

THE EFFECT OF GAMMA IRRADIATION ON THE VARO RACE OF *BOMBYX MORI* L.

II. Irradiation of eggs in the early and late embryonic stages

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Introduction

The biological effect of radioactive irradiation has been rather much discussed in recent years, still data available on the species of the order of Lepidoptera are scanty except for the *Bombyx mori* L. species of the family Bombycidae with the various races of which manyfold irradiation experiments were conducted. This is easy to understand since the economic importance of genuine silk continues to be considerable. Scientific studies connected with irradiation are dealing without exception with the practical problems of the breeding of silk worms and the processing of cocoons. So *e.g.* KARPOV (1960) attempted to heal larvae suffering from polyedrosis with X-ray irradiation. ARIFOV—GUMANSKY (1957) have dealt with the action on pupae of gamma irradiation. The objective of their work was to search for such radiation dosis values with which the pupae of the cocoons destined for processing can be killed by large-scale methods. ARIFOV and KLEIN (1958) studied gamma irradiation as related to the structure of silk thread. Also in Hungary the susceptibility of pupae to radiation was studied with the practical consequence that, instead of the Pellegrino heat treatment, killing of pupae with gamma irradiation seems to be more suitable for the purpose in view (BABOS, GUBICZA, LUKACSOVICS, MOLNÁR 1962).

The work of TAZIMA (1961) is of high economic significance since this worker succeeded to bring about with a radiosélection method sexual dimorphism already in the egg stage. From the dark coloured eggs male individuals while from the light ones females developed. Unfortunately the method, out of proportion to its practical significance, is deficiently described (as it only too often happens) and is thus irreproducible.

We are dealing with the effect on *Bombyx mori* L. of gamma rays since 1961. At the beginning of experiments we have only set the objective to examine the radiation sensitivity of the various degrees of egg, larva, pupa development, since in literature we have found insufficient data pertaining to this subject. Most of the authors, *e.g.* STRANNIKOV (1957) do not indicate the developmental stage of the irradiated eggs. The coworkers of the Research Institute of the Silk Industry in Usbegistane described the pattern of irradiation in full

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detail but even they omitted to extend to the very essential aspect, which developmental stage the experimental animals were in (ARIFOV—GUMANSKY 1957).

In our earlier experiments we tried to determine the developmental stage of *Bombyx mori* L. with approximate accuracy (BABOS, GUBICZA, LUKACSOVICS, MOLNÁR 1962, LUKACSOVICS, GUBICZA 1963).

As a continuation of our experiments with pupae and with eggs in diapause the objective of the present communication is to describe the effect of gamma irradiation and to indicate the experimental data related to early and late embryonic development of the eggs of the silk moth and to the development of their larvae.

Material and method

The eggs in the following developmental stages of the Varo race widespread in Hungary were chosen as experimental subject

A 10 to 12 hour age

B 40 to 45 hour age

C 50 to 56 hour age

D eggs in the last stage of embryonic development.

In the eggs of the group *A* the blastomeres are formed (in general 20 blastomeres). The colour of the eggs is straw-yellow.

The group *B* was in the last stage of early embryonic development where on the discus the primary furrow has already formed and even the segments of the embryo are visible. In this stage the colour of the eggs is light brown.

The eggs of the group *C* were in the state of rest in the stage after early embryonic development. The colour of such eggs is greyish brown. The eggs referred to and ranged in the groups *A*, *B*, *C* were separated with the aid of an isolator* and with the cellule method of PASTEUR.

The eggs of the group *D* were in the last stage of embryonic development where blastokinesis came to end and the hatching of the eggs occurred in about 10 to 15 hours. The colour of these eggs is light grey.

Irradiation of the lots referred to was conducted with the aid of gamma photons from Co^{60} . The quantum energy of these is 1.17 and/or 1.33 MeV. The objects were placed on a round table in whose centre was the source of radiation of 420 C activity.

From the groups *A*., *B*. and *C*. 6 separate subgroups each were formed and these have been irradiated with doses increasing from 200 r to 100 000 r.

