TRIBOLIUM INFORMATION BULLETIN

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1989

EDITOR

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TRIBOLIUM INFORMATION BULLETIN

Number 29

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Bibliography of Tribolium and Other Coleoptera

NOTE

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ACKNOWLEDGMENTS

The editors are indebted to ALEXANDRA SOKOLOFF, ELAINE SOKOLOFF and CAROL SMITH for assistance in the preparation and distribution of TIB 29.

ANNOUNCEMENT

Because of illness, M. Hani Soliman had to resign from his position as co-editor of the Tribolium Information Bulletin. The Senior Editor thanks Dr. Soliman for his assistance in publishing TIB for the last five years, and wishes him a speedy recovery.

ANNOUNCEMENT

INTERNATIONAL CONGRESS OF COLEOPTEROLOGY

European Association of Coleopterology
Barcelona. September 18-23, 1989

Asociación Europea de Coleopterología
Departamento de Biología Animal (Invertebrados)
Facultad de Biología
Universidad de Barcelona
Avda. Diagonal, 645
Teléfono 9 3 - 330 88 51 ext. 165
Telefax 9 3 - 330 71 57
08028 Barcelona (SPAIN)

Barcelona, 8th February 1989

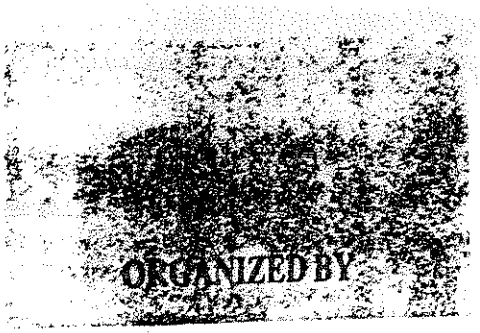
Sirs

We have the pleasure to send you a leaflet about the International Congress of Coleopterology to be held from 18th to 23rd September in Barcelona.

We will thank you very much if you could spread this Congress as you think fit.

Thanking in advance your collaboration.
Yours sincerely

The Secretary
Tomàs Yélamos



DEPARTAMENT DE BIOLOGIA ANIMAL
FACULTAT DE BIOLOGIA - UNIVERSITAT DE BARCELONA

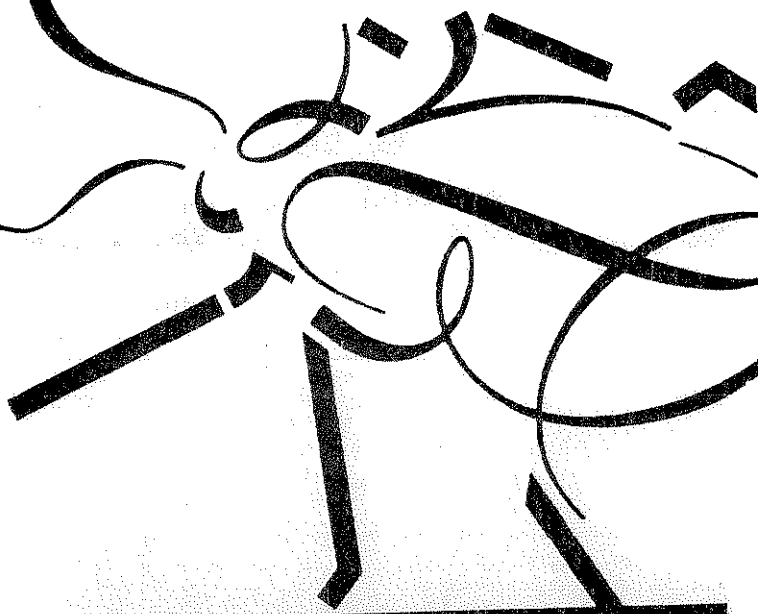
UNIVERSITÀ DI TORINO
DIPARTIMENTO DI BIOLOGIA ANIMALE

AEC
asociación europea de coleopterología

INTERNATIONAL CONGRESS OF COLEOPTEROLOGY

European Association of Coleopterology
Barcelona, September 18-23, 1989

design graphic by Jesús del Hoyo



Faculty of Biology University of Barcelona
Avda. Diagonal, 645 08028 Barcelona (SPAIN)
Telephone 93-3308851 ext 165 Telefax 93-3307157

PURPOSES

Oral communications and posters about any topic related to Coleopterology can be presented.

Several Lectures on general topics will be imparted by outstanding specialists, having accepted up to now Professors R.A. Crowson (University of Glasgow - Great Britain), G. Halffter (Instituto de Ecologia - Mexico), S.B. Peck (Carleton University - Canada) and E. Petitpierre (Universitat de les Balears - Spain). The title of their Lectures will be as follows:

Prof. **R.A. Crowson** - "Relation between Coleoptera and Cycads".
Prof. **G. Halffter** - "La evolución del comportamiento de los Insectos: el ejemplo de los Scarabaeidae coprófagos".
Prof. **S.B. Peck** - "Evolution and Biogeography of the Beetle Fauna of the Galápagos Islands, Ecuador".
Prof. **E. Petitpierre** - "Chromosomal and genomic evolution in two families of Coleoptera (Chrysomelidae and Tenebrionidae)"

The languages of the Congress sessions will be English, French, German and Spanish. However posters can be presented in these or other languages.

COMPLEMENTARY ACTIVITIES

In order to promote the participation of attendants at the Congress, some complementary activities will be carried out, such as Workshops (on Coleoptera families, or different topics), Coleoptera exhibition, video sessions, slide presentations, etc.

If you are interested in any of these activities, you should indicate so in the Suggestions section of the Registration Form

On the motion of Dr. G. Halffter and Dr. M. Zunino, a Workshop on Scarabaeidae is already ensured.

Some Outings and Social Events will be organized, as well as an Accompanying persons Program that we will detail in the next Circular.

Concurring with the Congress, a General Extraordinary Assembly of the European Association of Coleopterology will be held.

CALENDAR

Deadline for Registration and Submission of the title of the paper or poster: 15th April 1989.

Final date for reception of Abstracts of papers and posters: 15th May 1989.

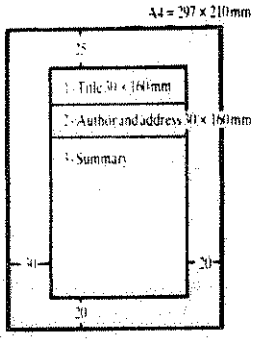
Sending of definitive Program: June - July 1989.

INSTRUCTIONS TO AUTHORS

The Abstracts of papers and posters must follow specifications shown in the figure. The length of these should be between 300 and 500 words (two double spaced typewritten DIN A4 sheets). Papers can be presented in any Latin alphabet language and will be submitted to the Scientific Board.

The book of Abstracts will be delivered at the Congress outset.

The entire works will be published after the end of the Congress in a special volume "Advances in Coleopterology", according to Instructions authors of ELYTRON. The final date to receive these works will be on 28th February 1990, being afterwards submitted to the Scientific Board. The languages of the articles should be the official ones of the Congress (English, French, German and Spanish).



Oral communications should take no more than 10-15 minutes, the audiovisual aids mentioned in the Registration Form being available.

The size of posters should be: maximum length 1.0 m and maximum high 1.10 m

Meetings to explain the posters will be held.

FEES

The Registration fee includes the Abstracts Book, attendance Official Events and Scientific Meetings, snacks and the right to publish a full paper

The fee must be paid on sending the Registration Form.

Common Members: 7.000.- Spanish Pesetas (70 $)

Student Members: 2.000.- Spanish Pesetas (20 $)

Accompanying persons: 4.000.- Spanish Pesetas (40 $)

Payment: Postal Order or International Money Order where posible. Bank Cheque or Bank Draft for other Countries.

Please, send you payment to:

INTERNATIONAL CONGRESS OF COLEOPTEROLOGY
2013.0404.02.0200126149
CAIXA D'ESTALVIS DE CATALUNYA
General Alvarez de Castro, 5
08003 BARCELONA (SPAIN)

(a copy of the Postal Order, International Money Order or Bank Draft should be sent with the Registration Form)

OUTINGS

Some projected Outings:

- Montseny highlands
- Puigsacalm highlands, Besalú, Banyoles lake and the Olot volcanic area
- The Garraf coastal range

ACCOMODATION AND TRAVEL

We enclose additional information.

ORGANIZING COMMITTEE

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Vicepresidents: Dr. X. Bellés
Dr. M. Zunino
Secretary: Dr. T. Yélamos
Treasurer: Mr. M. Tomás
Committee Members: Mr. J. Bosch, Dr. C. Palestrini, Mr. J. Dantart, Dr. X. Vázquez, Mr. O. Escolà, Mr. E. Vives

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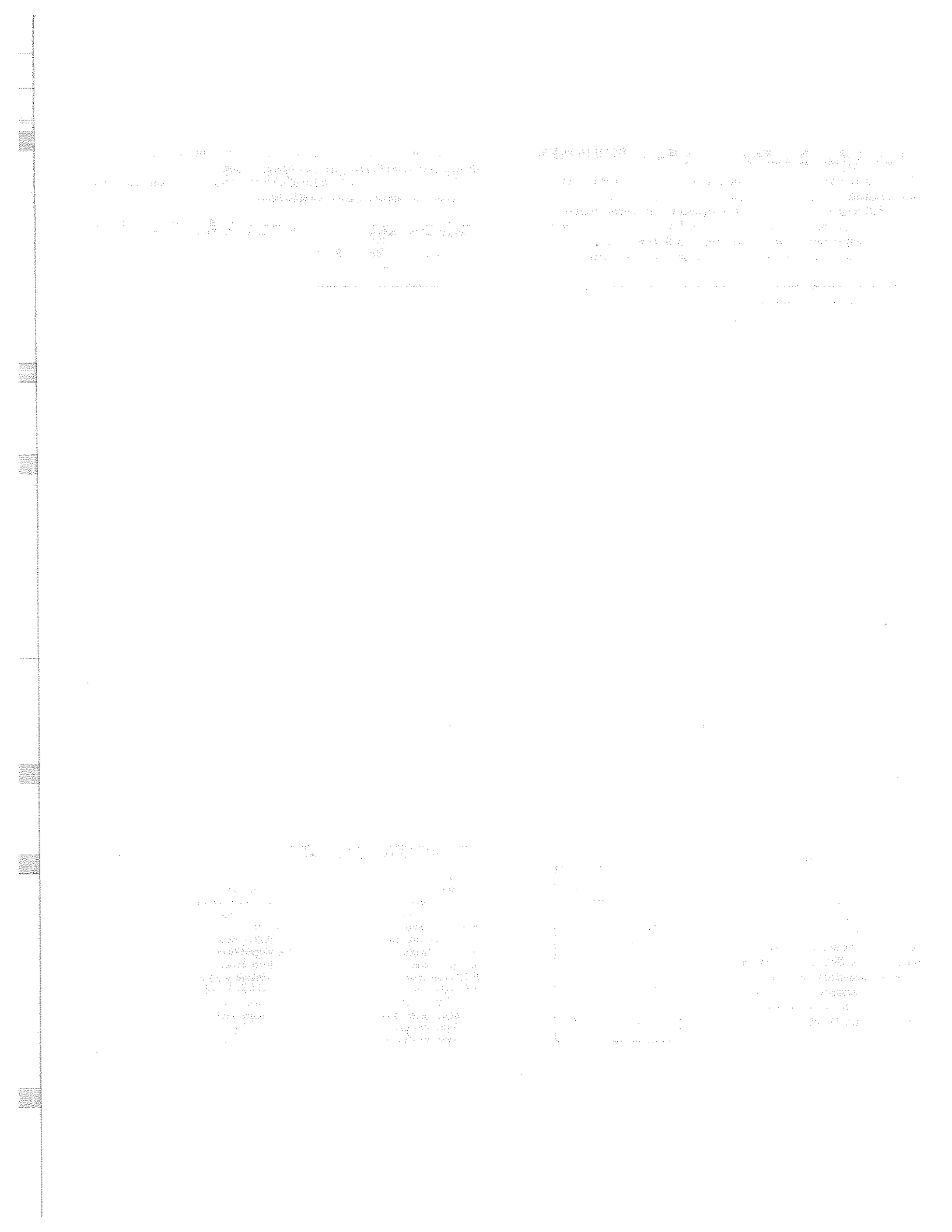

STOCK LISTS

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

Tribolium confusum

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

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

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

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

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

Tribolium brevicornis.

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

(Ed.).

BRIDGEPORT, CONNECTICUT
UNIVERSITY OF BRIDGEPORT
DEPARTMENT OF BIOLOGY

Tribolium confusum

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

(Ed.).

BURLINGTON, NORTH CAROLINA
CAROLINA BIOLOGICAL SUPPLY COMPANY

Tribolium castaneum

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

Tribolium confusum

1. Wild

(Ed.).

BURLINGTON, VERMONT 05401
UNIVERSITY OF VERMONT
DEPARTMENT OF ZOOLOGY

Tribolium castaneum

Unsaturated fatty acid corn oil sensitive (cos)

Tribolium confusum

Chicago wild
black

Tribolium madens

Tribolium brevicornis

All stocks derived from stocks at University of Rhode Island.

(Ed.).

Stock Lists

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

Tribolium castaneum

I. Wild type strains

1. Purdue + Foundation

II. Mutant strains

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

D.C. Englert

CARLISLE, PENNSYLVANIA
DICKINSON COLLEGE
DEPARTMENT OF BIOLOGY

I. Wild type strains (T. confusum)

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

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

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

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

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

II. Mutant (T. confusum).

1. Black -Sault Ste Marie (1956)
2. Ebony - Chicago (1957)
3. Eyespot - sex-linked - from a 1.1 strain above (1959)
4. Rough - from strain II.1 above (1957)
5. Split - from a wild strain in I.1 above (1956)
6. Striped - sex linked - from II.1 above (1957)
7. One strain each of Striped/black and split/black

Oryzaephilus surinamensis- from insects found in NYC, 1955.

Dan McDonald

Stock Lists

CHARLOTTESVILLE, VIRGINIA
UNIVERSITY OF VIRGINIA
DEPARTMENT OF BIOLOGY

Tribolium castaneum

I. Wild type strains

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

II. Mutant strains

1. McGill black	University of Chicago

(Ed.).

CHICAGO, ILLINOIS
UNIVERSITY OF CHICAGO
DEPARTMENT OF BIOLOGY

I. Wild type strains

A. Tribolium castaneum

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

B. Tribolium confusum

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

C. Tribolium madens

D. Latheticus oryzae

(Ed.)

Stock Lists

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

I. Wild type strains

A. Oryzaephilus surinamensis

B. Tribolium castaneum

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

C. Tribolium confusum

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

D. B. Mertz

CORAL GABLES, FLORIDA
UNIVERSITY OF MIAMI
DEPARTMENT OF BIOLOGY

I. wild type strains

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

II. Mutant

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

Earl R. Rich

CORVALLIS, OREGON
OREGON STATE UNIVERSITY
DEPARTMENT OF ZOOLOGY

I. Wild type strains

A. Tribolium castaneum
1. Oregon (synthetic)

B. Tribolium confusum
1. Oregon synthetic

II. Mutant strains

A. Tribolium castaneum

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

Tribolium confusum

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

Peter S. Dawson

DENTON, TEXAS
TEXAS WOMAN'S UNIVERSITY
DEPARTMENT OF BIOLOGY

I. Wild type strains and origin

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

(Ed.).

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

Tribolium castaneum wild type, Purdue University

(Ed.).

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

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

(Ed.).

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

Tribolium castaneum

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

Tribolium confusum

Chicago	Park 1955
black	via San Bernardino
pearl	via San Bernardino

Tribolium madens via San Bernardino

Tribolium brevicornis via San Bernardino

(Ed.).

LAFAYETTE, INDIANA 47907
PURDUE UNIVERSITY
ANIMAL SCIENCES DEPARTMENT

Tribolium castaneum

I. Wild type strains

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

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

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

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

A.E. Bell.

LAURINGBURG, NORTH CAROLINA
ST. ANDREWS COLLEGE

Tribolium confusum-- Wild type stock infected with Nosema whitei

(Ed.).

LEXINGTON, KENTUCKY
UNIVERSITY OF KENTUCKY
AGRICULTURAL EXPERIMENT STATION

I. Base populations

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

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

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

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

(Ed.).

MADISON, WISCONSIN
UNIVERSITY OF WISCONSIN

Xyleborus ferrugineus

I. Wild type strain WIS-1 from Costa Rica

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

NOTE: This insect in the wild exists in obligatory symbiosis

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

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

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

MANHATTAN, KANSAS
KANSAS STATE UNIVERSITY
DEPARTMENT OF ENTOMOLOGY

LEPIDOPTERA

Phycitidae: Cadra cautella and Plodia interpunctella

Gelechiidae: wild and red eyed strains.

Pyralidae: Corcyra cephalonica

COLEOPTERA

Anobiidae: Lasioderma serricorne and Stegobium paniceum

Bostrichidae: Rhyzopertha dominica

Bruchidae: Callosobruchus maculatus

Cucujidae; Cryptolestes ferrugineus, C. pusillus,

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

Dermestidae: Trogoderma inclusum, Attagenus megatoma

Ostomatidae: Tenebroides mauritanicus

Ptinidae: Gibbium psylloides

Silvanidae: Ahasverus advena, Oryzaephilus surinamensis, O. mercator

Tenebrionidae:

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

Valerie Wright

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

Tribolium castaneum

I. Insecticide-resitant strains

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

II. Mutant strains

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

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

R.W. Beeman

SAN BERNARDINO, CALIFORNIA
CALIFORNIA STATE UNIVERSITY
BIOLOGY DEPARTMENT

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

II. Tribolium audax

III. Tribolium brevicornis

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

IV. Tribolium castaneum

A. Wild type strains

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

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

B. Mutants

1. Sex-linked

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

Autosomal

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

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

416. au, s--aureate, sooty III,IV
417. h, s--hazel, sooty III, IV
428. c, Npp--chestnut, Nonpunctate prothorax VII, ?
430. au,Npp--aureate, Nonpunctate prothorax III, ?
436. au,mc--aureate, microcephalic III, V
442. Df,s,Mo--Deformed, sooty, Microphthalmic ?, IV, VI
444. i,lod,Mo--ivory, light ocular diaphragm, Microphthalmic II, III, VI
445. i,ppas-ivory, partially pointed abdom. sternites II, ?
448. Chr,ap--Charcoal, antennapedia III, VIII
450. au,ble--aureate, blistered elytra III, VII

ELL Pk

454. p /p II
462. mas, mc--missing abdominal segments, microcephalic II,V
469. i,lod--ivory, light ocular diaphragm II,III
470. lod,rb--light ocular diaphragm, ruby III, ?
473. fas-6--fused antennal segments-6

V. Tribolium confusum

Wild type strains

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

Synthetic strains

1. Berkeley

Mutant strains

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

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

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

VI. Tribolium destructor

VII. Tribolium freemani

VIII. Tribolium madens

A. Sokoloff

South Orange, New Jersey
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

Ho
Red Via California State

White Via California State

ca Via California State

Paddle Via California State

Short antenna Via Purdue University

Tribolium confusum Via Carolina Biological Supply

Eliot Krause

Stock Lists

SAVANNAH, GEORGIA
STORED-PRODUCT INSECTS RESEARCH AND DEVELOPMENT LABORATORY

I. Wild type strains

A. Lepidoptera

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

b. Coleoptera

1. Anthrenus flavipes LeConte	Savannah, and Durham
2. Attagenus megatoma (Fab.)	CSMA strains
3. Callosobruchus maculatus (Fab.)	Fresno, ca.
4. Cathartus quadricollis (Guerin-Meneville)	Unknown
5. Cryptolestes pusillus (Schonherr)	Tifton, Ga.
6. Dermestes maculatus De Geer	Madison, Wis.
7. Gibbium psylloides (Czenpinski)	Unknown
8. Lasioderma serricorne (Fab.)	Unknown
9. Oryzaephilus mercator (Fauvel)	Unknown
10. Oryzaephilus surinamensis (L.)	Manhattan, Kan.
11. Rhyzopertha dominica Fab.)	Unknown
12. Sitophilus granarius (L.)	Manhattan, Kan.
13. S. oryzae (L.)	Ark., Calif., Kan., La. Minn. and Tex.
14. S. zeamais Motchulsky	Estill, S.C.
15. Stegobium paniceum (L.)	Madison, Wis.
16. Tenebrio molitor (L.)	Manhattan, Ka, Durham, N.H.
17. Tenebroides mauritanicus (L.)	Savannah, Ga.
18. Tribolium castaneum (Herbst)	Unknown
19. Tribolium confusum duVal	Manhattan, Kan.
20. Tribolium madens Charpentier	Tifton, Ga.
21. Trogoderma glabrum (Herbst)	Madison, wis., Riverside, Ca.
22. T. inclusum LeConte	Madison; Riverside
23. T. variabile Ballion	Fresno, Riverside, Ca.

