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FISH PARASITES AS QUALITY INDICATORS OF AQUATIC ENVIRONMENT

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Abstract. Much research conducted during the last decades has shown that fish parasites are suitable indicators of aquatic environmental quality. They are sensitive to different kinds of pollution such as heavy metals, pesticides, oil-bearing substances, industrial and agricultural wastes and also thermal pollution.

Key words: bioindication, fish, parasite, pollution, environment.

Natural environment, which undergoes progressive degradation as a result of industrial and biological pollution needs permanent monitoring. Control of ecosystems usually includes only cyclic measurements of the degree of environment pollution based on physical, chemical and few sanitary (microbiological) parameters. More complete information about the ecosystems stability is provided by indicators, that is species which exhibit a possibly small range of tolerance of some factor are easy to recognise and which occur commonly. (OKULEWICZ, 2001). This makes possible to so called negative conclusion, that is the assumption, that the absence of some species in a reservoir results from unsuitable conditions and is not associated with its general rarity of occurrence (OGLĘCKI, 2003). Aquatic plants, algae, vertebrates or invertebrates, including fish parasites can be used as indicators.

Because of its relative stability, diversity of niches and richness of flora and fauna aquatic environment favourable conditions for parasite development, transmission and dispersal. Water pollution can effectively limit the occurrence of some species of fish parasites and affect their qualitative and quantitative composition through influencing their eggs, free living larval stages and their intermediate or final hosts (POPIOŁEK, 2001).

Theoretically unpolluted ecosystems should show a greater richness of parasite communities (MARCOGLIESE, 2005; HUDSON *et al*., 2006), while high levels of chemical pollution should limit the parasite species diversity (MARCOGLIESE *et al*., 2006). However the results of field investigations are contradictory: some species react to water pollutions with a decrease in their abundance and richness, and in addition with deformations of the attachment organ (monogeneans), other species increase in abundance.

The occurrence of fish parasites in water reservoirs can be limited by different kinds of pollution: chemical, thermal or oil derivates. Water pollution leads to a decrease in abundance of some species of fish parasites or to their absence. Digenetic flukes are sensitive to environment pollution. Studies in four lakes of central Finland, on the influence of toxic sewage from a paper-mill on the parasite fauna, showed a reduction in the number, or absence of adult intestinal digenetic flukes in more degraded reservoirs (VALTONEN *et al*., 1997). Chemical pollution is the restrictive factor for the nematode *Johnstonmawsonia compana – rougetae*, which was found in fish namely *Lipophhyrus pavo* inhabiting the Black Sea coast near Sevastopol. In response to chemical pollution the species deceases in number. In this investigation it was shown that the most abundant populations of the species were found at a considerable distance from the center of contamination, however in its direct vicinity the number of parasites was small or they were absent (MACHKEVSKY *et al.,* 2007).

Individual parasites species can react differently to changes in water pH. MARCOGLIESE and CONE (1996) observed, that the qualitative composition and quantitative characteristic of the parasite community of eel (*Anguila rostrata*) depended on water pH, which could be used as indicator of acid rains. Waters with increased pH held no, snails which precluded infection with digeneans while gammarids – intermediate hosts of acanthocephalan developed more intensely. HALMENTOJA *et al.,* (2000) studied reactions of parasites of perch to acidified water in two artificial lakes in Finland and found a decrease in the number of metazoan species and in their abundance in the acid waters, compared to lakes with pH approximating neutral; greater diversity of species was observed in more alkaline waters.

Water pollution influences also the qualitative composition of parasite fauna of reservoirs. In their investigations in mining sink-holes and sand pits of Upper Silesia, KWIATKOWSKI and POKORA (2003) noted different numbers of parasite species in the sunbleak. In relatively the least polluted reservoir "Paprocany" they found six parasite species: tapeworm plerocercoids *Ligula intestinalis* and *Schistocephalus solidus, Caryophyllaeides fennica,* metacercariae *Posthodiplostomum cuticola* and crustaceans *Argulus foliaceus* and *Lernea cyprinacea.* In the most polluted sink-hole pond "Kolejarz" they found only 3 species: *Argulus foliaceus, Ligula intestinalis* and *Lernea cyprinacea*. A small number of parasite species was observed in 10 studied fish species of the Mała Panew river basin: perch, ruft, gudgeon, tench, chub, white bream, bitterling, sunbleak, stone loach and catfish (POPIOŁEK and OKULEWICZ, 2000). The waters of the river are still subject to strong anthropopressure; they are degraded and

