Zoology and Ecology, 2022, Volume 32, Number 1
Online ISSN: 2165-8013
https://doi.org/10.35513/21658005.2022.1.10

REVIEWS

FISH WELFARE IN UKRAINE

Natalia Matvienko[a*], Vitalii Nedosekov[b], Mykhailo Koziy[c] and Alla Kravchenko[b]

[a] Department of Ichthyopathology, Institute of Fisheries of the NAAS of Ukraine, Kyiv, Ukraine; email: mnarine73@ukr.net, [b] Department of Epizootology, Microbiology and Virology, National University of Life and Environmental Sciences, Kyiv, Ukraine; email: nedosekov06@gmail.com, [c] Department of Medical Biology and Physics, Microbiology, Histology, Physiology and Pathophysiology, Petro Mohyla Black Sea National University, Mykolaiv, Ukraine; email: kozij67@gmail.com

Natalia Matvienko – https://orcid.org/0000-0001-8849-0099
Vitalii Nedosekov – https://orcid.org/0000-0001-7581-7478
Mykhailo Koziy – https://orcid.org/ 0000-0001-8131-8528
Alla Kravchenko – https://orcid.org/0000-0001-5785-9148

*Corresponding author. Email: mnarine73@ukr.net

Matvienko N., Nedosekov V., Koziy M., Kravchenko A. 2022. Fish welfare in Ukraine. *Zoology and Ecology* 32(1), 84–89. https://doi.org/10.35513/21658005.2022.1.10

Article history
Received: 11 February 2022; accepted 02 May 2022

Keywords:
Fish welfare; critical aspects of welfare; fish farming; fish diseases

Abstract. Fish welfare is a very important aquaculture criterion that is affected by various factors. In Ukraine, fish welfare is unregulated, except for certain aspects of fish keeping, fishing rules and sanitation requirements. In general, legislation is too general and concise. Therefore, we carried out a study on several critical aspects of fish welfare in Ukraine: 1) fish farming management, 2) environmental factors and parameters of the aquatic environment in fish farming, 3) staff, 4) feeding, 5) fish behaviour and stocking density, 6) fish health, 7) impact of stressors on fish reproduction, and 8) antimicrobial resistance. The analysis shows problems in specialized fish farms, such as non-compliance with rearing technology, lack of quality feed and high feed cost. Analysis of the epizootic situation regarding fish diseases during the last 10 years shows that invasive and infectious diseases are recorded in almost all fishpond farms. Nosological profile pathogens were bacteria of genera *Aeromonas* (40%), *Pseudomonas* (28%), and *Edwardsiella*, *Proteus*, *Yersinia*, *Flavobacterium*, and *Micrococcus* (all five accounting for 32%). Analysis of the state of welfare indicates the need to develop an evaluation system of fish welfare and its implementation in Ukraine. We consider that it is necessary to develop an algorithm for implementing the best practices of fish welfare based on assessment and research, improvement of legal framework, and implementation of effective programmes for the control of aquatic animal welfare.

INTRODUCTION

Aquaculture is a rapidly growing area of animal-origin food production. In 1990, aquaculture accounted for only 13% of the total world supply of fish, in 2010 it rose to 40%, and by 2018 it reached 62.5% (FAO 2016, 2020). Ukraine has a significant production potential and a history of the development of freshwater aquaculture (fish farming in inland waters), which is the third significant source of animal protein after cattle and poultry meat and contributes significantly to employment (Trofimchuk et al. 2021). The traditional aquaculture species are carp, silver carp, and grass carp. Additionally, aquafarmers also grow rainbow trout, European and clary catfish, pike, pike perch, tench, crucian, sterlet, Russian and Siberian sturgeon, bester, etc. (Trofimchuk et al. 2021). The total number of aquaculture enterprises is 4568, with various forms of ownership.

Ukraine has implemented Recirculating Aquaculture Systems (RAS) targeted on efficient production, reduction of environmental impact, and digitalization of production processes, which is important in conditions of expected deficit of water resources in Ukraine in the future (Public Report of the Head of the State Agency for Fisheries in Ukraine, 2020).

As aquaculture expands, so does our understanding of fish welfare; however, there are still large knowledge gaps (Saraiva et al. 2019). Fish welfare is a very important factor in aquaculture. It is affected by various aspects such as temperature, climate and environmental change, and so on. It is important in the context of the development of aquaculture farms to provide people with high-quality food products and to reproduce fish stocks in natural reservoirs (Brown and Day 2002; Huntingford et al. 2006).