* The isolator is used for the separation of cocoons selected for further breeding. The emergence of moths and copulation proceeds in compartments of 6×5 cm surface closed with 5 cm high tulle walls. After pairing for 6 to 8 hours the female moths are placed in perforated parchment bags where they lay 400 to 500 eggs and subsequently perish in 5 or 6 days. The body of the perished moths crushed in PETRI dishes with water to a pulp is examined with a 800 to 900× microscopic magnification. Only the eggs of sound female moths are bred further.

Sign of the subgroups			Irradiation dosage value
A_1	B_1	C_1	200 r
A_2	B_2	C_2	1 000 r
A_3	B_3	C_3	3 000 r
A_4	B_4	C_4	5 000 r
A_5	B_5	C_5	7 000 r
A_6	B_6	C_6	100 000 r

The individual subgroups were arranged around the radiation source in such a way that with the change of the distances all lots obtained the radiation dosage envisaged within one hour irradiation period. This of course had the consequence that the dosage intensity has changed in the case of the individual subgroups.

The group *D* was irradiated divided up in 3 subgroups:

D_1	992 r
D_2	2 490 r
D_3	4 480 r

At the irradiation of these lots the dosage values of not round figures were obtained as a consequence of the placement of the objects and of the establishment of irradiation times.

From each subgroup 2 to 3 thousand eggs were placed as object.

The eggs were pasted on cards so that they could be placed in a plane perpendicular to the direction of the spreading of the radiation and a practically identical dosage rate could be ensured for the eggs of the individual subgroups.

The hatching of the larvae and their breeding as well as the classification of the cocoons and the repeated production of the eggs was conducted according to the standards MNOSZ 6818—52, 6818—52 K and 6815—53.

In hatching 2000 while in breeding 1000 to 1500 individuals were studied.

In all subgroups where hatching of the larvae did not reach 10 per cent we had to omit breeding. It should be noted that the eggs of subgroups A_6 , B_6 and C_6 irradiated with 100 000 r were destroyed.

Eggs of the same year and of identical developmental stage from the Szekszárd plant of the Herbaria Silk Egg Production Works served as a control.

Examinations extended to the following:

1. Period of hatching
2. Per cent of hatching
3. Period of larva development
4. Occurrence of various diseases
5. Period of the emergence of moths
6. Distribution of the moths according to sex
7. Nosema infection of the pairs of moth
8. Per cent of sterile egg-layings
9. Output of eggs
10. Egg weight

The above examinations were carried out according to the methods described earlier (GUBICZA 1959).

Results

The eggs laid by one female each of A., B. and C. groups were irradiated on July 23th while the subgroups 1, 2 and 3 of group D on May 21 st. Data on hatching of larvae, breeding and further increase were tabulated.

Table 1

Hatching of larvae and breeding period in eggs treated with gamma irradiation

Denomination of groups	Period of the hatching of larvae, days	Hatching of larvae, per cent	Mortality of eggs per cent	Period of larval development, days
A/1	4	96.0	4.0	29
A/2	5	96.1	3.9	29
A/3	6	76.0	24.0	30
A/4	8	18.0	72.0	30
A/5	4	0.3	99.7	—
B/1	5	96.1	3.9	29
B/2	6	95.2	4.8	29
B/3	7	75.3	24.7	30
B/4	7	3.0	97.0	—
B/5	7	0.9	99.1	—
C/1	5	96.4	3.6	29
C/2	6	96.4	3.6	29
C/3	6	86.0	14.0	30
C/4	7	0.4	99.6	—
C/5	—	—	—	—
D/1	5	95.5	4.5	29
D/2	5	79.0	21.0	29
D/3	6	21.3	78.7	29
Control	5	95.4	4.6	29

From the data of *Table 1* it appears that with growing dosage values the period of the hatching of larvae has extended, the per cent hatching fell and the period of larval development was prolonged. The marks of injury did not appear with 200 and 1000 r but they did in all groups irradiated with higher r units.