II. mutant strains

A. Plodia interpunctella

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

B. Tribolium castaneum.

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

C. Tribolium confusum

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

New mutants

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

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

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

R. Davis

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

Tribolium castaneum

Wild Type Strains

Seton Hall-1	South Orange, N.J.
McGill	via Cal State U., S.B.

synthetic Strains

Pearl Foundation	via Purdue Univ.
Black Foundation	via Purdue Univ.

Mutant Strains

Paddle	via Cal State U., S.B.
Red (Ho)	" " " " " "
Short antenna (Sa)	via Purdue Univ.
short antenna (ca)	via Oregon State
white	via Cal State U., S.B.

tribolium confusum -wild strain via Carolina Biol. 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., Savannah, Ga.
A. elongatulus (Casey)	Madison, Wis.
Dermestes maculatus DeGeer	Madison, Wis., U. Minn.
Trogoderma variabile Ballion	Minnesota
Cucujidae	
Cathartus quadricollis (Guerin-Meneville	Savannah
Oryzaephilus surinamensis (L)	"
Silvanidae	
Ahasverus advena Waltl.	Minnesota
Tenebrionidae	
Cyaneus angustus (LeConte)	Winnipeg; Minnesota
Tribolium castaneum (Herbst)	Corvallis, Ore

Tribolium confusum duVal	Unknown
Bruchidae	
Acanthoscelides obtectus (Say)	Winnipeg
Anobiidae	
Lasioderma serricorne (Fab.)	Savannah, Ga.
Bostrichidae	
Rhizopertha dominica (F.)	Manhattan, Ka.
Curculionidae	
Sitophilus granarius (L.)	Unknown
S. oryzae (L.)	"
S. zeamais motsch.	Madison, Wis.

B. Lepidoptera

Pyralidae	
Anagasta kuehniella (Zeller)	Savannah, Ga.
Plodia interpunctella (Hubner)	Manhattan, Ka.
Gelechiidae	
Sitotroga cerealella (Oliver)	Savannah, Ga.

II. Mutant strains

Tribolium castaneum, wd (weird egg)	Corvallis, ore.
Attagenus elongatulus b (black)	Madison, Wis.

(Ed.).

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

BELGIUM

GEMBLOUX
INSTITUT AGRONOMIQUE DE L'ETAT
ZOOLOGIE GENRALE

No updated list has been received (Ed.).

Stock Lists

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

No updated list has been received (Ed.).

BRAZIL

CAMPINAS, SAO PAULO
INSTITUTO AGRONOMICO, SECAO DE ENTOMOLOGIA

No updated list has been received (Ed.).

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

No updated list has been received (Ed.).

CANADA

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

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

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

R.N. Sinha

COLOMBIA

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

Tribolium castaneum

Wild type strains

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

Mutant strains discovered in Colombia

antennapedia (1981)
bifurcated antenna (1980)
fused antennal segments (1980)
miniature appendaged (ma) (1981)
Charcoal (1979)
vestigial elytra (1981)
black? 1982
narrow eye (sq?) (1980)
dark grey eye (c?) (1980)
pearl eye (p?) (1982)
platinum eye (pte?) (1981)
Pk
rose eye (p ?) (1980)
deformed legs (dfl?) (1980)
twisted legs (1981)

Fernando Nunez del Castillo

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

DENMARK

LYNGBY
STATENS SKADEDYRLABORATORIUM
(DANISH PEST INFESTATION LABORATORY)

Alphitobius diaperinus
Anobius punctatus
Anthrenus museorum
A. vorax
Attagenus alfieri
A. piceus
Dermestes frischi
Hylotrupes bajulus

Lasioderma serricorne
Oryzaephilus mercator
O. surinamensis
Rhizopertha dominica
Sitophilus granarius
S. oryzae
Stegobium (Sitodrepa) paniceum
Tenebrio molitor
Tenebroides mauritanicus
Thylodrias contractus
Tribolium confusum
T. destructor
Trogoderma granarium

(Ed.).

FRANCE

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

A. Wild type strains

1. Sitophilus granarius L.

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

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

B. Selected lines of Sitophilus oryzae

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

P. Nardon

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

Wild type strains
1. Oryzaephilus surinamensis — Freiburg
2. Tribolium castaneum — San Bernardino
3. T. confusum — San Bernardino

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

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

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

K. Sander

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

Coleoptera

Bruchidae--Acanthoscelides obtectus (Say)

Cucujidae--Cryptolestes turcicus Grouv. — Munich, 1966

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

Silvanidae

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

Munich (cont'd)

Tenebrionidae

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

Lepidoptera

Phycitidae--Ephestia kuehniella (Zell.)	"	1966

E. Naton.

INSTITUT FUR FLUGMEDIZIN DER DFVLR
GODESBERGER ALLEE 70
5300 BONN 2

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

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

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

W. Briegleb

ISRAEL

TEL AVIV, ISRAEL
TEL AVIV UNIVERSITY
DEPARTMENT OF ZOOLOGY

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

A. Tribolium castaneum

1. Wild type strains

CS+/+ Berkeley	via Stony Brook, USA,	1970
CS+/+ McGill	TSC	
CS+/+ Golet	Israel,	1970
CS+/+ Ishaaya	Israel,	1972
CTC-12 (insecticide resistant)	Slough, England,	1977
Kano C (malathion resistant)	Slough, England,	1977

2. Mutant strains
   Visible mutants
   CS bb Stony Brook, N.Y.
   eu++ (extra urogomphi, normal body color, derived from EUbb, 1973
   EUbb(extra urogomphi) derived from CSbb, 1973.
   CSmc--microcephalic derived from PP x bb, 1979
   pd bb--paddle, black. Derived from pd x bb 1978
   CS pearl. TSC, 1977
   CS pygmy. TSC, 1979
   electrophoretic mutants
   CS bEs (slow esterase, b)--Derived from CSbb, 1977
   CS bPs (slow phosphatase)--derived from EUbb, 1980
   CS+PF (fast phosphatase)-- derived from eu++, 1981

B. Tribolium confusum
   Wild type strains
   Cf Chicago -from TSC.
   CF Ishaaya -- Israel, before 1972
   Mutant strains
   CFbb --via Stony Brook, 1970
   CF MSg PRO --from TSC, 1979
   p (pearl) from TSC, 1977
   XL (extra large) from TSC, 1979

c. T. brevicornis
   ++ Riverside via TSC, 1979

d. T. freemani
   ++ Japan, 1982

David Wool

JAPAN

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

Psocoptera		
Liposcelis bostrychophilus Badonel	Wild	
Coleoptera		
Silvanidae		
Oryzaephilus surinamentsis (L.)	Wild	
Cucujidae		
Cryptolestes sp.	Wild	
Tenebrionidae		
Gnathocerus cornutus (Fabricius)	Wild	(Okayama str.)
Latheticus oryzae Waterhouse	Wild	
Palorus ratzeburgi (Wissmann)	Wild	
Tribolium castaneum (Herbst)	Wild	
T. confusum Jacquelin du Val	Wild	
T. freemani Hinton	Wild	
Tenebrio molitor L.		
Anobiidae		
Lasioderma serricorne (Fabricius)	Wild	
Stegobium paniceum (L.)	Wild	
Bostrichidae		
Rhyzopertha dominica (Fabricius)	Wild	
Dinoderus minutus	Wild	
Curculionidae		
Sitophilus oryzae (l.)	Wild	
S. zeamais Motschulsky	Wild	
Bruchidae		
Callosobruchus chinensis (L.)	Wild	
Lepidoptera		
Phycitidae		
Ephestia elutella (Hubner)	Wild	
E. cautella (Walker)	Wild	
brown wing mutant		
E. kuhniella (Zeller	Wild	
Mutant:		
a (Red, Mishima str.)		
ab (Red-Black, Mishima strain)		
b black		
wa (white eyes)		
p1-1 white larval color strain		
p1-2 " " " "		
p1-9 red larval color strain		
p1-10 " " " "		
p1-11 Intermediate larval color strain		
p1-12 " " " "		
p1-13 " " " "		
Plodia interpunctella (Hubner)	Wild	

Gelechiidae
Sitotroga cerealella (Olivier) Wild

Hymenoptera
Ichneumonidae
ventria canescens (Graven

O. Imura, K. Kotaki.

Note: Dr. H. Nakakita"s list in TIB 24 also includes the following information on Tribolium stocks:
Wild type strains and geographic origin
Tribolium audax H.....derived from Dr. D.G.H. Halstead, Slough
T. castaneum (H.) Japan
T. castaneum (H.)
TCP.A (PH3-resistant)--derived from Dr. R.G.Winks, Stored Grain Research Lab, Division of Entomology, CSIRO
CTC4 (PH3-susceptible)--derived from R.G. Winks
T. confusum.....Japan
T. freemani..... captured in Japan (contaminated imported corn from Brazil).

H. Nakakita

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.	Rhysopertha 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

Stock Lists

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

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

Tribolium confusum

A. Wild type strains

71.	Coronada	La Coronada, Spain

B. Mutants

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

Ma. C. Fuentes

MEXICO

Instituto Nacional de Investigaciones Agrícolas
Centro de Investigaciones Agrícolas del Norte Centro
Pabellon, Aguascalientes, Zacatecas

Prostephanus truncatus--wild type strain.

M.C. Mario Ramirez Martinez

Poland

Polish Academy of Sciences, Institute of Ecology
Dziekanow Lesny, 05092 Lomianki, Poland

Acanthoscelides obtectus Say
Wild type from Poland

Tribolium castaneum (Hbst)
Wild strain from San Bernardino, via Freiburg
cI genetic strain from Chicago
cII--genetic strain from Chicago
sooty 4s) from San Bernardino via Freiburg

Tribolium confusum Duval
wild strain from San Bernardino via Freiburg
bIV - genetic strain from Chicago
ebony-2 (e-2) from San Bernardino via Freiburg

PEOPLE'S REPUBLIC OF CHINA

Beijing
Beijing Agricultural University
Department of Animal Science

Tribolium castaneum
A. Wild type strains
1. Base populations for quantitative genetics — Guelph, 1987
2. Inbred line (full-sib mating) — Beijing, 1988
3. Wu line (local line) — Beijing 1988

B. Mutant strains : py
(1) Base population maintained with no artificial selection and minimum of inbreeding — Guelph, 1988
(2) Inbred line (full sib-mating) — Beijing, 1988

STOCK LIST

ADAS Central Science Laboratory,
Ministry of Agriculture, Fisheries and Food
London Road
SLOUGH, Berks, U.K.
SL3 7HJ Tel: (0753) 34626 Fax: (0753) 824058

Insects mentioned below are bred in controlled environmental conditions and, as far as possible, free from disease. All new stocks pass through a quarantine procedure before acceptance into the main insectaries.

This list was last updated in November 1988. The country of origin and year of receipt at this laboratory are shown against strains, where this information is known. For some of the older strains, in particular, such information is not known. Please note also 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 for further details on any aspect of this list and with any requests for specimens. The latter will be met where sufficient are available, but a charge may have to be made.

Monica O'Donnell (Mrs)

Species	Strain	Country of origin	Year received at Lab.
COLEOPTERA			
AHASVERUS ADVENA (Waltl)	Insectary	W.Africa	1956
ALPHITOBIUS DIAPERINUS (Panz)	Insectary		
	Goose's foot	Britain	1983
	Droxford	Britain	1984
	35	Britain	1987
ANTHRENOCERUS AUSTRALIS (Hope)	Insectary	Britain	1933
ANTHRENUS FLAVIPES (LeC.)	Insectary		
ANTHRENUS PICTURATUS HINTONI (Mroczkowski)	Insectary	U.S.S.R.	
ANTHRENUS SARNICUS (Mroczkowski)	Insectary		
ANTHRENUS VERBASCI (L.)	Insectary	Britain	1951
ATTAGENUS BRUNNEUS Falderman	Insectary	Spain	
ATTAGENUS CYPHONOIDES Reitter		U.S.S.R.	1976
ATTAGENUS FASCIATUS CINNAMOMEUS (Roth)	Insectary	Botswana	1965
ATTAGENUS FASCIATUS FASCIATUS (Thunberg)	Insectary	Botswana	1972

Species	Strain	Country of origin	Year received at Lab.
ATTAGENUS INSIDIOSUS Halstead	Insectary	Kenya	
ATTAGENUS PELLIO (L.)	Insectary	Britain	
ATTAGENUS RUFIVENTRIS Pic	Insectary	Botswana	1970
ATTAGENUS SMIRNOVI Zhantier	Insectary	Kenya	1962
ATTAGENUS UNICOLOR JAPONICUS Reitter	Insectary	Japan	1956
ATTAGENUS UNICOLOR JAPONICUS Reitter (Synonym *ATTAGENUS UNICOLOR CANADENSIS* Casey)	Insectary	N.USA	1980
ATTAGENUS UNICOLOR SIMULANS Solsky	Insectary	U.S.S.R.	1976
ATTAGENUS UNICOLOR UNICOLOR (Brahm)(=*MEGATOMA* (F.) =*PICEUS* (Olivier))	Insectary		
ATTAGENUS WOODROFFEI Halstead and Green	Finland Sweden		1965 1978
CARPOPHILUS DIMIDIATUS (F.)	Insectary	USA	
CARPOPHILUS HEMIPTERUS (L.)	Insectary		
COELOPALORUS FOVEICOLLIS (Blair)	Trinidad		
CRYPTOLESTES CAPENSIS (Waltl)	Insectary		
CRYPTOLESTES FERRUGINEUS (Steph.)	9 strains from 2 countries held, many differing in their susceptibility to pesticides.		

Species	Strain	Country of origin	Year received at Lab.
CRYPTOLESTES PUSILLOIDES (Steel and Howe)		Canada	
CRYPTOLESTES PUSILLUS (Scho.)			
CRYPTOLESTES PUSILLUS FUSCUS Lefkovitch		Trinidad	
CRYPTOLESTES TURCICUS (Grouv.)			
CRYPTOLESTES UGANDAE Steel and Howe		E.Africa	1954
DERMESTES ATER Deg.		Britain	1953
DERMESTES FRISCHII Kug.		Nigeria	
DERMESTES HAEMORRHOIDALIS Kuster		Britain	
DERMESTES LARDARIUS L.		Britain	
DERMESTES MACULATUS Deg.		Bangladesh	1975
DERMESTES PERUVIANUS Castelnau		Britain	1961
GIBBIUM AEQUINOCTIALE (Boield.)		Britain	1937
GNATOCERUS CORNUTUS (F.)			
GNATOCERUS MAXILLOSUS (F.)			
LASIODERMA SERRICORNE (F.)	Insectary		
LATHETICUS ORYZAE Waterh.	Insectary		
MEZIUM AFFINE Boield.	Insectary	Britain	
MEZIUM AMERICANUM (Lap.)	Insectary		

Species	Strain	Country of origin	Year received at Lab.
NIPTUS HOLOLEUCUS (Fald.)	Insectary	Britain	
ORYZAEPHILUS ACUMINATUS Halstead	Insectary		
ORYZAEPHILUS MERCATOR (Fuv.)	Insectary		
	Senegal	Senegal	1979
	0-871	Cyprus	1979
ORYZAEPHILUS SURINAMENSIS (L.)	52 strains from 11 countries held, many differing in their susceptibility to pesticides		
PALORUS RATZEBURGII (Wissm.)	Insectary		
PALORUS SUBDEPRESSUS (Woll.)	Insectary	Turkey	
PSEUDEUROSTUS HILLERI (Reitt.)	Insectary	Britain	1940
PTINUS CLAVIPES Panz.		Britain	1954
PTINUS EXULANS Er.		Britain	
PTINUS PUSILLUS Sturm	Insectary		
PTINUS SEXPUNCTATUS Panz.	Insectary		
PTINUS TECTUS Boield.	Insectary A		
	Insectary B	Britain	1960
	Wild	Britain	1975
RHYZOPERTHA DOMINICA (F.)	8 strains from 5 countries held, many differing in their susceptibility to pesticides		

Species	Strain	Country of origin	Year received at Lab.
SITOPHAGUS HOLOLEPTOIDES (Cast.)	Insectary	Trinidad	1972
SITOPHILUS GRANARIUS (L.)	15 strains from 5 countries held, many differing in their susceptibility to pesticides		
SITOPHILUS ORYZAE (L.)	7 strains from 6 countries held, many differing in their susceptibility to pesticides		
SITOPHILUS ZEAMAIS Motsch.	Insectary		
	153	Guatemala	1972
	912	Kuwait	1972
	US	USA	1976
	PS-60	Britain	1984
SPHAERICUS GIBBOIDES (Boield.)	Insectary	Britain	1976
STEGOBIUM PANICEUM (L.)	Insectary		
STETHOMEZIUM SQUAMOSUM Hint.	Insectary	Britain	
TENEBRIO MOLITOR L.	Insectary		
TENEBRIO OBSCURUS F.	Insectary		
TIPNUS UNICOLOR (P. & M.)	Insectary	Kenya	
TRIBOLIUM ANAPHE Hint.	Insectary	Nigeria	
TRIBOLIUM AUDAX Halstead	Insectary	Canada	

Species	Strain	Country of origin	Year received at Lab.
TRIBOLIUM BREVICORNIS LeC	Insectary	USA	
TRIBOLIUM CASTANEUM (Herbst.)	7 strains from 5 countries held, many differing in their susceptibility to pesticides		
TRIBOLIUM CONFUSUM J. du V.	Insectary W-44 PS-108	 Britain	 1983
TRIBOLIUM DESTRUCTOR Uytt.	Ethiopia Denmark	Ethiopia Denmark	1968 1968
TRIBOLIUM FREEMANI Hinton	Insectary	Japan	1980
TRIBOLIUM MADENS (Charp.)	Insectary	Yugoslavia	
TRIGONOGENIUS GLOBULUS Sol.	Insectary	Ireland	
TRIGONOGENIUS PARTICULARIS Pic	Insectary	Kenya	
TROGODERMA ANGUSTUM (Solier)	Insectary	Germany	1975
TROGODERMA ANTHRENOIDES (Sharp)	Insectary	USA	
TROGODERMA GLABRUM (Herbst.)	Insectary	USA	
TROGODERMA GRANARIUM Everts	11 strains from 7 countries held.		