There are certain peculiarities regarding fish welfare legislation. The Animal Welfare Act 2006 (UK) and The Animal Health and Welfare (Scotland) Act 2006 provide fish with a basic level of welfare and commit to prevent unnecessary suffering of fish. In 2014, the Farm Animal Welfare Committee (FAWC) presented a report on the welfare of farmed fish and current issues: health, social behaviour, transportation, genetics and feeding, as well as water quality as the most important criterion for fish welfare (FAWC 2014, OIE 2021).

However, despite a thorough research into the welfare of farmed animals in Ukraine (Nedosekov et al. 2020; Nedosekov and Krytsia 2021), information on fish welfare is extremely insufficient. Public awareness about welfare is low. Most importantly, fish farming needs to understand the problem of animal welfare and development of protocols and algorithms to take action (Turnbull 2022). In Ukraine, the issue of fish welfare has not been studied. Therefore, the aim of our work is to analyse this issue, identify critical aspects, and consider prospects for development and implementation at the national level.

DISCUSSION

An analysis of legislative aspects has shown that European Directive 2010/63 (2010) is an important step towards ensuring fish welfare. However, despite positive aspects, information on fish welfare and health is too general and concise in Ukraine. A broad biological diversity of fish species and their different physiological and behavioural needs are almost ignored. Very small species-specific features are taken into account, and no specific instructions or reference documents are provided for each type that laboratories could rely on. In comparison to the key principles previously set out in the Recommendation 2007/526/CE, the current Directive seems even shorter and laconic.

In Ukraine, fish welfare is unregulated, except for certain aspects of fish keeping, fishing rules and sanitation requirements. Several laws exist, such as the Law on Aquaculture (https://zakon.rada.gov.ua/laws/show/5293-17/card3#Files), the Law of Ukraine on State Control over Compliance with Legislation on Food Products, Feeds, Animal By-products, Veterinary Medicine and Animal Welfare No 2042-VIII from 18 May 2017 (https://zakon_ukrajini_pro_derzhavnij_0_0_0_7294_1.html/), and the Law of Ukraine on Fisheries Economy, Industrial Fishing, and Protection of Aquatic Bioresources No 3677 from 08 July 2011 (https://zakon2.rada.gov.ua/laws/show/3677-17). However, the presented laws only concern the problem of fish welfare and do not consider or implement welfare guidelines in fisheries.

Analysis of literature and our own research allowed us to consider the welfare of fish in terms of the following critical aspects: 1) fish farming management, 2) environmental factors and parameters of the aquatic environment in fish farming, 3) staff, 4) feeding, 5) fish behaviour and stocking density, 6) fish health, 7) impact of stressors on fish reproduction, and 8) antimicrobial resistance. Below we elaborate on each of these aspects.

1. Fish farming management. There are a number of aspects in the Ukrainian fish farming systems that complicate the assessment and management of fish welfare: a) a very large number of groups (more than 100,000 fish), b) limited opportunities for monitoring, inspection and identification of fish, and c) operational options (farms may consist of a system of ponds). Ensuring the welfare of farmed fish is challenging due to a large number of environmental and species-specific factors that need to be known, considered or controlled, including physico-chemical parameters of water, feeding, environmental impact, fish density and behaviour. In addition, the biological and behavioural needs of different species of fish are very different (e.g., trout *vs*. carp), which brings additional difficulties in understanding and managing fish.

Our analysis shows concerns in specialized fish farms in Ukraine as they exhibit systematic non-compliance with rearing technology. These concerns are related to the lack of systemic preparation of ponds for stocking, lack of quality feed and high feed cost, non-compliance with the feeding regime, and lack of systemic ichthyopathological research. However, in Ukraine proactive students at the National University of Life and Environmental Sciences perform such studies to complete their master's projects. Nevertheless, no systemic research has been conducted on fish welfare in Ukraine.

