munich, 1966

Ptinidae
- Gibbium psylloides (Czemp) Regensburg, 1960
- Ptinus tectus (Boi.) Munich, 1972

Silvanidae

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

Munich (cont'd)

Tenebrionidae

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

Lepidoptera

Phycitidae--Ephestia kuehniella (Zell.)	"	1966

E. Naton.

GERMANY

D-80333 Munchen
Institut fur Zoologie
Luisenstrasse 14

WILD TYPE

Tribolium castaneum

MUTANTS provided by A. Sokoloff

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

Tribolium confusum
- Diminished eye (dim)

Marcus Friedrich

Tel Aviv University ,Israel

Tribolium Stock List

(Note : TSC Tribolium Stock Center, San Bernardino, Calif.)

T.castaneum

Wild Type Strains :	Origin :
CS++ Ishaaya	Israel,before 1972
CTC-12 (Insecticide resistant)	Slough (England), 1977
Kano C (Malathion resistant)	Slough (England), 1977

Mutant Strains :	
CS bb	Stony brook, 1970
EU++ (extra urogomphi)	Derived from CSbb, 1973
CSmc (microcephalic)	Derived from PPxbb, 1979
CS Paddle	TSC, 1988
CS Pearl	TSC, 1977
CS Pygmy	TSC, 1979

T.confusum

Wild Type Strains :	
CF Chicago	TSC, 1977
CF Tarovet	Israel, 1994

Mutant Strains :	
CF bb	Stony Brook, 1970
CF xl (extra large)	TSC, 1979

T.brevicornis

++ (Riverside)	TSC, 1979

T.freemani

	Japan, 1982

DAVID WOOL

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

STOCK LIST

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

<u>Tribolium confusum</u>

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

J.D. Saxena.

JAPAN

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

Psocoptera
Liposcelidae
Liposcelis bostrychophilus Badonel Wild
Liposcelis entomophilus (Enderlein) Wild
Trogiidae
Lepinotus reticulatus Endelein Wild

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

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

H. Nakakita H. Ikenaga

OKAYAMA
LABORATORY OF APPLIED ENTOMOLOGY
COLLEGE OF AGRICULTURE
OKAYAMA UNIVERSITY

1. Wild type strains

COLEOPTERA

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

HYMENOPTERA

1.	*Anisopteromalus calandrae*	Okayama
2.	*Choetospila elegans*	Okayama
3.	*Lariophagus distinguendus*	Okayama

Toshiharu Yoshida

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

Bruchidae

Callosobruchus chinensis

13 wild type strains from different localities in Japan and abroad

Black colored mutant derived from Shusenji strain.

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

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

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

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

K. Fujii

PEOPLE'S REPUBLIC OF CHINA

Beijing
Beijing Agricultural University
Dept of Animal Science

Tribolium castaneum

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

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

Lao Zhang

SPAIN

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

Tribolium castaneum

A. wild type strains

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

B. Mutant type strains

13. Black Purdue	Purdue, USA,	1964

C. Experimental lines

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

	selected for	Temperature (oC)
14. AN-I	high performance at	33
15. AN-II	" "	33
16. AF-I	" "	28
17. AF-II	" "	28
18. AT-I	" "	38
19. AT-II	" "	38
20. BN-I	low performance at	33
21. BF-I	" "	28
22. BF-II	" "	28
23. BT-I	" "	38
24. BT-II	" "	38
25. RN-I*	high cross performance at	33
26. SN-I*	" " " "	33
27. RN-II	" " " "	33
28. SN-II	" " " "	33
29. RF-I	" " " "	28
30. SF-I	" " " "	28
31. RF-II	" " " "	28
32. SF-II	" " " "	28
33. RT-I	" " " "	38
34. ST-I	" " " "	38
35. RT-II	high cross performance at	38
36. ST-II	" " " "	
37. CTD-I	high performance at diff. levels of selection	
38. CTD-II	" " " " " "	
39. DTD-I	" " " " " " "	
40. DTD-II	" " " " " " "	
41. ETD-I	" " " " " " "	
42. ETD-II	" " " " " " "	
43. FTD-I	" " " " " " "	
44. FTD-II	" " " " " " "	

D. mutants

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

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

Tribolium confusum

A. Wild type strains

71. Coronada La Coronada, Spain

B. Mutants

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

Ma. C. Fuentes

UNITED KINGDOM

CENTRAL SCIENCE LABORATORY

Insect Cultures Order Form

Name: ....

Address: ....

....

....

Tel No: .... Fax No: ....

Species	Quantity	Live/ Dead	Adult/ Larvae	Price
			Subtotal	
(Note: VAT is not payable for orders paid from outside UK)			VAT	
			Post & Packing	2.50
			TOTAL	

Latest date required: (see note about availability): ....

Signature: .... Date: ....

Please send or fax this order to:

Mrs C Trowe
Central Science Laboratory
London Road
SLOUGH, Berkshire, SL3 7HJ UK
Fax: 0753 824058
International code +44 -753 824058

(Cheques payable to Central Science Laboratory)

Number of insects per culture, charged at £50 + VAT

Cockroaches	100 sexed insects
Pharaoh's ants	Colony of 6-10 queens plus several hundred workers
Beetle, moth, silverfish and psocids. (Some species may be charged at a higher rate because they require special handling or are in limited supply).	50 insects (minimum) of mixed sexes except for parthenogenic psocids

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Payments must be made in Sterling.
Cheques must be made payable to Central Science Laboratory.

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Other services

- **Identification** - CSL runs courses on identification and on storage and public health pests. We run an identification service and a wide range of insect identification cards is available. Apply to the Librarian at CSL Harpenden (address below) for identification cards.
- **Advice** - on the care and maintenance of cultures can be provided.
- **Mites** - CSL can supply cultures of mites, for which a separate leaflet is available.

Contacts

Mrs C Trowe or Mrs S Henderson
Central Science Laboratory,
MAFF, London Road, Slough
Berks, SL3 7HJ UK

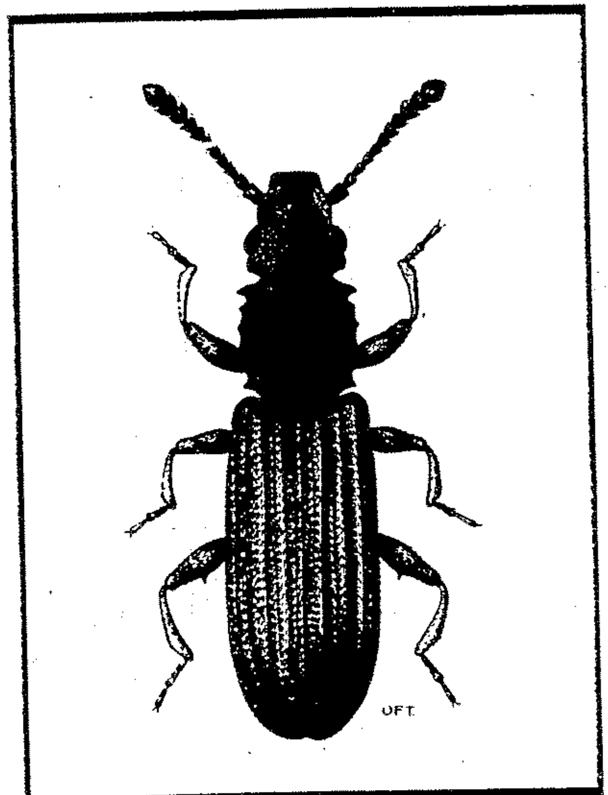
Telephone: 0753 534626
International code +44 -753 534626
Fax: 0753 824058
International Fax: +44 -753 824058

The Librarian,
Central Science Laboratory,
MAFF, Hatching Green
Harpenden, Herts, AL5 2BD UK

Telephone: 0582 715241
International code +44 -528 715241
Fax: 0582 762178
International Fax: +44 -582 762178

CENTRAL SCIENCE LABORATORY

Insect Cultures



Over 100 species of stored product and public health insects available

MAFF

Species currently available

Coleoptera

Ahasverus advena
Alphitobius diaperinus
Anthrenocerus australis
Anthrenus flavipes
Anthrenus flavipes seminiveus
Anthrenus picturatus hintoni
Anthrenus sarnicus
Anthrenus verbasci
Attagenus brunneus
Attagenus cyphonoides
Attagenus fasciatus cinnamomeus
Attagenus insidiosus
Attagenus pellio
Attagenus rufiventris
Attagenus smirnovi
Attagenus unicolor canadensis
Attagenus unicolor japonicus
Attagenus unicolor simulans
Attagenus unicolor unicolor
Attagenus woodroffei
Attagenus fasciatus fasciatus
Callosobruchus maculatus
Carpophilus dimidiatus
Carpophilus dimidiatus pearl-eye mutant
Carpophilus hemipterus
Coelopalorus foveicollis
Cryptolestes capensis
Cryptolestes ferrugineus
Cryptolestes pusilloides
Cryptolestes pusillus
Cryptolestes pusillus fuscus
Cryptolestes turcicus
Cryptolestes turcicus red-eye mutant
Cryptolestes ugandae
Dermestes ater
Dermestes frischi
Dermestes haemorrhoidalis
Dermestes lardarius
Dermestes maculatus
Dermestes maculatus pearl-eye mutant
Dermestes maculatus black-brown mutant
Dermestes peruvianus
Gibbium aequinoctiale
Gnatocerus cornutus
Gnatocerus maxillosus
Lasioderma serricorne
Lasioderma serricorne black mutant
Latheticus oryzae
Mezium affine
Mezium americanum
Niptus hololeucus
Oryzaephilus acuminatus
Oryzaephilus mercator
Oryzaephilus surinamensis
Oryzaephilus surinamensis small mutant
Palorus cerylonoides
Palorus ficicola
Palorus genalis
Palorus ratzeburgii
Palorus subdepressus
Prostephanus truncatus
Pseudeurostus hilleri
Ptinus clavipes
Ptinus exulans
Ptinus pusillus
Ptinus sexpunctatus
Ptinus tectus
Rhyzopertha dominica
Sitophagus hololeptoides
Sitophilus granarius
Sitophilus oryzae
Sitophilus zeamais
Sphaericus gibboides
Stegobium paniceum
Stethomezium squamosum
Tenebrio molitor
Tenebrio obscurus
Tipnus unicolor
Tribolium confusum
Tribolium anaphe
Tribolium audax
Tribolium brevicornis
Tribolium castaneum
Tribolium castaneum black mutant
Tribolium destructor
Tribolium freemani
Tribolium madens
Trigonogenius globulus
Trigonogenius particularis
Trogoderma angustum
Trogoderma anthrenoides
Trogoderma glabrum
Trogoderma granarium
Trogoderma grassmani
Trogoderma inclusum
Trogoderma irroratum
Trogoderma ornatum
Trogoderma sternale plagifer
Trogoderma variable
Trogoderma varium
Typhaea stercorea

Dictyoptera

Blatta orientalis
Blattella germanica
Diploptera punctata
Periplaneta americana

Lepidoptera

Ephestia cautella
Ephestia kuehniella
Galleria mellonella
Plodia interpunctella
Sitotroga cerealella
Tinea pellionella
Tineola bisselliella

Thysanura

Lepisma saccharina

Hymenoptera

Monomorium pharaonis

Psocoptera

Liposcelis bostrychophila
Liposcelis subfuscus
Liposcelis paetus
Lepinotus patruelis
Trogium pulsatorium

Hemiptera

Aphis fabae
Aphis gossypii
Brevicoryne brassicae
Macrosiphum euphorbiae
Myzus persicae
Nasonovia ribisnigri
Phorodon humuli
Rhopalosiphum padi
Sitobion avenae

Availability

Please give two weeks notice.
Although most species can be supplied within two weeks, those tl breed slowly may take longer to supply.
We will advise you if there is likely be a delay.

CENTRAL SCIENCE LABORATORY

LONDON ROAD
SLOUGH
BERKS U K
SL3 7HJ

TEL: 44 1753 534626
FAX 44 1753 82405

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 insectary. This list was last updated January 1995. The country of origin and year of receipt at this laboratory are shown against the strains where this information is known. For some of the older strains such information is not known. Please note that 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 or Carol TROWE 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 will have to be made.

CHRISTINE B MUGGLETON (Mrs)

INSECT DATABASE FOR TRIBOLIUM INFORMATION BULLETIN

Genus , species, sub-species.	Strain	Place of origin	Year received
COLEOPTERA			
Ahasverus advena	6 strains from 2 countries, many differing in their susceptibility to pesticides		
Alphitobius diaperinus	6 strains all from Britain, many differing in their susceptibility to pesticides		
Anthrenocerus australis		Britain	1933
Anthrenus flavipes			
Anthrenus flavipes seminiveus			
Anthrenus picturatus hintoni		Russia	1977
Anthrenus sarnicus	Wiltshire	Britain	1966
Anthrenus verbasci		Britain	1951
Attagenus brunneus	Canada		
Attagenus brunneus	Spain	Spain	
Attagenus cyphonoides		Tashkent	1976
Attagenus fasciatus fasciatus		New S. Wales	1972
Attagenus fasciatus cinnamomeus		Botswana	1965
Attagenus insidiosus		Kenya	
Attagenus pellio		Britain	1950
Attagenus rufiventris		Botswana	1970
Attagenus smirnovi		Kenya	1962
Attagenus unicolor canadensis		N. America	1980
Attagenus unicolor japonicus		Japan	1956
Attagenus unicolor simulans		U.S.S.R.	1976
Attagenus unicolor unicolor			pre 1958
Attagenus woodroffei	Sweden	Sweden	1978
Attagenus woodroffei	Finland	Finland	1965
Callosobruchus maculatus			
Carpophilus dimidiatus		USA	pre 1958
Carpophilus hemipterus			1962
Coelopalorus foveicollis		Trinidad	1972
Cryptolestes capensis			1961
Cryptolestes ferrugineus	24 strains all from Britain, many differing in their susceptibility to pesticides		
Cryptolestes pusilloides		Canada	1944
Cryptolestes pusillus			
Cryptolestes pusillus fuscus		Trinidad	1960
Cryptolestes turcicus			pre 1958
Cryptolestes ugandae		E. Africa	1954
Dermestes ater		Britain	1953
Dermestes frischii		Nigeria	pre 1958

Dermestes haemorrhoidalis		Britain	1962
Dermestes lardarius		Britain	pre 1958
Dermestes maculatus	Chittagong	Chittagong	1975
Dermestes peruvianus		Britain	1961
Gibbium aequinoctiale		Britain	1937
Gnatocerus cornutus			pre 1958
Gnatocerus cornutus			
Gnatocerus maxillosus			pre 1958
Lasioderma serricorne			pre 1958
Latheticus oryzae			pre 1958
Mezium affine		Britain	pre 1958
Mezium americanum			1960
Niptus hololeucus		Britain	pre 1958
Oryzaephilus acuminatus		Sri Lanka	
Oryzaephilus mercator			pre 1958
Oryzaephilus mercator	9127 Pickering	Britain	1994
Oryzaephilus surinamensis	54 strains from 4 countries, many differing in their susceptibility to pesticides		
Palorus ceryionoides		Indonesia	
Palorus ficicola	1168	Nigeria	
Palorus ficicola	1176	Nigeria	
Palorus genalis		Guyana	
Palorus ratzeburgii		Britain	1960
Palorus subdepressus		Turkey	1956
Prostephanus truncatus		Tanzania	1981
Pseudeurostus hilleri		Britain	1940
Ptinus clavipes		Britain	1954
Ptinus exulans		Britain	1971
Ptinus pusillus			pre 1958
Ptinus sexpunctatus			pre 1958
Ptinus tectus	Wild	Britain	1975
Ptinus tectus	PICL		1960
Ptinus tectus	Birkenhead	Britain	1975
Rhyzopertha dominica	7 strains from 3 countries, many differing in their susceptibility to pesticides		
Sitophagus hololeptoides		Trinidad	1972
Sitophilus granarius	11 strains from 3 countries, many differing in their susceptibility to pesticides		
Sitophilus oryzae	5 strains from 4 countries, many differing in their susceptibility to pesticides		
Sitophilus zeamais			pre 1958
Sitophilus zeamais	U.S.A.	U.S.A.	1982
Sphaericus gibboides		Britain	1976
Stegobium paniceum			1959
Stethomezium squamosum		Britain	1976
Tenebrio molitor			pre 1958

Tenebrio obscurus			pre 1958
Tipnus unicolor		Kenya	pre 1958
Tribolium anaphe		Nigeria	1956
Tribolium audax		Canada	1969
Tribolium brevicornis		U.S.A.	
Tribolium castaneum	9 strains from 3countries, many differing in their susceptibility to pesticides		
Tribolium confusum	W-44		
Tribolium confusum	Lab. susc.		
Tribolium confusum			1962
Tribolium destructor	African	Ethiopia	1968
Tribolium freemani		Japan	1980
Tribolium madens		Yugoslavia	1959
Trigonogenius globulus		Ireland	1961
Trigonogenius particularis		Kenya	1962
Trogoderma angustum		Germany	1975
Trogoderma anthrenoides		U.S.A	1957
Trogoderma glabrum		U.S.A.	1959
Trogoderma granarium		Britain	
Trogoderma granarium		Britain	pre 1958
Trogoderma grassmani		U.S.A.	1976
Trogoderma inclusum			pre 1958
Trogoderma irroratum		Egypt	1959
Trogoderma ornatum		U.S.A.	1974
Trogoderma sternale plagifer		New Mexico	1966
Trogoderma variabile		U.S.A.	1965
Trogoderma varium		Korea	1970
Typhaea stercorea	Datchet	Britain	1980
THYSANURA			
Lepisma saccharina		Britain	1978
LEPIDOPTERA			
Ephestia cautella		Cyprus	1969
Ephestia cautella	Brown/Yellow	Florida	
Ephestia cautella	Bedstock		
Ephestia elutella	Lab.		
Ephestia elutella	Millwall	Britian	1969
Ephestia kuehniella	Welsh Buffer Depot	Britain	
Ephestia kuehniella	Rhydymwyn	Britain	1988
Ephestia kuehniella		Britain	1949
Galleria mellonella	B	U.S.A.	1992
Galleria mellonella		U.S.A.	1987
Plodia interpunctella	88	Turkey	1977
Plodia interpunctella		Britain	1968
Plodia interpunctella	121	Chicargo	1977
Plodia interpunctella	102	Tanzania	1977
Sitotroga cerealella	623	U.S.A.	1972
Sitotroga cerealella	A68	Nepal	1981
Tinea pellionella		Britain	1989
Tineola bisselliella	U.S.A. Lab. strain		
Tineola bisselliella	U.K.Wild strain		
Tineola bisselliella		Britain	1989

MUTANTS

Carpophilus dimidiatus	pearl-eye		
Cryptolestes turcicus	Red-eye mutant		
Dermestes maculatus	Black-brown	Australia	1964
Dermestes maculatus	Pearl-eye	Australia	1964
Lasioderma serricome	Black mutant	U.S.A.	1975
Oryzaephilus mercator	0779 pearl-eye	Pacific Islands	1978
Oryzaephilus surinamensis	small	East Pakistan	1964
	484 -sp eye,lod	speckled eye, light ocular diaphragm	
	484-sp eye	speckled eye	1994
	484 black dd		
Tribolium castaneum	black		1983

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

TROPICAL DEVELOPMENT AND RESEARCH INSTITUTE (TDRI)

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

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

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

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

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

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

Stock Lists

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

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

The Director
Tropical Development and Research Institute
56-62 Gray's Inn Road
London WC1X 8LU
England (Telephone 01-242 5412)

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

I. Wild type strains

A. Coleoptera

Bostrichidae

1. Prostephanus truncatus -- Mexico, Tanzania

Bruchidae

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

Curculionidae

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

B. Lepidoptera

Galleriinae: Corcyra cephalonica -- Malawi

Gellechiidae: Sitotroga cerealella -- Sudan

Phycitinae: Ephestia cautella -- Brazil

CHEMICAL CONTROL SECTION

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

Wild type strains

Coleoptera

Bostrichidae

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

Bruchidae

Acanthoscelides obtectus -- Ethiopia

Callosobruchus chinensis -- India

Curculionidae

Sitophilus oryzae -- Insecticide-susceptible strain (reference strain) -- via MAFF Lab, Slough

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

Tenebrionidae

Tribolium castaneum -- Multiple insecticide-resistant strain (CTC 12) -- australia

T. castaneum -- Malathion-specific resistant strains (Kano C) -- Nigeria

T. castaneum -- Insecticide-susceptible strain (reference strain) -- MAFF Lab, Slough

Dr. P. F. Prevett
Deputy Head of Department

Stock Lists

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

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

The Director
Tropical Development and Research Institute
56-62 Gray's Inn Road
London WC1X 8LU
England (Telephone 01-242 5412)

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

I. Wild type strains

A. Coleoptera

Anobiidae

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

Bostrichidae

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

Bruchidae

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

Curculionidae

1. Sitophilus oryzae

i. Normal strains	a. Ex-MAFF
	b. India
	c. Morocco
	d. Zimbabwe
ii. Pulse-feeding	a. Burma
2. S. zeamais --	a. Ex-MAFF
	b. India

Dermestidae

1. Dermestes ater	a. Ex-MAFF
2. D. maculatus	a. Jamaica
3. Trogoderma granarium	a. India
	b. Sudan

Histeridae

1. Teretriosoma nigrescens	a. Mexico

Lophocateridae

1. Lophocateres pusillus	a. Philippines

Silvanidae

1. Ahasverus advena	a. Ex-MAFF
2. Oryzaephilus sp.	a. Kenya (4 strains)
3. Oryzaephilus surinamensis	a. Ex-MAFF

Tenebrionida

1. T. castaneum	a. Ex-MAFF
	b. Botswana*
	c. Indonesia (2 strains)
	d. Kenya #
	e. Mali*
	f. Mozambique
	g. Pakistan*
	h. Philippines +
	i. Sri Lanka
	j. Thailand (3 strains)***+
	k. Zimbabwe (2 strains)*
2. Latheticus oryzae	a. Ex-MAFF
3. Gnatocerus cornutus	a. Ex-MAFF
4. Palorus subdepressus	a. Ex-MAFF

Key

* Number of strains which have to date been found to be Phosphine resistant.

+ Malathion resistance noted.

Pirimiphos methyl resistance noted.

B. Lepidoptera

Pyralidae

1. Corcyra cephalonica a. Ex-MAFF
2. Ephestia cautella a. Ex-MAFF
   b. Ethiopia
3. Ephestia elutella a. Ex-MAFF

Gellechiidae:

1. Sitotroga cerealella a. Sudan

CHEMICAL CONTROL SECTION

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

Wild type strains

Coleoptera

Bostrichidae

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

Bruchidae

Acanthoscelides obtectus -- Ethiopia
Callosobruchus chinensis -- India

Curculionidae

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

Tenebrionidae

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

Dr. Chris P. Haines

RESEARCH, TEACHING AND TECHNICAL NOTES

Notes - Research, Teaching and Technical

Beeman., Richard W. and M. Susan Haas
USDA/ARS Biological REsearch Unit
U.S. Grain Marketing Research Lab.
1515 College Ave.
Manhattan, KS 66502

* Three Mutants of Tribolium castaneum.

1.
tar (tar) - Contents of the prothoracic quinone gland reservoirs are more darkly pigmented than normal, and are not secreted. The gland contents in the mutant are usually red-brown to purple-brown compared to the usual wax-yellow color characteristic of wild type. Posterior glands are seldom affected. We speculate that some faulty mechanism prevents the anterior glands from excreting their contents, which oxidize and become darker with time.

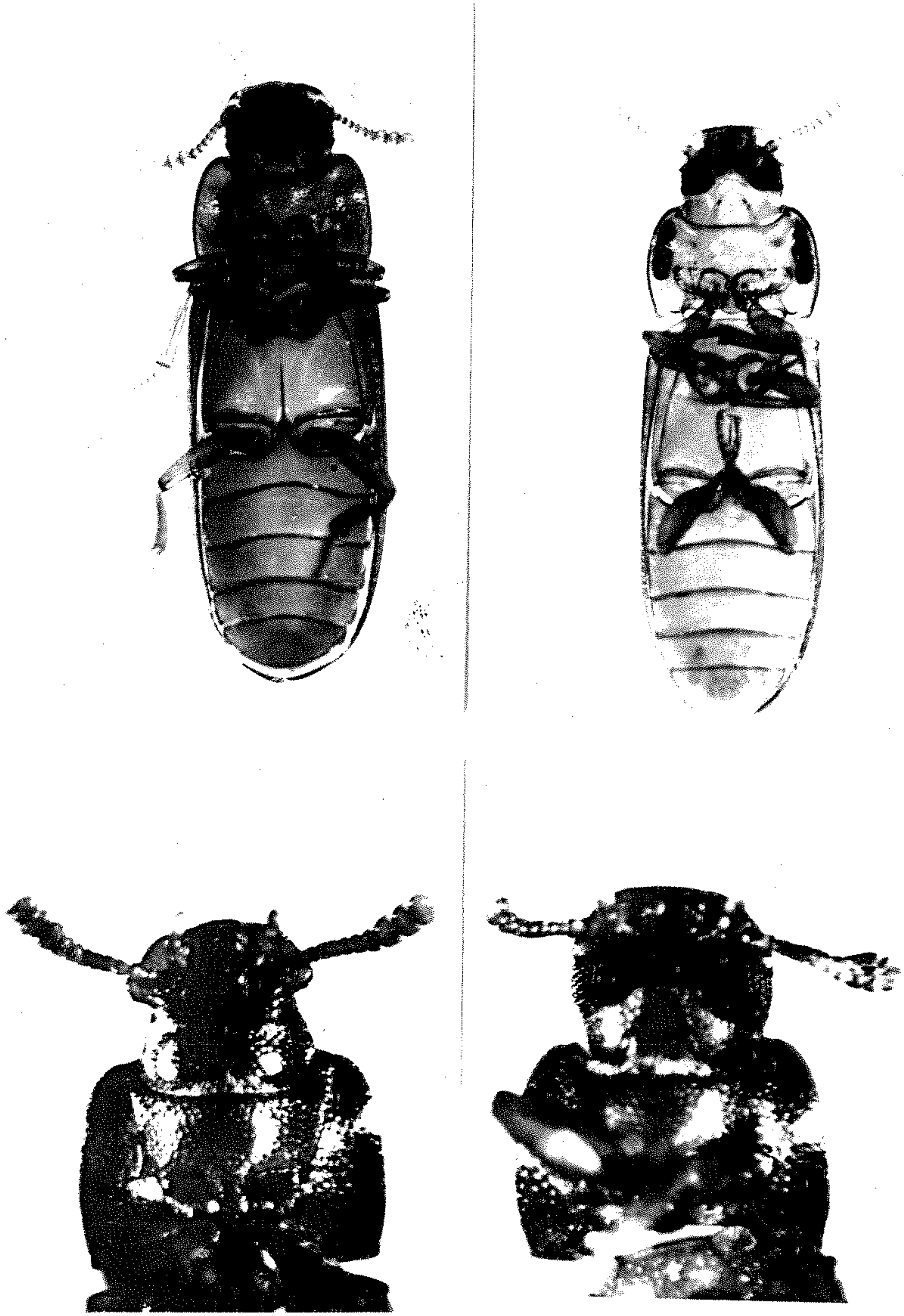
2. broken antennae (ba) - Club segments are often pale and undersclerotized or unevenly sclerotized with a patchy appearance. The funicle has uneven sclerotization, often with patches of excess pigment. Both club and funicle are brittle and subject to breakage.

3. Eyeless (Ey) - Resembles microcephalic (mc), but has a more severe phenotype. The eye-bearing portion of the head capsule is reduced, with an accompanying reduction of the eye itself. In the most strongly expressed individuals, no ommatidia develop. The gena is unaffected.

For illustration of these mutants see the accompanying Fig. 1.

Fig. 1. Upper Row: Left, a normal teneral adult; right, a tar/tar homozygote. Note the dark masses within the prothorax.

Lower Row: Left, an "eyeless" Ey/Es' translocation heterozygote. Note the complete absence of ommatidia. Right, a "broken antenna" (ba/ba) teneral adult. Note the right antenna with missing terminal club segments and left antenna with reduced club segments.



Richard W. Beeman and M. Susan Haas
USDA/ARS Biological Research Unit
U.S. Grain Marketing Research Lab.
1515 College Ave.
Manhattan, KS 66502

* New mutants in Tribolium castaneum.

1. Cleft gula (Cg). Dominant, radiation induced, homozygous lethal. Strongly indented or cleft gular sutures on ventral head, causing a slight widening of the head capsule, giving the eyes a "walleyed" look from the ventrum. Excellent penetrance and viability. It appears to be unlinked to any currently documented linkage group.

2. Unsclerotized elytra (ue). Spontaneous recessive. The mutation is characterized by a membranous stippling along the midline margin of each elytron. The prothoracic sternellum is often slightly indented at the posterior midline, giving it a lightly cleft appearance. It has complete penetrance, variable expression, and excellent viability as a homozygous stock. Linkage is undetermined at this time.

3. Pretzel (Pz) - EMS-induced, dominant, homozygous semi-lethal. Excellent viability and incomplete penetrance in the heterozygous condition. The original mutant was a male with warped prothoracic tibiae. Heterozygotes have normal antennae and gnarled, thichened legs (one or more legs may be affected). The homozygotes have very short antennae and radically reduced legs, consisting of only coxae, tarsal claws, and a hint of some intervening segment. Linkage is undetermined at this time.

4. Displaced sternellum (Ds) - Radiation induced, dominant, fully penetrant, viable, and tightly linked to Reindeer (Rd) on LG2. The prothoracic sternellum has a "pinched" appearance, i.e. is laterally narrowed and dorso-ventrally thickened. The mesothoracic sternellum is also enlarged. The pronotum has generalized dorsal dents, usually with a dorsal anterior midline dip, and abnormally pointed anterio-lateral corners. The ventral anterior of the pronotum also has a midline dip which is often devoid of the anteriorly projecting setae usually found at the anterior margin. Metathoracic antecoxae are disrupted along the common margin with the enlarged posterior metepisternum. All coxal sockets, including those of the maxillary palps, are enlarged, with a poorer fit to the coxae. This "looseness" at the maxillary palps gives the ventral head a "walleyed" look, and may also be responsible for an escape of saliva resulting in a crust of flour accumulating around the mouth region. Large setae are commonly found on coxae, with setae and spikes on antennal scape, and maxillary palps occasionally branched.