Species	Strain	Country of origin	Year received at Lab.
TROGODERMA GRASSMANII Beal	Insectary	USA	1976
TROGODERMA INCLUSUM LeC	Insectary		
TOGODERMA IRRORATUM Reitt.	Insectary	Egypt	
TROGODERMA STERNALE PLAGIFER Casey	Insectary	U.S.A.	
TROGODERMA VARIUM Matsumura and Yohoyama	Insectary	Korea	1970
TROGODERMA VARIABILE Ballion	Insectary	USA	
TYPHAEA STERCOREA (L.)	Somerset Datchet	Britain Britain	1980
DICTYOPTERA			
BLATTA ORIENTALIS L.	Insectary W. Middlesex	Britain	1986
BLATTELLA GERMANICA (L.)			
PERIPLANETA AMERICANA (L.)			
DIPTERA			
MUSCA DOMESTICA L.	6 strains from 2 countries held, several other strains also held, but on a short term basis		
HYMENOPTERA			
MONOMORIUM PHARAONIS (L.)		Britain	1953
LEPIDOPTERA			
ENDROSIS SARCITRELLA (L.)	Reading	Britain	1986
EPHESTIA CAUTELLA (Walker)	Insectary	Cyprus	1969

Species	Strain	Country of origin	Year received at Lab.
EPHESTIA ELUTELLA (Hubner)	Insectary Milwall 8F	Britain	1969
EPHESTIA KUEHNIELLA Zell.	Insectary	Britain	1949
	Southampton	Britain	1953
	Harlescott	Britain	1982
	Rhydymwyn	Britain	1988
GALLERIA MELLONELLA (L.)	Insectary A		
	Insectary B	USA	
PLODIA INTERPUNCTELLA (Hubner)	9 strains from 9 countries held		
SITOTROGA CEREALELLA (Oliv.)	A68	Nepal	1972
	S623	USA	1972
PSOCOPTERA			
LEPINOTUS PATRUELIS Pearman		Britain	
LIPOSCELIS BOSTRYCHOPHILUS Badonnel		Britain	1949
LIPOSCELIS SUBFUSCUS (Broadhead)			
TROGIUM PULSATORIUM (L.)		Britain	

MUTANT STOCKS

Species	Mutation	Strain/s mutation/s arose in	Country of origin
COLEOPTERA			
CARPOPHILUS DIMIDIATUS (F.)	Pearl-eye		
CRYPTOLESTES TURCICUS (Grouv.)	Red Eye		
DERMESTES MACULATUS Deg.	Pearl-eye Black/Brown		Australia
LASIODERMA SERRICORNE (F.)	Black		USA
ORYZAEPHILUS MERCATOR (Fauv.)	Pearl-eye (pe^x)	0-779	Pacific Isles
ORYZAEPHILUS SURINAMENSIS (L.)	Clear eye (cc)	00757	
	Dark body (dd)	484 Square	India
	Speckled eye (ss)	484 Diamond	India
	Speckled eye, L.O.D. (ss,ll)	484 Diamond	India
	Transparent eye (tt)	01061	Britain
	Clear eye, dark body (cc,dd)		
	Speckled eye, dark body (ss,dd)		
	Transparent eye, dark body (tt,dd)		
RHYZOPERTHA DOMINICA (F.)	Black		
TRIBOLIUM CASTANEUM (Herbst)	Black		

MUTANT STOCKS

Species	Mutation	Strain/s Mutation/s arose in	Country of origin
LEPIDOPTERA			
EPHESTIA CAUTELLA (Walker)	Yellow eye	Florida	U.S.A.
	Black eye, Diapause	Insectary x Florida	Cyprus/ U.S.A.
EPHESTIA ELUTELLA (Hubner)	White eye		
SITOTROGA CEREALELLA (Oliv.)	Pearl eye	A68	Nepal
	Red eye	A68	Nepal

Monica O'Donnell (mrs)

STOCK LISTS

Slough Berks U.K.

Overseas Development Natural Resources Institute, Slough Department

Overseas Development Administration

Pest Biology and Inspection Section

All stocks are maintained at 27°C 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.

1. Wild type strains

A. Coleoptera

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

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

B. Lepidoptera

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

Chemical Control Section

Stocks of some major 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 programmes.

Wild type strains

A. Coleoptera

21.	Cryptolestis sp., Cucujidae	a. Ethiopia
22.	Dermestes ater, Dermestidae	a. Ex MAFF Lab. Slough
23.	Dermestes frischii, Dermestidae	a. Ex MAFF Lab. Slough
24.	Dermestes maculatus, Dermestidae	a. Malawi
25.	Dermestes carnivorus, Dermestidae	a. Indonesia
26.	Sitophilus oryzae, Curculionidae	
	Insecticide-susceptible strain (reference)	a. Ex MAFF Lab. Slough
	Malathion- and lindane-resistant strain (A76)	b. Ex MAFF Lab. Slough
	Strains tested for phosphine resistance	c. Bhutan d. Nepal e. Pakistan (2 strains) f. Tunisia g. Brazil 1 h. Tanzania i. Philippines j. Morocco
27.	Sitophilus granarius Curculionidae	a. U.K. b. Cyprus
28.	Sitophilus zeamais, Curculionidae	
	Strains tested for phosphine resistance	a. Unknown b. Ghana c. Zimbabwe d. Burma e. Thailand
29.	Tribolium castaneum, Tenebrionidae	
	Multiple insecticide-resistant strain (CTC 12)	a. Australia
	Malathion-specific resistant strain (Kana C)	b. Nigeria
	Insecticide-susceptible strain (reference)	c. Ex MAFF Lab. Slough
	Strains tested for phosphine resistance	d. Nepal e. Pakistan (8 strains) f. Sri Lanka g. Ethiopia (2 strains) h. Liberia i. Mali (5 strains) j. Zimbabwe (2 strains) k. Ghana l. Philippines (2 strains) m. India (7 strains) n. Tunisia o. Uganda p. Indonesia (6 strains) q. Cyprus (3 strains) r. Tanzania s. Brazil

30.	Prostephanus truncatus, Bostrichidae	As Pest Biology
31.	Dinoderus sp. Bostrichidae	a. Jamaica
32.	Rhyzopertha dominica, Bostrichidae Strains tested for phosphine resistance	a. Nepal b. Pakistan (2 strai c. Sri Lanka (2 strai d. Mali (2 strai e. Indonesia f. Ethiopia g. Morocco h. Brazil
33.	Oryzaephilus surinamensis, Silvanidae Strains tested for phosphine resistance	a. Sri Lanka b. Ethiopia
34.	Teretriosoma nigrescens, Histeridae	As Pest Biology

RESEARCH, TEACHING, and TECHNICAL NOTES

Alvarez-Fuster, A., Bosch, R., Petitpierre, E. and Juan, C.
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* Genome sizes in some species of Tribolium flour beetles (Coleoptera, Tenebrionidae).

The DNA content of Feulgen stained spermatids has been measured from wild type laboratory strains of six species of Tribolium McLeay by using T. castaneum as an internal standard. The results are as follows:

	Indiv. N	Sperma- tids (N)	DNA content mean (pg)	SD
T. audax	10	300	0.164	1.7×10^{-3}
T. brevicornis	9	270	0.384	5.2×10^{-3}
T. castaneum	5	100	0.208	2.0×10^{-2}
T. confusum	10	300	0.248	4.1×10^{-3}
T. freemani	10	300	0.237	1.7×10^{-3}
T. madens	5	150	0.241	4.5×10^{-3}

The range of genome sizes among these congeneric species exceeds a two-fold difference. Pairwise comparisons between the six mean values give statistically significant differences in all but one of them, that between T. freemani and T. madens. T. castaneum and T. confusum are clearly separated in their nuclear DNA content. These genome data are in support of the karyological differencee reported between these species. T. castaneum has 20 chromosomes and a 9 + Xyp male meiotic formula, whereas T. confusum has 18 chromosomes and a 8 + neo XY formula (Smith, 1952). It agrees with their high genetic distance based upon allozyme electrophoretic studies (Sanchez, 1979; Wool, 1982). Therefore, a substantial increase in the genome size could explain the origin of T. confusum from T. castaneum, plus the presumed Autosome-X chromosome fusion. However, if T. brevicornis were the ancestral species of Tribolium as suggested by Hinton (1948), its highest DNA amount would necessarily imply that the evolution of the remaining species should have mostly taken place by decreases in the genome size.

LITERATURE

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

(NOTE: This investigation was presented at the International Congress of Coleopterology, Barcelona, September 18-23, 1989, organized by Asociacion Europea de Coleopterologia, Departamento de Biologia Animal, Facultad de Biologia, Universitat de Barcelona and Universita di Torino, Dipartimento di Biologia Animale).

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*A SET OF METHODS FOR DISTINGUISHING BETWEEN "6- AND 7-INSTAR INDIVIDUALS" IN TRIBOLIUM POPULATIONS.

Introduction

A phenomenon of a particular heterogeneity occurring in insects populations (stored product pests) has been observed for a long time (Howe 1961). There is a fraction of population which shows longer development time and larger weight, and has a one larval instar more in its development than the remaining fraction of individuals. Such heterogeneity in populations of Tribolium castaneum Hbst and T. confusum Duval was described (Prus 1976, Bijok 1984, Prus and Prus 1987) and examined in terms of its influence on autecological features (Prus, Bijok and Prus 1988) and reproductive effort (Prus, Prus and Bijok 1988). Carrying on such studies it is important to have a simple and effective method for distinguishing between these groups of individuals which have been called 6- and 7-instar groups.

Method 1 - Observation of whole development in synchronised individual cultures

It is the most labourious method, but giving possibility to collect data about duration of all developmental stages and to obtain a growth curve for each individual. This method gives the most reliable answer to the question whether the individual belongs to 6- or 7-instar group. This method has been used by Prus (1976), Bijok (1986), Prus and Prus (1987).

Newly hatched larvae (not older then 2 hours after hatching) were placed in separate, numerated glass vials each containing 1g of standard culture medium (95% wheat flour and 5% powdered baker's yeast, by weight). Cultures were run in a dark incubator at 29° C and 70% RH. Every 2 days a content of each vial was sifted through fine mesh (0.5 mm) and the individual was found. The animal was placed on preweighed aluminium foil pan and weighed on electrobalance with an accuracy of 0.01 mg. Besides the exuvium was looked for and its presence (or absence) as well as developmental stage of the individual recorded. Sex of animals was determined during a pupal stage (Sokoloff 1972).

In order to rank precisely each individual to 6- or 7-instar group, it is neccesary to plot growth curve for every one individual on a weight v. time scale, separately for males and females (Fig. 1.). On each curve a moment of pupa appearance and that of eclosion should be marked. If number of examined individuals is large enough two separate bunches of curves can be seen - for 6- and 7-instar individuals. Any curve (=individual)

not grouped in one or another bunch should be rejected as dubious case. In uncertain cases a number of exuviae found, and a time of apearance of developmental stages can be a helpful in making the decision.

Using this method to determine duration of subsequent developmental stages and time of whole development one should remember that handling and changes of temperature during sifting, weihging etc. have a significant influence on rate of development. Therefore, the temperature in laboratory during work with animals should be rather close to that used in the incubator.

Method 2 - Observations of final period of development in synchronised individual cultures.

This method is based on comparison of time of reaching pupal and/or adult stages and weight of newly apeared pupae.

Cultures were started just like in the previous method, but were left in incubator till 15-th day of larval development. Then the first observation took place. On that day 4-5 exuviae were found in each vial. The following observations were carried out every day till the time of eclosion. Only newly appeared pupae were weighed and their sex was determined.

In order to distinguish between 6- and 7-instar individuals it is neccesary to make two graphs separatelly for males and females on scale: time of pupae appearance versus weight of pupae. Each individual should be placed as a separate point (Fig. 2.). If number of examined individuals is sufficient, two clouds of points should be seen for 6- and 7-instar groups. Any point (=individual) not grouped in clouds should be rejected as dubious case. Number of exuviae found is not a precise criterion and can only have an accesory significance because smallest exuviae could be easily lost.

Method 3 - Selecton in respect of time of pupae appearance in synchronized cultures.

This method is not so precise as the previous two, but is less complicated and not so time-consuming. It is used to obtain large quantities of material, consisting of individuals split into 6- and 7-instar groups of males and females. Such material can be used for chemical analysis, for example, lipid content determinattion, calorific value etc. (Prus Prus and Bijok 1988).

A group of adult individuals (about 200-300) was placed in glass jar with about 100-150g of standard medium for egg lying. After 24 hours animals were separated from medium by sifting through a coarse mesh. Medium with eggs lied was incubated for 20 days at 29°C and 70% RH. Then content of jar was sifted in order to check a number of pupae appearing. All pupae were isolated, selected for males and females, counted and placed in vials. This operation should be made every day as long as pupae are appearing. In order to make selection a graph should be made: time versus number of pupae appearing. A curve should show two maxima - corresponding to maxima of appearance 6- and 7-instar pupae. Only individuals forming the very maxima should be taken as 6- or 7-instar groups (Fig. 3.).

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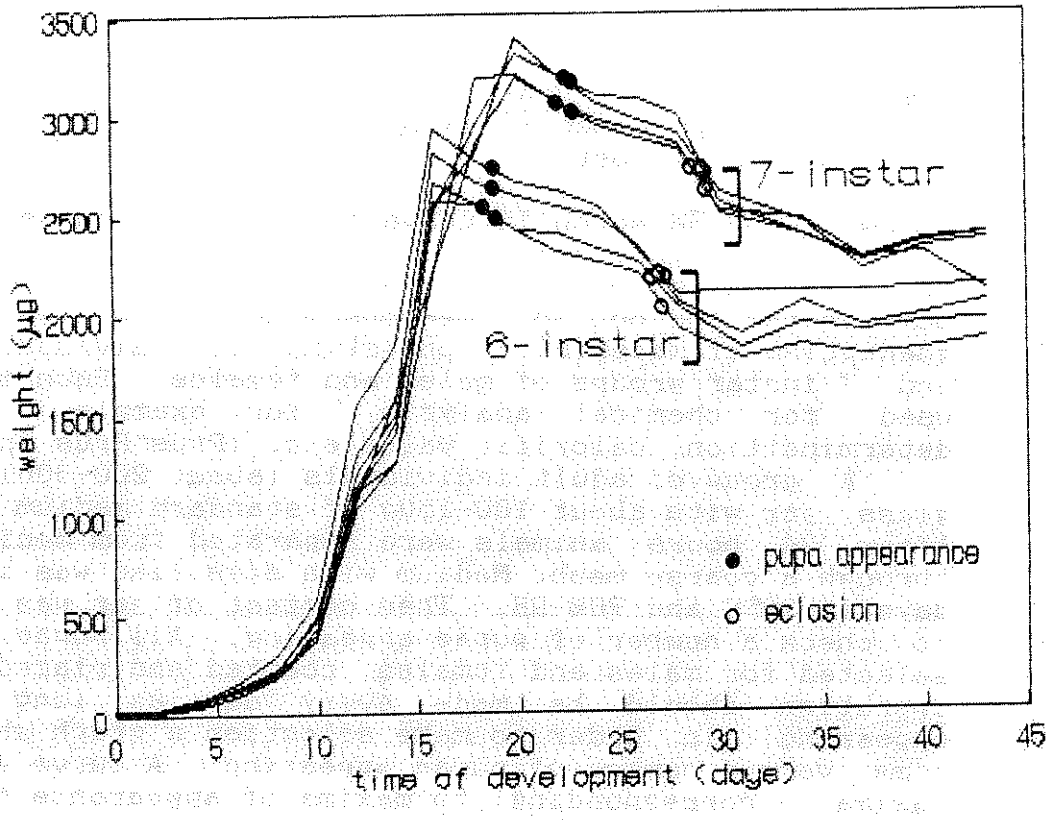

Figure 1. Growth curves of 6- and 7-instar males of T.confusum (an example).

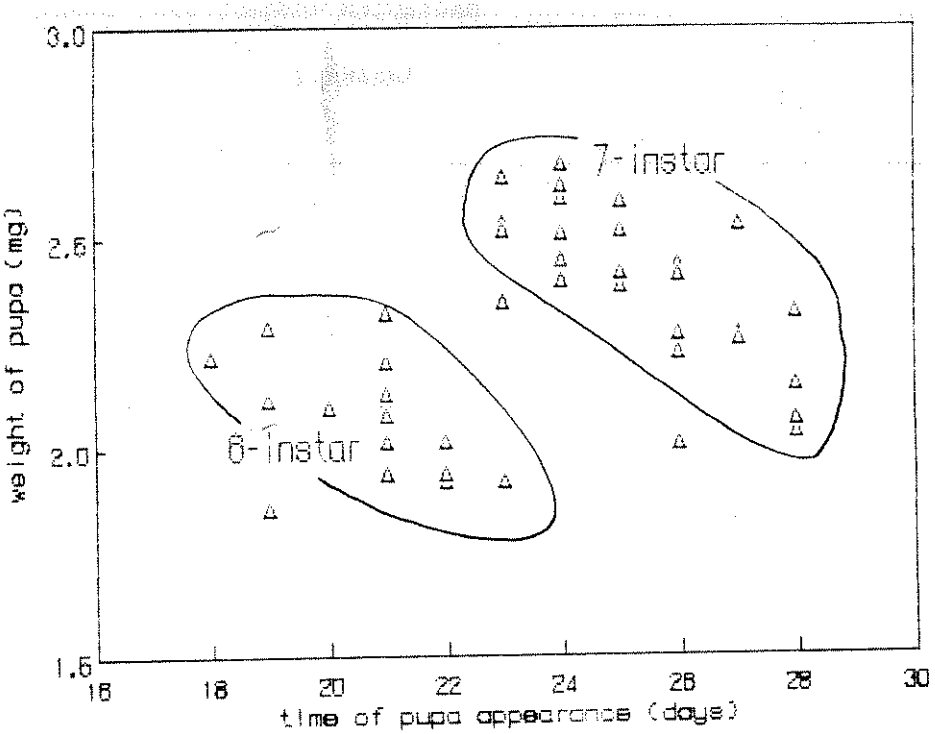

Figure 2. The developmental time – weight dependance in 6- and 7-instar males of T. castaneum (an example).