2. Environmental factors and parameters of the aquatic environment in fish farming. The natural aquatic environment is extremely diverse and offers places where fish can hide and feel safe, reducing stress and anxiety. However, in aquaculture pond systems fish cannot choose the habitat. Therefore, it is significant to create and harmonize the conditions of fish farming in order to ensure the proper behaviour of fish, their welfare and health while avoiding stress (Pounder et al. 2016). So, the enrichment to the captive environment thus promotes neural and behavioural changes that are likely to promote behavioural flexibility and improve post-release survival (Salvanes et al. 2013).

The key water factors that affect the welfare of fish are temperature, concentration of gases (O_2 and CO_2), pH, salinity, the presence of ammonia and nitrogen as metabolic by-products, chemical pollution (heavy metals and pesticides), as well as lighting, noise and vibration (Toni

et al. 2017). Analysis of the gas regime indicates that the reduction of oxygen to 2.5−2 mg/dm^3 leads to reducing the intensity of nutrition and metabolism in many fish (Kononenko et al. 2016). The main environmental factors are the deterioration of the aquatic environment and the anthropogenic overloading on reservoirs (Kozij and Matvienko 2017). The accumulation of conditional pathogenic bacteria can cause an outbreak of epizootics, due to the deterioration of water quality in the reservoir (Matvienko et al. 2020).

During 2016–2020, 279 samples of opportunistic bacteria were isolated from clinically healthy and sick fish from various fish farms of Ukraine (author's collection of microorganisms of the Department of Ichthyopathology of the Institute of Fisheries of the NAAS of Ukraine). Nosological profile pathogens revealed the dominating bacteria of genera *Aeromonas* (40%) and *Pseudomonas* (28%), while the remaining 32% were *Edwardsiella*, *Proteus*, *Yersinia*, *Flavobacterium*, and *Micrococcus*. An expert assessment of outbreaks indicates that epizootics had an associated manifestation. Unfortunately, in Ukraine, systematic research on fish welfare within the environmental context was not conducted.

3. Staff. An important point in maintaining the quality of life and welfare of fish is the involvement of qualified personnel that must be trained on welfare and thus have practical skills to work in the conditions of farms. This approach will allow implementation of fish welfare protocols. Staff should know the characteristics and signs of suffering, stress or positive welfare of fish species farmed, as well as to have the ability to assess the health of fish, understand the importance of changes in behaviour and assess fish welfare.

Key professionals (biologists, veterinarians and technologists) should be trained in universities. However, our analysis of training programmes on fish welfare in Europe showed a tendency to reduce teaching hours. In Ukraine, there has been no training of ichthyopathologists at veterinary faculties for 10 years, there are no master's programmes, and as a result significant shortage of staff for fish welfare is felt. In 2020–21, together with colleagues from the EU project Europe Aid/139852/DH/SER/UA (EU4 Safer Food) we developed recommendations for the improvement of the curriculum and programmes for the training of veterinary doctors. But a detailed consideration of animal welfare in the training of veterinarians is a topic of future research.

4. Fish feeding. Extremely crucial is the feeding of fish and the influence of certain environmental factors on the rational feeding of fish, which is assessed on the peculiarities of nutrition of certain species of fish in natural reservoirs (Zheltov and Matvienko 2013). Optimization of the process of sterlet feeding in recirculating aquaculture systems allows improving the physiological status and pre-spawning performance of fish (Matvienko et al. 2022). The Atlantic salmon reared in the enriched environment expressed higher feeding rates, and parr of wild origin started to forage earlier on natural prey (Rodewald et al. 2011). Feeding is one of the largest costs in a fish farm and can be one of the biggest stressors for fish (López-Olmeda et al. 2012). We believe that rationing feeding based on a complete and balanced diet to maintain the physiological condition of fish and the formation of full-fledged repair groups and breeders of fish is highly important.

In Ukraine, each farm uses its own rations, depending on the purpose. In Ukraine, for pond aquaculture of carp, several types of food are used such as grain mixtures, as well as granulated and extruded domestic feed production. For each age group, the appropriate balance between protein and fats is selected, and their feeding scheme is used. High-quality balanced feeds are used for sturgeon and salmon fish imported production (Oltek-Copens, Biomar, Aler-Aqua, Scratching).

5. Fish behaviour and stocking density of fish. Behaviour and fish density are the key factors of welfare, as fish social systems are often characterized as a combination of hierarchy of dominance and territoriality. Given that aggressive behaviour can disrupt metabolic and immune functions, it can lead to stress and injury (Huntingford et al. 2006; Ashley 2007). Perhaps, the fish familiarity is a key factor affecting shelter occupancy if the number of shelters was less than the number of conspecifics and available resources are primarily used on the basis of familiarity (Slavík et al. 2012). Therefore, one of the most difficult problems of fish welfare is managing collective behaviour.

