PROGRAMME AND ABSTRACT BOOK

THE HEIGHT, BREADTH AND DEPTH OF PHYSIOLOGICAL DIVERSITY: VARIATION ACROSS LATITUDINAL, ALTITUDINAL AND DEPTH GRADIENTS

1 JULY 2018
FIRENZE FIERA CONGRESS
AND EXHIBITION CENTRE,
FLORENCE, ITALY

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SOCIETY FOR EXPERIMENTAL BIOLOGY

THE HEIGHT, BREADTH AND DEPTH OF PHYSIOLOGICAL DIVERSITY: VARIATION ACROSS LATITUDINAL, ALTITUDINAL AND DEPTH GRADIENTS

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Name badges contain a barcode which will be scanned on entry to record attendance at meeting for SEB administrative purposes only. Each badge barcode contains the following information which has been supplied during the registration process: full name, institution and email address.

Badges must be worn for the duration of the meeting, both for security purposes and catering identification.

CATERING

Lunch and refreshments during the satellite meeting are included in your registration fee and will be served in the breakout area located on the ground floor of Palazzo Affari.

CERTIFICATE OF ATTENDANCE

Delegates requiring a certificate of attendance should visit the SEB registration desk on their departure or by email from admin@sebiology.org

VENUE

Firenze Fiera Congress and Exhibition Centre
Piazza Adua, 1, 50123, Firenze FI, Italy
Tel: +39 055 49721
Web: www.firenzefiera.it/en/

The scientific sessions will be taking place in room Adua 2 located on the second floor in Palazzo Affari.

WI-FI INTERNET ACCESS

Internet access is available during the meeting and free of charge. Log in details will be available at the registration desk.

LIABILITY

Neither the Society for Experimental Biology nor the Firenze Fiera Congress and Exhibition Centre will accept responsibility for damage or injury to persons or property during the meeting. Participants are advised to arrange their own personal health and travel insurance.

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No photographs are to be taken of the speakers and their slides during the satellite meeting unless consent is given by the speaker.

**Please note: The SEB will be taking photos during the event for promotional purposes. If you have any concerns, please visit the SEB registration desk.*

POSTER SESSION

The poster session will be taking place in the breakout area between 17:00 – 18:00 on Sunday 1 July. Poster presenters are invited to hang their poster on their arrival (Velcro will be provided) and are asked to remove their posters by 18:00. Any posters left behind will be disposed of.

REGISTRATION

The registration desk will be open during the hours of the meeting and a SEB staff member will be on hand during the refreshment and lunch breaks should you require any assistance.

SOCIAL MEDIA

We're looking to increase the conversation at the meeting using:
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PROGRAMME

SUNDAY 1 JULY 2018

08:30 REGISTRATION

09:00
Introduction
Simon Morley, John Spicer and Francisco Bozinovic
Meeting organising committee

CHAIR: JOHN SPICER

09:10
PLENARY LECTURE
Prof Steven Chown
Monash University, Australia
Thermal foraging traits as mediators of ant abundance and occupancy variation
AS18.1

09:40
Dr Jennifer Sunday
McGill University, Canada
Environmental variability across marine and terrestrial gradients
AS18.2

10:00
Prof Andrew G Hirst
University of Liverpool, United Kingdom
Patterns in the temperature, latitudinal and seasonal body size gradients within aquatic and terrestrial arthropod species
AS18.3

10:15
Prof Johannes Overgaard
Aarhus University, Denmark
Assessing the role of acclimation and adaptation in thermal performance curves
AS18.4

10:30
Wilco C E P Verberk
Radboud University Nijmegen, Netherlands
Can an oxygen perspective explain the temperature-size rule?
AS18.5

10:45 REFRESHMENT BREAK/POSTERS

CHAIR: FRANCISCO BOZINOVIC

11:15
Enrico Rezende and Prof Francisco Bozinovic
Pontifical Catholic University of Chile, Chile
Thermal performance across levels of biological complexity
AS18.6

11:35
Dr Curtis Deutsch
University of Washington, United States
Diversity of marine hypoxia traits: Implications for biodiversity and extinction
AS18.7

11:55
Dr Scott Bennett
Mediterranean Institute of Advanced Studies (IMEDEA), Spain
Population vulnerability to ocean warming across latitudinal gradients
AS18.8

12:15
Lisa B Jørgensen
Aarhus University, Denmark
How to measure insect heat tolerance: unifying static and dynamic assays
AS18.9

PROGRAMME

12:30
Prof David Atkinson
University of Liverpool, United Kingdom
Water depth and contrasting correlations among metabolic scaling, metabolic level and body shape change: cephalopods versus teleost fish
AS18.10

12:45 LUNCH/POSTERS

CHAIR: SIMON MORLEY

13:40
Prof John Spicer
University of Plymouth, United Kingdom
Dr Simon Morley
British Antarctic Survey, United Kingdom
There may be giants – but why? Testing the oxygen hypothesis of gigantism with amphipod crustaceans
AS18.11

