INSTITUTIONEN FÖR BIOLOGI
OCH MILJÖVETENSKAP

Masters presentations in biology

May 2022

Schedule & abstracts

Tuesday May 24

At Botan (Room 6), 13-16

Wednesday May 25

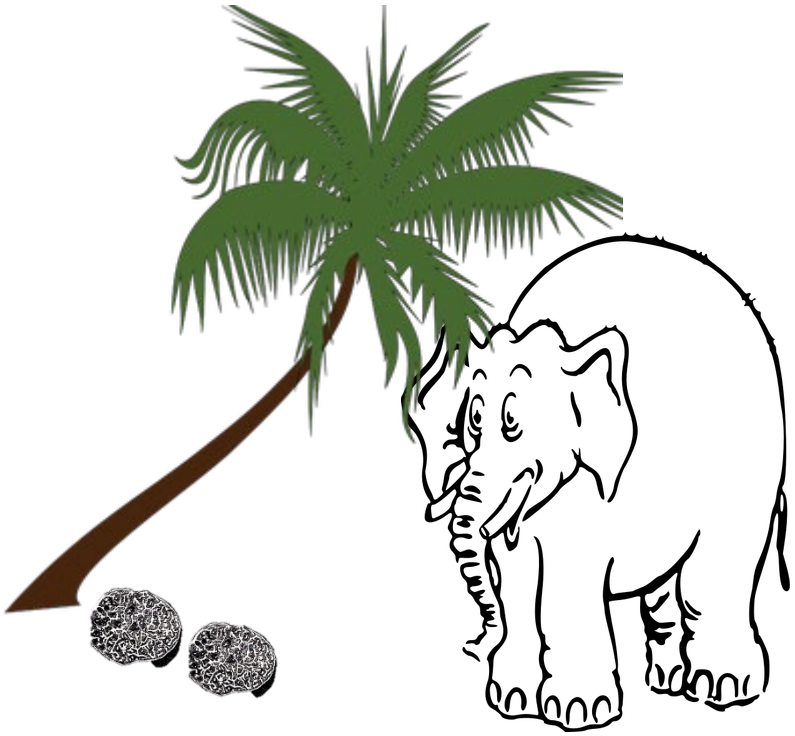
At Zoologen (ALC-room), 8.30-16.30

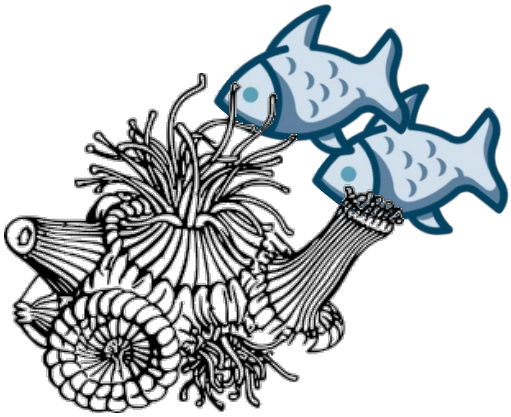
Monday May 30

At Zoologen (Seminar room), 9-15

All presentations can also be followed via Zoom, see “events” on our web page

Welcome!





Schedule

Times below are approximate (except for first presentation each day)

Tuesday May 24

13.00 **Charlie Havsblad** (Conservation biology, 30 hp)

The effect of suspended sediment on embryos and larvae of cold-water coral *Lophelia pertusa*

Opponent: Matilda Ahvenainen

13.50 **Arnold Tobias Jansson** (Biodiversity & systematics, 60 hp)

Troublesome truffles – a phylogenetic and taxonomic study of *Hymenogaster* (Basidiomycota)

Opponent: Rhonda Ridley

Ca. 14.45 *Short break*

15.00 **Rhonda Ridley** (Biodiversity & systematics, 60 hp)

Reconciliation of species delimitation in *Genipa* L. (Rubiaceae) using integrative taxonomy

Opponent: Arnold Tobias Jansson

Wednesday May 25

8.30 **Monica Olsson** (Physiology & cell biology, 60 hp)

Polystyrene nanoparticles and North Sea marine oil: A toxic mixture?