6. Crab (Cr(- Radiation-induced, dominant, homozygous lethal, fully penetrant. Moderately viable (has difficulty eclosing and moving about due to warped legs); Crab is located on LG7, with 0% crossover with chestnut eye (c). It is currently maintained as balanced stock of Crab/PL4. The tibiae of all three pairs of legs are enlarged, and bowed. Males are occasionally seen with a "sex patch" on the prothoracic tibiae, indicating this mutant is a tibia to femur transformation. Random tarsomeres are also often fused.

7. Folded elytra (fe). Spontaneous recessive derived from the dominant eu (euD) stock. It has incomplete penetrance with excellent viability. It is characterized by elytra which are folded under at the tips. The trait is visible in pupae. Linkage is undetermined at this time.

* Podapolipid Mites (Acari: Podapolipidae) Associated with Tenebrionidae

R. W. Husband, Biology Dept., Adrian College, Adrian MI 49221

Podapolipus tribolii Feldman-Muhsam and Havivi 1972 was described from laboratory specimens of *T. confusum* maintained in the Medical Entomology Laboratory, Hebrew University, Jerusalem, Israel in 1961. The specimens were removed from under the elytra and from the tergites of the abdomen of the beetle. This was the first and last report of *Podapolipus* from *T. confusum*.

Sokoloff (1974) lists several parasitic mites of *Tribolium* including another mite in Tarsonemoidea, *Pyemotes ventricosus*. The tenebrionid genera *Akis, Pimelia, Blapstinus, Gonocephalum* and *Alphitobius* are hosts for these ectoparasites and it is very likely that additional tenebrionid beetles may serve as hosts. Keys to species of *Podapolipus* associated with tenebrionid beetles appear in Husband and Baker (1992). A new genus of podapolipid mite was recently discovered by Kurosa on a tenebrionid beetle collected in Japan.

Although many podapolipid mites may parasitize one beetle, the mites are seldom seen because the incidence may be very low in a population. The life cycle of podapolipid mites is abbreviated. Adult male *Podapolipus* with 3 pairs of legs hatch directly from the egg. Larval female and adult male mites mate under the elytra of beetles. The larval female mite is the stage which migrates to new hosts. This may occur when beetles mate or cluster. Feldman-Muhsam and Havivi (1972) point out that low humidity is detrimental to the survival of the mites. When reaching a new host, the larvae attach with cheliceral stylets and molt to the adult stage. Adult females have one pair of legs and are not capable of much movement. Larval female exoskeletons may be seen attached to adult females. This has resulted in confusion when parts of larval females have been mistaken for structures of the adult females. It is likely that a few larval females (about 0.15mm) or males (about 0.01mm) will be overlooked. However, adult females appear as round clear or white spheres about 0.5mm in diameter and many eggs may remain attached to the posterior of the abdomen. Feldman-Muhsam (personal communication, 1989) noted raised elyta in some parasitized *T. confusum*. Sokoloff (personal communication, 1995) noted raised elytra in *Tribolium* due to elytral blisters of genetic origin. Thus, raised elytra in *Tribolium* may not be due to parasitism.

Feldman-Muhsam, B. and Y. Havivi. 1972. Two new species of the genus *Podapolipus* (Podapolipidae: Acarina), redescription of *P. aharonii* Hirst 1921 and some notes on the genus. Acarologia 14: 657-674.

Husband, R.W. and A. Baker. 1992. A new species of *Podapolipus* (Acari: Podapolipidae) ectoparasitic on *Alphitobium laevigatus* (Tenebrionidae) from Trinidad. Internat. J. Acarol. 18(2): 83-87.

Sokoloff, A. 1974. The Biology of *Tribolium*. Volume 2: 276-277.

*A Request for Help in Collecting Additional *Podapolipus tribolii* from *Tribolium confusum*

by Robert W. Husband, Biology Dept., Adrian College, Adrian MI 49221

Podapolipus tribolii was collected once, in 1961, and reported by Feldman-Muhsam and Havivi (1972). It seems unlikely that only a single incidence of ectoparasitism by *P. tribolii* under elytra of *T. confusum* exists. Your assistance in finding additional cases of parasitism by podapolipid mites is requested.

I maintain a reference collection of nearly 100 species of mites in this family for my own study and for use by others. Some mites are maintained in alcohol and have been used in studies involving electron microscopy and electrophoresis. At present I have no *P. tribolii* in alcohol. If you notice these parasites, please contact me. If abundant, the long caudal setae (setae h_1) of larval females will be conspicuous. Females will appear as clear or white spheres about 0.5mm (+ 0.2mm) in diameter and will be located on the abdominal tergites under the elytra. Larval females and males have 6 legs while adult females have 2 legs. Two small anterior lobes are characteristic of female *Podapolipus* from tenebrionid beetles. Your help will be very much appreciated.

I hope the paragraphs above may be appropriate. Please change them as you see fit.

Thank you for your help.

Sincerely,

Robert W. Husband
Professor of Biology

Listov, M.V.
S.M. Kirov Military Medical Academy
St. Petersburg, Russia.

*Experimental models available in mice.

Two experimental models, one resulting in cardiomyositis, and the other producing experimental primary glaucoma in inbred mice DBA/2 have been developed by the author.
A summary of the models is included. The Editor of TIB has been informed by the author that he does not have the required financial support to continue working on these models, hence he is making the models available for sale. If you are interested contact Dr. Listov at the above address.

M. V. Listov, Ph.D. (Biology)

Experimental Model of Cardimyositis in Mice

Summary

The disease is manifested in mice of two lines (DBA/2 and C57Bl) after peroral injection of 2 substances one of which is inhibitor of the known enzyme and the other one is metabolic precursor of the substrate of this enzyme. The substances are injected with water (0.2 ml/mouse) daily during 3 to 4 weeks.

The pathology has been originally registered by the electrocardiography method. Histological study has shown diffuse injury of the whole of the myocardium: absence of the cross lines in some fibers, necrosis and destruction of some muscular fibers, a small edema. Lymphohistocystic and inflammatory reactions are moderately expressed. Observations of the experimental mice have demonstrated that some of the mice had their motion functions disturbed and spine crooked. An assumption arises whether the pathology in question is the model of one of the widely spread forms of polimyositis (Wagner - Unferricht form).

The advantage of this method of reproduction of the heart pathology is that it is easy to implement and also the fact that one of the injected substances is an inhibitor of the enzyme which is especially interesting in connection with the opportunity to understand the natural mechanism of the origin of the pathology in question.

M. V. Listov, Ph.D. (Biology)

Experimental Model of Primary Glaucoma in Linear Mice DBA/2

Summary

The disease is manifested in the form of acute bout in 5 to 20% of mice taken for the experiment (mass of the animals is from 18 to 20 g, animals of both sexes) after intraperitoneal injection of aqueous solutions (0.2 ml/mouse) of two substances. Within 1 - 1.5 hours after injection of the solutions pathological process (stable increase of the intraoccular pressure resulting in the clearly visible increase of the size of the eyeball) occupies one or both eyes and is accompanied by the cornea turbidity. Within 24 hours the increased eyeball assumes the form of a cone and wrinkles, the animal becomes blind.

The injected substances are well soluble, they are injected in relatively low doses, can be natural metabolites of the organisms. The model advances a researcher to understanding of the natural mechanism of the intraoccular pressure regulation, outlines ways of development of the early diagnostics of primary glaucoma and search for new drugs to treat this disease.

The model can be used for screening of chemical substances with hypotensive activity as well as substances - inactivators of those natural metabolites analogs of which have been used in our experiment.

The main advantage of the model is that it advances a researcher to understanding of the natural mechanism of the origin of primary glaucoma.

PARVEEN, B. AND B.J. SELMAN
Department of Agricultural and Environmental Science
University of Newcastle upon Tyne NE1 7RU, U.K.

*Effects of _Annona squamosa_ Linn. seed oil on adult emergence and sex-ratio of _Tribolium castaneum_ (Herbst). (Coleoptera: Tenebrionidae).

ABSTRACT

The petroleum ether (40-60 C) extracted _Annona squamosa_ Linn. seed oil was found to be effective for the reduction of adult emergence of _Tribolium castaneum_ (Herbst). But this seed oil did not significantly deviate the sex-ratio from an ideal sex-ratio 1:1.

INTRODUCTION

Annona squamosa Linn., the custard apple, is a small tree or shrub widely distributed mainly in tropical America, but has long been introduced into India and south east Asia. Annona squamosa bears heart-shaped, yellowish-green, juicy, sweet, delicately flavoured and cream, yellow or white fruit. Economically, the family is of appreciable importance as a source of edible fruits. Oils from the seeds of some of these plants may be used for the production of edible oils and soap. Many members of this family are used in folk medicine for various purposes. The seed extracts of this plant have been used as an abortifacient (Shenoy et al., 1968).

The most effective application appears to be against various aphids and human body lice (Reyes and Santos, 1931). Insecticidal materials are precipitated from custard apple seed extract concentrated with ether or petroleum ether at 0°C (Feinstein, 1952).

Tribolium castaneum (Herbst) is a major pest of stored products and is cosmopolitan in distribution (Good, 1933; Sokoloff, 1972, 1974). Both adults and larvae are able to exploit a wide variety of stored commodities (Ziegler, 1977). Infestation by these beetles leads to persistent release of unpleasant odours in the commodity. These are due to the secretion of benzoquinones from two pairs of defence glands, one pair in the thorax, and the other in the abdomen.The species is particularly suitable for many kinds of experiments because both the intra and extra medium conditions can be maintained at a constant level. By using similar flour in all experiments and by ensuring similar weights, surface exposure and external conditions, a total environment can be established which is relatively constant and reproducible (Park, 1934).

*B. Parveen, Scientific Officer, BCSIR Laboratories, Rajshahi 6206, Bangladesh.

MATERIALS AND METHODS

The insecticidal properties of petroleum ether (40-60 C) extracted Annona squamosa seed oil have been examined. Petroleum ether extracts of the seeds ccontained unsaturated fatty acids such as linoleic acid (24.7%) and oleic acid (75.3%) in the seed oil, and it has insecticidal properties (Kumar and Thakur, 1988).

Newly hatched T. castaneum larvae were reared in either fresh or treated flour medium. Larvae were regularly observed until pupated. The pupae were collected by sieving the medium through a 250 micrometer aperture sieve and sexed by microscopic examination of the exogenital processes of the male and female pupae (Ho, 1969). The genital lobes in the female pupae are large, bifid and flexible, whereas in the male pupae the lobes are minute. The pupae are easily sexed on the basis of these lobes.

After the pupae were sexed, the flour particles were removed from the pupae with a fine soft brush. The sexed pupae were returned to the individual tubes and observed daily for adult emergence. The experiments were conducted with four replicates for each treatment and each replicate consisted of ten newly hatched larvae.

RESULTS

Adult emergence and sex ratio: The results and statistical analysis of the experiments are shown in Table 1. The effect of different doses of A. squamosa seed oil on adult emergence was tested by analysis of variance. The significant differences between the doses were determined by a Student-Newman-Keul's multiple comparison test (Zar, 1984).

Deviations of the sex-ratio from an ideal 1:1 ratio were determined using the binomial test (Zar, 1984). The percentage emergence of adults was measured from the numbers of adults emerging in relation to the total numbers of larvae used. All pupae produced adults. Arcsine transformed data for the percentage emergence of adults were used here for analysis of variance. There was a significant ($P<0.001$) reduction in adult emergence from the larvae treated with A. squamosa seed oil compared to the control. The average percentage of adult emergence with A. squamosa seed oil was not dose-dependent. In the controls and in some chemical treatments the sex-ratio deviated from the typical 1:1 sex-ratio but not significantly ($P> 0.05$) (Table 2).

DISCUSSION

There was a significant reduction in adult emergence from the larvae treated with A. squamosa seed oil compared to the control (Table 1). In the present experiment the sex-ratio deviated from the typical 1:1 sex ratio, but the deviation

of the sex-ratio was not significant (P<0.05) in either the control or treatments (Table 2).
In nature, natural selection favours a 1:1 sex-ratio at conception for most species (Leigh, 1970) but some organisms show a deviation from this typical sex ratio. These deviations may be due to the influence of environmental factors on the physiology of the offspring after conception (Anderson, 1961; Trivers and Willard, 1973; White 1973; Charnov and Bull ,1977).

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Table 1. The effects of *A. squamosa* seed oil on the percentage of *T. castaneum* adult emergence after the larvae exposed to the seed oil treated medium.

Dose (ppm)	Mean percentage of adult emergence ± S.E.
Control	85.39 ± 4.61 a
90	60.64 ± 4.47 b
180	59.19 ± 5.61 b
360	54.22 ± 5.32 b
720	47.89 ± 5.09 b
1440	43.50 ± 3.69 b

Student-Newman-Keul (SNK) multiple comparison test values followed by the same letters are not significantly different at 5% level ($P>0.05$).

Table 2. The percentage of *T. castaneum* adult emergence and sex-ratio from larvae reared on fresh medium and medium treated with different concentrations of *Annona squamosa* seed oil. The values of t, a test for significant departure from a 1:1 sex-ratio.

Treatments (ppm)	% of total emergence	% of emergence M.	F.	Sex-ratio M. F.	"t"	
Control	97.50	43.59	56.41	1: 1.29	0.644	N.S
90	75.00	50.00	50.00	1: 1	0.187	N.S
180	72.50	44.83	55.17	1: 1.23	0.563	N.S
360	65.00	46.15	53.85	1: 1.17	0.192	N.S
720	55.00	45.45	54.55	1: 1.17	0.223	N.S

Four replicates for each dose, each replicate consisting of 10 larvae (N=10x4=40), M=Male, F=Female, N.S=Not significant, P>0.05.

"t" is based on the formula.

$$t = \frac{(n\hat{p} - nc) - 0.5}{\sqrt{n\hat{p}\hat{q}}} \quad \text{(Zar, 1984)}$$

Where n is the total number of insects emerged p^q^ are the proportions of insects of each sex (p^ being the greater), c is the expected value of p i.e, 0.5.

Parveen, B. and Selman, B.J.
Department of Agricultural and Environmental Science.
University of Newcastle upon Tyne. NE1 7RU, U.K.

Efficacy of Annona squamosa Linn. seed oil on the reduction of pupal and adult weight of Tribolium castaneum (Herbst) (Coleoptera: Tenebrionidae).

ABSTRACT

The effect pf Annona squamosa L. seed extracted oil was found to be highly significant ($P < 0.001$) for the reduction in the weight of pupae and adults of Tribolium castaneum (Herbst). The prolongation of the pupal period with the treatment of Annona squamosa L. seed oil was highly significant ($P<0.001$).

INTRODUCTION

Annona squamosa Linn, the custard apple, widely distributed naturally in tropical America, has long been available in India and southeast Asia. It bears heart-shaped, yellowish green fruit which are juicy sweet, delicately flavoured and cream, yellow or white. The seeds are many, brownish black, smooth and oblong. In many countries locally available plant materials are widely used as protectants of stored products against insect pests. The effectiveness of many derivatives for use against grain pests has been reviewed by Jacobson (1958, 1975, 1990). The seeds, leaves and immature dried fruits are used as an insecticide against bedbugs, head and body lice (Harper et al, 1947). The leaves of A. squamosa have a disagreeable odour, while the seeds contain an acrid principle fatal to insects (Lindley, 1946). The insecticidal principles of Annona spp. have received considerable investigation summarized by Harper et al (1947).
The seeds and roots of custard apple A. squamosa contain an insecticidal material which when concentrated with ether appears to be as potent against several insect species as rotenone (Harper et al, 1947). The seed extract of this plant was used as an abortifacient (Shenoy et al. 1968). Annona extracts have been claimed to act as both contact and stomach poisons (Harper et al., 1947).
Tribolium castaneum (Herbst) is one of the most serious pests of stored products and it occurs all over the world wherever stored products are found. The effect of temperature and humidity on the rate of development and mortality of T. castaneum over a series of temperatures was found to be between 15 C and 35 C at 70% relative humidity (Howe, 1956). Pupal development can be completed in 4-5 days. Adults are small, flat elongate, red brown beetles 3-4mm long. They are winged and fly well (Hill, 1990). The life of this beetle is longest at 25 C. and 70-80% relative humidity (Simwat and Chahal, 1970).

The following experiments were undertaken to study the efficacy of locally available plant materials on the pupal and adult growth of T. castaneum which have not been investigated or published elsewhere before.

MATERIALS AND METHODS

The insecticidal properties of petroleum ether (40-60 C) extracted Annona squamosa Linn. seed oil have been examined in this and the accompanying article (Parveen and Selman, 1995).

PUPAE: Newly hatched T. castaneum larvae were reared in flour medium, either fresh or treated. Larvae were regularly observed until all pupated. The pupae were collected by sifting the medium through a 250 micrometer aperture sieve and sexed by microscopic examination of the exogenital processes of the male and female pupae (Ho, 1969).

The genital lobes in the female pupae are large, bifid and flexible whereas in the male pupae the lobes are minute. The pupae were easily sexed on the basis of these lobes. After the pupae were sexed, the flour particles were removed from the pupae with a fine soft brush. Then the pupae were individually weighed.

The sexed pupae were returned to individual tubes (50 x 25 mm).with 0.3g of either fresh or treated media into each tube, and the tubes were capped with cotton wool. Adult emergence was observed regularly and the pupal period was recorded. The pupal period was recorded from the time of pupal formation to the time of adult emergence.

ADULTS: When the adults emerged, they were separated from the medium by sieving through a 500 micrometer sieve and they were then cleaned and weighed individually.

RESULTS

PUPAL WEIGHT AND DEVELOPMENT: The results and statistical analysis for the pupal weight and pupal period of T. castaneum are shown in Table 1. The effects of the treatment with A. squamosa on the decrease in the weight (in micrograms) and the pupal period were analyzed by analysis of variance. The significant difference between the means of the pupal weight and period was tested using the Student-Newman-Keul (SNK) multiple comparison method. All the treated media significantly reduced the pupal weight ($P < 0.001$) and this reduction in weight was found to be dose-dependent. The SNK multiple comparison showed that the pupal weight loss at the different doses was statistically significant.

ADULT WEIGHT AND DEVELOPMENT: The effect of the treatment with A. squamosa seed oil on the reduction in the weight (in micrograms) of the adults of T. castaneum, compared to the control, was significant ($P < 0.001$) (TAble 2). The reduction

in the adult weight after treatment with A. squamosa seed oil was dose dependent.
The results were analyzed by analysis of variance. All the treated media significantly reduced the adult weight in comparison with the control. The significant difference between the means of the adult weigfht was tested by using the Student-Newman-Keul multiple comparison test. The adult weight reduction at the higher dose, for example at 1440 ppm concentration of A. squamosa seed oil, was very high compared to the weight at the other doses.

DISCUSSION

PUPAL, AND ADULT WEIGHT AND DEVELOPMENT: The ether and petroleum ether insoluble resins have previously been extracted from A. squamosa seed oil and fed to the beetles. It was found that the oil has a profound effect, reducing the weight of all stages of T. castaneum. It also lengthened significantly the developmental period compared to the control.
Turmeric oil, sweetflag oil, neem oil and margosan "O" have repellent and growth inhibiting effects on the larvae, pupae and adults of T. castaneum (Jilani et al., 1988). These investigators found that the body weight of T. castaneum larvae, pupae and adults reared in treated wheat flour was significantly lower than that of the control, and that the reduction in body weight was dose dependent. The results of the present experiments using A. squamosa seed oil agree with the results obtained by Jilani et al (1988).
Other investigations have shown that nicotine incorporated into an artificial diet significantly reduced the 7-day old larval and pupal weights and prolongued the pupation time of the tobacco budworm Heliothis virescens F. (Gunnasena et al., 1990). Larval development to the adult stage was greatly delayed by Azadirachtin, and the reduction was dose dependent in Epilachna varivestis M., Ephestia kuehniella Zell., and Apis mellifera L. (Rembold et al. 1982). Nine different oils (almond, shark liver, khaskhas, groundnut, sesamum, castor, mustard, coconut and cucurbit) have been found to retard the growth and development of the larvae, pupae and adults of Trogoderma granarium and T. castaneum (Punji et al., 1970). The present studies, therefore, adds one more oil, that extracted from A. squamosa seeds, is an agent which significantly delayed larval development and reduced body weight of the adults, and the effect was dose dependent.

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Table 1. The efficacy of *Annona squamosa* Linn. seed oil on the pupal weight (µg) and developmental period (days) of *Tribolium castaneum* Herbst.

Dose (ppm)	Mean weight (µg) of pupae	± S.E	Mean pupal period (days)	± S.E.
Control	2486.25 a	± 85.20	3.75 a	± 0.48
90	2031.75 b	± 98.48	6.08 b	± 0.71
180	1855.75 be	± 68.63	7.31 b	± 0.63
360	1539.50 cd	± 24.70	8.17 b	± 0.56
720	1213.50 de	± 182.42	10.17 c	± 0.22
1440	934.75 e	± 151.21	10.59 c	± 1.03

Student - Newman - Keul (SNK) multiple comparison test values followed by the same letters are not significantly different at 5% level (P>0.05).

Table 2. The effect of *Annona squamosa* Linn. seed oil on the adult weight (µg) of *Tribolium castaneum* Herbst.

Dose (ppm)	Mean weight (µg) of adult ± S.E.	
Control	1992.20 a	± 64.48
90	1864.73 ab	± 43.00
180	1786.53 abc	± 86.96
360	1703.50 bc	± 85.73
720	1552.25 c	± 46.38
1440	1352.25 d	± 60.41

Student - Newman - Keul (SNK) multiple comparison test values followed by the same letters are not significantly different at 5% level (P>0.05). S. E. = Standard Error.

Sokoloff, A. Biology Department, California State University, San Bernardino, Ca 92410 and Hoy, M.J. Biology Department, University of Florida, Gainesville, FL 32602.

* Criteria for identifying the intensity of intra-species competition in *Tribolium*.

Weight and survival are attributes usually employed in studies of the effect of density on interspecies or intraspecies competition. Biomass usually describes the amount of living material directly related to the amount of energy fixed by the producers of an ecosystem. However, there is no reason why the use of this term cannot be extended to experimental studies of competition if used to inquire how much living material is produced by an organism from a given amount of food. In the present investigation we have used a known amount of flour to rear *T. castaneum* under different conditions of crowding and determined the individual and the gross weight of the adult survivors. It is in this context that we use the term biomass. This note is part of a more extensive investigation on intra-species competition in *Tribolium castaneum* which will be published elsewhere. But the use of biomass (rather than individual weights of survivors as a criterion for determining the intensity of competition, and a method of identifying cohorts in intraspecies competition studies may be of interest to population biologists.

MATERIALS AND METHODS

A. Strains and substrains.

The material used in this investigation was derived from two basic strains differing in body color and substrains were selected from them as follows:

1. Strains.

a. Berkeley synthetic strain. This is a highly heterozygous strain derived from seven laboratory strains (for method of synthesis see Lerner and Ho 1961 or Sokoloff 1974). Its phenotype is referred to as chestnut or red rust, the normal body color of the majority of species of the genus *Tribolium*. In this study, these beetles are referred to simply as strain E.

b. Black synthetic strain. This strain was obtained by crossing the semidominant black mutant with beetles from the Berkeley strain. The bronze F1 beetles were intercrossed, and the F2 black beetles resulting from these crosses were selected to obtain strain G, a black strain with the highly heterozygous Berkeley synthetic background.

2. Substrains. Ian Franklin, using the Berkeley synthetic strain, selected four strains for high body weight (HBW) and four strains for low body weight (LBW). These strains had been selected for 7 generations of brother-sister mating. For our study, Franklin made available one strain selected for HBW which weighed about twice as much as the strain from which it was originally derived, and another strain selected for LBW which weighed about half as much as the normal strain. At the time when these two strains became available for this study selection had been relaxed because of loss in viability (for details see

Franklin, 1967). To eliminate the inbreeding effects and to detect possible maternal effects in our study, HBW females were crossed with the Berkeley synthetic wild type males and HBW females giving A strain larvae heterozygous for the black gene. The reciprocal cross gave larvae which were likewise heterozygous for black and referred to as strain B larvae. Berkeley synthetic wild type males were crossed with LBW females to obtain C strain larvae, and the reciprocal cross gave D strain larvae. F strain larvae were obtained by crossing Berkeley synthetic males with black females; the reciprocal cross gave F' strain larvae. Finally, black beetles with Berkeley synthetic background were obtained by crossing Berkeley synthetic beetles with black, crossing the F1 to each other. In the F2 black beetles were crossed with each other to obtain the G strain. Although A-G are substrains derived from strain E, they will be referred to as strains in the rest of the paper. For a graphic representation of the relationship between the original and the derived strains see Fig. 1.

B. Procedure for controls and experimentals.

1. CONTROLS.

Larvae of each strain were allowed to pupate in corn plus yeast medium and allowed to hatch as imagoes. When they were 10 days old, 100 pairs of beetles of each needed strain were distributed over five oviposition jars containing corn flour enriched with brewers yeast in a proportion of 19:1, respectively. The adults were trasferred to fresh food daily to minimize cannibalism of the eggs. The eggs were allowed to hatch, and 0-4 hours-old larvae were aspirated into an empty vial and transferred to another vial containing 1 gram of medium. For each strain or combination of strains there were three densities (10, 40, and 100 larvae/gram). Ten replicates were set up for each a strain or combination of strains. The larvae were reared in an incubator maintained at 32°C. and 70% relative humidity. When the beetles hatched, they were sexed, identified to body color, and placed in separate empty vials according to sex and phenotype, and killed by placing the vials in a high temperature oven. The adults were then stored until time became available to weigh them. Prior to weighing them, the beetles in their vials were left overnight in an oven to dehydrate them. The contents were then placed <u>en masse</u> in an analytical balance, and the number of beetles producing the dry weight recorded.

2. Experimentals.

The sources of larvae for the experimentals were the same as for the eight strains just described for the controls. They were introduced into vials containing 1 gram of medium enriched with brewers yeast in the following combinations: AF, AF' AG, BF, BF', BG, CF, CF' CG, DF, DF' and DG in equal proportions, i.e., 5A and 5F to total a density of 10, 20A and 20F to equal a density of 40, and 50A and 50F for a density of 100, and the same for the other combinations of strains. The E strain was used only as a "control". It was not used in the experimentals because its phenotype is chestnut, the same as that of the A-D strains.

In all the 12 types of mixed-strain vials listed above, we could distinguish wild type adults from bronze adults by their color and not by their size, which may be unreliable as a criterion for identifying beetles to their respective strain when competition conditions are imposed at the higher densitities. For example, A or B HBW beetles may be reduced in size to such an extent as to be be confused with F strain beetles, and strain C or D LBW beetles may likewise be confused for F beetles at the high densities. However, since the F beetles are bronze (heterozygous for black) mistaken identification of the beetles to a a wrong strain is not likely to occur. Except for a few inadvertent technical errors, there were 10 replicates for each strain or strain combination, and density.

C. Analysis of data.

The data were analyzed by using Student's t-test, followed by Analysis of Variance and Multiple Regression Analyses to reinforce the conclusions, taking advantage of the SPSS (Statistical Package for the Social Sciences) developed for the IBM personal computer. Because of certain limitations of the program and because of the very nature of inter-density comparisons of biomass which will be discussed later, biomass data had to be converted into biomass per individual to be able to obtain the significance between any differences in the means. This conversion leads to values similar to those obtained when mean weight of individuals is considered and can be used to compare data across densities for each of the strains. The main difference lies in that, where weights are available the effect of sex on weight can be determined. In biomass, the values of males and females are combined, so the effect of density on the biomass of individual sexes cannot be determined.
With these introductory remarks out of the way, we can proceed to examine the actual results.

RESULTS

A. Effect of density on Survival and biomass.

1. Single strains.

a. Survival.

(1). Density 10.

Table 1 shows the symbols for the single strains used (column 1); the number of replicates (column 2) and the mean number of survivors to the adult stage. Due to technical errors the number of survivors in column 3 exceeds 100% for strains A and D. Strains B, C had an excess of 95% survival; strains E, F, F', and G had a survival rate of over 83%.

(2). Density 40.

Table 1 shows that all of the strains had a modicum of mortality. The largest mortality was observed in the G strain. Nevertheless, 78.75% of the beetles survived to the adult stage. The remaining strains had a survival rate of 89-98%.

(3). Density 100.

Table 1 shows that C, D, F, F' had the greatest survival rates (over 90%). The E strain had about 89% survival and the G strain had 72% survival. The lowest survival was observed in strains A and B, the HBW strains, which showed 45 and 65% survival, respectively.

(4). Other observations.

(a) Variance.

Columns 4, 5, and 6 in Table 1 show the standard deviation, the variance and the standard error, respectively, for all densities. Most notable are the variance values: At density 10, the variance is 2.1 units for strain D and much less for strains A, B, C, F, and F'. The highest variance (6.5) is seen for the G strain. In density 40, the variance of all strains remains less than 11 units, but the variance of the G strain increases to about 78 units. At density 100, the lowest variances are observed in the LBW strains (less than 20 units). Larger than 20 but less than 80 units are the variances obtained for strains F, and F'. A, B and E have a variance larger than 50, but less than 80 units. But strain G has a variance astonishingly valued at 457 units!

(b) Correction factor for survival.

Table 1a shows the strains shown in Table 1 (except for E) in column 1; the mean number of survivors (column (2) and their biomass (column 3). Because the mean number of survivors is not equal to density 10, we have corrected the biomass (given in column 3) to show, in column 4, the value the biomass should be had all the beetles survived to the adult stage. Thus, for example, we have a mean of 10.1 survivors of strain A which produced 12.67mg of biomass. Multiplying 12.67 by a factor of 10/10.1=12.52mg for the biomass of A at density 10. On the other hand, a mean of 9.7 B strain beetles produced 13.82mg. Therefore, 10/9.7 = 14.25mg is the corrected value for the B strain if we assume 100% survival. And so on for the other strains. For Density 40 (D-40), strain A, we divide the biomass by the number of survivors and multiply by 40 (49.56 x 40/37.7 = 52.58. The same procedure for data under density 100. The results will be like those shown in Table 1a.