14:00
Dr Christine E Cooper
Curtin University, Australia
Macrophysiology informs conservation for widespread species
AS18.12

14:15
Dr Norman L C Ragg
Cawthron Institute, New Zealand
Genetic basis for acute thermotolerance in the mussel *Perna canaliculus* distributed across a wide latitudinal range
AS18.13

14:30
Miss Saskia Jurriaans
James Cook University, Australia
Thermal acclimation strategies of reef-building corals along a latitudinal gradient on the Great Barrier Reef
AS18.14

14:45
Ms Jacinta D Kong
The University of Melbourne, Australia
The egg stage drives life cycle adaptation to climate in the widely distributed matchstick grasshoppers (*Vandiemenella* and *Warramaba*, Orthoptera: Morabidae)
AS18.15

15:00
Discussion: Key Research Questions

15:40 REFRESHMENT BREAK/POSTERS

16:10
Presentation of discussion points

16:40
Closing Remarks

17:00
Poster Session

18:00 END OF MEETING

POSTER SESSION 1 JULY 2018

Richelle L Tanner
University of California Berkeley, United States
Plasticity of upper critical limits in the eelgrass sea hare, *Phyllaplysia taylori*, not correlated with habitat thermal history
AS18.16

Miss Pauline C Dufour
The University of Hong Kong, Hong Kong
Divergent melanism strategies in Andean butterfly communities structure diversity patterns and climate responses
AS18.17

Dr Oldrich Tomasek
Charles University Faculty of Science, Czech Republic
Latitudinal and altitudinal variation in blood glucose levels in songbirds
AS18.18

Dr Eric J Armstrong
Genoscope CEA, France
Warm adaptation trades-off against heat tolerance plasticity in intertidal nudibranch molluscs
AS18.19

Nigel R Andrew
University of New England, Australia
Ant thermal tolerances under climate, land cover and land use change
AS18.20

THE HEIGHT, BREADTH AND DEPTH OF PHYSIOLOGICAL DIVERSITY: VARIATION ACROSS LATITUDINAL, ALTITUDINAL AND DEPTH GRADIENTS

AS18.1 THERMAL FORAGING TRAITS AS MEDIATORS OF ANT ABUNDANCE AND OCCUPANCY VARIATION

SUNDAY 1 JULY 2018 **09:10**

STEVEN CHOWN (MONASH UNIVERSITY, AUSTRALIA)

In this work, we test key hypotheses about the way in which thermal traits mediate interspecific variation in abundance and occupancy across broad spatial scales, and their implications for global change impact forecasts. We use a decade-long, bi-annual survey of abundance variation in 53 ant species from 37 sites, spanning major climatic gradients in Southern Africa. We show that broad relationships do exist between microclimate, thermal tolerance limits and foraging limits. However, interspecific variation in the range of temperatures over which ants can forage and, in consequence, the time available for foraging in given settings (which includes the influence of interspecific interactions), are much better predictors of variation in abundance and occupancy.

AS18.2 ENVIRONMENTAL VARIABILITY ACROSS MARINE AND TERRESTRIAL GRADIENTS

SUNDAY 1 JULY 2018 **09:40**

JENNIFER SUNDAY (MCGILL UNIVERSITY, CANADA)

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Connecting physiological responses at the organism level to species-level patterns of abundance and distribution is a key challenge in ecology. Indeed, as the world has warmed over the past half-century, species distributions have responded through range shift, throwing into focus our need to mechanistically understand these connections. Here I present macro physiological analyses showing that marine and terrestrial ectotherms differ in the extent to which they are physiologically limited within their distributional ranges. I then explore the role of temporal variability in temperature in improving linkages between physiological data and species distributions, and projecting responses to environmental change. I use records of species' range shifts to further elucidate the relative roles of environmental variability in mediating range shifts in a warming world.

AS18.3 PATTERNS IN THE TEMPERATURE, LATITUDINAL AND SEASONAL BODY SIZE GRADIENTS WITHIN AQUATIC AND TERRESTRIAL ARTHROPOD SPECIES

SUNDAY 1 JULY 2018 **10:00**

ANDREW G HIRST (UNIVERSITY OF LIVERPOOL, UNITED KINGDOM), CURTIS R HORNE (UNIVERSITY OF LIVERPOOL, UNITED KINGDOM), DAVID ATKINSON (UNIVERSITY OF LIVERPOOL, UNITED KINGDOM)

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Body size is fundamental to the fitness of species and relates to the speed of many biological rates, while the variation in body size has fascinated scientists for over a century. In ectotherms, individuals of the same species commonly grow to a smaller adult body size in the warm than in the cold. This near-universal biological phenomenon, known as the Temperature-Size Rule (TSR), occurs in over 80% of ectothermic species. Similarly, larger adults within a species are often found at higher colder latitudes, whilst seasonal body size variation is also common in a wide range of ectotherms that have multiple generations in a year, as successive cohorts experience different environmental conditions during ontogeny. Yet, there is limited appreciation of the patterns and drivers of these major body size responses within species, and the degree to which they co-vary and share explanatory mechanisms. We present the largest meta-analysis to date of these major body size gradients in arthropods. We find that aquatic species consistently show the greatest reduction in body size with increasing temperature in the laboratory and across seasons, and with decreasing latitude towards the equator. We suggest this is indicative of the low availability of oxygen in water in comparison to air, and the increased demand for oxygen in the warm. We show that the direction and magnitude of all three of these major body size gradients co-vary among taxonomic orders, suggesting that they are driven by similar selective pressures.

