From bacteria to zooplankton, the impact of food-limitation on their physiology and biochemistry

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Marine Ecophysiology Group EOMAR
Universidad de Las Palmas de Gran Canaria

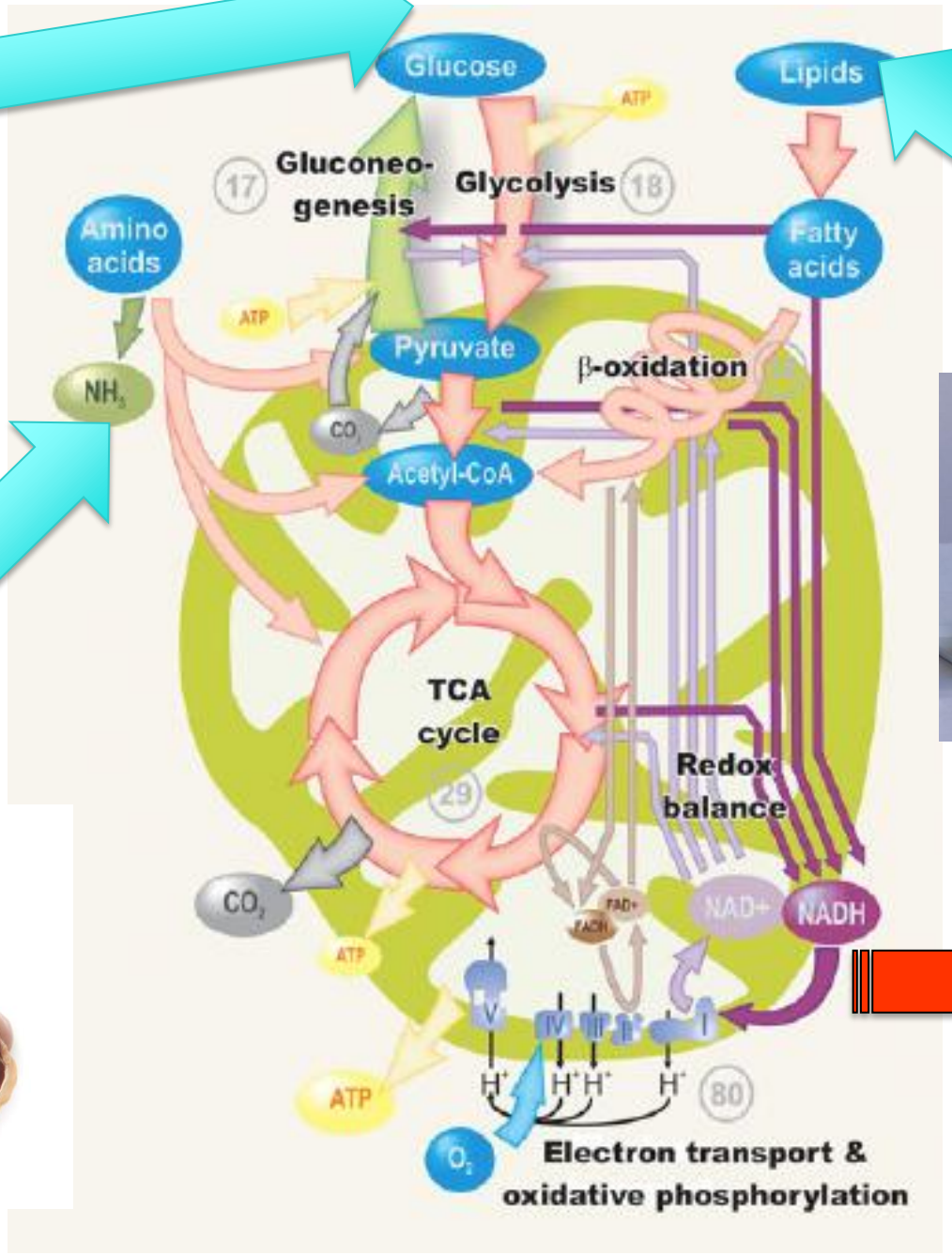
2015 Aquatic Sciences Meeting
Aquatic Sciences: Global And Regional Perspectives — North Meets South
22-27 February 2015 — Granada, Spain