We now ask the question: to what extent are the values in Table 1a consistent with expectation? In the experimental protocol we have increased the density from 10 to 40, a four-fold increase, and from 10 to 100, a 10-fold increase. All things being equal, the biomass for D-40 is expected to be four times greater than the biomass at D-10. (We chose D-10 as our standard on the assumption that at this density there is no competition between the beetles because there is an excess of food). The first four columns of Table 1b are identical to Table 1a. Column 5 in Table 1b shows the expected values of biomass corrected to 100% survival using the D-10 values as a standard. Actually we have two standards to compare the observed values: one is an "internal" correction: the biomass of a particular strain is multiplied by a ratio of potential survivors to actual survivors. The other is an "external" correction, and it utilizes the corrected results obtained at D-10 as a standard. An example will show the difference between the two types of correction:

1. Internal Correction.

Strain	Col. 3	Correction factor	= Column 4
A	49.56	40/37.7	= 52.58
B	52.87	40/37.3	= 56.70

(Under Col. 4 are the Expected values for A and B at D-40).

For D-100 A = 48.49; B + 77.86. Correcting for mortality:

A = 48.9 X 100/44.9 = 108.9
B = 77.8 X 100/95.4 = 119.4

2. External correction:

D-40; A = 49.56; B = 52.87

Basing calculations on values in D-10, column 4:
A = 12.52 X 4 = 50.08
B = 14.25 X 4 = 57.00

D-100: Standard from values in D-10:
A = 12.52 X 10 = 125.2
B = 14.25 X 10 = 142.5

for the comparisons at D-40, when mortality is low, sometimes the internal and other times the external correction results will give a closer value to the observed value.
For D-100, if the survival is high, there will be little difference between the observed and either the internal or external correction. If the survival is low, the observed biomass will be so different from the corrected values that it makes little difference whether the observed values are compared to the internally or externally corrected values.

2. Mixed-strains.

a. Survival.

Table 2 shows the basic statistics for survivors for each of the strains involved. For each of the three densities, the strains involved are shown in column 1, the number of successful replicates is shown in column 2. Columns 3 to 7 show the symbol of strain 1 (also referred to as genotype 1) in column 3, the mean number of survivors in column 4 and in columns 5, 6, and 7 are shown the corresponding standard deviation, the variance, and the standard error. Columns 8-12 show the same statistics for genotype 2. The survival of the various strains at the three densities can be summarized as follows:

1. Density 10. The mean survival values for strains A and B (the HBW strains) and C and D (the LBW strains) are comparable: For the HBW strains the average survival value is 96.3%; for the LBW strains it is 96.7%. For the F strains 95.5, for F' 91% and for the G strain only 77%.

2. Density 40. The mean survival value for the HBW strains is 97.7%, for the LBW 98.1%, and for the F, F' and G strains the survival values are 79.4, 89.4 and 69.1%, respectively.

3. Density 100.

The mean survival value for the HBW strains drops markedly to 66%. The LBW strains maintain a high survival value of over 93.8%. The F and F' strains have a mean survival value of 73.4 and 72.2%, respectively, and G drops in mean survival to 58.7%.

A glance at Table 2 shows that there is a decrease in survival as density increases. The HBW strains are most affected by the increase in density, and of these, strain A is more affected than strain B. The C and D LBW strains are minimally affected. Of the intermediate weight strains, the F and F' 95.5 and 91%, respectively at D-10, drop to 79.4 and 89.4 at D-40, and to 73.4 and 72.2% respectively at D-100. The G strain shows a gradual drop from 77% average survival at D-10, to 69.1% at D-40, and 58.7% at D-100.

4. Other observations.

(a). Variance.

Analysis of the data in the single strains showed that the variance was a useful statistic to determine the effect of density on survival. Examination of the variance in Table 2 shows that generally, at D-10, the variance is very low (less than one unit) for most strains, and less than 2 units for strains F' and G. As density increases, the variance at D-40 increases to 2.5-5.1 units for most strains. The only exception is the G strain whose variance becomes 7.5 units.

For D-100, the variance of the A and B strains is about 58 and 27 units, respectively. For the C and D strains is about 12 and 16 units, respectively,. For the F and F' strains the variance is about 24 units.

Although the variances in Table 2 are high, those in Table 1 (for the single strains) are much higher. We can conclude from these values that both strains benefit by being reared in association with another strain in mixed-strain vials.

b. Biomass.

Table 2a summarizes the basic statistics of biomass for each strain (genotype). The mean and its standard deviation are given for 10 replicates of each strain except as noted. As we have done for survival, column 1 gives the symbols for the strains reared together; column 2 gives the symbol of one of the strains; column 3 gives the number of replicates; column 4 and 5 the biomass and its standard deviation; column 6 gives the symbol of the other strain (genotype 2); column 7 the number of replicates; columns 8 and 9 the biomass and standard deviation of the other strain (genotype 2). Columns 10, 11 and 12 give the t-values, degrees of freedom and p values respectively, obtained when genotype 1 and genotype 2 are compared within a density. Column 13 gives the significance of the p value obtained. Column 14 gives the total biomass produced by genotypes 1 and 2, and columns 15 and 16 the percentage of the biomass produced by each of the strains of genotype 1 and 2, respectively. (The figures in parenthesis are sums of the six percentages obtained at that block of numbers).

Table 2a shows the overall results of the biomass calculations:

1. Density 10

Taking the data at face value, at D-10 the greatest average biomass is that produced by HBW strains A and B (7.2 and 6.9mg, respectively), and the lowest is produced by the LBW strains C and D. (4.0 and 4.4 mg, respectively). The biomasses of the F, F', and G strains are intermediate between the HBW and LBW strains (5.8, 5.5 and 4.2mg, respectively).

2. Density 40.

The relative standings of the biomasses at this density are not altered: the HBW strains produce the greatest biomasses, both producing about 28 mg.; the C and D strains produce the lowest biomasses (16 and 18mg, respectively); the F, and F' strains are intermediate (19 and 21mg, respectively) and the G strain produced 15mg of biomass. All things being equal and basing the theoretical values on those obtained in D-10, the expected values for A = 28.8; B = 27.6; C = 16; D = 18; F = 23; F' = 22; and G = 16.5 mg., so the observed and the theoretical (uncorrected) values are very close.

3. Density 100.

The observed biomasses at D-100 do not change their relative standing from that observed at D-10 and D-40, but the expected and the observed values have become highly disparate. In the following we list the strains alphabetically, and the observed and expected values in that order: A 34 and 72; B 53 and 69; C 40 and 40; D 41 and 44; F 41 and 58; F' 39 and 55; and G 31 and 42. The fact that C and D agree between their observed and calculated values suggests that the LBW strains are the only ones obtaining sufficient food at this density. The remaining strains are actively competing for the available food supply, but A and B are the strains showing the most obvious effects of starvation.

c. Ratio of biomasses of coexisting strains.

Before undertaking long series of calculations using statistical methods, a few simple calculations were carried out the better to understand the data: Ratios were calculated to obtain a trend, if any, other than a visual observation that as density increases the variance of the biomass increases.

It was expected that ratios of Hi over Intermediate strains would give a ratio greater than 1, and ratios of Lo over intermediate would give a ratio less than 1 under normal conditions, but it might be modified under abnormal conditions such as high density, and it might be altered at the higher densities in an unknown way, since all of the strains were highly heterozygous but differed in their body-weight determining genes.

The results were interesting: On face value, the HBW strains appeared to be more efficient in the production of biomass than the F, and F' strains by 10-28% (the difference in their body weights) and more so than the G strain by a factor of 54-65%. The C and D strains were less efficient in producing biomass than the F and F' strains by a factor of .01 to +.20, and by a a factor of -.01 to .12% compared with the G strain. As crowding increased to D-40, the A and B strains increased in biomass 32-53% over the F and F' strains and 71-100% over the G strain. The C strain was less efficient than the F or F' in producing biomass by a factor of 16%, while the D strain was less efficient than the F' strain by 16%, but more efficient than F by 11%. Both C and D were more successful than the G strain in producing a biomass by a factor of 10 and 26%, respectively. At D-100 the level of efficiency in biomass production of the A and B strains over the F and F' strains was between 23 and 37% for A and between 36 and 64% for B. A was inferior in biomass production to G by 12%, while B was superior to G by 84%. C was inferior to F and F' in biomass production by 5 and 6% respectively, while D was inferior by 18 and 25%, respectively. Both C and D were superior to G in biomass production by a factor of 28 and 31%, respectively.

e. Ratios of biomass using D-10 as standard.

Assuming the biomass values given in D-10, columns 4 and 9 are correct, we have calculated the expected values of biomass for genotype 1 and genotype 2 combinations in columns 17, 18, and 19 and the corresponding percentages for each strain in columns 20 and 21 in Table 2a, part 2, and from columns 17 and 18 we have re-estimated the ratios with the following results:

1. Density 40.

For D-40, the ratios of A and B with F and F' show that the biomass of A is greater than F and F' by 16 and 20%, respectively, while that of B is greater by 10 and 28%. The ratios of A with G and B with G show that biomass of the HBW strains is 70 and 54%, respectively, than the G strain. The C and D strains biomass is less than the biomass of F and F' by 7 and 20% for C, while that for D is less than F and F' by 6 and 19%, respectively. The biomass of G, when reared with C, is equal. When G is reared with D the biomass of G is less by 12.5%.

2. Density 100.

For D-100, the ratio of biomass is about 16 and 21% greater for A and 10 and 27% greater for B over F and F'. The ratio of A and B is 63 and 56% greater, respectively over G. The C and D ratios of biomass are below by 17 and 20% with F, respectively, and 6 or 19% lower, respectively when compared with F'. Finally, the biomasses of C and G are equal, while that of strain D is greater than the biomass of G by 12 per cent.

The above estimates for biomass ratios have been determined without any correction. Table 2b shows the corrected values of genotype 1, genotype 2 and the sum of genotypes 1 and 2. The corrected values are based on observed numbers of survivors of each genotype. For example, for D-10 in the AF vials, there was a mean of 4.5 beetles out of 5 A larvae originally introduced, a 90% survival which weighed 6.95mg. Therefore to correct this for 100% survival we multiply 5/4.5 X 6.95 = 7.72 for genotype 1; 5/4.9 x 5.99 = 6.11 for genotype 2 and 10/9.4 X12.94 = 13.83 for the corrected values of genotypes 1 + 2. Density 10 provides the standard values for the determination of the theoretical values for D-40 and D-100 just as we did for single strains.

3. Correction factor for biomass.

Table 2c is an abbreviated version of Table 2b. Column 1 shows the combination of mixed strains; column 2 the strain referred to as genotype 1; column 3 the mean number of survivors for genotype 1. Column 4 the mean weight of survivors of genotype 1. Column 5 gives the corrected weight assuming 100% survival. column 6 gives the symbol for genotype 2; column 7 the number of survivors; column 8 the mean weight of biomass of genotype 2; column 9 the corrected value based on 100% survival; and column 10 the total biomass (adding columns 4 and 8). We can now see how close the observed and the calculated values of biomass are to each other.

Density 10.

All the comparisons between biomasses 1 and 2 are very close to each other. The greatest difference between the genotypes grown together in mixed strain vials is observed for strain G when grown with C (0.88mg). The remaining biomasses differ much less than that.

Density 40.

At this density there is a greater gap between the observed and the calculated biomasses, especially if there is a large drop in the number of survivors. A, reared with F has the greater difference in biomass. But the difference in biomass between A and F' and A and G is less than 0.2mg. B with F, F' and G have a difference between observed and calculated biomass of the order of 0.4-2.2mg. C and D differ from F, F' and G by 0-1.2mg. On the other hand, F, F' and G range in difference from 0 to almost 8 at this density.

Density 100.

At this density the difference between the biomasses of co-existing strains becomes manifest: The differences in biomass between F and F' observed and calculated values when reared with A is 11.7-25.5mg; 10-19 when reared with B; 9-14mg when reared with C and 5.5-6.3 when raised with D. The difference between G and A is 17.5mg; with B it is 24.7mg; and with C and D the difference is about 22 units. Occasionally we may observe that the weight of biomass of the C and D strains may significantly exceed the weight of the G strain, which under less dense conditions behaves as an intermediate weight strain.

Table 3a summarizes the number of replicates, the mean weight of the biomasses produced at three densities with their accompanying statistics (mean, standard deviation, variance and standard error) by the single strains, and Table 3b does the same for the two strains in mixed strain vials. Tables 4a and 4b do the same as Tables 3a and 3b, except that instead of number of replicates the number of individuals (survivors) contributing to the biomass is given. In Table 4a the biomass estimated from values in D-10 are used as standard to contain the calculated values in biomass for D-40 and D-100.

d. Paired comparisons.

The statistics given in Tables 4a and 4b have been used in paired comparisons to determine whether the difference between the means is significant or not by applying Student's t-test.

The results of the t-tests have been summarized in graphic form in Fig. 4 for the single strains; in Fig. 5 for the biomasses of mixed-strains of genotype 1 and genotype 2 within a vial, and in Fig. 6 for comparisons between a given genotype between single and mixed-strains.

1. Single strain comparisons.

a. Density 10.

Fig. 4, D-10 shows that the A and B strains are significantly different from each other and from every other strain used. None of the other paired comparisons of the other strains (i.e. LBW and Intermediate weight strains) is significant.

b. Density 40.

The A and B strains are significantly different from each other and from every other strain. For the other paired comparisons, C is not significantly different from D, E, or G, but it is significantly different from F and F'. Strain D is not significantly different from E, nor from G, but it is significantly different from F' and G. F is significantly different from strains F' and G, and F' is significantly different from G.

c. Density 100.

A is significantly different from every other strain; B is significantly different from F and F'; C is not significantly different from D, but both C and D are significantly different from E, F, F' and G. E is significantly different from F and F', but not from G. F is not significantly different from F', but both F and F' are significantly different from G.

2. Mixed strain comparisons of genotypes 1 and 2.

a. Density 10.

Fig. 5 shows that the HBW strains A and B and the LBW strains differ significantly from the intermediate weight strains F, F' and G.

b. Density 40.

The HBW and LBW strains differ significantly from each other and from the intermediate strains F, F' and G.

c. Density 100.

The D strain is not significantly different from the F' strain, nor from the G strain. Every other paired comparison is significantly different.

3. Comparisons between single and mixed-strains.

The only useful comparisons are those between single and mixed-strains of the same genotype, and these are summarized in Fig. 6.

a. Density 10.

The single strain A in group 1 differs significantly from A in groups 9, 10, 11. The B strain in group 2 differs significantly from B in group 13 but not from Groups 12 or 14. C from group 3 differs from C in groups 15, 16, 17. D from group 4 differs significantly from D in group 20, but not in groups 18 or 19. F in group 6 differs from F in groups 9, 12, 15 and 18. F' in group 7 differs significantly from F' in groups 10, 13, 16, and 19. G in group 8 differs from G in groups 11, 14, and 20, but not from G in 17.

b. Density 40.

A in group 1 differs significantly from A in groups 9,10,11.

B in group 2 differs from B in group 14, but not from B in groups 12 and 13.

C in group 3 differs from C in group 15 but does not differ from C in groups 16 and 17.

D in group 4 differs from D in groups 18 and 20 but not from D in group 19.

F in group 5 differs from F in group 12 but not from d in groups 9, 15 and 18.

F' in group 6 differs from F' in groups 10, 13, 16, and 19.

G in group 8 differs from G in groups 11, 14, 17, and 20.

c. Density 100.

A in group 1 differs from A in groups 9 and 11, but not from 10.

B in group 2 differs from B in groups 12, 13 and 14.

C in group 3 does not differ from C in groups 15, 16, 17.

D in group 4 differs from D in group 20 but not from groups 18 or 19.

F in group 6 differs from F in group 9, but not from groups 12, 15 or 18.

F' in group 7 does not differ from F' in groups 10 or 13, but it does differ from groups 16 and 19.

G in group 8 does not differ from G in groups 11 and 14 but does differ from G in groups 17 and 20.

E. A further model for testing survival and biomass. Based on the results obtained for the single strains summarized in Table 1b, column 4, we have created some data to serve as a model against which we could compare the resul ts of the mixed-strains of equivalent density. Since mixed-strain vials consist of larvae of st rain 1 and strain 2 in equal numbers, we have added the corrected values of strain A (12.52) and strain F (10.5) in density 10 and divided their sum by 2 (i.e., 12.52 + 10.5/2 = 11.51. This procedure was repeated for all the remaining combinations of strains for all the three densities. Next we have compared each of these values with the values obtained at equivalent densities and combinations of strains with the results summarized in Table 5c, left, under the heading of single strains. Then we have transferred the corrected values of Table 2b, column 12 and transferred them to Table 5c, right column, under the heading mixed-strains for immediate visual comparison. The results are obvious if it is remembered that at D-40 the number of initial larvae is four times the number of larvae introduced into vials at D-10, and the number at D-100 is ten times larger than at D-10: Looking at Table 5c it is evident that there is very little difference between the calculated and the observed values as expected. At D-40, the values for combinations including the C or D strains are closer than the values that include the A or B strains. At D-40 the differences between the observed and the theoretical values, especially for the combinations that include the A and B strains become more obvious. At D-100 the closest data between the calculated and observed values, as expected are those for mixed-strains involving C and D strains. The biomasses of mixed strains involving A and B are generally higher than the calculated values. This, again, leads to the conclusion that at high densities in vials involving C and D strains, both LBW and the intermediate weight strains, by being reared together, are able to produce a greater biomass than single strains of equivalent density. Mathematically, it makes sense that if food is abundant, a large strain and a middle sized strain will produce as much biomass as they are physiologically capable. If food is in short supply, larger body sized strains will show a greater mortality and reduction in body size than smaller sized strains. And 50 A (HBW) larvae, grown with 50 F (intermediate) larvae in one gram of medium will fare much better than 100 A larvae grown in the same amount of food. However, the genotype of the strain is also important as we have seen: Judging from the behavior of the black body color strain G the genetic make up is important: Even though this strain had the same heterzozygous backgroun as the other strains apparently G is more sensitive to crowding, resulting in beetles with lower survival even at the lowest - density, and at higher densities it showed a greater reduction in body weight that other strains of comparable intermediate size.

F. Variance of biomass.

By squaring the standard deviations shown in Tables 6a and 6b we can obtain the variance of each strain and some idea of the effect of density on the biomass of each strain. The results of our analysis are as follows.

Single strains.

It will be recalled that first instar larvae were introduced into vials containing 1g of flour at densities of 10, 40, and 100 larvae per vial. There were 10 replicates for each strain and density.

Density 10.

The variance for strains A-E exceeds one unit of variance, but it is less than 3 units. The variance for the F and F' strains, F1 heterozygotes of crosses between E and G are less than 1 unit. The variance of the G strain exceeds 6 units, and it is the most variable of all strains even in the absence of crowding. We will use these values as a standard.

Density 40.

There is no increase in the variance of strain D. For the remaning strains, there is roughly a four-fold increase in variance for strain B and a 10-fold increase for strains A, C and E, an increase of 9-15 times in the variance of F and F', and a 12-fold increase for the variance of strain G.

Density 100.

The least increase in variance is exhibited by strains C and D. C increases only 8-fold over the variance observed in density 10, while D shows a 38-fold increase in variance. Strain e variance increases about 60X the value observed in density 10. F' increases by 100X and F' by more than 200x the values observed in density 10. Strain G increases by 80 fold the variance observed in Density 10.

In the single strain biomass data in Table A we can see that at density 10 the variance of A and B (the Hi body weight strains) and C and D (the Lo body weight strains is comparable. The F and F' (heterozygous for black) show the lowest variance and G, the black strain, shows the highest variance.

Density 40.

All the strains show an increase in their respective biomasses, which have become about 4 times larger than those observed in density 10, as expected. The variances of comparable strains have not encreased equally: The variance of A has increased five-fold, while tha variance of B has increased about four-fold over that observed at D-10. The variance of the C strain has increased about five-fold, while that of the D strain is about the same as that observed in D-10. The variance of the E strain has increased about seven-fold over the variance in D-10. The variance of the heterozygous strain F has increased about 9-fold, and that of the strain F' has increased almost 20-fold.

At density 100, the variance of A and B has increased 100-200-fold, compared with that of density 10. The variance of strains C and D, although the lowest for all strains, has increased about 8-fold for strain C and 30-fold for strain D. The E strain has increased 50-fold over that seen in D-10. F and F' have increased in variance about 200-fold and 300-fold, respectively over that observed at D-10, and the variance of G, the black mutant strain, has increased 80-fold.

Mixed-strains.

We refer now to Table 6b to obtain a rough picture of what is happening to the biomasses and variances of co-existing strains.

Density 10.

Strain A, co-inhabiting with strains F, F', and G, has a variance of about 1.5-1.6 units when reared with F and F', respectively, and about 0.8 units when reared with strain G. Variance of B, when reared with F, gives a variance of 1.000, about 0.7 when reared with F' and about 0.3 when reared with G. The Lo body weight strains C has a variance which ranges from 1 to about 0.6 when reared with F, F', and G, and D, when reared with the same middle weight strains has a variance of 0.1 to 0.6. The F, F' and G strains have very low variances, ranging from .02 to 0.5.

Density 40.

the variances for the Hi body weight strains A and B range from 1.5 to 10.6 for the A strain, and from 3 to 6 for the B strain. The Lo body weight strains range in variance from 0.6 to 6.1 for the C strain and from 0.4 to 7.6 for the D strain. None of the strains co-inhabiting with A, B, C, or D has a variance exceeding 1.2 units.

Density 100.

The variance of the Hi body weight strain A ranges from 80 to 184, while the variance for the Hi body weight strain B ranges from 41 to about 79 units. For the Lo body strains the variance has increased from 4.3-11.6 units for the C strain and from 10 to 22 units for the strain D. For the intermediate weight strains, The variances of the F strain range from 2.1-16.9; for the F' from 3.4 to 25.6 and for the G strain from 1.7 to about 35 units.

To simplify the presentation all the variances of each strain have been pooled and averaged for the number of entries (three entries each for the A, B, C, D strains, and four for the F, F', and G strains with the following results:

Density 10

A: 3.93/3 = 1.31	F: 0.686/4 = 0.172
B: 2.01/3 = 0.67	F': 0.395/4 = 0.10
C: 1.04/3 = 0.34	G: 0.576/4 = 0.144
D: 1.08/3 = 0.36	

Density 40

A: 22.1/3 = 7.36	F: 1.51/4 = 0.377
B: 13.7/3 = 4.89	F': 2.23/4 = 0.558
C: 9.6/3 = 3.20	G: 3.33/4 = 0.832
D: 11.8/3 = 3.92	

Density 100

A: 381.8/3 = 127.3	F: 27.9/4 = 6.98
B: 193.6/3 = 64.5	F': 67.45/4 = 16.86
C: 25.2/3 = 8.4	G: 89.77/4 = 22.44
D: 42.2/3 = 14.1	

The simplified table above shows that at Density 10 only one of the strains (A) exceeds one unit of variance. Strains B, C, and D range between 0.36 and 0.67 units of variance, while the F, F' and G strains have a variance between 0.1 and 0.17 units

At D-40, A and B, the Hi body weight strains have a variance of about 7 and 5 units, respectively, and the Lo weight strains C and D have less than 4 units of variance. The intermediate weight strains F, F' and G still have a variance lower than one unit.

At D-100, the greatest increase in variance is observed for strains A and B, the Hi body weight strains with 127 and 64 units, respectively. Overall, the A strain produces a lower biomass and a higher variance, and the B strain produces a higher biomass and a lower variance. The C and D Lo body weight strains have a much lower variance than A and B, but comparable to the variance of F and F'. The G strain has a higher variance than F and F' and C and D, but much lower than the variance of A and B.

When we compare the data of the single strains in Table 6a with the data in 6b it is evident that the highest effect of density becomes manifest in the Hi body weight strains which show a greater mortality, greater loss in biomass, and greatest variability. A similar effect is observed in the performance of G, the black mutant strain, but this effect has a different cause: the black strain does well in low population density conditions, but it has a lowered viability under crowded population conditions as Sokoloff (1977) has shown.

DISCUSSION AND CONCLUSIONS

The present paper deals only with survival and biomass as criteria for determining the effect of density in intraspecies competition. These two criteria and two others (weight by gender and disregarding sex, and development) will be the subject of a more comprehensive paper to be published elsewhere.

We have chosen biomass rather than weight of individuals as one of the criteria because biomass data are somewhat easier to obtain than individual weights, and yet, to our knowledge, this criterion has seldom (if ever) been used by population biologists. The section on Results is rather long, but this is due to our desire to see whether statistical models other than variance could be used more readily to detect competition.

The main findings of this investigation are as follows:

1. Survival.

For convenience and to visualize what is happening, we offer a histogram of the single strains (Fig. 2) and one for each density to show survival of the individual strains (Figs. 3, a, b and c).

a. Single strains (see Fig. 2).

(1) A and B, the HBW strains) show about the same percentage of survival at D-10 and D-40, but a significant drop in survival at D-100.

(2) C and D (the LBW strains) show no significant changes in their near 100% survival in all of densities used.

(3) The IBW (intermediate weight strains (=IWS) E, F, F' and G, show about the same mortality at D-100: there is a significant difference in survival for E and G, but not for F and F'.

B. Mixed-strains (see Figs 3a, 3b, and 3c).

(1) D-10. The A, B, C, D, F and F' strains show about the same percent survival, F has a higher survival than F'; G has a lower survival than A, B, C or D.

(2) D-40. The survival for strains A, B, C, and D is maintained over 90%. F shows a significant drop in survival over that shown by A, B, C, and D; F' has lower survival than B and D; G has a lower survival than A, B, C, and D.

(3) D-100. A and B have a severe drop in survival; C and D maintain their high level of survival. F has a lower survival (about 60%) than at D-10 and D-40. F drops in survival to 50% with A 60% with B, but it stays at 80% or 90% survival with C or D. G has 60-65% survival with A or B, but higher (about 75% survival) with C or D.

2. Biomass.

a. Single strains.

The data in Fig. 4 show that, at D-10 and D-40, A and B are significantly different from each other and from every other strain used. C and F are not significantly different from each other at D-10, but at D-40 F is significantly different from C, D, and E; F' is significantly different from C, D, and F, and G is significantly different from F and F'. At D-100 A remains significantly different from the remaining strains except G; B is significantly different from F and F'; C and D are significantly different from E-G. E differs from F and F; F is not significantly different from F' but is different from G. F' is also significantly different from G.

b. Mixed-strains

As can be seen in Fig. 5, the two genotypes reared together in combinations AF to DG are significantly different at D-10 and D- 40. At D-100 strain combinations AF to DF are still significantly different, but combinations DF' and DG are not.

c. Comparisons between single strains with same genotype in mixed strain.

We omit the E strain because it was not involved in inter-strain competition. Out of 24 comparisons possible for each density, 5/24 comparisons at D-10 were not significant while 19/24 were significant; at D-40 8/24 were not significantly different while 16/24 were. At D-100 13/24 were significantly different, while 11/24 were not. Note that as density increases the number of significant paired comparisons decreases, meaning that the biomass of single strains becomes of the same order of magnitude at the highest densities.

D. Models.

The discovery that a few technical errors had been made while the experiment was being set up (resulting in survivals of larvae to >100%) led us to attempt to apply some corrections to the data. We also noted, comparing densities, that biomasses of D-40 increased very close to four-fold, over the biomasses obtained at D-10, and the biomasses of D-100 did not increase ten-fold over those at D-10 (all things being equal). Since the survival values of the single strains is not equal, survival was equated by multiplying the biomass by a ratio (see Section on Results for examples), which became a corrected biomass. It was observed that the observed biomass at D-40 was very close to the expected value using the corrected value of the biomasses of each strain at D-10 and multiplied by 4. But the observed and expected biomasses for D-100 differed significantly even with correction. The discrepancy between the observed and the expected values of biomasses at D-100 and not at D-40 is attributed to the onset of competition at a density somewhere between 40 and 100 larvae per gram. In other words, when competition is taking place at these higher densities, it will become evident because there will be fewer survivors and the biomass values between observed and calculated values will be obviously different. Similar conclusions can be made for the models developed for the mixed-strain vials.

d. Variance.

One of the advantages of the personal computer is that statistics such as mean, standard deviation, variance and standard error, among others, are very easy to obtain. This is very useful because the variance which is the standard deviation squared, greatly magnifies any differences in the standard deviation. In the present paper we have seen that each of the strains, not unexpectedly, had its own variance. The variance may be vary low at low densities but increase tremendously at densities where competition is taking place, and it may increase even further in strains which are sensitive to crowding such as the G strain.

Thus, variances can be used as an index of the degree of competition taking place or sensitivity of the strain(s) to crowding. In mixed-strains, the variances shown in Table 2 are high, but they are not as high as those for single strains in Table 1. The highest variances are reached at D-100 for strains A and B (the HBW strains) and the lowest for strains C and D (the LBW strains). Those for F, F' and G are intermediate, but G's variance is higher than the variance of F or F'. Because the variances in Table 2 are lower than the variances in Table 1, we conclude that in mixed strain vials both strains benefit from being reared in association with another than being reared singly at the same density, especially if there is a big difference in the size of the two strains. We believe this is the first time that such a phenomenon has been observed experimentally in the Coleoptera.

Finally a few words about the interaction observed in these experiments. As the title of the paper indicates, we regard the interactions observed both within and between the highly heterozygous strains of T. castaneum as being examples of competition. Competition and not predator-prey interaction because the interactions occurred for less than one generation in duration (first instar larvae 0-4 hours old were used to initiate the experiments in all single strain and mixed-strain vials) and the experiment was brought to an end when the adults were obviously sexually mature (there were no imagoes that were white or pale in color). Thus, during the experiments, larvae are growing synchronously within vials of the same density. Differences in density may result in a decrease in size of the adults at density 40 and density 100 (as manifested by the total biomass and a decrease in the number of survivors, especially in the HBW strains at D-100, which resulted, in our opinion, from a shortage of food and not from predator-prey interactions. Although predator-prey interactions have been demonstrated in Tribolium (see Sokoloff 1975 and Sokoloff 1977), they are observed in long lasting experiments of several generations or several years duration, when the components of a population (eggs, larval instars, prepupae, pupae, teneral adults and mature adults) cannot be controlled. In our view, by starting the experiments with larvae 0-4 hours old we have minimized age differences in both single strain and mixed-strain vials and cannibalistic propensities which may occur: large larvae or adults preying on egg, small larvae, pupae or teneral adults. Since all the individuals were of about the same age in any given vial, the decrease in survivors at the higher densities is ascribed more to the shortage of food or to natural mortality than to predator-prey interactions.

