Khuong Van Dinh - DTU Orbit (22/01/2018)
Khuong Van Dinh

Organisations

Section for Marine Ecology and Oceanography
16/07/2015 → 31/03/2017 Former
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Postdoc, National Institute of Aquatic Resources
15/07/2015 → present
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Section for Oceans and Arctic
31/03/2017 → present
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Publications:

Assessing and managing multiple risks in a changing world — The Roskilde recommendations

General information
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Organisations: National Institute of Aquatic Resources, Section for Marine Ecology and Oceanography, Department of Civil Engineering, Section for Structural Engineering, Roskilde University, Stockholm University, University of Michigan, DHI Denmark, Simon Fraser University, Delft University of Technology, Enviiresearch, Newcastle-upon-Tyne, Halmstad University, Aarhus University, Norwegian Institute for Water Research, University of Aveiro, U.S. Environmental Protection Agency, Norwegian Geotechnical Institute, Polish Academy of Sciences, Chapema Environmental Strategies, University of Gothenburg, Roskilde Universitet, Roskilde Universitetscenter
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Scopus rating (2016): CiteScore 2.74 SJR 1.19 SNIP 1.031
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Scopus rating (2015): SJR 1.446 SNIP 1.055 CiteScore 3
Web of Science (2015): Indexed yes
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Scopus rating (2014): SJR 1.506 SNIP 1.129 CiteScore 2.89
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**Effects of global warming and pollutants on marine copepods across space and time**

**General information**

State: Published

Organisations: National Institute of Aquatic Resources, Section for Oceans and Arctic

Authors: Dinh, K. V. (Intern), Nielsen, T. G. (Intern)

Number of pages: 1

Publication date: 2017

**Host publication information**

Title of host publication: Book of Abstracts Sustain 2017

Publisher: Technical University of Denmark
Increased tolerance to oil exposure by the cosmopolitan marine copepod *Acartia tonsa*

Oil contamination is an environmental hazard to marine ecosystems, but marine organism tolerance to oil after many generations of exposure remains poorly known. We studied the effects of transgenerational oil exposure on fitness-related traits in a cosmopolitan neritic copepod, *Acartia tonsa*. Copepods were exposed to an oil compound, the PAH pyrene, at concentrations of 1, 10, 100 and 100+ (the saturated pyrene concentration in seawater) nM over two generations and measured survival, sex ratio, size at maturity, grazing rate and reproductive success. Exposure to the pyrene concentration of 100+ nM resulted in 100% mortality before adulthood in the first generation. At the pyrene concentration of 100 nM, pyrene reduced grazing rate, increased mortality, reduced the size of females and caused lower egg production and hatching success. Importantly, we found strong evidence for increased tolerance to pyrene exposure in the second generation: the reduction in size at maturity of females was less pronounced in the second generation and survival, egg production and hatching success were recovered to control levels in the second generation. The increased tolerance of copepods to oil contamination may dampen the direct ecological consequences of a coastal oil spill, but it raises the concern whether a larger fraction of oil components accumulated in survived copepods, may be transferred up the food web.

**General information**
State: Published
Organisations: National Institute of Aquatic Resources, Section for Oceans and Arctic
Authors: Krause, K. E. (Ekstern), Dinh, K. V. (Intern), Nielsen, T. G. (Intern)
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Volume: 607-608
ISSN (Print): 0048-9697
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Web of Science (2017): Indexed yes
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Scopus rating (2016): CiteScore 5.09 SJR 1.621 SNIP 1.849
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.674 SNIP 1.642 CiteScore 4.33
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.635 SNIP 1.847 CiteScore 4.2
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Scopus rating (2013): SJR 1.527 SNIP 1.759 CiteScore 3.73
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 1.773 SNIP 1.811 CiteScore 3.7
ISI indexed (2012): ISI indexed yes
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BFI (2011): BFI-level 2
Scopus rating (2011): SJR 1.798 SNIP 1.681 CiteScore 3.61
ISI indexed (2011): ISI indexed yes
Preliminary results: Deep sea oil spill in the Arctic – effects of pyrene on overwintering Calanus copepods