Opponent: Terese Hjelleset

9.30 **Terese Hjelleset** (Physiology & cell biology, 30 hp)

It's the world's most underrated aquaculture species – but how do we feed it?

Opponent: William Tejler

Ca. 10.15 *Short break*

10.30 **Eleftherios Kasiouras** (Physiology & cell biology, 60 hp)

Impact of intraspecific variation in personality on stress physiology and gut function in rainbow trout (*Oncorhynchus mykiss*)

Opponent: Giovanni Fini

Ca. 11.30 *Lunch break*

12.30 **Karin Witt** (Evolutionary and behavioural ecology, 30 hp)

Human pharmaceuticals – an enemy of the sea anemone?

Opponent: Pernilla Hansson

13.15 **Matilda Ahvenainen** (Conservation biology, 60 hp)

Physiological and behavior differences in offspring of migratory sea trout

Opponent: Charlie Havsblad

Ca. 14.15 *Longer break*

14.40 **Helena Sundell** (Evolutionary and behavioural ecology, 30 hp)

Arctic plant communities rise along with temperatures - Plant functional traits as a tool to predict global climate change

Opponent: Monica Olsson

15.30 **Emma Stenlund** (Conservation biology, 30 hp)

Sphagnum re-establishment on bare peat - an evaluation of restoration results

Opponent: Lisen Källman

Monday May 30

9.00 **William Tejler** (Evolutionary and behavioural ecology, 60 hp)

Large-scale dietary changes over the past 30 years in African forest elephants (*Loxodonta cyclotis*) in Lopé national park, Gabon

Opponent: Karin Witt

Ca. 10.00 *Short break*

10.15 **Pernilla Hansson** (Conservation biology, 60 hp)

Changed morphology in brown trout (*Salmo trutta*) in the presence of an invasive fish species and possible consequences for the benthic invertebrate community

Opponent: Eleftherios Kasiouras

11.15 **Giovanni Fini** (Conservation biology, 60 hp)

Spatio-temporal petterns of the wolf and its prey in a Mediterranean area

Opponent:

Ca. 12.15 *Lunch break*

13.00 **Lisen Källman** (Conservation biology, 30 hp)

Endophytic fungi in living trees - are communities affected more by tree species, tree age, or geographic origin?

Opponent: Emma Stenlund

13.45 **Otto Minas** (Physiology & cell biology, 60 hp)

Arctic mycorrhizal interactions under climate change

Opponent: Helena Sundell

Ca. 14.45 "Fika" for all presenters, examiners and supervisors

Abstracts

The effect of suspended sediment on embryos and larvae of cold-water coral *Lophelia pertusa*

Charlie Havsblad (Conservation biology, 30 hp)

Supervisor: Ann Larsson, Department of Marine Sciences, GU
Examiner: Karin Hårding

The cold-water coral *Lophelia pertusa* provides important habitats in deep-sea ecosystems, allowing for a biodiversity similar to that of tropical coral reefs. However, trawling and drilling leads to increased concentrations of suspended sediment (SS), which can potentially cause various negative effects in juvenile corals. The purpose of this thesis was to study the effects of suspended benthic sediments on embryo and larvae of *L. pertusa*. The embryos/larvae were exposed to one of four SS concentrations (control, 2.5 mg/L, 5 mg/L & 25 mg/L), during one or three days. Assessments were made on embryo and larvae survival, embryo development and larvae swimming speed. The embryos started exposure at around 1 day of age, while larvae were either 5, 9 or 12 days old. After one day of exposure, embryos appeared to tolerate the highest SS concentration, but with a much higher proportion of oocytes, indicating that either fertilization or development was stunned. After three days of exposure, the embryos had decreased survival rate and were likely to lack cilia with increasing SS concentrations. They also often responded by falling apart into multiple smaller embryos with higher sensitivity. Meanwhile, the larvae were mostly unaffected in both their survival and swimming speed. Future studies need to develop more reliable techniques to study large quantities of embryos, as well as other life-stages of *L. pertusa*, to understand the effects of SS. Knowledge gained on this topic can aid management decisions, to mitigate potential implications on dispersal and deep-sea biodiversity.