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LEGENDS FOR TABLES

Table 1. Survival statistics, single strains.

Table 1a. Abbreviated statistics of survivors and biomasses of strains. Column 1 gives the symbol of the strains; Column 2 the mean number of survivors; strains. Column 3 gives biomass of survivors as observed. Column 4 the corrected biomass assuming 100 per cent survival,

Table 1b. For legends for columns 1 to 4 see Table 1a. For column 5 biomass of the single strains has been calculated using Density values as standard.

Table 2. Statistics for survival of genotypes 1 and 2 in mixed-strain vials.

Table 2a. Mean (mg) of biomass of genotypes 1, genotype 2, and the total biomass of genotype 1 + 2.

Table 2a, Part 2. Biomass of genotype 1 and genotype 2 and percent of genotype 1 and paercent of genotype 2.

Table 2b. N survivors, biomass and biomass corrected to 100% survival for genotyupe 1, genotype 2, and genotypes 1 + 2.

Table 2c. Same as 2b, simplified.

Table 3a. Statistics for N replicates and total biomass of genotype 1 and 2.

Table 3b. Statistics for N replicates and biomasses of genotypes 1 + 2.

Table 4a. Statistics for N survivors and biomass of genotypes 1 and 2,

Table 4b. Statistics for strains of genotypes 1 and 2.

Table 4c. Biomass of genotype 1 corrected to 100% survivors and genotype 2 corrected to 100% survivors. Total biomass. Percent of genotype 1 and 2 in the biomass. Ratio of larger biomass/smaller biomass. Column 8, expected biomass using that of D-40 in column 7 as standard and assuming 100% survivors.

Table 5a. Simplified survivors and their biomasses (Mixed-Strains).

Table 5b. Survivors and biomass expected taking from Density 10 values as standard.

Table 5c. "Corrected" values assuming 100% survivors (left column) vs values derived from Table 1b.

3/ 10/ 95

TABLE 1

DENSITY 10

(1)*	(2)*	(3)*	(4)*	(5)*	(6)*
A	10	10.1	1.101	1.211	0.348
B	10	9.7	0.675	0.456	0.213
C	10	9.6	1.265	1.600	0.400
D	10	10.1	1.449	2.100	0.458
E	9	8.444	1.333	1.778	0.444
F	10	8.600	0.843	0.711	0.267
F'	10	8.300	0.675	0.456	0.213
G	9	7.556	2.555	6.528	0.852

DENSITY 40

A	10	37.7	1.494	1.233	0.473
B	10	37.3	1.418	2.011	0.448
C	10	39.3	2.111	4.456	0.667
D	10	39.1	1.912	3.656	0.605
E	10	35.7	2.669	7.122	0.844
F	10	36.6	2.271	5.156	0.718
F'	10	36.8	3.225	10.400	1.020
G	10	31.5	8.860	78.500	2.802

DENSITY 100

A	10	44.9	8.865	77.878	2.791
B	10	65.2	7.843	61.511	2.480
C	10	95.4	3.748	14.044	1.185
D	10	96.2	4.442	19.733	1.405
E	8	70.88	8.741	76.411	3.091
F	9	85.78	6.978	48.694	2.326
F'	9	85.78	6.978	48.694	2.326
G	10	72.00	21.377	456.989	6.760

* 1. Strains;
2. Replicated number;
3. $\overline{m}$;
4. S.D.;
5. Variance;
6. S.E.

TABLE 1a

DENSITY 10

(1)*	(2)*	(3)*	(4)*
A	10.1	12.67	12.52
B	9.7	13.82	14.25
C	9.6	8.04	8.38
D	10.1	8.35	8.27
F	7.9	8.30	10.50
F'	9.3	8.26	8.88
G	6.8	6.47	9.51

DENSITY 40

A	37.7	49.56	52.58
B	37.3	52.87	56.70
C	39.3	33.66	34.26
D	39.1	32.77	33.52
F	36.6	42.34	46.27
F'	36.8	36.64	39.82
G	31.5	30.14	38.27

DENSITY 100

A	44.9	48.49	108.00
B	65.2	77.86	119.42
C	95.4	82.23	86.19
D	96.2	80.96	84.16
F	77.2	98.38	127.44
F'	83.5	90.94	108.91
G	65.1	64.33	98.80

*The headings for this table are:
1. Strains;
2. Mean number of survivors;
3. Biomass observed;
4. Biomass corrected to 100% survival.

TABLE 1b

DENSITY 10

(1)*	(2)*	(3)*	(4)*	(5)*
A	10.1	12.67	12.52	
B	9.7	13.82	14.25	
C	9.6	8.04	8.38	
D	10.1	8.35	8.27	
F	7.9	8.30	10.50	
F'	9.3	8.26	8.88	
G	6.8	6.47	9.51	

DENSITY 40

A	37.7	49.56	52.58	50.08
B	37.3	52.87	56.70	57.00
C	39.3	33.66	34.26	33.52
D	39.1	32.77	33.52	33.08
F	36.6	42.34	46.27	42.00
F'	36.8	36.64	39.82	35.52
G	31.5	30.14	38.27	38.04

DENSITY 100

A	44.9	48.49	108.00	125.20
B	65.2	77.86	119.42	142.50
C	95.4	82.23	86.19	83.80
D	96.2	80.96	84.16	82.70
F	77.2	98.38	127.44	105.00
F'	83.5	90.94	108.91	88.80
G	65.1	64.33	98.80	95.10

*The headings for this table are:
1. Strains;
2. Mean number of survivors;
3. Biomass observed;
4. Biomass corrected to 100% survival;
5. Expected biomass using "Density 10" values as standard.

3/ 10/ 95

TABLE 2

DENSITY 10

		Genotype 1						Genotype 2			
(1)*	(2)*	(3)*	(4)*	(5)*	(6)*	(7)*	(8)*	(9)*	(10)*	(11)*	(12)*
AF	10	A	4.5	0.707	0.500	0.224	F	4.9	0.568	0.322	0.180
AF'	10	A	4.8	0.789	0.622	0.249	F'	4.7	0.675	0.456	0.213
AG	10	A	5.2	0.422	0.178	0.133	G	3.7	1.252	1.567	0.396
BF	10	B	4.7	0.483	0.233	0.153	F	4.9	0.316	0.100	0.100
BF'	10	B	4.7	0.483	0.233	0.153	F'	4.7	0.483	0.233	0.153
BG	6	B	5.0	0.000	0.000	0.000	G	4.1	0.408	0.167	0.167
CF	10	C	4.7	0.483	0.233	0.153	F	4.6	0.843	0.711	0.267
CF'	10	C	4.6	0.699	0.489	0.221	F'	4.5	0.707	0.500	0.224
CG	10	C	5.0	0.471	0.222	0.149	G	4.0	0.667	0.444	0.211
DF	10	D	4.7	0.675	0.456	0.213	F	4.7	0.675	0.456	0.213
DF'	10	D	5.1	0.568	0.322	0.180	F'	4.3	1.160	1.344	0.367
DG	10	D	4.9	0.316	0.100	0.100	G	3.5	1.269	1.611	0.401

DENSITY 40

(1)*	(2)*	(3)*	(4)*	(5)*	(6)*	(7)*	(8)*	(9)*	(10)*	(11)*	(12)*
AF	10	A	20.000	2.539	6.444	0.803	F	16.200	1.476	2.178	0.467
AF'	9	A	19.444	2.186	4.778	0.729	F'	17.778	1.563	2.444	0.521
AG	10	A	19.900	2.079	4.322	0.657	G	13.200	2.150	4.622	0.680
BF	10	B	19.300	1.252	1.567	0.396	F	16.500	1.900	3.611	0.601
BF'	10	B	20.100	2.025	4.100	0.640	F'	17.100	2.514	6.322	0.795
BG	10	B	18.500	1.354	1.833	0.428	G	14.700	1.947	3.789	0.616
CF	10	C	18.800	3.048	9.289	0.964	F	16.500	2.068	4.278	0.654
CF'	10	C	20.000	0.667	0.444	0.211	F'	18.200	1.398	1.956	0.442
CG	10	C	19.500	1.179	1.389	0.373	G	14.400	3.098	9.600	0.980
DF	10	D	19.900	2.079	4.322	0.657	F	14.300	2.058	4.233	0.651
DF'	10	D	20.400	0.966	0.933	0.306	F'	18.500	1.354	1.833	0.428
DG	10	D	19.100	2.726	7.433	0.862	G	13.000	3.528	12.444	1.116

DENSITY 100

(1)*	(2)*	(3)*	(4)*	(5)*	(6)*	(7)*	(8)*	(9)*	(10)*	(11)*	(12)*
AF	10	A	33.100	6.724	45.211	2.126	F	30.500	4.301	18.500	1.360
AF'	10	A	26.000	5.676	32.222	1.795	F'	25.000	4.104	16.844	1.298
AG	10	A	19.700	9.821	96.456	3.106	G	30.900	4.458	19.878	1.410
BF	9	B	40.400	6.126	37.528	2.042	F	34.889	3.516	12.361	1.172
BF'	10	B	41.200	4.849	23.511	1.533	F'	31.200	4.417	19.511	1.397
BG	10	B	37.500	4.528	20.500	1.432	G	26.400	4.881	23.822	1.543
CF	9	C	46.222	2.991	8.944	0.997	F	36.889	5.510	30.361	1.837
CF'	10	C	47.900	3.178	10.100	1.005	F'	40.000	4.082	16.677	1.291
CG	10	C	48.500	3.951	15.611	1.249	G	29.500	5.061	30.500	1.600
DF	10	D	44.000	2.867	8.222	0.907	F	44.400	3.502	12.267	1.108
DF'	10	D	47.400	5.835	34.044	1.845	F'	44.900	4.677	21.878	1.479
DG	10	D	48.300	2.541	6.456	0.833	G	30.600	4.624	21.378	1.462

* 1. Strain mix; 2. Replicated number; 3. Genotype 1; 4. Mean number of survivors; 5. Standard deviation; 6. Variance; 7. Standard error; 8. Genotype 2; 9. Mean number of survivors; 10. Standard deviation; 11. Variance; 12. Standard error.

TABLE 2a

DENSITY 10

		GENOTYPE 1				GENOTYPE 2									
(1)*	(2)*	(3)*	(4)*	(5)*	(6)*	(7)*	(8)*	(9)*	(10)*	(11)*	(12)*	(13)*	(14)*	(15)*	(16)*
AF	A	10	6.9480	1.228	F	10	5.9970	0.676	2.14	18	0.046		12.9450	53.67	46.33
AF'	A	10	7.1150	1.275	F'	10	5.9070	1.049	2.31	18	0.033		13.0220	54.7	45.3
AG	A	10	7.5380	0.892	G	10	4.5680	1.380	6.71	18	0.000		12.1060	62.2	37.8
BF	B	10	6.7660	1.000	F	10	6.1290	0.392	1.88	18	0.077	NS	12.8950	52.5	47.5
BF'	B	10	6.9940	0.851	F'	10	5.4760	0.634	3.72	18	0.002		12.4700	56.1	43.9
BG	B	6	6.9867	0.532	G	6	4.5450	0.609	7.40	10	0.000		11.5310	60.6(339.8)	39.4(269.8)
CF	C	10	4.7770	0.507	F	10	5.7540	1.208	-2.36	18	0.030		10.5310	45.4	54.6
CF'	C	10	3.5950	0.718	F'	10	4.4900	0.823	-2.59	18	0.018		8.0850	44.5	55.5
CG	C	10	3.5400	0.512	G	10	3.5050	0.901	0.11	18	0.916	NS	7.0450	50.2	49.8
DF	D	10	4.3970	0.752	F	10	5.4540	0.826	-2.99	18	0.008		9.8510	44.6	55.4
DF'	D	10	4.2190	0.631	F'	10	4.4220	1.331	-0.44	18	0.668	NS	8.6410	48.8	51.2
DG	D	10	4.4960	0.346	G	10	4.0210	1.559	0.94	18	0.359	NS	8.5170	52.8(286.3)	47.2(343.7)

DENSITY 40

(1)*	(2)*	(3)*	(4)*	(5)*	(6)*	(7)*	(8)*	(9)*	(10)*	(11)*	(12)*	(13)*	(14)*	(15)*	(16)*
AF	A	10	28.6770	3.262	F	10	18.6620	2.196	8.05	18	0.000		47.3390	60.6	39.4
AF'	A	10	26.4244	3.151	F'	10	21.4344	2.527	5.19	16	0.000		52.8588	53.8	46.2
AG	A	10	28.3600	1.224	G	10	14.1510	2.179	17.98	18	0.000		42.5110	66.7	33.3
BF	B	10	26.8810	1.715	F	10	20.2670	2.505	6.89	18	0.000		47.1480	57.0	43.0
BF'	B	10	28.9360	2.402	F'	10	20.3510	3.237	6.74	18	0.000		49.2870	58.7	51.3
BG	B	10	28.1540	2.441	G	10	16.4910	2.324	10.94	18	0.000		44.6450	63.1(359.9)	46.9(260.1)
CF	C	10	17.9850	2.472	F	10	19.2040	1.932	-1.23	18	0.235	NS	37.1890	48.4	51.6
CF'	C	10	16.6350	0.824	F'	10	20.7410	1.712	-6.83	18	0.000		37.3760	44.5	55.5
CG	C	10	16.8100	0.754	G	10	15.3300	3.450	1.33	18	0.202	NS	32.1400	52.3	47.7
DF	D	10	18.2410	1.942	F	10	16.4800	1.950	2.02	18	0.058	NS	34.7210	52.5	47.5
DF'	D	10	17.6010	1.340	F'	10	21.0200	2.017	-4.47	18	0.000		38.6210	45.6	54.4
DG	D	10	17.9680	2.755	G	10	14.2530	3.354	2.71	18	0.014		32.2210	55.8(299.1)	44.2(300.9)

DENSITY 100

(1)*	(2)*	(3)*	(4)*	(5)*	(6)*	(7)*	(8)*	(9)*	(10)*	(11)*	(12)*	(13)*	(14)*	(15)*	(16)*
AF	A	10	44.6140	10.859	F	10	32.4760	6.132	3.08	18	0.006		77.0920	57.9	42.1
AF'	A	10	31.4970	8.955	F'	10	25.5910	5.814	1.75	18	0.097	NS	57.0880	55.2	44.8
AG	A	10	25.7910	13.552	G	10	29.4040	4.135	-0.81	18	0.431	NS	54.9950	46.9	53.1
BF	B	9	54.3511	8.901	F	9	39.9156	4.356	4.37	16	0.000		94.2667	57.7	42.3
BF'	B	10	53.8060	8.587	F'	10	32.7490	4.905	6.73	18	0.000		86.5550	62.2	37.8
BG	B	10	50.9360	6.370	G	10	27.6050	5.086	9.05	18	0.000		78.5410	64.9(354.8)	35.1(255.2)
CF	C	9	39.1500	3.035	F	9	41.3200	6.817	-0.87	16	0.396	NS	80.4700	48.6	51.4
CF'	C	10	40.3690	3.413	F'	10	47.9310	5.057	-3.92	18	0.001		87.9310	45.9	54.1
CG	C	10	40.5590	2.085	G	10	31.6490	5.906	4.50	18	0.000		72.2080	56.2	43.8
DF	D	10	37.8630	3.139	F	10	50.3010	4.108	-7.61	18	0.000		88.1640	42.9	47.1
DF'	D	10	41.3380	4.666	F'	10	50.4330	3.800	-4.78	18	0.000		91.7710	45.0	65.0
DG	D	10	43.9240	3.336	G	10	33.5690	5.224	5.28	16	0.000		77.4930	56.7(295.3)	43.3(294.7)

* 1. Strain mix; 2. Strain or genotype 1; 3. Replicated number; 4. m1; 5. S.D.; 6. Strain or genotype 2; 7. N; 8. m2; 9. S.D.; 10. t; 11. df; 12. p; 13. Significance; 14. m1+m2; 15. Uncorrected % biomass of genotype 1 (m1/m1+m2.100); 16. Uncorrected % biomass of genotype 2 (m2/m1+m2.100).

Table 2a part 2

These are expected values from
the uncorrected Density 10 values.

(17)*	(18)*	(19)*	(20)*	(21)*
28.7	18.7	47.4	60.54	39.45
28.4	23.6	52.0	54.64	45.38
31.2	18.3	49.5	63.03	36.96
27.1	24.4	51.5	52.62	47.38
28.0	22.0	50.0	56.00	44.00
28.0	18.2	46.2	60.61	39.40
19.1	23.0	42.1	45.37	54.63
14.4	18.0	32.4	44.44	55.56
14.0	14.0	28.0	50.00	50.00
17.6	21.8	39.4	44.67	55.33
16.9	17.7	34.6	49.30	51.60
18.0	16.0	34.0	52.94	47.06
69.5	60.0	129.5	53.67	46.33
71.2	59.0	130.2	54.69	45.31
75.0	46.0	121.0	61.98	38.02
67.7	61.3	129.0	52.48	47.52
70.0	55.0	125.0	56.00	44.00
70.0	45.0	115.0	60.87	39.13
48.0	58.0	106.0	45.28	54.72
36.0	45.0	81.0	44.44	55.56
35.0	35.0	70.0	50.00	50.00
44.0	54.0	98.0	44.90	55.10
42.0	44.0	86.0	48.84	51.16
45.0	40.0	85.0	52.94	47.06

17. Genotype 1; 20. % Genotype 1;
18. Genotype 2; 21. % Genotype 2
19. Genotype 1+2;

TABLE 2b

DENSITY 10

		GENOTYPE 1				GENOTYPE 2			GENOTYPE 1+2		
(1)*	(2)*	(3)*	(4)*	(5)*	(6)*	(7)*	(8)*	(9)*	(10)*	(11)*	(12)*
AF	A	4.5	6.95	7.72	F	4.9	5.99	6.11	9.4	12.94	13.83
AF'	A	4.8	7.12	7.42	F'	4.7	5.91	6.28	9.5	13.03	13.70
AG	A	5.2	7.54	7.25	G	3.7	4.57	6.25	8.9	12.11	13.50
BF	B	4.7	6.77	7.20	F	4.9	6.13	6.25	9.6	12.90	13.45
BF'	B	4.7	6.99	7.44	F'	4.7	5.75	6.12	8.4	12.47	13.56
BG	B	5.0	6.99	6.99	G	4.1	4.54	5.54	9.1	11.53	12.53
CF	C	4.7	4.78	5.05	F	4.6	5.75	6.25	9.3	10.53	11.30
CF'	C	4.6	3.60	3.91	F'	4.5	4.90	5.44	9.1	8.50	9.35
CG	C	5.0	3.54	3.54	G	4.0	3.50	4.38	9.0	7.04	7.92
DF	D	4.7	4.40	4.68	F	4.7	5.45	5.80	9.4	9.85	10.48
DF'	D	5.1	4.22	4.14	F'	4.3	4.42	5.14	9.4	8.64	9.28
DG	D	4.9	4.50	4.59	G	3.5	4.02	5.74	8.4	8.52	10.33

DENSITY 40

(1)*	(2)*	(3)*	(4)*	(5)*	(6)*	(7)*	(8)*	(9)*	(10)*	(11)*	(12)*
AF	A	16.2	28.68	35.41	F	20.0	18.66	18.66	36.2	47.34	54.07
AF'	A	20.1	28.42	28.28	F'	17.8	21.93	26.44	37.9	50.35	54.72
AG	A	19.9	28.36	28.50	G	13.2	14.15	21.44	33.1	42.50	49.94
BF	B	19.3	26.88	27.85	F	16.5	20.27	24.57	35.8	47.15	52.42
BF'	B	20.1	28.94	28.80	F'	17.1	20.35	23.80	37.2	49.29	52.60
BG	B	18.5	28.15	30.43	G	14.7	16.49	22.44	33.2	44.64	52.87
CF	C	18.8	17.98	19.13	F	16.5	19.20	23.27	35.3	37.18	42.40
CF'	C	20.0	16.64	16.64	F'	18.2	16.64	18.29	38.2	33.28	34.93
CG	C	19.5	16.81	17.24	G	14.4	15.33	26.29	33.9	32.11	38.53
DF	D	19.9	18.24	18.33	F	14.3	16.48	23.04	34.2	34.82	41.37
DF'	D	20.1	17.60	17.25	F'	18.5	21.02	22.72	38.6	38.62	39.97
DG	D	19.1	17.97	18.82	G	13.0	14.25	21.92	32.1	32.22	40.74

DENSITY 100

(1)*	(2)*	(3)*	(4)*	(5)*	(6)*	(7)*	(8)*	(9)*	(10)*	(11)*	(12)*
AF	A	33.1	44.61	67.39	F	30.5	32.48	43.25	63.6	77.09	110.64
AF'	A	26.0	36.50	60.58	F'	25.0	25.59	51.18	51.0	57.09	111.76
AG	A	19.7	25.79	65.45	G	31.3	29.40	46.96	51.0	55.19	112.41
BF	B	40.4	54.35	67.26	F	34.9	39.92	57.19	75.3	94.27	124.45
BF'	B	41.2	53.81	65.30	F'	31.2	32.75	52.48	72.4	86.56	117.78
BG	B	37.3	50.94	68.28	G	26.4	27.60	52.27	63.7	78.54	120.55
CF	C	46.2	39.15	42.37	F	36.3	41.32	59.50	82.5	80.47	101.87
CF'	C	47.9	40.37	42.14	F'	42.0	47.93	57.06	89.9	88.30	99.20
CG	C	48.5	40.56	41.81	G	29.5	31.65	53.64	78.0	72.21	95.45
DF	D	44.0	37.86	43.02	F	44.4	50.30	56.64	88.4	88.16	99.66
DF'	D	47.4	41.34	43.61	F'	44.9	50.43	56.16	92.3	91.77	99.77
DG	D	48.3	43.92	45.47	G	30.6	33.57	54.85	78.9	77.49	100.32

* 1. Strain mix;
2. Strain or genotype 1;
3. Mean survivors;
4. Mean biomass;
5. Biomass corrected to 100% survival;
6. Strain or genotype 2;
7. Mean survivors;
8. Mean biomass;
9. Biomass corrected to 100% survival;
10. Total of 3+7;
11. Total of 4+8;
12. Total of 5+9.

TABLE 2c

DENSITY 10

		GENOTYPE 1				GENOTYPE 2			
(1)*	(2)*	(3)*	(4)*	(5)*	(6)*	(7)*	(8)*	(9)*	(10)*
AF	A	4.5	6.95	7.72	F	4.9	5.99	6.11	13.83
AF'	A	4.8	7.12	7.42	F'	4.7	5.91	6.28	13.70
AG	A	5.2	7.54	7.25	G	3.7	4.57	6.25	13.50
BF	B	4.7	6.77	7.20	F	4.9	6.13	6.25	13.45
BF'	B	4.7	6.99	7.44	F'	4.7	5.75	6.12	13.56
BG	B	5.0	6.99	6.99	G	4.1	4.54	5.54	9.73
CF	C	4.7	4.78	5.05	F	4.6	5.75	6.25	11.30
CF'	C	4.6	3.60	3.91	F'	4.5	4.90	5.44	9.35
CG	C	5.0	3.54	3.54	G	4.0	3.50	4.38	7.92
DF	D	4.7	4.40	4.68	F	4.7	5.45	5.80	10.48
DF'	D	5.1	4.22	4.14	F'	4.3	4.42	5.14	9.28
DG	D	4.9	4.50	4.59	G	3.5	4.02	5.74	10.33

DENSITY 40

AF	A	16.2	28.68	35.41	F	20.0	18.66	18.66	54.07
AF'	A	20.1	28.42	28.28	F'	17.8	21.93	26.44	54.72
AG	A	19.9	28.36	28.50	G	13.2	14.15	21.44	49.94
BF	B	19.3	26.88	27.85	F	16.5	20.27	24.57	52.42
BF'	B	20.1	28.94	28.80	F'	17.1	20.35	23.80	52.60
BG	B	18.5	28.15	30.43	G	14.7	16.49	22.44	52.87
CF	C	18.8	17.98	19.13	F	16.5	19.20	23.27	42.40
CF'	C	20.0	16.64	16.64	F'	18.2	16.64	18.29	34.93
CG	C	19.5	16.81	17.24	G	14.4	15.33	26.29	38.53
DF	D	19.9	18.24	18.33	F	14.3	16.48	23.04	41.37
DF'	D	20.1	17.60	17.25	F'	18.5	21.02	22.72	39.97
DG	D	19.1	17.97	18.82	G	13.0	14.25	21.92	40.74

DENSITY 100

AF	A	33.1	44.61	67.39	F	30.5	32.48	43.25	110.64
AF'	A	26.0	36.50	60.58	F'	25.0	25.59	51.18	111.76
AG	A	19.7	25.79	65.45	G	31.3	29.40	46.96	112.41
BF	B	40.4	54.35	67.26	F	34.9	39.92	57.19	124.45
BF'	B	41.2	53.81	65.30	F'	31.2	32.75	52.48	117.78
BG	B	37.3	50.94	68.28	G	26.4	27.60	52.27	120.55
CF	C	46.2	39.15	42.37	F	36.3	41.32	59.50	101.87
CF'	C	47.9	40.37	42.14	F'	42.0	47.93	57.06	99.20
CG	C	48.5	40.56	41.81	G	29.5	31.65	53.64	95.45
DF	D	44.0	37.86	43.02	F	44.4	50.30	56.64	99.66
DF'	D	47.4	41.34	43.61	F'	44.9	50.43	56.16	99.77
DG	D	48.3	43.92	45.47	G	30.6	33.57	54.85	100.32

* 1. Strain mix; 2. Strain or genotype 1; 3. Mean survivors; 4. Mean biomass; 5. Biomass corrected to 100% survival; 6. Strain or genotype 2; 7. Mean survivors; 8. Mean biomass; 9. Biomass corrected to 100% survival; 10. Total biomass.

TABLE 3a

(1)*	(2)*	(3)*	(4)*	(5)*	(6)*
		DENSITY 10			
1	10	12.669	1.449	2.100	0.458
2	10	13.820	1.080	1.167	0.342
3	10	8.043	1.409	1.985	0.446
4	10	8.352	1.293	1.672	0.409
5	9	7.854	1.207	1.457	0.402
6	10	8.297	0.951	0.905	0.301
7	10	8.259	0.628	0.394	0.199
8	9	7.186	2.468	6.089	0.823
		DENSITY 40			
1	10	49.564	3.369	11.348	1.065
2	10	52.871	2.040	4.160	0.645
3	10	33.655	3.339	11.152	1.056
4	10	32.767	1.268	1.608	0.401
5	10	34.716	3.188	10.165	1.008
6	10	42.335	2.865	8.206	0.906
7	10	36.640	2.742	7.518	0.867
8	10	30.141	8.514	72.494	2.692
		DENSITY 100			
1	10	48.492	15.405	237.325	4.872
2	10	77.857	14.609	213.420	4.620
3	10	82.227	4.197	17.616	1.327
4	10	80.963	7.852	61.648	2.483
5	8	67.893	9.011	81.200	3.186
6	9	98.384	13.670	186.862	4.557
7	10	90.941	10.883	118.449	3.442
8	10	64.329	22.198	492.742	7.020

* 1. Strains; 2. Replicated number; 3. m1; 4. S.D.; 5. Variance; 6. S.E.

TABLE 3b

(1)*	(2)*	(3)*	(4)*	(5)*	(6)*	(7)*	(8)*	(9)*	(10)*
DENSITY 10									
9	10	6.948	1.228	1.508	0.388	5.997	0.676	0.458	0.214
10	10	7.115	1.275	1.626	0.403	5.907	1.049	1.101	0.332
11	10	7.538	0.892	0.796	0.282	4.568	1.380	1.905	0.436
12	10	6.766	1.000	1.000	0.316	6.129	0.392	0.153	0.124
13	10	6.944	0.851	0.724	0.269	5.746	0.634	0.403	0.201
14	6	6.180	0.532	0.217	0.283	4.545	0.609	0.249	0.371
15	10	4.777	0.507	0.257	0.160	5.754	1.208	0.382	1.458
16	10	3.595	0.718	0.516	0.227	4.490	0.823	0.677	0.260
17	10	3.540	0.512	0.262	0.162	3.505	0.901	0.812	0.285
18	10	4.397	0.752	0.565	0.238	5.454	0.826	0.683	0.261
19	10	4.219	0.631	0.398	0.200	4.422	1.331	1.771	0.421
20	10	4.496	0.346	0.120	0.109	4.021	1.559	2.431	0.493
DENSITY 40									
9	10	28.677	3.262	10.640	1.032	18.662	2.196	4.822	0.694
10	9	28.424	3.151	9.929	1.050	21.434	2.527	6.385	0.842
11	10	28.360	1.224	1.499	0.387	14.151	2.179	4.749	0.689
12	10	26.881	1.715	2.943	0.542	20.267	2.505	6.276	0.792
13	10	28.936	2.402	5.769	0.760	20.351	3.237	10.479	1.024
14	10	28.154	2.441	5.961	0.772	16.491	2.324	5.400	0.735
15	10	17.985	2.472	6.111	0.782	19.204	1.932	3.734	0.611
16	10	16.635	0.824	0.679	0.261	20.741	1.712	2.931	0.541
17	10	16.810	0.754	0.569	0.239	15.330	3.450	11.902	1.091
18	10	18.241	1.942	3.770	0.614	16.480	1.950	3.803	0.617
19	10	17.601	1.340	1.795	0.424	21.020	2.017	4.068	0.638
20	10	17.968	2.755	7.588	0.871	14.253	3.354	11.248	1.061
DENSITY 100									
9	10	44.614	10.859	117.917	3.434	32.478	6.132	37.598	1.939
10	10	31.497	8.955	80.192	2.832	25.591	5.814	33.798	1.838
11	10	25.791	13.552	183.658	4.286	29.404	4.135	17.100	1.308
12	9	54.351	8.901	79.220	8.967	39.916	4.356	18.974	1.452
13	10	53.806	8.587	73.739	2.715	32.749	4.905	24.062	1.551
14	10	50.936	6.370	40.577	2.014	27.605	5.088	25.890	1.609
15	9	39.150	3.035	9.208	1.012	41.320	6.817	46.473	2.272
16	10	40.369	3.413	11.652	1.079	47.931	5.057	25.569	1.599
17	10	37.863	3.139	9.851	0.993	31.649	5.906	34.878	1.868
18	10	41.338	4.666	21.774	1.476	50.301	4.108	16.877	1.299
19	10	49.940	3.336	11.128	1.055	50.433	3.800	14.441	1.202
20	10	32.478	6.132	37.598	1.939	33.569	5.224	27.292	1.652

* 1. Strains; 2. Replicated number; 3. m1; 4. S.D.; 5. Variance; 6. S.E.; 7. m2; 8. S.D.; 9. Variance; 10. S.E.