Spatial patterns of behaviour were often tested depending on the stocking density that can be an indicator of stress, a lower fish growth rate and higher metabolic needs (Bégout and Lagardère 2004; Laursen et al. 2013). Data on social systems and behaviour of farmed fish species during feeding must be integrated to correctly determine density and modulate aggressive activity in aquaculture. Social systems of fish species are often based on social hierarchy, and the density of fish depending on the distribution and amount of food strongly affects the level of social interactions (Ashley 2007). Therefore, feeding behaviour and stocking density should be integrated with social behaviour of each fish species to reliably assess fish welfare.

6. Fish health. Fish health is a prerequisite for welfare. To assess the welfare of fish in aquaculture, it is necessary to constantly monitor fish diseases, with laboratory confirmation of pathogens and supervision. Analysis of the epizootic situation regarding fish diseases in Ukraine during the last 10 years shows that invasive and infectious diseases are registered in almost all fishpond farms. In

addition, the number of parasites and their species composition is significantly expanding. Thus, during clinical examinations and parasitological studies fish were found to be infested by ecto- and endoparasitic species such as *Apiosoma piscicola* (Blanchard 1885), *Chilodonella cyprini* (Moroff, 1902), *Ichtyophthirius multifiliis* (Fouquet, 1876), *Dactylogyrus vastator* (Nybelin, 1924), and *Gyrodactilus* spp., etc. (Matvienko et al. 2015).

In aquaculture farms of Ukraine, there has been a stable trend in the spread of various fish diseases. This situation is due to the disregard of preventive measures. Of course, parasitic infestation affects fish welfare and health, but from a farming biosecurity perspective it is also extremely important to avoid cross-contamination of pathogens from one farm to another, which are located in different geographical zones. So, the main task today is the prevention of pathogen introduction into aquaculture farms (Matvienko et al. 2020). The critical point is the timely identification (laboratory diagnosis) of fish diseases, as well as monitoring of the immune status of fish. Implementing effective approaches will promote safe and high quality products, as well as ensure fish health.

Analysis of the ichthyopathological situation in Ukraine in the period from 2016 to 2020 shows that infectious diseases were registered in all types of farms with a prevalence of 38% (versus 36% in the period of 2010–2015). Invasive diseases were found in 52% (versus 43% in period of 2010–2015), and nutritional diseases in 10% of cases. Thus, every fish farm has its own structure of pathogens, requiring a detailed study and analysis.

7. Influence of stressors on fish reproduction. Fish welfare in early stages begins with broodstock welfare. Welfare should be understood as a continuous link between generations that connects adaptation of offspring with the resources of parents. Parents' experience (food, social, ecological), especially during gametogenesis, is important for offspring (Best et al. 2017). The influence of the environment on embryogenesis varies in different species of fish, alters the normal development of fish larvae and thus the fish may not cope with some environmental conditions (Labbé et al. 2017). The impact of environmental conditions is not a trivial problem that requires constant monitoring in the future to avoid fish welfare problems (Aleström et al. 2020).

Feeding has a direct effect on fish welfare during the larval and juvenile period. The use of live feed for larval feeding (*Artemia*, paramecia and rotifers) allows the fish to behave like a predator and also provides the larva with valuable nutrients such as polyunsaturated fatty acids (Monteiro et al. 2018; Martins et al. 2019). Probiotics have also been proven to improve welfare by modulating immunity or bowel function (Davis et al. 2016).

An important stress factor both for fertilized caviar and for adult fish is transportation, especially in uncontrolled temperature and gas regimes. Good practice shows that farm owners usually import fertilized eggs in special containers. However, due to inadequate isolation and temperature at the time of transportation, fertilized eggs can be exposed to extreme temperatures.

In the early stages of development, fish are highly sensitive to many types of stressors, including many reactions that can affect fish and be passed on to offspring. The welfare of eggs and larvae is a continuous process that includes both parenting experience and development. Therefore, environmental parameters must be monitored throughout the animal's lifetime, but especially at the stages of gametes and organogenesis (Ramos et al. 2021).

