REPORT NO. IAEA-R-1622-F

TITLE

The use of radiation induced sterility for the control of the moths Laspeyresia pomonella L. and Laspeyresia molesta B. (part of a coordinated programme on the control of lepidopterous insects by the sterile-male technique)

FINAL REPORT FOR THE PERIOD

1975-06-01 - 1978-05-31

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PLANT PROTECTION INSTITUTE

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F I N A L R E P O R T

(Second part)

Contract No I622 /RL/ RB

FINAL REPORT

I. Contract No 1622 /RB/ RB

II. Title of project: "The use of radiation induced sterility in the control of the moths Laspeyresia pomonella and Laspeyresia molesta" (part of coordinated programme on the control of Lepidopterous insects by sterile-male technique)

Second part: 1. Rearing of L. molesta on larval artificial diets.

2. Physical properties of the tested diets in conditions of temperature and humidity favourable to the larval development of L. pomonella and L. molesta.

3. Field studies on the changes of the attractiveness of Pherocon CM (codling moth) traps depending on the meteorological factors (temperature, humidity, rainfall etc.).

III. Contractor: Plant Protection Institute, 2230 Kostinbrod, P.O. Box 238 Sofia Bulgaria.

IV. Chief Scientific Investigator: Dr. M. Tzalev

V. Time period covered: 1976 - 1978

Excepting the preparatory procedures and final data analysis the experimental work was carried out mainly through 1977 - 1978 year.

REARING OF ORIENTAL FRUIT MOTH ON ARTIFICIAL DIETS

Purpose of the research programme

See Final Report, part I, codling moth.

Material and methods

1. Characteristics of the evaluated artificial diets. Diet No 1 (Sender, 1969) and diet No 2 are completely analogous to mediums No 1 and 3 for the codling moth (FR, part 1, table 1). Diet No 3 is a modification of the Sender's medium in which the apple flour is substituted by peach puree. This product is used for industrial production of various baby foods. For the other ingredients see the previous final report.

2. Technique of diet preparation. The same like that for codling moth.

3. Rearing procedures. Larval rearing was conducted on "artificial apples" (see L. pomonella), prepared of the corresponding diet (two larvae per one ball). Control: immature apples.

4. Methods of rearing, rearing room conditions and biological parameters taken into consideration. The same as those for codling moth (see FR, part 1).

5. Ststistics. The experiments were conducted with more than 6000 individuals. Simbols: $\bar{X}$ - mean value, $S_{\bar{x}}$ - standard error.

6. Number of generations reared during the experimental period: control and diets NoNo I and 3 - x 8; diet No 2 - 7.

Results and discussion

Some biological characteristics of the oriental fruit moth in Bulgaria

The oriental fruit moth (Laspeyresia molesta B.) is spread chiefly in the East and South regions of Bulgaria. Host plants: peach,almond,apricot plum,wild plum (on fruits and sprouts),apple,quince,pear,medlar (only on fruits).The species develops 4-5 generations per year and hibernates as larva in the last instar.Usually the development of summer generations continues from 22 to 35 days depending on the climatic factors.The spring and autumn generations develop for 38-50 days.Generally the separate generations overlap each other.The mean egg producion varies between I9 and 60 eggs per female (maximum I90).

Larva and pupa

Survival (table 2 A,B; table 7 I,III). Comparatively the highest percentage of fully developed larvae was established after rearing on immature apples followed by diets NoNo I and 3 (no difference between the two, In comarison with them diet No 2 showed a little lower efficacy.But,taken as a whole there is not any great difference in this respect between the diets and between them and the control.In all cases the mortality of the developed larvae and the pupae is quite low.

Duration of development (table 3; table 7 II). For the individuals reared on immature apples the development from larva to imago was shorter (about 3-4 days compared with the artificial diets).However,there is not any significant difference between the diets and also between the two sexes.

Pupal weight (table 4; table 7 IV). Males: There is not any great difference between the individuals reared on the tested mediums and between them and the apples. Females: The pupal weight is a little greater for diets NoNo I and 2 in comparison with diet No 3 and control.On the whole the weight of female pupae is greater than this of males.

Imago

Adult emergence and sex ratio (table 2 C/a,b/,D; table 7 V,VI,VII).The adult emergence (♂♀) expressed as a percentage of the completely developed larvae varied between 85 and 98 % without any significant difference between the separate variants and generations.The same tendency was established for the emergence expressed as a percentage of the total number experimented larvae (50-80 %).The sex ratio (♂♂:♀♀) is a rather stable parameter and practically could be accepted as "I" for all the variants.

Longevity of moths (table 5; table 7 VIII). According to certain authors (after Balachowsky,1966) the longevity of adult L.molesta of the summer generations varies from IO to I8 days and for the spring generation - 20-2I days.The results of our experiments did not show any significant difference between the longevity of male and female moths.For the individuals reared on diets NoNo I and 3 and on immature apples the average life duration was I8-21 days and a little shorter for medium No 2 (I7-18 days).These data coincide with those quoted in the literature.