AS18.4 ASSESSING THE ROLE OF ACCLIMATION AND ADAPTATION IN THERMAL PERFORMANCE CURVES

SUNDAY 1 JULY 2018 **10:15**

JOHANNES OVERGAARD (AARHUS UNIVERSITY, DENMARK), HEIDI J MACLEAN (AARHUS UNIVERSITY, DENMARK), TORSTEN N KRISTENSEN (AARHUS UNIVERSITY, DENMARK), JESPER G SØRENSEN (AARHUS UNIVERSITY, DENMARK), VOLKER LOESCHCKE (AARHUS UNIVERSITY, DENMARK), KRISTIAN BEEDHOLM (AARHUS UNIVERSITY, DENMARK), VANESSA KELLERMANN (MONASH UNIVERSITY, AUSTRALIA)

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Thermal performance curves (TPC) of ectotherms are often used to infer species responses to changes in temperature, including long-term responses to climate change. Even so there are still many aspects of TPC's that are poorly studied as only few empirical studies have investigated theories about the evolution, shape and plasticity of TPCs. Textbook examples often show temperate species to have broader thermal performance curves and lower optimal temperature compared to tropical species. Furthermore, theory predicts that plasticity of TPC is larger in species originating from variable environments. Here we measure thermal tolerance limits and TPCs of fitness components in 22 species of Drosophila reared at a common temperature. For 10 species we also measured these traits following acclimation to different temperatures. Using this data we test assumptions about the evolution and plasticity of TPCs. As expected, low temperature tolerance varied strongly and predictably with environmental origin of species and in response to cold acclimation. This confirms the marked effect of adaptation and acclimation on thermal tolerance. However, contrary to expectation the breadth of TPCs is similar in temperate, widespread and tropical species and we also find that plasticity of TPCs is very limited. Accordingly, thermal tolerance limits are under strong selection by the extreme environmental conditions that limits species persistence. In contrast, the temperature range for optimal thermal performance is under selection by the temperatures that prevail during the growing season and TPCs in Drosophila are therefore more stable over evolutionary and ecological space than predicted by current theories.

AS18.5 CAN AN OXYGEN PERSPECTIVE EXPLAIN THE TEMPERATURE-SIZE RULE?

SUNDAY 1 JULY 2018 **10:30**

WILCO C E P VERBERK (RADBOUD UNIVERSITY NIJMEGEN, NETHERLANDS), NATAN HOEFNAGEL (RADBOUD UNIVERSITY NIJMEGEN, NETHERLANDS)

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Bergmann noted that animal species from colder habitats (high latitude or altitude) tend to be larger than closely related species living in warmer habitats (low latitude or altitude). These Bergmann's clines are mirrored by thermal responses in body size when rearing ectotherms in the laboratory: temperature stimulates juvenile growth, but decreases adult size, resulting in animals growing faster but to a smaller size. The majority of ectotherms follow this temperature-size rule, and many physiological and evolutionary mechanisms have been proposed to explain the temperature-size rule. A promising idea that is gaining traction in the literature is that an oxygen perspective may be helpful for understanding how thermal responses in growth, development and body size are linked. Adequate supply of oxygen could be a prerequisite for animals to grow to a large body size even under warmer conditions. Here I discuss this idea in light of recent laboratory experiments on two crustacean species and published

studies that compare responses across latitudinal and altitudinal clines. Unravelling the physiological basis for the TSR may also shed light on Bergman's cline.

AS18.6 THERMAL PERFORMANCE ACROSS LEVELS OF BIOLOGICAL COMPLEXITY

SUNDAY 1 JULY 2018 11:15

ENRICO L REZENDE (CENTRE OF APPLIED ECOLOGY AND SUSTAINABILITY (CAPES), PONTIFICAL CATHOLIC UNIVERSITY OF CHILE, CHILE), FRANCISCO BOZINOVIC (CENTRE OF APPLIED ECOLOGY AND SUSTAINABILITY (CAPES), PONTIFICAL CATHOLIC UNIVERSITY OF CHILE, CHILE)

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Forecasting which lineages and ecosystems are vulnerable or resilient to ongoing global climate change remains a crucial challenge. The relationship between environmental temperature and performance among ectotherms, or thermal performance curve, is currently used as a baseline to examine the response of organisms under scenarios of global warming. Unfortunately, predictions ignore the confounding effects of increasing complexity as biological levels of organisation increase: whereas measurements often focus on performance at the level of the organism, responses involve demographic processes other than survival that are expressed at the population level or higher. We developed an integrative analysis to study if thermal performance curves vary predictably across levels of biological complexity, and show that this is indeed the case. We discuss how this observation might impact their putative use as an indicator of the effect of global warming on organisms along geographic gradients.