Research on the transportation of fish and caviar in Ukraine was conducted fragmentary and non-systematically. Therefore, standard protocols should be developed including all environmental parameters, as well as indicators related to stress and welfare of fish.

8. Antimicrobial resistance. Antimicrobials are used for therapeutic purposes in diseases of larvae and juvenile fish, mainly in salmon and sturgeon. However, they are not used for most commercial fish. The level of antibiotic use in aquaculture in Ukraine is not high. It is connected with the fact that valuable fish species are grown in RAS conditions, where biofiltrationis used, so the systematic use of antibiotics will lead to its ineffectiveness. That is why specialized farms are looking for opportunities for young sturgeon and salmon fish to use alternatives to antibiotics, including prebiotics and probiotics (Vashchenko et al. 2017).

Antibiotics can be used for young valuable fish species in the period of up to 4 months and only on the recommendation of ichthyopathologists after sensitivity testing in the laboratory. Upon reaching the marketable condition, the residual amount of antibiotics in the mass of fish is not detected. As for carp, then the use of antibiotics is limited by the specifics of their introduction and the significant cost of drugs themselves. But it is important to raise awareness among farmers of not using antibiotics without vet expert advice. Therefore, in order to prevent the development of antibiotic resistance, a list of drugs is being developed for use in fisheries, which will be approved by the order of the Ministry of Agriculture.

CONCLUSION

Fisheries, especially aquaculture, need more scrutiny on fish welfare. To monitor and evaluate the welfare of fish, it is necessary to create a group of experts utilizing modern approaches and methodologies. This will enable the assessment and development of welfare recommendations and management protocols.

Assessment of fish welfare in Ukraine is either absent or sporadic and mainly focused on individual indicators of fish health and assessment of cultivation conditions. Ukraine needs to establish criteria and develop a system assessing fish welfare, improving the legal framework and implementing practice. The adoption of welfare protocols will raise the level of fish welfare and will improve the management of specialized fish farms. The absolute priority is to identify risk factors and the likely occurrence of negative fish welfare and the development of legislation on the welfare of fish in Ukraine in the near future.

Analysis of the state of the problem regarding the status of fish in legislation revealed significant differences in Ukraine and Europe. In 2021, the Parliament of Ukraine adopted a new Law on Veterinary Medicine, which is as close as possible to the European legislation. The law addresses the key health and safety issues ensuring animal welfare. However, we think that the provisions of this law are not sufficient to fully ensure the welfare of fish and need to be updated.

To ensure the welfare of fish, it is necessary to have adequate knowledge of the biology of fish species and related equipment and welfare protocols, taking into account both biodiversity and features of ecological conditions of each species.

The competence and education of specialists (veterinarians, biologists, and technologists) are an important focus of fish welfare programmes. This requires connection to the EU standards for the organization of the educational process, promoting fish farmers, ichthyologists, hydrochemists and ichthyopathologists among students and novices, and also cooperation with international universities on the organization of educational programmes and internships.

As a conclusion, we believe that it is necessary to develop an algorithm for implementing the best practices of fish welfare in Ukraine based on the animal welfare assessment, improvement of legal framework, research on fish welfare, and implementation of effective programmes for the control of aquatic animal welfare.

COMPETING INTEREST

The authors declare that they have no competing interest.

ACKNOWLEDGMENTS

We are most grateful to two anonymous reviewers for their helpful comments.

REFERENCES

Aleström, P., D'Angelo, L., Midtlyng, P.J., Schorderet, D.F., Schulte-Merker, S., & Sohm, F. 2020. Zebrafish: housing and husbandry recommendations. *Laboratory Animals* 54(3), 213–24. https://doi.org/10.1177/0023677219869037

Ashley, P. 2007. Fish welfare: current issues in aquaculture. *Applied Animal Behaviour Science* 104, 199–235.

Bégout Anras, M.L., & Lagardère, J.P. 2004. Measuring cultured fish swimming behaviour: first results on rainbow trout using acoustic telemetry in tanks. *Aquaculture* 240, 175–186.