Polar Oceans are some of the least impacted by human activities due to seasonal or permanent sea ice that limits human access. Projections of future polar ice loss suggest that the impact will increase substantially because of changing environmental conditions and pollution. Arctic Oceans hold a substantial amount of the world’s remaining oil and gas reserves, but exploration is extremely technically challenging. To enable proper risk assessment, it is crucial to understand how oil spills can impact Arctic marine ecosystems. During polar night, biological processes in Arctic marine ecosystems are conventionally believed to slow down or cease. Indeed, several marine species have overwintering strategies, such as the Calanus copepods that overwinters for 8-10 months at depths of 200-2000 m and migrate to the productive surface layers to feed on the short Arctic bloom. We conducted a winter experiment with two species of Artic copepod to study the impact of long term exposure to oil during polar night. We used the ecological important Calanus hyperboreus (winter breeder) and C. glacialis (spring breeder) as tests species, and quantified effects on the fitness-related traits mortality, egg production, grazing and egg hatching. Females were incubated in bottles with seawater and the oil compound pyrene (in concentrations of 0.1, 1, 10, 100 and 100+ nM) from December to March. They were transferred to clean seawater and fed in excess for 2-3 weeks until termination of the experiment. Mortality was checked daily, and egg and fecal pellets were collected within 24 h of production. Egg hatching success was determined at the beginning, middle and end of the experiment. Preliminary results indicate that C. hyperboreus exhibit a delayed response to pyrene through reduced feeding after transfer to clean seawater. Effects diminish over time, and feeding rate is recovered after 14 days without exposure to oil. Both egg production and feeding rate of C. glacialis is impacted by exposure in a concentration dependent manner after transfer to clean seawater. These findings suggest, that long term oil exposure during overwintering does indeed impact both Calanus species, and that C. hyperboreus seem to be more robust than the smaller C. glacialis. While effects on C. glacialis may have implications for stock recruitment within the season, potential effects on C. hyperboreus are likely delayed until next season. Negative effects on copepods may potentially affect the entire food chain and have severe ecosystem effects.
Sensitivity of a tropical micro-crustacean (Daphnia lumholtzi) to trace metals tested in natural water of the Mekong River

General information
State: Published
Organisations: National Institute of Aquatic Resources, Section for Marine Ecology and Oceanography, Ho Chi Minh City University of Technology, Vietnam National University, Nha Trang University, University of Rennes
Authors: Dao, T. (Ekstern), Le, V. (Ekstern), Bui, B. (Ekstern), Dinh, K. V. (Intern), Wiegand, C. (Ekstern), Dao, C. (Ekstern), To, T. (Ekstern), Nguyen, L. (Ekstern), Vo, T. (Ekstern)
Pages: 1360-1370
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Main Research Area: Technical/natural sciences

Publication information
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BFI (2015): BFI-level 2
Scopus rating (2015): SJR 1.674 SNIP 1.642 CiteScore 4.33
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Scopus rating (2014): SJR 1.635 SNIP 1.847 CiteScore 4.2
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Scopus rating (2013): SJR 1.527 SNIP 1.759 CiteScore 3.73
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Web of Science (2013): Indexed yes
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BFI (2011): BFI-level 2
Scopus rating (2011): SJR 1.798 SNIP 1.681 CiteScore 3.61
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.644 SNIP 1.513
Species-specific vulnerability of Arctic copepods to oil contamination and global warming

Arctic ecosystems are predicted to have more severe effects from global warming as during the last decades the temperatures have increased in this region at a rate of 2-4 times higher than the global average. In addition, oil exploitation and shipping activities in the Arctic are predicted to increase under global warming as the result of the retreat of sea ice, posing the risk of oil contamination. It is poorly known how cold adapted copepods in the Arctic deal with the combined effects of global warming and oil exposure. To address this, we exposed females of two copepods species Calanus glacialis and C. finmarchicus to pyrene at three temperatures: 2, 6 and 10°C. Both species co-exist in the Disko Bay, Greenland, but only C. glacialis is a true Arctic species while C. finmarchicus is of north Atlantic origin. Pyrene is one of the most toxic components of crude oil to marine copepods. The temperatures of 2, 6 and 10°C represent the mean sea water temperature during the reproductive season, the 4°C increase in mean temperature by 2100 as predicted by IPCC scenario RCP8.5 (2013) and the extreme sea water temperature, respectively, in Disko Bay. Four degree temperature increase did not have an effect on grazing rate and survival of both species. However, the extreme temperature (10°C) increased the grazing rate and mortality of C. glacialis, but not in C. finmarchicus. Exposure to high pyrene strongly reduced survival and grazing rate in both species and this pattern was independent of temperatures. Notably, exposure to high pyrene resulted in ca. 70% of mortality in C. finmarchicus, the species with North Atlantic Origin, that was two times higher than the mortality observed for C. glacialis, the true Arctic species. These results suggest that extreme temperature under global warming and oil contamination may drastically change the relative abundance of the Arctic pelagic copepod community by changing the species-specific vulnerability to extreme temperature and oil exposure.
Strong delayed interactive effects of metal exposure and warming: latitude-dependent synergisms persist across metamorphosis

As contaminants are often more toxic at higher temperatures, predicting their impact under global warming remains a key challenge for ecological risk assessment. Ignoring delayed effects, synergistic interactions between contaminants and warming, and differences in sensitivity across species’ ranges could lead to an important underestimation of the risks. We addressed all three mechanisms by studying effects of larval exposure to zinc and warming before, during, and after metamorphosis in Ischnura elegans damselflies from high- and low-latitude populations. By integrating these mechanisms into a single study, we could identify two novel patterns. First, during exposure zinc did not affect survival, whereas it induced mild to moderate postexposure mortality in the larval stage and at metamorphosis, and very strongly reduced adult lifespan. This severe delayed effect across metamorphosis was especially remarkable in high-latitude animals, as they appeared almost insensitive to zinc during the larval stage. Second, the well-known synergism between metals and warming was manifested not only during the larval stage but also after metamorphosis, yet notably only in low-latitude damselflies. These results highlight that a more complete life-cycle approach that incorporates the possibility of delayed interactions between contaminants and warming in a geographical context is crucial for a more realistic risk assessment in a warming world.
Strong delayed interactive effects of metal exposure and warming: latitude-dependent synergisms persist across metamorphosis

