Welfare of bivalves in aquaculture?

A first literature scan and plan for a comprehensive search

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Summary

The welfare of the animals that we produce for our food consumption is increasingly becoming a socially relevant topic. In bivalves, however, assessing their welfare in aquaculture is not common practice. There is still a lot of uncertainty regarding the question on whether bivalves are sentient beings and whether welfare is a relevant topic in the production of bivalves or not.

On behalf of the Dutch Shellfish Quality Foundation (SKS, Stichting Kwaliteit Schelpdieren) and the Foundation for the Protection of Fish (Stichting Vissenbescherming), Wageningen Marine Research (WMR) started a literature search in the Scopus database to assess whether the literature about welfare issues surrounding bivalves in aquaculture already exists.

During the literature search in Scopus, no scientific papers that were specifically focused on the welfare of bivalves in aquaculture could be located. In addition, no papers were found which directly provided evidence to show whether bivalves are sentient or not. However, a few scientific studies focusing on the behavioural adaptations in bivalves to the presence of predators (Robson et al., 2010; Garner & Litvaitis, 2013), learning in bivalves (Selbach et al., 2022) and information on the physiological role of serotonin (Liu et al., 2018) could be identified. These types of papers indicate that bivalves might indeed be sentient. However, the quantity and nature of these available biological studies do not sufficiently demonstrate a firm conclusion that the welfare of bivalves in aquaculture is a relevant topic at the moment. On the other hand, these studies do provide evidence, although very limited, that bivalves can perceive feelings and are even capable of learning.

Our report describes the start of a literature search and a route map towards a comprehensive literature study on the welfare of farmed bivalves in the Scopus database. A thorough evaluation of the identified literature was not carried out, as this was beyond the assignment given by the sponsors. Therefore, we recommend a follow-up project to initiate a complete literature review that would provide a clear description of what is known about the sentience, instead of welfare, of bivalves. We would recommend to focus more on sentience as aanimal welfare is relevant when an organism is sentient. Moreover, by conducting a more-extensive literature review, knowledge gaps regarding the sentience of bivalves could hopefully then be identified and elaborated upon. Subsequently, based on these knowledge gaps, experimental studies can then be designed to answer the fundamental question of whether bivalves are sentient and whether bivalve welfare is indeed a relevant topic in aquaculture.

1 Contents

2 Introduction

2.1 Background

More and more people are concerned about the welfare of animals being produced for human food consumption. Until two decades ago, the focus of this concern has mainly centred around the welfare of farm animals such as cattle, pigs and poultry. Since then, the interest over animal welfare in aquaculture has been increasing substantially. This is especially true for the welfare of farmed fish. The number of published scientific studies on fish welfare is continually expanding (e.g. Kristiansen et al., 2020). These studies enhance our understanding of the factors that have a positive or negative effect on the welfare of farmed fish. However, a substantial part of the total global marine production for human consumption consists of the production of bivalves (Wijsman et al., 2019). These are a group of aquatic animals in the phylum, mollusca, and have a soft body enclosed in a hard, hinged shell. Yet presently, the assessment of the welfare of invertebrates, such as bivalves, in aquaculture is not common practice.

In addition, there is no clear-cut definition for animal welfare in general. For the purpose of our project, we decided to use the definition of Duncan, 2006.

"Welfare is a wide term that embraces both the physical and mental well-being of the animal. Any attempt to evaluate welfare, therefore, must take into account the scientific evidence available concerning the feelings of animals that can be derived from their structure and functions and also from their behaviour".

Animal welfare is relevant when an organism has some degree of sentience (Proctor, 2012). Being sentient means that an organism is able to have positive and negative experiences caused by external influences or sensations within the body. A question that arises is whether bivalves have some degree of sentience and, if so, which welfare issues would need to be addressed in the production of bivalves for food.

2.2 Knowledge question

The Dutch Shellfish Quality Foundation (SKS, Stichting Kwaliteit Schelpdieren) and the Foundation for the Protection of Fish (Stichting Vissenbescherming) asked Wageningen Marine research to start a literature search on what is known from the existing scientific literature about the welfare of cultured bivalves. An in-depth review is not part of this work. In this report, we only present the results from a preliminary literature search as a first step in the research on the welfare of bivalves.