Among the larvae of the subgroups A/2, A/3 and A/4 several individuals were found that suffered visible morphological changes. Instead of the bilaterally arranged 4—4 pedes coronati 5—4, 4—3, 4—2, 3—2 arrangement was found.

In the larvae seen on *Fig. 2*. from the four left hand feet two are missing. Concrecence of the pseudopods of the larvae frequently occurred (*Figs. 1a, 1b*). Radiation injury was manifest in most cases in the malformation of the 8—9. body segments. Injury by radiation frequently was so extensive that the position of segments and pedes spurii could not be recognized (*Fig. 3*).

In groups irradiated at the 40 to 45. hour of the early embryonic development of eggs and in the groups irradiated at the 50 to 55. hour (group C) no malformed larvae occurred.

In the subgroups A parallel with the increase of radiation dosage rate the number of malformed larvae has grown (*Table 2*).

Table 2

The malformation per cent of larvae hatched from eggs irradiated in the 10 hour age

Group	Dosis value r	Number of experimental larvae	Number of malformed larvae	Per cent of malformed larvae
A/1	200	731	—	0.0
A/2	1 000	709	3	0.42
A/3	3 000	552	35	0.34
A/4	5 000	80	38	47.50

It should be noted that in order to conduct further experiments, the malformed larvae and their progeny (pupae, moths and eggs) were treated separately and their data have been separately processed in the following (see *Tables 3., 4., 5.*).

Besides the occurrence of torsos also the high proportion of larvae perished from diseases was remarkable, as reflected by the data of *Table 3.*

It should be noted to the data of the above *Table* that in the groups *A/3* and *A/4* and those formed from their breeding larvae, besides the high losses caused by diseases no losses of larvae by pebrine occurred but contamination was found as will be demonstrated later. It can be safely stated that the irradiation of the eggs did not afford protection against any disease and it can be even assumed that the resistance of the animals has diminished and the possibility for the pathogens present in the cultures was given. Only the exceptionally careful and expert breeding work prevented a greater extent of losses by infectious diseases.

Table 3

The incidence of diseases during larval development

Groups	Polyedrosis	Flacherie	Muscardine	Gattine	Larvae perished from diseases total per cent
A/1	—	—	—	—	—
A/2	—	—	—	0.14	0.14
A/3	—	3.44	—	—	3.44
A/4	—	11.25	—	—	11.25
A/3 malformed	—	14.30	—	—	14.30
A/4 malformed	—	23.70	—	—	23.70
B/1	—	—	—	—	—
B/2	0.17	0.17	0.16	—	0.50
B/3	—	0.28	—	—	0.28
C/1	—	—	—	—	—
C/2	—	—	—	—	—
C/3	0.18	0.36	—	—	0.56
D/1	—	0.12	—	—	0.12
D/2	—	0.19	0.19	—	0.38
Control	—	—	—	—	—

Table 4

Groups	Number of	Number and per cent of moths emerged from cocoons		Distribution of moths according to sex	
				♂	♀
A/1	558	555	99.5	50.3	49.7
A/2	465	460	98.9	55.2	44.8
A/3	215	208	96.7	55.7	44.3
A/4	49	45	91.8	64.4	35.6
A/3 malformed	31	29	93.5	55.2	44.8
A/4 malformed	13	12	92.3	58.3	41.7
B/1	301	299	99.3	42.8	57.2
B/2	395	387	97.9	45.2	54.8
B/3	97	92	94.8	82.6	17.4
C/1	763	760	99.5	47.9	52.1
C/2	615	606	98.5	53.3	46.7
C/3	170	161	94.4	67.7	32.3
D/1	601	596	99.2	45.6	54.4
D/2	376	371	98.7	54.4	45.6
D/3	45	43	95.5	37.2	62.8
Control	790	782	99.0	50.3	49.7