Fecundity and egg hatch (table 6 A,B; table 7 IX,X). According to Stearns & Neiswander (I930) and Snapp & Swingel (I929) the fecundity of L.molesta varies from 48 to 58 eggs per female for the summer generations and from I7 to 66 eggs per female for the spring generations (after Balachowsky,1966). Our results do not differ greatly from the data indicated by the above authors (average 21-38 eggs per female).There is not any significant difference between the separate diets and generations.

PHYSICAL PROPERTIES OF THE TESTED DIETS

Material and methods

The investigations were conducted on all artificial mediums used for laboratory rearing of L.pomonella and L.molesta in our experimental programme (the diet indicated as No Iom = diet No 3 for oriental moth). Variants: I. a/ Spheres ("artificial apples") with volume of II-12 cm^3, placed beneath plastic cups (see FR,part I Material and methods); b/ The same spheres placed out of the cups. II. a/ 2 cm thick layers in plastic boxes,dimensions II/6/3,5 cm (S=66 cm^2) covered up by a lid with 8 small holes (diam. about I mm); b/ The same layers covered with paraffin film without any lid; c/ The same layers without paraffin films and lids.

Experimental conditions: temperature 26 ± I°C, RH in the room 80 - 82 %, RH in the cups and boxes - about 90-95 %. There were no larvae reared neither on the spheres nor on the layers.

Parameters taken into consideration: the change in the spheres (layers) weight for a certain period of time; the change of H_2O-content in the spheres (layers) for the same period of time (dessiccation).

Results and discussion

Spheres (figure I a,b,c,d). There were not any greate defferences between the separate mediums with respect to the changes of weight and H_2O content when plastic cups were used for covering of the spheres. Generally, their humidity and consistence were maintained in favourable for the larval development conditions for more than 40 days. On the contrary, the dessiccation of the uncovered spheres passed very quickly which did not provide normal conditions for the larval development during an adequate period of time. The best physical parameters demonstrated medium No 3.

Layers (figure 2 a,b,c,d,e). In the experiments where the boxes with medium were covered with plastic lids there was established a tendency similar to those observed with the spheres under plastic cups. (optimal conditions for larval development were provided for more than 45 days). In the case of the layers covered by paraffin film the dessiccation was quicker. Possibly it was due to the progressive cracking of the paraffin because of the layer deformation, caused by drying. Taken as a whole the paraffin film did not protect the mediums from dessiccation for a sufficiently long period of time (humidity above 70 % was maintained only for about 25 days).

FIELD STUDIES ON THE CHANGES OF THE ATTRACTIVENESS OF PHEROCON CM TRAPS

Material and methods

The observations were carried out in an abandoned apple orchard near Kostinbrod (Sofia district). No insecticide treatmens were made during the period of investigations. The flight of codling moth was traced out by means of a Pherocon I CM trap supplied with CM cap. The meteorological factors were registered on the terrain. The registration of moths caught in the trap was made daily, in the morning and during the whole seasons of I977 and I978 years.

Results and discussion

In table 8 are given some moments of codling moth flight in 1977 and 1978 which illustrate the influence of certain meteorological factors on the number of moths caught in the trap. As it can be seen, this number was negatively affected mainly from rainfalls above 5 mm and/or the reduction of the temperature below I0°C. In this respect the combined action of these two factors was stronger. The independent effect of the air humidity was not of greate significance.The same is valid for the wind with velocity below IO m/sec.However,it is possible that wind with velocity above IO m/sec would affect negatively the number of moths caught in the trap. But,on the other hand,a relatively light wind could contribute to strengthaning of the effect of rainfall and low temperatures.

In fact,the meteorological factors do not influence directly on the effectiveness of traps.The observed effects are the result of their influence on the intensity of moth flight within the framework of the existing population.

GENERAL CONCLUSIONS

The artificial diets tested for laboratory rearing of L.molesta demonstrated a good efficacy (survival from larva to imago between 60-63 %).A little lower was the efficacy of diet No 2.

The individuals of oriental fruit moth reared on the diets had normal biological parameters (pupal weight,longevity of moths,sex ratio,fecundity and egg hatch).

Taking into consideration the obtained results we think that the experimented diets could be recommended for large-scale breeding of L.molesta in trays.