General information
State: Published
Organisations: National Institute of Aquatic Resources, Section for Oceans and Arctic, University of Leuven
Authors: Debecker, S. (Ekstern), Dinh, K. V. (Intern), Stoks, R. (Ekstern)
Publication date: 2017
Main Research Area: Technical/natural sciences
Source: PublicationPreSubmission
Source-ID: 128771258
Publication: Research - peer-review › Journal article – Annual report year: 2017
Transgenerational interactions between a pesticide and warming in a vector mosquito.
Climate change imposes a strong pressure on the persistence of natural populations and together with pollution it exerts a global threat to biodiversity. While many transgenerational studies have revealed the capacity of species to adapt to a temperature increase, it remains unknown if this ability may change in a polluted environment. We set up a full-factorial transgenerational experiment where Culex pipiens vector mosquitoes were reared at two temperatures (20°C vs 24°C) and, when they reached the final larval stage, exposed to one of two chlorpyrifos treatments (absent vs present). We studied effects on larval survival and age and size at metamorphosis. In both generations, warming and the pesticide reduced larval survival and accelerated development in the survivors. While warming reduced size at metamorphosis, pesticide exposure did not affect size. As expected, the effect of chlorpyrifos on mortality was stronger under warming. We could show delayed effects of parental rearing temperature on their offspring with parents reared at 24°C producing offspring with a lower survival, slower development, but a larger size at metamorphosis. For survival the effect was particularly strong in offspring that was reared at 20°C, thereby providing evidence for transgenerational acclimation resulting in poor offspring performing under thermal conditions different from their parents. Parental pesticide exposure influenced the response of the offspring to both stressors, with offspring from parents exposed to the pesticide being more susceptible to warming in terms of survival, but performing better when also exposed to the pesticide in terms of size at metamorphosis. Our results indicate some signals of transgenerational acclimation to the pesticide: offspring exposed to the pesticide did better when the parents were also exposed to the pesticide. However, when combining stressors, we could show that parental pesticide exposure increased the vulnerability to warming indicating the complexity of transgenerational acclimation. This highlights the importance of looking at the combined impact of pesticides and warming increase across generations to come to a better understanding of the impact of pesticides in a warming world.

Delayed effects of chlorpyrifos across metamorphosis on dispersal-related traits in a poleward moving damselfly
How exposure to contaminants may interfere with the widespread poleward range expansions under global warming is largely unknown. Pesticide exposure may negatively affect traits shaping the speed of range expansion, including traits related to population growth rate and dispersal-related traits. Moreover, rapid evolution of growth rates during poleward range expansions may come at a cost of a reduced investment in detoxification and repair thereby increasing the
vulnerability to contaminants at expanding range fronts. We tested effects of a sublethal concentration of the widespread pesticide chlorpyrifos on traits related to range expansion in replicated edge and core populations of the poleward moving damselfly, Coenagrion scitulum reared at low and high food levels in a common garden experiment. Food limitation in the larval stage had strong negative effects both in the larval stage and across metamorphosis in the adult stage. Exposure to chlorpyrifos during the larval stage did not affect larval traits but caused delayed effects across metamorphosis by increasing the incidence of wing malformations during metamorphosis and by reducing a key component of the adult immune response. There was some support for an evolutionary trade-off scenario as the faster growing edge larvae suffered a higher mortality during metamorphosis. Instead, there was no clear support for the faster growing edge larvae being more vulnerable to chlorpyrifos. Our data indicate that sublethal delayed effects of pesticide exposure, partly in association with the rapid evolution of faster growth rates, may slow down range expansions.

**General information**

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Organisations: KU Leuven, University of Antwerp, Ghent University
Authors: Dinh, K. V. (Intern), Janssens, L. (Ekstern), Therry, L. (Ekstern), Bervoets, L. (Ekstern), Bonte, D. (Ekstern), Stoks, R. (Ekstern)
Publication date: 2016
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Scopus rating (2010): SJR 1.987 SNIP 1.633
Web of Science (2010): Indexed yes
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Scopus rating (2009): SJR 1.996 SNIP 1.701
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 1.904 SNIP 1.713
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.839 SNIP 1.747
Evolution determines how global warming and pesticide exposure will shape predator-prey interactions with vector mosquitoes