polluted by industrial and agricultural sewage and communal waste (WITKOWSKI *et al.,* 1997). In the 15 studied sites, 14 of which were situated on the Mała Panew or its tributaries, and one in a dam reservoir "Turawa" only two tapeworm species, four digenean flukes, one nematode species and four acanthocephalan species were found. (POPIOŁEK and OKULEWICZ, 2000).

The problem of thermal pollution affects, among others Gosławskie lake which in 1969 was included in the cooling system of the power station Pątnów – Konin. The investigations of 30 years showed changes in the qualitative and quantitative structure of the parasite fauna of the bream. The long-lasting influence the high temperature caused also changes in the dominance structure. At present the dominant group are digenean flukes namely *Diplostomum,* which in 1972 – 74 the dominant was *Bucephalus polymorphus*, and in 1982-84 – *Dactylogyrus wunderi.* During the thirty years in Gosławskie lake the abundance of the tapeworm *Caryophyllaeus laticeps* increased. The extensity of invasion with the species increased from 26 % (1970s) to 55.2 % at present. The change in infection level of the bream, generally concern mainly earlier or later occurrence of peak numbers of the parasite which is certainly associated with earlier temperature optimum of the helminths and their intermediate hosts (JEŻEWSKI, 2007).

ŠEBELOWÁ and KOUBKOVÁ (1997) in their investigations on the parasite fauna of the chub (*Leuciscus cephalus*) in the Morawa river in two areas (BOLELOUC and BRODSKÉ) and of the bream (*Abramis brama*) and blue bream (*Abramis ballerus*) in the reservoir Nove Mlýny observed deformations of the attachment organ in five species: *Paradiplozoon homoion homoion, P. ergensi* and *P. megan* – chub parasites, *P. nagibinae* – blue bream gill parasite and *Diplozoon paradoxum* – bream gill parasite. Most frequently anomalies of the attachment organ in Diplozoidae occurred in polluted reservoirs (ŠEBELOWÁ and KOUBKOVÁ, 1997) Also KUPERMAN *et al.* (1995) observed anomalies of clamps structure in species *Diplozoon paradoxum* parasitize of bream in polluted Szeksna river. The frequency of deformations of the attachment organ of *Paradiplozoon homoion homoion* – parasite of spirlin (*Alurnoides bipunctatus*) (32%) was higher in the strongly polluted Vlara river (KOUBKOVÁ *et al.,* 2001). Also DZIKA (2002) conducted investigations on deformations of the attachment organ in Diplozoidae. The studies included parasites of roach, white bream and bream from four lakes: Dgał Wielki, Warniak. Ukiel and Wulpińskie and Łyna river. These reservoirs differed in their trophic parameters and the character of their pollution. The highest frequency of deformations occurred in polluted lakes Łyna and Wulpińskie and dystrophic Warniak, while the lowest proportion of deformations occurred in two relatively clean and eutrophic lakes Dgał Wielki and Ukiel.

In polluted ecosystems some fish parasites tend to increase in abundance. KHAN (2004) studied the parasite fauna of *Pleuronectes americanus* and *Myoxocephalus scorpius* along the coast of Canada, where many kinds of pollution were present. For comparison he studied the parasite fauna also in unpolluted reservoirs. Both fish species showed a greater number of parasites *Cryptocotyle lingua* and *Trichodinia* sp. in the polluted reservoirs compared to unpolluted