The optimal physical properties of these mediums were maintained better under plastic shield (lids or cups) appropriately perforated for ventilation

Table I. FORMULAE OF THE TESTED DIETS (FOR I Kg MEDIUM)

Ingredients / Diet No	I	2	3
Agar, g.+	23/I9/	23/I9/	29/25/
Brewer's yeast (dry), g.	45	45	45
Wheat germ, g.	55	30	55
Corn flour, g.	48	48	48
Apple flour, g.	45	0	0
Product I++, g.	0	45	0
Peach puree, g.	0	0	I50
Corn oil, ml.	2	I	I
Saccharose, g.	0	0	I0
Ascorbic acid, g.	4,5	4,5	4,3
Vitamin E, g.	0	0	0,05
Vicomplex, g.	0	0	0,2
Phytin, g.	0	0	0,25
Nipagin, g.	I,5	I,5	I,5
Benzoic acid, g.	I,5	I,5	I,5
Tetracyclin (sol.), ml.	4,5	4,5	4,5
Distilled water, ml.	770	800	680

+The amount put im brackets is refered to the powdered product produced in Japan

++See FR, part I.

Table 2. DATA FOR LARVAL AND PUPAL SURVIVAL, ADULT EMERGENCE AND SEX RATIO

Diet No	Generation	A	B	C		D
				a	b	
I	I	55,9	I0,0	90,0,	50,4	0,89
	II	60,8	7,7	85,8	52,2	I,56
	III	75,6	I2,0	88,0	66,9	I,00
	IV	72,3	5,9	94,I	68,I	I,04
	V	66,5	5,2	94,8	62,6	0,8I
	VI	62,1	7,4	92,6	57,5	0,9I
	VII	84,3	5,I	94,9	80,0	I,00
	VIII	69,9	I3,0	77,8	54,2	0,9I
2	I	56,6	6,7	93,3	52,8	I,22
	II	72,2	2,2	97,8	70,6	I,I9
	III	56,9	2,6	97,4	55,5	0,90
	IV	64,3	I2,5	87,5	56,3	I,04
	V	72,5	3,5	96,6	70,0	0,7I
	VI	7I,6	7,6	92,5	66,2	I,05
	VII	52,0	9,I	90,9	47,3	I,I2
3	I	59,9	8,6	9I,4	54,7	0,97
	II	62,2	I0,6	89,4	55,6	0,94
	III	67,7	7,I	92,9	62,9	0,88
	IV	71,3	3,9	96,1	68,5	0,94
	V	66,5	8,I	9I,9	61,I	I,65
	VI	74,0	I0,6	89,4	66,2	1,I8
	VII	73,4	5,9	94,1	69,I	0,92
	VIII	72,7	5,8	94,2	68,5	0,98
Control	I	66,7	4,2	95,8	63,9	1,00
	II	70,5	5,4	94,6	66,7	0,74
	III	80,2	7,1	92,9	74,5	I,2I
	IV	6I,8	4,3	95,7	59,2	I,I3
	V	70,0	9,5	90,5	63,3	I,50
	VI	69,2	5,6	94,4	65,4	0,77
	VII	74,4	3,3	96,7	71,9	I,25
	VIII	70,0	3,6	96,4	67,5	0,96

A: Fully developed larvae,%
B: Mortality of developed larvae and pupae,% (integrated value)
C: Adult emergence
a: as % of the developed larvae
b: as % of the whole number of larvae
D: Sex ratio (♂♂ : ♀♀)

Table 3. DURATION OF DEVELOPMENT FROM LARVA TO IMAGO, DAYS ($\bar{x} \pm S_{\bar{x}}$)

D:	Control		I		2		3	
G:	♂♂	♀♀	♂♂	♀♀	♂♂	♀♀	♂♂	♀♀
I	23,8±0,32	24,6±0,35	33,I±0,89	30,3±0,I6	29,6±0,4I	30,0±0,28	28,2±0,24	28,1±0,06
II	24,6±0,66	20,8±I,26	29,4±0,38	29,8±0,35	27,9±0,27	28,0±0,2I	27,I±0,33	27,5±0,37
III	26,7±I,0I	29,1±0,93	28,2±0,21	27,8±0,I8	26,7±0,37	27,5±0,55	26,I±0,36	26,5±0,36
IV	23,7±2,79	27,4±0,59	27,I±0,65	27,I±0,37	26,I±0,23	26,2±0,22	25,6±0,54	24,9±0,43
V	28,5±0,82	29,4±0,64	26,5±0,34	26,5±0,25	26,3±0,62	25,6±0,37	23,5±I,I4	27,I±0,47
VI	22,0±I,20	26,3±0,5I	27,7±0,25	27,9±0,I8	27,2±2,I3	29,6±0,58	27,I±0,59	26,2±I,II
VII	25,7±0,45	25,6±0,36	26,4±0,53	26,4±0,69	29,8±I,35	3I,I±0,36	26,4±0,65	27,3±0,23
VIII	23,2±0,45	25,0±0,50	30,6±0,64	30,3±0,4I	–	–	29,5±0,75	29,8±0,38

D: diet No G: generation

Table 4. PUPAL WEIGHT, MG ($\bar{X} \pm S_{\bar{x}}$)

