

## Hereditary changes of male aggressiveness after gamma irradiation of mouse spermazoa with 600 R

by

Johannes Horst SCHRÖDER \*) \*\*)

(Institut für Biologie, Gesellschaft für Strahlen- und Umweltforschung Neuherberg bei München  
and Institut für Zoologie der Universität Innsbruck)

### Erbliche Veränderungen der Aggressivität männlicher Mäuse nach Gamma-Bestrahlung der väterlichen Spermatozoen mit 600 R

**S y n o p s i s :** Männliche  $F_1$ -Nachkommen von bestrahlten NMRI-Labormäusen, deren Spermatozoen einer Gammabestrahlung von 600 R ausgesetzt worden waren, wurden mit männlichen NMRI-Mäusen unbestrahlter Väter für die Dauer von 24 Stunden zu Paaren zusammengesetzt. Die von bestrahlten Vätern abstammenden  $F_1$ -Männchen zeigten eine durchschnittlich höhere Aggressivität als die von unbestrahlten Männchen abstammenden Tiere, wobei das Maß der Aggressivität durch Auszählung der am Schwanz und Körper vorgefundenen Läsionen bestimmt wurde. Die Aggressivität der aus bestrahlten Spermatozoen hervorgegangenen  $F_1$ -Männchen war jedoch nicht einheitlich: Neben schwach-aggressiven Männchen, die etwa dasselbe Aggressionsniveau wie ihre unbestrahlten Kontrahenten besaßen, gab es hoch-aggressive  $F_1$ -Männchen, von denen die Hälfte sich als steril erwies. Nach Weiterzucht mit unbestrahlten NMRI-Weibchen zeigten zwar alle Söhne der  $F_1$ -Männchen eine durchschnittlich geringere Aggressivität als ihre unbehandelten Kontrahenten, was auf Rezessivität für hohe Aggressivität hinweist, doch war die Aggressivität der von schwach-aggressiven  $F_1$ -Vätern abstammenden Männchen signifikant stärker reduziert als die Aggressivität der von hoch-aggressiven  $F_1$ -Vätern abstammenden Männchen. Es wird angenommen, daß hohe Aggressivität hauptsächlich auf strahleninduzierten Translokationen beruht.

\*) Dedicated to Nobel-prize winner Prof. Dr. Dr. Dr. h.c. mult. K. Lorenz on the occasion of his 75 th birthday.

\*\*) Author's address: Univ.-Prof. Dr. J.H. Schröder, Institut für Biologie, Gesellschaft für Strahlen- und Umweltforschung, Ingolstädter Landstraße 1, D-8042 Neuherberg, BRD.

## Introduction:

An increase in male aggressiveness found in  $F_1$  mice (*Mus musculus domesticus*) derived from spermatozoa irradiated with 600 R of gamma rays was presumed to be of genetic nature (SCHRÖDER, 1977). It was proposed to investigate the hereditary basis of altered aggressiveness by selective breeding of low and high aggressive males as has already been shown for offspring of irradiated cichlid fish (HOLZBERG and SCHRÖDER, 1975). The present paper deals with this topic and thus completes the first communication on radiation-induced increases in aggressiveness in the house mouse.

## Material and Methods:

The Neuherberg NMRI strain used in these experiments is kept as a specific-pathogen free mouse strain as described elsewhere (SCHRÖDER, 1977). Males were irradiated with 600 R of Cs-gamma rays at a dose-rate of 30 R/min, measured by a Victoreen-dosimeter. During exposure, only the pelvic region was irradiated directly while the head and the front part of the trunk were shielded with 10 - 12 mm of lead. To use irradiated spermatozoa for fertilization of the ova, irradiated and sham-treated males were mated to untreated NMRI females during the first week after exposure (OAKBERG, 1957). 10 to 12 week old male  $F_1$  offspring of both series were put together for 24 hours (from 10 a.m. to 10 a.m. next day) in Macrolon boxes, 25 x 20 x 14 cm. Each box contained one pair of males, one irradiated (I) and one control (C)  $F_1$  male.  $F_1$  males selected for further breeding were mated to untreated NMRI females thus producing an outcross generation with an average of one quarter of the replicates of the irradiated genome. The outcross males were divided into two groups according to the aggressiveness of their  $F_1$  fathers, *i. e.* one group of outcross males was derived from high aggressive I- $F_1$  males while the second group stemmed from low aggressive I- $F_1$  fathers. For the determination of aggressiveness, the outcross males were handled in the same manner as their  $F_1$  ancestors. Because all the males were isolated from weaning, the two males of a given pair were unknown to each other and inexperienced in fighting before being tested. After separation of the paired males, the number of wounded sites ("sores") on the tail and on other parts of the body was counted according to the procedure of COLLINS (1970) and LEVINE *et al.* (1965). The male which delivered more and received fewer bites than his opponent was designated the "winner", while the "loser" received more and delivered fewer bites than his opponent. In order to prevent home-cage effects, both males were put together into a new box simultaneously. Although weight differences between the two males of a pair were minimized as far as possible and most of the pairs were of equal weight at the beginning of the test, some weight differences had to be tolerated. The weight differences between the two males of a pair varied between 0 and 3 g for  $F_1$  and between 0 and 1.7 g for outcross males, the absolute values of weights ranging from 37 to 47 g for  $F_1$  and from 29 to 37 g for outcross males. As shown by statistical calculations, weight differences did not influence the success of fighting under the conditions of the experiment. Therefore, any detectable differences between the aggressiveness of outcross males derived from either high or low aggressive  $F_1$  fathers would be indicative of the hereditary basis of altered aggressiveness.