Funded by a FONDECYT grant 1170017 to ELR and a CAPES FB 0002-2014 grant to FB.

AS18.7 DIVERSITY OF MARINE HYPOXIA TRAITS: IMPLICATIONS FOR BIODIVERSITY AND EXTINCTION

SUNDAY 1 JULY 2018 11:35

CURTIS DEUTSCH (UNIVERSITY OF WASHINGTON, UNITED STATES), JUSTIN PENN (UNIVERSITY OF WASHINGTON, UNITED STATES), BRAD SEIBEL (UNIVERSITY OF SOUTH FLORIDA, UNITED STATES)

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The role of climate in shaping species habitats is mediated by a variety of physiological and ecological traits. Here we analyse three traits regulating aerobic habitat of marine animals: the physiological oxygen tolerance, its sensitivity to temperature, and the factor by which resting O_2 demand is elevated by the energetic requirement for ecological activity. Across >70 diverse species, hypoxia vulnerability varies widely, and is shown to arise from coupled variations in O_2 supply and demand. Despite this physiological diversity, species from disparate ocean environments all currently encounter a lower limit of O_2 supply to demand (Metabolic Index) whose distribution of values is indistinguishable from the active to resting energetic ratios of terrestrial animals. These results extend and strengthen previous findings that the geographic range of marine species is limited in part by energetic requirements common to all life.

AS18.8 POPULATION VULNERABILITY TO OCEAN WARMING ACROSS LATITUDINAL GRADIENTS

SUNDAY 1 JULY 2018 11:55

SCOTT BENNETT (MEDITERRANEAN INSTITUTE OF ADVANCED STUDIES (IMEDEA), SPAIN), FRANÇOIS DUFOIS (UWA OCEANS INSTITUTE, UNIVERSITY OF WESTERN AUSTRALIA, AUSTRALIA), AMANDA BATES (OCEAN SCIENCES CENTRE MEMORIAL UNIVERSITY, CANADA), GRAHAM J EDGAR (INSTITUTE FOR MARINE AND ANTARCTIC STUDIES, UNIVERSITY OF TASMANIA, AUSTRALIA), RICK D STUART-SMITH (INSTITUTE FOR MARINE AND ANTARCTIC STUDIES, UNIVERSITY OF TASMANIA, AUSTRALIA), THOMAS WERNBERG (SCHOOL OF BIOLOGICAL SCIENCES, UWA OCEANS INSTITUTE, UNIVERSITY OF WESTERN AUSTRALIA, AUSTRALIA)

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Global projections of the biological impacts of climate change have primarily considered that thermal niches remain constant across a species range, overlooking important variation in adaptive capacity among populations, with major implications for predicting warming vulnerability. Here we estimate warming vulnerability for coastal marine communities across the globe, capturing the full spectrum of local physiological adaptability that may exist among species within a community. We identify several global hot-spots and safe-spots of climate change vulnerability for marine communities and highlight many coastal areas where populations with locally-adapted and conserved thermal niches display stark differences in climate change vulnerability. These findings highlight important variation in warming vulnerability within and among biological communities across latitudinal gradients, enhancing our capacity to anticipate climate change impacts and identify areas of management priority from local to global scales.

AS18.9 HOW TO MEASURE INSECT HEAT TOLERANCE: UNIFYING STATIC AND DYNAMIC ASSAYS

SUNDAY 1 JULY 2018 12:15

LISA B JØRGENSEN (AARHUS UNIVERSITY, DENMARK), HANS MALTE (AARHUS UNIVERSITY, DENMARK), JOHANNES OVERGAARD (AARHUS UNIVERSITY, DENMARK)

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Temperature is one of the most important determinants of species distribution and climate change will likely affect future distributions of many species. Prediction of such distributional changes calls for simple and comparable measures of heat tolerance that correlate with species performance in their natural environments. A recent model (thermal tolerance landscapes – TTLs) uses the exponential relation between temperature and knockdown time to describe the thermal tolerance of ectotherms in different time/temperature intervals. TTLs therefore allow for parametrisation of the complex interaction between absolute temperature (i.e. heat stress intensity) and duration of heat exposure across a range of stressful temperatures. Previous analyses of TTLs have reported an apparent trade-off between tolerance to acute and chronic heat stress in ectotherms. However, this trade-off may represent an inherent property of the model, rather than a true biological phenomenon. To test the "ecological applicability" of TTLs and examine the apparent trade-off, we measured knockdown time at 9-17 static temperatures (0.5°C intervals) to establish TTLs for 11 species of *Drosophila* representing different thermal ecotypes. Additionally, we measured knockdown temperature during three dynamic assays (heating flies with different ramp rates). With this data we show that static and dynamic assays give comparable information on heat tolerance. We also show that both dynamic and static measures of heat tolerance correlate tightly with the environmental characteristics encountered by the 11 species. Finally, our data clearly demonstrates that trade-offs between chronic and acute tolerance are absent within and between species when the data is analysed using curve interpolation.