2.3 Acknowledgements

We would like to thank Paul Denekamp MSc (Stichting Vissenbescherming), Wouter van Zandbrink MSc (SKS), en Addy Risseeuw MSc (SKS) for the fruitful discussions. We also want to thank dr Ruud van den Bos for sharing his knowledge on cognition and emotions in animals.

3 Method

3.1 Project process

The Dutch Shellfish Quality Foundation (SKS, Stichting Kwaliteit Schelpdieren) and the Foundation for the Protection of Fish (Stichting Vissenbescherming) were the sponsors of this project. Two meetings were organized with the sponsors during the project. The research question and the method, including the literature search terms, were discussed during the kick-off meeting. During the second meeting, the initial results were discussed. Because no relevant papers on the welfare of bivalves were found during the first part of the project, dr Ruud van den Bos from Wageningen University was consulted as an expert in the field of cognition and emotions in animals. He advised us to add search terms that focused on the learning ability and nervous system of bivalves, as these kinds of key terms may give an indication over the concept of sentience. The results of the search queries were discussed with the sponsors. The final results, conclusions and recommendations were then shared during a presentation to the Shellfish Welfare Focus Group.

3.2 Search strategy

For this literature search, the Scopus database was used. Scopus is Elsevier's abstract and citation database, which was launched in 2004. It covers nearly 36,377 titles from approximately 11,678 publishers, out of which 34,346 are peer-reviewed journals.

In order to produce a preliminary list of scientific papers addressing welfare issues in farmed bivalves, it was important to construct a comprehensive search strategy. This means that the search terms used in a database are tested and determined beforehand. This is especially important since the quality of the search strategy could affect how the papers will be assessed in terms of eligibility and inclusion in a future literature study. It was therefore an important phase that constituted the core of our work. There are several scientific approaches to working towards an efficient search strategy (Bramer et al., 2018). In most of these approaches, it is especially important to determine a clear and focused question, to determine which key concepts address the different elements in this question, to determine the key index terms that match the key concepts and to check for search errors, for example, by testing search terms in other databases. An example of steps that can be taken to formulate a search strategy are described in Bramer et al., 2018:

1. Determine a clear and focused question: *"What literature can we find about welfare issues in cultured bivalves."*
2. Decide which key concepts address the different elements of the question
3. Decide which elements should be used for the best results
4. Choose an appropriate database and interface to start with
5. Document the search process in a text document
6. Identify appropriate index terms in the thesaurus of the first database
7. Identify synonyms in the thesaurus (synonym dictionary)
8. Add variations in search terms
9. Use database-appropriate syntax, with parentheses, Boolean operators, and field codes
10. Optimize the search
11. Evaluate the initial results
12. Check for errors

Please note that our study is only the start of a comprehensive literature search.

3.3 Quick scan of the Scopus results

The results of the search queries used in Scopus consisted of a long lists of papers. To determine whether this list might contain papers that discussed the welfare, or later in the project process, the sentience of bivalves, the title, key words and abstract of the 20 most-relevant papers (accordingly to Scopus) were quickly scanned with the help of a small check list.

1. Is it a peer-reviewed book chapter or scientific article with an impact factor?
2. Is the main study subject a bivalve?
3. Does the paper provide evidence for the bivalve showing a behavioural response to positive or negative stimuli?
4. Does the paper provide evidence for the bivalve showing a physiological/neurophysiological response to positive or negative stimuli?
5. Does the paper provide evidence that the physiological/neurophysiological or behavioural response is related to welfare in bivalves?
6. Does the article provide evidence that the physiological/neurophysiological or behavioral response is directly caused by aquaculture practices?

4 Results

4.1 Key concepts and index terms

In our literature search, we focused on 5 key concepts (table 1), namely: bivalves, aquaculture, welfare, sentience and nervous system. The concepts of bivalves, aquaculture and welfare arise directly form the research question: *'What is known in scientific literature about the welfare of farmed bivalves'.* Because sentience is seen as a key issue in the discussion of the welfare of animals, the key concepts of sentience, learning ability and nervous system were added. For each concept, we proposed possible keywords and synonyms that could be of interest in the search queries. Table 1 gives a list of all of the key index terms used in the search queries entered in Scopus.

