Fish as Research Tools: Alternatives to In Vivo Experiments

Marlien Schaeck,1 Wim Van den Broeck,1 Kathleen Hermans2 and Annemie Decostere1

1Ghent University, Faculty of Veterinary Medicine, Department of Morphology, Merelbeke, Belgium; 2Ghent University, Faculty of Veterinary Medicine, Department of Pathology, Bacteriology and Poultry Diseases, Merelbeke, Belgium

Summary — The use of fish in scientific research is increasing worldwide, due to both the rapid expansion of the fish farming industry and growing awareness of questions concerning the humane use of mammalian models in basic research and chemical testing. As fish are lower on the evolutionary scale than mammals, they are considered to be less sentient. Fish models are providing researchers, and those concerned with animal welfare, with opportunities for adhering to the Three Rs principles of refinement, reduction and replacement. However, it should be kept in mind that fish should also be covered by the principles of the Three Rs. Indeed, various studies have shown that fish are capable of nociception, and of experiencing pain in a manner analogous to that in mammals. Thus, emphasis needs to be placed on the development of alternatives that replace, as much as possible, the use of all living vertebrate animals, including fish. This review gives the first comprehensive and critical overview of the existing alternatives for live fish experimental studies. The alternative methods described range from cell and tissue cultures, organ and perfusion models, and embryonic models, to in silico computer and mathematical models. This article aspires to guide scientists in the adoption of the correct alternative methods in their research, and, whenever possible, to reduce the use of live fish.

Key words: alternatives, animal experiments, cell culture, computer models, fish, mathematical models, organ culture, Three Rs.

Address for correspondence: Marlien Schaeck, Ghent University, Faculty of Veterinary Medicine, Department of Morphology, Salisburylaan 133, B-9820 Merelbeke, Belgium.
E-mail: Marlien.Schaeck@UGent.be

Introduction

Over recent decades, the use of fish as research animals has increased significantly on a global scale (1–5). This increase can, to a large extent, be traced back to the rapid expansion of the fish farming industry. Nowadays, aquaculture is the fastest growing food-production sector worldwide, whereas traditional fisheries are in decline (6). Consequently, an increasing amount of research is being conducted on the conditions that maximise the growth and quality of cultivated fish, which is mainly focused on nutrition, the rearing environment, overall management, and disease control. In addition, due to the growing awareness of the possible negative environmental impacts of aquaculture practices, greater emphasis is being placed on research that aims to minimise pollution and maximise both the conservation and protection of freshwater and marine ecosystems.

In addition, fish are increasingly being used as substitutes for mammalian model organisms in fundamental research, and as a research model for chemical testing. The debate on the use of fish instead of mammals started over 25 years ago (7), due to increasing awareness of the importance of the humane use of ‘higher’ vertebrates in research and testing. Also, researchers have increasingly recognised that a comparative approach is often useful for revealing new information about biological systems of interest. Fish represent the oldest and most diverse class of vertebrates, comprising around 48% of the known extant species in subphylum Vertebrata. Their evolutionary position relative to those of other vertebrates, together with their high adaptive capacities, makes them valuable objects for study in various branches of biology. As a consequence, fish are being used as experimental models in studies on biomedicine, cancer, developmental biology, ecology, environmental toxicology, endocrinology, gerontology, genetics, molecular evolution, neurobiology, and pharmacology. Overall, it could be stated that fish have played a critical role in the development of several research disciplines (8, 9).

Accurate data on the number of fish used worldwide for experimental purposes are not available, due to a lack of common international practice in regulating and recording animal experiments (4, 10). Europe is home to the most comprehensive legal protection of animals and the strictest reporting of the number of research animals, including fish (11). In 2006, the UK’s overall number of scientific procedures on fish was 270,000 (12), but this number had more than doubled to 563,903 in 2011 (13). The statistics for the European Union