## Results:

### 1. $F_1$ males:

The effect of paternal irradiation on the agonistic behaviour of  $F_1$  males was already described in a previous paper (SCHRÖDER, 1977). However, it was not yet de-

terminated that the aggressiveness did not increase in a uniform way: 13 out of 34  $F_1$  males exhibited an extreme high level of aggressiveness, 6 were of lower aggressiveness, and the remaining 15 males derived from irradiated spermatozoa were of median aggressiveness (Table 1). Only the high and low aggressive I- $F_1$  males which differed significantly from each other were selected for further breeding, whereas the 15 males with median aggressiveness remained unmated. Among the 13 high aggressive  $F_1$  males, 6 males were unsuccessful in producing offspring after mating to untreated NMRI females, thus constituting a fourth group of sterile males which differed significantly only from the low aggressive group. The median aggressive group was significantly different from the high aggressive group but did not differ significantly from the mean of the low aggressive  $F_1$  males (t-test,  $p < 0.05$ ). The overall aggressiveness of all I- $F_1$  males as compared to their C- $F_1$  opponents was significantly higher as described in more detail in the previous paper (SCHRÖDER, 1977).

Table 1: Agonistic behaviour of NMRI  $F_1$  (I) males (600 R of Cs-gamma rays to paternal spermatozoa) directed to untreated (C) NMRI males.

Characterization of the I- $F_1$ males	Number	Proportion of winners (W), losers (L), and ties (T)	Wounded sites ("sores") on the tails (Mean $\pm$ S.E.)	
			Bites received	Bites delivered
Selected for further breeding; high aggressive (HA)	7	7 W, 0 L, 0 T	0.00	28.00 $\pm$ 5.98 <sup>1)3)</sup>
Selected for further breeding; low aggressive (LA)	6	1 W, 2 L, 3 T	3.17 $\pm$ 2.40	0.50 $\pm$ 0.50 <sup>1)2)</sup>
Sterile; high aggressive	6	5 W, 0 L, 1 T	0.00	13.83 $\pm$ 4.11 <sup>2)</sup>
Not mated; median aggressive	15	11 W, 1 L, 3 T	0.15 $\pm$ 0.09	4.07 $\pm$ 1.01 <sup>3)</sup>

<sup>1)2)3)</sup> Significant differences between high, low and median aggressive  $F_1$  males.

## 2. Outcross males:

The outcross males were then divided into two groups according to their derivation from either high or low aggressive  $F_1$  fathers (Table 2). When one compares their agonistic behaviour with that of their control (C) opponents, both types of outcross males were found to be less aggressive than the corresponding opponents. However, in the case of outcross males derived from high aggressive  $F_1$  fathers (part A of Table 2), a significant level (95 %-confidence limits, standard chi-square test) was reached only

Table 2: Agonistic behaviour of NMRI outcross (I) males ( $F_1$  male x untreated female) directed to untreated (C) NMRI males.A. I-males derived from high aggressive  $F_1$  fathers.