AS18.10 WATER DEPTH AND CONTRASTING CORRELATIONS AMONG METABOLIC SCALING, METABOLIC LEVEL AND BODY SHAPE CHANGE: CEPHALOPODS VERSUS TELEOST FISH

SUNDAY 1 JULY 2018 12:30

DAVID ATKINSON (UNIVERSITY OF LIVERPOOL, UNITED KINGDOM), HANRONG TAN (QUEEN MARY UNIVERSITY OF LONDON, UNITED KINGDOM), DOUGLAS S GLAZIER (JUNIATA COLLEGE, UNITED STATES), ANDREW G HIRST (UNIVERSITY OF LIVERPOOL, UNITED KINGDOM)

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Biological power drives many ecological processes, and commonly scales with body mass with an exponent (b_R) between 2/3 and 1 for reasons still debated. According to the 'Metabolic-Level Boundaries Hypothesis', b_R varies systematically, depending on metabolic level (L_R). Like many animals, cephalopods and teleost fish from shallow sunlit waters are generally more energetic (have a higher 'metabolic level') than benthic species and those from greater water depths. However, we show that, in contrast to teleost fish, which show a negative correlation between b_R and L_R, cephalopod b_R during ontogeny correlates positively across species with not only L_R, but also the degree to which estimated body surface area increases with mass. The most active epipelagic cephalopod species maintain nearly constant mass-specific rates of not just metabolism, but also growth and probably cutaneous material exchange throughout their lives. The contrasting metabolic

scaling of cephalopods and fish can be explained by combining body shape-shifting with costs and size-scaling of growth and locomotion, adapted to different mortality and energetic pressures. Thus, rather than emphasising universal metabolic scaling, we illustrate how differences in lifestyle, growth and body shape with changing water depth may be used to predict contrasting metabolic scaling, even for similar-sized coexisting animals.

AS18.11 THERE MAY BE GIANTS – BUT WHY? TESTING THE OXYGEN HYPOTHESIS OF GIGANTISM WITH AMPHIPOD CRUSTACEANS

SUNDAY 1 JULY 2018 **13:40**

JOHN SPICER (UNIVERSITY OF PLYMOUTH, UNITED KINGDOM), SIMON MORLEY (BRITISH ANTARCTIC SURVEY, UNITED KINGDOM)

Adaptation to the Polar oceans has led to the evolution of unique physiological traits to cope with life in the constant cold, where metabolic rates are low. The paradigm states that body size of polar marine ectotherms can be bigger than in warmer or lower oxygen environments. The resultant expectations are that: 1) large species will have poor physiological capacity under low oxygen and 2) larger species and individuals will be more susceptible to oxygen limitation under warming. To test these hypotheses, the oxygen consumption of 3 species of Antarctic amphipod, collected at Rothera research station (67°S), was investigated in closed cell respirometers. Paracerodocus miersi (30-40mm), Prostabbingia brevicornis (20mm) and P. gracilis (15mm) all live in hollows underneath rocks. The swimming speeds of two of these species, P. miersi and P. brevicornis, were tested at temperatures ranging between 0 and 9°C. P. miersi is an oxyconformer; its oxygen consumption fell with ambient oxygen concentration and it did not alter its ventilation rate. This species also maintained the same speed of locomotion between 0 and 9°C. P. brevicornis maintained constant oxygen consumption from 100 to 40% of air saturation with increased ventilation rate, possibly assisted by its extra-branchial surfaces. The swimming speed of P. brevicornis increased up to 3°C but dropped at higher temperatures. P. gracilis was intermediate to the two other amphipods. The differences between these species suggest that mixed strategies have evolved in response to oxygen availability in polar waters.

AS18.12 MACROPHYSIOLOGY INFORMS CONSERVATION FOR WIDESPREAD SPECIES

SUNDAY 1 JULY 2018 **14:00**

CHRISTINE E COOPER (CURTIN UNIVERSITY, AUSTRALIA), PHILIP C WITHERS (UNIVERSITY OF WESTERN AUSTRALIA, AUSTRALIA), SUZY MUNNS (JAMES COOK UNIVERSITY, AUSTRALIA), FRITZ GEISER (UNIVERSITY OF NEW ENGLAND, AUSTRALIA), WILLIAM A BUTTEMER (UNIVERSITY OF WOLLONGONG, AUSTRALIA)