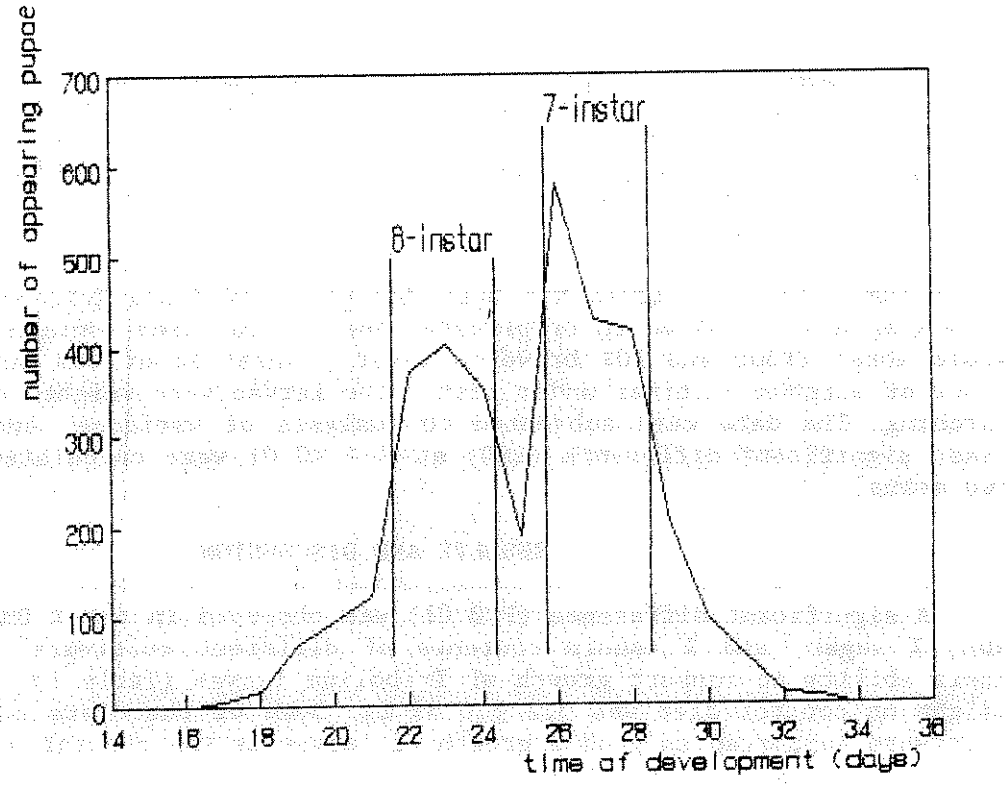

Figure 3. The frequency of pupal appearances in synchronized culture of T. castaneum (an example).

*GROWTH RESPONSE OF TRIBOLIUM LARVAE ON DIFFERENT CULTIVARS OF SORGHUMS

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ABSTRACT

Different cultivars of sorghums differ significantly in their ability to support growth of *Tribolium castaneum* larvae. The growth response of the larvae could not be predicted on the basis of chemical composition of the cultivars.

INTRODUCTION

Tribolium larvae are a useful model for evaluating the nutritional value of cereals (Shariff *et al.*, 1983; Rogel *et al.*, 1983), and legumes (Gerpacio *et al.*, 1980; Pao *et al.*, 1987). Ten cultivars of sorghum (*Sorghum bicolor* (L.) Moench) were found to differ significantly in their content of dry matter (DM), crude protein (CP), ether extract (EE), ash, sugar (as glucose), starch, and tannins; and their ability to support growth of *Tribolium castaneum* larvae (Banda-Nyirenda et al., 1987). Seventeen more cultivars of sorghum have been compared in the present study for their chemical composition, and their ability to support growth of Tribolium larvae.

MATERIALS AND METHODS

Seventeen cultivars of sorghum, listed in Table 1, were grown at Davis, CA, during the 1980-81 seasons. The dried grain were ground to pass through a 100 mesh sieve. Two or three replicates of these ground samples were used for chemical analysis. Dry matter (DM), crude protein (%CP = % Kjeldahl N x 6.25), ether extract (EE), and ash were determined according to AOAC (1979). Acid detergent fiber (ADF) and neutral detergent fiber were determined as described by Goering and Van Soest (1970). Available carbohydrates (ACHO) are the sum of starch and glucose, and were determined by the method outlined by Southgate (1969). The procedure of Price *et al.* (1978) was used for measuring tannins as catechin equivalent.

The procedure for the bioassay of sorghum cultivars to support growth of *Tribolium castaneum* larvae has been described by Banda-Nyirenda *et al.* (1987). Each sample was assayed in triplicate. The control diet contained 90% unbleached whole wheat flour and 10% brewer's yeast. Wheat flour was substituted by the flour of sorghum cultivar under test. The larvae were weighed on 14th day after hatching. The data were subjected to analysis of variance, and the values for least significant difference (LSD) at $P = <0.01$ were calculated to compare any two means.

RESULTS AND DISCUSSION

A significant difference ($P<0.01$) was observed in the % DM, % EE, % ADF, % NDF, % sugar, and % tannin contents of different cultivars of sorghums, and their ability to support growth of Tribolium larvae (Table 1). The mean larval weight on control diet was 3.2 ± 0.03 mg. Some of the diets containing sorghum cultivars supported as good a growth of larvae as the control diet.

Table 1. Cultivars of sorghums, their % composition and ability to support growth of Tribolium larvae

Sorghum cultivar	DM %	CP %	EE %	ADF %	NDF %	Ash %	ACHO Sugar %	ACHO Starch %	Tannin %	Larval wt. mg
P.A.G. 4474	88.7	12.3	2.9	7.0	13.3	2.3	1.1	66.5	0.38	2.8±0.4
P.A.G. 4433	90.3	12.2	3.7	6.6	10.1	1.8	1.8	66.1	0.25	1.5±0.3
P. Valley PV5365R	89.4	12.1	7.7	3.9	6.9	1.6	1.3	71.5	0.30	2.4±0.3
N. King X79552	90.3	12.1	3.4	4.3	7.7	1.9	1.2	71.1	0.32	3.0±0.2
Poineer X3015	91.2	12.1	3.5	5.7	9.7	2.0	3.4	68.7	0.18	2.1±0.4
F. Morse 7601	90.5	12.0	3.9	4.8	9.7	2.1	1.0	69.9	0.19	2.8±0.3
Poineer 883	91.9	11.9	3.7	4.0	7.2	1.7	2.6	69.6	0.25	2.7±0.2
O'Gold EXP9519	88.3	11.8	2.8	3.5	8.5	1.6	1.7	61.5	0.21	2.2±0.2
NC+ 161	90.3	11.7	4.2	6.3	11.3	1.9	1.9	66.4	0.31	2.9±0.3
F. Morse 7804	89.8	11.7	7.2	7.1	10.2	2.0	1.5	66.5	0.18	2.9±0.2
Asgrow H783	88.7	11.6	2.8	5.5	10.9	1.9	2.9	69.2	0.41	3.1±0.2
P. Valley 530GR	88.4	11.5	2.8	5.2	10.8	1.9	1.6	66.8	0.21	3.0±0.2
F.M. ADV 1922	91.6	11.3	5.6	4.9	11.6	1.9	1.6	68.9	0.23	1.6±0.1
Poineer 8855	90.6	11.3	3.4	5.2	8.5	1.9	1.3	66.2	0.11	2.0±0.2
P. Valley PV515GR	91.0	11.3	5.4	3.2	7.6	1.6	2.2	64.2	0.15	1.5±0.3
Asgrow 7812	92.8	11.1	6.0	5.8	10.1	1.9	0.8	65.9	0.30	2.5±0.1
NC 55X	94.2	11.0	5.7	5.2	9.5	1.7	2.8	68.6	0.14	3.0±0.1
ANOVA Table										
DF Error	34	17	17	34	34	17	17	17	17	34
Mean Square Error	0.02	0.08	0.04	0.05	0.16	0.24	0.04	6.4	0.001	0.06
F ratio	23*	2.82	112*	87*	56*	1.45	26*	2.0	20*	15.6*
LSD (P<0.01)	0.2		0.13	0.1	0.1		0.1		0.17	0.2

Different cultivars of sorghums differed significantly in supporting the growth of Tribolium larvae. No significant correlation was observed between any of the chemically determined parameters for different cultivars of sorghums. The growth of Tribolium larvae was also not significantly correlated to any of the individually determined parameters. The multiple correlation coefficient (r^2 = 0.41) for Tribolium growth as dependent variable and other parameters as independent variables also suggested a poor prediction of larval growth from the determined parameters.

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Karyotypic formulae of Spanish Tenebrionidae from Balearic and Canarian archipelagos.

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Most species of Tenebrionids are apterous or at least flightless beetles, a characteristic which very probably explain the high rates of speciation found in the insular biotas. The Baleares and Canary Islands are not exceptions to this general rule since most of their darkling beetles are endemics. Therefore, the chromosomal analyses started herein stand for the first contribution on the cytotaxonomy and karyologic evolution of these insular tenebrionids in relationship with the remaining so far known species. Thirty-five species are chromosomally checked, most from Balearic Islands out of nine from Canary Islands and two from Catalonia, nearest to the Baleares. The results obtained are reporte below.

Subfamily and species	source	karyotypic formula
ERODIINAE		
Erodius emondi laevis Sol.	Ibiza	9 + Xyp
TENTYRIINAE		
Tentyria grossa Bess.	Mallorca, Menorca	9 + Xyp
Tentyria ophiusae Cod.	Ibiza	9 + Xyp
Tentyria schaumi Kr.	Mallorca	9 + Xyp
Pachychila sublunata Sol.	Mallorca Formentera	9 + Xyp
Hegeter lateralis Brullé	Tenerife	9 + Xyp
Hegeter politus Heer.	Lanzarote	9 + Xyp
Hegeter tenuipunctatus Brullé	Tenerife	9 + Xyp
Hegeter transversus Brullé	Tenerife	9 + Xyp
Melanochrus lacordairei Woll.	Lanzarote	9 + Xyp
STENOSIINAE		
Stenosis intricata Reitt.	Mallorca	9 + Xyp

ASIDINAE		
Asida jurinei Sol.	Catalonia	9 + Xy_p
Asida planipennis Schauf.	Mallorca	9 + Xy_p
Alphasida depressa Sol.	Mallorca, Menorca	9 + Xy_p
Alphasida ibicensis P. Arcas	Ibiza	9 + Xy_p
AKIDINAE		
Akis acuminata F.	Mallorca, Menorca	7 + neoXY
Akis bacarozzo Schrank	Mallorca, Menorca	7 + neoXY
Akis bremeri Ardoin	Formentera	7 + neoXY
SCAURINAE		
Scaurus striatus F.	Mallorca	11 + neoXY
PIMELIINAE		
Pimelia criba Sol.	Mallorca, Menorca	9 + Xy_p
Pimelia elevata Sénac	Ibiza	9 + Xy_p
Pimelia radula ascendens Woll.	Tenerife	8 + Xy_p
Pimelia laevigata costipennis Woll.	Hierro	8 + Xy_p
OPATRINAE		
Isocerus balearicus Schauf.	Mallorca	9 + Xy_p
Phylan abbreviatus Ol.	Catalonia	9 + Xy_p
Phylan mediterraneus Pioch.	Ibiza, Formentera	9 + Xy_p
Micrositus nitidicollis P. Arcas	Cabrera	12 + Xy_p
Micrositus semicostatus Muls.	Mallorca	12 + Xy_p
Gonocephalum rusticum Ol.	Mallorca, Ibiza	9 + Xy_p
Melasmana lineatum Brullé	Lanzarote	10 + neoXY
PHALERIINAE		
Phaleria acuminata Küst.	Mallorca	9 + Xy_p
CRYPTICINAE		
Crypticus gibbulus Quens.	Mallorca	9 + Xy_p
Crypticus navicularis latihumeralis Har. Lindb.	Tenerife	9 + Xy_p

DIAPERINAE

Diaperis boleti bipustulata L.	Mallorca	6 + neoXY

HELOPINAE

Nesotes viridicollis Schauf.	Mallorca	9 + Xyp

As it can be seen in the above findings the most frequently encountered formula is 9 + Xy_p, in agreement with previous results in Tenebrionidae (Yadav et al. 1980). The tenebrionids keep the primitive and most frequent beetle formula despite their great morphological differences, which implies a high degree of canalisation of the gross karyological features in correspondance with their larval uniformity. Only some Pimelia, the Akis, Scaurus, Micrositus and Diaperis deviate from the common formula. Both increases and decreases account for these deviations which can involve translocations in the sex-chromosomes too as shown in Akis, Scaurus and Diaperis. From our work we can also conclude that not only Blaptinae and Elenophorinae display centric fissions as reported by Yadav and Pillai (1976) but the Scaurinae and a few Opatrinae can display increases in number too, by centric fissions presumably.

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Nuclear DNA content of Tribolium castaneum and Tenebrio molitor (Coleoptera: Tenebrionidae).

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Undoubtedly Tribolium castaneum is the best surveyed beetle on genetic grounds (Sokoloff, 1966; 1977), and has been reasonably well studied from the cytogenetic viewpoint (Smith, 1952). Nevertheless, its nuclear DNA amount was unknown to date. Since we have recently used T.castaneum as standard for calibration to measure genome sizes in several species of beetles, we report herein the C value of this species and that of another, Tenebrio molitor, also extensively used in many laboratories.

The technique we followed was the conventional Feulgen staining of teased and squashed testes according to the regular procedures, except for the fixation in 10% formaline and a 5N HCl hydrolysis at room temperature for 45 minutes. The measures of light extinction were performed by a MPV microdensitometer coupled to a Leitz Dialux-20 microscope. Both the intensity of monochromatic light and the size of window were kept invariant in each set of experiments. Moreover, the cell size of every checked spermatid was scored by an ocular micrometer.

Since the DNA content of Dermestes maculatus was previously known (Rees et al., 1976), we took its spermatids as standard to estimate the C value of Tribolium castaneum (CSIC wild type strain from Barcelona). The DNA amounts of spermatids for the two species are given in Table 1. Also, the range of variation of the total 100 DNA measures is depicted in the histograms of fig. 1.

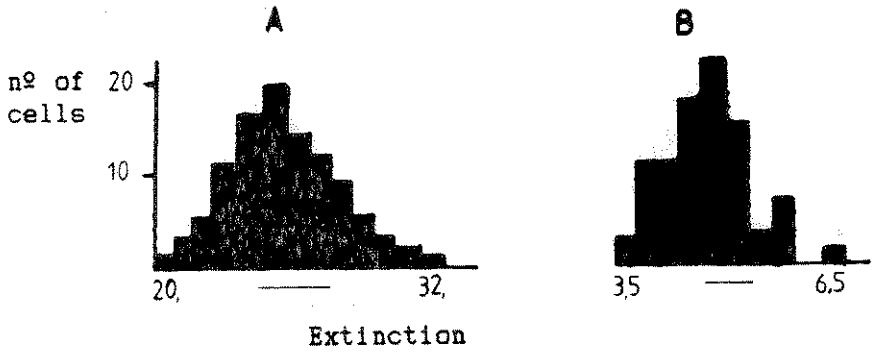
Table 1. Mean light extinctions (arbitrary units) and standard errors per individual of Dermestes maculatus and Tribolium castaneum.

		Dermestes maculatus	T.castaneum
indv.	nº esperm.	Mean ± S.E.	Mean ± S.E.
1	20	27.834±0.593	4.632±0.103
2	20	24.383±0.529	4.685±0.118
3	20	25.849±0.371	4.586±0.123
4	20	25.546±0.452	5.253±0.098
5	20	26.228±0.399	4.825±0.156
Total	100	25.963±0.237	4.789±0.058

1C nuclear DNA content of D.maculatus 1.129 pg (Rees et al., 1976), id. of T.castaneum 0.208±0.002 pg.

After estimating the DNA content of T.castaneum, this species was used as standard to measure the counterpart value of Tenebrio molitor spermatids (CSIC wild type strain from Barcelona), by checking again five individuals and twenty spermatids of each individual. This gave a mean 1C value of 0.517±0.007 pg.

Figure 1. Histograms of the distribution of spermatid extinctions (arbitrary units)for the 100 cells measured of Dermestes maculatus (A) and Tribolium castaneum (B).



The nuclear DNA contents of Tribolium castaneum and Tenebrio molitor espermatids are among the lowest and the highest values, respectively, so far found in a sample of near twenty species of tenebrionids (Juan & Petitpierre, 1988). The genome size of T.castaneum is similar to that of Drosophila melanogaster (0.18 pg.), but the haploid value of the latter, n=4, is lower than that of the former, n=10 chromosomes. Therefore, the averaged DNA content of T.castaneum chromosomes is clearly smaller than the averaged chromosomes of D.melanogaster.

SUMMARY

The nuclear DNA content of Tribolium castaneum spermatids was measured by Feulgen microdensitometry using those of Dermestes maculatus as standard. The mean value of genome size for T.castaneum was 0.208±0.002 pg. Furthermore, the analysis of Tenebrio molitor spermatids, using T.castaneum as standard for calibration, gave a higher value 0.517±0.007 pg, about 2,5-fold that of the previous species.

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* Influence of pupal age on the adult recovery and survival of Tribolium anaphe Hinton. to different doses of gamma irradiation.

Tribolium anaphe Hint. is an obnoxius pest of the stored commodities and cosmopolitan in distribution, and is originating in Ethiopia (Hinton, 1948). The adults of this pest are long-lived and laid eggs continuously over a long periods belongs to the second type of oviposition in Coleoptera (Dick, 1937). Applied pest control largely depends on limiting the longivity of the beetls which survive to go on reproducing and add to the desolation of food materials.

Inoizing radiation has been used successfully to control several insect species and may prove valuable in controlling stored grain pests (Brown et al., 1972; Dramola, 1980; Huda & Rezaur, 1982; Khattak & Jilani 1984; Arunachalam & Curtis, 1985; Dawes et al., 1987 and Navon et al., 1988). Gamma radiation appears to be a potential alternative to chemical for pest control in stored products (Laudni et al., 1965 and Cornwell, 1966) and have no residual problems like chemical insecticides (Patterson et al., 1975). Inoizing radiation destroy life by causing physical and chamical changes in the cell that they penetrate, and among different rays, gamma rays have great penetrating effects and hence these rays are most considered for insect control (Bushland, 1958).

Attempts have been made to determine the effect of radiation on the flour beetles by several researcher's (Cork, 1957; Ducoff & Walburg, 1961; Sokoloff, 1961; Tilton et al., 1966; Yang et al., 1970; McKibben & Mills, 1972; Brower & Tilton, 1973; Faustini, 1976; Ramos-Elorduy de Conconi, 1978; Bhatia & Sethi, 1980; Bhat et al., 1981; Bongirwar et al., 1981; Ratti et al. 1982 and Wool, 1982). But information concerning the effect of gamma radiation on T. anaphe is very scanty. So, the following experiments were set up to determine the effect of gamma radiation on the adult recovery and longivity of T. anaphe when exposed on different ages of pupae.

Insects used for this study were originally obtained from Pest Infestation Control Laboratory, Slough, England and maintained for 3 years in the Dept. of Zoology, Rajshahi

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University. Eggs were collected by placing a large number of adults of nearly similar age on a thin layer of wholemeal flour in a Petri dish and sieving (60-mesh) the content, on the next day. Then they were incubated at 30 ± 0.5°C for hatching. Newly hatched T. anaphe larvae were transferred to jars (20 X 9 cm) containing 300g of standered food medium (Park & Frank, 1948). Ten indentical jars were used each having 450 larvae. The larvae were carefully checked from time to time by sieving (18- mesh) for pupation. After pupation they were collected and sexed on the basis of exo-genital processess (Halstead, 1963). When the pupae reached the desired age, they were irradiated from the Co-60 source (75 krad/hr). The exposed doses were 1, 2, 4 and 6 krad, and the age of the pupae at the time of exposure were 1, 2, 3 and 4 days. A control batch was maintained without any exposure. Then they were kept in an incubator for adult eclosion. After eclosion, the recovery was recorded. The adults of both sex were placed in separate glass jars (10.5 X 4.5 cm) containing food medium and secured at the top with fine net. The mortality of the beetles were observed for 30 days. In every counting day the medium was replaced to avoid conditioning by the adult (Ogden, 1969). All experiments were conducted in an incubator at 30 ± 0.5°C, uncontrolled relative humidity and without light.

