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Effects of Robot Fish in Animal Welfare for Aquaculture Applications: Preliminary Studies

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***Abstract* – This paper describes the mini free swimming robots implemented and improved to carry out the behavioural experiments with zebrafish and how the data was collected and analysed to measure stress in the behavioural responses of the fish by studying different evaluative measures.**

Keywords - Aquaculture, robot-fish, fish behaviour, robot biomimicry, behavioural experiments.

I. INTRODUCTION

In this paper several conceptual models from the study of anxiety in zebrafish (Danio Rerio) to study the stress generated by different components are used as well as new designs of mini-robot fish, in order to apply the results to the optimisation of robotic biomimicry. Until now, most of the experiments used fish mock-up models driven by elements external to the tank, whereas this study uses free-swimming robots to study the interactions between the robot and an individual zebrafish under more realistic conditions. A preliminary phase of prototypes and experiments were outlined in [1]. Since then, these prototypes have been improved to evaluate the responses of zebrafish to different types of actuators and electronics, and the experiments have been redesigned to study behavioural responses based on evaluative measures that can be measured in all three dimensions of the tank. The results obtained have been statistically analysed using different data analysis software.

II. MATERIALS AND METHODS

Thanks to the preliminary tests that had already been carried out, behavioural tests that would allow to obtain more accurate results were planned. To record the experiments in three dimensions, two cameras [2] were used simultaneously to record the tank from the front and top planes. For the experiments carried out at the facilities of the Institute of Aquaculture of Torre la Sal, a 27x22x15 cm tank was used where the interaction of a total of 32 real fish with the different types of mini-robots was recorded. Each robot fish model was tested 7 times with a duration of 7.5 minutes per each recording. In addition, recordings of a control group were made where only the behaviour of the real fish was studied without any disturbance in order to have reference values.

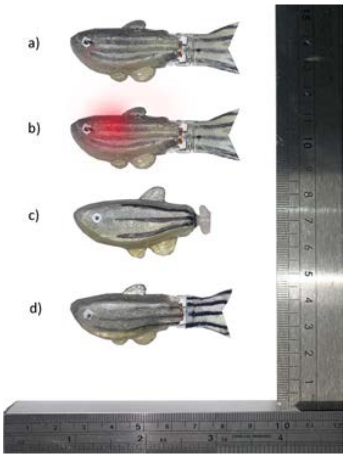

Fig 1. Robot Fish Models. a) Electromagnetic tail model; b) Electromagnetic tail model with a red led light; c) Propeller tail model; d) Model without electronics.

III. STATISTICAL ANALYSIS

Based on the behavioural patterns analysed in the literature [3][4][5], the evaluative measures that have been studied are: the proportional time that the real fish pass in top area of the tank, the number of visits to this area, the proportional time that it spends on the perimeter area, the accumulated euclidean distance between the robot and the real fish, the percentage of time that the real fish is in freezing, the euclidean velocity, the accumulated tracking distance and the velocity dispersion.

Thanks to image analysis software applied to animal behaviour, EthoVision®XT software (NoldusInc.,Wageningen,TheNetherlands) and AnimalTA [6] , the behaviours and trajectories of the fish and the robots were analysed, from which the x,y,z coordinates and the aforementioned parameters could be obtained. From here, SPSS and Origin software were used to carry out statistical analyses to make comparisons between the groups and to obtain graphs illustrating the results obtained.

IV. RESULTS

In the graphs obtained from the analysis of some of the aforementioned evaluative measures, differences in patterns and trends can be observed. This is true for measurements of the speed (Fig 2.), the Euclidean distance between the robot and the fish with respect to the speed and the positioning of the fish in the tank over time.

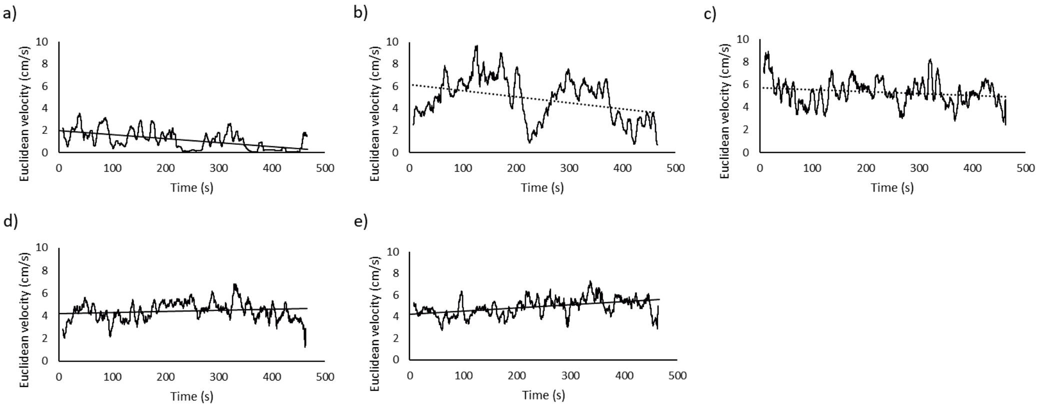

Fig 2. Reference velocities of how most real fish behaved when interacting with a) Electromagnetic tail model; b) Electromagnetic tail model with a red led light; c) Propeller tail model; d) Model without electronics; e) No robot

However, when statistically analysing the evaluative measures, using the one-factor anova procedure, working on the hypothesis of equality of means, using the test of homogeneity of variances, on the hypothesis of equality of variances, and applying the post hoc tests, for a confidence factor of 95%, it has been concluded that it can only be stated that there are significant differences between the population means of the fish tested with the “Electromagnetic tail model with a red led light” and those of the model fish used as a reference, for the evaluative measure of “Proportion time in top”.

In the same way, significant differences were found between the population means of the “Electromagnetic tail model”, the “Electromagnetic tail model” and the “Model without electronics”, for the “Number of visits to top” measure and between the “Electromagnetic tail model” the “Electromagnetic with light model” and “Propeller tail model”, for the measure of “Proportion time on the perimeter”.

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