2/23/95

TABLE 4a

DENSITY 10

(1)*	(2)*	(3)*	(4)*	(5)*	(6)*	(7)*
A	10.1	12.670	1.449	2.099	0.458	
B	9.7	13.820	1.080	1.166	0.342	
C	9.6	8.043	1.409	1.985	0.446	
D	10.1	8.352	1.293	1.672	0.409	
E	7.6	7.854	1.207	1.457	0.402	
F	7.9	8.297	0.951	0.904	0.301	
F'	9.3	8.259	0.628	0.394	0.199	
G	6.8	6.467	2.468	6.091	0.823	

DENSITY 40

(1)*	(2)*	(3)*	(4)*	(5)*	(6)*	(7)*
A	37.7	49.56	3.369	11.350	1.065	50.68
B	37.3	52.87	2.040	4.162	0.645	55.28
C	39.3	33.66	3.339	11.149	1.056	31.17
D	39.1	32.77	1.268	1.608	0.401	33.41
E	35.7	34.72	3.188	10.163	1.008	31.42
F	36.6	42.34	2.865	8.208	0.906	33.19
F'	36.8	36.64	2.742	7.519	0.867	33.04
G	31.5	30.14	8.514	72.488	2.692	25.87

DENSITY 100

(1)*	(2)*	(3)*	(4)*	(5)*	(6)*	(7)*
A	44.9	48.90	15.405	237.310	4.872	126.7
B	65.2	77.86	14.610	213.450	4.620	138.20
C	95.4	82.23	4.197	17.615	1.327	80.43
D	96.2	80.96	7.852	61.653	2.483	83.52
E	56.7	54.31	9.011	81.198	3.186	78.54
F	77.2	98.38	13.670	186.869	4.557	82.97
F'	83.5	90.94	10.883	118.440	3.442	82.59
G	65.1	64.33	22.198	492.751	7.020	64.67

* 1. Strains; 2. N/10; 3. m; 4. S.D.; 5. Variance; 6. S.E. 7. Estimated from values from Density 10 used as standard.

32

2/ 23/ 95

TABLE 4b

DENSITY 10

			STRAIN 1							STRAIN 2		
(1)*	(2)*	(3)*	(4)*	(5)*	(6)*	(7)*	(8)*	(9)*	(10)*	(11)*	(12)*	(13)*
AF	A	4.5	6.948	1.229	1.508	0.388	F	4.9	5.997	0.676	0.4570	0.214
AF'	A	4.8	7.115	1.275	1.626	0.403	F'	4.7	5.907	1.049	0.1100	0.332
AG	A	5.2	7.538	0.892	0.796	0.282	G	3.7	4.568	1.360	0.1900	0.436
BF	B	4.7	6.766	1.000	1.000	0.316	F	4.9	6.129	0.392	0.0154	0.124
BF'	B	4.7	6.994	0.851	0.724	0.269	F'	4.7	5.746	0.634	0.0404	0.201
BG	B	5.0	4.192	0.532	0.283	0.217	G	4.1	4.545	0.609	0.0620	0.249
CF	C	4.7	4.777	0.507	0.257	0.160	F	4.6	5.754	1.208	0.1460	0.382
CF'	C	4.6	3.595	0.718	0.516	0.227	F'	4.5	4.490	0.823	0.0676	0.260
CG	C	5.0	3.540	0.512	0.262	0.162	G	4.0	3.505	0.901	0.0812	0.285
DF	D	4.7	4.397	0.752	0.566	0.238	F	4.7	5.454	0.826	0.0681	0.261
DF'	D	5.1	4.219	0.632	0.399	0.200	F'	4.3	4.422	1.331	0.1770	0.421
DG	D	4.9	4.496	0.346	0.120	0.109	G	3.5	4.021	1.559	0.2430	0.493

DENSITY 40

AF	A	16.2	28.68	3.262	10.641	1.032	F	20.0	18.66	2.196	0.126	0.694
AF'	A	20.1	28.42	3.151	9.929	1.050	F'	17.8	21.93	2.527	0.709	0.642
AG	A	19.9	28.36	1.224	1.498	0.387	G	13.2	14.15	2.179	0.475	0.689
BF	B	19.3	26.88	1.715	2.941	0.542	F	16.5	20.27	2.505	0.627	0.792
BF'	B	20.1	28.94	2.402	5.770	0.760	F'	17.1	20.35	3.237	1.049	1.024
BG	B	18.5	28.15	2.441	5.956	0.772	G	14.7	16.49	2.324	0.540	0.735
CF	C	18.8	17.98	2.472	6.111	0.782	F	16.5	19.20	1.932	0.373	0.611
CF'	C	20.0	16.64	0.824	0.679	0.261	F'	18.2	16.64	0.824	0.068	0.261
CG	C	19.5	16.61	0.754	0.569	0.239	G	14.4	15.33	3.450	1.190	1.091
DF	D	19.9	18.24	1.942	3.771	0.614	F	14.3	16.48	1.950	0.381	0.617
DF'	D	20.4	17.60	0.631	0.398	0.200	F'	16.5	21.02	2.017	0.407	0.638
DG	D	19.1	17.97	2.755	7.590	0.871	G	13.0	14.25	3.354	1.125	1.061

DENSITY 100

AF	A	33.1	44.61	10.86	117.940	3.434	F	30.5	32.48	6.132	3.759	1.939
AF'	A	26.0	31.50	8.96	80.282	2.832	F'	25.0	25.59	5.814	3.376	1.838
AG	A	19.7	25.79	13.55	183.602	4.286	G	31.3	29.40	4.135	1.711	1.308
BF	B	40.4	54.35	8.90	79.210	2.967	F	34.9	39.92	4.356	2.108	1.452
BF'	B	41.2	53.81	8.59	73.788	2.715	F'	31.2	32.75	4.905	24.059	1.551
BG	B	37.3	50.94	6.37	40.577	2.014	G	26.4	27.60	5.088	25.888	1.609
CF	C	46.2	39.15	3.04	9.242	1.012	F	36.3	41.32	6.817	5.162	2.272
CF'	C	47.9	40.37	3.41	11.628	1.079	F'	42.0	47.93	5.057	25.513	1.599
CG	C	48.5	40.56	2.08	4.326	0.659	G	29.5	31.65	5.906	34.881	1.668
DF	D	44.0	37.86	3.14	9.860	0.993	F	44.4	50.30	4.108	16.676	1.299
DF'	D	47.4	41.34	4.67	21.609	1.476	F'	44.9	50.43	3.800	14.440	1.202
DG	D	46.3	43.92	3.34	11.156	1.055	G	30.6	33.57	5.224	27.290	1.652

* 1. Strain mix;
2. Strain or genotype 1;
3. N/10;
4. m1;
5. S.D.;
6. Variance;
7. S.E.;
8. Strain or genotype 2;
9. N/10;
10. m2;
11. S.D.;
12. Variance;
13. S.E.

TABLE 4c

DENSITY 10

(1)	(2)*	(3)*	(4)*	(5)*	(6)*	(7)	(8)*
AF	7.72	6.11	13.83	55.8	44.2	1.26	
AF'	7.42	6.28	13.70	54.2	45.8	1.18	
AG	7.25	6.25	13.50	53.7	46.3	1.16	
BF	7.20	6.25	13.45	53.5	46.5	1.16	
BF'	7.44	6.12	13.56	54.9	45.1	1.22	
BG	6.99	5.54	12.53	55.8	44.2	1.26	
CF	5.05	6.25	11.30	44.7	55.3	1.24	
CF'	3.91	5.44	9.35	41.8	58.2	1.39	
CG	3.54	4.38	7.92	44.7	55.2	1.23	
DF	4.68	5.80	10.48	44.7	55.3	1.24	
DF'	4.14	5.14	9.28	44.6	55.4	1.24	
DG	4.59	5.74	10.33	44.4	55.6	1.25	

DENSITY 40

(1)	(2)*	(3)*	(4)*	(5)*	(6)*	(7)	(8)*
AF	35.41	18.66	54.07	65.49	34.51	1.90	
AF'	28.28	26.44	54.72	51.68	48.32	1.07	
AG	28.36	21.44	49.80	56.95	43.05	1.32	
BF	27.85	24.57	52.42	53.10	46.89	1.13	
BF'	28.80	23.80	52.60	54.75	45.25	1.21	
BG	30.43	22.44	52.87	57.56	42.44	1.36	
CF	19.13	23.27	42.40	45.04	54.88	1.22	
CF'	16.64	18.29	44.93	37.03	40.73	1.10	
CG	17.24	21.29	38.53	44.74	55.25	1.23	
DF	18.33	23.04	41.37	44.31	55.61	1.26	
DF'	17.25	22.72	39.97	43.16	56.84	1.32	
DG	18.82	21.92	40.74	46.20	53.80	1.16	

DENSITY 100

(1)	(2)*	(3)*	(4)*	(5)*	(6)*	(7)	(8)*
AF	67.39	43.25	110.64	60.91	39.09	1.56	135.2
AF'	60.58	51.18	111.76	54.21	44.90	1.21	136.8
AG	65.45	46.96	112.41	58.22	41.78	1.39	124.5
BF	67.26	57.19	124.45	54.05	45.95	1.18	131.0
BF'	65.30	52.48	117.78	55.44	44.56	1.24	131.5
BG	68.28	52.27	120.55	56.64	43.36	1.31	132.2
CF	42.37	59.50	101.87	41.59	58.41	1.40	106.0
CF'	42.14	57.06	99.20	42.48	57.52	1.35	112.3
CG	41.81	53.64	95.45	43.80	56.20	1.49	96.2
DF	43.02	56.64	99.66	43.17	56.83	1.32	103.4
DF'	43.61	56.16	99.77	43.71	55.29	1.26	99.9
DG	45.47	54.85	100.32	45.32	54.68	1.21	101.8

* 1. Strain mix;
2. Biomass of genotype 1 corrected to 100% survival;
3. Biomass of genotype 2 corrected to 100% survival;
4. Total biomass of genotype 1 + genotype 2;
5. Biomass proportion of genotype 1 in percent;
6. Biomass proportion of genotype 2 in percent;
7. Ratio of biomass of genotype 1/ biomass of genotype 2;
8. Expected biomass in terms of values of Density 40 in column 7 assuming 100% survival.

TABLE 5a. Survivors and their biomass.(Mixed strains)

	DENSITY 10			
	GENOTYPE 1		*GENOTYPE 2*	
(1)*	(2)*	(3)*	(4)*	(5)*
AF 9	4.5	6.948	4.9	5.997
AF' 10	4.8	7.115	4.7	5.907
AG 11	4.8	7.538	3.7	4.568
BF 12	4.7	6.766	4.9	6.129
BF' 13	4.7	6.994	4.7	5.746
BG 14	3.0	4.192	2.5	2.727
CF 15	4.7	4.778	4.6	5.754
CF' 16	4.6	3.595	4.5	4.490
CG 17	5.0	3.540	4.0	3.505
DF 18	4.7	4.397	4.7	5.454
DF' 19	5.7	4.219	4.3	4.422
DG 20	4.9	4.496	3.5	4.021
	DENSITY 40			
AF 9	20.0	28.677	16.2	18.662
AF' 10	17.5	25.582	16.0	18.291
AG 11	19.9	28.360	13.2	14.151
BF 12	19.3	26.881	16.5	20.267
BF' 13	20.1	28.936	17.1	20.351
BG 14	18.5	28.264	14.7	16.491
CF 15	18.8	17.985	16.5	19.204
CF' 16	20.0	16.635	18.2	20.741
CG 17	19.5	16.810	14.4	15.330
DF 18	19.9	18.241	14.3	16.480
DF' 19	20.4	17.601	18.5	21.020
DG 20	19.1	17.968	13.0	14.253
	DENSITY 100			
AF 9	33.1	44.614	30.5	32.478
AF' 10	26.0	27.397	25.2	25.591
AG 11	19.7	25.781	30.9	29.404
BF 12	36.4	48.916	31.4	35.924
BF' 13	41.2	53.806	31.2	62.749
BG 14	37.5	50.936	27.1	28.427
CF 15	41.6	35.235	33.2	37.188
CF' 16	46.9	40.369	40.0	47.931
CG 17	48.5	40.559	29.5	31.649
DF 18	44.0	37.863	44.4	50.341
DF' 19	47.4	41.338	44.9	50.334
DG 20	48.3	43.021	30.6	33.569

* 1. Mixed strains;
2. Mean survivors of genotype 1;
3. Mean biomass of genotype 1;
4. Mean survivors of genotype 2;
5. Mean biomass of genotype 2.

TABLE 5b. Survivors and biomass expected taking from Density 10 values as standard.

	DENSITY 40			
	GENOTYPE 1		*GENOTYPE 2*	
(1)*	(2)*	(3)*	(4)*	(5)*
AF 9	180	27.672	196	23.988
AF' 10	192	28.460	188	23.629
AG 11	196	30.152	148	18.272
BF 12	188	27,064	196	24.516
BF' 13	188	27.976	188	22.984
BG 14	120	16.768	100	10.908
CF 15	188	19.112	184	23.016
CF' 16	184	14.380	180	17.960
CG 17	200	14.160	160	14.020
DF 18	188	17.588	188	21.816
DF' 19	204	16.876	172	17.688
DG 20	196	17.984	140	16.084
	DENSITY 100			
AF 9	450	69.18	490	59.97
AF' 10	480	71.15	470	59.07
AG 11	480	75.38	370	45.68
BF 12	470	67.66	490	61.29
BF' 13	470	69.94	470	57.46
BG 14	300	41.92	250	27.27
CF 15	470	47.78	460	57.54
CF' 16	460	35.95	450	44.90
CG 17	500	35.40	400	35.05
DF 18	470	43.97	470	54.54
DF' 19	510	42.19	430	44.22
DG 20	490	44.96	350	40.21

* 1. Mixed strains;
2. Mean survivors of genotype 1;
3. Mean biomass of genotype 1;
4. Mean survivors of genotype 2;
5. Mean biomass of genotype 2.

TABLE 5o. These data have been "corrected", assuming 100% survival of beetles both in single and mixed strain vials using the data in Table 6e.

DENSITY 10

Single Strains			Mixed Strains		
(A+F)/2=	6.26+5.25	= 11.51	(A+F) =	7.72+6.11	= 13.83
(A+F')/2=	6.26+4.44	= 10.7	(A+F')=	7.42+6.28	= 13.70
(A+G)/2=	6.26+4.76	= 11.02	(A+G) =	7.25+6.25	= 13.50
(B+F)/2=	7.18+5.25	= 12.43	(B+F) =	7.20+6.25	= 13.45
(B+F')/2=	7.18+4.44	= 11.62	(B+F')=	7.44+5.75	= 13.19
(B+G)/2=	7.18+4.76	= 11.94	(B+G) =	4.19+5.54	= 9.73
(C+F)/2=	4.189+5.25	= 9.44	(C+F) =	5.05+6.25	= 11.30
(C+F')/2=	4.189+4.44	= 8.63	(C+F')=	3.91+5.44	= 9.35
(C+G)/2=	4.189+4.76	= 8.95	(C+G) =	3.54+4.38	= 7.92
(D+F)/2=	4.135+5.25	= 9.385	(D+F) =	4.68+5.45	= 10.13
(D+F')/2=	4.135+4.44	= 8.575	(D+F')=	4.14+5.14	= 9.28
(D+G)/2=	4.135+4.76	= 8.895	(D+G) =	4.63+5.74	= 10.37

DENSITY 40

(A+F)/2=	25.04+21	= 46.04	(A+F) =	35.41+18.66	= 54.07
(A+F')/2=	25.04+17.65	= 42.69	(A+F')=	28.28+26.44	= 54.72
(A+G)/2=	25.04+19.2	= 44.24	(A+G) =	28.50+21.44	= 49.94
(B+F)/2=	28.7+21	= 49.7	(B+F) =	27.85+24.57	= 52.42
(B+F')/2=	28.7+17.6	= 46.3	(B+F')=	28.80+23.80	= 52.60
(B+G)/2=	28.7+19.2	= 47.9	(B+G) =	30.43+22.44	= 52.87
(C+F)/2=	16.76+21	= 37.76	(C+F) =	19.13+23.27	= 42.40
(C+F')/2=	16.76+17.65	= 34.41	(C+F')=	16.64+18.29	= 34.93
(C+G)/2=	16.76+19.2	= 35.96	(C+G) =	17.24+21.29	= 38.53
(D+F)/2=	16.6+21	= 37.6	(D+F) =	18.33+23.04	= 41.37
(D+F')/2=	16.6+17.65	= 34.25	(D+F')=	17.25+22.72	= 39.97
(D+G)/2=	16.6+19.2	= 35.8	(D+G) =	18.82+21.92	= 40.74

DENSITY 100

(A+F)/2=	(108+127.44)/2	= 117.72	(A+F) =	67.39+43.25	= 110.6
(A+F')/2=	(108+108.9)/2	= 108.45	(A+F')=	60.58+51.18	= 111.8
(A+G)/2=	(108+98.8)/2	= 103.4	(A+G) =	65.45+46.96	= 112.4
(B+F)/2=	(119+127.4)/2	= 123.2	(B+F) =	67.26+57.19	= 124.4
(B+F')/2=	(119+108.9)/2	= 113.95	(B+F')=	65.30+52.48	= 117.8
(B+G)/2=	(119+98.8)/2	= 108.9	(B+G) =	68.28+52.27	= 120.5
(C+F)/2=	(86.2+127.4)/2	= 106.8	(C+F) =	42.37+59.50	= 101.9
(C+F')/2=	(86.2+108.9)/2	= 97.55	(C+F')=	42.14+57.06	= 99.2
(C+G)/2=	(86.2+98.8)/2	= 92.5	(C+G) =	41.81+53.64	= 95.4
(D+F)/2=	(84.2+127.4)/2	= 105.8	(D+F) =	43.02+56.64	= 99.7
(D+F')/2=	(84.2+108.9)/2	= 96.55	(D+F')=	43.61+56.16	= 99.8
(D+G)/2=	(84.2+98.8)/2	= 91.5	(D+G) =	45.47+54.85	= 100.3

Legends for Figures

Figure 1. Flow chart showing interrelationship of strains and substrains of Tribolium castaneum.

Figure 2. Significance of t-tests of biomass, single strains.

Figure 3. Significance of t-tests, mixed-strains genotype 1 vs genotype 2 within a vial.

Figure 4. Significance of t-tests betwwen biomasses of single vs mixed strains of same genotype.

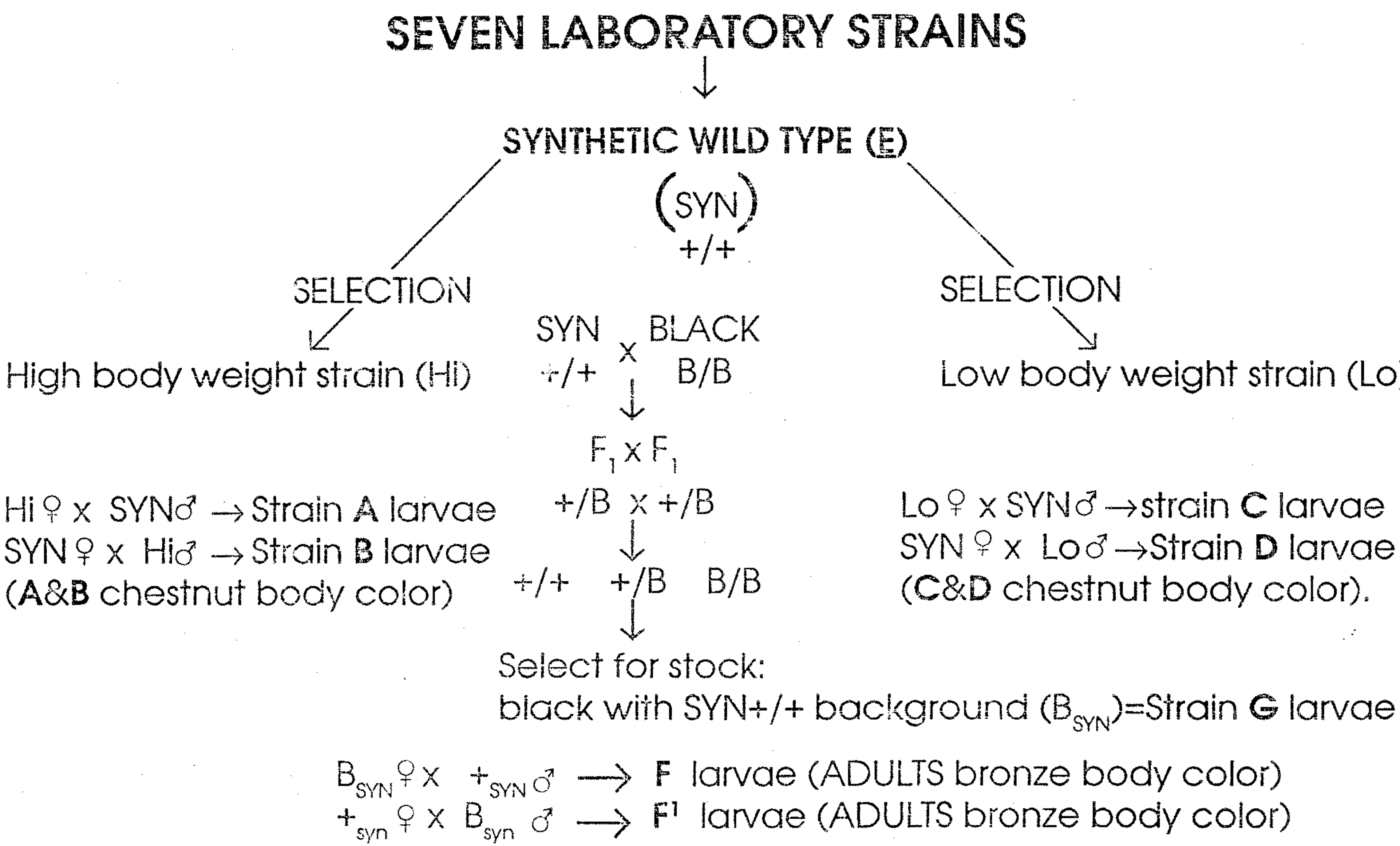
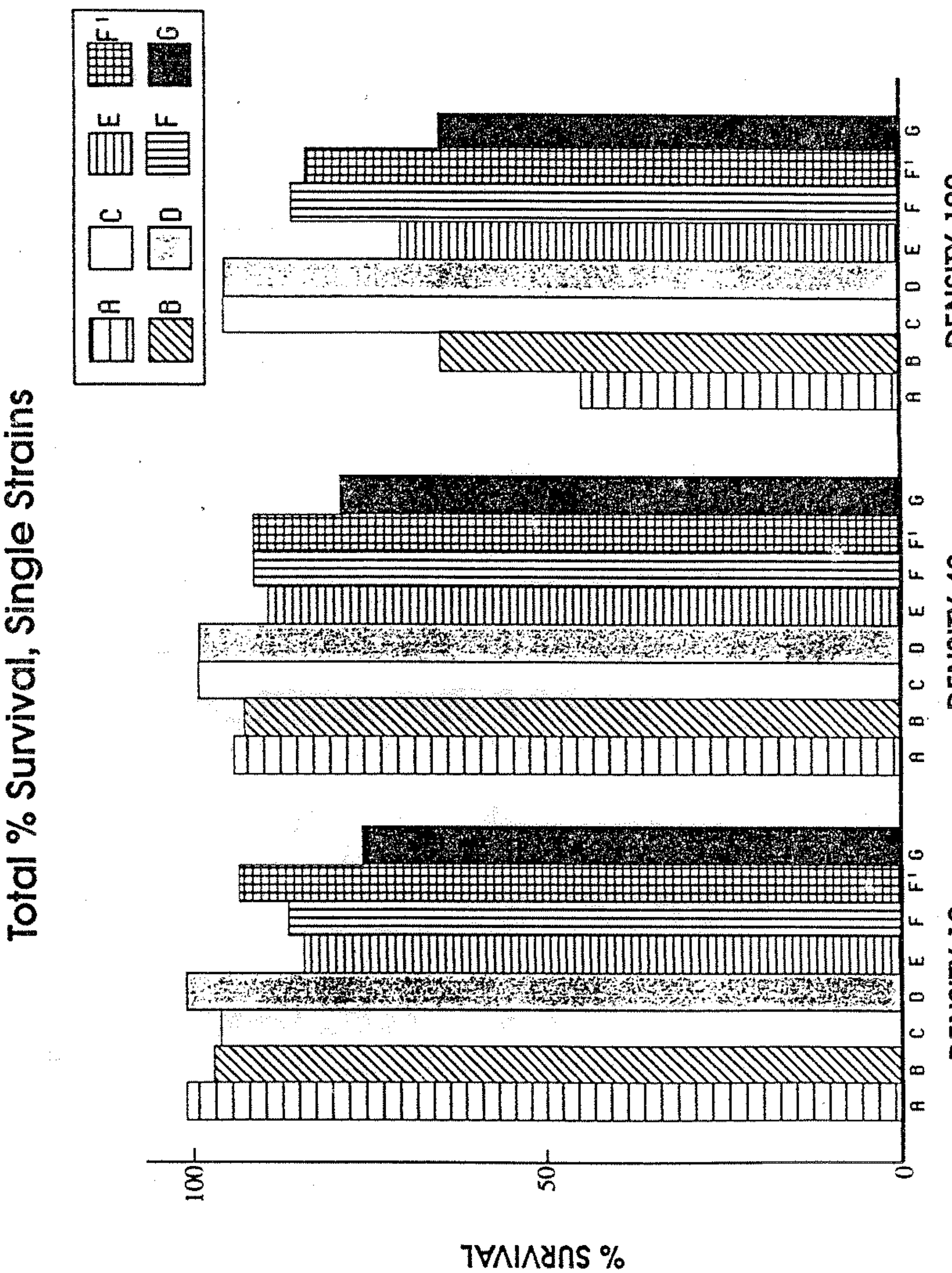
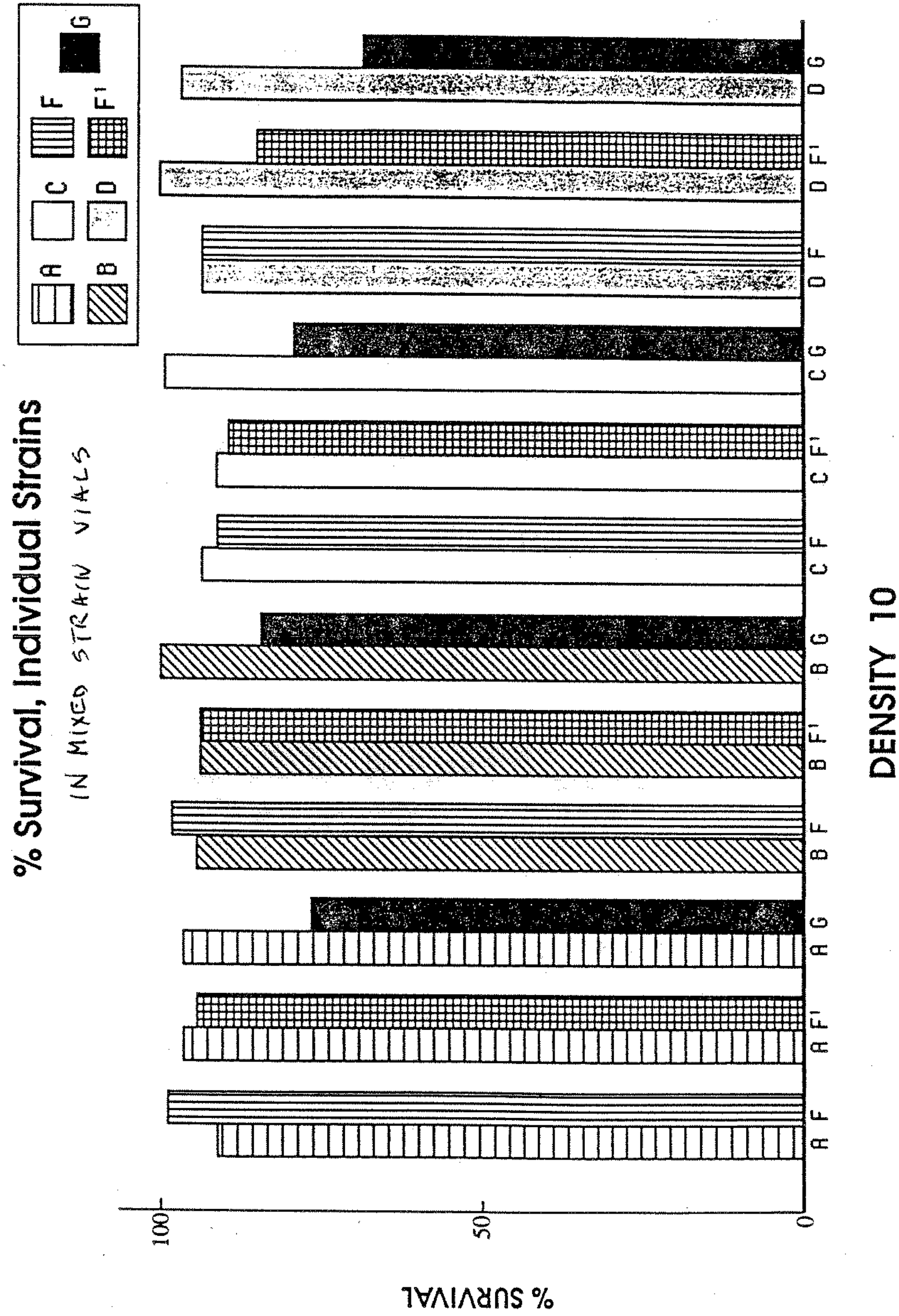
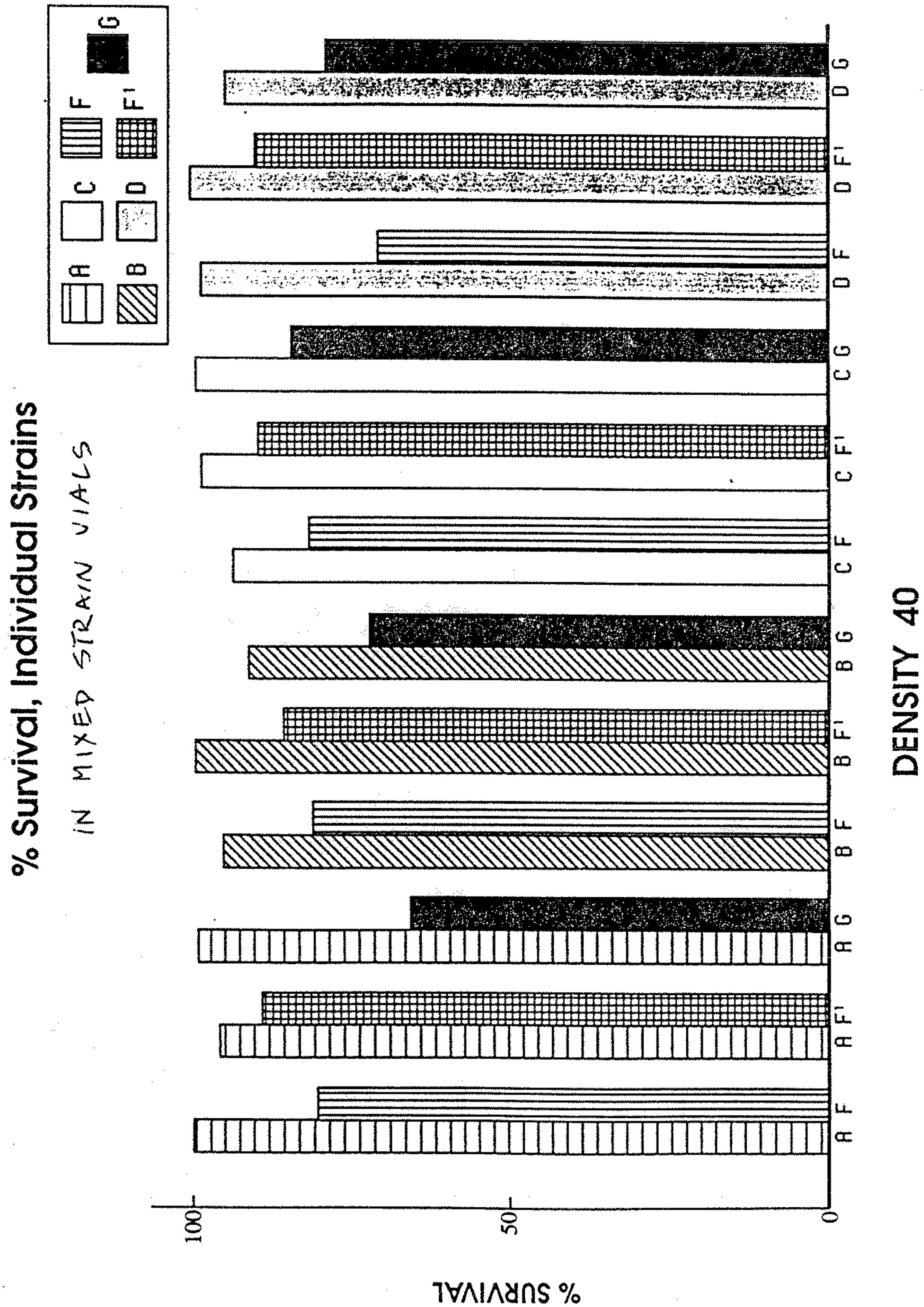