ones. SHMIDT *et al.* (2003) obtained similar results. They observed a higher number *Trichodina* sp. in the polluted Elba river in comparison with less polluted areas. Also in the case of the genus *Trichodina* sp., a gill parasite of whiting (*Merlangius merlangus*) OGUT and PALM (2005) observed a higher prevalence in water polluted with nitrites, nitrates and phosphates and in polluted waters of the German Gulf (DZIKOWSKI *et al*., 2003). The bream helminth fauna from lake Gosławskie (thermal polluted) was richer than in lake Gopło (natural reservoir) by about three species: *Bucephalus polymorphus*, *Ligula intestinalis* and *Acanthocephalus lucii* (KĘDRA and SIKORA, 2003). In a strongly polluted zone of the Gdańsk Gulf SULGOWSKA and STYCZYŃSKA-JUREWICZ (1996) recorded a higher extensity of infection of flounder (*Platichthys flesus*) by the nematode *Cucullanus minutus.* The authors explained this fact with better development condition for free-leaving stages of this parasite. MACKENZIE *et al.* (1995) observed that the prevalence and intensity of invasion with *Diclidophora merlangi* was significantly higher in areas polluted with oil derivates than in unpolluted reservoirs. They explained the fact with the contact of gills with oil derivates, causing irritation of these organs. The infected fish, showed an excessive mucus production, which created favourable living conditions for the parasite. Water pollution often favours eutrophication, which generally promotes increase in the richness of free-living fauna. (LAFERTY and KURIS, 1999) Eutrophication usually leads to an impoverishment of fish parasite fauna, but has a positive effect on the species living in these reservoirs. ESCH (1971) observed elimination of autogenic fish parasites in centrarchid fishes, however VALTONEN *et al*. (1987) and VALTONEN and TASKINEN (1998) observed an increasing prevalence and intensity of fish ectoparasites. DZIKA (2003), studying metazoan parasites of roach in four lakes of different degree of eutrophication and pollution in the Masurian Lakeland showed a greater species richness of parasite communities in lakes Dgał Wielki and Warniak, which could be explain by their higher water quality resulting from their location away from human settlements, which in turn offers better conditions for development and colonization of new hosts to numerous species. In lakes Wulpińskie and Ukiel an important role was played by pollution, which influenced the situation in many ways, generally indirectly favouring an increase in abundance of pollution – tolerant species. The studies showed that only complex communities could be used as indicators of habitat quality. They are: communities of all roach metazoans, communities of allogenic parasites, communities of helminths and communities of eye and gill parasites. These communities showed the greatest differences in diversity and dominance indices between the studied lakes under different degree of anthropopressure.

Fish parasites provide information about water pollution through their presence or absence, but also through their ability to accumulate heavy metals in tissues, mainly arsenic, copper, lead, zinc and cadmium (POPIOŁEK, 2001). Intestinal parasites *Proteocephalus percae* and *Acanthocephalus lucii* of perch have this ability; their tissues contain 300 times more of these toxins than the muscles and liver of their fish host (TURČEKOVÁ and HANZELOVÁ, 1997),

Pomphorhynchus laevis contains about 2700 times more lead, and 400 times more cadmium than the muscle of its host – chub (SURES and TARASCHEWSI, 1995; SURES, 1999).

The results of other investigations support the thesis that fish parasites can be regarded indicators of environmental pollution. It turns out, that some parasite groups are exceptionally sensitive to water pollution and they provide information about contamination of water environment through their presence or absence, occurrence of morphological deformations e.g. monogeneans and the ability to accumulate toxins in their tissues. Many zoologist appreciate fish parasites for their indication properties more than other invertebrates, for example bivalves. Parasites, because they move with their hosts, can provide information about variation in the level of water pollution in the whole range of host's occurrence.

PASOŻYTY RYB JAKO WSKAŹNIK JAKOŚCI ŚRODOWISKA WODNEGO

STRESZCZENIE

Rezultaty kolejnych badań wskazują na słuszność obserwacji pasożytów ryb jako naturalnych wskaźników zanieczyszczenie środowiska wodnego. Okazuje się, że niektóre grupy pasożytów są wyjątkowo wrażliwe na zanieczyszczenia środowiska wodnego, dostarczają one informacji o skażeniu środowiska wodnego poprzez swoją obecność lub brak, występowanie deformacji morfologicznych (na przykład u przywr monogenicznych) oraz zdolność kumulacji toksyn w tkankach. Pasożyty ryb są przez wielu zoologów bardziej cenione za swoje właściwości bioindykacyjne niż inne bezkręgowce jak na przykład małże. Pasożyty bowiem, ze względu na przemieszczanie się razem z żywicielem mogą dostarczać informacji o zróżnicowaniu poziomu zanieczyszczenia wody w całym zasięgu występowania żywiciela.