***

Troublesome truffles – a phylogenetic and taxonomic study of *Hymenogaster* (Basidiomycota)

Arnold Tobias Jansson (Biodiversity & systematics, 60 hp)

Supervisor: Henrik Nilsson, Department of Biological and Environmental Sciences, GU
Examiner: Bengt Oxelman

In the current biodiversity crisis knowing which species exist, and where they exist is critical. This is especially true of fungi since more than 90 % of the number of estimated species are still unknown to science. Among fungi, the non-monophyletic group called hypogeous fungi (true and false truffles) which includes the genus *Hymenogaster* is often overlooked. This genus is poorly known, species concepts vary between authors, typification is lacking, and type-derived sequences are rare. Recently, projects in Norway and Sweden to collect *Hymenogaster* material have yielded an assemblage of specimens that have now been sequenced. In this study, this material was combined with a set of GenBank sequences from previous *Hymenogaster* studies. Data on mycorrhizal partners were also included. Using Bayesian phylogenetic analyses, the object was exploring how the species composition in the Nordic countries compares to Europe, the relationships within *Hymenogaster*, and if *Hymenogaster* is monophyletic. Overall, the results are that the genus needs much attention. The species composition of the Nordic countries reflects that of Europe, although sampling is biased. Relationships within the genus have only been partially resolved, and *Hymenogaster*

in its traditional sense is not monophyletic. It will remain this way too, unless efforts are directed to designate neotypes and epitypes, and sequence existing types. It might also be wise to begin viewing some *Hymenogaster* species as species complexes to move forward and establish a better grasp of the genus.

***

Reconciliation of species delimitation in *Genipa* L. (Rubiaceae) using integrative taxonomy

Rhonda Ridley (Biodiversity & systematics, 60 hp)

Supervisor: Christine Bacon, Department of Biological and Environmental Sciences, GU
Examiner: Bengt Oxelman

The genus *Genipa* L. is a widespread, lowland, Neotropical tree in the coffee family, Rubiaceae. There is long-standing disagreement on the number of species that should be recognised in the genus. I used an integrative taxonomy approach encompassing genomic, morphology and distribution data to attempt to resolve the classification of *Genipa*. A comprehensive species phylogeny was produced under the multi-coalescent model, using a high resolution dataset from Angiosperm 353 target sequence capture data. I show, the first molecular evidence that *Genipa spruceana* Steyerm. often synonymised with *Genipa americana* L. is a distinct monophyletic species, similarly the monophyly of *Genipa infundibuliformis* Zappi & Samir is also demonstrated. The species delimitation for *Genipa spruceana* and *Genipa infundibuliformis* is supported by morphological characters and distribution data in *Genipa infundibuliformis*. The phylogeny shows that the widespread species *G. americana* has three distinct clades. These are likely to be independently evolving lineages. However following an integrative taxonomy approach no taxonomic rank is recommended until they can reliably be determined with evidence other than genomic data. Additionally the importance of leaf indumentum as a diagnostic character was investigated and scanning electron micrograph images of leaf trichomes in *Genipa* are presented.

***

Polystyrene nanoparticles and North Sea marine oil: A toxic mixture?

Monica Olsson (Physiology & cell biology, 60 hp)

Supervisors: Joachim Sturve & Marianne Brookman-Amissah, Department of Biological and Environmental Sciences, GU
Examiner: Kristina Snuttan Sundell

The awareness of micro-and nanoplastic pollution and its impact on the marine ecosystem has increased over the last decade. Nanoplastics may affect aquatic organisms since their small size and high surface-to-volume ratio increases their bioavailability and ability to cross biological membranes. An enhanced understanding interactions between nanoplastics and other environmental pollutants is needed for risk assessment and management. This study aims to examine possible toxic effects associated with single and combined exposure of polystyrene nanoparticles (PsNPs) and water-accommodated fractions (WAF) of North Sea marine oil on two in vitro fish models, measuring acute toxicity and exploring more sensitive in vitro assays. Rainbow trout gill and liver cell lines were exposed to either 25 nm PsNP (1-100 µg/mL), WAF (10-90%) or a mixture of them for 24 h. AlamarBlue and NeutralRed assays revealed a dose-dependent decrease in cell metabolic activity and lysosomal stability after WAF exposure. 80%-90% WAF concentration significantly reduced cell viability also in CFDA-