How evolution may mitigate the effects of global warming and pesticide exposure on predator–prey interactions is directly relevant for vector control. Using a space-for-time substitution approach, we addressed how 4°C warming and exposure to the pesticide endosulfan shape the predation on Culex pipiens mosquitoes by damselfly predators from replicated low- and high-latitude populations. Although warming was only lethal for the mosquitoes, it reduced predation rates on these prey. Possibly, under warming escape speeds of the mosquitoes increased more than the attack efficiency of the predators. Endosulfan imposed mortality and induced behavioral changes (including increased filtering and thrashing and a positional shift away from the bottom) in mosquito larvae. Although the pesticide was only lethal for the mosquitoes, it reduced predation rates by the low-latitude predators. This can be explained by the combination of the evolution of a faster life history and associated higher vulnerabilities to the pesticide (in terms of growth rate and lowered foraging activity) in the low-latitude predators and pesticide-induced survival selection in the mosquitoes. Our results suggest that predation rates on mosquitoes at the high latitude will be reduced under warming unless predators evolve toward the current low-latitude phenotype or low-latitude predators move poleward.
Exposure to a heat wave under food limitation makes an agricultural insecticide lethal: a mechanistic laboratory experiment

Extreme temperatures and exposure to agricultural pesticides are becoming more frequent and intense under global change. Their combination may be especially problematic when animals suffer food limitation. We exposed Coenagrion puella damselfly larvae to a simulated heat wave combined with food limitation and subsequently to a widespread agricultural pesticide (chlorpyrifos) in an indoor laboratory experiment designed to obtain mechanistic insights in the direct effects of these stressors in isolation and when combined. The heat wave reduced immune function (activity of phenoloxidase, PO) and metabolic rate (activity of the electron transport system, ETS). Starvation had both immediate and delayed negative sublethal effects on growth rate and physiology (reductions in Hsp70 levels, total fat content, and activity levels of PO and ETS). Exposure to chlorpyrifos negatively affected all response variables. While the immediate effects of the heat wave were subtle, our results indicate the importance of delayed effects in shaping the total fitness impact of a heat wave when followed by pesticide exposure. Firstly, the combination of delayed negative effects of the heat wave and starvation, and the immediate negative effect of chlorpyrifos considerably (71%) reduced larval growth rate. Secondly and more strikingly, chlorpyrifos only caused considerable (ca. 48%) mortality in larvae that were previously exposed to the combination of the heat wave and starvation. This strong delayed synergism for mortality could be explained by the cumulative metabolic depression caused by each of these stressors. Further studies with increased realism are needed to evaluate the consequences of the here-identified delayed synergisms at the level of populations and communities. This is especially important as this synergism provides a novel explanation for the poorly understood potential of heat waves and of sublethal pesticide concentrations to cause mass mortality.

General information
State: Published
Organisations: National Institute of Aquatic Resources, Section for Marine Ecology and Oceanography, University of Leuven, KU Leuven, Nha Trang University
Authors: Dinh, K. V. (Intern), Janssens, L. (Ekstern), Stoks, R. (Ekstern)
Pages: 3361-3372
Publication date: 2016
Main Research Area: Technical/natural sciences

Publication information
Journal: Global Change Biology
Volume: 22
Issue number: 10
**Extreme temperature and oil contamination shape the relative abundance of copepod species in the Arctic**

The retreat of sea ice in the Arctic under global warming is predicted to intensify oil exploitation and shipping activities in this region, posing the risk of oil contamination. Knowledge on how Arctic secondary producers deal with the combined effects of global warming, particularly the extreme temperature and oil exposure is limited. To address this, we exposed females of two copepod species Calanus glacialis and C. finmarchicus to pyrene at three temperatures: 2, 6 and 10°C. Both species co-exist in the Disko Bay, Greenland, but only C. glacialis is a true Arctic specialist while C. finmarchicus is of north Atlantic origin. Pyrene is one of the most toxic components of crude oil to marine copepods. The temperatures of 2, 6 and 10°C represent the mean sea water temperature, the 4°C increase in mean temperature by 2100 as predicted by IPCC scenario RCP8.5 (2013) and the extreme sea water temperature, respectively, in Disko Bay. Four-degree temperature increase did not have an effect on grazing rate and survival of both species. However, the extreme temperature (10°C) increased the grazing rate and mortality of C. glacialis, but not in C. finmarchicus. Exposure to high pyrene strongly reduced survival and grazing rate in both species and this pattern was independent of temperatures. Notably, exposure to high pyrene resulted in than 70% of mortality in C. finmarchicus that was two times higher than the mortality observed for C. glacialis. These results suggest that extreme temperature under global warming and oil pollution may drastically change the relative abundance of pelagic copepod community by changing the species-specific vulnerability to extreme temperature and oil exposure.