Table 5

Data related to further increase

Groups	Infection of pairs of moth in per cent		Sterile (skart) eggs per cent	Egg output per pairs of moth units	Eggs unit/g
	Nosema	other			
A/1	—	2.3	4.7	461	1475
A/2	—	2.4	4.5	476	1402
A/3	—	5.5	21.0	471	1397
A/4	—	—	—	426	1341
A/3 malformed	—	—	—	384	1384
A/4 malformed	—	—	25.0	392	1387
B/1	—	2.4	2.4	554	1430
B/2	—	5.7	18.9	498	1424
B/3	—	6.7	13.3	467	1403
C/1	2.1	—	14.6	496	1470
C/2	2.3	2.3	4.5	450	1441
C/3	1.9	3.9	25.0	364	1381
D/1	—	—	4.8	456	1404
D/2	—	—	13.0	500	1370
D/3	—	—	6.3	511	1395
Control	—	2.1	12.8	463	1323

In the cocoons of individuals irradiated by lower dosage-values, the per cent emergence of moths was higher in each group, while the per cent proportion of male moths increased in the groups exposed to more intensive irradiation.

It appears from the data that also *Nosema* infection occurred. The fact that pairs of moth infected with *Nosema bombycis* N. was found only in sub-

groups *C* can be explained by that at the microscopical examination of the moths of the previous generations 1 or 2 such weakly infected individuals remained in the lot that could not be demonstrated and therefore were not excluded from further increase. This may occur in the framework of large-scale examination methods even with the most careful control.

In groups *A*, *B* and *C* with increased radiation dosage rate the number of units/g of eggs decreased, that is the weight of one egg increased.

As a contrast, in group *D* with the increase of the radiation dosage the number of eggs per 1 g increased that is the weight of the individual eggs has diminished.

According to the data of *Table 5*, in the groups *A*, *B* and *C* the number of eggs per 1 pair of moths diminished with the increase of the dosage rates. The opposite trend was observed in Group *D*.

There are greater differences among the per cent values of the sterile (skart) eggs. From the fact that the groups *A/3*, *B/3* and *C/3* contained more sterile eggs, only with due care and repeated experiments can the consequence be drawn that the number of the „skart” eggs increases in direct proportion to the higher radiation dosage rates. This is contradicted on the one hand by the fact that also the moths of the control group laid a high proportion of sterile eggs and on the other hand that in the large-scale egg production also considerable differences occur among the individual lots.

Discussion

The eggs treated with gamma irradiation of different strength in the stages of early embryonic development and in the last stage of embryonic development of the Varo race of *Bombyx mori* L. and/or the larvae hatched from these eggs responded uniformly in some cases while differently in others.

At the irradiation of 3000 r unit the marks of injury consisting in a prolonged period and in a reduced per cent of hatching manifested themselves equally in the eggs of different developmental stages. The extent of injury may be regarded as identical in all subgroups. In the groups *A*, *B* and *C* the developmental period of the larvae in the subgroups irradiated with 3000 r was 1 day longer as compared with the control (*Table 1*).

Among the groups *A*, *B*, *C* and *D* there is a difference in the appearance of malformed larvae. Only in larvae hatched from eggs irradiated in the 10 hour age (Group *A*) were visible changes observed that consisted in the concrescence of the pedes spurii, in the reduction of their number, in the modification of the body segments and in other alterations. In the *A/2* subgroup irradiated with 1000 r 0.42 per cent of the larvae while in the subgroup *A/4* irradiated with 5000 r about 47.5 per cent showed abnormal development. The progeny of the larvae malformed in various ways were stored separately for the purposes of further observations.

Silkworm diseases (polyedrosis, flacherie, muscardine, gattine) did not occur in the subgroups irradiated with 200 r while at higher dosage rates all diseases of the worms were found.

In the groups *A/3*, *A/4* and that of malformed larvae the losses caused by diseases exhibited a very high per cent. This can be explained by the reduced resistance of the irradiated animals.

The per cent of moths emerged from cocoons diminished parallel with the intensity of irradiation. This reduction is of lesser extent than in the hatching of larvae.