AM assay measuring membrane integrity. PsNPs alone did not significantly affect the cytotoxicity. However, higher concentration of PsNP in the mixtures significantly decreased the cell viability, indicating an additive effect. Generation of intracellular reactive oxygen species measured with DCFH-DA assay increased over a 6h period for all treatments. No significant differences among single exposures of PsNP, WAF, or of different PsNP concentrations in the mixtures were found, even if a slightly protective effect can be discussed. Pilot studies showed a trend of increasing induction of CYP1A dependent EROD activity in cells exposed to 20-50% WAF, and to mixtures with higher PsNP concentration. Sublethal and lethal effects in zebrafish embryos tended to increase with higher concentration of WAF alone, and with higher PsNPs concentrations in the mixtures. To conclude, PsNPs alone were generally not found to be toxic but may increase toxicity of organic pollutants found in crude oil.

***

It's the world's most underrated aquaculture species – but how do we feed it?

Terese Hjelleset (Physiology & cell biology, 30 hp)

Supervisors: James Hinchcliffe & Kristina Sundell, Department of Biological and Environmental Sciences, GU
Examiner: Michael Axelsson

Aquaculture is an exponentially growing industry accounting for almost half of the fish production in the world, including molluscs, crustaceans and other aquatic animals. Fishmeal is the most commonly used feed in aquaculture, but it is getting increasingly expensive and is not an environmentally sustainable product. Mussel meal has been proven to be a valid protein source replacement and is more sustainable to produce, as mussels are unfed and can be cultured specifically to remove nutrient overloads in eutrophicated areas. However, the shells are viewed as a waste product and deshelling is an energy demanding process. Swedish aquaculture has a big potential because of the access to water resources, the well-developed infrastructure, and high veterinary status. However, today Sweden's fish import costs exceed what is earned from export and the aquaculture production numbers and species diversity are low. Rainbow trout accounts for almost 90% of the total fish production. In order to have a more economically and environmentally sustainable fish production, Swedish aquaculture needs to expand and diversify. The spotted wolffish is a promising potential aquaculture species because of its many favorable traits; high market value, high growth rate, resistance to diseases and low-stressed behavior make it the perfect farm animal. However, the nutritional demands are not met with commercial feeds and results in health and welfare issues. The aim of this project was to investigate how the inclusion of shells in musselmeal affects growth, health and welfare parameters in blood plasma. The results show that there are no significant differences in ion and acids-base balance, growth performance parameters or stress and growth biomarkers. Mussel meal with shells can therefore effectively replace mussel meal without negatively affecting the health, welfare, or growth of the spotted wolffish.

***

Impact of intraspecific variation in personality on stress physiology and gut function in rainbow trout *(Oncorhynchus mykiss)*

Eleftherios Kasiouras (Physiology & cell biology, 60 hp)

Supervisor: Lynne Sneddon, Department of Biological and Environmental Sciences, GU
Examiner: Michael Axelsson

Higher demands on the aquaculture industry have increased dramatically, over the last decades. To address global food demand and sustainability challenges, aquaculture has appeared as an essential element in food systems. Although aquaculture is one of the most sustainable industries in food production, still there are many implications that need to be resolved. One of the most important factors and main focus of this thesis, is welfare. Rainbow trout *(Oncorhynchus mykiss)* belongs in salmonids, which is one of the most economically important and well-known groups of farmed fish. Rainbow trout exhibits two different personalities: bold and shy. These personalities affect the stress response, physiology and welfare. Additionally, these personalities are heritable, also affecting the fitness of populations. In order to apprise the effects, we designed a series of experiments. Firstly, we conducted a series of behavioral experiments. Initially the aim was to classify fish as bold or shy, with a novel object test. During this test, a novel object is introduced in the tank and fish that approach the object in less than three minutes, in a five cm distance, are classified as bold. The rest as shy. Afterwards a second novel object was conducted, and then an open field test and a pairwise contest. These tests are important for monitoring the behavior of fish and their heart rate (with biologgers), to examine how fish react in stressful situations. Finally, a third novel object conducted, to induce stress and then fish were euthanized and sampled. The samples were from brain, gut and blood. These physiological parameters were cortisol, lactate and glucose form the blood samples. The gut samples were transferred to Ussing chambers. The results evince that the latency to approach the novel object, in 5 cm distance, is the most indicative parameter of boldness or shyness. Furthermore, in agreement with previous studies, were the results about levels of cortisol. In shy fish the average levels were higher than the bold fish. Also, the heart rate during and after the tests, indicate that personality has an effect in physiology and stress response. This concludes that good welfare should be considered when farming or studying rainbow trout and in general animals.