Criterion of agonistic behaviour	Series	Number *	Mean $\pm$ S.E.	95 %-Confidence limits of the mean	$\chi^2$ p
Males with wounded tails	I	17	0.39 $\pm$ 0.07	0.25 - 0.53	0.53
	C	13	0.30 $\pm$ 0.07	0.16 - 0.44	0.45
Wounded sites ("sores") on the tails	I	120	2.73 $\pm$ 0.73	1.00 - 4.46	8.45
	C	79	1.80 $\pm$ 0.63	0.51 - 3.09	0.0035
Males with lesions other than wounded tails	I	8	0.18 $\pm$ 0.06	0.06 - 0.30	0.47
	C	11	0.25 $\pm$ 0.07	0.11 - 0.39	0.49
Males with both types of lesions	I	10	0.23 $\pm$ 0.06	0.11 - 0.35	0.22
	C	8	0.18 $\pm$ 0.06	0.06 - 0.30	0.65
Wounded males with any lesion	I	25	0.57 $\pm$ 0.08	0.41 - 0.73	0.02
	C	24	0.55 $\pm$ 0.08	0.39 - 0.71	0.89
Males without any detectable lesion	I	19	0.43 $\pm$ 0.08	0.27 - 0.59	0.026
	C	20	0.45 $\pm$ 0.08	0.29 - 0.61	0.87

\*) 44 NMRI males of each series tested.

B. I-males derived from low aggressive  $F_1$  fathers.

Criterion of agonistic behaviour	Series	Number **	Mean $\pm$ S.E.	95 %-Confidence limits of the mean	$\chi^2$ p
Males with wounded tails	I	24	0.75 $\pm$ 0.08	0.58 - 0.92	2.63
	C	14	0.44 $\pm$ 0.09	0.25 - 0.63	0.11
Wounded sites ("sores") on the tails	I	169	5.84 $\pm$ 1.34	3.03 - 8.65	98.99
	C	29	0.91 $\pm$ 0.27	0.34 - 1.48	$< 10^{-10}$
Males with lesions other than wounded tails	I	1	0.03 $\pm$ 0.03	0.00 - 0.09	4.50
	C	7	0.33 $\pm$ 0.07	0.07 - 0.37	0.035
Males with both types of lesions	I	18	0.56 $\pm$ 0.09	0.37 - 0.75	7.35
	C	5	0.16 $\pm$ 0.07	0.01 - 0.31	0.007
Wounded males with any lesion	I	25	0.78 $\pm$ 0.07	0.63 - 0.93	0.35
	C	21	0.66 $\pm$ 0.09	0.47 - 0.85	0.56
Males without any detectable lesion	I	7	0.22 $\pm$ 0.07	0.07 - 0.37	0.88
	C	11	0.34 $\pm$ 0.09	0.15 - 0.53	0.34

\*\*) 32 NMRI males of each series tested.

for the different number of wounded sites on the tails as compared to the controls. Males derived from low aggressive  $F_1$  fathers differed significantly more often from their opponents: More wounded sites on the tails were observed in I than in C males, more C males were found with lesions other than wounded tails, and more I than C males exhibited both types of lesions (part B of Table 2). Accordingly, the reduction of aggressiveness in comparison to the corresponding opponents was found actually to be more pronounced in I males derived from low aggressive  $F_1$  males than in I males sired by high aggressive  $F_1$  fathers. The comparison of the agonistic behaviour of both types of outcross males by use of the I/C values also reflects this situation (Table 3). The differences of the I/C values for outcross males derived either from high or low aggressive  $F_1$  fathers reached significant levels ( $p < 0.05$ ) for wounded sites on the tails and for the proportion of winners/losers (chi-square test for two independent samples; SIEGEL, 1956; SACHS, 1973). Thus, outcross males sired by low aggressive  $F_1$  males received significantly more bites and were more often losers in the sense as defined above than did outcross males sired by high aggressive  $F_1$  males. In other words, outcross males derived from high aggressive  $F_1$  fathers were more aggressive than those from low aggressive  $F_1$  fathers.

Table 3: Comparison of the agonistic behaviour of outcross males derived from either high or low aggressive  $F_1$  fathers.

Criterion of agonistic behaviour	I/C high aggressive *	I/C low aggressive *
Males with wounded tails	1.31	1.71
Wounded sites ("sores") on the tails	1.52 <sup>1)</sup>	5.83 <sup>1)</sup>
Males with lesions other than wounded tails	0.73	0.14
Males with both types of lesions	1.25	3.60
Wounded males with any lesions	1.04	1.19
Males without any detectable lesion	0.95	0.64
<u>Winners</u> Losers	0.83 <sup>2)</sup>	0.30 <sup>2)</sup>

\*) I/C calculated as: 
$$\frac{\text{Number of scores (males) in the irradiated series}}{\text{Number of scores (males) in the control series}}$$

<sup>1)2)</sup> Significant differences between outcross males derived from high and low aggressive  $F_1$  fathers