REFERENCES

DZIKA, E., 2002: Deformations of the attachment organ in Diplozoidae (PALOMBI, 1949) (Monogenea). Wiad. Parazyt., **48**: 69-77.

DZIKA, E., 2003: Pasożyty (Metazoa) płoci *Rutilus rutilus* L. w jeziorach Pojezierza Mazurskiego jako wskaźnik jakości środowiska wodnego. Wydawnictwo Uniwersytetu Warmińsko-Mazurskiego w Olsztynie **73**: 1-83.

DZIKOWSKI, R., PAPERNA, I., DIAMANT A., 2003: Use of fish parasite species richness indices in analyzing anthropogenically impacted coastal marine ecosystems. Helgoland. Mar. Res., **57**: 220-227.

ESCH, G.W., 1971: Impast of ecological succesion on the parasite fauna in centrarchids from oligotrophic and eutrophic ecosystems. Am. Midl. Natl., **86**: 160-168.

HALMENTOJA, A., VALTONEN, E.T., KOSKENNIEMI, E., 2000: Perch (*Perca fluviatilis* L.) parasites reflect ecosystem conditions: a comparison of natural lake and two acidic reservoirs in Finland. Int. J Parasitol., **30**: 1437-1444.

HUDSON, P., DOBSON, A.P., LAFFERTY, K.D., 2006: Is a healthy ecosystem one that is rich in parasites? Trends Ecol. Evol., **21**: 381-385.

JEŻEWSKI, W., 2007: Analiza długotrwałego oddziaływania podwyższonej temperatury na helmintofaunę leszcza (*Abramis brama*) jeziora Gosławskiego. Wiad. Parazyt., **53**: 351-363.

KĘDRA, A.H., SIKORA, B., 2003: Występowanie pasożytniczych Metazoa leszcza (*Abramis brama*) w zbiornikach naturalnych i sztucznych w Polsce. Wiad. Parazyt., **49**: 21-29.

KHAN, R.A., 2004: Parasites of fish as biomarkers of environmental degradation: a field study. Bull. Envir. Contam. Toxicol., **72**: 394-400.

KUPERMAN, B.I., ZHARIKOVA, T.I., ZHOKHOV, A.E., 1995: Biomonitoring of pollution using parasite communities. 4th International Symposium of Fish Parasites, October 3–7, Munich, Germany p. 4.

KOUBKOVÁ, B., MATEJUSOVA, I., KRACMAR, S., GELNAR, M., 2001: Morphologic abnormalities of the opisthaptor of *Paradiplozoon homoion* (Monogenea, Diplozoidae). 4th International Symposium on Monogenea. Brisbane, Queensland, Australia July 9-13 p. 112.

KWIATKOWSKI, S., POKORA, Z., 2003: Badania nad parazytofauną słonecznicy *Leucaspius delineatus* (HENKEL, 1843) w wybranych antropogenicznych zbiornikach wodnych Górnośląskiego Okręgu Przemysłowego. Arch. Ochr. Środ., **29**: 61-70.

LAFFERTY, K.D., KURIS, A.M., 1999: How environmental stress affects the impacts of parasites. Part 2. Limnol. Oceanogr., **44**: 925-931.

MACHKEVSKY, V.K., BELOFASTOVA, I.P., PRONKINA, N.V., 2007: The response of the fish nematode *Johnstonmawsonia campana-rougetae* to the environmental pollution. Parassitologia, **49**: 264.

MACKENZIE, K., WILLIAMS, H.H., WILLIAMS, B., MCVICAR, A.H., SIDDALL, R., 1995: Parasites as indicators of water quality and the potential use of helminth transmission in marine pollution studies. Advan. Parasit., **35**: 85-144.

MARCOGLIESE, D.J., 2005: Parasites of the superorganizm: Are they indicators of ecosystem health? Int. J Parasitol., **35**: 705-716.

MARCOGLIESE, D.J., CONE, D.K., 1996: On the distribution and abundance of eel parasites in Nova Scotia: influence of pH. J Parasitol., **82**: 389-399.