Fig. 1. **History of laboratory strains of *T. castaneum* used in this study.**
Single strains were introduced as first instar larvae not more than six hours old into vials containing 1g of corn flour + yeast at densities of 10, 40 & 100 larvae per vial. There were 10 replicates for each strain or strain combination. For mixed strain vials, equal numbers of larvae


Total % Survival, Single Strains
A
B
C
D
E
F
F'
G
% SURVIVAL
100
50
0
DENSITY 10
DENSITY 40
DENSITY 100


% Survival, Individual Strains
IN MIXED STRAIN VIALS
A
B
C
D
F
F'
G
A F
A F'
A G
B F
B F'
B G
C F
C F'
C G
D F
D F'
D G
0
50
100
% SURVIVAL
DENSITY 10


% Survival, Individual Strains
IN MIXED STRAIN VIALS
A
B
C
D
F
F'
G
A F
A F'
A G
B F
B F'
B G
C F
C F'
C G
D F
D F'
D G
DENSITY 40
100
50
0
% SURVIVAL

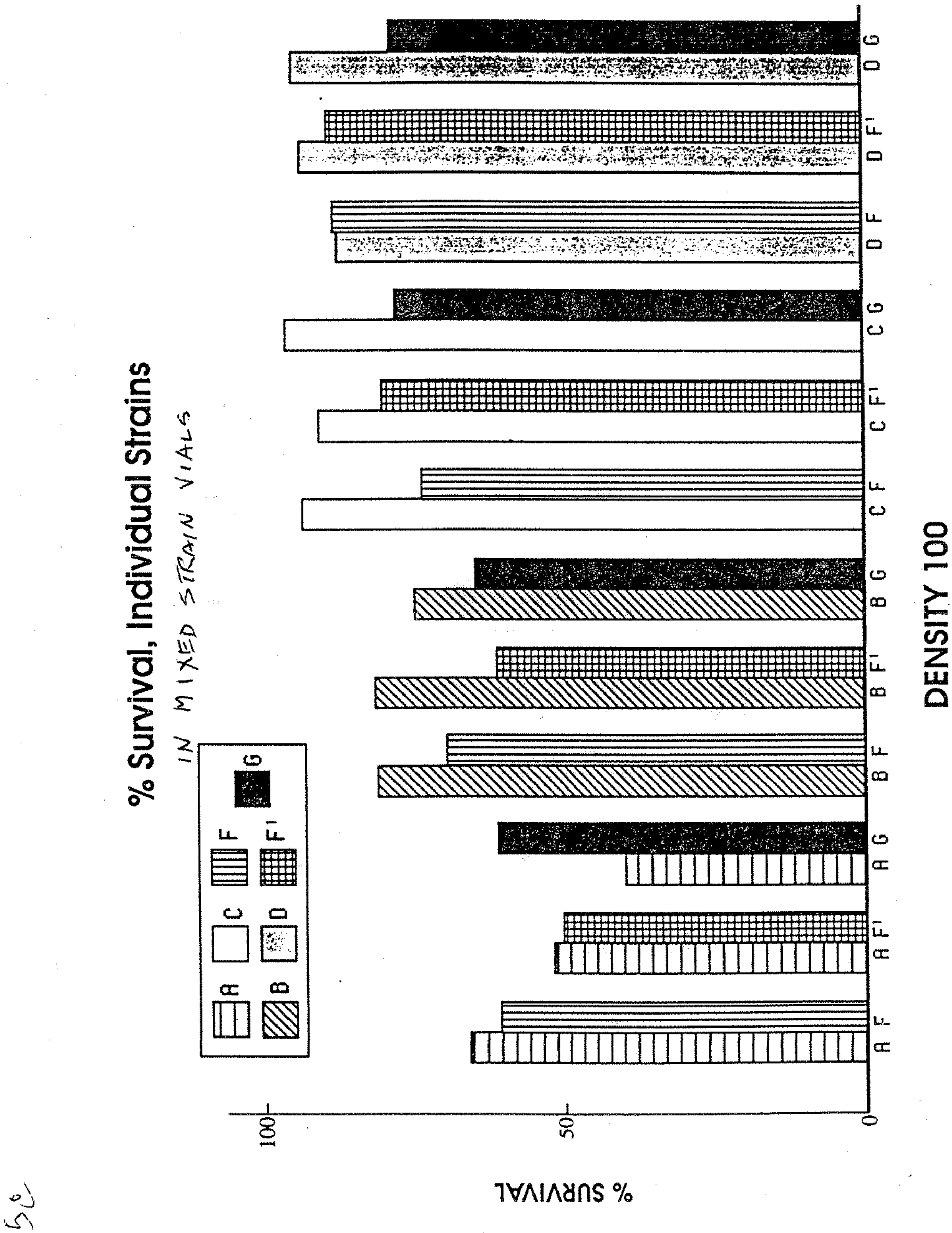

% Survival, Individual Strains
IN MIXED STRAIN VIALS
DENSITY 100
% SURVIVAL
0
50
100
A
C
F
B
D
F'
G
A F
A F'
A G
B F
B F'
B G
C F
C F'
C G
D F
D F'
D G

Figure 4. t-tests biomass, single strain.

DENSITY 10

		A	B	C	D	E	F	F'	G
		1	2	3	4	5	6	7	8
A	1		+	+	+	+	+	+	+
B	2			+	+	+	+	+	+
C	3				--	--	--	--	--
D	4					--	--	--	--
E	5						--	--	--
F	6							--	--
F'	7								--
G	8								

DENSITY 40

A	1		+	+	+	+	+	+	+
B	2			+	+	+	+	+	+
C	3				--	--	+	+	--
D	4					--	+	+	--
E	5						+	--	--
F	6							+	+
F'	7								+
G	8								

DENSITY 100

A	1		+	+	+	+	+	+	--
B	2			--	--	--	+	+	--
C	3				--	+	+	+	+
D	4					+	+	+	+
E	5						+	+	--
F	6							--	+
F'	7								+
G	8								

Figure 5. t-tests biomass mixed-strains genotype 1 vs. genotype 2 within a group.

DENSITY 10

GENOTYPE 2

		AF 9	AF' 10	AG 11	BF 12	BF' 13	BG 14	CF 15	CF' 16	CG 17	DF 18	DF' 19	DG 20
	AF 9	+											
	AF' 10		+										
	AG 11			+									
	BF 12				+								
	BF' 13					+							
GENOTYPE 1	BG 14						+						
	CF 15							+					
	CF' 16								+				
	CG 17									+			
	DF 18										+		
	DF' 19											+	
	DG 20												+

DENSITY 40

		AF 9	AF' 10	AG 11	BF 12	BF' 13	BG 14	CF 15	CF' 16	CG 17	DF 18	DF' 19	DG 20
	AF 9	+											
	AF' 10		+										
	AG 11			+									
	BF 12				+								
	BF' 13					+							
GENOTYPE 1	BG 14						+						
	CF 15							+					
	CF' 16								+				
	CG 17									+			
	DF 18										+		
	DF' 19											+	
	DG 20												+

DENSITY 100

		AF 9	AF' 10	AG 11	BF 12	BF' 13	BG 14	CF 15	CF' 16	CG 17	DF 18	DF' 19	DG 20
	AF 9	+											
	AF' 10		+										
	AG 11			+									
	BF 12				+								
	BF' 13					+							
GENOTYPE 1	BG 14						+						
	CF 15							+					
	CF' 16								+				
	CG 17									+			
	DF 18										+		
	DF' 19											--	
	DG 20												--

Figure 6. t-tests biomass of single vs. mixed-strains of same genotype.

DENSITY 10

		AF 9	AF' 10	AG 11	BF 12	BF' 13	BG 14	CF 15	CF' 16	CG 17	DF 18	DF' 19	DG 20
A	1	+	+	+									
B	2				--	+	--						
C	3							+	+	+			
D	4										--	--	+
E	5	+	+	+	+	+	+	+	+	+	--	+	--
F	6	+			+			+			+		
F'	7		+			+			+			+	
G	8			+			+			--			+

DENSITY 40

		AF 9	AF' 10	AG 11	BF 12	BF' 13	BG 14	CF 15	CF' 16	CG 17	DF 18	DF' 19	DG 20
A	1	+	+	+									
B	2				--	--	+						
C	3							+	--	--			
D	4										+	--	+
E	5	+	+	+	+	+	+	--	+	+	+	+	--
F	6	--			+			--			--		
F'	7		+			+			+			+	
G	8			+			+			+			+

DENSITY 100

		AF 9	AF' 10	AG 11	BF 12	BF' 13	BG 14	CF 15	CF' 16	CG 17	DF 18	DF' 19	DG 20
A	1	+	--	+									
B	2				+	+	+						
C	3							--	--	--			
D	4										--	--	+
E	5	+	+	+	+	+	+	+	+	+	+	+	+
F	6	+			--			--			--		
F'	7		--			--			+			+	
G	8			--			--			+			+

APPENDIX

Appendix Table 1. Paired comparisons between biomass of strain 1 vs biomass of strain 2, single strain vials.
Key: 1 = Strain A
2 = Strain B
3 = Strain C
4 = Strain D
5 = Strain E
6 = Strain F
7 = Strain F'
8 = Strain G

For key to numbers at the head of the columns see the definitions at the bottom of the table.

2/ 3/ 95

TABLE 1a

DENSITY 10

(1)*	(2)*	(3)*	(4)*	(5)*	(6)*	(7)*	(8)*	(9)*
1, 2	12.6690	1.449	13.8200	1.080	-2.01	18	0.059	NS
1, 3	12.6690	1.449	8.0430	1.409	7.24	18	0.000	
1, 4	12.6690	1.449	8.3520	1.293	7.03	18	0.000	
1, 5	12.6690	1.449	7.8544	1.207	7.82	17	0.000	
1, 6	12.6690	1.449	8.2970	0.951	7.98	18	0.000	
1, 7	12.6690	1.449	8.2590	0.628	8.83	18	0.000	
1, 8	12.6690	1.449	7.1856	2.468	5.98	17	0.000	
2, 3	13.8200	1.080	8.0430	1.409	10.29	18	0.000	
2, 4	13.8200	1.080	8.3520	1.293	10.26	18	0.000	
2, 5	13.8200	1.080	7.8544	1.207	11.37	17	0.000	
2, 6	13.8200	1.080	8.2970	0.951	12.13	18	0.000	
2, 7	13.8200	1.080	8.2590	0.628	14.07	18	0.000	
2, 8	13.8200	1.080	7.1856	2.468	7.74	17	0.000	
3, 4	8.0430	1.409	8.3520	1.293	-0.51	18	0.616	NS
3, 5	8.0430	1.409	7.8544	1.207	0.31	17	0.759	NS
3, 6	8.0430	1.409	8.2970	0.951	-0.47	18	0.642	NS
3, 7	8.0430	1.409	8.2590	0.628	-0.44	18	0.663	NS
3, 8	8.0430	1.409	7.1856	2.468	0.94	17	0.359	NS
4, 5	8.3520	1.293	7.8544	1.207	0.86	17	0.400	NS
4, 6	8.3520	1.293	8.2970	0.951	0.11	18	0.915	NS
4, 7	8.3520	1.293	8.2590	0.628	0.20	18	0.840	NS
4, 8	8.3520	1.293	7.1856	2.468	1.31	17	0.207	NS
5, 6	7.8544	1.207	8.2970	0.951	-0.89	17	0.385	NS
5, 7	7.8544	1.207	8.2590	0.628	-0.93	17	0.365	NS
5, 8	7.8544	1.207	7.1856	2.468	0.73	16	0.476	NS
6, 7	8.2970	0.951	8.2590	0.628	0.11	18	0.917	NS
6, 8	8.2970	0.951	7.1856	2.468	1.32	17	0.203	NS
7, 8	8.2590	0.628	7.1856	2.468	1.33	17	0.200	NS

* 1. Strains;
2. Mean weight of strain 1;
3. Standard Deviation of strain 1;
4. Mean weight of strain 2;
5. Standard Deviation of strain 2;
6. t;
7. df;
8. p;
9. Significance.

2/3/95

TABLE 1b

DENSITY 40

(1)*	(2)*	(3)*	(4)*	(5)*	(6)*	(7)*	(8)*	(9)*
1, 2	49.5640	3.369	52.8710	2.040	-2.66	18	0.016	
1, 3	49.5640	3.369	33.6550	3.339	10.61	18	0.000	
1, 4	49.5640	3.369	32.7670	1.268	14.76	18	0.000	
1, 5	49.5640	3.369	34.7160	3.188	10.12	18	0.000	
1, 6	49.5640	3.369	42.3350	2.865	5.17	18	0.000	
1, 7	49.5640	3.369	36.6400	2.742	9.41	18	0.000	
1, 8	49.5640	3.369	30.1400	8.514	6.71	18	0.000	
2, 3	52.8710	2.040	33.6550	3.339	15.53	18	0.000	
2, 4	52.8710	2.040	32.7670	1.268	26.47	18	0.000	
2, 5	52.8710	2.040	34.7160	3.188	15.17	18	0.000	
2, 6	52.8710	2.040	42.3350	2.865	9.47	18	0.000	
2, 7	52.8710	2.040	36.6400	2.742	15.02	18	0.000	
2, 8	52.8710	2.040	30.1400	8.514	8.21	18	0.000	
3, 4	33.6550	3.339	32.7670	1.268	0.79	18	0.442	NS
3, 5	33.6550	3.339	34.7160	3.188	-0.73	18	0.477	NS
3, 6	33.6550	3.339	42.3350	2.865	-6.24	18	0.000	
3, 7	33.6550	3.339	36.6400	2.742	-1.28	18	0.042	
3, 8	33.6550	3.339	30.1400	8.514	1.22	18	0.240	NS
4, 5	32.7670	1.268	34.7160	3.188	-1.80	18	0.089	NS
4, 6	32.7670	1.268	42.3350	2.865	-9.66	18	0.000	
4, 7	32.7670	1.268	36.6400	2.742	-4.05	18	0.001	
4, 8	32.7670	1.268	30.1400	8.514	0.96	18	0.347	NS
5, 6	34.7160	3.188	42.3350	2.865	-5.62	18	0.000	
5, 7	34.7160	3.188	36.6400	2.742	-1.45	18	0.165	NS
5, 8	34.7160	3.188	30.1400	8.514	1.59	18	0.129	NS
6, 7	42.3350	2.865	36.6400	2.742	4.54	18	0.000	
6, 8	42.3350	2.865	30.1400	8.514	4.29	18	0.000	
7, 8	36.6400	2.742	30.1400	8.514	2.30	18	0.034	

* 1. Strains;
2. Mean weight of strain 1;
3. Standard Deviation of strain 1;
4. Mean weight of strain 2;
5. Standard Deviation of strain 2;
6. t;
7. df;
8. p;
9. Significance.

2/3/95

TABLE 1c

DENSITY 100

(1)*	(2)*	(3)*	(4)*	(5)*	(6)*	(7)*	(8)*	(9)*
1, 2	48.4920	15.405	77.8570	14.609	-4.35	18	0.000	
1, 3	48.4920	15.405	82.7870	4.197	-6.68	18	0.000	
1, 4	48.4920	15.405	80.9630	7.852	-5.94	18	0.000	
1, 5	48.4920	15.405	67.8925	9.011	-3.15	16	0.006	
1, 6	48.4920	15.405	98.3844	13.670	-7.43	17	0.000	
1, 7	48.4920	15.405	90.9410	10.883	-7.12	18	0.000	
1, 8	48.4920	15.405	64.3290	22.198	-1.85	18	0.080	NS
2, 3	77.8570	14.609	82.7870	4.197	-0.91	18	0.375	NS
2, 4	77.8570	14.609	80.9630	7.852	-0.59	18	0.561	NS
2, 5	77.8570	14.609	67.8925	14.609	1.68	16	0.112	NS
2, 6	77.8570	14.609	98.3844	13.670	-3.15	17	0.006	
2, 7	77.8570	14.609	90.9410	10.883	-2.27	18	0.036	
2, 8	77.8570	14.609	64.3290	22.198	1.61	18	0.125	NS
3, 4	82.2270	4.197	80.9630	7.852	0.45	18	0.659	NS
3, 5	82.2270	4.197	67.8925	9.011	4.48	16	0.000	
3, 6	82.2270	4.197	98.3844	13.670	-3.57	17	0.002	
3, 7	82.2270	4.197	90.9410	10.883	-2.36	18	0.030	
3, 8	82.2270	4.197	64.3290	22.198	2.51	18	0.022	
4, 5	80.9630	7.852	67.8925	9.011	3.29	16	0.005	
4, 6	80.9630	7.852	98.3844	13.670	-3.45	17	0.000	
4, 7	80.9630	7.852	90.9410	10.883	-2.35	18	0.003	
4, 8	80.9630	7.852	64.3290	22.198	2.23	18	0.038	
5, 6	67.8925	9.011	98.3844	13.670	-5.35	15	0.000	
5, 7	67.8925	9.011	90.9410	10.883	-4.81	16	0.000	
5, 8	67.8925	9.011	64.3290	22.198	0.42	16	0.677	NS
6, 7	98.3844	13.670	90.9410	10.883	1.32	17	0.204	NS
6, 8	98.3844	13.670	64.3290	22.198	3.97	17	0.001	
7, 8	90.9410	10.883	64.3290	22.198	3.40	18	0.003	

* 1. Strains;
2. Mean weight of strain 1;
3. Standard Deviation of strain 1;
4. Mean weight of strain 2;
5. Standard Deviation of strain 2;
6. t;
7. df;
8. p;
9. Significance.

Appendix Table 2 a,b,c. paired comparisons of total biomass of the same and different genotype in mixed-strain vials
The key for symbols is as follows:

9 = AF	12 = BF	15 = CF	18 = DF
10 = AF'	13 = BF'	16 = CF'	19 = DF'
11 = AG	14 = BG	17 = CG	20 = DG

Other symbols:
(1) symbols of strains; (2) = mean biomass, genotype 1; (3) = standard deviation; (4) = mean biomass, genotype 2; (5)=standard deviation; (6) = t; (7) = degrees of freedom; p = probability; (9) significance: NS = not significant; B = borderline significance; blank ( ) = significant.

TABLE 2a

DENSITY 10

(1)*	(2)*	(3)*	(4)*	(5)*	(6)*	(7)*	(8)*	(9)*
9, 10	6.4725	1.081	6.5110	1.294	-0.10	38	0.919	NS
9, 11	6.4725	1.081	6.0530	1.898	0.66	38	0.934	NS
9, 12	6.4725	1.081	6.4475	0.606	0.08	38	0.754	NS
9, 13	6.4725	1.081	6.3700	0.971	0.32	30	0.118	NS
9, 14	6.4725	1.081	5.7658	1.387	1.61	38	0.001	
9, 15	6.4725	1.081	5.2655	1.031	3.61	38	0.000	
9, 16	6.4725	1.081	4.0425	0.881	7.79	38	0.000	
9, 17	6.4725	1.081	3.5225	0.713	10.18	38	0.000	
9, 18	6.4725	1.081	4.9255	0.941	4.83	38	0.000	
9, 19	6.4725	1.081	4.3205	1.019	6.48	38	0.000	
9, 20	6.4725	1.081	4.2585	1.126	6.34	38	0.000	
10, 11	6.5110	1.294	6.0530	1.898	0.89	38	0.378	NS
10, 12	6.5110	1.294	6.4475	0.806	0.19	38	0.843	NS
10, 13	6.5110	1.294	6.3700	0.971	0.39	38	0.699	NS
10, 14	6.5110	1.294	5.7658	1.387	1.54	30	0.135	NS
10, 15	6.5110	1.294	5.2655	1.031	3.37	38	0.002	
10, 16	6.5110	1.294	4.0425	0.881	7.05	38	0.000	
10, 17	6.5110	1.294	3.5225	0.713	9.04	38	0.000	
10, 18	6.5110	1.294	4.9255	0.941	4.43	38	0.000	
10, 19	6.5110	1.294	4.3205	1.019	5.95	38	0.000	
10, 20	6.5110	1.294	4.2585	1.126	5.87	38	0.000	
11, 12	6.0530	1.898	6.4475	0.808	-0.86	38	0.398	NS
11, 13	6.0530	1.898	6.3700	0.971	-0.67	38	0.510	NS
11, 14	6.0530	1.898	5.7658	1.387	0.46	30	0.652	NS
11, 15	6.0530	1.898	5.2655	1.031	1.63	38	0.111	NS
11, 16	6.0530	1.898	4.0425	0.881	4.30	38	0.000	
11, 17	6.0530	1.898	3.5225	0.713	5.58	38	0.000	
11, 18	6.0530	1.898	4.9255	0.941	2.38	38	0.022	
11, 19	6.0530	1.898	4.3205	1.019	3.60	38	0.001	
11, 20	6.0530	1.898	4.2585	1.126	3.64	38	0.001	
12, 13	6.4475	0.808	6.3700	0.971	0.27	38	0.785	NS
12, 14	6.4475	0.808	5.7658	1.387	1.77	30	0.088	NS
12, 15	6.4475	0.808	5.2655	1.031	4.03	38	0.000	
12, 16	6.4475	0.808	4.0425	0.881	9.00	38	0.000	
12, 17	6.4475	0.808	3.5225	0.713	12.14	38	0.000	
12, 18	6.4475	0.808	4.9255	0.941	5.49	38	0.000	
12, 19	6.4475	0.808	4.3205	1.019	7.31	38	0.000	
12, 20	6.4475	0.808	4.2585	1.126	7.06	38	0.000	
13, 14	6.3700	0.971	5.7658	1.387	1.45	30	0.158	NS
13, 15	6.3700	0.971	5.2655	1.031	3.49	38	0.001	
13, 16	6.3700	0.971	4.0425	0.881	7.94	38	0.000	
13, 17	6.3700	0.971	3.5225	0.713	10.57	38	0.000	
13, 18	6.3700	0.971	4.9255	0.941	4.78	38	0.000	
13, 19	6.3700	0.971	4.3205	1.019	6.51	38	0.000	
13, 20	6.3700	0.971	4.2585	1.126	6.35	38	0.000	
14, 15	5.7658	1.387	5.2655	1.031	1.17	30	0.252	NS
14, 16	5.7658	1.387	4.0425	0.881	4.31	30	0.000	
14, 17	5.7658	1.387	3.5225	0.713	6.06	30	0.000	
14, 18	5.7658	1.387	4.9255	0.941	2.05	30	0.050	B
14, 19	5.7658	1.387	4.3205	1.019	3.39	30	0.002	
14, 20	5.7658	1.387	4.2585	1.126	3.36	30	0.002	
15, 16	5.2655	1.031	4.0425	0.881	4.03	38	0.000	
15, 17	5.2655	1.031	3.5225	0.713	6.22	38	0.000	
15, 18	5.2655	1.031	4.9255	0.941	1.09	38	0.283	NS
15, 19	5.2655	1.031	4.3205	1.019	2.91	38	0.006	
15, 20	5.2655	1.031	4.2585	1.126	2.95	38	0.005	
16, 17	4.0425	0.881	3.5225	0.713	2.05	38	0.047	B
16, 18	4.0425	0.881	4.9255	0.941	-3.06	38	0.004	
16, 19	4.0425	0.881	4.3205	1.019	-0.92	38	0.362	NS
16, 20	4.0425	0.881	4.2585	1.126	-0.68	38	0.503	NS
17, 18	3.5225	0.713	4.9255	0.941	-5.31	38	0.000	
17, 19	3.5225	0.713	4.3205	1.019	-2.87	38	0.007	
17, 20	3.5225	0.713	4.2585	1.126	-2.47	38	0.018	
18, 19	4.9255	0.941	4.3205	1.019	1.95	38	0.058	NS
18, 20	4.9255	0.941	4.2585	1.126	2.03	38	0.049	B
19, 20	4.3205	1.019	4.2585	1.126	0.18	38	0.856	NS

* 1. Strains; 2. Mean weight of strain 1; 3. Standard Deviation of strain 1; 4. Mean weight of strain 2; 5. Standard Deviation of strain 2; 6. t; 7. df; 8. p; 9. Significance.