The applied doses significantly reduced the adult emergence of T. anaphe in all levels of age group (Table 1), and higher doses (6krad) drastically affected the longivity of both sexes (Table 2). It was also found that younger pupae were more sensitive than the older one, and with the increase in ages the adult mortality decreased. Flint et al., (1966) reported that when pupae of the boll weevil, Anthonomus grandis grandis Boheman, of three different ages were irradiated with 3 krad of X-rays, adult emergence was less reduced in older pupae than the younger. Similar results were obtained by Burgess & Bennett(1972) with the alfalfa weevil when pupae of different ages were exposed to gamma radiation. Chen et al. (1983) also noted that 68.70% adult emerged from 1.1 krad irradiated pupae of 2 days old. Dawes et al., (1987) observed that the 5 krad severely affected the adult production of sweet potato weevil, Cylas formicarius elegantulus (Summers) when exposed on 2 day old pupae. In the present investigation, none of the dose could impede the adult emergence but the percentage was very meagre at 6 krad and died within 10 days, and both sexes of 1 day adult died within the same day at 2 & 4 krad. It was also observed that with the increase in doses the adult production decreased. These findings are in close conformity with Nair (1962) working on house fly, Davich & Linddquist (1962) on boll weevil, Datta et al. (1980) on uzi fly, Tezcan & Zumreoglu (1981) on fruit fly and Parsad & Sethi (1980) on Dacus dorsalis.

Insect populations in stored products can be controlled by producing immediate mortality (Cornwell & Bull, 1960). Considerable variation in results may occur when factors like radiation dose rate and age of species are not considered (O'Brien & Wolfe, 1964 and Brown & Davich, 1973). From that standpoint, in present investigation, a wide range of parameters both for age and low doses of gamma radiation have considered so as to determine the minimal effective dose for the specific pupal age.

It is inferred from the over all results that the treated doses are not sufficient to inhibit hundred per cent emergence and their quick mortality. So, it is suggested that the higher doses ( )6 krad) may be used for controlling this pest.

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Table 1 : Influence of pupal age on the adult recovery of T. anaphe, to different doses of gamma irradiation.

Age (day)	No. of pupae	Control %	1 kard. %	d-val.	2 kard. %	d-val.	4 kard. %	d-val.	6 kard. %	d-val.
1	150	92.67 (139)	59.33 (89)	5.88 **	45.33 (68)	7.35 **	32.00 (48)	8.56 **	9.33 (14)	10.30 **
2	150	95.33 (143)	68.00 (102)	5.54 **	64.67 (97)	5.95 **	48.67 (73)	7.65 **	16.67 (25)	8.50 **
3	150	94.67 (142)	72.00 (108)	4.98 **	66.00 (99)	5.77 **	57.33 (86)	6.76 **	21.33 (32)	9.94 **
4	150	93.33 (140)	86.00 (129)	2.04 *	74.00 (111)	4.18 **	62.00 (93)	5.78 **	28.00 (42)	9.06 **

●d = Standardized normal deviate: * P < 0.05 , ** P < 0.001.
Figure in parantheses indicate the number.

Table 2 : Influence of pupal age on the adult survival of T. anaphe, to different doses of gamma irradiation.

Dose (krad)	Age (day)	No. of obs.	No. alive that days after treatment 1	5	10	15	20	30	Mortality %	Corrected mortality
1	1	49*	49	49	49	49	49	46	6.12	4.80
		40**	40	40	40	40	40	40	0.00	--
	2	54	54	54	54	54	54	53	1.85	0.41
		48	48	48	48	48	48	48	0.00	--
	3	59	59	59	59	59	59	57	3.39	2.03
		49	49	49	49	49	49	49	0.00	--
	4	69	69	69	69	69	69	68	1.45	0.06
		60	60	60	60	60	60	60	0.00	--
control-		72	72	72	72	72	72	71	1.39	--
		67	67	67	67	67	67	67	0.00	
2	1	37	37	--	--	--	--	--	--	--
		31	31	22	--	--	--	--	--	--
	2	51	51	51	50	50	46	40	21.57	20.21
		46	46	46	46	46	44	42	8.70	8.70
	3	53	53	53	52	52	52	49	7.55	5.95
		46	46	46	46	46	46	44	4.35	4.35
	4	59	59	59	59	59	57	56	5.08	3.44
		52	52	52	52	52	52	52	3.85	3.85
control-		73	73	73	73	73	73	72	1.70	--
		70	70	70	70	70	70	70	0.00	
4	1	27	27	5	--	--	--	--	--	--
		21	21	16	--	--	--	--	--	--
	2	38	38	32	32	32	31	28	26.32	24.05
		35	35	35	35	35	33	31	11.43	10.23
	3	45	45	43	43	42	42	36	20.00	17.53
		41	41	41	41	41	41	38	7.32	6.07
	4	49	49	49	47	47	45	40	18.37	15.85
		44	44	44	43	43	42	42	4.55	3.26
control-		67	67	67	67	67	67	65	2.99	--
		75	75	75	75	75	75	74	1.33	--
6	1	8	8	--	--	--	--	--	--	--
		6	6	--	--	--	--	--	--	--
	2	14	14	--	--	--	--	--	--	--
		17	17	--	--	--	--	--	--	--
	3	18	18	2	--	--	--	--	--	--
		14	14	6	--	--	--	--	--	--
	4	23	23	2	--	--	--	--	--	--
		19	19	7	--	--	--	--	--	--
control-		68	68	68	68	68	68	67	2.94	--
		72	72	72	72	72	72	72	0.00	

* Male; ** Female.

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* Effect of egg cannibalism on larval growth of Tribolium confusum.

Introduction

Tribolium is a major pest of stored products and is cosmopolitan in distribution. In Tribolium the larval growth is affected by environmental factors such as temperature,relative humidity,limitation of food and flour conditioning (Holdaway,1932;Howe,1956;Boyer,1976 and Mondal,1986). Depending on various conditions the number of larval instars ranges from 5 to 11 or more (Brindley,1930) and larval period varies from 18 to 100 days (Howe,1956;Mondal,1986). At 30°C which appears to be optimum,the majority of larvae have six instars and the larval period varies from 22-27 days (Good,1936).

In the population of the flour beetles Tribolium egg cannibalism by both adults and larvae (Park et al., 1965) is one of the natural forces and regulate population size (Park,1933).

There is no information concerning the effects of egg cannibalism on the larval growth of Tribolium . This led to the present work.

Materials and Methods

Newly hatched larvae were reared in flour medium mixed with 1-2 day old Tribolium eggs at a density of 20,50 or 100 g^{-1} of medium. Groups of control larvae were maintained on food without eggs.

Individual larva was placed in flat bottom glass tubes(50 X 25 mm) containing 0.5g of either fresh or treated medium and secured at the top with cotton wool. They were kept in an incubator at 30°C without light and relative humidity control. Every three days the medium was replaced to avoid conditioning by larvae (Mondal,1983) and eggs were also replaced to avoid hatching. Larvae were regularly observed for pupation and the larval period was noted.

The weights of the larvae were taken on 3rd,6th,9th,12th and 18th day from hatching which correspond to the second,third,fourth,fifth and sixth instar in control respectively (Mondal,1984). Although larval instars in the treated medium were not known,their weights were taken on these days to make comparison with those of control. Larvae were collected by sieving the medium through a 250 micrometer sieve and the surface of the larvae was thoroughly cleaned by a fine paint brush to remove the flour,if any. Larvae were individually weighed in an electric balance. Twenty larvae from each age were weighed for different treatments.

Results and Discussion

The results are shown in tables 1 and 2. The effect of different treatments on both larval period and larval weight was determined by analysis of variance.

Eggs treated media reduced the larval period and increased the larval weight in comparison with those of control. The weights of all ages particularly those of sixth instars were found increased significantly ($P < 0.05$) in the eggs treated medium in comparison with those of control. The increased weight of larvae is probably due to the phenomenon of egg cannibalism by larvae (Park et al., 1965;Teleky,1980). In the present experiments the significantly ($P < 0.05$) increased weight of larger larvae also support the findings of Ho and Dawson (1966) who reported that the younger larvae of Tribolium are not very active in egg eating,but as the larvae age and increase in size they become much more cannibalistic. The probable reason of the larval increased weight is that there is a higher concentration of utilizable nutrients in eggs than in the surrounding medium due to high caloric content (Slobodkin,1962). However,there was no significant difference ($P > 0.05$) in the larval period between treatments and control.

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Table 1 : Larval period (days) of T.confusum reared on fresh medium (control) and medium treated with different densities of eggs.

Treatment	No. of larvae	Mean ± S.E.	Range
Control	42	21.00 ± 0.11	18.00 - 23.00
Eggs(20 g^{-1})	40	20.00 ± 0.12	18.00 - 22.00
Eggs (50 g^{-1})	40	20.20 ± 0.15	18.00 - 22.00
Eggs (100 g^{-1})	40	18.50 ± 0.16	17.00 - 22.00

Table 2 : The average weight (µg) of T.confusum larvae reared on fresh medium (control) and medium treated with different densities of eggs.

Treatments	Age (in days) from hatching				
	3	6	9	12	18
	Mean ± S.E.	Mean ± S.E.	Mean ± S.E.	Mean ± S.E.	Mean ± S.E.
Control	32.00 ± 1.55	68.00 ± 2.50	190.00 ± 5.80	412.00 ± 19.70	1780.00 ± 62.00
Eggs ($20\ g^{-1}$)	32.50 ± 1.65	72.00 ± 2.60	188.00 ± 6.12	410.00 ± 18.30	1790.00 ± 61.00
Eggs ($50\ g^{-1}$)	32.00 ± 1.53	75.00 ± 2.55	196.00 ± 5.90	440.00 ± 19.20	2120.00 ± 83.50
Eggs ($100\ g^{-1}$)	33.50 ± 1.70	81.00 ± 2.80	197.00 ± 5.80	560.00 ± 18.50	2330.00 ± 85.40

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* Effect of synthetic methylquinone on adult mortality in Tribolium confusum Duval.

Introduction

The life span of adult Tribolium ranges from 3 months to 3 years and males live longer than females (Good,1933,1936; Pajni and Virk,1982). It may be reduced due to adverse temperatures,relative humidities (Pajni and Virk, 1982) and conditioning of medium (Park,1935).

Methylquinone (2-methyl-1,4-benzoquinone) is one of the quinoid secretions of adult Tribolium (Roth,1943) and are responsible for conditioning of flour medium (Park and Woolcott, 1937). The synthetic methylquinone is repellent to Tribolium adults (Loconti and Roth,1953) and larvae (Mondal and Port,1984). It also reduces both fecundity (Taher and Cutcomp, 1983) and fertility (Mondal,1987) in Tribolium.

There is no information on the effect of synthetic methylquinone on adult mortality in T.confusum . This led to the present work.

Materials and Methods

Ten adults aged between 0-1 day were placed im a petri dish provided with 4g of either fresh (control) or treated medium and covered with a lid. The medium of each dish was changed every ten days to avoid conditioning by the beetles (Park,1935). Mortality was assessed after 60 days (Khan, 1981) and the percentage mortality was corrected using Abbott's formula (Abbott, 1925). The medium was treated with different concentrations of synthetic methylquinone by subliming into fresh medium (Ogden,1969).

Five replicates were used for each treatment and for each sex. Experiments were conducted at 30°C without light and relative humidity control. The adults used in the experiments were all survivors (Ashford, 1970).

Results and Discussion

The results of the experiments are shown in table 1. In the treated medium particularly in higher concentration mortality of both male and female were higher than those in control. In control there was no difference in mortality between male and female adults,but in case of treated medium the

females show slightly higher mortality compared with males. In the present experiments the higher mortality in treated medium indicates that the life span of Tribolium adults may be reduced due to methylquinone which agrees with the findings of Park (1935). The higher mortality of female adults recorded in the present experiment also supports the results of Good (1936) who reported that males live longer than females.

There are no published data on the effects of synthetic methylquinone on adult mortality to compare with present results,but the present results confirm the assertion of Park (1935) that the life span of Tribolium adults may be reduced by conditioning of medium.

Tribolium adult's life span is very long and they reproduce throughout the year. Thus,the reduced longevity could be important in the control of Tribolium (Mondal,1986).

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Table 1 : The percentage mortality of T.confusum adults reared on fresh medium (control) and medium treated with synthetic methylquinone.

Sex	Concentration of methylquinone (g^{-1} of medium)	Total adults dead	% mortality	Corrected mortality (%)
Male	Control	3	6	-
	0.2mg	5	10	4.25
	1.0mg	10	20	14.89
	5.0mg	15	30	25.53
Female	Control	2	4	-
	0.2 mg	10	20	16.67
	1.0 mg	14	28	25.00
	5.0 mg	20	40	37.50

Five replicates per test,each replicate consisting of 10 adults(N=50).

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*DEVELOPMENT TIME AND SURVIVAL IN 6- AND 7-INSTAR GROUPS OF TRIBOLIUM CASTANEUM HBST. AND T. CONFUSUM DUVAL UNDER THE EFFECT OF TRICALCIUM PHOSPHATE.

INTRODUCTION

Inorganic substances in the form of minutely grounded powder are harmful for insects in spite of the fact that they remain inactive chemically. Their impact depends on destruction, either by adsorption or by mechanical injuring, of the lipid layer of cuticle which prevents evaporation (Ebeling and Wagner 1959, Hassan 1981). Looking for substances which would be not toxic for man but harmful to insects, 66 mineral salts, mainly containing calcium, were examined, by exposure 5 insect pest species (Boczek, 1984). The strongest inhibitory effect was that of ammonium nitrate and tricalcium phosphate (TCP).

Chemical purity (Rao et al., 1971) and the degree of powdering of TCP (Baker et al., 1976) both exert the strong influence on effectiveness of this salt.

The paper aimed at learning about reaction of 6- and 7-instar groups of T. castaneum cI and T. confusum bIV strains earlier discerned by Prus (1976) and Bijok (1984) to different concentrations of tricalcium phosphate in the food. Both survival and duration of development were examined at three concentrations of TCP.

MATERIAL AND METHODS

Experiments were carried out on two strains of Tribolium cI of T. castaneum and bIV of T. confusum both derived from Professor Thomas Park at his Laboratory of the University of Chicago. In each strain, 6- and 7-instar groups were discerned and cultured at 29 C and RH - 75% in dark incubator. The same climatic conditions were maintained at the present experiments. Standard mixture of wheat flour and baker's yeast in weight proportion 20:1 was used as culture medium. To this medium tricalcium phosphate was added in adequate proportions to form three concentrations: 0.5, 1.0 and 1.5% (by weight). The substance originated from USDA Laboratory, Savannah, Georgia. Culture medium was used as control.

There were two experiments; the first one depended on placing a hundred newly laid eggs into 50 g of medium. After hatching the egg the number of larvae was recorded every two days. Later on the pupation and eclosion moments were ascertained with simultaneous record of reduction in number of

pupae and adults. Sex of individuals was determined in th pupal stage. The second experiment was the exact replica of th first, one with only difference that newly hatched larvae (hundred for each treatment) were used to start the experimen instead of eggs.

The whole set of each experiment involved the followir design: two species x two instar groups x four TC concentration x 3 replications, which gives a total of 4 samples.

RESULTS

The effect of tricalcium phosphate on T. castaneum cI ar T. confusum bIV strains, seperately for 6- and 7-instar groups was presented in the form of survival curves for eac concentration of the inhibitory salt. In T. castaneum, 6 instar group shows stronger reaction than 7-instar group (Fig. and 2). The effect of TCP concentration is differentiatec resulting in higher mortality with increasing concentratior The strongest effect was observed in 6- instar group a concentration of 1.5%, where only a few individuals survived t the pupal stage and eclosed later. Considering th developmental time, a strong reduction is observed in the eg stage (25 - 40%) which reflects the combined effect hatchability and mortality due to TCP.

Further reduction follows in the early larval stages, wi the curve reaching a certain plateau in elder larvae. Nex rather strong reduction is observed in pupal stage or eclosion time. The total reduction in 6-instar group, related to controls, amounts to 15% in 0.5%, 20% in 1.0% a over 40% in 1.5% concentrations. In 7-instar gro corresponding percentages are as follows: 25%, 40% and 45%.

The development is prolonged at medium with TCP by about days, except for concentration 1.0% in 6-instar group, whe the shift in appearance of pupae amounts to two days compared with the control (Fig. 1 and 2).

In T. confusum, 6-instar group shows also strong reaction to TCP than 7-instar group, though the effect is le differentiated here (Fig. 3 and 4). In 6-instar grou attention is drawn to a very low hatchability of eggs (55% controls) as compared with that in 7-instar group (70%). Fr these stage on, the survival in controls of 6-instar group rather good (only 10% reduction) and mortality due to the sa effect is about the same in the two first concentrations, a 25% in 1.5% concentration.

In 7-instar group of T. confusum bIV further reduction larval and pupal stages amounts 15% in control Concentrations: 0.5% and 1.0% bring about less than 1 reduction, and 1.5% - 10% reduction.

The development is prolonged at TCP concentrations in both instar groups by 4-5 days except for concentration 0.5% in which it is the same as in controls (Fig. 3 and 4).

In order to avoid the obscuring effect of differentiated egg hatchability on the reults of TCP impact another experiment was performed with newly hatched larvae used at the starting point. In T. castaneum 6-instar group, the reduction in postlarval stages amounts to about 15% in controls, 35% in concentration 0.5% and over 90% in 1.0% concentration. A hundred per cent mortality was observed at 1.5% concentration at the beginning of the experiment (Fig. 5). In 7-instar group the survival of individuals was very high and similar as in controls and in 0.5%, whereas it was rather poor at 1.0% and very low at 1.5% concentration. The reduction occurred mostly in early larval stages except for 0.5% concentration in both instar groups, where there was either no reduction (in 7-instar group) or small one (in 6-instar group).

Concerning the developmental time the similar pattern of delayed effect was observed as in the first experiment. In general, survival of individuals representing both instar groups in T. confusum is better than in T. castaneum, but the course of reduction shows a similar pattern (Fig.6).

At a very low reductn in controls, the concentration of 1.0% and 1.5% caused reduction by about 50% in 6-instar group (0.5% concentration brings about slightly higher reduction than in control) and in 7-instar group the reduction is from 35% in 0.5% to 60% in 1.5% concentration.

Prolongation of development of individuals representing the two instar groups (Fig.6) in T. confusum bIV is very clear and it amounts to 6 days to the moment of pupal appearance.

DISCUSSION

According to Hassan (1981), in screening tests the Polish TCP did not affect the development of Trogoderma granarium, while American one showed a strong inhibitory effect. Since the only difference between these two products originating from different sources was the size of particle the latter was considered to be the main reason of such difference. This author suggested that the main effect of TCP was through its action on cuticle and through alimentary tract. Small particles having larger surface injure the epicuticle more intensely than larger ones. Small particles get with food in larger amounts inside the alimentary canal of the insects. The high mortality of larvae observed in the present experiments (Fig. 5 and 6) is a direct effect of such action.