D:	Control		I		2		3	
G:	♂♂	♀♀	♂♂	♀♀	♂♂	♀♀	♂♂	♀♀
I	8±0,3	II±0,3	9±0,2	I2±0,3	9±0,2	I2±0,4	8±0,2	I0±0,7
II	–	–	I0±0,3	I3±0,3	I0±0,4	I2±0,3	9±0,2	I2±0,3
III	–	–	II±0,3	I4±0,3	I0±0,2	I3±0,6	9±0,3	I2±0,5
IV	9±0,2	I2±0,7	I0±0,2	I4±0,3	I0±0,2	I3±0,2	9±0,3	II±0,3
V	–	–	I0±0,3	I3±0,3	II±0,8	I4±0,5	9±0,2	I2±0,3
VI	–	–	I0±0,3	I2±0,4	I0±0,4	I3±0,5	I0±0,3	I2±0,3
VII	–	–	I0±0,2	I3±0,5	I0±0,3	I2±0,3	9±0,2	II±0,4
VIII	I0±0,2	I2±0,3	II±0,2	I3±0,5	–	–	I0±0,2	I2±0,2

D: diet No G: generation

Table 5. LONGEVITY OF MOTHS, DAYS ($\bar{X} \pm S_{\bar{x}}$)

D:	Control		I		2		3	
G:	♂♂	♀♀	♂♂	♀♀	♂♂	♀♀	♂♂	♀♀
I	24,0±0,40	24,6±0,75	23,5±0,65	24,5±0,75	18,I±0,53	I9,I±0,57	I7,9±0,45	20,7±0,46
II	I5,9±0,76	I6,7±0,46	I7,6±I,95	I7,4±I,68	I5,5±0,39	I6,2±0,48	I5,3±0,63	I9,5±I,I8
III	I7,6±0,44	I8,5±0,75	2I,2±0,82	24,3±0,78	I6,6±0,65	I7,I±0,81	22,3±2,66	23,8±0,98
IV	2I,7±0,48	22,6±0,47	I7,8±0,56	I8,9±0,74	I8,5±I,35	I6,3±I,53	I8,4±0,57	I9,4±0,46
V	I7,0±0,34	I8,6±0,35	I9,5±I,06	20,9±0,95	I7,6±0,46	I6,5±I,41	I8,5±I,46	I8,3±I,38
VI	I5,7±0,35	I5,9±0,25	I8,3±0,46	I7,3±0,98	I9,6±I,75	I5,4±0,77	I8,0±0,89	I6,0±0,73
VII	I9,0±I,73	I9,8±I,43	I9,4±I,43	I8,8±I,I4	2I,6±0,52	2I,2±0,81	I5,7±0,29	I9,8±0,79
VIII	I6,4±0,48	I8,2±0,56	I8,4±0,40	I7,8±0,39	-	-	I6,9±0,60	2I,8±0,74

D: diet No G: generation

Table 6. EGG PRODUCTION PER FEMALE AND EGG HATCH

D:	Control		I		2		3	
G:	A	B	A	B	A	B	A	B
I	34	83,I	2I	73,5	23	75,3	29	70,9
II	24	84,4	23	80,I	2I	69,5	26	76,6
III	24	86,6	30	88,0	20	80,2	22	64,4
IV	26	77,9	30	82,0	-	-	27	96,I
V	28	90,9	23	83,7	-	-	26	68,7
VI	38	93,I	25	79,6	22	8I,4	32	78,5
VII	32	95,3	2I	8I,2	33	8I,2	I9	89,2
VIII	37	93,3	27	9I,6	-	-	34	75,0

A: Average egg production per female (number, $\bar{x}$)

B: Egg hatch, %

D: diet No G: generation

Table 7 INTEGRATED VALUES OF THE DIFFERENT PARAMETERS ($\bar{X} \pm S\bar{x}$)

G: \ D:	Control	I	2	3	SEX
I	70,4 ± I.89	68,4 ± 3,20	63,7 ± 3,25	68,5 ± I,89	
II	24,8 ± 0,82	29,1 ± 0,62	28,I ± 0,50	27,3 ± 0,36	♂♂
	24,8 ± I,00	28,5 ± 0,24	28,[illegible] ± 0,30	27,5 ± 0,24	♀♀
III	5,4 ± 0,73	8,3 ± I,08	6,3 ± I,44	7,6 ± 0,83	
IV	9,I ± 0,22	I0,2 ± 0,24	9,9 ± 0,26	9,2 ± 0,22	♂♂
	II,6 ± 0,32	I2,9 ± 0,33	I2,6 ± 0,36	II,3 ± 0,42	♀♀
V	94,6 ± 0,63	89,8 ± 2,07	93,7 ± I,37	92,4 ± 0,75	
VI	66,6 ± I,72	6I,5 ± 3,5I	59,8 ± 3,45	63,3 ± 2,02	
VII	I,I ± 0,09	0,9 ± 0,20	I,0 ± 0,07	I,I ± 0,08	
VIII	I8,7 ± 0,52	20,3 ± 0,84	I7,I ± 0,46	I7,6 ± 0,50	♂♂
	I9,I ± 0,46	20,8 ± 0,88	I7,7 ± 0,64	20,0 ± 0,53	♀♀
IX	30 ± 2,0	25 ± I,3	24 ± 2,4	27 ± I,7	
X	88,I ± 2,II	82,5 ± I,95	77,5 ± 2,29	76,2 ± 2,96	