The distribution of sex showed an interesting trend. While in the groups *A*, *B* and *C* the number of male moths increased parallel with the gamma irradiation dosage, in the *D* group irradiated late in the embryonic stage a reduction was observed. It should be stressed that in subgroup *B/3* the proportion of male moths was 82.6 while in *D/3* only 37.2.

In moths emerged from eggs irradiated in the latest stage of embryonic development (*D/3*) the low proportion of males can be explained with the high degree of losses in hatching. It is likely that in this case the hatching of the males was of a lower proportion. In the subgroup *B/3* irradiated in the latest stage of early embryonic development — as seen from *Table 1* — the hatching of larvae amounted to 75 per cent. The 82 per cent proportion of males in this case can not be explained with the loss of female individuals in hatching even if the non-hatched larvae were female without exception. Considering the average 50 to 50 sexual distribution and the 3 to 4 per cent natural loss in hatching the proportion of the males ought to be at the most 68 to 70 per cent. It is probable that besides the higher rate of loss in females in this stage of egg development the effect of irradiation manifests itself in a change of sex. In the next experimental year we shall attempt to study this problem in more detail.

As a result of the microscopic examination of the pairs of moth *Nosema bombycis* N spores were found only in the *C* groups, while other pathogens were found in the groups *A* and *B* and no infectious disease occurred in group *D*.

The *Nosema* infection can not be brought in connection with the gamma irradiation. The experience of several years shows that after microscopic study of the moths in the breeding material chosen for further increase even in the case of most careful work 0.1 to 0.02 per cent of infected eggs remain. This is enough to raise the proportion of infection in the next generation — depending on the breeding conditions — to 1 to 2 per cent. The occurrence of *Nosema* infection proves — as seen in the other infectious diseases — that the intensive gamma irradiation did not cause injury to the pathogen.

The output of eggs in the moths from irradiated eggs in groups *B* and *C* diminishes parallel with the intensity of the irradiation dosage while it increases in group *C*. As to the weight of eggs it increases in all groups parallel with the increase of the dosage of irradiation, without attaining the weight of the eggs in the control lot. This latter occurrence is the only phenomenon where the higher irradiation dosage rate caused a change in positive direction of an important parameter of the breeding material. Whether this is really the case is decided by the viability test of the eggs and larvae of the *F/2* generation.

Finally, thanks are due to Mrs ÖDÖN GULYÁSI who performed with great expert knowledge and care the tending of the experimental larvae and the treatment of the breeding material.

Summary

Authors as a continuation of their earlier work treated with gamma rays of various dosage rates the eggs of the Varo race of *Bombyx mori* L. of different developmental stages and examined them as well as in the larvae hatched the important biological changes, the period and per cent of the hatching of larvae,

the period of larval development, the occurrence of diseases and the further increase, as well as the properties of repeatedly laid eggs.

As a result of experiments it was established that eggs irradiated in the various stages of early embryonic development as well as in the last stage of late embryonic development and the larvae hatched from these respectively exhibit properties substantially changed upon the effect of irradiation.

Radiation injury occurred in each group at 3000 r units (Table 1).

Malformed larvae developed only from eggs irradiated in the earliest stage of embryonic development (Figs. 1a, 1b, 2. and 3).

No diseases of silkworms (polyedrosis, flacherie, muscardine, gattine) occurred in the subgroups irradiated with 200 r while in the groups treated with higher dosage values all kinds of larval diseases were found (Table 3).

The per cent of moths emerged from the cocoons diminished with the increased dosage rate but to a lesser degree than in the case of the hatching of larvae.

In groups A, B and C among the moths with the increase of gamma irradiation dosage the number of males increased while it diminished in group D irradiated in the late embryonic stage (Table 4).

In microscopic examination of the moths of irradiated groups the spores of *Nosema bombycis* N and of other pathogens were found.

Gamma irradiation affords no protection from the pathogens and even reduces the resistance.

