THEME SECTION

Advances in the ecology of freshwater mysids

Idea and coordination: Lars G. Rudstam, Ora E. Johannsson

CONTENTS

Rudstam LG, Johannsson OE
Introduction .......................................................... 246–248

Johannsson OE, Bowen KL, Arts MT, Smith RW
Field assessment of condition indices (nucleic acid and protein) in Mysis diluviana ........................................ 249–262

Boscarino BT, Rudstam LG, Eileenberger JJ, O’Gorman R
Importance of light, temperature, zooplankton and fish in predicting the nighttime vertical distribution of Mysis diluviana ......................................................... 263–279

Whall JD, Lasenby DC
Differences in the trophic role of Mysis diluviana in two intermontane lakes .................................................... 281–292

Koksvik JI, Reinertsen H, Koksvik J
Plankton development in Lake Jonsvatn, Norway, after introduction of Mysis relicta: a long-term study ............... 293–304

ABSTRACT: Mysids can be considered the krill of lakes. These crustaceans are relatively small (<30 mm), omnivorous, perform extensive vertical migrations, are a major food source for fishes, and can be the dominant species by mass in lakes. This Theme Section comprises 4 papers that represent significant advances in the study of these ecologically important animals, including techniques that were not available 20 years ago, such as DNA:RNA:protein ratios, fatty acids and stable isotopes as growth indicators, quantitative analysis of acoustics data and vertical migration models. The Theme Section thus represents a step forward towards better understanding long-term zooplankton time series, mysid omnivory, and the mysid ecological role in lake food webs.

KEY WORDS: Mysis relicta · Mysis diluviana · Zooplankton · Lakes · Food web

Introduction

Lars G. Rudstam1,*, Ora E. Johannsson2

1Cornell Biological Field Station, Department of Natural Resources, Cornell University, Bridgeport, New York 13030, USA
2Fisheries and Oceans, Canada, Great Lakes Laboratory for Fisheries and Aquatic Sciences, 867 Lakeshore Rd, Burlington, Ontario L7R 4A6, Canada

ABSTRACT: Mysids can be considered the krill of lakes. These crustaceans are relatively small (<30 mm), omnivorous, perform extensive vertical migrations, are a major food source for fishes, and can be the dominant species by mass in lakes. This Theme Section comprises 4 papers that represent significant advances in the study of these ecologically important animals, including techniques that were not available 20 years ago, such as DNA:RNA:protein ratios, fatty acids and stable isotopes as growth indicators, quantitative analysis of acoustics data and vertical migration models. The Theme Section thus represents a step forward towards better understanding long-term zooplankton time series, mysid omnivory, and the mysid ecological role in lake food webs.

KEY WORDS: Mysis relicta · Mysis diluviana · Zooplankton · Lakes · Food web

Mysids, or opossum shrimps, are members of the mostly marine order Mysidacea. There are some 30 species occurring in freshwater lakes and rivers, and the group has a worldwide distribution. Of these species, members of the Mysis relicta species complex have received the greatest attention because of their high abundance in some lakes (reported densities >1000 ind. m⁻²), their importance as a food source for fishes, and their sometimes large effect on food web dynamics. The Mysis relicta species complex consists of
Migrating organisms.

be useful for understanding the distribution of other
2009), and the approach by Boscarino et al. should also
cal migrations are common in zooplankton (DeMeester
and more realism to predator–prey models. Diel verti-
deration (review in Rudstam 2009), but they are
difficult to measure
tween mysids and their prey and predators likely occur
were supposed to enhance (Lasenby et al. 1986, Nesler
& Bergersen 1991). Effects can cascade through eco-
system food webs to top predators such as bears and
eagles (Spencer et al. 1991).