MARCOGLIESE, D.J., GENDRON, A.D., PLANTE, C., FOURNIER, M., CYR, D., 2006: Parasites of potential shiners (*Notropis hudsonius*) in the St. Lawrence Reiver: effects of municipal effluents and habitat. Can. J. Zool., **84**: 1461-1481.

OGUT, H., PALM, H., 2005: Seasonal dynamics of *Trichodina* spp. on whiting (*Merlangius merlangus*) in relation to organic pollution on the eastern Black Sea coast of Turkey. Parasitol. Res., **96**: 149-153.

OKULEWICZ, A., 2001: Rola pasożytów w biologicznym monitorowaniu środowiska. In:Parazytologia w ochronie środowiska i zdrowia. Podręcznik dla studentów ochrony środowiska, kierunków przyrodniczych i medycznych. (E. LONC (red.)), Wydawnictwo Volumed, Wrocław 233-237.

OGLĘCKI, P., 2003: Co warto wiedzieć o bioindykacji. Wiadomości Wędkarskie sierpień 76-77.

POPIOŁEK, M., 2001: Helmintofauna ryb wybranych rzek i cieków Dolnego Śląska na tle stopnia czystości wód. Uniwersytet Wrocławski, Wydział Nauk Przyrodniczych, (praca doktorska)

POPIOŁEK, M., OKULEWICZ, J., 2000: Helmintofauna ryb dorzecza Małej Panwi. Wiad. Parazyt., **46**: 63-73.

SCHMIDT, V., ZANDER, S., KÖRTING, W., BROEG, K., VON WESTERNHAGEN, D.H., HANSEN P.D., SKOURAS A., STEINHAGEN D., 2003: Parasites of flounder (*Platichthys flesus* L.) from the German Bigth, North Sea, and their potential use in biological effects monitoring. Helgoland Mar. Res., **57**: 262-271.

ŠEBELOVÁ, Š., KOUBKOVÁ, B., 1997: Representatives of monogenean family *Diplozoidae* (PALOMBI, 1949) as potential bioindicators of environmental disturbances. The 3rd International Symposium on Monogenea, Brno, Czech Republic: 41.

SULGUSTOWSKA, T., STYCZYŃSKA-JUREWICZ, E., 1996: Internal helminth parasites of the flounder, *Platichthcys flesus* L. as tags of pollution in the gulf of Gdańsk, Southern Baltic Sea. Crangon, **1**, 211-220.

SURES, B., 1999: Fish parasites as promising indicators of environmental pollution: facts, appraisal and perspectives. 5th International Symposium on Fish parasites. Institute of Parasitology Academy of Sciences of the Czech Republic: 140.

SURES, B., TARASCHEWSKI, H., 1995: Heavy metals in fish parasites and their hosts. 4th International Symposium of Fish Parasites, Munich, Germany: 89.

TURČEKOVÁ, L., HANZELOVÁ, V., 1997: Parasites as possible bioindicators of water pollution. Materiały Konferencyjne X Wrocławska Konferencja Parazytologiczna. Karpacz, Streszczenia materiałów konferencyjnych: 53.

VALTONEN, E.T, HOLMES, J.C, KOSKIVAARA, M., 1997: Eutrophication, pollution and fragmentation: effects on parasite communities in roach (*Rutilus rutilus*) and perch (*Perca fluviatilis*) in four lakes in Central Finland. Can. J. Aquat. Fish Sci., **54**: 572-585.

VALTONEN, E.T., TASKINEN, J., 1988: *Rhipidocotyle campanula* In its first and second intermediate host in central Finland; associated with pollution? Abstract of the European Multicolloqium of Parasitology, Budapest, Hungary, 110.

VALTONEN, E.T., BRUMMER-KONVERKONTIO, H., KOSKIVAARA, M., 1987: Parasites of roach in central Finland in relation to environmental stress. Proceedings of the 13th Scandinavian Symposium of Parasitology. Information Institute of Parasitology, Finland, **19**: 52.

WITKOWSKI, A., KUSZNIERZ, J., KOTUSZ, J., 1997: Ichtiofauna dorzecza Małej Panwi (Dorzecze Odry), Roczniki Naukowe PZW **10**: 61-84.

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