Finally it has been established that the output of eggs of the moths originating from the larvae of irradiated eggs diminished in the groups A, B and C with the increasing dosage of irradiation while it increased in group D.

The weight of the eggs increased proportionally to the higher dosage of irradiation in all groups, without attaining, however, the weight of the control-eggs.

Breeding material obtained from irradiated *Bombyx* eggs will be examined in more detail in 1964.

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GAMMA-SUGÁRZÁS HATÁSA A *BOMBYX MORI* L. VARO RASSZÁRA. II. PETÉK BESUGÁRZÁSA A CSIRAFEJLŐDÉS ÉS EMBRIONÁLÓDÁS SZAKASZÁBAN

Gubicza András és Molnár István

Összefoglalás

A szerzők korábbi munkájuk folytatásaként különböző dózisu gamma-sugárral kezelték az eltérő fejlettségű *Bombyx mori* L. Varo rasszának petéit, és vizsgálták az embrionális fejlődés időtartamát, a tojásmortalitást, a lárvafejlődés időtartamát, a betegségek előfordulását, valamint a petékből kifejlődött lárvák fontosabb biológiai változásait, a továbbszaporítást és az ekkor lerakott peték tulajdonságait.

A kísérletek eredményeként megállapították, hogy a kezdeti csirafejlődés fázisaiban és az embrionálódás utolsó szakaszában besugárzott peték, illetve azokból kibújt lárvák tulajdonságai jelentős mértékben megváltoznak a sugárzás hatására.

A sugárkárosodás minden egyes csoportban 3000 r egységnél mutatkozott (1. táblázat).

Torz hernyók csak a csirafejlődés legkorábbi fázisában besugárzott petékből fejlődtek (1a, 1b, 2., 3. ábrák).

Selyemhernyó-betegség (sárgaság, renyhekór, mészkór, aszkór) a 200 r-rel besugárzott alcsoportoknál nem fordult elő, míg a magasabb dózisértékekkel kezelt csoportoknál minden hernyóbetegség előfordult (3. táblázat).

A gubókból kifejlődött lepkék százaléka a besugárzás dózisának emelkedésével csökkent.

Az A., B. és C. csoportok a lepkéknél a gamma-sugárdózis növekedtével emelkedett a hím lepkék száma, az embrionálódás végén besugárzott D csoportnál pedig csökkent (4. táblázat).

A besugárzott csoportok lepkéinek mikroszkópi vizsgálatánál *Nosema bombycis* N. spórákat és egyéb kórokozók spóráit is megtalálták, tehát a kísérletben a gamma-sugárzás nem nyújtott védelmet a betegségek kórokozóival szemben, sőt csökkentette a hernyók ellenálló képességét.

Végül megállapították, hogy a besugárzott peték lárváitól származó lepkék peteszámát az A., B. és C. csoportoknál a növekvő sugárdózissal csökkent, a D. csoportnál emelkedett.

A peték súlya a sugárdózis emelkedésével arányosan, minden csoportnál emelkedett. Bár a peték súlya a 200 r-rel besugárzott példányoktól a sugárdózis mértékével arányosan növekedett, a kontroll súlyát mégsem érte el.

ВЛИЯНИЕ ГАММА-ЛУЧЕЙ НА РАСУ Varo ТУТОВОГО ШЕЛКОПРЯДА

1. Облучение яиц.

Резюме

А. Губица, Молнар И.

Продолжая ранее опубликованные работы авторы облучали яйца расы Varo Bombyx mori L. на различных стадиях развития разными дозами гамма лучей и изучали важнейшие биологические изменения; время и процент вылезания гусениц, срок личиночного развития, появление болезней, дальнейшее размножение и вторичный яйцеклад.

Были изучены свойства яиц, облученных на первых стадиях развития или на последней стадии эмбриогенеза. Установлено, что гусеницы изменяются в значительной мере под действием облучения.

Уроды появились в каждой группе при дозах выше 3000 рентген (см. таблицу).

Уродливые гусеницы развивались только из яиц облученных в раннейшем возрасте (рис. 1а, 1б, 2 и 3).