The impact of food-limitation

Starvation

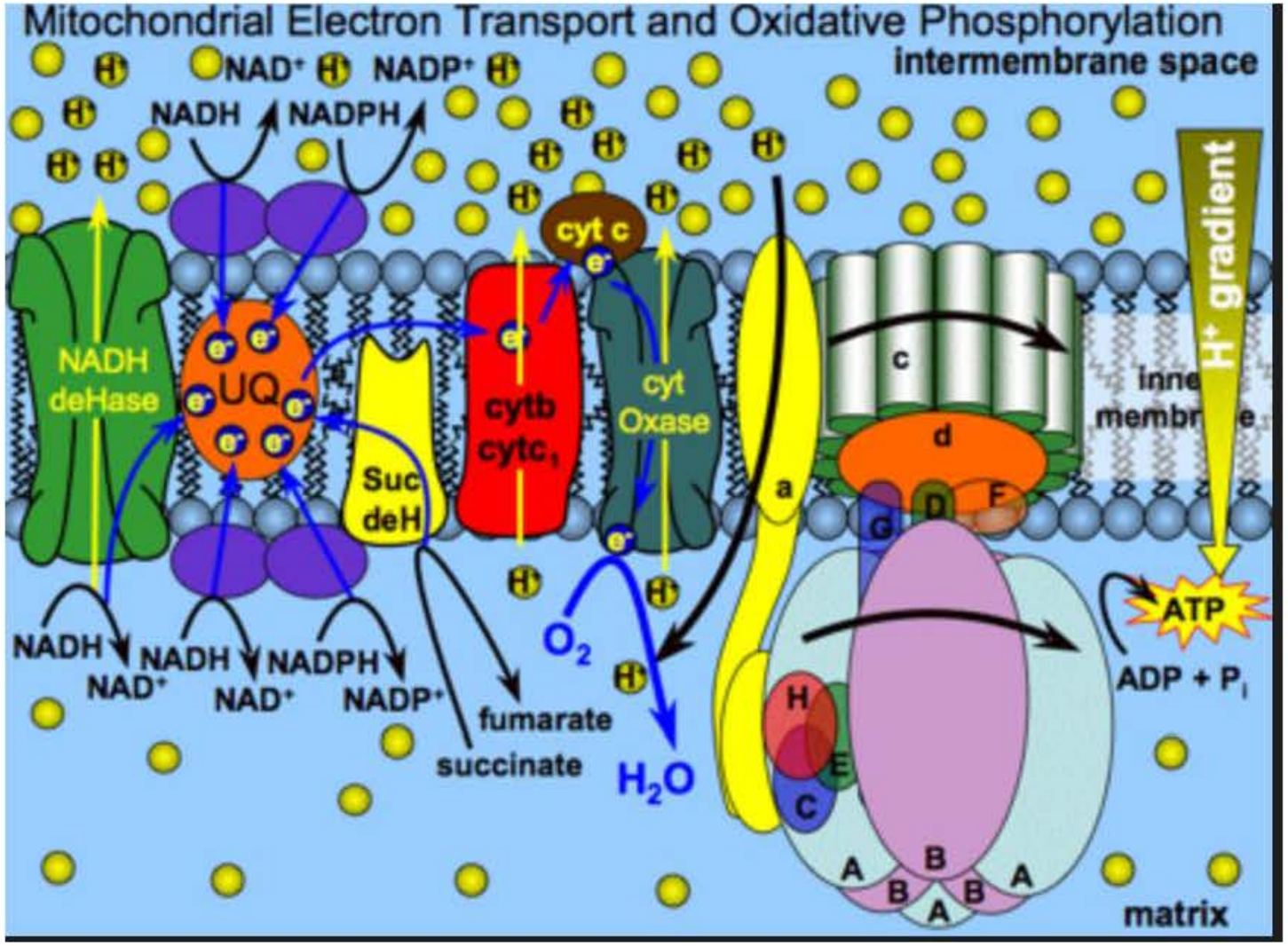
Let’s have a look into a key metabolic pathway,