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A fundamental goal of comparative physiology is to determine how variation in physiological traits differs spatially both between and within species. Macro-physiological studies have commonly focused on broad inter-specific comparisons, but recognition of lower-taxonomic-level physiological variation is gaining prominence. Identifying intraspecific variation in physiological traits is pertinent to conservation physiology. Conservation translocations would benefit from quantitative appraisal of how the physiology of source populations differs, and how this relates to differences in habitat and climate variables. Here we explore geographic variation in the physiology of the brushtail possum *(Trichosurus)*. This widely distributed marsupial is involved in numerous translocation programmes, particularly in Australia's arid zone. We found significant geographical patterns in metabolism, body temperature, thermal conductance, evaporative water loss and relative water economy, with possums from warmer, drier habitats having more frugal energy and water use, reduced environmental heat gain, and increased capacity for heat loss at high temperatures. We suggest that the sub-species *T. vulpecula hypoleucus* from Western Australia would be most physiologically appropriate for translocation to arid habitats, having physiological traits most favourable for the low productivity, low and variable water availability and extreme T_a of arid environments. Our data indicates that geographically widespread populations can differ physiologically in a manner that makes some populations more suitable for particular habitats than others. Consideration of these differences will likely improve the success and welfare outcomes of translocation, reintroduction and management programmes.

AS18.13 GENETIC BASIS FOR ACUTE THERMOTOLERANCE IN THE MUSSEL *PERNA CANALICULUS* DISTRIBUTED ACROSS A WIDE LATITUDINAL RANGE

SUNDAY 1 JULY 2018 **14:15**

NORMAN L C RAGG (CAWTHRON INSTITUTE, NEW ZEALAND), BRENDON J DUNPHY (UNIVERSITY OF AUCKLAND, NEW ZEALAND), MELLANIE G COLLINGS (UNIVERSITY OF AUCKLAND, NEW ZEALAND), ELLIE WATTS (CAWTHRON INSTITUTE, NEW ZEALAND), KATHY RUGGIERO (UNIVERSITY OF AUCKLAND, NEW ZEALAND), FRITZ GEISER (UNIVERSITY OF NEW ENGLAND, AUSTRALIA), WILLIAM A BUTTEMER (UNIVERSITY OF WOLLONGONG, AUSTRALIA)

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The Greenshell mussel, *Perna canaliculus*, is found in shallow seas along the entire latitudinal range of New Zealand (34-48°S). Populations are therefore exposed to a broad range of geographically-influenced temperatures. Ocean warming and increasingly dramatic ENSO events have led to concerns for the future of this keystone species that also supports New Zealand's largest aquaculture industry. The potential for genetic adaptation to local thermal conditions associated with latitude was explored in pelagic veliger larvae, representing arguably the most vulnerable life stage. Full-sibling F2 larvae of populations sourced from D'Urville Island (40°41'S, ~18.5°C mean summer maximum), Banks Peninsula (43°50'S, ~16.0°C) and Stewart Island (47°10'S, ~13°C) were sourced from Cawthron Institute's selective breeding programme and exposed to 3 h heat challenge. The temperature predicted to kill 50% of the larvae ($LT_{50\text{-}3h}$) was not significantly influenced by origin (33.0-34.0°C). In contrast, $LT_{50\text{-}3h}$ was lower in F2 adults and found to be under significant genetic control, with full-sib family $LT_{50\text{-}3h}$ ranging from 28.9±0.3°C to 31.8±0.2°C, following assessment of a cohort of 43 families. A 1 h pre-stress at 29°C 24 h before challenge also revealed some phenotypic plasticity in adults, demonstrated by a 1.6 to 2.4°C increase in mean $LT_{50\text{-}3h}$ of summer- and winter-acclimated animals, respectively. Metabolomic profiling showed moribund mussels accumulated succinic acid and had reduced GAB*Aergic* synapse activity; mitigation of these changes following pre-stress imply a delay to the onset on anaerobiosis. Larval resilience plus adaptation and acclimation potential among adults suggests that this species will tolerate acute temperature challenges associated with near-future environmental changes.

AS18.14 THERMAL ACCLIMATION STRATEGIES OF REEF-BUILDING CORALS ALONG A LATITUDINAL GRADIENT ON THE GREAT BARRIER REEF

SUNDAY 1 JULY 2018 **14:30**

SASKIA JURRIAANS (JAMES COOK UNIVERSITY, AUSTRALIA), MIA O HOOGENBOOM (JAMES COOK UNIVERSITY, AUSTRALIA)

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To cope with spatial and temporal thermal heterogeneity, species have evolved different thermal strategies. For instance, species with broad spatial distributions may be thermal generalists that perform well across a broad range of temperatures, or subpopulations are formed within homogeneous patches of the thermal environment that are thermal specialists with a higher maximal performance. Here we quantified the variation in thermal performance along a latitudinal temperature gradient on the Great Barrier Reef of two coral species with broad geographic distributions. The performance of a thermally tolerant coral species, *Porites cylindrica*, was compared with that of a thermally sensitive coral species, *Acropora sp.*, at Lizard Island (northern GBR, 14°S), Orpheus Island (central GBR, 18°S) and Heron Island (southern GBR, 23°S). Several physiological performance traits were measured on coral fragments exposed to an acute temperature increase and decrease up to 5°C above and below the local environmental temperature. Results showed that there was geographic variation in the performance curves for all physiological traits of both species, indicating that these species are plastic thermal specialists. However, the optimal temperature for performance was generally well below the average temperature of the local environment, suggesting that the capacity for thermal acclimation of the coral populations was constrained resulting in suboptimal performance. Yet, significant within-population variability showed that some colonies were coping better with high temperatures, indicating that some individual may better tolerate heat stress from ocean warming. These findings may contribute to improve our understanding of traits that facilitate coral resilience.

