Contenido archivado el 2024-05-27

Contradicting responses to multiple stressors reduce the resilience of zooplankton community

Informe

Información del proyecto

CONTRASTRESS

Identificador del acuerdo de subvención: 249273

Proyecto cerrado

Fecha de inicio
1 Junio 2010

Fecha de finalización
31 Mayo 2013

Financiado con arreglo a
Specific programme "People" implementing the Seventh Framework Programme of the European Community for research, technological development and demonstration activities (2007 to 2013)

Coste total
€ 45 000,00

Aportación de la UE
€ 45 000,00

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Este proyecto figura en...

Final Report Summary - CONTRASTRESS (Contradicting responses to multiple stressors reduce the resilience of zooplankton community)

Executive Summary:

The aim of the project is to find out what happens within zooplankton community when individuals are forced to choose between contradictory strategies. Aquatic ecosystems are subject to many anthropogenic stressors, which include eutrophication with toxic cyanobacterial blooms, chemical pollution (e.g. pesticides) and invasive species linked with climate change. Also natural factors like predation, resource competition and food quality may cause substantial changes in populations and communities. Organisms need to use different strategies to cope with these stressors and these strategies can exclude each other. This situation may lead to losses in genetic biodiversity or even to exclusion of a species.

Zooplankton plays important role in aquatic food webs and it is crucial to know how chemical interactions affect population dynamics and community structure. The aim of this study was to check what are the strategies of individuals to cope with such contrasting conditions and what their role is in biodiversity loss. Moderate stress like bad food conditions, small doses of toxicants, either cyanotoxins or pesticides, stimulate Daphnia to grow bigger and produce larger offspring. A stimulatory response from a low dose or concentration of a non-essential substance which results in increase of biological function, but at higher doses produces toxic effects, is called hormesis. The strategy of an organism is to invest more into quality than numbers, since larger individuals cope with toxins better than smaller ones. In this case bigger is better. However, vertebrate predators using vision when hunting, such as fish, select for larger prey. In this scenario the strategy should be to grow smaller and produce smaller offspring. Here smaller is better.

To solve the problem several approaches were used to bring together paleolimnology, evolutionary ecology and ecotoxicology. Molecular biology was employed to assess the genetic biodiversity. Two main hypotheses were tested (1) Hormesis of a trait is maladaptive (i.e. strategy ‘bigger is better’ decreases fitness and hence indicates a negative response), (2) Interaction of hormetic effect with fish infochemicals can induce developement of a new zooplankton community. Based on these working hypotheses we

decided to test the effects of contradicting signals on life history traits of contemporary and resurrected Daphnia clones that existed before the presence of cyanobacterial blooms in a lake.

In order to collect material for Daphnia resurrection, sediment cores were taken from lakes known for cyanobacteria blooms and good ecological conditions in the past. These allowed to compare life strategies of organisms that were experienced with cyanobacteria with those that were not. Several sediment cores were taken from hypertrophic lakes with frequent cyanobacteria blooms. The sediment cores were dated (137Cs and 210Pb method) and used for chemical and biological analyses. They were also used for resurrecting Daphnia and hatching experiments. The resurrected clones of Daphnia as well as those isolated from pelagial of a lake were used in life-history experiments. These animals were exposed to toxic and non toxic cyanobacteria in various concentrations, and fish infochemicals in a full factorial design. A flow through culture system with 140 ml flasks was used in the experiments. The depth of sediment's laminas, organic matter content and diatom analysis revealed quick eutrophication starting in mid 50's of the last century. The hatchability of Daphnia was extremely low and narrowed to the youngest layers of sediments. The oldest individual daphnid was ca. 40 years old but the clone did not survive in the culture. However, Rotifera and small cladocerans (e.g. Bosmina longirostris) were hatching in high numbers. Eventhough one of the investigated lakes has undergone the restoration process which included fish biomanipulation in order to reduce the pressure of planktivorous fish on zooplankton, the rebuilding Daphnia community was still consisting of only 2 species present previously, with the smallest D. cucullata dominating. It seems that there is lack of biodiversity in the sediment egg bank to restore population of daphnids capable of controlling the phytoplankton biomass. The microsatellite analyses revealed very low genetic diversity in the sediment egg bank and even lower in the pelagic waters. The highest numbers of ephippia found was in the sediment layers from 80's and since then they were decreasing till present times. That was the case in all sediment cores used for hatching experiments and paleolimnological analyses.

During the life-history experiments the daphnids' response to several concentrations of cyanobacteria was tested. It is well known that cyanobacteria interfere with filtering apparatus of Daphnia and can substantially reduce the grazing and food availability. However larger species are more vulnerable than small ones. During these experiments it was discovered that when filaments of cyanobacteria are even in relatively low numbers (ca. 1.8mln/mL) they can cause significant damages in filtering apparatus of larger Daphnia. This can hamper the filtration process and reduce the impact on filaments. The mechanism is unknown and it is not clear whether damage is caused by worse food availability, toxins or else. More detailed studies are necessary. A possible explanation gives another discovery done during the project, that filamentous cyanobacteria (Aphanizomenon gracile) change their morphology in the presence of grazers such as Daphnia. Aphanizomenon filaments became significantly shorter and thicker when exposed to Daphnia's grazing or excreted chemicals alone. The filaments in the presence of Daphnia switch their growing mode and invest more heavily in width than in length. Our results support the hypothesis that Daphnia is at least partly responsible for the changes in filament width observed in the field. Widening could be a strategy that helps to withstand grazer's pressure during early stages of a bloom. The wider filaments are also stronger and this can enhance the damage caused to the filtering appendages. Such phenomenon is of a great importance for any restoration processes involving biomanipulation, especially that the change in morphology can enhance cyanobacterial growth in the presence of competitors such as green algae. Moreover, filamentous cyanobacteria can stabilize the whole phytoplankton community under the grazing pressure of Daphnia. The damages were observed only in larger species and the experiments on life history confirmed that communities of hypertrophic lakes are adapted to the presence of cyanobacteria. This is because of the small size that protects daphnids from mechanical interference with filaments. However, they are too small to control cyanobacteria. The results from hatching experiments and counts of subfossil ephippia confirmed absence of larger species and the long lasting state of low biodiversity. That reduces the chances of successful recovery of a lake, especially when neighbor reservoirs are also hypertrophic and thus the total pool of diversity is low. This is a potential bottleneck for the restoration of lakes especially in agricultural landscape with long lasting anthropogenic eutrophication. The differences among species were more important than these induced by cyanobacteria (hormesis) or fish, among clones within one species. The significant differences among clones within one species were caused more by food availablility rather than chemical effects of cyanobacteria.

The conducted research widened our knowledge on mechanisms resposible for changes in zooplankton communities during eutrophication and cyanobacterial blooms. We found new facts that are responsible for the success of cyanobacteria and linked it with biodiversity loss in zooplankton. The results of this project added a new theme of research in the ecology of lake plankton that will help to understand the relations among zooplankton, cyanobacteria and prokaryotic algae. This will enable better management of the environment and any future restoration programmes should take into account bottlenecks such as low biodiveristy in egg bank and neighboring reservoirs.

Última actualización: 27 Junio 2014

Permalink: https://cordis.europa.eu/project/id/249273/reporting/es