Table 1: Key concepts and index terms used in the literature search

KEY CONCEPTS	KEY INDEX TERMS
BIVALVES	Bivalv*, clam, cockle, mollusc*, mussel, shellfish, oyster, scallop
AQUACULTURE	Aquaculture, "shellfish culture", farm*, production
WELFARE	Welfare, "well being", wellbeing, pain, stress
SENTIENCE	Awareness, behaviour, behavior, sentience, sentient, nociception, self-aware, conscious
LEARNING	learn*, memory
NERVOUS SYSTEM	"Nervous system", serotonin, transmitter, "sensory neurons", ganglia

4.2 Search queries

Ultimately, too many search queries were constructed to list them all. In Table 2, we show examples of the main search queries used in Scopus. By removing or adding key index terms, many variations of these queries could be made. During the literature search in Scopus, no scientific papers on the welfare of bivalves in aquaculture were found. In addition, no papers were found that directly showed evidence of bivalves being sentient beings. However, a few scientific studies were found on behavioural adaptations in bivalves to the presence of predators (Robson et al., 2010; Garner & Litvaitis, 2013), learning in bivalves (Selbach et al., 2022) and information on the physiological role of serotonin (Liu et al., 2018).

Table 2: An example of select search queries used in Scopus

1	(bivalv* OR clam* OR cockle* OR mollusc* OR mussel* OR shellfish OR oyster* OR scallop*) AND (aquaculture OR "shellfish culture", OR farm* OR production) AND (welfare OR "well being" OR wellbeing OR pain OR stress)
2	(bivalv* OR clam* OR cockle* OR mussel* OR shellfish OR oyster* OR scallop*) AND (aquaculture OR "shellfish culture", OR farm* OR production) AND (welfare OR "well being" OR wellbeing)
3	(bivalv* OR mussel* OR oyster*) AND (aquaculture OR "shellfish culture", OR farm* OR production) AND (welfare OR "well being" OR wellbeing)
4	(bivalv* OR oyster* OR mussel*) AND (sentience OR sentient OR nociception)
5	(bivalv* OR oyster* OR mussel*) AND (learn*) AND (behavior* OR behaviour*) AND ("nervous system" OR transmitter)
6	(bivalv* OR oyster* OR mussel*) AND (learn*) AND (behavior* OR behaviour*)

5 Conclusions and discussion

5.1 Evaluation of query results

No scientific papers regarding the welfare of bivalves in aquaculture or papers that directly demonstrated evidence for sentience in bivalves were found in our literature search in Scopus. The very few scientific papers that we could find on the behavioural adaptations and learning behaviour of bivalves suggest that bivalves might be sentient. However, the reported studies provide very limited evidence that bivalves can perceive feelings or are capable of learning.Therefore, we can conclude that there are still large knowledge gaps regarding the sentience of bivalves.

As mentioned before, a key issue in the discussion of the welfare of animals is whether they are sentient and aware of what is happening around them (Broom, 2007). However, the question also remains on whether this means that non-sentient animals have moral status or not. It can be argued that, not only sentient organisms, but all living beings have intrinsic value. If natural entities have intrinsic value, this may imply that they should, or even have to, be considered in ethical issues.

5.2 Recommendations

Our report describes a first literature scan and plan for a comprehensive search on the welfare of farmed bivalves in the Scopus database. During the project process, we also added the question on whether we could find scientific papers that provided evidence for bivalves being sentient beings. A thorough evaluation of the literature that we did find was not carried out, as this was beyond the assignment given by the sponsors. We therefore recommend that a complete literature review be carried out which would formulate a clear description of what is known about sentience, instead of welfare, in bivalves. To do this, it is important to clearly define "sentience" and it is also advisable to break it down in different well-defined components such as "nervous system" and "learning ability". By conducting a more-extensive literature review, knowledge gaps on the sentience of bivalves can be described in greater detail. Based on these knowledge gaps, experimental studies could then be designed to answer the fundamental question of whether bivalves are sentient and whether bivalve welfare is, or should be, a relevant topic in aquaculture or not. We stress that the design of these kinds of experiments is challenging and requires a multi-disciplinary approach.

6 Quality Assurance

Wageningen Marine Research utilises an ISO 9001:2015 certified quality management system. The organisation has been certified since 27 February 2001. The certification was issued by DNV.

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Justification

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The scientific quality of this report has been peer reviewed by a colleague scientist and a member of the Management Team of Wageningen Marine Research

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