I. Fully developed larvae, %
II. Duration of development from larva to imago, days
III. Mortality of the developed larvae and pupae (integr. value), %
IV. Pupal weight, mg.
V. Adult emergence as % of the developed larvae
VI. Adult emergence as % of the total number exper. larvae
VII. Sex ratio (♂♂ : ♀♀)
VIII. Longevity of moths, days
IX. Egg production per female.
X. Egg hatch, %
D: diet No
G: generation

Table 8 CODLING MOTH: TRAP ATTRACTIVENESS AND METEOROLOGICAL FACTORS

Year	Date	G:	t°C	RH %	Rain-fall mm	Wind m/sec.	Q %
I977	I3.V	I	9,2	88	I,3		0,3
	I4.V	"	9,7	88		5,3	I,7
	I5.V	"	I7,3	53			3,6
	I6,V	"	I4,5	76	5,5		I,3
	20.VI	I	I9,5	8I		3,3	4,6
	21.VI	"	I6,2	96	7,9		I,7
	22.VI	"	I5,7	89	7,0		0
	23.VI	"	I4,5	97	3,6	4,0	0
	24.VI	"	I4,3	86	0,5		0,7
	25.VI	"	I3,3	99	3,0		I,7
	26.VI	"	I6,3	82	3,I		I,7
	27.VI	"	I4,0	9I	8,0	2,0	I,0
	28.VI	"	I6,7	83	0,8		2,3
	29.VI	"	I2,7	84			2,3
	30.VI	"	I4,8	8I	7,6		0
	I.VII	"	I4,7	98			I,3
	2.VII	"	I4,8	93	18,2	2,7	0
	3.VII	"	I7,7	84		4,3	I,3
I978	25.VI	I	20,3	65			I,2
	26.VI	"	I9,5	70		5,7	I,7
	27.VI	"	I9,8	82	8,8	6,0	0,5
	28.VI	"	I5,0	99	II,4	5,0	0,2
	29.VI	"	I3,3	76	0,8	7,7	2,9
	30.VI	"	I3,3	8I	0,3	9,4	2,4
	I.VII	"	I6,7	77		4,0	2,2
	I3.VII	I	24,2	77			I,2
	I4.VII	"	23,3	81	I,5		I,9
	I5.VII	"	22,5	97	9,6	I,7	0
	I6.VII	"	23,0	78		3,3	0,5
	I4.VIII	II	I3,3	77			I,9
	I5.VIII	"	I5,5	78			2,9
	I6.VIII	"	I5,8	72			2,2
	I7.VIII	"	I7,7	6I			I,2
	I8.VIII	"	I7,5	60			2,6

G: generation RH: relative air humidity

Q: catch of moths expressed as a percentage of the total number of moths caught during the whole season.

DENOTATION OF FIGURES

Figure I /a,b,c,d/: I,2 - changes in the weight and H_2O content of spheres placed under plastic cups.

3 - changes in H_2O content of uncovered spheres.

abscissa: days

Figure 2 /a,b,c,d,e/: 1,Ia - changes in the weight and H_2O content of layers under plastic lids.

2,2a - changes in the weight and H_2O content of layers covered with paraffin film.

3,3a - changes in the weight and H_2O content of uncovered layers.

abscissa: days

R E F E R E N C E S

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2. Sender,C. Elevage permanent du carpocapse des pommes Carpocapsa (= Laspeyresia) pomonella L. sur milieu artificiel simplifite. Ann.Zool.Ecol.anim.,I,1969,3.