***

Human pharmaceuticals – an enemy of the sea anemone?

Karin Witt (Evolutionary and behavioural ecology, 30 hp)

Supervisor: Lynne Sneddon, Department of Biological and Environmental Sciences, GU
Examiner: Lotta Kvarnemo

Derivatives and metabolites of human pharmaceuticals and chemical compounds are polluting both freshwater ecosystems and the earth's oceans. It is important to understand how these compounds affect animal behaviour. *Metridium senile* is a sea anemone common to the intertidal fauna of the Swedish west coast and was used and a model species. By exposing *M. senile* to the anti-anxiety drug diazepam, the beta-blocker propranolol and caffeine this study explored the potential impact of human pharmaceuticals and chemical compounds on risk-taking behaviour. A four-week experiment was performed on 44 anemones in four groups under controlled laboratory conditions. In week one normal startle response times (SRTs) were measured repeatedly for each individual, which is an indicator of risk-taking behaviour. The anemones were exposed to one of the three agents over a two-

week period followed by a recovery week with SRTs measured each week. Caffeine was the only drug to have an effect, causing *M. senile* to become shyer, reducing its risk-taking behaviour and survival. This study demonstrates that caffeine alters the behaviour of *M. senile* and given caffeine is present in high quantities in the environment globally, its actions may have a significant effect on individuals, populations and the ecosystem which should be explored in future studies.

***

Physiological and behavior differences in offspring of migratory sea trout

Matilda Ahvenainen (Conservation biology, 60 hp)

Supervisor: Johan Höjesjö, Department of Biological and Environmental Sciences, GU
Examiner: Lotta Kvarnemo

The brown trout (*Salmo trutta*) as a species present a great deal of plasticity, both in habitats, feeding niches and in migratory patterns. It has been shown in a vast range of species, one of them being brown trout, that certain personality traits such as aggression and boldness and some physiological trait seems to be related to an individuals' dispersal and migratory patterns. In this study we therefor wanted to investigate differences in juvenile offspring of brown trout with different migratory distances. All individuals in this study originated from three catchment areas in Haga å in western Sweden at 0.5 and 2.5 kilometers from the river mouth, respectively, to present offspring from fish with two different migratory distances. This present study was divided into two main parts, one with a main focus on physiological differences and one part with a more in depth behavior scoring. Our findings from the first part showed that offspring of long distance migratory exhibited relatively longer pectoral fins, a trait that might be related to an enhanced swimming performance and could be explained by a more demanding migratory route. These results also revealed a higher body condition value for long migratory individuals, a result that contradicts well established concepts such as the River Continuum Concept and might be affected by environmental disturbances. The second part exhibited a clear difference in personality traits where offspring of long distance migratory fish displayed a more aggressive personality and won dyad trials at a significantly higher frequency. Despite a significant difference in aggression, no difference in boldness or activity was displayed. Making it, as with many behavioral studies, hard to draw firm conclusions about the effect of personalities and further research might be required to answer the question of how different migratory patterns affect populations.