Mysid growth rate is a key component in calculating productivity of the mysid population and mysid consumption of various prey items (Johannsson et al. 2003), which are needed for inferences on the role of mysids in the food web. Growth rates vary widely, and are highest in highly productive lakes. Growth rates range from 0.2 mm mo⁻¹ in Lake Tahoe to 1.5 mm mo⁻¹ in meso-
trophic lakes (review in Rudstam 2009), but they are
difficult to measure in situ, especially when generations overlap. Johannsson et al. (2008) used nucleic acids and protein ratios as indicators of mysid growth and condition in laboratory experiments. Johannsson et al. (2009, this Theme Section) use this method to investigate in-
ter-annual and spatial growth rate differences in Lake
Ontario. The indices demonstrate differences in condi-
tion and growth rate, and suggest that certain essential fatty acids may be limiting in Lake Ontario.

*Mysis* spp. perform diel migrations at dusk and dawn from their daytime refuge in dark, deep water to the meta- or epilimnion, where they feed on zooplankton and algae. These migrations can be over 100 m and are limited by temperatures above 12 to 16°C and light levels above 10⁻⁴ lux, i.e. light levels that limit fish visual feeding. Boscarino et al. (2009a, this Theme Section) show that the actual distributions, not just the mean depth, can be predicted from the response of mysids to these variables in the laboratory (Boscarino et al. 2007, 2009b). Including the distribution of mysid prey and predators did not improve the predicting ability of the models. Because most of the interactions between mysids and their prey and predators likely occur at the edges of their vertical distributions, a better understand-
ing of the whole distribution, not only the mean depth, is essential for adding a spatial dimension and more realism to predator–prey models. Diel vertical migrations are common in zooplankton (DeMeester 2009), and the approach by Boscarino et al. should also be useful for understanding the distribution of other migrating organisms.

Mysids are omnivores and capable of both filter-feeding and raptorial feeding. Mysids also feed on benthic prey, detritus and sediment during the day (Van Duyn-Henderson & Lasenby 1986). Diets of mysids can vary greatly between neighboring lakes (Nordin et al. 2008). Whall & Lasenby (2009, this Theme Section) examined the trophic role of *Mysis diluviana* in 2 neighboring lakes, one in which the introduction of mysids was associated with the collapse of kokanee salmon *Onco-
ryynchus nerka* (Okanagan Lake), and the other, in which it was not (Kalamalka Lake). They predicted that zooplankton would form a greater proportion of the diet of mysids in Okanagan Lake, where they were expected to compete more strongly with kokanee for zooplankton prey. However, comparison of mysid diets and clearance rates together with stable isotope signatures suggested that this was not the case. The study by Whall & Lasenby (2009) shows how these different techniques can be combined to investigate mysid prey choice. The reason for the different food web effects in the 2 lakes, however, remains unknown.

Mysids were introduced in 1949 to Kootenay Lake, BC, Canada, and are thought to be responsible for a large increase in growth rate of kokanee salmon and the spectacular fishery that developed after the intro-
duction. After this reported success, mysids were intro-
duced to many lakes and reservoirs in North America and Scandinavia to increase fish growth and produc-
tion. However, results were not often those intended, as mysid predation caused declines in cladocerans, in particular in *Daphnia*. Koksvik et al. (2009, this Theme Section) show that an initial decline in cladocerans can be a transitory phenomenon. In Lake Lille Jons-
vatn, the cladocerans returned after a period of 11 yr with depressed *Daphnia* abundance. Koksvik et al. (2009) think that this may be due to increased water clarity, which limits mysid migration into shallower water and provides a refuge for cladocerans in the epil-
imnion. This study highlights the importance of long-
term studies.

The contributions to this Theme Section represent the state of the art in mysid ecology. The papers are based on a symposium on mysid biology organized by Lars Rudstam, Ora Johannsson and Michael Arts at the In-
ternational Society of Limnology meeting in Montreal in 2007. The mysid symposium represented an update of similar symposia held in the 1980s and 1990s (Morgan 1982, Nesler & Bergersen 1991). The contributions to the present Theme Section include the use of tech-
niques that were not available 20 years ago, such as DNA:RNA:protein ratios, fatty acids and stable isotopes as growth indicators, as well as quantitative analysis of acoustics data and vertical migration models, and thus represent a step forward towards better understanding the ecology of mysids in freshwater systems.
LITERATURE CITED