Best, C., Kurrasch, D.M., & Vijayan, M.M. 2017. Maternal cortisol stimulates neurogenesis and affects larval behaviour in zebrafish. *Science Reports* 7, 40905. https://doi.org/10.1038/srep40905 4

Brown, C., & Day, R.L. 2002. The future of stock enhancements: Lessons for hatchery practice from conservation biology. *Fish and Fisheries* 3(2), 79–94. https://doi.org/10.1046/j.1467-2979.2002.00077.x

Davis, D.J., Bryda, E.C., Gillespie, C.H., & Ericsson, A.C. 2016. Microbial modulation of behaviour and stress responses in zebrafish larvae. *Behavioural Brain Research* 311, 219–27. https://doi.org/10.1016/j.bbr.2016.05.040

FAO. 2016. *The State of World Fisheries and Aquaculture 2016. Contributing to food security and nutrition for all*. Rome, 200 pp. https://www.fao.org/3/i5555e/i5555e.pdf

FAO. 2020. *The State of World Fisheries and Aquaculture 2020. In brief. Sustainability in action*. Rome. https://doi.org/10.4060/ca9231en

FAWC. 2014. *Opinion on the Welfare of Farmed Fish*, *FAWC*. http://www.defra.gov.uk/fawc/advice-2/opinions/

Huntingford, F.A., Adams, C., Braithwaite, V., Kadri, S., Pottinger, T., Sandøe, P., & Turnbull, J. 2006. Current issues in fish welfare. *Journal of Fish Biology* 68, 332–372.

Kononenko, R.V., Shevchenko, P.G., Kondratyuk, V.M., & Kononenko, I.S. 2016. *Intensivni tekhnologiï v akvakul'turi*. Kyiv, Tsentr uchbovoï literaturi. [Intensive technologies in aquaculture]. Kyiv. Center for Educational Literature, Ukraine, 410 pp.

Kozij, M.S., & Matvienko, N.N. 2017. Bioindication of Natural Waters Using a Histological Analysis of the *Carassius Auratus* Mesonephros Structure. *Journal of Water Chemistry and Technology* 39(3), 177–180. https://doi.org/10.3103/S1063455X17030109

Labbé, C., Robles, V., & Herraez, M.P. 2017. Epigenetics in fish gametes and early embryo. *Aquaculture* 47, 96–103. https://doi.org/10.1016/j.aquaculture.2016.07.026

Laursen, D.C., Andersson, M.A., Silva, P.I., Petersson, E., & Höglund, E. 2013. Utilising spatial distribution in two-tank systems to investigate the level of aversive-

ness to crowding in farmed rainbow trout *Oncorhynchus mykiss*. *Applied Animal Behaviour Science* 144, 163–170.

López-Olmeda, J.F., Noble, C., & Sánchez-Vázquez, F.J. 2012. Does feeding time affect fish welfare? *Fish physiology and biochemistry* 38(1), 143–152. https://doi.org/10.1007/s10695-011-9523-y

Martins, G., Diogo, P., Pinto, W., & Gavaia, P.J. 2019. Early transition to microdiets improves growth, reproductive performance and reduces skeletal anomalies in zebrafish (Daniorerio). *Zebrafish* 16, 300–7. https://doi.org/10.1089/zeb.2018.1691

Matvienko, N., Vaschenko, A., Tsiganok, I., & Buchatsky, L. 2015. Results of Surveillance Studies of Infectious Fish Diseases in Freshwater Aquaculture Ukraine. *Agricultural Science and Practice* 2(2), 32–38. https://doi.org/10.15407/agrisp2.02.032

Matvienko, N., Levchenko, A., Danchuk, O., & Kvach, Y. 2020. Assessment of the occurrence of microorganisms and other fish parasites in the freshwater aquaculture of Ukraine in relation to the ambient temperature. *Acta Ichthyologica Et Piscatoria* 50(3), 333–348. https://doi.org/10.3750/AIEP/02979

Matvienko, N., Koziy, A., Didenko, A., & Sherman, I. 2022. Assessment of the Effect of Catosal on the Stimulation of Ovogenesis in Sterlet During PreSpawning Period. *Aquaculture Studies* 22. http://doi.org/10.4194/AQUAST583

Monteiro, J.F., Martins, S., Farias, M., Costa, T., & Certal, A.C. 2018. The impact of two different cold-extruded feeds and feeding regimens on zebrafish survival, growth and reproductive performance. *Journal of Developmental Biology* 6, 15. https://doi.org/10.3390/jdb6030015 27