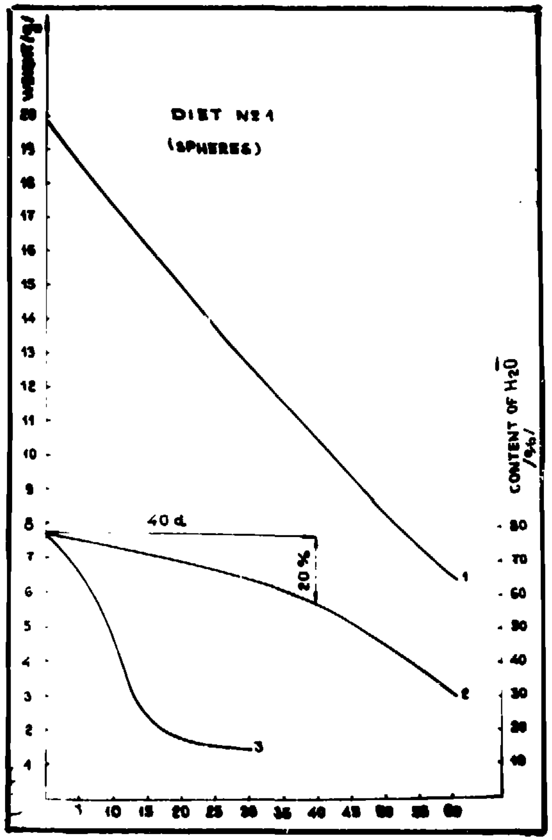
WEIGHT /g/
DIET Nº 1
(SPHERES)
40 d
20 %
CONTENT OF H_2O /%/

FIG. 1a

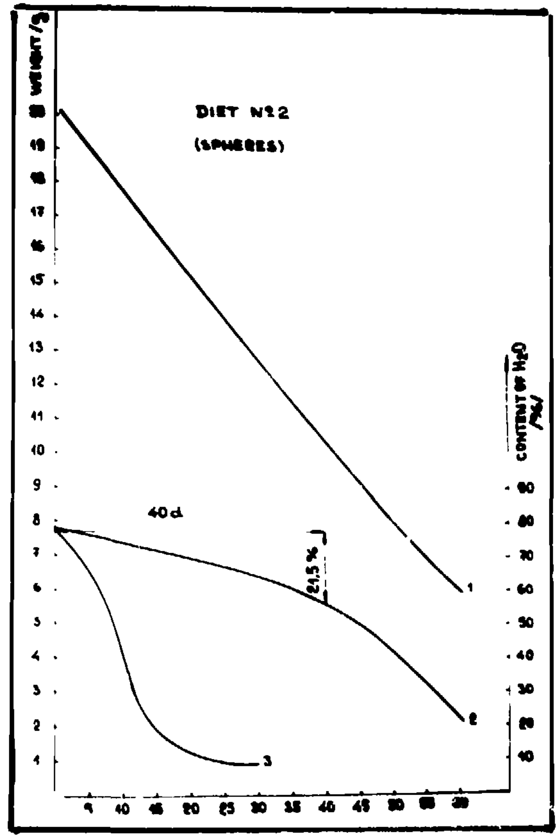
WEIGHT /g
DIET Nº 2
(SPHERES)
40 d
21,5 %
CONTENT OF H_2O /%/