The strong effect of TCP on larvae of T. castaneum was observed by Majumder and Bano (1964) in the form of delayed growth and change in body coloration. At 2.0% concentration, TCP exerted strong toxic effect hindering the pupation process

and killing adults in the moment of metamorphosis.

Bearing all this in mind the concentrations of TCP below 2% were chosen for the experiments in order to be able to trace any differentiated effect on survival and duration of development in both groups of two species of Tribolium.

The intrapolulation differentiation, originally expressed by different number of exuviae during development at the same climatic and food conditions and by the course of growth curve (Prus, 1976, Bijok, 1984, Prus and Prus, 1987), is also perceivable in the way of response of these groups to different concentrations of TCP.

At much stronger effect of TCP on T. castaneum than on T. confusum, the examined concentrations of the toxine bring about more variable effect in 6-instar group than in 7-instar group. It can be inferred from 100% mortality only in 6-instar group at 1.5% concentration and lack of effect in 0.5% concentration in 7-instar group (Figs 1, 2 and 5). In T. confusum, on the other hand, 6-instar group seems to be less vulnerable to harmful effect of TCP, especially at the lowest concentration (Figs 3, 4 and 6).

Similar delay of development as in both species of Tribolium was observed by Kraszpulski (1984) in Khapra beetle Trogoderma granarium treated with 2.5% concentration of TCP. In this species delay of development amounted to 3 days.

Further studies will deal with the effect of TCP on such population features as: fecundity, hatchability of eggs, reproductive effort, etc.

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Explanation to Figures

Fig. 1. Survival of T. castaneum cI 6-instar group at various concentrations of TCP during its development (starting from egg stage).

Fig. 2. Survival of T. castaneum cI 7-instar group at various concentrations of TCP during its development (starting from egg stage).

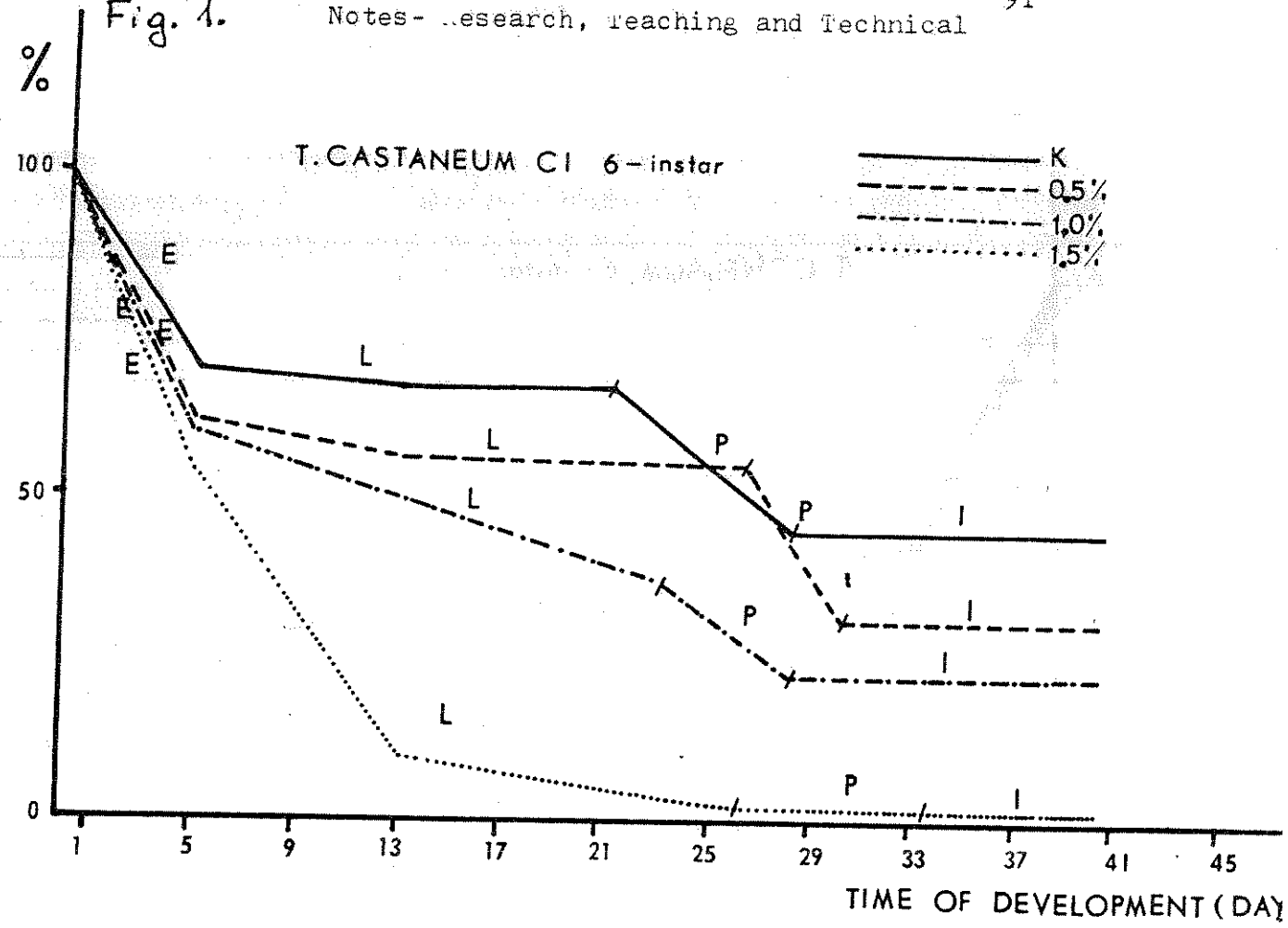
Fig. 3. Survival of T. confusum bIV 6-instar group at various concentrations of TCP during its development (starting from egg stage).

Fig. 4. Survival of T. confusum bIV 7-instar group at various concentrations of TCP during its development (starting from egg stage).

Fig. 5. Survival of T. castaneum cI 6- and 7-instar groups at various concentrations of TCP during its development (starting with newly hatched larvae).

Fig. 6. Survival of T. confusum bIV. 6- and 7-instar groups at various concentrations of TCP during its development (starting with newly hatched larvae).

Fig. 1.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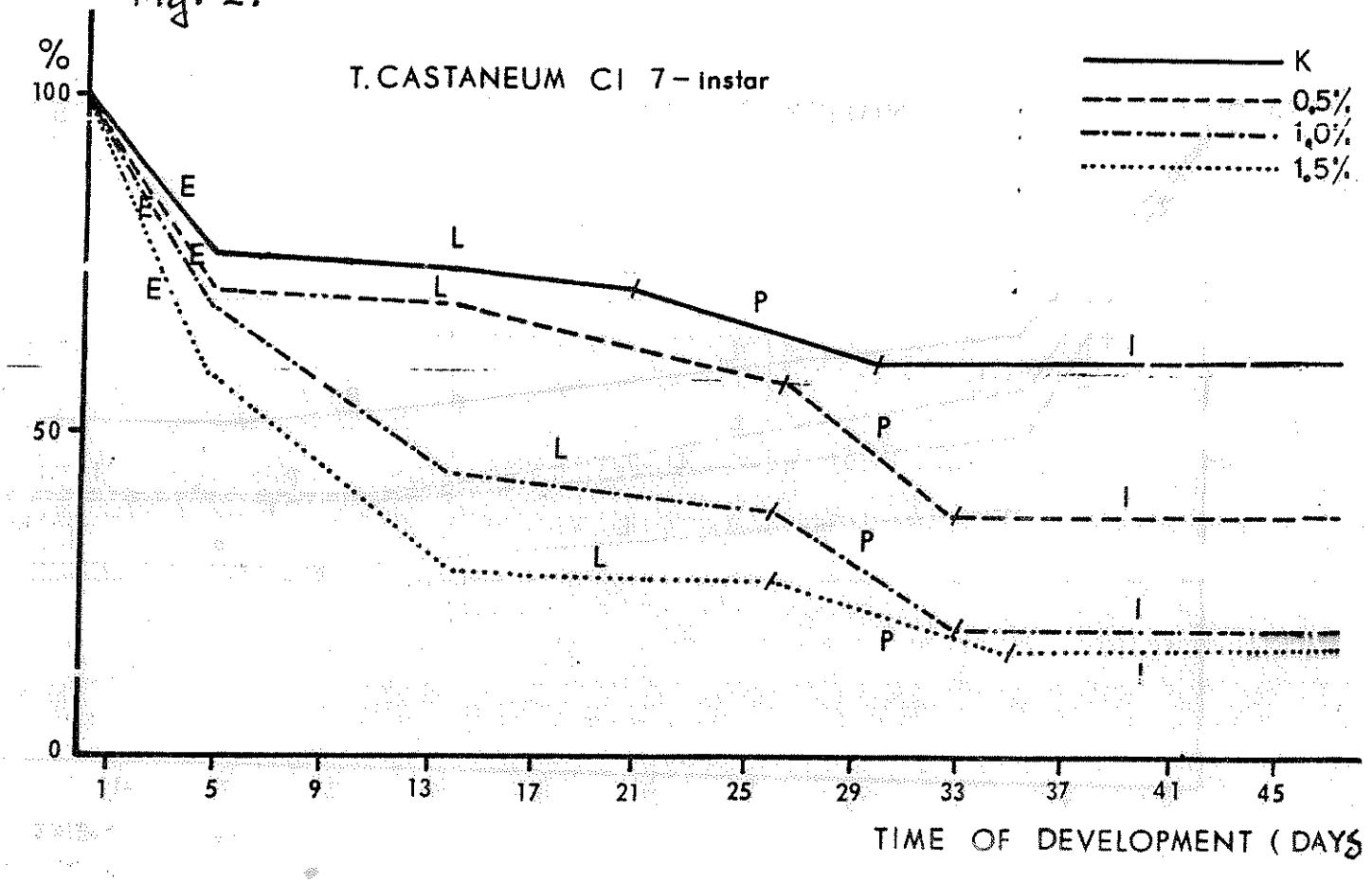
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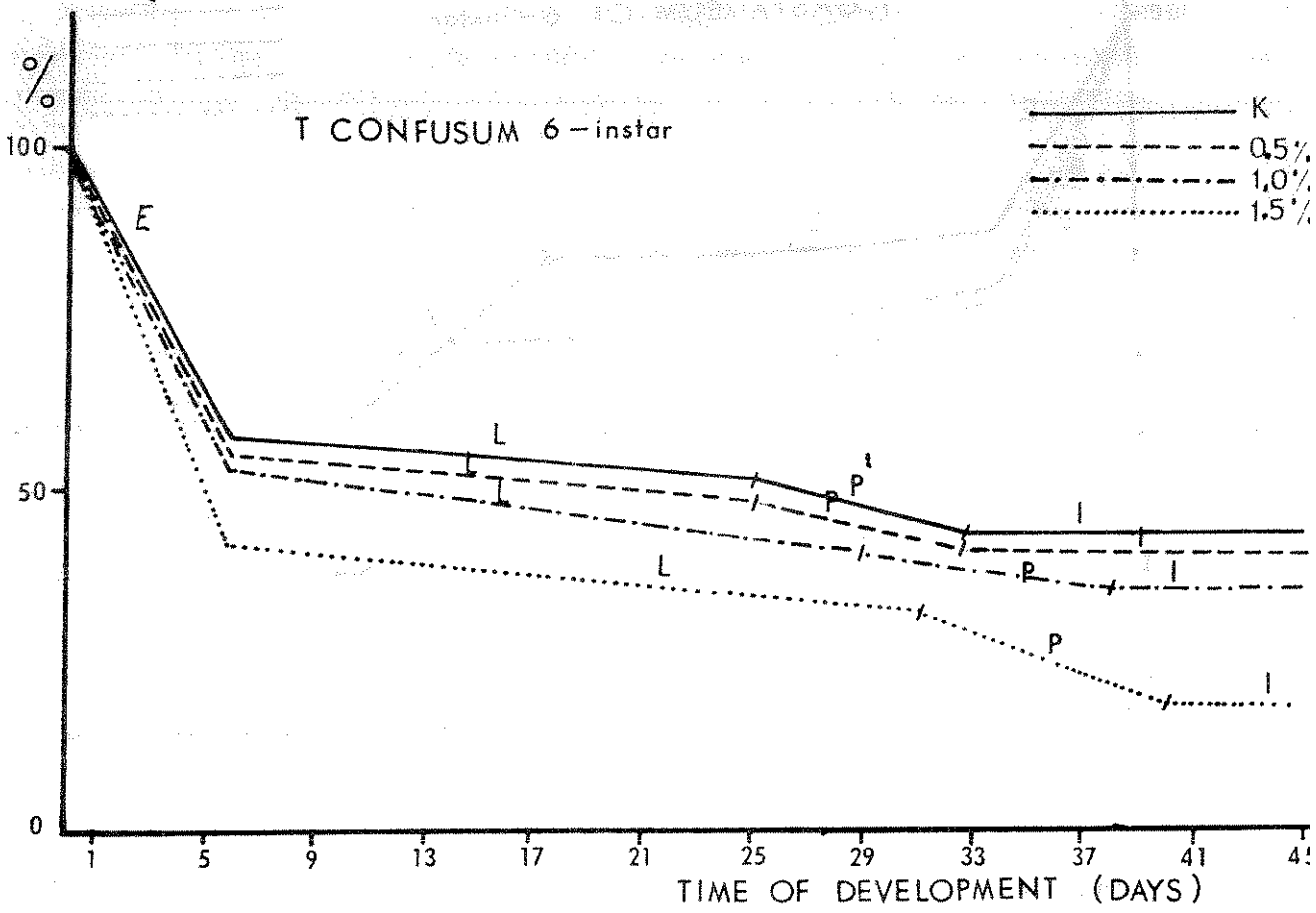
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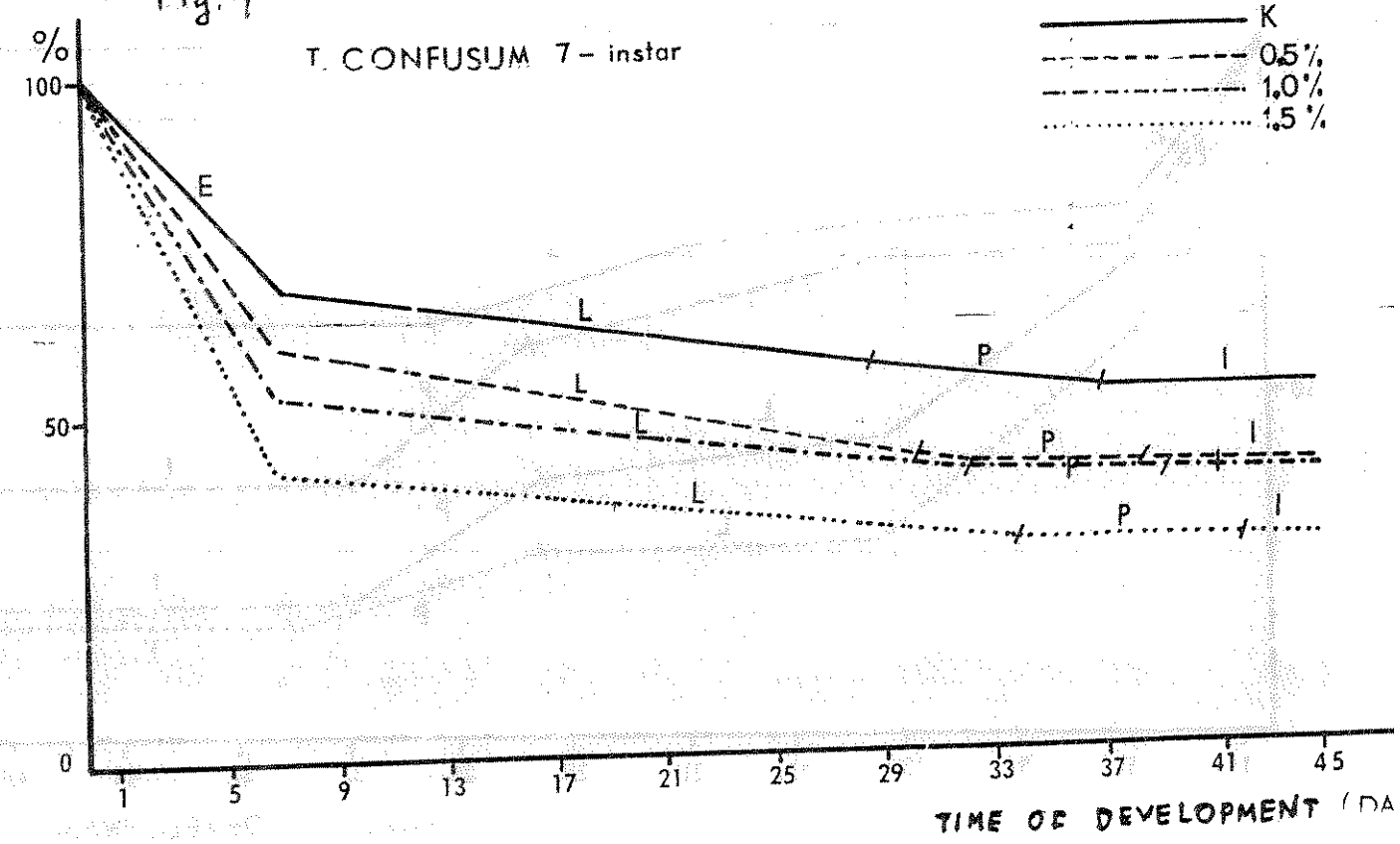
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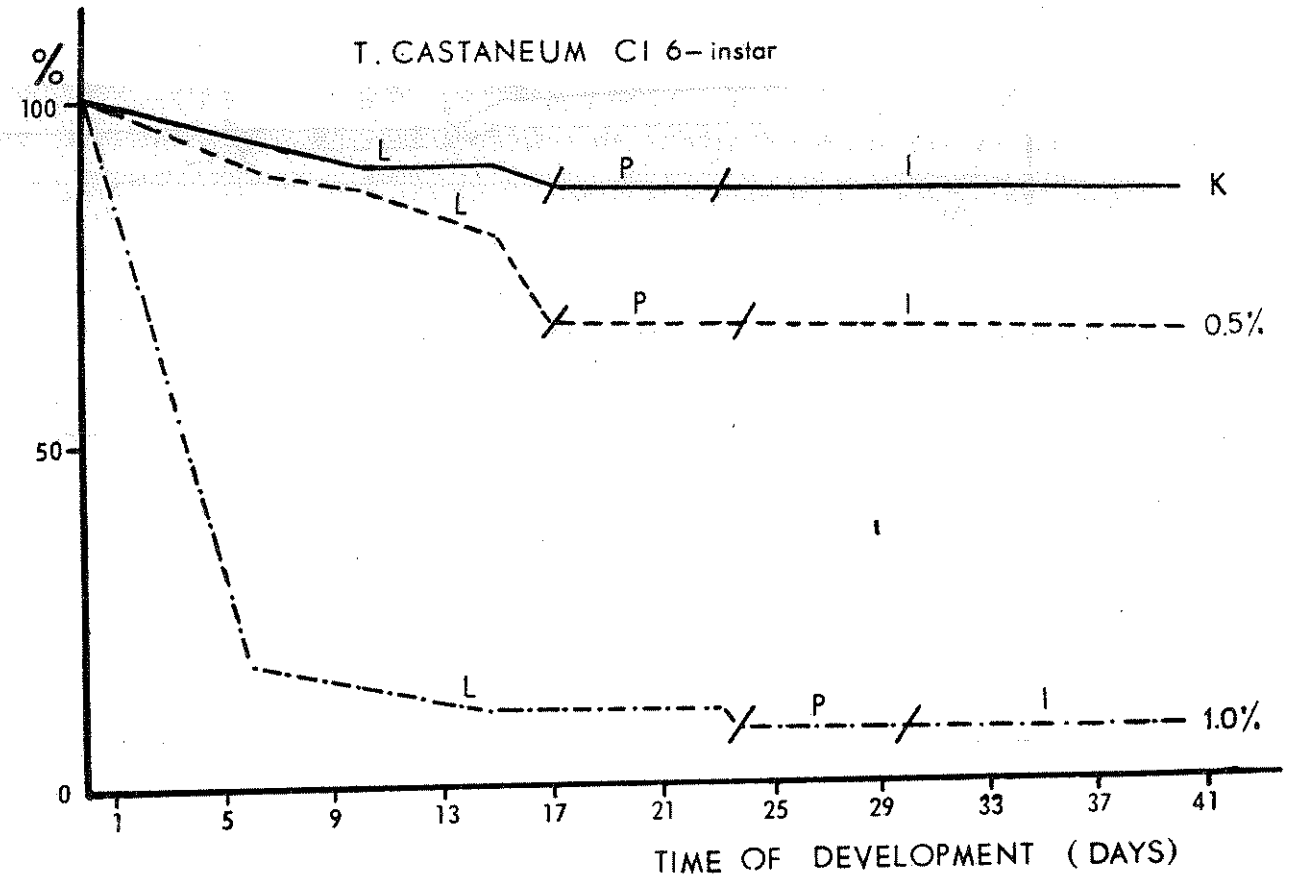
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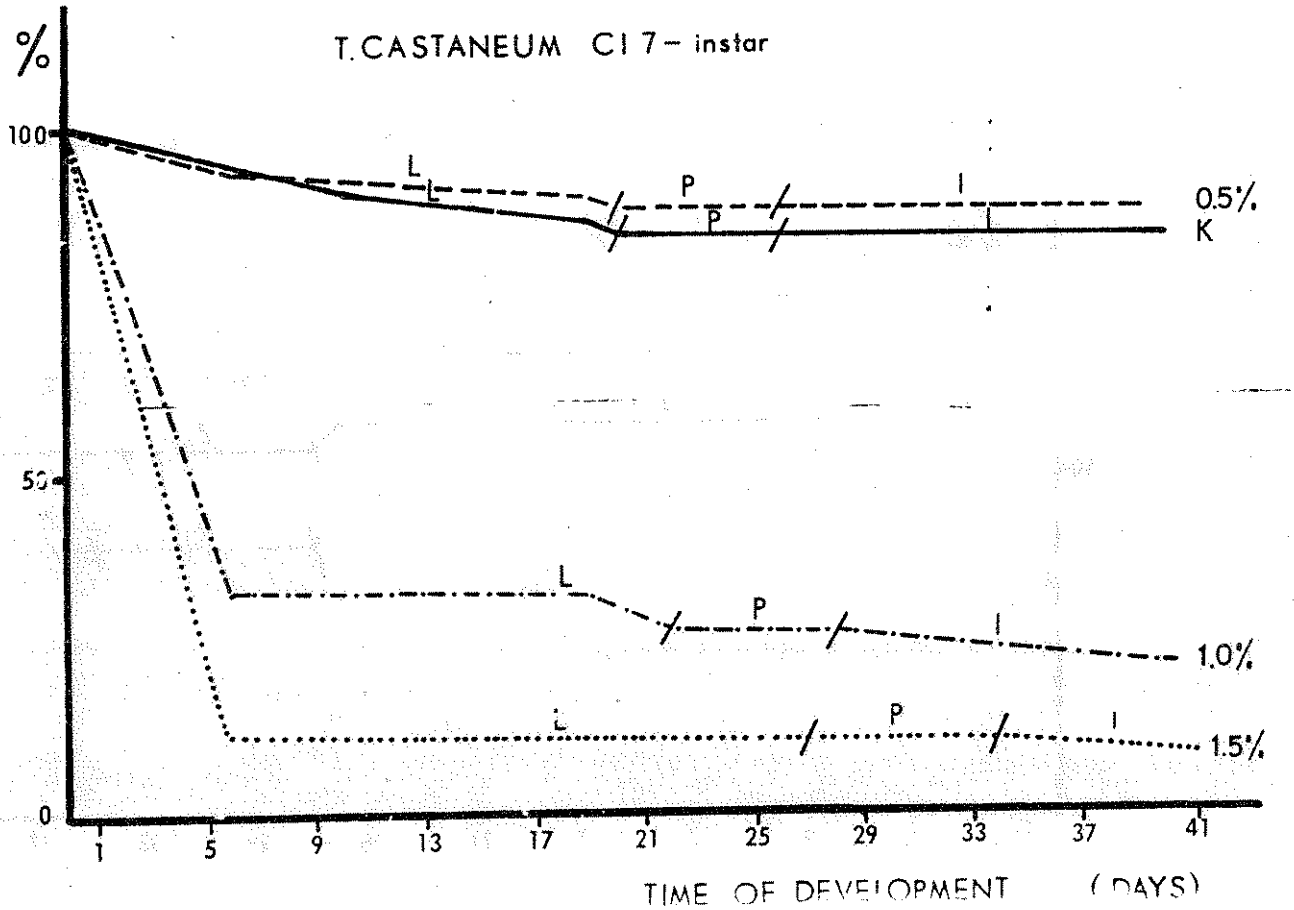
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Fig. 6. Notes- ..esearch, Teaching and Technical