**General information**
State: Published
Organisations: National Institute of Aquatic Resources, Section for Marine Ecology and Oceanography
Authors: Dinh, K. V. (Intern), Nielsen, T. G. (Intern)
Publication date: 2016
Event: Abstract from SETAC North America, Orlando, United States.
Main Research Area: Technical/natural sciences
Publication: Research › Conference abstract for conference – Annual report year: 2016

**Immediate and delayed interactions of global warming and contaminants on aquatic invertebrates**

**General information**
State: Published
Organisations: National Institute of Aquatic Resources, Section for Marine Ecology and Oceanography
Authors: Dinh, K. V. (Intern)
Publication date: 2016
Event: Abstract from Annual Meeting of the British Ecological Society, Liverpool, United Kingdom.
Main Research Area: Technical/natural sciences

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Invited talk
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**Low larval densities in northern populations reinforce range expansion by a Mediterranean damselfly**

1. Contemporary climate change triggers a poleward range shift in many species. A growing number of studies document evolutionary changes in traits accelerating range expansion (such as growth rate and dispersal-related traits). In contrast, the direct impact of decreasing conspecific densities towards the very edge of the expansion front has been neglected. Density effects may, however, have a profound direct impact on traits involved in range expansion and influence range dynamics. 2. In this study, we contrast the effects of high conspecific larval density typical for established populations and low larval density typical for newly founded populations at the edge of the expansion front on a set of larval traits that may affect the range dynamics in the poleward moving damselfly Coenagrion scitulum. We therefore ran an outdoor mesocosm experiment with a low- and high-density treatment close to the species’ northern expansion front. Density effects on survival, growth rate and body size are scored both during the pre-winter growth period and during the subsequent winter period. Additionally, foraging activity was scored at the end of the pre-winter period and body condition [size-corrected body mass, fat content and activity of phenoloxidase (PO)] was scored at the end of the winter period. 3. The low-density treatment had strong direct positive effects on survival, growth rate and body size of larvae before winter indicating relaxed competition. Lower foraging activity at the low-density treatment indicated higher food availability at low conspecific densities. Interestingly, the initial density treatment had stronger effect than densities experienced at the time of quantification on survival during the pre-freezing winter period and body condition estimates at the end of the experiment, indicating also delayed effects of the initial density treatment. Survival throughout a freezing period indicated extreme winter conditions are not likely a limiting factor in the range expansion of this Mediterranean species. 4. The increased survival and individual growth rates (through causing shifts in voltinism) at low conspecific density will translate in increased population growth rates. Furthermore, nutritional advantages at low conspecific density may increase investment in dispersal ability. Together, these direct and delayed...
density-dependent effects that gradually increase towards the expansion front are expected to accelerate range expansion
Rapid adaptation to oil exposure in the cosmopolitan copepod Acartia tonsa

Oil spills are potential environmental hazards to marine ecosystems worldwide. Oil spills may persist in seawater longer than one generation of many zooplankton species. However, whether populations of short-lived and fast growing marine organisms adapt to oil exposure through natural selection is not known. To test this, the cosmopolitan estuarine copepod Acartia tonsa was exposed to pyrene continuously for two generations, at the concentrations 0, acetone control, 1, 10, 100 and the saturated pyrene concentration in seawater, 100+ nM. Pyrene is one of the most toxic components in crude oil to marine copepods. The key fitness-related traits were quantified: survival, size at maturity, grazing rate and the reproductive success. Exposure to the concentration of pyrene saturated in seawater (100+ nM) resulted in 100 % mortality before adulthood in the first generation. In the other treatments (≤ 100nM), the first generation had a higher grazing rate than the second generation. Exposure to pyrene had no effect on the grazing rate. At the concentration of 100 nM, pyrene exposure caused reductions in survival, size at maturity of females, egg production and hatching success. The reduction in size at maturity of females was less pronounced in the second generation. Strikingly, both survival, egg production and hatching success were recovered in the second generation, indicating a rapid selection towards individuals with adaptations to deal with pyrene exposure. Our results show that populations of short-lived and fast-growing copepods have the potential of showing surprisingly strong resilience to the type of oil contamination they might face in their natural coastal habitats

Rapid evolution of increased vulnerability to an insecticide at the expansion front in a poleward moving damselfly

Many species are too slow to track their poleward-moving climate niche under global warming. Pesticide exposure may contribute to this by reducing population growth and impairing flight ability. Moreover, edge populations at the moving range front may be more vulnerable to pesticides because of the rapid evolution of traits to enhance their rate of spread that shunt energy away from detoxification and repair. We exposed replicated edge and core populations of the poleward-moving damselfly Coenagrion scitulum to the pesticide esfenvalerate at low and high densities. Exposure to esfenvalerate had strong negative effects on survival, growth rate, and development time in the larval stage and negatively affected flight-related adult traits (mass at emergence, flight muscle mass, and fat content) across metamorphosis. Pesticide effects did not differ between edge and core populations, except that at the high concentration the pesticide-induced mortality was 17% stronger in edge populations. Pesticide exposure may therefore slow down the range expansion by lowering population growth rates, especially because edge populations suffered a higher mortality, and by negatively affecting dispersal ability by impairing flight-related traits. These results emphasize the need for direct conservation efforts toward leading-edge populations for facilitating future range shifts under global warming
Integrating ecology and evolution in aquatic toxicology: insights from damselflies