Болезни тутового шелкопряда (желтуха, чахлость, мускордина, мертвенность) не были найдены в подгруппах, облученных дозами ниже 200 рентген, в то время как в подгруппах облученных более высокими дозами встречались все типы болезней. (Табл. 3.)

Процент выхода бабочек с повышением дозы облучения уменьшался, также как и вылезания гусениц, но в меньшей степени.

У бабочек групп А, В и С увеличилось число самцов с увеличением дозы, а бабочек группы D, число самцов уменьшилось при таких же условиях (таблица 4).

При микроскопическом исследовании бабочек облученных групп были найдены споры *Nosema bombycis* N. и других болезнетворных. Гамма облучение не защищает против различных болезней, а наоборот понижает сопротивляемость.

Наконец, было установлено, что выход яиц бабочек, происходящих от гусениц облученных яиц, у групп А, В и С понизился, а в группе D повышался с увеличением дозы.

Вес яиц с увеличением дозы увеличился в каждой группе но не достиг веса контрольных яиц.

Потомство облученных яиц шелкопряда в дальнейшем будет изучено более подробно.

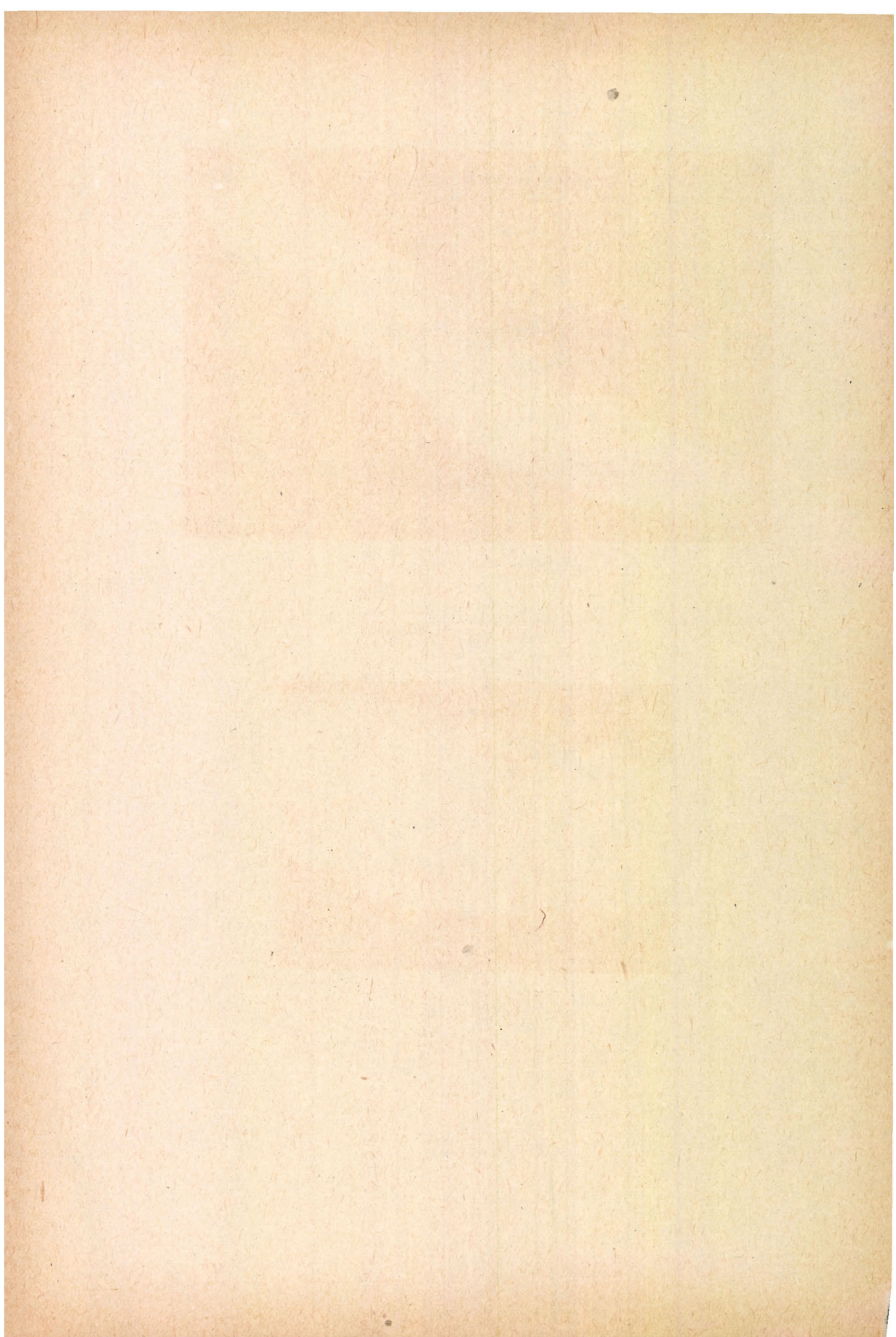




Fig. 1a. One of the larvae hatched from *Bombyx* eggs irradiated with Co^{60} in the V. developmental stage

1a ábra. A Co^{60} -nal besugárzott *Bombyx* petékből kibújt lárvák egyike az V. fejlődési fokozatban

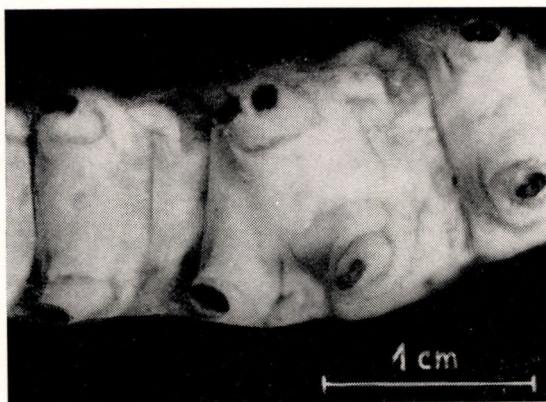


Fig. 1b. Magnified picture of the pedes coronati grown together of the larva seen in *Fig. 1a*

1b ábra. A fenti ábrán (*1a ábra*) látható hernyó összenőtt állábainak (pedes coronati) kinagyított képe



Fig. 2. Irradiation of the eggs frequently causes lack of extremities in larvae. In the larva represented two of the 4 left side pedes spurii are missing

2. ábra. A peték besugárzása a lárváknál gyakran végtaghiányt okoz. Az ábrázolt hernyónál a négy baloldali álláb közül kettő hiányzik

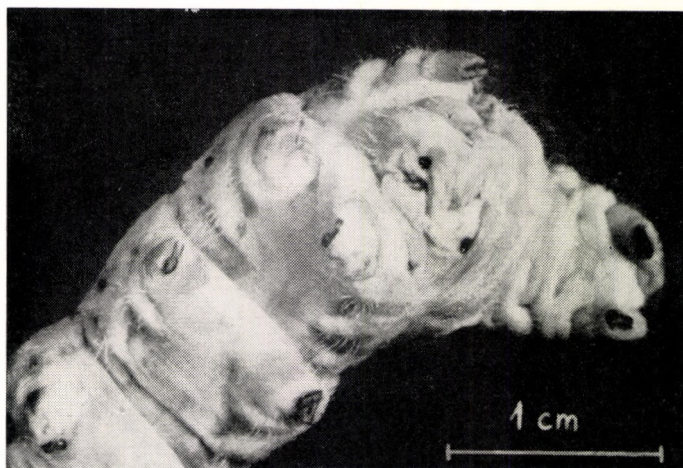


Fig. 3. Radiation injury manifested itself in most cases in the malformation of the 8—9. body segment of the larvae

3. ábra. A sugárkárosodás legtöbb esetben a lárvák 8—9. testszelvényének torzulásában jelentkezett