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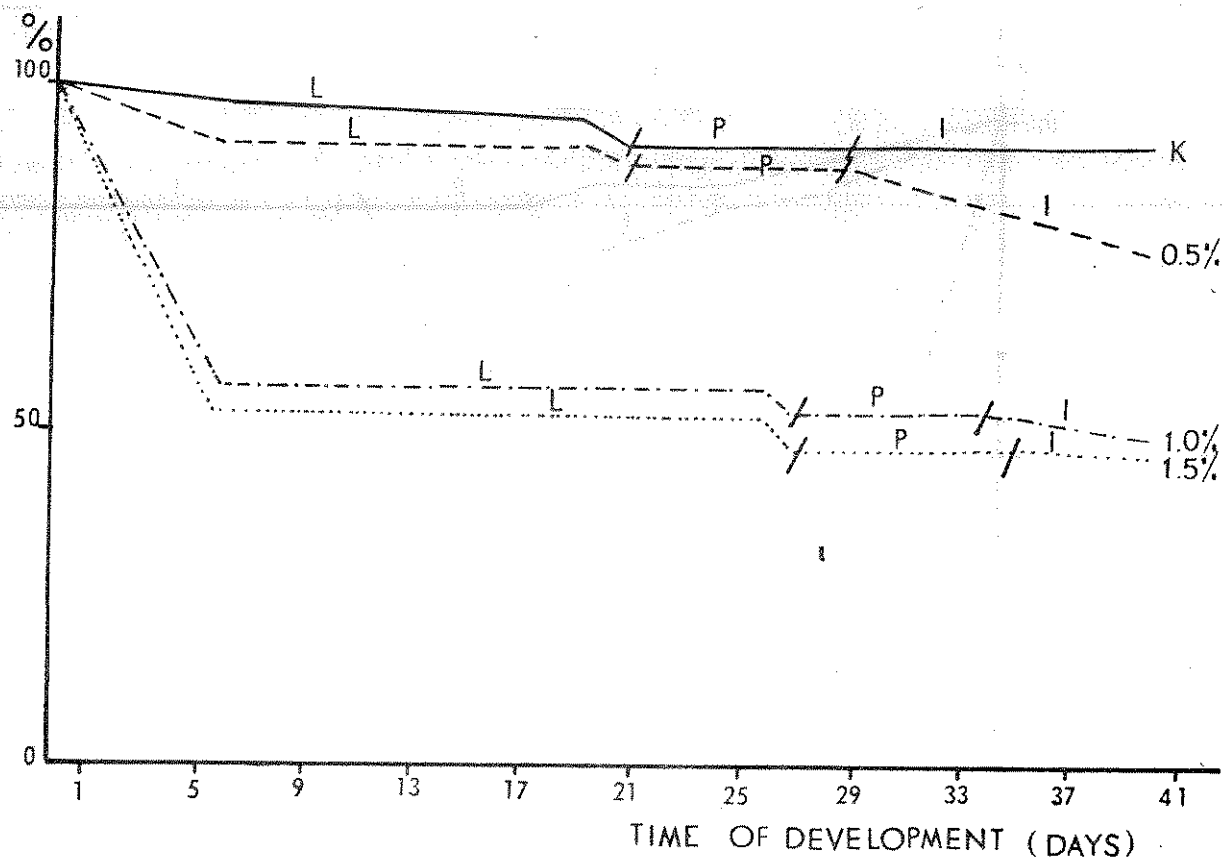

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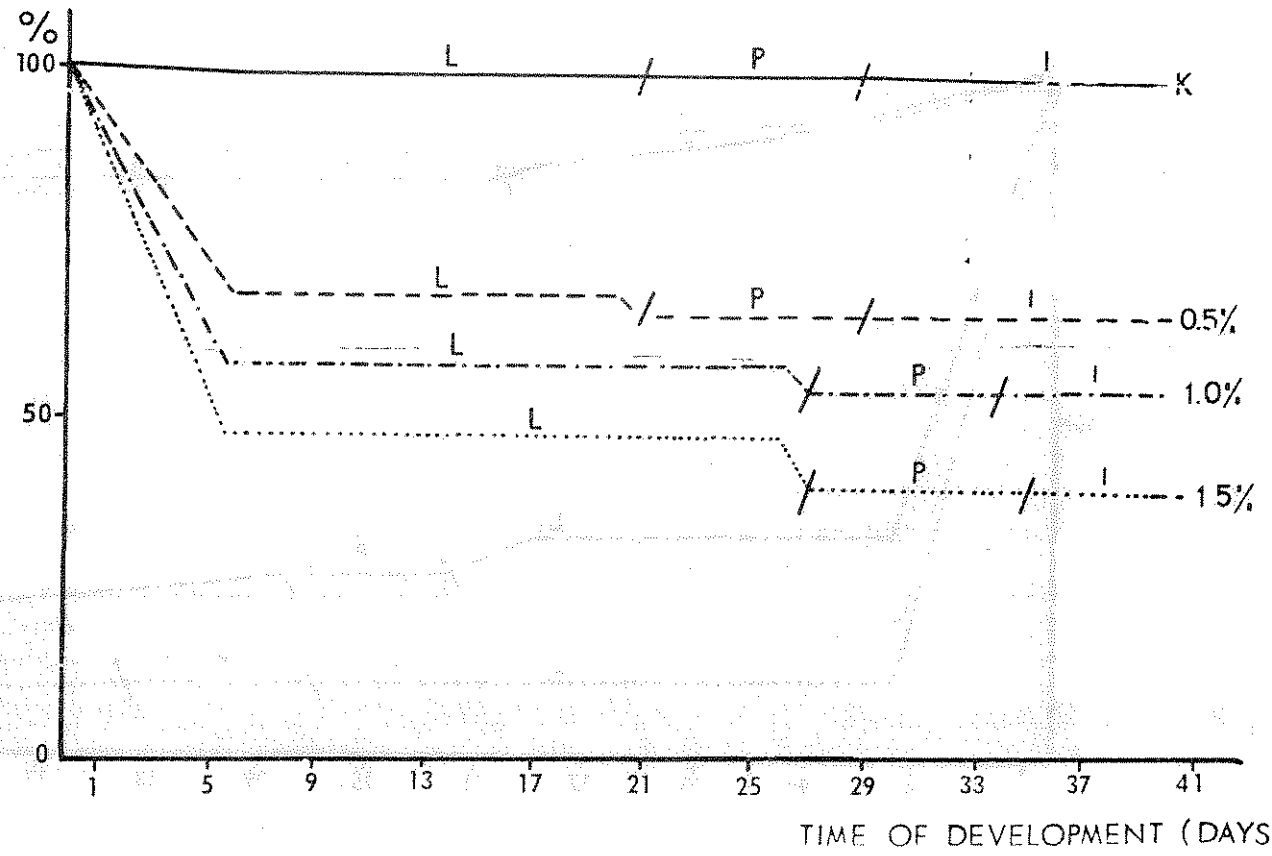

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* Temperature Shock Induced Growth in Tribolium confusum Duval. (Coleoptera : Tenebrionidae).

The confused flour beetle, Tribolium confusum is a serious pest of stored grains and grain-products throughout the globe. Temperature has a great bearing on the physiology of an insect. The egg is, in some cases, the most vulnerable stage. Unfortunately it is the least studied in terms of its relative susceptibility. Insects, like other animals, require a thermal environment optimum for their survival and temperature is involved directly or indirectly in the natural control of abundance of insect species (Uvarov, 1931; Birch, 1948, 1957; Klomp, 1962; Huffaker and Messenger, 1964).

In recent years there has been a growing concern over the indiscriminate application of chemical insecticides on pests. The rate of infestation of an insect depends on the growth, formation and duration of developmental stages, among others. The present investigation aims at determining effects of temperature shock on the egg stage on the above mentioned parameters of T. confusum.

Adults of T. confusum were collected from a stock culture reared on wholemeal flour and maintained at the Department of Zoology, Rajshahi University. A large number of beetles were put on a thin film of wholemeal flour for egg collection. Eggs were collected by sieving and 24-hour old eggs were exposed to 30 (control), 35, 40 and 45 °C in an oven for 24 hours. Treated eggs were then incubated in separate Petri dishes approximately at 30 °C for hatching. Newly hatched larvae, 200 for each temperature, were then transferred to glass jars (25.4 X 11.4 cm), containing 150 gm of wholemeal flour each, with the aid of a camel hair brush. The jars were secured at the top with cloth tied with a rubber band.

Mature T. confusum larvae were weighed individually on an electric balance. The larval length was measured with a scale and their head-capsule width with a micrometer (40X). Mature larvae were put on Petri dishes and were carefully observed for pupation. The larval period was noted. Freshly formed pupae were similarly weighed and measured. They were segregated in Petri dishes and were observed for the emergence of adults. The pupal period was also recorded. Freshly emerged

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adults were similarly weighed and measured. The percentages of pupae and adults formed were also calculated. All the experiments were conducted in an incubator set approximately at 30 °C.

Temperature shock produced deleterious effects on the growth of all the stages of T. confusum (Table 1). The sequence was : 30 > 35 > 40 °C. Lengthened larval and pupal periods were observed in the treated insects. However, insects exposed to 40 °C showed a significantly lengthened larval period ($P < 0.001$)(Table 2). The production of adults was in the order : 30> 35> 40 °C, but no significantly reduced adult production was observed. It was also observed that eggs exposed to 45°C did not hatch.

The rate of infestation largely depends on the vigour of the actively feeding stages. The detrimental effects of temperatures on the growth of T. confusum is very much important from an applied control point of view. The lengthened larval period determines a lower production of progeny over a particular period of time. Lower production of adults, though not statistically significant, observed in the present investigation is also suggestive of a lower rate of infestation.

The electric balance installed at the Department of Biochemistry, Rajshahi University, was used in the present works for which the authors remain thankful.

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Table 1 : Effect of temperature shock on the growth of T. confusum.

	Temperature (°C)	No. of observation	Mean wt ± SD (mg)	V.R.*	Mean length ± SD (mm)	V.R.	Mean head capsule width ± SD (mm)	V.R.
A.	30 (control)	35	3.13 ± 0.06		6.17 ± 0.18		0.72 ± 0.07	
	35	35	3.07 ± 0.06	6.67	6.10 ± 0.14	5.87	0.65 ± 0.04	14.41
	40	35	3.04 ± 0.09		6.05 ± 0.09		0.61 ± 0.03	
B.	30 (control)	70	2.88 ± 0.11		4.50 ± 0.34		0.66 ± 0.05	
	35	70	2.82 ± 0.10	16.43	4.45 ± 0.34	9.26	0.65 ± 0.04	14.00
	40	70	2.77 ± 0.11		4.34 ± 0.24		0.62 ± 0.03	
C.	30 (control)	70	2.01 ± 0.13		3.98 ± 0.31		0.72 ± 0.06	
	35	70	1.94 ± 0.24	3.25	3.87 ± 0.26	8.20	0.71 ± 0.05	5.00
	40	70	1.90 ± 0.17		3.77 ± 0.25		0.70 ± 0.05	

A = Larvae; B = Pupae and C = Adults

*V.R. = Variance ratio

Table 2: Effect of temperature shock on the duration and formation of various stages in T. confusum (days).

Temperature (°C)	Larval Period	Pupal period	% Pupae	% Adults
30 (control)	20.15 ± 1.12(191*)	7.44 ± 0.53(182)	96.00(191)	91.00(182)
35	20.29 ± 2.72(184)	7.45 ± 0.52(177)	92.00(184)	88.50(177)
40	20.54 ± 1.93(177)	7.50 ± 0.53(172)	91.00(177)	86.00(172)

* No. of observation

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* Homosexual behavior in three melanic mutants of Tribolium castaneum

Observations made in this laboratory over a period of several years were reported in a note by Rich (1972). These involved two strains of beetles which carried the melanic mutation jet. Both jet males and jet-pearl males then showed similar high frequencies of homosexual mountings. Since that time observations have been continued as laboratory exercises for students. One singular set was done under specially careful supervision and that set provides the basis of this report. A standard observation routine was used: ten test males and ten females of different, recognizable phenotype were placed together in an arena 10 cm in diameter. The background was new white paper and the lighting was as uniform as could be arranged in the laboratory. The bench top was synthetic stone and the temperature at the arena was between 22 and 23.5 C. In this series of observations all of the test animals were between one and four weeks post-ecdysis. They had been reared at low density at 28 C, sexed as pupae and held in four gram vials of standard laboratory medium (95% whole wheat flour and 5% dry brewers yeast) in single sex groups of ten until used in the experiments. None of the animals were used more than once. Each observation consisted of the count of mountings, heterosexual and homosexual during a ten minute period, with the clock starting with the first mounting. This delay was used because of the very real possibility that the disturbance of handling and introduction would not be uniform from one time to another and the beetles were being given an opportunity to calm down. For a mounting attempt to be counted the mounting animal had to be pointed in the right direction and the aedeagus had to be extended to contact the mounted animal. In every case the mounting beetle was a male, but even in heterosexual mounting attempts intromission was not necessarily accomplished. Duration of the mounting attempt might be as brief as less than 5 seconds or last as long as 90 seconds. In this series the duration was not noted.

The melanic strains used in this work were derived from the Sokoloff laboratory and maintained at the University of Miami for several years. These were Tribolium castaneum standard (std), jet (j), dark sooty (ds), and Chicago black (cb). All combinations of standard and melanic males and females were replicated 8 to 10 times.

If mounting attempts by the males were random one would expect about 47% of the mountings to be homosexual and 53% to be heterosexual.