AS18.15 THE EGG STAGE DRIVES LIFE CYCLE ADAPTATION TO CLIMATE IN THE WIDELY DISTRIBUTED MATCHSTICK GRASSHOPPERS (*VANDIEMENELLA* AND *WARRAMABA*, ORTHOPTERA: MORABIDAE)

SUNDAY 1 JULY 2018 **14:45**

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Life cycles mediate the responses of insects to variable and changing climates. Life cycles of widely distributed insects may be adapted to local climates at the egg stage because eggs are immobile and reliant on environmental conditions to develop. Variation in life cycles may be generated by variation in environments, in developmental responses, or through their interaction. Teasing these causal factors apart requires an understanding the consequences of the egg stage for life cycles under variable climates. Here, we examine genetic, phenotypic and environmental sources of variation in the thermal response of egg development within and among matchstick grasshoppers (austral winter active *Vandiemenella* and summer active *Warramaba*). Matchstick grasshoppers are widely distributed, have a simple univoltine life cycle driven by the egg stage, are flightless, and have well understood phylogenetic relationships. We characterised the thermal response of egg development within and among species and lineages of these two genera and tested for local adaptation in egg development. We use the data to parameterise a microclimate-driven model of egg development to examine the adaptive significance of egg development between environments. Matchstick grasshoppers showed remarkable diversity at the egg stage, primarily in the expression of dormancy. Interactions between such developmental variation and local environmental temperatures generated the diversity of life cycle syndromes expressed. This diversity of life cycles highlights the potent role of adaptation at the egg stage for widely distributed insects under a variable climate.

POSTER SESSION SUNDAY 1 JULY

AS18.16 PLASTICITY OF UPPER CRITICAL LIMITS IN THE EELGRASS SEA HARE, *PHYLLAPLYSIA TAYLORI*, NOT CORRELATED WITH HABITAT THERMAL HISTORY

SUNDAY 1 JULY 2018

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Intertidal mollusks are subject to extreme temperature changes when low tides expose these nearly-sessile invertebrates to air on extremely hot or cold days. Local weather or microclimate causes variation in the frequency and severity of exposure to extreme temperatures across populations. Furthermore, climate change is expected to increase the magnitude and frequency of thermal extremes. Population and individual responses to variation in thermal means and extremes can be through long-term genetic or short-term plastic mechanisms. We investigated short-term plasticity in multiple populations of the direct-developing sea hare, *Phyllaplysia taylori*, to determine whether differences in microclimate influenced acclimation capacity. *P. taylori* were collected along the western US coast from Ocean Shores, WA to Morro Bay, CA and acclimated to winter, summer, and future summer temperatures. Critical thermal maxima, regardless of acclimation temperature, were well above average habitat temperatures across all habitats, even when considering average daily variation in habitat temperature (CT_{max} ranged from 24-35ºC, average=30.1±0.2ºC; average habitat temperature ranged from 12-20ºC, average=21±0.8ºC). Intraspecific variation in CT_{max} in this species was on the high end of values reported in the literature and was correlated with average habitat temperatures and average daily variation in these temperatures experienced by populations, although the plasticity of this trait was not. This suggests that the plasticity of upper critical limits is not driven by habitat thermal history, and therefore may not be under positive selection.

AS18.17 DIVERGENT MELANISM STRATEGIES IN ANDEAN BUTTERFLY COMMUNITIES STRUCTURE DIVERSITY PATTERNS AND CLIMATE RESPONSES

SUNDAY 1 JULY 2018

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Distribution of species result from the combination of environmental exposure and sensitivity. One key trait in deciphering species responses to environment is color. The thermal melanism hypothesis (TMH) states that ectotherms would benefit from dark coloration in environments with low temperatures and that it would result in altitudinal and latitudinal clines in coloration. We used a long-term data set on two prominent butterfly genera *Catasticta* and *Leptophobia* for which we recompiled community assemblies across elevation in the Ecuadorian Andes based on colour lightness, species-specific heating rate and maximum temperature (under experimental solar exposure). We show that the two genera assemble according to their colour lightness across elevation but exhibit opposite strategies to achieve it – ones are getting

darker and the others are getting lighter with altitude – and opposite pigmentation configurations between their body and body + wings. However, they seem to achieve comparable thermoregulation, assessed via their heating rates under experimental solar exposure. We found that the elevational patterns of traits in *Catasticta* remained after correction for phylogeny but not in *Leptophobia*. These biogeographic trait patterns correspond strikingly with the distribution of montane cloud forests, where habitat fragmentation and loss of cloud cover due to climate change are likely to result in increased exposure to solar radiation and have important consequences for the vulnerability and distribution of these diverse montane communities.