***

Arctic plant communities rise along with temperatures - Plant functional traits as a tool to predict global climate change

Helena Sundell (Evolutionary and behavioural ecology, 30 hp)

Supervisor: Anne Bjorkman, Department of Biological and Environmental Sciences, GU
Examiner: Håkan Pleijel

In the arctic regions, global warming occurs at a rate at least two-fold compared to the rest of the world. This study aims to investigate how future predicted temperature increase may affect arctic plant communities. Plant functional traits and potential feedback mechanisms was assessed at the community level in natural (unmanipulated) and temperature manipulated environments in arctic areas of Sweden (Latnajajure and Abisko), and Finland (Kilpisjarvi). The temperature was manipulated using Open Top Chambers (OTC) of

approximately 1 m^2, that induces a local temperature increase ranging between 1.5-3°C in 5-24 randomly selected plots within each arctic site. Data of five different functional traits was subsequently compared between the temperature manipulated and the natural plots. The study focused on two functional traits associated with plant growth, height and leaf area and three functional traits associated with the economic resource spectrum, Leaf Dry Matter Content (LDMC), Leaf nitrogen content (LeafN) and Specific Leaf Area (SLA). The results show a positive correlation between increasing temperatures and plant height, indicating that plant communities are growing taller when exposed to higher temperatures. A thorough literature review on plant functional trait variations and their possible association with climate change feedback mechanisms was performed. The main possible feedback mechanism found was reduction albedo from taller plants. Albedo is the amount of solar energy reflecting from earth's surface back through the atmosphere. Hence a lower albedo creates more absorption of heat to the planet accelerating global warming. On the other hand, woody plants that grow taller also have a larger ability to store carbon in trunks. Resulting in reduced CO2 in the atmosphere and a deceleration of the temperature increase, thus a negative feedback mechanism. In summary, this study has focused on plant functional traits influenced by global warming and their feedback on the temperature increases and can allow us to better predict changes of arctic plant communities as well as global climate change induced by such changes.

***

Sphagnum re-establishment on bare peat - an evaluation of restoration results

Emma Stenlund

Supervisors: Åslög Dahl, Department of Biological and Environmental Sciences, GU & Kristofer Paulsson, The County Administrative Board of Jönköping
Examiner: Anne Bjorkman

Restoration of former peat extraction sites is a rather young practice in Sweden. As part of the EU-funded project *Life to Ad(d)mire*, the County Administrative Board of Jönköping have restored a number of areas affected by peat extraction, with the purpose of achieving a favorable conservation status for the habitats and the species that depend on them. The main purpose of this project has been to examine to what extent peat mosses, *Sphagnum*, have re-established on the bare peat surfaces exposed after excavation on two of these sites. I further wanted to look into potential causes for within-site variation. *Sphagnum* coverage, species composition, thickness of the *Sphagnum* layer and relative water table position was measured in the field. The results indicate that a higher water table is preferable to a lower one in terms of thickness and coverage of *Sphagnum.* However, the species that were commonly found in the wettest areas are known to decompose faster than their hummock-living relatives more typically found in the slightly drier sites. The main purpose of the restoration project was to counteract the habitat loss due to overgrowth in order to favor birds. Poor *Sphagnum* establishment may therefore not be an urgent problem. It could, however, indicate that the water table is still too low or unstable in certain areas. If this is the case, higher vegetation could potentially re-establish and increase the need for further interventions.

***

Large-scale dietary changes over the past 30 years in African forest elephants (*Loxodonta cyclotis)* in Lopé national park, Gabon

William Tejler (Evolutionary and behavioural ecology 60 hp)

Supervisor: Luc Bussière, Department of Biological and Environmental Sciences, GU
Examiner: Mats Olsson

Anthropogenic pressures are rapidly causing many environmental changes, which negatively impact wild populations. The result of a large biodiversity crisis could be catastrophic and would most definitely lead to a less inhabitable planet for humans. These pressures can be seen first-hand in Lopé national park in Gabon. Here, scientists have made a compelling case linking climate change-induced fruit decline and body condition loss in African forest elephants – a keystone species in this ecosystem. However, direct evidence of dietary change was missing. In this study we investigated seasonal and decadal changes to the diet of these elephants, using 30-year-old dung data, as well as newly collected dung data from 2021-22, in order to make inference about dietary changes. From the dung samples we identified different types of foods, and the amount eaten of them, as well as other parameters. The data were analysed using Generalized additive models (GAMs), and the results showed that the diet patterns differed substantially between the decades in many regards. Firstly, the breadth of fibre-rich foods such as grass and wood had increased, furthermore, these fibre-rich foods were also eaten at much larger quantities than before – both observations indicating compensatory feeding due to lower fruit availability. Secondly, more fruit species had decreased in utilization than increased in the diet – a concerning trend for this frugivorous species. These results highlight that large-scale and long-term changes are happening in Lopé NP, which is one of the last strongholds of pristine and untouched wildlife. These findings are therefore of utmost importance in order to make wise management plans that can help this endangered population cope in a fast-changing world.