RESULTS

Male	Female	Tests	Homosexual #	%	mean	Heterosexual #	%	mean	Total	Mean#
std	j	9	38	38	4.2	63	63	7.0	101	11.2
std	ds	10	64	50	6.4	64	50	6.4	128	12.8
std	cb	8	69	58	8.6	50	42	6.2	119	14.9
j	std	10	172	82	17.2	38	18	3.8	210	21.0
ds	std	10	141	70	14.1	59	30	5.9	200	20.0
cb	std	10	118	66	11.8	61	34	6.1	179	17.9

It is obvious that the proportion of homosexual mounting attempts is greater in all three of the melanic mutants. But perhaps equally striking is the higher rate of mounting attempts by the melanic males. In the 1972 note the tentative interpretation was put forth that either the jet has a sex behavior manifestation or that there is a closely associated gene responsible for the homosexual behavior. Now we must add the possibility that some factor related to melanism - or the biosynthetic pathways involved may be related to this behavioral attribute.

The work of Sinnock (1970) suggested that mating behavior might well have a role in the fitness of a genotype. One might expect that if the homozygous melanic males "waste their time" in homosexual mounting efforts in a situation where sperm precedence affords advantage to the frequent copulating male (Schlager, 1960) then such melanic genes might have quite low fitness values. Here, however, the high frequency of homosexual mountings seems to be in addition to, not instead of, the important business of reproduction.

It may be that thhe most promising future research route could involve signals that seem to stimulate mounting behavior. Ryan and O'Callachian (1976) reported that male Tribolium respond more strongly to male produced than to female produced pheromones. Keville and Kannowski (1975) had earlier reported that several chemically related pheromones had similar effects on the male stimulating copulatory activity.

It is unlikely that this line of research will be actively pursued in this laboratory and the writer offers to share both data and experience with interested students.

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* A cytogenetic examination of eight species of Tribolium.

A technique was developed to make permanent preparations of Tribolium chromosomes. After dissection testes are hypotonically treated with Simmons citrate, fixed in 3:1 methanol and glacial acetic acid, and are spread along the surface of a slide that has been covered with fixative. Utilizing this technique eight species of Tribolium representing three species-groups were chromosomally examined and are consistant with the other tenebrionids that have been previously examined (Smith, 1952b; Moore and Sokoloff, 1982; and Juan and Petitpierre, 1988).

In the castaneum species-group T. castaneum and T. freemani have 2N = 20 chromosomes and a 9 + Xy_p meioformula. T. audax and T. madens have 2N = 20 chromosomes and supernumeraries; four are seen in T. audax and ten in T. madens. The meioformula of T. audax is 9 + Xy_p + BII 1 + BI 1, and T. madens is 9 + Xy_p + BII 3 + BI 2. In the confusum species-group T. confusum, T. destructor, and T. anaphe have 2N = 18 chromosomes. T. confusum has an 8 + neo-XY meioformula while T. destructor and T. anaphe have nine bivalents with no heteromorphic sex chromosomes identified.

T. brevicornis, of the brevicornis species-group had 2N = 18 and nine bivalents during metaphase I. No heteromorphic sex bivalent was identified.

The average lengths of chromosomes numbers 1 through 9 is recorded in Table 2. Tukey's analysis of the chromosome measurements revealed significant differences in their sizes intraspecifically and interspecifically.

Table 1. Chromosomally sampled species of Tribolium, including chromosome number and meioformula.

Species	Cells counted: Mitoses	Meioses	Chromosome number	Meioformula
T. castaneum	22	17	20	9 + Xy_p
T. freemani	12	18	20	9 + Xy_p
T. madens	14	16	30	9 + Xy_p + (BII 3 + BI 2)
T. audax	12	19	24	9 + Xy_p + (BII 1 + BI 1)
T. confusum	2	25	18	8 + neo-XY
T. anaphe	11	16	18	9, with no heteromorphic sex chromosome identified.
T. destructor	3	18	18	9, with no heteromorphic sex chromosome identified.
T. brevicornis	2	26	18	9, with no heteromorphic sex chromosome identified.

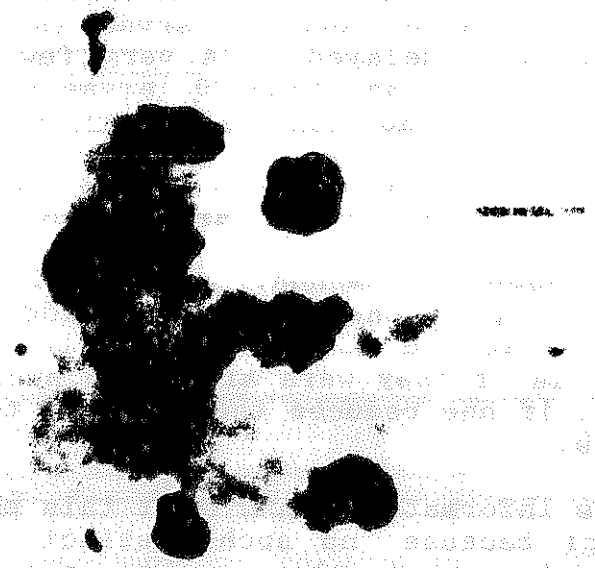
Table 2. Average length* of meiotic chromosomes numbers 1 through 9 for the eight species of Tribolium examined in this study.

Species	Chromosome number 1	2	3	4	5	6	7	8	9
T. castaneum	3.5	3.0	3.0	3.0	3.0	2.5	2.5	2.5	2.0
T. freemani	3.17	3.0	2.33	2.0	1.83	1.83	1.67	1.5	1.67
T. madens	4.0	4.0	3.0	3.0	2.5	2.5	2.0	2.0	1.5
T. audax	4.0	3.5	3.5	3.0	2.5	2.5	2.5	2.0	2.0
T. confusum	4.5	4.0	4.0	3.0	3.0	3.0	2.5	2.5	2.0
T. anaphe	2.75	2.42	2.42	2.3	1.9	1.58	1.5	1.29	1.04
T. destructor	3.50	3.00	2.33	2.0	1.75	1.5	1.0	1.0	1.0
T. brevicornis	3.58	3.42	3.08	3.0	3.0	2.75	2.5	2.42	2.17

* Measurements in microns.

Figure 1. Spermatogonial metaphase of Tribolium freemani. 19 + y. 3,50X.

Figure 2. Metaphase I of Tribolium freemani, with 9 + Xy_p, showing the Xy_p arrowed. 4,000X.



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*Notes on the behavior of Tribolium freemani.

Tribolium freemani Hinton became available for research after its discovery in imported grain (corn) in Japan, and shortly after 1985 Dr. H. Nakakita, Stored-product Entomology Laboratory, National Food Research Institute, Ministry of Agriculture, Forestry and Fisheries, Tsukuba, Ibaraki, Japan, and Dr. D. G. H. Halstead, Pest Infestation Laboratory, Slough, Bucks, England made samples available for research to the writer. With these stocks it has been possible to observe the behavior of T. freemani in respect to some behavioral characteristics.

1. Effect of density on development.

Nakakita (1983) has described some of the demographic characteristics of Tribolium freemani. At 30°C., under uncrowded conditions (5 larvae or less in 2g of flour), these beetles can complete their development (egg-adult) on an average of 38.3 days (Nakakita, 1983). However, under crowded conditions (more than 10 larvae in the same amount of medium) pupation is greatly delayed. "A very few larvae had pupated sporadically when densities higher than 20 larvae by the 180th day when the observation was ended. However, all larvae that had failed to pupate by the 30th or 60th day due to the crowding effect shortly pupated when the larvae were isolated to reduce the density to either two larvae on 2g diet in a vial or one larva in an empty vial."

We have observed the same phenomenon. If we allow 50-100 pairs of beetles to remain in 100g of wheat flour (no additives) for a week, larvae become large larvae and will remain in the last larvae instar for a very long time, as if they were afraid to succumb to cannibalism by other larvae. But, if one reduces the density, they pupate in a few days and become adults.

Nakakita states in his informative paper that this phenomenon is unique for Tribolium freemani because "no such distinct crowding effect has been observed in T. castaneum or other insects in the genus Tribolium." This statement should be modified to read "this phenomenon has also been observed in Tribolium destructor." The Tribolium Stock Center maintains this species which apparently prefers a temperature of about 24°C. At temperatures of 29°C or higher stocks of this species do not do well and eventually die out. At room temperature they will do very well, but in crowded cultures the larvae will remain as larvae for an exceedingly long time, and larvae skins accumulate on the surface of the medium.

2. Flying ability.

Imura (1987) reported his observations regarding the degree at which this species will attempt flight under experimental conditions. He concluded that both males and females of this species can fly, but their inclination for flying is not strong, both under conditions of

dark and light. (The probability of flight per individual per day was .0155 + .0167 for females and .0036 + 0.0089 for males.) The writer's observations have been confined to those instances when the beetles are removed (at normal temperatures) from the flour and the adults transferred from the sieve to a plate. As soon as the beetles are transferred to the porcelain soup dish a few extend their membranous wings and a few have been seen flying the 15-18 centimers of the plate to land on the other side of the plate. Both Imura's and these observations should alert investigators utilizing T. freemani in their studies to be extra cautious, lest they become serious pests in countries where T. freemani does not exist.

3. "Self-poisoning"

Sokoloff (1977) has summarized observations on the effect of quinones on the various stages of Tribolium. This self-poisoning phenomenon has been reported up to now in T. castaneum, T. destructor and T. confusum. It occurs when the beetles are removed from the flour and placed in any kind of glass container which is not broad and shallow like a petri dish, but it has walls about 2-3 cms high or higher. If one of the beetles becomes irritated, it may release quinones, and the other beetles may release quinones from their stink gland reserviors in self-defense. As a result, the quinones in the container increase and since they are highly volatile, they become gaseous, and since they are heavier than air they displace the air around the beetles. The net result is that some or all of the beetles of all stages in the container will be found dead or dying. My previous observations indicated that T. confusum is more likely to undergo this self-poisoning than T. castaneum. Judging from Palm's (1946) observations T. destructor is also likely to commit suicide. T. freemani now can be added to this list. Both sexes are likely to release their quinones and poison themselves by poisoning their surrounding atmosphere with quinones. There is a preventive measure, and that is to keep the beetles in their flour medium until they are ready to be examined (since they will apparently not suddenly release quinones when they are hiding in the flour and commit suicide) or by sifting only a few vials at a time.

4. Death-feigning.

If beetles are touched they "freeze" or play "possum," or play death. After a variable interval of time they may move their antennae or twitch their legs and eventually resume walking. Tenebrionid flour beetles are no exception to this adaptive behavior. But of all the species of Tribolium so far observed, T. freemani is more likely to feign death when touched and it will remain in that posture, with antennae close to the head and the legs closely applied to the ventral surface of the thorax or abdomen, for about a minute or longer, a relatively long time. Under the microscope it is, of course, possible to determine which beetles are alive (feigning death) and which are dead. But with the unaided eye it is very difficult to distinguish live from dead beetles. This may be due to the short time T. freemani has been under domestication in the laboratory.

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*THE ESTIMATIONS FOR GENETIC PARAMETERS OF 30-DAY OLD ADULT WEIGHT IN TRIBOLIUM CASTANEUM

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Tribolium castaneum Herbst is an excellent laboratory organism. It serves as an important interiace between the theorists and the animal breeders.

The means of 21-day old pupal weight and 30-day old adult weight in Tribolium castaneum were 2162.4±10.75,1799.3±8.21μg and 2369.8±10.37,1956.9±8.45μg for males and females respectively. The average body weight of the two traits of females were 207.4μg and 157.6μg heavier than that of males.

The heritabilities of 21-day old pupal weight and 30-day old adult weight were 0.2134 and 0.2874 for males resp. 0.4036 and 0.3858 for females resp. The genetic correlations of the two traits were 0.7322 and 0.8433 for males and females resp. Heritabilities and genetic correlations of the two traits were estimated using variance components. these traits can be used for selection experiments.

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THE EFFECT OF DIFFERENT AIR TEMPERATURES AND HUMIDITIES ON THE DURATION OF THE DEVELOPMENT OF COMMON BEAN WEEVIL ACANTHOSCELIDES OBTECTUS SAY

INTRODUCTION

The common bean weevil Acanthoscelides obtectus Say (Coleoptera, Bruchidae), originating from hot climatic regions, is widespread all over the world as a dangerous pest of common bean. It has been found in Poland since 1934, initially in Lower Silesia (Filipek 1962, Niezgodzinski 1963). At present it occurs throughout the whole of Poland and is on the quarantine list. This insect is a dangerous pest in storehouses and in fields.

A. obtectus damages bean seeds by contaminating them with excre ta, exuviae etc., causing elevation of air temperature and humidity, inducing bacterial infections and lowering the germination power. All this greatly deteriorates the commercial value of bean seeds (Boczek, Stepien 1976).

The aim of the present studies was to determine the effect of certain environmental changes, e.g. different air temperatures, air humidities and population densities, on the duration of the development of common been weevil.

MATERIAL AND METHODS

The material comprised common bean weevil Acanthoscelides obtectus Say, wild strain originating from a suburb of Warsaw. White bean (Phaseolum vulgaris L.) in laboratory experiments were used. Starting cultures were kept in 1-L jars covered with a fine plastic gauze. Jars were maintained at ca. 18°C and at a mean air humidity of ca. 70%.

Individual experiments were performed in thermostats, using 5 temperature levels and 4 humidity levels. Individuals of the same age, which have just emerged from bean seeds were used in the experiments. Prior to each experiment, bean seeds were humudified for 1 week in a jar at air humidity of ca. 75%. It was aimed to soft bean, seed epidermis and to facilitate penetration of the hatched larvae into seeds for further development.

In individual experiments, 30 bean seeds (ca. 10 g) were placed into 50-mL culture vessels together with 10 adult weevils (lower population density) or 40 adult weevils (higher population density). These culture vessels were covered with fine plastic gauze and then placed into 1-L jars containing also small salt containers. Salt solutions in the

containers were used to maintain constant air humidity ($MgCl_2$ - 33%, $Mg(NO_3)_2$ - 55%, NaCl - 76 %, KCl - 85%, air humidity, respectively) (Hempel-Zawitkowska, Klekowski 1968).

The jars were tightly closed and placed in culture thermostats at 22, 24, 26, 28 and 30°C, respectively. Each experimental variant was performed in 6 replications. After 21 days all adult individuals were discarded. Then culture vessels were inspected daily until the end of the experiment (i.e. until no more adult beetles emerged from been seeds), for counting and discarding the second - generation adults. Thus the duration of the development in each experimental variant was obtained.

RESULTS

Table 1 presents the duration of the development of common bean weevil at 22, 24, 26, 28 and 30° C, respectively, at air humidities of 33, 55, 76 and 85%, respectively, under conditions of low population density. In the present experiments the duration of the development of A. obtectus was shortest at 28°C. In general, the duration of the development is the shorter, the higher the temperature. Air humidity exerted an only very slight effect on the duration of the development.

Table II presents the duration of the development of A. obtectus at the same air temperatures and humidities as in Table I but under conditions of high population density. Similarly as in Table I, the duration of the development of A. obtectus was shorter, with the rise of temperature (the shortest duration of the development was shorter at 30°C). Also in this case air humidity only very slightly influenced the duration of the development. Under conditions of high population density, as compared with low population density, the duration of the development was prolonged.

DISCUSSION

So far, studies of biology and ecology of common bean weevil have mainly concerned the effect of food and population density on its development (Sandner 1961, 1962, Sandner, Cichy 1962, Howe, Currie 1964, Umeya, Kato 1970, Sandner, Pankanin 1973). On account of the large losses of bean seeds in storehouses it is of importance to determine the response of this pest to some environmental conditions.

Various parts of storehouses differ in air temperature and humidity. In the external layer of bean seeds, as compared with the internal layers, the temperature is much lower. Newly hatched larvae are very sensitive to low temperatures, their mortality being 100 % at 10°C. According to Zachariae (1960), young larvae survive only at temperatures higher than 12°C; older larvae and pupae survive even at 10°C. Filipek (1962) has studied the development of larvae and pupae of A. obtectus at 15, 18, 22 and 25°C, respectively, and at several air humidities. Author found that - at all air humidities - the duration of the development was prolonged at lower temperatures, particularly below 20°C. Likewise, Romankow (1958) has found a substantial difference between the

duration of the development at 17°C and at 25°C. In general, the duration of the development is shortest at 27 - the 31°C and at air humidity of 80 - 90% (Zachariae 1960).

The present findings consist with the above literature data. Additionally we found that higher population density prolongs the duration of the development.

CONCLUSIONS

1. The duration of the development of common bean weevil Acanthoscelides obtectus Say is shorter at higher temperatures. The development is optimal at 28 - 30°C.

2. Relative air humidity (between 33 - 85%) exerts an only very slight effect on the duration of the development.

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°t C	22		24		26		28		30	
Humidity %	Days of appearance of adult individuals									
	from-to	mean	from-to	mean	from-to	mean	from-to	mean	from-to	mean
33	44-60	52.0	40-52	46.0	37-45	41.0	25-45	35.0	29-48	38.5
55	43-59	51.0	40-57	48.5	37-48	42.5	26-43	34.5	29-47	38.0
76	41-59	50.0	42-53	47.5	38-51	44.5	25-46	35.5	26-55	38.5
85	42-56	49.0	41-51	46.0	38-46	42.0	24-44	34.0	32-49	40.5

Table II. The duration of the development of common bean weevil Acanthoscelides obtectus Say at different air temperatures and humidities under conditions of high population density

t °C	22		24		26		28		30	
Humidity %	Days of appearance of adult individuals									
	from-to	mean	from-to	mean	from-to	mean	from-to	mean	from-to	mean
33	48-66	57.0	43-62	52.5	40-56	48.0	33-59	46.0	32-57	44.5
55	47-71	59.0	43-65	54.0	41-57	49.0	33-59	46.0	35-52	43.5
76	45-67	56.0	46-64	55.0	42-53	47.5	34-72	53.0	32-53	42.5
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%	from-to	mean	from-to	mean	from-to	mean	from-to	mean	from-to	mean
33	44-60	52.0	40-52	46.0	37-45	41.0	25-45	35.0	29-48	38.5
55	43-59	51.0	40-57	48.5	37-48	42.5	26-43	34.5	29-47	38.0
76	41-59	50.0	42-53	47.5	38-51	44.5	25-46	35.5	26-55	38.5
85	42-56	49.0	41-51	46.0	38-46	42.0	24-44	34.0	32-49	40.5

Table II. The duration of the development of common bean weevil Acanthoscelides obtectus Say at different air temperatures and humidities under conditions of high population density

t °C	22		24		26		28		30	
Humidity %	Days of appearance of adult individuals									
	from-to	mean	from-to	mean	from-to	mean	from-to	mean	from-to	mean
33	48-66	57.0	43-62	52.5	40-56	48.0	33-59	46.0	32-57	44.5
55	47-71	59.0	43-65	54.0	41-57	49.0	33-59	46.0	35-52	43.5
76	45-67	56.0	46-64	55.0	42-53	47.5	34-72	53.0	32-53	42.5
85	44-66	55.0	46-63	54.5	43-50	46.5	38-60	49.0	32-53	42.5

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Sinha, R.N., Ph.D. Ecology of granary insects, mites and fungi. (5, 10, 12)
Smith, L.B., Ph.D. Stored product insect ecology, low temperature effects. (5, 7, 10, 12)
Watters, F.L., Ph.D. Storage pest control, behavior and control

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Onyearu, A.K., B.Sc. (London), Ph.D. (St. Andrews). Ecology of infestation behavior and biology applied to control genetics. (5,7,12)

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