FIG. 1B

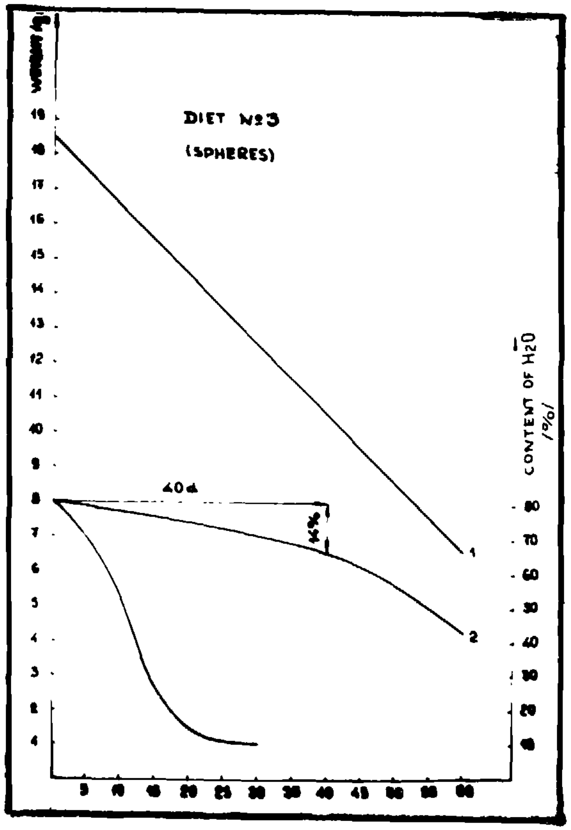

Fig. 1c

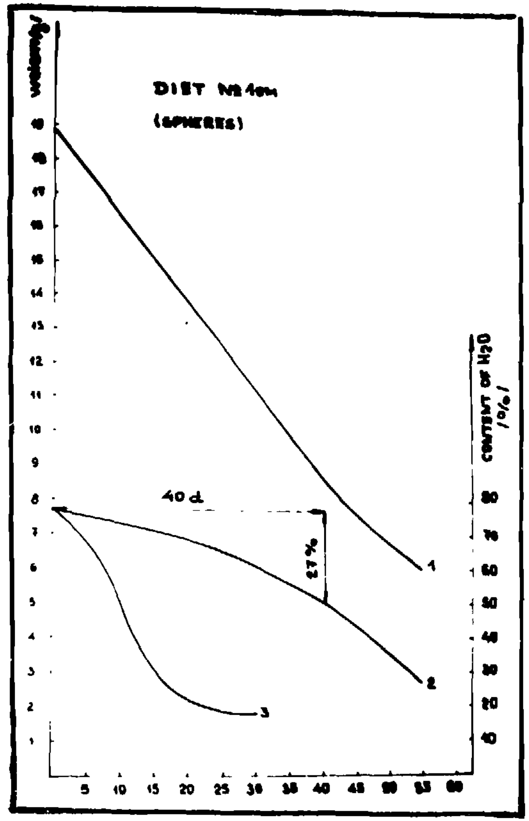

Fig. 1d

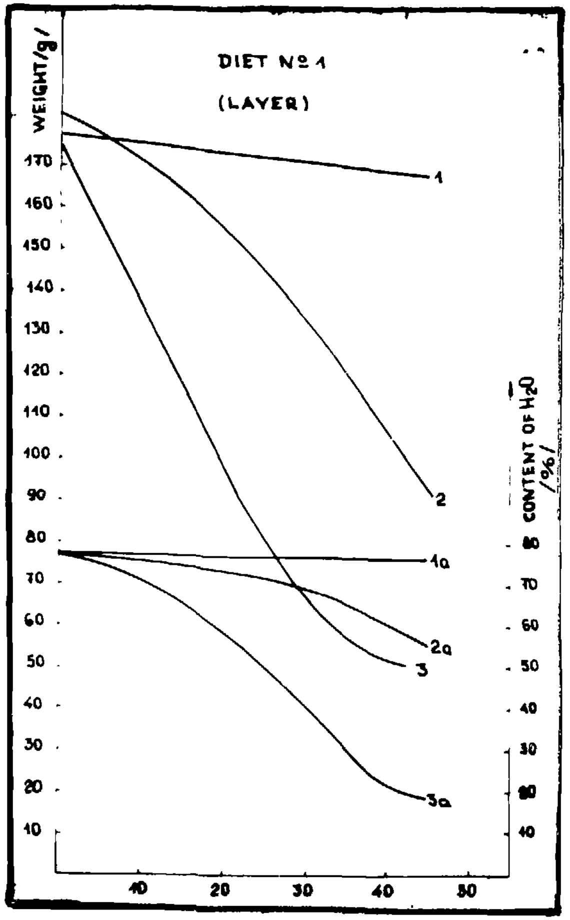

Fig. 2a

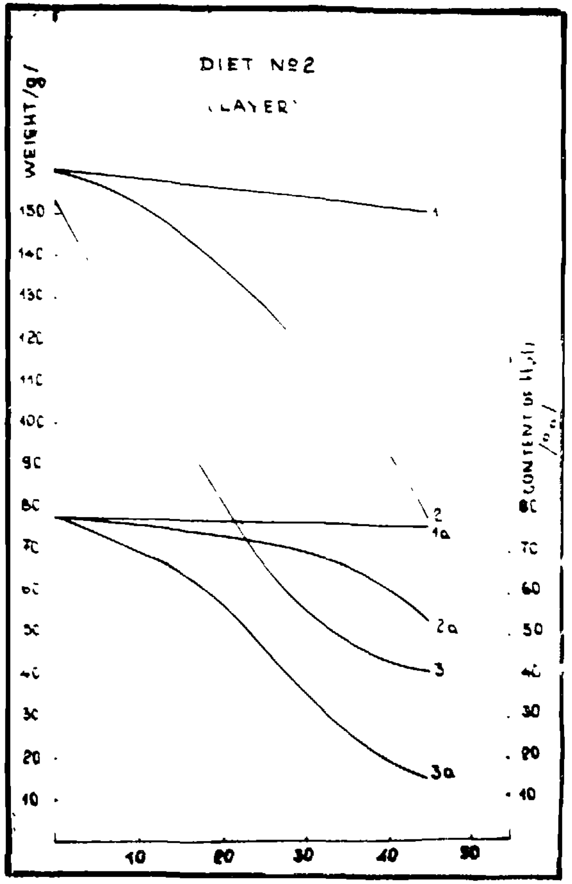

Fig. 2b

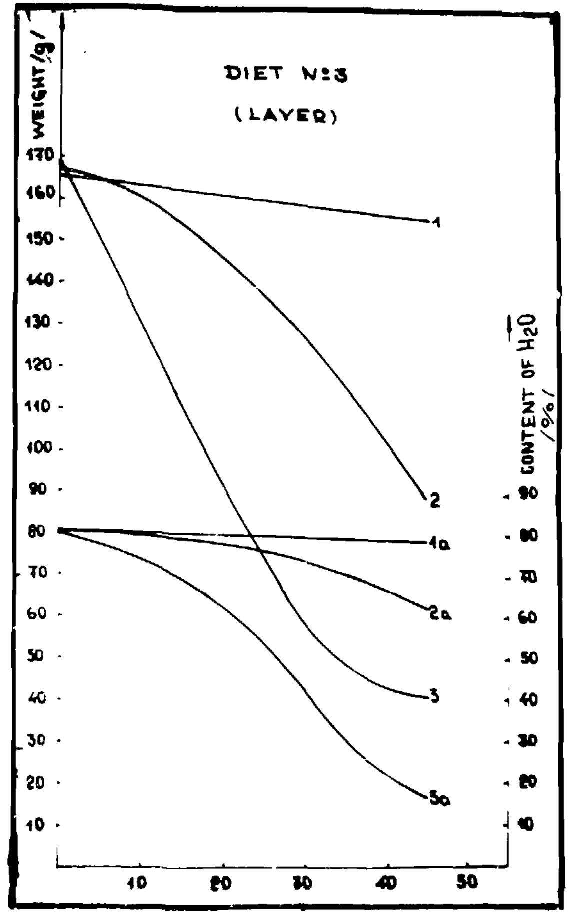

Fig. 2c

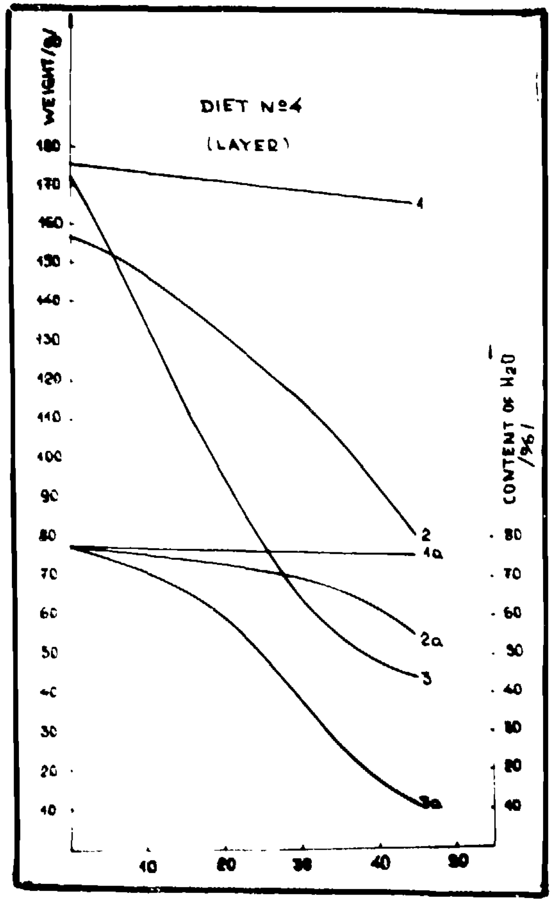
WEIGHT /g/
DIET Nº4
(LAYER)
