8 Summary

Numerous trophic interactions characterize the predator-prey-relationship between copepods and ciliates. Ciliates belong to the prey spectrum of copepods due to their spatial and temporal availability as well as to their cell size. Vulnerability and prey-induced biochemical composition of the ciliates should have impact on their quality as prey for the copepods.

Experiments with calanoid and cyclopoid copepods were conducted to answer the question whether ciliates could be an adequate food source to sustain copepodid development and reproduction (hypothesis I). Several predator-prey combinations were tested with ciliate species of different trophic modes (algivorous versus bacterivorous), cell size, and cell surface texture as prey for copepods in comparison to *Cryptomonas,* and in comparison to controls without food supply. From literature *Cryptomonas* is known as good food quality for copepods development and reproduction. The results show large predator and prey specific differences for development and reproduction of the copepods.

The small prostomatid algivorous ciliate *Urotricha farcta* was identified as adequate food source for significantly the fastest copepodid development of the calanoid *Eudiaptomus gracilis*, *E. graciloides*, but also for the development of the cyclopoid *Cyclops vicinus*, *C. abyssorum* as well as *Mesocyclops leuckarti*. *Thermocyclops oithonoides* on the other hand was not able to perform its copepodid development feeding on this ciliate, but showed a high mortality of the young copepodid instars in the experiments. In comparison to the *Cryptomonas* treatments *M. leuckarti* also showed a significantly higher mortality rate in the *Urotricha* treatments despite the high developmental rate of the copepodites. There were no significant differences in the mortality rates of *M. leuckarti* between the treatment with *Urotricha*, *Cyclidium*, and without prey supply.

Urotricha induced the significantly highest egg production rates for *E. gracilis* and *M. leuckarti* in comparison to the tested bactereivorous ciliates and *Cryptomonas*. The mortality rates were not increased in these experiments in comparison to the other prey treatments. According to hypothesis II it was confirmed that algivorous ciliates constitute a better food quality as bacterivorous ciliates for *E. gracilis*, *E. graciloides*, *M. leuckarti* and also for *C. vicinus.*

The somewhat larger *Coleps* sp. belongs to the Prostomatida too and exhibits a calcerous spiny plating and was also tested for its suitability as prey for the reproduction of *E. graciloides*. *Coleps* was ingested at high rates but induced reproductive rates that were only half of that induced by *Cryptomonas*. These differences were significant.

The bacterivorous ciliate *Tetrahymena pyriformis* on the other hand has no protective plating but was ingested in significantly lower rates and supported no reproductive effort of *E. graciloides*. The survival time of *E. graciloides* in the *Tetrahymena* treatments was significantly lower than in the *Coleps* and *Cryptomonas* treatments.

The likewise bacterivorous ciliate *Colpidium campylum,* which was of similar size as *Tetrahymena*, was depleted at high rates by all tested copepods and supported copepodite development of the calanoids *E. gracilis* and *E. graciloides* as well as the cyclopoids *C. vicinus* und *C. abyssorum* when offered in high concentrations. It was demonstated that *Colpidium* supports the egg production of both *Eudiaptomus* species and of *C. vicinus*. An increased mortality of copepods was not found in any of the *Colpidium* treatments.

M. leuckarti as well as *T. oithonoides* could perform the whole copepodid development until maturity when feeding on the distinct smaller bacterivorous ciliate *Cyclidium* sp. The developmental rate of *M. leuckarti* was significantly the highest in the *Urotricha* treatments and that of *T. oithonoides* was significantly the highest in the *Cryptomonas* treatments. The egg production rate of *M. leuckarti* was significantly lower when feeding on *Cyclidium* as when feeding on *Urotricha*, but both treatments were significantly higher than in the *Cryptomonas* treatments. *Cyclidium* was not the best food source for any of the tested copepod species, but was sufficient to support the copepodid development and reproduction.

The phytoflagellate *Cryptomonas* was tested in all copepodid development and reproduction experiments. *Cryptomonas* supported the development up to maturity and egg production of all tested copepods. *T. oithonoides* reached significantly the highest copepodit developmental rates in the *Cryptomonas* treatments and was confirmed as an algivorous copepod.

At least the males of *M. leuckarti* developed up to maturity when feeding on *Cryptomonas*. *E. graciloides* showing significantly the highest egg production rates in the *Cryptomonas* treatment in comparison to when feeding on *Coleps*, *Tetrahymena* and to the controls without prey.

Overall, all mesozooplankter that were tested in the *in situ* grazing experiments in the DCM decimated ciliates except *T. oithonoides.* Furthermore ciliates were positively selected against other possible prey items. The only exception was *T. oithonoides*, which did not ingest any ciliates but show an algivorous feeding behavior, as confirmed in the laboratory experiments. The evaluated selection coefficients according to Jacobs (1974) showed no positive selection of al-

givorous against bacterivorous ciliates. The selection coefficients were positively correlated to the cell size of the ciliates.

With exception of the rotifers, nearly all tested mesozooplankter were able to deplete the long filamented cyanobacteria, which was the opposite of the hypothesis III. *E. graciloides* exhibit the highest grazing pressure on the ciliat community as well as on the filamentous cyanobacteria. A high concentration of the filamentous cyanobacteria connected with dominance of very long filaments had a negative impact on the ingestion rates of cyclopoid copepodites, but less impact on *E. graciloides.*

The results from the laboratory grazing experiments with *E. graciloides* feeding on ciliates at different oxygen saturations showed no impairment of ingestion up to a lower saturation of 5 %. In the treatments with an oxygen saturation of 2 % all copepods died within 1 hour. *E. graciloides* could use the DCM as food source in the beginning phase, when oxygen saturation is higher than 2 %, but later in the year, only a restricted utilization from the upper oxygen richer water layers is possible with short term residence in the microaerobic water layer of the DCM. The microbial community is therefore widely protected against grazing by *E. graciloides* because of the microaerobic conditions.

The long chained cyanobacteria filaments were widely protected against the grazing of cyclopoid copepodids when they occurred in higher concentrations. Cyclopoid copepodites and rotifers are more tolerant against oxygen deficiency and stay constantly in the DCM and have a negative effect upon ciliates and flagellates.

The very abundant large sulphur bacteria *Chromatium* could be ingested by the adult *E. graciloides*, *T. oithonoides* as well as by the cyclopoid copepodids. The most obvious direct impact of the tested mesozooplankter on the community of the DCM could be detected on ciliates, Chl a concentration, as well as on cryptomonads and hetrotrophic flagellates. The impact on the autotrophic picoplankton and the bacteria were, with the exception of the sulphur bacteria *Chromatium,* more or less indirect.

Ciliates do not only sustain a heavy feeding pressure by copepods and are selected positively against algae, but – as shown in my work – serve also as a high quality food for several copepods, which could be – with species-specific differences – better than that of cryptomonads. Dif-

ferences in food quality of algivorous versus bacterivorous ciliates could be shown, whereas no unequivocal valuation is possible solely on account of the trophic mode of the ciliates. Other features such as escape behaviour, possible chemically induced defence mechanisms, or the biosythesis capability of essential organic molecules (e. g. highly unsaturated fatty acids) could strengthen or interfere with the feature of the trophic mode.

These differeces in quality could have different effects on the fitness parameter developmental rate, egg production rate, or survival rate. As shown for *T. oithonoides*, cilites could not serve as alternative food souce for explicit algivorous copepods.

Deep chlorophyll maxima with associated high ciliate abundances in stable stratified lakes could be an attractive food source for copepods, but are protected against unrestricted exploitation by unfavorable environmental conditions.