A Preliminary Assessment of Radiation Effects on American Flagfish

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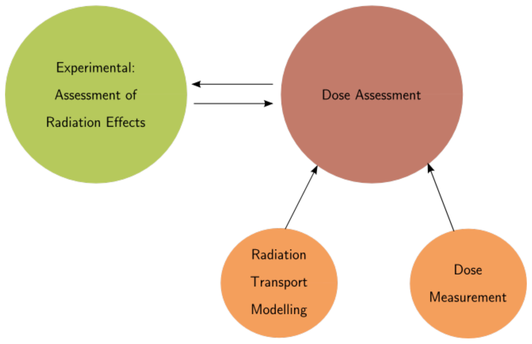
Abstract

It is important to define benchmark values for the effects of ionizing radition for a variety of species and to identify biological endpoints. To address this, an experimental set-up was designed to investigate effects from irradiation with Cs-137 on American Flagfish. Preliminary experiments were conducted by exposing Flagfish eggs to 44 h of ionizing radiation of four different dose rates. The observation of the developing fry showed no effect on hatching. The mortality and observed vertebral malformations were increased with increasing absorbed dose. One reoccurring malformation that became apparent at high dose rates after hatching but before absorption of the yolk sack is a bending of the spine. This is suspected to be a result of developmental defects in the embryonic stage.

Introduction



American Flagfish

- Freshwater species.
- Excellent test species: Short life-cycle of 90-120 days.
- Similar sensitivity as other commonly used test species to contaminants [1].

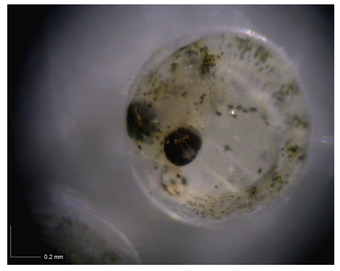


Fig. 1: Flagfish egg before hatching and Flagfish fry.

Experimental Design

Table 1: Number of eggs and radiation doses in each group.

Group	Number of Eggs	Dose [Gy] ±11.3 %
Group 1	41	8
Group 1 control	44	–
Group 2	60	11
Group 2 control	59	–
Group 3	70	13
Group 3 control	72	–
Group 4	71	17
Group 4 control	70	–

- Development of an irradiation set-up that minimizes environmental effects and self-shielding.
- Irradiation with a 7.85 Ci Cs-137 source (Hopewell G10 gamma beam irradiator) with dose rates of 3.03, 4.27, 4.82, 6.26 mGy/min
- Dosimetry performed with Landauer OSL nanoDots with an average percent error of 11.3%.

Figure 2: Set-up for the irradiated group in front of the source and the control group with a lead shield.

Observations

A) Hatchability and Mortality

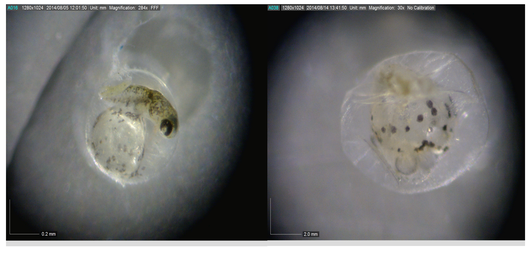


Figure 3: Malformed Flagfish egg and moribund egg.

Table 2: Hatchability of eggs and mortality of fry in percent.

Group	Hatchability [%]	Mortality [%]
Group 1	93	37
Group 1 control	95	30
Group 2	95	17
Group 2 control	95	7
Group 3	99	42
Group 3 control	100	0
Group 4	100	15
Group 4 control	99	1

B) Vertebral Malformations

Table 3: Percent of vertebral malformations in fry.

Group	Vertebral Malformations [%]
Group 2	5
Group 2 control	2
Group 3	14
Group 3 control	3
Group 4	42
Group 4 control	13

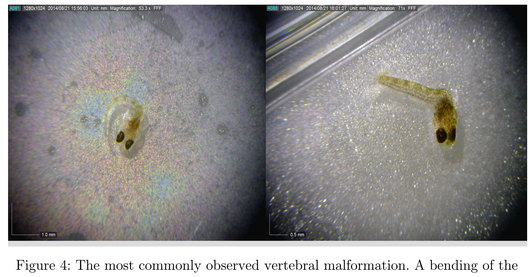


Figure 4: The most commonly observed vertebral malformation. A bending of the spine that results in motion impairment.

Conclusions

- Successful design of an experiment with less than 5% mortality in the control group.
- Long-term survival: increase of mortality with dose (reaching 40% at doses over 13 Gy).
- Suspected decrease in hatching time with increasing exposure.
- No effect of ionizing radiation on hatchability which is in contrast to what studies of Medaka have shown.
- Suspected developmental defects in the embryonic stage that lead to the observed vertebral malformations, agreeing with previous observations of radiation effects on Medaka [2]. These malformations lead to motion impairment of the specimen and are suspected to lead to higher mortality rates.

Future Work

- 30 day experiments to determine long-term effects and measurement of the LD-50/30, expected at 25 Gy [3].
- Investigation of dose-rate and effects of fractionated exposure for comparison with the findings for Medaka and other freshwater species.
- Generation spanning experiments to investigate inherited defects.
- Investigation of other irradiation methods, mainly low energy X-ray irradiation.

References

[1] Foster, N. R., Cairns, J., and Kaesler, R. L., 1969. The flagfish, Jordanella floridae, as a laboratory animal for behavioral bioassay studies. Proceedings of the National Academy of Science Philadelphia, Vol. 121, pp. 129-152

[2] Etoh H. and Hyodo-Taguchi Y. 1993, "Vertebral malformations in Medaka (teleost fish) after exposure to tritiated water in the embryonic stage.", Rad. Res., Vol. 135, Iss. 3, 1993, pp. 400-404.

[3] W.W. Kuhne et al, 2009 "Biological effects of high-energy neutrons measured in vivo using a vertebrate model", Radiat. Res., Vol. 172, Iss. 4, 2009, pp. 473-480.

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