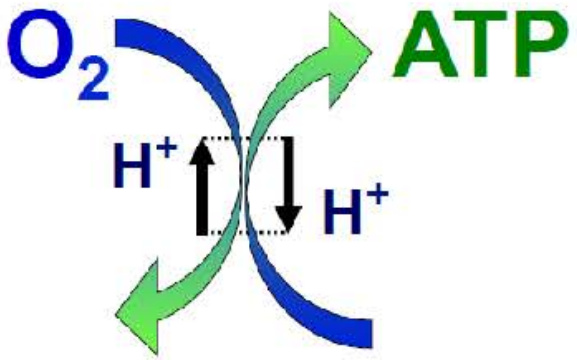
The Krebs Cycle


Glucose
Lipids
ATP
17
Gluconeo-
genesis
Glycolysis
18
Amino
acids
Fatty
acids
ATP
Pyruvate
β-oxidation
NH3
CO2
Acetyl-CoA
TCA
cycle
29
Redox
balance
CO2
FAD+
FADH
NAD+
NADH
ATP
V
IV
I
H+
H+H+
H+
80
ATP
O2
Electron transport &
oxidative phosphorylation

Substrates

ETS controls the ATP production.



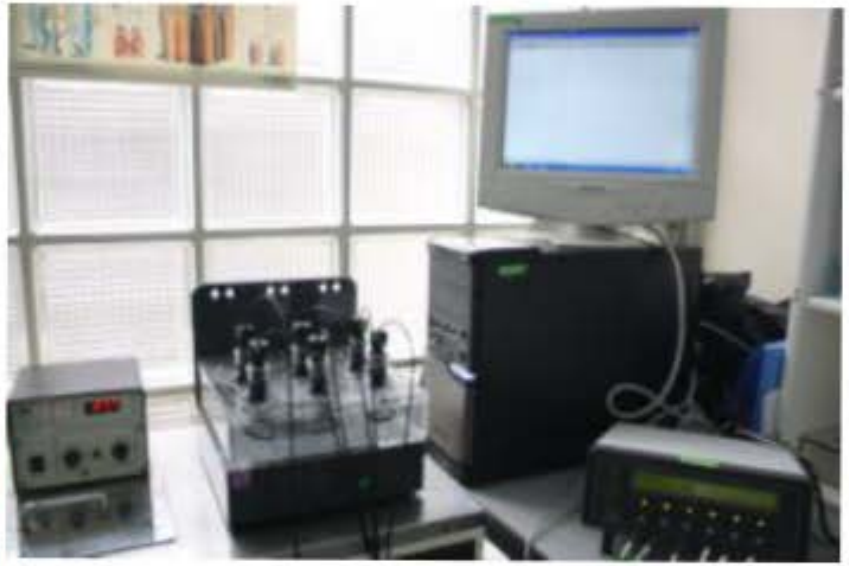


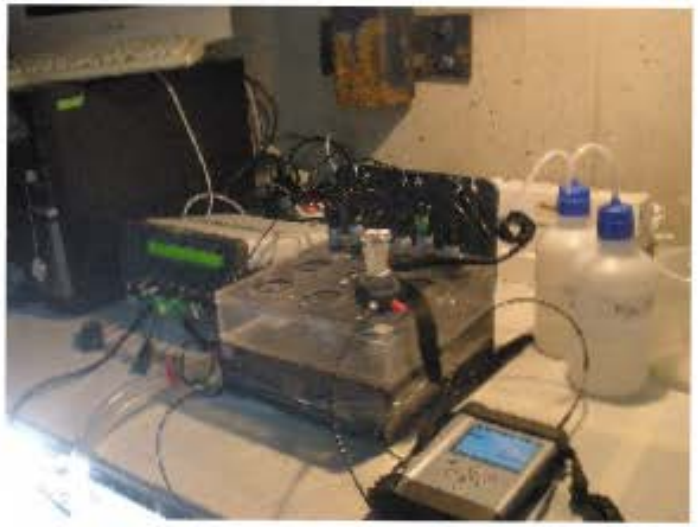
ATP ATP
ATP ATP
ATP ATP

What happens to respiration when organisms pass from well-fed to starvation conditions?