Current legislation and ecological risk assessment fails to protect aquatic biodiversity at low levels of contaminants. We addressed 3 topics embedded in general stress ecology and evolutionary ecology that are relevant to arrive at a better evaluation of the risk of low contaminant levels in aquatic systems: 1) delayed effects of contaminants, 2) interactions between contaminants and biotic interactors, and 3) vulnerability to contaminants under global warming. We developed these topics by capitalizing on the key insights obtained using damselflies as model organisms. First, delayed contaminant effects on important fitness-related effects exist during the larval stage and after metamorphosis in the adult stage. Second, synergistic interactions of contaminants with bacteria and predation risk have been demonstrated, and we present advances in the mechanistic understanding of these synergisms with biotic interactors. Third, we illustrate the strength of assessing the effect of contaminants under global warming using a space-for-time substitution approach and the need to consider temperature extremes. These studies using damselflies as model organisms highlight the relevance of considering contaminant effects after the exposure period and in the presence of natural stressors, such as predation.
risk and higher temperatures. They further highlight the need for spatially explicit risk-assessment and conservation tools. These insights are relevant for most aquatic taxa. Indeed most aquatic taxa have a complex life cycle, are strongly affected by predation risk and by warming, and show latitudinal gradients. Better integration of these topics in ecological risk assessment will be a major challenge for both scientists and policy makers, but of crucial importance to preserve aquatic biodiversity.

General information
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Scopus rating (2005): SJR 1.414 SNIP 1.355
Scopus rating (2004): SJR 1.413 SNIP 1.704
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aquatic biodiversity, aquatic toxicology, biotic interactor, fitness-related effect, predation risk, space-for-time substitution, species ecology, species evolution, Insecta Arthropoda Invertebrata Animalia (Animals, Arthropods, Insects, Invertebrates) - Odonata [75338] Coenagrion scitulum species Coenagrion puella species Enallagma cyathigerum species Ischnura elegans species Xanthocnemis zealandica species, Microorganisms (Bacteria, Eubacteria, Microorganisms) - Bacteria [05000] bacteria common, contaminants toxin, 07502, Ecology: environmental biology - General and methods, 07508, Ecology: environmental biology - Animal, 07514, Ecology: environmental biology - Limnology, 22501, Toxicology - General and methods, 22506, Toxicology - Environment and industry, 30000, Bacteriology, general and systematic, 31000,
Spatial-specific vulnerability of animals to contaminants under global warming: ERA in a changing world

General information
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Organisations: National Institute of Aquatic Resources, Section for Marine Ecology and Oceanography
Authors: Dinh, K. V. (Intern)
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Main Research Area: Technical/natural sciences
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Extreme temperatures in the adult stage shape delayed effects of larval pesticide stress: A comparison between latitudes

Global warming and pesticide pollution are major threats for aquatic biodiversity. Yet, how pesticide effects are influenced by the increased frequency of extreme temperatures under global warming and how local thermal adaptation may mitigate these effects is unknown. We therefore investigated the combined impact of larval chlorpyrifos exposure, larval food stress and adult heat exposure on a set of fitness-related traits in replicated low- and high-latitude populations of the damselfly Ischnura elegans. Larval pesticide exposure resulted in lighter adults with a higher water content, lower fat content, higher Hsp70 levels and a lower immune function (PO activity). Heat exposure reduced water content, mass, fat content and flying ability. Importantly, both stressors interacted across metamorphosis: adult heat exposure lowered the reduction of fat content, and generated a stronger decrease in PO activity in pesticide-exposed animals. Larval pesticide exposure and larval food stress also reduced the defense response to the adult heat stress in terms of increased Hsp70 levels. In line with strong life history differences in the unstressed control situation, high-latitude animals were less sensitive to food stress (body mass and water content), but more sensitive to pesticide stress (development time and PO activity) and heat exposure (PO activity and Hsp70 levels). While low-latitude adults could better withstand the extreme temperature as suggested by the weaker increase in Hsp70, heat exposure similarly affected the delayed effects of larval pesticide exposure at both latitudes. Our study highlighted two key findings relevant for ecological risk assessment under global warming. Firstly, the delayed effects of larval pesticide exposure on adult damselflies depended upon subsequent adult heat exposure, indicating that larval pesticide stress and adult heat stress interacted across metamorphosis. Secondly, low- and high-latitude animals responded differently to the imposed stressors, highlighting that intraspecific evolution along natural thermal gradients may shape sensitivity to pesticides. (C) 2014 Elsevier B.V. All rights reserved.