51

TABLE 2b

DENSITY 40

(1)*	(2)*	(3)*	(4)*	(5)*	(6)*	(7)*	(8)*	(9)*
9, 10	23.6695	5.807	24.9294	4.540	-0.74	36	0.465	NS
9, 11	23.6695	5.807	21.2555	7.489	1.14	38	0.262	NS
9, 12	23.6695	5.807	23.5740	3.985	0.06	38	0.952	NS
9, 13	23.6695	5.807	24.6435	5.205	-0.56	38	0.580	NS
9, 14	23.6695	5.807	22.3225	6.417	0.70	36	0.491	NS
9, 15	23.6695	5.807	18.5945	2.248	3.64	38	0.001	
9, 16	23.6695	5.807	18.6880	2.479	3.53	38	0.001	
9, 17	23.6695	5.807	16.0700	2.546	5.36	38	0.000	
9, 18	23.6695	5.807	17.3605	2.098	4.57	38	0.000	
9, 19	23.6695	5.807	19.3105	2.419	3.10	38	0.004	
9, 20	23.6695	5.807	16.1105	3.543	4.97	36	0.000	
10, 11	24.9294	4.540	21.2555	7.489	1.80	38	0.080	NS
10, 12	24.9294	4.540	23.5740	3.985	0.98	36	0.333	NS
10, 13	24.9294	4.540	24.6435	5.205	0.18	36	0.859	NS
10, 14	24.9294	4.540	22.3225	6.417	1.43	36	0.161	NS
10, 15	24.9294	4.540	18.5945	2.248	5.54	36	0.000	
10, 16	24.9294	4.540	18.6880	2.479	5.33	36	0.000	
10, 17	24.9294	4.540	16.0700	2.546	7.52	36	0.000	
10, 18	24.9294	4.540	17.3605	2.098	6.71	36	0.000	
10, 19	24.9294	4.540	19.3105	2.419	4.83	36	0.000	
10, 20	24.9294	4.540	16.1105	3.543	6.71	36	0.000	
11, 12	21.2555	7.489	23.5740	3.985	-1.22	38	0.229	NS
11, 13	21.2555	7.489	24.6435	5.205	-1.66	38	0.105	NS
11, 14	21.2555	7.489	22.3225	6.417	-0.48	38	0.631	NS
11, 15	21.2555	7.489	18.5945	2.248	1.52	38	0.136	NS
11, 16	21.2555	7.489	18.6880	2.479	1.46	38	0.154	NS
11, 17	21.2555	7.489	16.0700	2.546	2.93	38	0.006	
11, 18	21.2555	7.489	17.3605	2.098	2.24	38	0.031	
11, 19	21.2555	7.489	19.3105	2.419	1.11	38	0.276	NS
11, 20	21.2555	7.489	16.1105	3.543	2.78	38	0.008	
12, 13	23.5740	3.985	24.6435	5.205	-0.73	38	0.470	NS
12, 14	23.5740	3.985	22.3225	6.417	0.74	38	0.463	NS
12, 15	23.5740	3.985	18.5945	2.248	4.87	38	0.000	
12, 16	23.5740	3.985	18.6880	2.479	4.66	38	0.000	
12, 17	23.5740	3.985	16.0700	2.546	7.10	38	0.000	
12, 18	23.5740	3.985	17.3605	2.098	6.17	38	0.000	
12, 19	23.5740	3.985	19.3105	2.419	4.09	36	0.000	
12, 20	23.5740	3.985	16.1105	3.543	6.26	38	0.000	
13, 14	24.6435	5.205	22.3225	6.417	1.26	38	0.217	NS
13, 15	24.6435	5.205	18.5945	2.248	4.77	38	0.000	
13, 16	24.6435	5.205	18.6880	2.479	4.62	38	0.000	
13, 17	24.6435	5.205	16.0700	2.546	6.62	38	0.000	
13, 18	24.6435	5.205	17.3605	2.098	5.80	38	0.000	
13, 19	24.6435	5.205	19.3105	2.419	4.16	38	0.000	
13, 20	24.6435	5.205	16.1105	3.543	6.06	36	0.000	
14, 15	22.3225	6.417	18.5945	2.248	2.45	38	0.019	
14, 16	22.3225	6.417	18.6880	2.479	2.36	36	0.023	
14, 17	22.3225	6.417	16.0700	2.546	4.05	38	0.000	
14, 18	22.3225	6.417	17.3605	2.098	3.29	36	0.002	
14, 19	22.3225	6.417	19.3105	2.419	1.96	38	0.057	NS
14, 20	22.3225	6.417	16.1105	3.543	3.79	38	0.001	
15, 16	18.5945	2.248	18.6880	2.479	-0.12	38	0.901	NS
15, 17	18.5945	2.248	16.0700	2.546	3.32	38	0.002	
15, 18	18.5945	2.248	17.3605	2.098	1.79	38	0.081	NS
15, 19	18.5945	2.248	19.3105	2.419	-0.97	38	0.338	NS
15, 20	18.5945	2.248	16.1105	3.543	2.65	38	0.012	
16, 17	18.6880	2.479	16.0700	2.546	3.29	38	0.002	
16, 18	18.6880	2.479	17.3605	2.098	1.83	38	0.075	NS
16, 19	18.6880	2.479	19.3105	2.419	-0.80	38	0.427	NS
16, 20	18.6880	2.479	16.1105	3.543	2.67	38	0.011	
17, 18	16.0700	2.546	17.3605	2.098	-1.75	36	0.088	NS
17, 19	16.0700	2.546	19.3105	2.419	-4.13	36	0.000	
17, 20	16.0700	2.546	16.1105	3.543	-0.04	38	0.967	NS
18, 19	17.3605	2.098	19.3105	2.419	-2.72	38	0.010	
18, 20	17.3605	2.098	16.1105	3.543	1.36	38	0.183	NS
19, 20	17.3605	2.098	16.1105	3.543	1.36	38	0.183	NS

* 1. Strains; 2. Mean weight of strain 1; 3. Standard Deviation of strain 1; 4. Mean weight of strain 2; 5. Standard Deviation of strain 2; 6. t; 7. df; 8. p; 9. Significance.

TABLE 2c.

DENSITY 100

(1)*	(2)*	(3)*	(4)*	(5)*	(6)*	(7)*	(8)*	(9)*
9, 10	38.5460	10.603	28.5440	7.948	3.36	38	0.002	
9, 11	38.5460	10.603	27.5975	9.926	3.37	38	0.002	
9, 12	38.5460	10.603	47.1333	10.068	-2.55	36	0.015	
9, 13	38.5460	10.603	43.2775	12.768	-1.27	38	0.210	NS
9, 14	38.5460	10.603	39.2705	13.219	-0.19	38	0.849	NS
9, 15	38.5460	10.603	40.2350	5.239	-0.61	36	0.545	NS
9, 16	38.5460	10.603	44.1500	5.717	-2.08	38	0.044	
9, 17	38.5460	10.603	36.1040	6.283	0.89	38	0.381	NS
9, 18	38.5460	10.603	44.0820	7.306	-1.92	38	0.062	NS
9, 19	38.5460	10.603	45.8855	6.239	-2.67	38	0.011	
9, 20	38.5460	10.603	38.7465	6.813	-0.07	38	0.944	NS
10, 11	28.5440	7.948	27.5975	9.926	0.33	38	0.741	NS
10, 12	28.5440	7.948	47.1333	10.068	-6.35	36	0.000	
10, 13	28.5440	7.948	43.2775	12.768	-4.38	38	0.000	
10, 14	28.5440	7.948	39.2705	13.219	-3.11	38	0.004	
10, 15	28.5440	7.948	40.2350	5.239	-5.29	36	0.000	
10, 16	28.5440	7.948	44.1500	5.717	-7.13	38	0.000	
10, 17	28.5440	7.948	36.1040	6.283	-3.34	38	0.002	
10, 18	28.5440	7.948	44.0820	7.306	-6.44	38	0.000	
10, 19	28.5440	7.948	45.8855	6.239	-7.68	38	0.000	
10, 20	28.5440	7.948	38.7465	6.813	-4.36	38	0.000	
11, 12	27.5975	9.926	47.1333	10.068	-6.02	36	0.000	
11, 13	27.5975	9.926	43.2775	12.768	-4.34	38	0.000	
11, 14	27.5975	9.926	39.2705	13.219	-3.16	36	0.003	
11, 15	27.5975	9.926	40.2350	5.239	-4.63	36	0.000	
11, 16	27.5975	9.926	44.1500	5.717	-6.46	38	0.000	
11, 17	27.5975	9.926	36.1040	6.283	-3.24	38	0.002	
11, 18	27.5975	9.926	44.0820	7.306	-5.98	36	0.000	
11, 19	27.5975	9.926	45.8855	6.239	-6.98	38	0.000	
11, 20	27.5975	9.926	38.7465	6.813	-4.14	36	0.000	
12, 13	47.1333	10.068	43.2775	12.768	1.03	36	0.312	NS
12, 14	47.1333	10.068	39.2705	13.219	2.04	36	0.048	B
12, 15	47.1333	10.068	40.2350	5.239	2.58	34	0.014	
12, 16	47.1333	10.068	44.1500	5.717	1.14	36	0.263	NS
12, 17	47.1333	10.068	36.1040	6.283	4.10	36	0.000	
12, 18	47.1333	10.068	44.0820	7.306	1.06	36	0.289	NS
12, 19	47.1333	10.068	45.8855	6.239	0.46	36	0.645	NS
12, 20	47.1333	10.068	38.7465	6.813	3.03	36	0.004	
13, 14	43.2775	12.768	39.2705	13.219	0.96	38	0.336	NS
13, 15	43.2775	12.768	40.2350	5.239	0.94	36	0.353	NS
13, 16	43.2775	12.768	44.1500	5.717	-0.28	38	0.782	NS
13, 17	43.2775	12.768	36.1040	6.283	2.25	38	0.030	
13, 18	43.2775	12.768	44.0820	7.306	-0.24	38	0.808	NS
13, 19	43.2775	12.768	45.8855	6.239	-0.82	38	0.417	NS
13, 20	43.2775	12.768	38.7465	6.813	1.40	38	0.170	NS
14, 15	39.2705	13.219	40.2350	5.239	-0.29	36	0.774	NS
14, 16	39.2705	13.219	44.1500	5.717	-1.52	38	0.138	NS
14, 17	39.2705	13.219	36.1040	6.283	0.97	38	0.339	NS
14, 18	39.2705	13.219	44.0820	7.306	-1.42	38	0.162	NS
14, 19	39.2705	13.219	45.8855	6.239	-2.02	38	0.050	B
14, 20	39.2705	13.219	38.7465	6.813	0.16	38	0.876	NS
15, 16	40.2350	5.239	44.1500	5.717	-2.19	36	0.035	
15, 17	40.2350	5.239	36.1040	6.283	2.19	36	0.035	
15, 18	40.2350	5.239	44.0820	7.306	-1.85	36	0.073	NS
15, 19	40.2350	5.239	45.8855	6.239	-3.00	36	0.005	
15, 20	40.2350	5.239	38.7465	6.813	0.75	36	0.459	NS
16, 17	44.1500	5.717	36.1040	6.283	4.24	38	0.000	
16, 18	44.1500	5.717	44.0820	7.306	0.03	38	0.974	NS
16, 19	44.1500	5.717	45.8855	6.239	-0.92	38	0.365	NS
16, 20	44.1500	5.717	38.7465	6.813	2.72	38	0.010	
17, 18	36.1040	6.283	44.0820	7.306	-3.70	38	0.001	
17, 19	36.1040	6.283	45.8855	6.239	-4.94	38	0.000	
17, 20	36.1040	6.283	38.7465	6.813	-1.28	38	0.210	NS
18, 19	44.0820	7.306	45.8855	6.239	-0.84	38	0.406	NS
18, 20	44.0820	7.306	38.7465	6.813	2.39	38	0.022	
19, 20	45.8855	6.239	38.7465	6.813	3.46	38	0.001	

* 1. Strains; 2. Mean weight of strain 1; 3. Standard Deviation of strain 1; 4. Mean weight of strain 2; 5. Standard Deviation of strain 2; 6. t; 7. df; 8. p; 9. Significance.

APPENDIX Table 3

Paired comparisons between single strains and strains of equivalent genotype from mixed-strain vials

Key:

Single strains
1 = A
2 = B
3 = C
4 = D
5 = E
6 = F
7 = F'
8 = G

Mixed-strains
9, 10, 11 = strain A
12, 13, 14 = strain B
15. 16. 17 = strain C
18, 19, 20 = strain D

9, 12, 15, 18 = strain F
10, 13, 16, 19 = strain F'
11, 14, 17, 20 = strain G

Note: if the mean of genotype 1 is larger than the mean of genotype 2, the t value is positive. If the mean of Genotype is smaller than the mean of genotype 2 the t value is negative.

NS = Not significant; B = borderline significance; blank = significant.

TABLE 3a

DENSITY 10

(1)*	(2)*	(3)*	(4)*	(5)*	(6)*	(7)*	(8)*	(9)*	(10)*	(11)*
1 : 9	10	1.2545	0.048	10	1.5324	0.103	-7.72	18	0.000	
1 : 10	10	1.2545	0.048	10	1.4837	0.116	-5.78	18	0.000	
1 : 11	10	1.2545	0.048	10	1.5678	0.086	-10.05	18	0.000	
2 : 12	10	1.4241	0.031	10	1.4385	0.136	-0.33	18	0.749	NS
2 : 13	10	1.4241	0.031	10	1.4867	0.074	-2.45	18	0.025	
2 : 14	10	1.4241	0.031	6	1.3973	0.106	0.76	14	0.461	NS
3 : 15	10	0.8334	0.046	10	1.0177	0.058	-7.85	18	0.000	
3 : 16	10	0.8334	0.046	10	0.7756	0.060	-2.40	18	0.027	
3 : 17	10	0.8334	0.046	10	0.7098	0.095	3.70	18	0.002	
4 : 18	10	0.8278	0.050	10	0.9317	0.043	-4.97	18	0.000	
4 : 19	10	0.8278	0.050	10	0.8251	0.047	0.12	18	0.903	NS
4 : 20	10	0.8278	0.050	10	0.9180	0.046	-4.19	18	0.001	
5 : 9	9	0.9318	0.049	10	1.5324	0.103	-15.87	17	0.000	
5 : 10	9	0.9318	0.049	10	1.4387	0.116	-13.22	17	0.000	
5 : 11	9	0.9318	0.049	10	1.5678	0.086	-19.44	17	0.000	
5 : 12	9	0.9318	0.049	10	1.4385	0.136	-10.53	17	0.000	
5 : 13	9	0.9318	0.049	10	1.4867	0.074	-16.98	17	0.000	
5 : 14	9	0.9318	0.049	6	1.3973	0.106	-11.58	13	0.000	
5 : 15	9	0.9318	0.049	10	1.0177	0.058	-3.47	17	0.003	
5 : 16	9	0.9318	0.049	10	0.7756	0.060	6.16	17	0.000	
5 : 17	9	0.9318	0.049	10	0.7098	0.095	6.29	17	0.000	
5 : 18	9	0.9318	0.049	10	0.9317	0.043	0.00	17	0.997	NS
5 : 19	9	0.9318	0.049	10	0.8251	0.047	4.86	17	0.000	
5 : 20	9	0.9318	0.049	10	0.9180	0.046	0.63	17	0.534	NS
6 : 9	10	0.9640	0.045	10	1.2256	0.049	-12.33	18	0.000	
6 : 12	10	0.9640	0.045	10	1.2546	0.099	-8.47	18	0.000	
6 : 15	10	0.9640	0.045	10	1.2495	0.090	-8.99	18	0.000	
6 : 18	10	0.9640	0.045	10	1.1608	0.057	-8.53	18	0.000	
7 : 10	10	0.8890	0.044	10	1.2560	0.117	-9.30	18	0.000	
7 : 13	10	0.8890	0.044	10	1.2246	0.088	-10.76	18	0.000	
7 : 16	10	0.8890	0.044	10	0.9968	0.090	-3.40	18	0.003	
7 : 19	10	0.8890	0.044	10	1.0171	0.054	-5.85	18	0.000	
8 : 11	9	0.9467	0.031	10	1.2571	0.117	-7.72	17	0.000	
8 : 14	9	0.9467	0.031	10	1.0903	0.097	-4.17	13	0.001	
8 : 17	9	0.9467	0.031	10	0.8717	0.133	1.64	17	0.119	NS
8 : 20	9	0.9467	0.031	10	1.1411	0.073	-7.34	17	0.000	

* 1. Strain compared;
2. Replicated number of strain 1;
3. Mean weight of strain 1;
4. Standard Deviation of strain 1;
5. Replicated number of strain 2;
6. Mean weight of strain 2;
7. Standard Deviation of strain 2;
8. t;
9. df;
10. p;
11. Significance.

TABLE 3b

DENSITY 40

(1)*	(2)*	(3)*	(4)*	(5)*	(6)*	(7)*	(8)*	(9)*	(10)*	(11)*
1 : 9	10	1.3146	0.074	10	1.4374	0.067	-3.90	18	0.001	
1 : 10	10	1.3146	0.074	9	1.4627	0.044	-5.23	17	0.000	
1 : 11	10	1.3146	0.074	10	1.4358	0.124	-2.66	18	0.016	
2 : 12	10	1.4176	0.017	10	1.3939	0.053	1.34	18	0.198	NS
2 : 13	10	1.4176	0.017	10	1.4424	0.061	-1.24	18	0.231	NS
2 : 14	10	1.4176	0.017	10	1.5210	0.042	-7.26	18	0.000	
3 : 15	10	0.8554	0.055	10	0.9684	0.151	-2.22	18	0.040	
3 : 16	10	0.8554	0.055	10	0.8317	0.029	1.21	18	0.243	NS
3 : 17	10	0.8554	0.055	10	0.8635	0.038	-0.38	18	0.707	NS
4 : 18	10	0.8389	0.034	10	0.9168	0.030	-5.39	18	0.000	
4 : 19	10	0.8389	0.034	10	0.8620	0.031	-1.57	18	0.134	NS
4 : 20	10	0.8389	0.034	10	0.9397	0.027	-7.32	18	0.000	
5 : 9	10	0.9721	0.045	10	1.4374	0.067	-18.36	18	0.000	
5 : 10	10	0.9721	0.045	9	1.4627	0.044	-24.21	17	0.000	
5 : 11	10	0.9721	0.045	10	1.4358	0.124	-11.17	18	0.000	
5 : 12	10	0.9721	0.045	10	1.3939	0.053	-19.19	18	0.000	
5 : 13	10	0.9721	0.045	10	1.4424	0.061	-19.73	18	0.000	
5 : 14	10	0.9721	0.045	10	1.5210	0.042	-28.49	18	0.000	
5 : 15	10	0.9721	0.045	10	0.9684	0.151	0.07	18	0.942	NS
5 : 16	10	0.9721	0.045	10	0.8317	0.029	8.37	18	0.000	
5 : 17	10	0.9721	0.045	10	0.8635	0.038	5.85	18	0.000	
5 : 18	10	0.9721	0.045	10	0.9168	0.030	3.26	18	0.004	
5 : 19	10	0.9721	0.045	10	0.8620	0.031	6.40	18	0.000	
5 : 20	10	0.9721	0.045	10	0.9397	0.027	1.97	18	0.064	NS
6 : 9	10	1.1564	0.030	10	1.1497	0.040	0.43	18	0.675	NS
6 : 12	10	1.1564	0.030	10	1.2275	0.023	-6.00	18	0.000	
6 : 15	10	1.1564	0.030	10	1.1713	0.101	-0.45	18	0.658	NS
6 : 18	10	1.1564	0.030	10	1.1578	0.067	-0.06	18	0.952	NS
7 : 10	10	0.9969	0.031	9	1.2034	0.049	-11.20	17	0.000	
7 : 13	10	0.9969	0.031	10	1.1960	0.126	-4.84	18	0.000	
7 : 16	10	0.9969	0.031	10	1.1395	0.023	-11.73	18	0.000	
7 : 19	10	0.9969	0.031	10	1.1332	0.046	-7.78	18	0.000	
8 : 11	10	0.9565	0.039	10	1.0738	0.045	-6.22	18	0.000	
8 : 14	10	0.9565	0.039	10	1.1211	0.035	-9.84	18	0.000	
8 : 17	10	0.9565	0.039	10	1.0633	0.051	-5.24	18	0.000	
8 : 20	10	0.9565	0.039	10	1.1081	0.094	-4.69	18	0.000	

* 1. Strain compared;
2. Replicated number of strain 1;
3. Mean weight of strain 1;
4. Standard Deviation of strain 1;
5. Replicated number of strain 2;
6. Mean weight of strain 2;
7. Standard Deviation of strain 2;
8. t;
9. df;
10. p;
11. Significance.

TABLE 3c

DENSITY 100

(1)*	(2)*	(3)*	(4)*	(5)*	(6)*	(7)*	(8)*	(9)*	(10)*	(11)*
1 : 9	10	1.0625	0.173	10	1.3370	0.103	-4.31	18	0.000	
1 : 10	10	1.0625	0.173	10	1.1998	0.128	-2.02	18	0.059	NS
1 : 11	10	1.0625	0.173	10	1.3083	0.088	-4.01	18	0.001	
2 : 12	10	1.1995	0.136	9	1.3420	0.032	-3.24	17	0.005	
2 : 13	10	1.1995	0.136	10	1.3004	0.067	-2.29	18	0.034	
2 : 14	10	1.1995	0.136	10	1.3576	0.034	-3.75	18	0.001	
3 : 15	10	0.8619	0.024	9	0.8489	0.068	0.57	17	0.579	NS
3 : 16	10	0.8619	0.024	10	0.8607	0.039	0.08	18	0.935	NS
3 : 17	10	0.8619	0.024	10	0.8517	0.064	0.47	18	0.644	NS
4 : 18	10	0.8403	0.056	10	0.8602	0.028	-1.01	18	0.328	NS
4 : 19	10	0.8403	0.056	10	0.8737	0.039	-1.55	18	0.139	NS
4 : 20	10	0.8403	0.056	10	0.8905	0.017	-2.72	18	0.014	
5 : 9	8	0.9574	0.034	10	1.3370	0.103	-9.96	16	0.000	
5 : 10	8	0.9574	0.034	10	1.1998	0.128	-5.18	16	0.000	
5 : 11	8	0.9574	0.034	10	1.3083	0.088	-10.62	16	0.000	
5 : 12	8	0.9574	0.034	9	1.3420	0.032	-23.90	15	0.000	
5 : 13	8	0.9574	0.034	10	1.3004	0.067	-13.18	16	0.000	
5 : 14	8	0.9574	0.034	10	1.3576	0.034	-24.61	16	0.000	
5 : 15	8	0.9574	0.034	10	0.8489	0.068	4.04	16	0.001	
5 : 16	8	0.9574	0.034	10	0.8607	0.039	5.46	16	0.000	
5 : 17	8	0.9574	0.034	10	0.8517	0.064	4.18	16	0.001	
5 : 18	8	0.9574	0.034	10	0.8602	0.028	6.58	16	0.000	
5 : 19	8	0.9574	0.034	10	0.8737	0.039	4.74	16	0.000	
5 : 20	8	0.9574	0.034	10	0.8905	0.017	5.41	16	0.000	
6 : 9	9	1.1429	0.096	10	1.0588	0.058	2.34	17	0.032	
6 : 12	9	1.1429	0.096	9	1.1431	0.021	-0.01	16	0.995	NS
6 : 15	9	1.1429	0.096	9	1.1197	0.063	0.61	16	0.552	NS
6 : 18	9	1.1429	0.096	10	1.1330	0.019	0.32	17	0.752	NS
7 : 10	10	1.0867	0.093	10	1.0068	0.085	2.01	18	0.060	NS
7 : 13	10	1.0867	0.093	10	1.0486	0.021	1.26	18	0.223	NS
7 : 16	10	1.0867	0.093	10	1.1986	0.045	-3.43	18	0.003	
7 : 19	10	1.0867	0.093	10	1.0969	0.030	-3.22	18	0.005	
8 : 11	10	0.9886	0.102	10	0.9592	0.056	0.80	18	0.435	NS
8 : 14	10	0.9886	0.102	10	1.0490	0.024	-1.82	18	0.085	NS
8 : 17	10	0.9886	0.102	10	1.0703	0.050	-2.27	18	0.035	
8 : 20	10	0.9886	0.102	10	1.0969	0.030	-3.22	18	0.005	

* 1. Strain compared;
2. Replicated number of strain 1;
3. Mean weight of strain 1;
4. Standard Deviation of strain 1;
5. Replicated number of strain 2;
6. Mean weight of strain 2;
7. Standard Deviation of strain 2;
8. t;
9. df;
10. p;
11. Significance.

TABLE 1. DEVELOPMENTAL PERIOD FOR SINGLE AND MIXED STRAINS AT THREE DENSITIES

		DENSITY 10			DENSITY 40			DENSITY 100		
	WEEKS	4	5	6	4	5	6	4	5	6
GROUP	STRAIN									
SINGLE STRAINS										
1	A	10	0	0	10	0	0	10	0	0
2	B	0	10	0	0	10	0	0	10	0
3	C	6	4	0	8	2	0	5	5	0
4	D	10	0	0	10	0	0	5	5	0
5	E	10	0	0	10	0	0	10	0	0
6	F	10	0	0	10	0	0	10	0	0
7	F'	10	0	0	10	0	0	4	6	0
8	G	9	0	0	10	0	0	5	5	0
MIXED STRAINS										
9	A	0	10	0	0	10	0	0	10	0
	F	0	10	0	0	10	0	0	10	0
10	A	0	10	0	0	10	0	0	10	0
	F'	0	10	0	0	10	0	0	10	0
11	A	10	0	0	10	0	0	4	6	0
	G	10	0	0	10	0	0	6	4	6
12	B	0	10	0	0	10	0	0	10	0
	F	0	10	0	0	10	0	0	10	0
13	B	0	10	0	0	10	0	0	10	0
	F'	0	10	0	0	10	0	0	10	0
14	B	0	6	0	10	0	0	8	2	0
	G	0	6	0	10	0	0	10	0	0
15	C	0	10	0	0	10	0	0	9	0
	F	0	10	0	0	10	0	0	9	0
16	C	6	4	0	0	10	0	0	10	0
	F'	10	0	0	0	10	0	0	10	0
17	C	10	0	0	10	0	0	0	4	0
	G	10	0	0	10	0	0	0	4	0
18	D	0	10	0	0	10	0	0	10	0
	F	0	10	0	0	10	0	0	10	0
19	D	0	10	0	0	10	0	0	10	0
	F'	0	10	0	0	10	0	0	10	0
20	D	0	10	0	0	6	6	0	2	8
	G	0	10	0	0	6	4	0	2	8

THE FIGURES ARE NUMBERS OF VIALS IN WHICH DEVELOPMENT TO THE ADULT STAGE HAD BEEN COMPLETED

SOKOLOFF, A. and PARK, SANG
BIOLOGY DEPARTMENT
CALIFORNIA STATE UNIVERSITY
SAN BERNARDINO, CA 92407

*Further experiments to test the possibility of fertility in hybrids of T. castaneum (Herbst) and T. freemani Hinton.

The genus Tribolium at present consists of over 30 described species distributed unequally over five species-groups (review in Sokoloff, 1972). Within the castaneum species-group two pairs of species resemble each other : T. audax (AU) and T. madens (MD) are blackish in body color. AU and MD were once mistaken for a single species until Halstead (1969) took a closer look, observing differences in various characters in the larvae, pupae and adults. Attempts to hybridize these two species were successful: they can produce a few fertile hybrids. The second pair of species includes T. castaneum (CS) and T. freemani (FR). They resemble each other in their antennal morphology and the inter-ocular distance and their chestnut body color. (For other characteristics see Sokoloff 1966).
FR was found in the Kashmir as a single specimen and it had been described by Hinton. (1948) as a new species included in the castaneum group, but it was not until the Japanese intercepted a contaminated shipment of corn imported from Brazil (Nakakita et al,. 1983) that living material became available for research. Nakakita et al. 1981 showed that even though FR weighs about three times more than CS, the two species can mate with each other, producing abundant but strile progeny.
Through the courtesy of Dr. Nakakita T. freemani bacame available for genetic studies. One of us (A.S.) and a number of students have undertaken a series of studies to establish to what extent the genomes of CS and FR are similar. Brownlee and Sokoloff (1988) showed by hybridizing CS dominant mutants with recessive lethal effects: semidominants and sex-linked recessive females with FR males and the same kinds of mutants with T. castaneum wild type males for controls that the mutant traits are transmitted in the proper proportion to the F1 hybrids. Furthermore, the expressivity and the degree of penetrance of the genes in the hybrids varied to the same extent as those observed within CS control matings, attesting to the similar genetic library in the two species.
Carrillo and Sokoloff (1991) reported 10 mutations and about 3 dozen teratologies which appeared spontaneously in FR. Spray and Sokoloff (1991) found that the black mutation found in T. freemani was a semidominant mutation and the scar (sc) mutation was a semidominant gene influenced by temperature in its expression: when scar beetles are reared at 32 C. the F1 beetles are non-scarred, while those reared

at 24 are scarred. The same results are obtained when sc FR beetles are mated with sc CS and their hybrid progeny are reared at two temperatures: the hybrid sc CS/sc FR beetles reared at 32 appear normal, while those reared at 24 show a certain proportion of sc beetles.

Henry-Ford and Sokoloff (1992) carried out reciprocal crosses between FR + and CS homozygous for black and hemi- or homozygous for r and py, and another reciprocal cross involving FR + and CS pd pte. The results were interesting: In the first cross (CS b: r py male X FR +/+ female) the hybrid F1 were phenotypically bronze body color but normal in respect to the other traits. The reciprocal cross failed to produce progeny even though the b r py females and their FR +/+ mates were moved to fresh medium several times. The second cross involving FR +/+ females and CS pd pte males also gave normal F1 progeny, but the reciprocal cross failed to produce any F1 progeny.

Because in these two experiments we expected to obtain viable F1 from both reciprocal crosses, and because we had a great abundance of FR beetles from another experiment, we decided to carry out an extensive experiment to try to explain the results obtained by Henry-Ford and Sokoloff.

Methods

Crosses were carried out between CS virgin females collected, sexed and allowed to hatch and mature from the stocks shown in Table 2 and FR males of the opposite sex. For the reciprocal crosses we obtained FR virgin females from creamers where large larvae had been introduced in small numbers to avoid crowding (crowding greatly extends the larval period). The creamers containing larvae were periodically sifted to separate the pupae. The pupae were sexed and placed in vials to allow them to hatch to adults before mating. When the F1 from these experiments emerged, the males and females were paired and introduced into vials. The number of F1 X F1 crosses varied from 1-33 pairs depending on the number of beetles produced by the P1 pairs. The vials were placed in a walk-in incubator for a period of 6-9 months before checking to see whether the beetles were fertile or sterile.

Results

Table 1 summarizes the results of crosses between hybrids of reciprocal crosses between the wild type FR and wild type or mutant CS beetles. Table 2 identifies the types of mutants present in T. castaneum in the P1 cross which in column 2 of Table 1 were identified by number.

The results in F2 are given in Table 1 in two columns. The first, headed by STERILE shows whether the mating was successful or not. If the mating was not successful the letters N/A are given. The fraction shows the number of sterile crosses over the number of crosses attempted. This is followed by a column headed by FERTILE. This column was created should any of the crosses be fertile. (As it turned out, this column was unnecessary because all the F1 X F1 crosses were sterile). In some of the crosses we were unsuccessful in setting up reciprocal matings because a limited number of FR females virgins was available. In other cases abundant F1 progeny were available so larger numbers of vials could be set up.

With these introductory remarks the data in TAble 1 speak for themselves. In both series A and B F1 X F1 crosses (about 600 crosses for series A and over 750 crosses for series B) all the crosses gave 100% sterile results. Furthermore, where large numbers of replicates of reciprocal crosses are available, if all the replicates in one cross show sterility, the replicates from the reciprocal cross will also show sterility.