***

Changed morphology in brown trout (*Salmo trutta*) in the presence of an invasive fish species and possible consequences for the benthic invertebrate community

Pernilla Hansson (Conservation biology, 60 hp)

Supervisor: Johan Höjesjö, Department of Biological and Environmental Sciences, GU
Examiner: Mats Olsson

The introduction of the American brook trout (*Salvelinus fontinalis*) into European streams has led to the establishment of reproducing populations. In streams where its occurrence overlaps with brown trout (*Salmo trutta*) which is native to Europe, the brown trout changes behaviour in a convergent fashion, choosing to hunt for drifting terrestrial prey in the same way brook trout does, rather than the aquatic invertebrates that are otherwise characteristic for its diet. This dietary change has been associated with a shift in morphological traits, and similar morphological changes in brown trout is observed in this study in two streams in southern Sweden. Brown trout living in sympatry with brook trout had higher body height, smaller heads, and smaller eyes. The morphological differences between streams decreased in sympatry, potentially indicating a possible breakdown of local adaptation. Additionally, the aquatic invertebrate community varied between stretches of the different competition types, where *Ephemeroptera* became less prominent in sympatric stretches and some taxonomic groups were more associated with one competition type. While the invertebrate composition

differs between competition types and stream, there is no clear overall consistent pattern between streams and competition type. As the analysis was only carried out on two streams, part of the variation could be due to the variable benthic environment along the stream stretches, but the identification of some taxonomic groups consistently associated with sympatry or allopatry can be taken as an indication that there might be some taxonomic.

***

Spatio-temporal petterns of the wolf and its prey in a Mediterranean area

Giovanni Fini (Conservation biology, 60 hp)

Supervisors: Francesco Ferretti, University of Siena & Karin Hårding, Department of Biological and Environmental Sciences, GU
Examiner: Luc Bussière

Starting from the 1970s, populations of top predators such as the wolf *Canis lupus* have been expanding across the Europe thanks to the protection regime accorded, the creation of many protected areas, the increased abundance of wild ungulates and other several factors. The return of these animals can trigger significant consequences from the ecological as well as management points of view. Large carnivores have been reported to exerting a great impact on ecosystems by triggering trophic cascades. However, a large portion of studies showing the effects of predator-prey relationships on ecosystems come from large, protected areas in North America or Africa with absent or little human disturbance. Conversely, in more anthropized ecosystems such as the European ones, characterized by smaller and scattered protected areas, the presence and activity of humans may influence predator-prey relationships, affecting the potential of apex predators to influence other components of ecosystems. As predators should match their spatiotemporal patterns to those of prey, the latter are expected to develop behaviors that allow them to avoid a direct encounter with the predator. However, the anti-predatory responses can be not univocal, especially in fragmented contexts such as the European ones, where animals cohabit with human activities. I focused on spatiotemporal pattern of the wolf and its may prey in a costal protected area in central part Italy (Maremma Regional Park). Wolf presence in the area is stable from 2015, and the fallow deer has been reported as their main prey in the first 2-3 years after their settlement. I used data collected through intensive camera trapping (57 camera traps) from April 2020 to March 2021. Over 20000 detections of wolf, ungulates and people were collected and analyzed (n = 1523, wolf; n = 5441, wild boar; n = 5424, fallow deer; n = 589, roe deer; n = 8292, people). As expected, the wolf showed nocturnal activity patterns, with peaks statistically associated with the activity rhythms of the wild boar, with whom a remarkable temporal overlap was detected (Δ_4 = 0.91). Diurnal activity was observed in the fallow deer, with a medium-low overlap with the wolf (Δ_4 = 0.53). Results contrasted with findings obtained in the 1900s, i.e., when the wolf was absent from the area and fallow deer showed nocturnal/crepuscular activity. Moreover, results were different from what found in 2017-2018, i.e., a couple of years after the stable return of the wolf, when diurnal activity was only reported in sites highly attended by predators. The roe deer showed activity peaks at sunrise and sunset, as typically reported for this species, resulting in a low overlap with the wolf (Δ_4 = 0.48). Results suggest an anti-predatory response based on temporal avoidance by fallow deer, whereas no support for spatial avoidance was detected. Future studies should evaluate potential alternative responses in wild boar, as well as the potential for wolf predation to modulate ungulate abundance and impact on habitats.