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Local adaptation and the potential effects of a contaminant on predator avoidance and antipredator responses under global warming: a space-for-time substitution approach

The ability to deal with temperature-induced changes in interactions with contaminants and predators under global warming is one of the outstanding, applied evolutionary questions. For this, it is crucial to understand how contaminants will affect activity levels, predator avoidance and antipredator responses under global warming and to what extent gradual thermal evolution may mitigate these effects. Using a space-for-time substitution approach, we assessed the potential for gradual thermal evolution shaping activity (mobility and foraging), predator avoidance and antipredator responses when Ischnura elegans damselfly larvae were exposed to zinc in a common-garden warming experiment at the mean summer water temperatures of shallow water bodies at southern and northern latitudes (24 and 20 degrees C, respectively). Zinc reduced mobility and foraging, predator avoidance and escape swimming speed. Importantly, high-latitude populations showed stronger zinc-induced reductions in escape swimming speed at both temperatures, and in activity levels at the high temperature. The latter indicates that local thermal adaptation may strongly change the ecological impact of contaminants under global warming. Our study underscores the critical importance of considering local adaptation along natural gradients when integrating biotic interactions in ecological risk assessment, and the potential of gradual thermal evolution mitigating the effects of warming on the vulnerability to contaminants.

General information

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Scopus rating (2010): SJR 1.633 SNIP 1.014
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Temperature- and latitude-specific individual growth rates shape the vulnerability of damselfly larvae to a widespread pesticide

1. Freshwater ecosystems are especially vulnerable to climate change and pollution. One key challenge for aquatic toxicology is to determine and manage the combined effects of temperature increase and contaminants across species' ranges.  
2. We tested how thermal adaptation and life-history evolution along a natural temperature gradient influence the vulnerability of an aquatic insect to a pesticide under global warming. We applied a space-for-time substitution approach to study the effect of warming on the vulnerability of Ischnura elegans damselfly larvae to the pesticide chlorpyrifos in a common garden warming experiment (20 and 24 degrees C) with replicated populations from three latitudes spanning >1500 km in Europe.  
3. Chlorpyrifos was more toxic to damselfly larvae at the higher temperature: mortality only occurred at 24 degrees C and the reductions in growth rate were stronger at 24 degrees C. This could partly be explained by parallel reductions in food intake but not by the activities of two widespread enzymatic biomarkers, glutathione S-transferase (GST) and acetylcholinesterase (AChE).  
4. There was some evidence that the increased toxicity of the high chlorpyrifos concentration at 24 degrees C was stronger in terms of growth reduction in the faster-growing larvae from the low-latitude populations. This is consistent with energy allocation trade-offs between growth rate and pesticide tolerance, but suggests that local thermal adaptation does not play a role in coping with pesticide stress.  
5. Synthesis and applications. Damselfly larvae from populations in lower latitudes were more vulnerable to a common pesticide at higher temperatures and pesticide concentrations, whereas evidence for the influence of local thermal adaptation on the vulnerability of larvae was weak. These results emphasize the need for spatially explicit bioassessment and conservation tools. Management practices aimed at mitigating pesticide run-off into aquatic ecosystems are particularly important in agricultural areas at low latitudes.

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**Warming increases chlorpyrifos effects on predator but not anti-predator behaviours**

Recent insights indicate that negative effects of pesticides on aquatic biota occur at concentrations that current legislation considers environmentally protective. We here address two, potentially interacting, mechanisms that may contribute to the underestimation of the impact of sublethal pesticide effects in single species tests at room temperature: the impairment of predator and antipredator behaviours and the stronger impact of organophosphate pesticides at higher temperatures. To address these issues we assessed the effects of chlorpyrifos on the predator and antipredator behaviours of larvae of the damselfly *Ischnura elegans*, important intermediate predators in aquatic food webs, in a common-garden warming experiment with replicated low- and high-latitude populations along the latitudinal gradient of this species in Europe. Chlorpyrifos reduced the levels of predator behavioural endpoints, and this reduction was stronger at the higher temperature for head orientations and feeding strikes. Chlorpyrifos also impaired two key antipredator behavioural endpoints, activity reductions in response to predator cues were smaller in the presence of chlorpyrifos, and chlorpyrifos caused a lower escape swimming speed; these effects were independent of temperature. This suggests chlorpyrifos may impact food web interactions by changing predator-prey interactions both with higher (predators) and lower trophic levels (food). Given that only the interaction with the lower trophic level was more impaired at higher temperatures, the overall pesticide-induced changes in food web dynamics may be strongly temperature-dependent. These findings were consistent in damselflies from low- and high-latitude populations, illustrating that thermal adaptation will not mitigate the increased toxicity of pesticides at higher temperatures. Our study not only underscores the relevance of including temperature and prey-predator interactions in ecological risk assessment but also their potential interplay and thereby highlights the complexity of contaminant effects on predator-prey interactions being differentially temperature-dependent pending on the trophic level. (C) 2014 Elsevier B.V. All rights reserved.