AS18.18 LATITUDINAL AND ALTITUDINAL VARIATION IN BLOOD GLUCOSE LEVELS IN SONGBIRDS

SUNDAY 1 JULY 2018

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Glucose is one of the major energetic substrates circulating in vertebrate blood mainly fuelling intense short-term activities and thermoregulation. We have found recently that baseline blood glucose level correlates negatively with body mass and positively with reproductive output, suggesting its coevolution with life histories. As both life histories and thermoregulatory demands are known to vary across latitude and altitude, we here tested whether corresponding variation exists in baseline and stress blood glucose levels. To this end, we captured 488 and 602 individuals of 40 European and 51 African songbird species, respectively, and measured blood glucose concentration within 3 (baseline; G_0) and after 30 minutes (stress; G30) from the capture. Using phylogenetic MCMC GLMM models with individual measurements, we found that tropical lowland species (272 individuals of 22 species) had significantly lower G_0 compared to temperate songbirds, attesting to their slow pace of life. Although not significant, tropical lowland species tended to have more intense glucose stress response, resulting in no association between G_{30} and latitude. In the tropics, altitude was positively correlated with G_0, but not with the stress response intensity suggesting higher energy demands of thermoregulation and/or faster pace of life in higher altitudes. In summary, our data show both latitudinal and altitudinal variation in blood glucose with the lowest concentrations found in tropical lowland species. The results suggest that this variation is primarily due to the variation in G_0. The low costs and the ease of blood glucose measurement renders it a promising tool for the macrophysiological research.

AS18.19 WARM ADAPTATION TRADES-OFF AGAINST HEAT TOLERANCE PLASTICITY IN INTERTIDAL NUDIBRANCH MOLLUSCS

SUNDAY 1 JULY 2018

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Rapid ocean warming may alter habitat suitability for marine ectotherms and susceptibility to thermal perturbations will depend in part on a species' relative ability to plastically adjust its upper thermal limits of performance. However, we currently lack data regarding heat tolerance and tolerance plasticity for several major marine taxa including nudibranch molluscs. We investigated heat tolerance limits

(CT_{max}), heat tolerance plasticity (acclimation response ratio), thermal safety margins (TSMs), temperature sensitivity of metabolism (Q_{10}), and metabolic cost of heat-shock in nine species of nudibranchs from several sites along the northeastern Pacific coast of California in order to determine relative sensitivity to future warming. Heat tolerance differed significantly between species but not across latitudes within a species and ranged from 25.4 ± 0.5 °C to 32.2 ± 1.8 °C (x- ± SD). Heat tolerance plasticity (ARR) was generally high (0.52 ± 0.06, x- ± SE) and was strongly negatively correlated with heat tolerance in accordance with the Trade-off Hypothesis of thermal adaptation. Acute metabolic costs of thermal challenge were low with no significant alteration in respiration rate of any species 1 h post-exposure to heat-shock. Thermal safety margins, calculated against maximum habitat temperatures, were negative for nearly all species examined (-2.6 ± 1.1°C). From these data, we conclude that warm-adaptation in intertidal nudibranchs constrains acclimatory responses to acute thermal challenge, that warm-adapted species are likely most vulnerable to future warming, and that metabolic recovery is rapid after heat shock in these species.

AS18.20 ANT THERMAL TOLERANCES UNDER CLIMATE, LAND COVER AND LAND USE CHANGE

SUNDAY 1 JULY 2018

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Rapid ocean warming may alter habitat suitability Thermal stress is a key issue for species dominant within ecosystems especially those that carry out key ecosystem service roles. Here we integrate the observed phenotypic plasticity of the dominant and ubiqitous meat ant Iridomyrmex purpureus in critical thermal limits across altitudinal, land cover and land use gradients to: (i) predict the adaptive capacity of a key terrestrial ecosystem service provider to changes in climate, land cover and land use, and (ii) assess the ability of multiple use landscapes to confer maximum resilience to terrestrial biodiversity in the face of a changing climate. The research was carried out along a 270km aridity gradient in northern New South Wales, Australia. When we assessed critical thermal maximum temperatures (CT_{max}) of meat ants in relation to the environmental variables, and within the model we had critical thermal minimums of meat ants (CT_{min}) as a random slope and as a fixed effect we detected a negative aridity effect on CT_{max}, a negative effect of land use intensity, and no overall correlation between CT_{max} and CT_{min} . We also found a negative relationship with warming tolerance of I. purpureus and landscape aridity. In conclusion, we expect to see a reduction in the physiological resilience of I. purpureus as land use intensity increases and as the climate becomes more arid. Meat ants are key ecosystem engineers and as they are put under more stress, wider ecological implications may occur if populations decline or disappear.

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