A few of the vials, when sifted, showed larvae of all sizes, sometimes pupae and sometimes living adults in a greater number than those introduced at the beginning of the experiment. However, these on examination proved to be contaminants belonging to the species T. confusum (CF), escapees which had managed to crawl up on the outer surface of the vial taking advantage of the data gummed label which helped in identifying the type of cross contained therein, and which were large enough to reach the lower surface of the perforated plastic caps we use to close the experimental vials. Once they had reached the top of the vial, they had found access to the inside through the ventilation holes we had made in the cap to allow exchange of gases and thus allow normal respiration and survival of the introduced beetles and their progeny. (Without the holes, the caps are so tight on the vial that asphixiation of the beetles may take place). Some of the contaminants were males, but they posed no problem in this experiment because, even if they mated with the experimental females, no hybrid progeny can be produced in matings between CF males and CS or FR females. A few vials contained female CF contaminants which must have been virgins when they entered the vials. Had they been inseminated females, they would have been able to produce recognizable CF beetles. There were, in fact, some vials which, in addition to the pair of experimental F1 hybrid beetles contained as many as 40 to 60 CF beetles which had been produced in the vial in the course of the experiment, and the numbers of larvae, pupae and adults attested to the fact that they were contaminants of relative recent invasion. These vials contaminated with CF beetles fortunately were few in number and did not interfere with the initial purpose of the experiment and its conclusion. They served as a warning that such an invasion of the vials is possible, and they permit taking appropriate measures to prevent their recurrence .

As to the results reported by Henry-Ford and Sokoloff (1992), and described above, these experiments do not explain them. Plans are to carry further experiments to determine whether it was a true phenomenon or just an accidental occurrence.

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TABLE 1

				EXPERIMENT 93-1				
		Series A					Series B	
	P1 Cross: T.c(male) * T.f(female +/+)					P1 Cross: T.c(female) * T.f(male +/+)		
	T.c Stock No. in P1 Cross	Results in F2 *Sterile*	*Fertile*			T.c Stock No. in P1 Cross	Results in F2 *Sterile*	*Fertile*
1	306	6 / 6	NONE		1	N/A	N/A	N/A
3	N/A	N/A	N/A		3	310	8 / 8	NONE
4	N/A	N/A	N/A		4	313	4 / 4	NONE
5	N/A	N/A	N/A		5	314	5 / 5	NONE
6	315				6	N/A	N/A	N/A
7	317	5 / 5	NONE		7	317	3 / 3	NONE
8	324	16/16	NONE		8	N/A	N/A	N/A
10	357	21/21	NONE		10	357	4 / 4	NONE
11	11+	9 / 9	NONE		11	11+	19/19	NONE
12	14+	3 / 3	NONE		12	N/A	N/A	N/A
13	N/A	N/A	N/A		13	15+		
15	N/A	N/A	N/A		15	20+	22/22	NONE
16	N/A	N/A	N/A		16	23+	11/11	NONE
19	38+	24/24	NONE		19	38+	7 / 7	NONE
20	40+	7 / 7	NONE		20	40+	6 / 6	NONE
22	N/A	N/A	N/A		22	42 r ph	1 0/1 0	NONE
23	44 ag	19/19	NONE		23	N/A	N/A	N/A
24	51 dve pd	5 / 5	NONE		24	N/A	N/A	N/A
26	56 msg pyr	14/14	NONE		26	56 msg pyr	1 0/1 0	NONE
27	59 rsp(p)	16/16	NONE		27	59 rsp(p)	7 / 7	NONE
29	ptl/E4	5 / 5	NONE		29	N/A	N/A	N/A
30	stb d/Es	5 / 5	NONE		30	N/A	N/A	N/A
31	mxp NG/Es'	9 / 9	NONE		31	mxp NG/Es'	3 / 3	NONE
32	sfm - Ey	24/24	NONE		32	sfm - Ey	1 / 1	NONE
33	Ag/Es'	8 / 8	NONE		33	N/A	N/A	N/A
34	Dch3/Ey6	9 / 9	NONE		34	Dch3/Ey6	17/17	NONE
35	Bes	6 / 6	NONE		35	Bes	11/11	NONE
36	N/A	N/A	N/A		36	Sq 33	12/12	NONE
37	CSUSB	7 / 7	NONE		37	CSUSB	13/13	NONE
38	N/A	N/A	N/A		38	14(Texas +/+)	6 / 6	NONE
39	N/A	N/A	N/A		39	31	9 / 9	NONE
40	23(NYf)	4 / 4	NONE		40	23(NYf)	3 / 3	NONE
41	rs p	4 / 4	NONE		41	rs p	1 0/1 0	NONE
42	74	4 / 4	NONE		42	N/A	N/A	N/A
43	83	1 / 1	NONE		43	83	12/12	NONE
44	93	12/12	NONE		44	93	21/21	NONE
45	94				45	N/A	N/A	N/A
46	91	3 / 3	NONE		46	91	21/21	NONE
47	N/A	N/A	N/A		47	109	6 / 6	NONE
48	96	8 / 8	NONE		48	N/A	N/A	N/A
49	70	3 / 3	NONE		49	N/A	N/A	N/A
50	68	1 / 1	NONE		50	68	9 / 9	NONE
52	98	12/12	NONE		52	N/A	N/A	N/A
53	99	11/11	NONE		53	99	14/14	NONE
54	103	2 / 2	NONE		54	103	4 / 4	NONE
56	N/A	N/A	N/A		56	123	15/15	NONE
57	N/A	N/A	N/A		57	124	16/16	NONE
58	376	8 / 8	NONE		58	376	31/31	NONE
59	377	13/13	NONE		59	N/A	N/A	N/A
60	N/A	N/A	N/A		60	379	4 / 4	NONE
61	381	9 / 9	NONE		61	N/A	N/A	N/A
62	386	12/12	NONE		62	386	6 / 6	NONE
63	391	1 0/1 0	NONE		63	391	22/22	NONE
64	N/A	N/A	N/A		64	393	6 / 6	NONE
67	N/A	N/A	N/A		67	402	4 / 4	NONE
68	406	7 / 7	NONE		68	406	8 / 8	NONE
70	408	3 / 3	NONE		70	N/A	N/A	N/A
72	414	9 / 9	NONE		72	N/A	N/A	N/A
73	417	8 / 8	NONE		73	N/A	N/A	N/A

EXP93-1.XLS

74	N/A	N/A	N/A		74	421	7 / 7	NONE
75	N/A	N/A	N/A		75	422	11/11	NONE
76	424	16/16	NONE		76	424	18/18	NONE
77	428	8 / 8	NONE		77	428		
78	N/A	N/A	N/A		78	431	11/11	NONE
79	442	3 / 3	NONE		79	442		
80	N/A	N/A	N/A		80	444	16/16	NONE
81	N/A	N/A	N/A		81	448	11/11	NONE
81a'	449	4 / 4	NONE		81b'	449	12/12	NONE
82	N/A	N/A	N/A		82	452	6 / 6	NONE
83	453	3 / 3	NONE		83	453	8 / 8	NONE
84	454	11/11	NONE		84	454	6 / 6	NONE
85	N/A	N/A	N/A		85	473	19/19	NONE
87	478	29/29	NONE		87	478	9 / 9	NONE
88	Sa - 2	4 / 4	NONE		88	Sa - 2	13/13	NONE
90	Exp 2063	12/12	NONE		90	Exp 2063	3 / 3	NONE
91	Exp 1065	3 / 3	NONE		91	Exp 1065	2 / 2	NONE
92	mxp	7 / 7	NONE		92	mxp	2 / 2	NONE
93	fas-like modif of	7 / 7	NONE		93	N/A	N/A	N/A
	DC+ +/mas p							
95	(au)Rd(?)	4 / 4	NONE		95	N/A	N/A	N/A
97	272	14/14	NONE		97	272	22/22	NONE
98	257	13/13	NONE		98	257	3 / 3	NONE
99	254	6 / 6	NONE		99	254	12/12	NONE
100	264	12/12	NONE		100	N/A	N/A	N/A
102	276	14/14	NONE		102	276	29/29	NONE
103	278	5 / 5	NONE		103	N/A	N/A	N/A
104	284	3 / 3	NONE		104	284	23/23	NONE
105	286	7 / 7	NONE		105	N/A	N/A	N/A
107	212	2 / 2	NONE		107	212	7 / 7	NONE
109	N/A	N/A	N/A		109	221	3 / 3	NONE
111	236	2 / 2	NONE		111	N/A	N/A	N/A
113	239	3 / 3	NONE		113	N/A	N/A	N/A
114	241	6 / 6	NONE		114	N/A	N/A	N/A
118	N/A	N/A	N/A		118	197	14/14	NONE
119	N/A	N/A	N/A		119	189	33/33	NONE
120	196	1 / 1	NONE		120	N/A	N/A	N/A
121	N/A	N/A	N/A		121	200	1 0/1 0	NONE
122	N/A	N/A	N/A		122	206	6 / 6	NONE
123	N/A	N/A	N/A		123	209	17/17	NONE
124	N/A	N/A	N/A		124	210	11/11	NONE
125	N/A	N/A	N/A		125	153	9 / 9	NONE
127	159	6 / 6	NONE		127	N/A	N/A	N/A
128	161	1 / 1	NONE		128	N/A	N/A	N/A
129	N/A	N/A	N/A		129	162	4 / 4	NONE
130	N/A	N/A	N/A		130	162a	9 / 9	NONE
131	N/A	N/A	N/A		131	165	20/20	NONE
133	168	8 / 8	NONE		133	168	11/11	NONE
136	N/A	N/A	N/A		136	324	9 / 9	NONE
141	143	8 / 8	NONE		141	143	4 / 4	NONE
143	255	8 / 8	NONE		143	N/A	N/A	N/A
144	296(bp pd)	2 / 2	NONE		144	296(bp pd)	14/14	NONE
145	296(pg? py)	4 / 4	NONE		145	N/A	N/A	N/A
146	N/A	N/A	N/A		146	276	14/14	NONE
147	N/A	N/A	N/A		147	358	—	—
148	415	5 / 5	NONE		148	415	14/14	NONE
149	No Number	5 / 5	NONE		149	N/A	N/A	N/A

Table 2. Stock identification

Wild type strains
11. CSUSB +
14. TEXAS +
15. YUCAIPA +
20. SYNTHETIC +
23. NEW YORK +

Mutant strains

31. p
33. sq
38. r
    Ho
40. r
    ph
42. r
44. ag (argentum)
51. dve pd
56. msg, pvr
59. r sp p
68. Malta p
70. pg

74. mas p
83. b McGill
91. lod p
93. Gi
94. Gi ptl
96. mt
    t
98. b
    t
99. b (tawny)
103. apt, mxp
109. ctp-1, ju
122. ptl Rd
123. Be
124. Be s
159. Sa-1
161. Sa c mxp
166. Sa-2
189. apt
196. mas
197. ppas p
200. Davis line 2.
206. ptl Rd
212. Chr Rd
221. bj

236 Dch mxp p
238. mxp
239. mxp
241. nude eggs
254. ty
257. weird eggs
264. sh
272. supergiant
276. Davis low body weight
278. la
284. s umb-1, w
286. p-like
296. b p pd
298. p pv
306. b p pe
310. p s
313. apt Mo p
314. pd p knp (msg)
315. mas p
317. aa p
324. b p
357. pd py sp
376. b ppas
377. b mc
381. b ptl
386. sq
391. j ppas
393. j mc
402. ims s
406. ap s
408. cas s
414. h, s mxp
415. mxp sp
417. h, s
421. Rd ptl p
422. Dch knp p
424. Rd, mas p
428. c Npp
431. Rd ptl knp p
442. Df, Mo s
444. i lod Mo
448. ap Chr
449. ap Chr bt-1
452. fas p
453. Chr cfl
Pk
454. ell p
6
473. fas
478. Spa p
494. Ag/Es
3 6
495. Dch /Ey
496. stbd/Es

498. stm - Ev
499. mxp NG/Es

Exp. 1065
Exp. 2063
500. fas-like modif. Dch/mas p

501. (au) Rd (?)

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., Ph.d. Grain protectants, fumigants, stored products pest management.
Collins, P. J., Ph.d. Insecticide and fumigant resistance, fumigation, stored products pest management.
Daglish, G. J. Ph.D. Grain protectants, fumigants, stored products 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.

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)
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
Ecology of Field and Stored Product Pests Section
Agriculture and Agri-Food Canada
Research Station
Stored Products Section
195 Dafoe Road

Dr. David Abramson: Mycotoxicology, Analytical Chemistry.
Mr. Colin J. Demianyk: Biologist; Insects Ecology, Industry Relations
Dr. Paul G. Field: Entomology, Physiology, Insect Behavior.
Dr. John T. Mills: Mycology, Ecology.
Dr. Noel D.G. White Section Head: Entomology, Insecticides, Physical controls.

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. Genetics of Tribolium. Natural insecticides.

DENMARK

Lyngby
Statens Skadedyrlaboratorium

Arevad, K.
Mourier, H.

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

D-80333 Munchen
Luisenstrasse 14
Institut fur zoologie

List of lab members working with Tribolium, and fields of interest:

Friedrich, Markus	Ph. D. student	eye development
Hausdorf, Bernhard	Ph. D. student	head gap genes
Klingler, Martin	Res. Associate	segm. mutants; transgenics
Schroder, Reinhard	Postdoc fellow	maternal organizers; anti-sense.
Tautz, Diethard	Professor	early development; evolution
Wolff, Christian	Ph.D. student	regulation of hunchback

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

Adams, R.G.	Insect identification
Bell, Dr. C.H.	Non chemical control, fumigation, development biology.
Binns, T.J.	Insecticide efficacy and resistance
Cogan, P.M.	Insect monitoring
Cox, Dr. P.D.	Stored product entomology
Mills, Dr. K.A.	Fumigation, controlled atmospheres, gene-
Muggleton, Dr. J.	Insecticide resistance, population genetics
Prickett, Dr. A.J.	Insecticides, resistance statistics (5, 7,
Walter, Miss C.	Insecticide biochemistry

Infestation Risk Evaluation Group
Mrs. S. Henderson
Mrs. C. Trowe

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

Brice, J. B. Sc. Storage and fumigation technology.

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

Dales, M.J. B. Sc. PhD. Control of stored-product insects (Chemical dusts, botanicals, IGR's). aFumigation with carbon dioxide.

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

Farrell, G. B. Sc. 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. B.Sc. PhD F.R.E.S. Biology and Behavior of stored products pests.

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)

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)

Taylor, R.W.D. B. Sc. Control of stored-product pests, especially awith fumigants.

Wright, M. B.Sc., M.Sc., PhD. Storage technologist. Project management.

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)

New Delhi 11 00 12

Saxena, J.D., Ph.D. Insecticide Resistance (7,8)

Sinha, S.R. M.Sc. Dip. Journ. Insecticide Resistance

Srivastava, Chitra, Ph.D. Insecticide Resistance

Ludhiana 141 004
Punjab agricultural University
Department of Entomology

Bakhetia, D.R.C. professor cum Head

Chawla, R.P. Ph.D. Insecticide resistance, lab. bioefficacy.

Joia, B.S. Ph.D. Insecticide resistance, lab. bioefficacy

Ramzan, M. Ph.D. Biology lab and field evaluation of grain protectants.

Udeaan, A.S. Ph.D. fumigants resistance.

IRELAND

+Dunsinea
Dublin County
Agricultural Institute

Cunningham, E.P.

+Dublin
University College
Zoology Department

Ryan, Michael, Ph.D.

ISRAEL

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)
Agami, talia - graduate student
Levy, Tamar - Technician

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

IBARAKI 305
Kan -nondai, Tsukuba
National Food Research Institute
Ministry of Agriculture, Forestry and Fisheries
Stored Product Entomology Laboratory

Fujii, Hiroshi, Ph.D.
Ikenaga, H.
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

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).

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)
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

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

CALIFORNIA

+BERKELEY, CALIFORNIA 94720
University of California
Donner Radiation Laboratory

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

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.
Fang, Janet. 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

+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
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

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 83201
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 60601
University of Illinois at Chicago Circle
Department of Biological Sciences

Mertz, David B., Ph.D. Professor. (5,7)

CHICAGO, Illinois 60637
University of Chicago
Department of Ecology and Evolution

Wade, Michael J., Ph.D. Departmental Chair. Ecology, Population Ecology, Genetics and Phenotypic Variation, Speciation (2, 5, 7)
Johnson, Norman A. Ph. D. Research Associate

+URBANA, Illinois 61801
University of Illinois
Department of Physiology and Biophysics

Ducoff, H.S., Ph.D., Professor, Radiation Biology, Experimental Gerontology (9,13). Retired.
Heath, M., Ph.D.; Physiological Ecology, Radiation Biology (5,9,13).

INDIANA

WEST LAFAYETTE, IN 47907
Purdue University
Department of Animal Sciences

Muir, W.M. Ph.D. Population and Quantitative Genetics (7,16)

Bell, A.E., 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)
Wright, Valerie, Ph. D.

MANHATTAN, Kansas 66502
U.S. grain Marketing Research Lab., ARS, USDA

BEEMAN LAB.

Beeman, R. W., Ph. D., Program Director
DeCamillis, M. Postdoctoral fellow (homeotic genes)
Res. Assts.: Friesen, K.S. (selfish genes, balancers); Haas, S. (homeotic genes, genetic stocks); Stauth, D. retrotransposons, transformant selection genes).

DENELL LAB.

Denell, R. Program Director
Brown, S. Assistant Scientist
Postdoctoral Fellows: Benett, R. and Guo, J.H. (homeotic genes).
Res. Assistants: Denell, M. (Lab. Admin. & Organiz.; K. Hummels (embryology); Van Slyke (segmentation genes).
Graduate Students: He, P. (homeotic genes); Parrish, J. (homeotic and segmental genes); Short, T. Transposons.

KENTUCKY

LEXINGTON, Kentucky 40506
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 20705
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

+SOUTH LANCASTER, Massachusetts
Atlantic Union College
Department of Biology

Kissinger, D.G., Ph.D. Taxonomy, genetics and development of Curculionidae. (3,5,17)

MICHIGAN

ALMA, Michigan 48801
Alma Collegete University
Biology Department

*Grimnes, KarIn A.,Ph. D.
Kadish, Anna
Roberts, Melissa M.
Wietstock, Steven M. Ph.D.

MINNESOTA

ST. PAUL, Minnesota 55101
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).

Department of Entomololgy
Stored Grain Pest Management Program Tel. 612-624-9292

Subramanyam, bhadriraju. Ph. D. Ecology, sampling, and management.
Narayanamma Madamanchi, M.S. Evaluation of chemicals.
Susan Norwood, B.S. (Senior) Laboratory technician.
Mike Tufte, B.S. (Senior) Laboratory technician.

ST. PAUL, Minnesota 55101
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 63501
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)

MONTANA

+BOZEMAN, Montana 59715
Montana State University
Animal and Range Sciences Department

Kress, D.D.

NEW JERSEY

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 14850
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 14850
New York State College of Agriculture
Cornell University

Knutson, Lloyd V., Ph.D.
Kramer, John P., Associate Professor. (11)

+New York City (Flushing), New York 10010
Queens College of the City University of New York
Department of Biology

Calhoon, Robert E. (7, 15, 16)

+Schenectady, New York 12308
Union College
Department of Biological Sciences

Boyer, John F. Ph.D.

NORTH CAROLINA

+Raleigh, North Carolina
North Carolina State University
School of Agriculture and Life Sciences
Department of Genetics

Grosch, Daniel S., Ph.D. Professor of Genetics. Cytological and genetic effects of chemical and physical agents. (4, 7, 13).

NORTH DAKOTA

+Fargo, North Dakota 58102
Metabolism and Radiation Research Laboratory
Insect Genetics and Radiation Biology Section

Riemann, John G. Ph.D. Insect cytology (4)
Wagoner, Dale E. Ph.D. Insect genetics (7)

Grand Forks 58201
University of North Dakota
Institute for Ecological Studies

Kannowski, Paul B., Ph.D. Pheromones and behavior (2, 5, 13).

OHIO

+Bowling Green, Ohio 43402
Bowling Green State University
Department of Biology

Schurr, Karl (9, 12, 13).

+Marietta, Ohio 45750
Marietta College
Department of Biology

Brown, Wm. P. Ph.D. Population genetics (7).

OKLAHOMA

+Edmond, Oklahoma 73034
Department of Biology
Central State University

Guthrie, Peggy Ph.D.

+Norman, Oklahoma 73069
University of Oklahoma
Department of Zoology

Sonleitner, Frank J. Associate Professor (5).

PENNSYLVANIA

+Carlisle, PA. 17013
Dickinson College
Department of Biology

McDonald, Daniel J., Ph.D. Population genetics (7).

+Pittsburgh, Pennsylvania 15219
Duquesne University
Department of Biological Sciences

Sillman, E. I. Ph.D.

PUERTO RICO

Rio Piedras, Puerto Rico 00928
University of Puerto Rico
Agricultural Experiment Station
Department of Crop Protection

Sepulveda, J. Undergraduate.
Virkki, Niilo Ph.D. Cytogenetics (4).

RHODE ISLAND

+Kingston, Rhode Island 02881
University of Rhode Island
Department of Zoology, Biological Sciences.
Building 401-792-2372

Costantino, R.F., ph.D., Associate Prof. Population Biology (5, 7).

TEXAS

+Denton, Texas 76201
Texas Woman's University
Box 2391, TWU station
Department of Biology

Erdman, Howard E., Ph.D., Radiation Biology, Ecology and Genetics (5,7,9).

UTAH

+Salt Lake City, Utah 84112
University of Utah
Department of Zoology and Entomology

Grundmann, A.W. Ph.D., Parasitology and Medical Entomology (11).

VERMONT

+Burlington, Vermont 05401
University of Vermont
Department of Zoology

Goodnight, Charles J., Ph. D.
Schwartz, James M., Ph. D.
Stevens, Lori, Ph. D.
Pray, Leslie (Ph. D. candidate)
Yan Guiyun, M. S. (Ph. D. candidate)
Goff, Peter, (M.S. candidate)

VIRGINIA

Charlottesville, VA 22904
University of Virginia
Deparment of Biology

Howell, Barbara L., M.S. Graduate Student.
Murray, J.J. Ph.D. Ecological genetics (5,7).
Wasserman, Steven S. Ph. D. Assistant Professor

+Fairfax 22030
George Mason College
Department of Biology

Stanley, M.S.M., Ph. D. Development of Tribolium confusum (3)

WASHINGTON

Pullman, Washington 99163
Washington State University
Department Poultry Sciences

Becker, W.A.

WISCONSIN

Beloit, Wisconsin, 53511
Beloit College
Deparment of Biology

Resseguie, Lawrence J.

Milwaukee
University of Wisconsin
Zoology Department

Hsiao, Ku-Chuan, B.S., Teaching Assistant
Lange, E.L. Ph.D. Assistant Professor

U. S. S. R.

Moscow
All-Union Grain and Grain Products Research Institute

Cherkovskaya, A. Ya.

WEST INDIES

Jamaica, Kingston 10
Ministry of Industry and Commerce
Storage and Infestation Division
20 Hope Road

+Jayasingh, D.B., B. Ed., Ph.D. (2,5,8,12).
Walker, K.R.

PERSONAL DIRECTORY*

AL-HAFIDH, E.M.T., Department of Agricultural Biology, The University, Newcastle upon Tyne, NE1 7RU, U.K.

ALVAREZ-FUSTER, A., laboratorio de Genetica, Departament de Biologia Ambiental, Universitat de les Illes Balears, Palma de Mallorca o7o71, Spain.

AMOS, T.G., Department of Agriculture, Victorian Plant Research Institute, Burnley, Victoria, Australia. (2, 5, 13)

ARBOGAST, RICHARD, T. Ph. D. USDA, ARS. Stored-Product Insects Research and Development Lab. 340 Edwin St. Savannah, Ga. 31405.

ARTHUR, FRANKLIN H. Ph. D. USDA, ARS. Stored-product Insects Research and Development Lab. 340 Edwin St. Savannah, ga. 31405

ASO, Y., Department of Entomology, Kansas State University, Manhattan, Kansas.

BAKER, JAMES E. Ph. D. USDA-ARS. Savannah, Ga. 31405.

BAKER, R.L., Ruakura Agricultural Research Centre, Private Bag, Hamilton, New Zealand.

BALASUBRAMANIAN, M., Tamil Nadu Agricultural University, Department of Agricultural Entomology, Coimbatore-641 003 India.

BARKER, P.S., Canada Dept. of Agriculture, Research Station Winnipeg, Manitoba. (5, 12)

BARRERA, A., Instituto Nacional de Investigaciones Agronomicas, Madrid, Spain. (5, 7)

+BARTLETT, A.D., United States Department of Agriculture, Agricultural Research Station, Cotton Insects Research Branch, Tucson, Arizona. (5, 7)

BAUMGARTNER, J., Institut fur Geflugelforschund, Poultry Research Institute, 900 28 Ivanka pri Dunajl, Czechoslovakia.

BECKER, W.A. Department of Poultry Science, Washington State University, Pullman Washington 99163.

BEEMAN, R.W., Department of Entomology, Kansas State University, and U.S. Grain Marketing Research Laboratory, ARS, USDA, Manhattan, Kansas 66502

*Nmbers in parenthesis represent research specialties.

DIRECTORY - PERSONAL

BELL, A.E., Purdue University, Population Genetics Institute, Lafayette, Indiana. (5, 7, 10) (retired).

BELL, M.E., Northeast Missouri State College, Kirksville, Missouri 63501. (5)

+BENDER, H.A., University of Notre Dame, Notre Dame, Indiana. (7)

BENNETT, RANDY, U.S. Grain Marketing Res. Lab. USDA, ARS, Manhattan, KA 66502

BENSKIN, J., Universite Laval, Quebec, Canada. (13)

BENSON, A.J., Southern Illinois University at Carbondale, Department of Zoology, Carbondale, Illinois. (6, 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)

BLOCH, MARGARET C. Biology Department, Tufts University, Medford Massachusetts 02155.

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.

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.

DIRECTORY - PERSONAL

BRUCE, W.A., U.S. Department of Agricultural Research Service, Savannah, Georgia. (13)

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 G128QQ, U.K.. (Retired).

+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.

+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)

DeCAMILLIS, MARCO, U.S. GRAIN MARKETING RES. LAB. ARS, USDA, Manhattan, Ka 66502

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.

DENELL, ROBIN, Program Director U.S. Marketing & Res. Lab. Manhattan, KA. 66502.

DETURCK, J.E., Cabrini College, King of Prussia Road, Radnor, PA 19087.

DIEZ-BARRA, R., Instituto Nacional de Investigaciones Agronomicas, Madrid Spain (7).

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) (Retired).

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)

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)

FRIARS, G.W., Ontario Agricultural College, Department of Poultry Science, Guelph, Ontario, Canada. (7)

FRIAS, A., Instituto Nacional de Investigaciones Agronomicas, Madrid, Spain.

FRIEDRICH, MARCUS. Ph. D. Student. Institut fur Zoologie. Luisenstrasse 14 D-80333 Munchen, Germany .

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.

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)

HAREIN, P.K., University of Minnesota, Department of Entomology, Fisheries, and Wildlife, St. Paul, Minnesota. (5, 12, 13)

HAUSDORF, BERNHARD. Ph.D. student. Inst. fur zoologie. Luisenstrasse 14, D-80333, Munchen, Germany.

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.

HUSBAND, R.W. Biology Department, adrian college, adrian, Mi 49221-2575.

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)

JAYASINGH, D.B., Ministry of Industry and Communication, Storage and Infestation Division, 20 Hope Road, Kingston 10, Jamaica, W.I..

JIAN, HWA GUO, U.S. Marketing & Research Lab., USDA-ARS, Manhattan, KA 66502

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.

JOHNSON, G., Department of Biology Sciences California State University, Hayward, California.

JOHNSON, N.A. Ph.D. Dept. of Ecology and Evolution, University of Chicago. Chicago IL 60637-1573.

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)

KLINGLER, MARTIN. Research Associate. Inst. fur Zoologie. Luisenstrasse 14, D-80333, Munchen, Germany.

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)

+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.

LAVIE, B., University of Haifa, Institute of Evolution, Haifa, Israel. (Deceased).

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. 3401 Edwin St. Savannah, Georgia 31405.

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.

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.

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.

MOURIER, H. Statens Skadedyrlaboratorium. Danish Infestation Laboratory. Skovbrynet 14, DK-2800 Lyngby, Denmark.

MUIR, W.M., Department of Dairy Science, University of Illinois, Urbana, Illinois, 61801.

MULLEN, M.A., U.S.D.A. ARS 3401 Edwin St. Savannah, Georgia. 31405 (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 food Research Institute, Ministry of Agriculture, Forestry and Fisheries. 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.

NUNEZ, F., Dept. de Biologia, U.N., Apdo Aereo 23227, Bogota, 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.

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.

PRESS, JOHN W. Stored-Product Insect research and Development

Lab. 3401 Edwin St., Savannah, GA 31405.

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.

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.

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.

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)

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.

SCHRODER, REINHARD. postdoctoral Fellow. Institut fur Zoologie. Luisenstrasse 14. D-80333 Munchen, Germany.

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, LINCOLN, Ph.D. Stored-Product Insect Research and Development Laboratory, 3401 Edwin St. Savannah, GA 31405.

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)

SUBRAMANYAM, BHADRIRAJU. Ph.D. Store-Grain Pest Management Program, Dept of Entomology, University of Minnesota

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

TAUTZ, DIETHARD. Professor. Insitut fur Zoologie. Luisenstrasse 14, D-80333, Munchen, Germany.

THOMAS, I., Pest Infestation Laboratory, Slough, Bucks, England.

THRONE, JAMES E. Ph. D. Stored-Product Insects Research and Development Laboratory 3401 Edwin St., Savannah GA 31405.

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.

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.J. Chair, Department of Ecology and Evolution, 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.

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)

WEAVER, D.K. Ph. D. Stored-Product Research and Development Laboratory, 3401 Edwin St. Savannah, GA 31405.

WEIDNER, H., Zoologisches Institut und Zoologisches Museum der Universitat, Hamburg, Germany.

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.

WILEY, E. PAUL. Ph. D. Stored-Product Insect Research and Development Laboratory 3401 Edwin St. Savannah, GA 31405.

DIRECTORY - PERSONAL

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)

WOLFF, CHRISTIAN. Ph. D. student. Institut fur Zoologie. Luisenstrasse 14, Muchen, Germany.

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.

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.D.A. A.R.S. 3401 Edwin St., Savannah, GA. 13405. (8, 13).

ZISSLER, D., Biologisches Institut I (Zoologie) der Universitat Freiburg i. Br. Germany. (3, 4, 6, 7, 11)