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
CONTENT OF H_2O /%/
80
70
60
50
40
30
20
10
4
2
4a
2a
3
3a
10
20
30
40
50

Fig. 2d

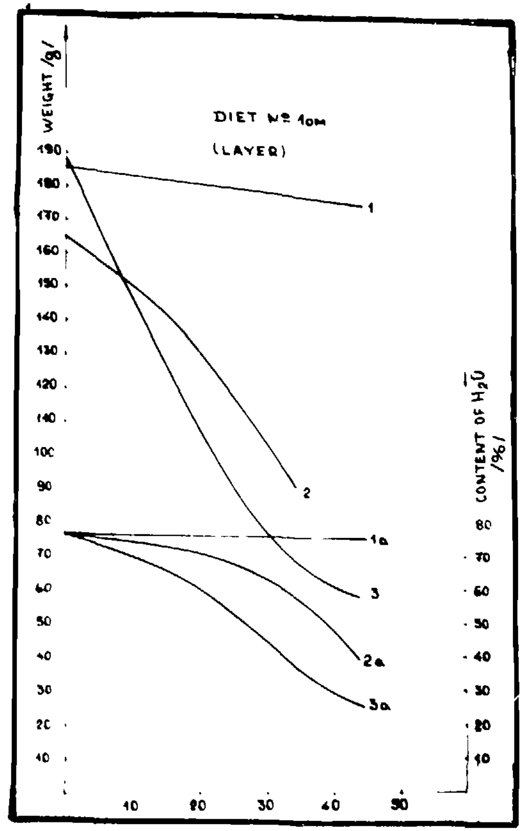
WEIGHT /g/
DIET Nº 1om
(LAYER)
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
CONTENT OF H_2O /%/
80
70
60
50
40
30
20
10
1
2
1a
3
2a
3a
10
20
30
40
50

Fig. 2e