***

Endophytic fungi in living trees - are communities affected more by tree species, tree age, or geographic origin?

Lisen Källman (Conservation biology, 30 hp)

Supervisors: Björn Nordén, Norwegian Institute for Nature research & Oskar Gran, Department of Biological and Environmental Sciences, GU
Examiner: Frank Götmark

Endophytic fungi are ubiquitous living vascular living plants and identified in several different environments. The endophytes may have various ecological roles such as commensals, symbionts and latent invaders. Woody plants harbour diverse array of different endophytic species that have been detected in various habitats, from leaves to roots. However, the knowledge and research about endophytic communities are scarce, especially in relation to conservation of biodiversity. One of the reasons is the difficulties in detecting and identifying the fungal species, especially in the more complex hosts. The project aims to investigate if the species density and species composition differ between tree species (*Acer plataniodes, Fagus sylvatica, Quercus robur, Tilia cordata, Acer plataniodes*), and among three regions in southern Norway and between tree sizes. The analyses were bases on a dataset of environmental DNA samples from sapwood 208 trees. The result show that *Q. robur* differs significantly from the other tree species in both species composition and density with considerably more species and red-listed species. Oak also harboured a large portion of species only sampled in one sample. There was no significant difference in species density for the three regions. Stem size affected the fungal endophyte communities composition, but not for all tree species. That oak differed significantly from the other species indicates that it has a very distinct funga from the other tree species, with oak almost entirely harbouring the red-listed species. The large portions of singleton species imply that the oak is an important host of many rare species. This emphasizes the importance of oak for rare and red-listed species and could be an essential factor for protecting areas where oaks are located to prevent the rare and red-listed species from decreasing in abundance.

***

Arctic mycorrhizal interactions under climate change

Otto Minas (Physiology & cell biology, 60 hp)

Supervisors: Anne Bjorkman & Wilhelm Osterman, Department of Biological and Environmental Sciences, GU
Examiner: Johan Uddling

The Arctic is experiencing climate change at an extreme rate, and as the Arctic stores large amounts of below ground carbon, understanding how climate change will affect the carbon cycle is of utmost importance. Additionally, as temperatures warm, the rate of soil nutrient cycling is also expected to increase, benefitting organisms relying on mineralized soil nutrients. Two potential beneficiaries of these changes are graminoids and arbuscular mycorrhizal fungi (AM). A changing plant community composition with an increase in graminoid abundance could affect the carbon cycle through increased rates of growth and decomposition. Additionally, an increased prevalence of AM could affect the carbon cycle due to the fungi storing low levels of carbon below ground and decomposing relatively quickly. However, how the association between graminoids and AM will be affected by climate change is relatively poorly understood. This thesis used an altitudinal gradient from ~950 to 1250 m in northern Sweden to investigated how the association between the arctic graminoid *Poa*

alpina and AM is affected by warming temperatures. The results found a weak positive relationship between temperature and AM colonization, supporting the belief that the association between graminoids and AM will benefit from climate change. However, no positive trend was found between AM and mineralized soil nutrients. These results indicate that while increasing temperatures could be a driver of increased AM prevalence in the Arctic, increased nutrient cycling might not be. If continued research confirms these trends, climate change could give the graminoid–AM association an advantage as the Arctic warms, with potential effects on carbon cycling in the Arctic.

***