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Susceptibility to a metal under global warming is shaped by thermal adaptation along a latitudinal gradient

Global warming and contamination represent two major threats to biodiversity that have the potential to interact synergistically. There is the potential for gradual local thermal adaptation and dispersal to higher latitudes to mitigate the susceptibility of organisms to contaminants and global warming at high latitudes. Here, we applied a space-for-time substitution approach to study the thermal dependence of the susceptibility of Ischnura elegans damselfly larvae to zinc in a common garden warming experiment (20 and 24 degrees C) with replicated populations from three latitudes spanning >1500 km in Europe. We observed a striking latitude-specific effect of temperature on the zinc-induced mortality pattern; local thermal adaptation along the latitudinal gradient made Swedish, but not French, damselfly larvae more susceptible to zinc at 24 degrees C. Latitude-and temperature-specific differences in zinc susceptibility may be related to the amount of energy available to defend against and repair damage since Swedish larvae showed a much stronger zinc-induced reduction of food intake at 24 degrees C. The pattern of local thermal adaptation indicates that the predicted temperature
increase of 4 degrees C by 2100 will strongly magnify the impact of a contaminant such as zinc at higher latitudes unless there is thermal evolution and/or migration of lower latitude genotypes. Our results underscore the critical importance of studying the susceptibility to contaminants under realistic warming scenarios taking into account local thermal adaptation across natural temperature gradients.
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Web of Science (2005): Indexed yes
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Thermal evolution may mediate the changed interactions with contaminants and predators in a warming world: a space-for-time substitution using damselflies

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Projects:
Adaptability of tropical copepods to warmer and polluted future: with emphasis on metagenomics after multiple-generation exposure
The adaptability of tropical copepods to global warming and polluted environment will be tested using metagenomics approach.

National Institute of Aquatic Resources
Section for Oceans and Arctic
Period: 01/09/2017 → 31/08/2019
Number of participants: 1
tropical marine ecosystem, Pseudodiaptomus annandalei, global warming, adaptation, metagenomics, gut microbiomes, contaminants, PAH
Effects of dispersed oil droplets and produced water components on growth, development and reproduction of Arctic pelagic copepods (PWC-Arctic) (39297)

As the Oil & Gas industry moves north towards the Arctic, it is crucial to understand and be able to predict the potential for detrimental effects of regular (produced water) and accidental oil spills on Arctic organisms, which often are characterized by high lipid content. Organisms with high lipid content are susceptible to accumulation of lipophilic organic components like produced water components (PWC) including oil droplets. Limited data exist on accumulation of oil components in Arctic lipid-rich species which are parameterized so they can be applied as input to models predicting bioaccumulation and body residues as a function of exposure time/concentration. Even less data exist where body residues of oil components are explicitly linked to sub-lethal and delayed effects (e.g. on offspring). Finally, the potential contribution of oil droplets to bioaccumulation has never been studied in Arctic species.

The present project aims at:
- providing parameterized data on uptake/elimination kinetics and internal administration (partitioning coefficients between lipids and body fluids) for PW components in the Arctic lipid-rich copepods Calanus glacialis and C.hyperboreus:
- determine effect concentrations for PW components on early life stages of these copepods; and finally
- assess the potential for maternal transfer of PW components to eggs by exposing females prior to egg-laying and determine potential developmental effects in early stages developing in clean sea water.

The parameterized data collected in this project will provide direct input to numerical models aimed at predicting impact of PW on Arctic organisms. The approaches and methodologies used are based on extensive experience from previous toxicological studies on the two Arctic species and in particular the related boreal species Calanus finmarchicus. The main objective of the current proposal is to increase the knowledge of the potential effects of dispersed oil and other produced water components on growth and reproduction in lipid-rich Arctic planktonic crustaceans. This project is coordinated by SINTEF, Norway. The project is funded by the Research Council of Norway.

Marine pelagic secondary production under environmental stress - impacts of climate change and oil exposure

In this project, we used copepods as key species to assess the secondary production in marine ecosystems from Arctic to tropical regions under changing environment. We experimentally test the vulnerability of both generalist and specialist copepods to crude oil components in a warmer environment.

Marine pelagic secondary production under environmental stress - impacts of climate change and oil exposure

In this project, we used copepods as key species to assess the secondary production in marine ecosystems from Arctic to tropical regions under changing environment. We experimentally test the vulnerability of both generalist and specialist copepods to crude oil components in a warmer environment.
**Activities:**

**Species-specific vulnerability of Arctic copepods to oil contamination and global warming**  
*Period:* 9 May 2017  
Khuong Van Dinh (Speaker)  
Torkel Gissel Nielsen (Other)  
National Institute of Aquatic Resources  
Section for Oceans and Arctic  

**Description**  
Special session: Combined effects of chemical and environmental stressors: from local stressors towards climate change, SETAC Europe 27th Annual Meeting in Brussels, Belgium

**Related external organisation**  
**Society of Environmental Toxicology and Chemistry**  
United States  
Activity: Talks and presentations › Conference presentations

**Immediate and delayed interactions of global warming and contaminants on aquatic invertebrates**  
*Period:* 10 Dec 2016 → 14 Dec 2016  
Khuong Van Dinh (Speaker)  
National Institute of Aquatic Resources  
Section for Oceans and Arctic  

**Description**  
Annual Meeting of the British Ecological Society - Liverpool, United Kingdom

**Related external organisation**  
**British Ecological Society**  
London, United Kingdom  
Activity: Talks and presentations › Conference presentations