## Discussion:

The question arises of how to explain the lower aggressiveness of outcross males as compared to their opponents in view of the fact that they all were derived from  $F_1$  males exhibiting an overall higher aggressiveness than untreated NMRI male mice. Keeping in mind that 6 out of 13 high aggressive  $F_1$  males were sterile (Table 1), almost 50 % of high aggressive males could not be tested for the possible inheritance of increased aggressiveness. Otherwise, sterility and semi-sterility are well-known phenomena explained by heterozygosity for translocations caused by radiation-induced chromosome breaks (e. g. ADLER, 1978; CACHEIRO *et al.*, 1974; HERTWIG, 1940; SEARLE *et al.*, 1974). Therefore, one can imagine that heterozygous carriers of radiation-induced chromosomal rearrangements may contribute considerably to the increase in aggressiveness found in the irradiated  $F_1$ . Thus, only semisterile  $F_1$  males might be included in the group of 7 high aggressive  $F_1$  males selected for further breeding. If an increase in aggressiveness is associated with heterozygosity for translocations, only less severe translocations can be tested by further breeding. Despite this handicap, the remaining  $F_1$  males selected for further breeding gave clear evidence that high aggressive  $F_1$  males sired more aggressive sons than did low aggressive  $F_1$  males. There is no doubt that radiation-induced alterations in aggressiveness have a genetic origin. Differences in juvenile environment resulting from smaller litter-sizes of  $F_1$  males derived from irradiated spermatozoa (SCHRÖDER, 1977) have only a minor, if any, influence on agonistic behaviour.

## Acknowledgement:

The author is grateful to Mdmes. E. Neubner, I.S. Otten, and K. Peters for conscientious technical assistance. Mrs. W. Kobza helped in careful breeding of the mice. For both critical correlation and formal improvement of the manuscript, the help of Dr. J.A. Farr is gratefully acknowledged.

## References:

- ADLER, I.-D. (1978): The cytogenetic heritable translocation test. – *Biol. Zbl.* **97**: 441 - 451.
- CACHEIRO, N.L.A., L.B. RUSSELL and M.S. SWARTOUT (1974): Translocations, the predominant cause of total male sterility in sons of mice treated with mutagens. – *Genetics* **76**: 73 - 91.
- COLLINS, R.A. (1970): Aggression in mice selectively bred for brain weight. – *Behav. Genetics* **1**: 169 - 171.
- HERTWIG, P. (1940): Vererbare Semisterilität bei Mäusen nach Röntgenbestrahlung verursacht durch reziproke Chromosomentranslocationen. – *Z. Vererbungsl.* **79**: 1 - 27.
- HOLZBERG, S. and J.H. SCHRÖDER (1975): The inheritance of aggressiveness in the convict cichlid fish, *Cichlasoma nigrofasciatum* (Pisces: Cichlidae). – *Anim. Behav.* **23**: 625 - 631.

- LEVINE, C., C.A. DIAKOW and G.E. BARSEL (1965): Interstrain fighting in male mice. – *Anim. Behav.* **13**: 52 - 58.
- OAKBERG, E.F. (1957): Duration of spermatogenesis in the mouse. – *Nature* **180**: 1137 - 1139.
- SACHS, L. (1973): *Angewandte Statistik. Planung und Auswertung. Methoden und Modells.* – Berlin, Heidelberg, New York; Springer: 269 - 273.
- SCHRÖDER, J.H. (1977): Testing mutagenicity in mice by scoring agonistic behaviour of males. – *Ber. nat.-med. Ver. Innsbruck* **64**: 171 - 177.
- SEARLE, A.G., C.E. FORD, E.P. EVANS, C.V. BEECHY, M.D. BURTENSHAW and H.M. CLEGG (1974): The induction of translocations in mouse spermatozoa. – *Mutation Res.* **22**: 157 - 174.
- SIEGEL, S. (1956): *Nonparametric statistics for the behavioral sciences.* – McGraw-Hill Kogakusha, Ltd., Tokyo: 104 - 111.

# ZOBODAT - [www.zobodat.at](http://www.zobodat.at)

Zoologisch-Botanische Datenbank/Zoological-Botanical Database

Digitale Literatur/Digital Literature

Zeitschrift/Journal: [Berichte des naturwissenschaftlichen-medizinischen Verein Innsbruck](#)

Jahr/Year: 1979

Band/Volume: [66](#)

Autor(en)/Author(s): Schröder Johannes Horst

Artikel/Article: [Hereditary changes of male aggressiveness after gamma irradiation of mouse spermatozoa with 600 R. 131-137](#)