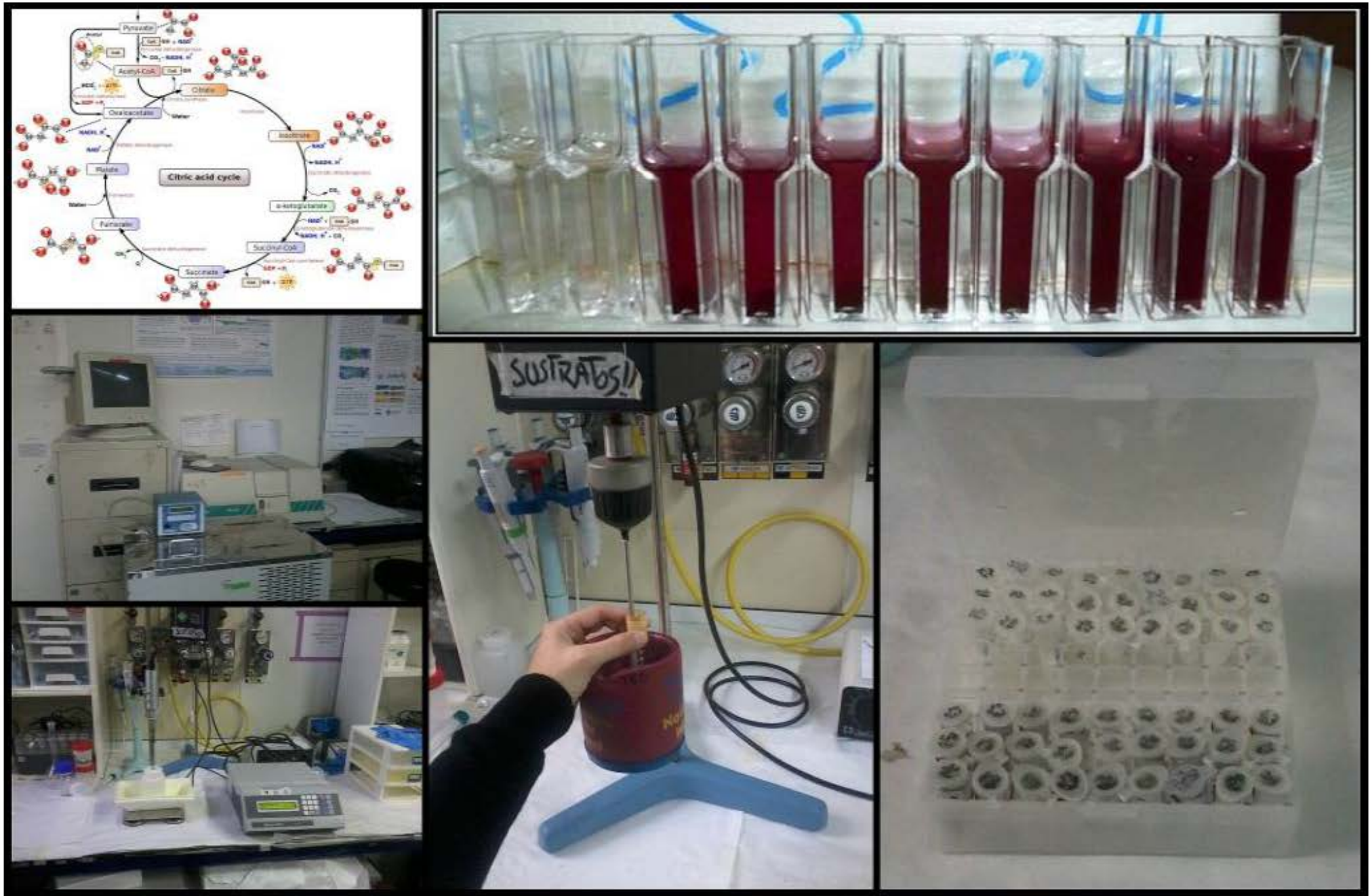
From bacteria to zooplankton

Phisiological experimentation



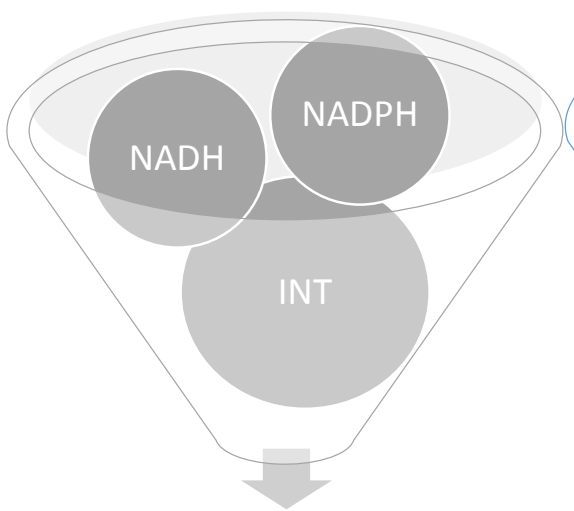


Marine enzymology



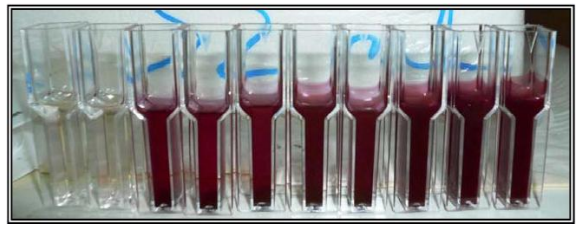
Three basic enzymatic tools