Nedosekov, V., & Krytsia, Y. 2021. Welfare problems of horses. *Naukovi dopovidi NUBiP Ukraïni* 2, 90. http://dx.doi.org/10.31548/dopovidi2021.02.011

Nedosekov, V., & Petkun, H. 2021.Welfare of dairy animals. *Naukovi dopovidi NUBiP Ukraïni* 4, 92. doi: http://dx.doi.org/10.31548/dopovidi2021.04.011

Nedosekov, V.V., Kravchenko, A.G., Kleimenov, I.S., & Kleimenova, N.V. 2020. Welfare of laying hens in the industrial production. *Vestnik agrarnoi nauki* 4(85), 66–77. https://doi.org/10.17238/issn2587-666X.2020.4.66

OIE. 2021. *Aquatic Animal Health Code. Introduction to recommendations for the welfare of farmed fish*. https://www.oie.int/en/what-we-do/standards/codes-and-manuals/aquatic-code-online-access/?id=169&L=1&htmfile=chapitre_welfare_introduction.htm

Pounder, K.C., Mitchell, J.L., Thomson, J.S., Pottinger, T.G., Buckley, J., & Sneddon, L.U. 2016. Does environmental enrichment promote recovery from stress in rainbow trout? *Applied Animal Behaviour Science* 176, 136–142.

Public report of Head of the State Fisheries Agency of Ukraine for 2020. https://darg.gov.ua/_publichnij_zvit_golovi_0_0_0_10694_1.html#:~:text

Ramos, J., Balasch, J.C., & Tort, L. 2021. About Welfare and Stress in the Early Stages of Fish. *Frontiers in Veterinary Science* 8, 634434. https://doi.org/10.3389/fvets.2021.634434

Rodewald, P., Hyvärinen, P., & Hirvonen, H. 2011. Wild origin and enriched environment promote foraging rate and learning to forage on natural prey of captive reared Atlantic salmon parr. *Ecology of Freshwater Fish* 20, 569–579.

Salvanes, A.G., Moberg, O., Ebbesson, L.O., Nilsen, T.O., Jensen, K.H., & Braithwaite, V.A. 2013. Environmental enrichment promotes neural plasticity and cognitive ability in fish. *Proceedings of the Royal Society B: Biological Sciences* 280, 1331.

Saraiva, J., Arechavala-Lopez, P., Castanheira, M., Volstorf, J., & Heinzpeter Studer, B. 2019. A Global Assessment of Welfare in Farmed Fishes: The Fish EthoBase. *Fishes* 4(2), 30. https://doi.org/10.3390/fishes4020030

Slavík, O., Maciak, M., & Horký, P. 2012. Shelter use of familiar and unfamiliar groups of juvenile European catfish *Silurus glanis*. *Applied Animal Behaviour Science* 142, 116–123.

Toni, E., Malavasi, S., Alleva, E., & Cioni, C. 2017. Variation in environmental parameters in research and aquaculture: effects on behaviour, physiology and cell biology of teleost fish. *Journal of Aquaculture & Marine Biology* 5, 00137.

Trofimchuk, A.M., Grinevich, N.E., Trofimchuk, M.I., Kunovskii, Yu.V., Bondar, O.S., Tkachenko, O.V., & Savchuk, O.V. 2021. Suchasnii stan i tendenciï rozvitku ribnictva v Ukraïni ta sviti. Tehnologiya virobnictva i pererobki produkciï tvarinnictva: zbirnik naukovih prac. [The state of the fish farming industry and its development trends in Ukraine and the world. Technologies of production and processing of livestock products. Collection of scientific works]. *Bila Cerkva Ukraine* 2(166), 123–133. https://doi.org/10.33245/2310-9289-2021-166-2-123-133

Turnbull, J.F. 2022. The Complex Influences on How We Care for Farmed Fish. *Frontiers in veterinary science* 8, 765797. https://doi.org/10.3389/fvets.2021.765797

Vashchenko, A.V., Matvienko, N.N., & Koziy, M.S. 2017. Influence of probiotic preparation "Biomos" in compositions on the structure of intestines carp and channel catfish. *Breeding and genetics of animals* 54, 29–37.

Zheltov, Yu.A., & Matvienko, N.N. 2013. *Food for the prevention and treatment of diseases*. Kyiv, Inkos: Ukraine, 281 pp.