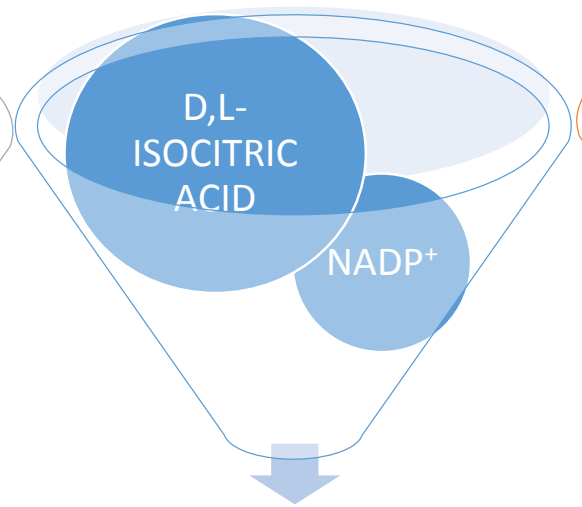
Maximum capacity



FORMAZAN

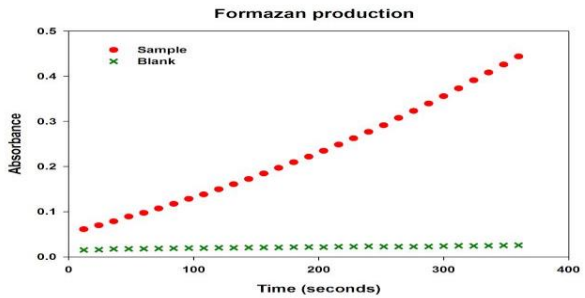
ETS ASSAY

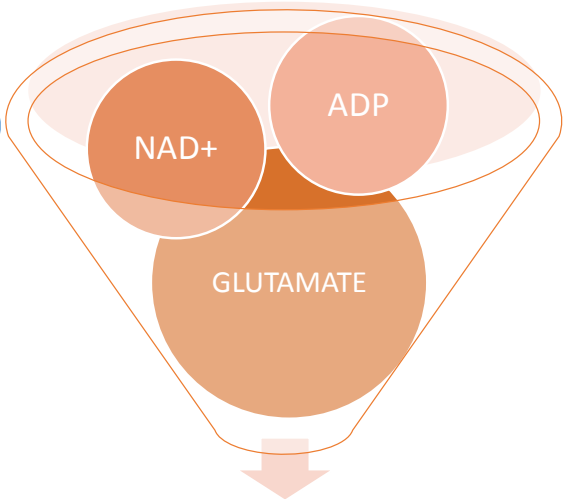




NADPH

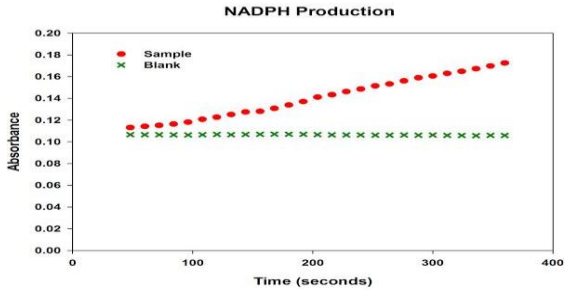
IDH ASSAY





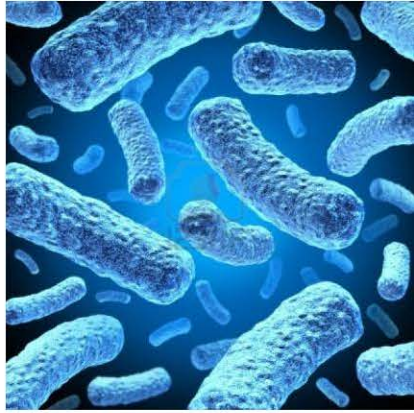
NADH

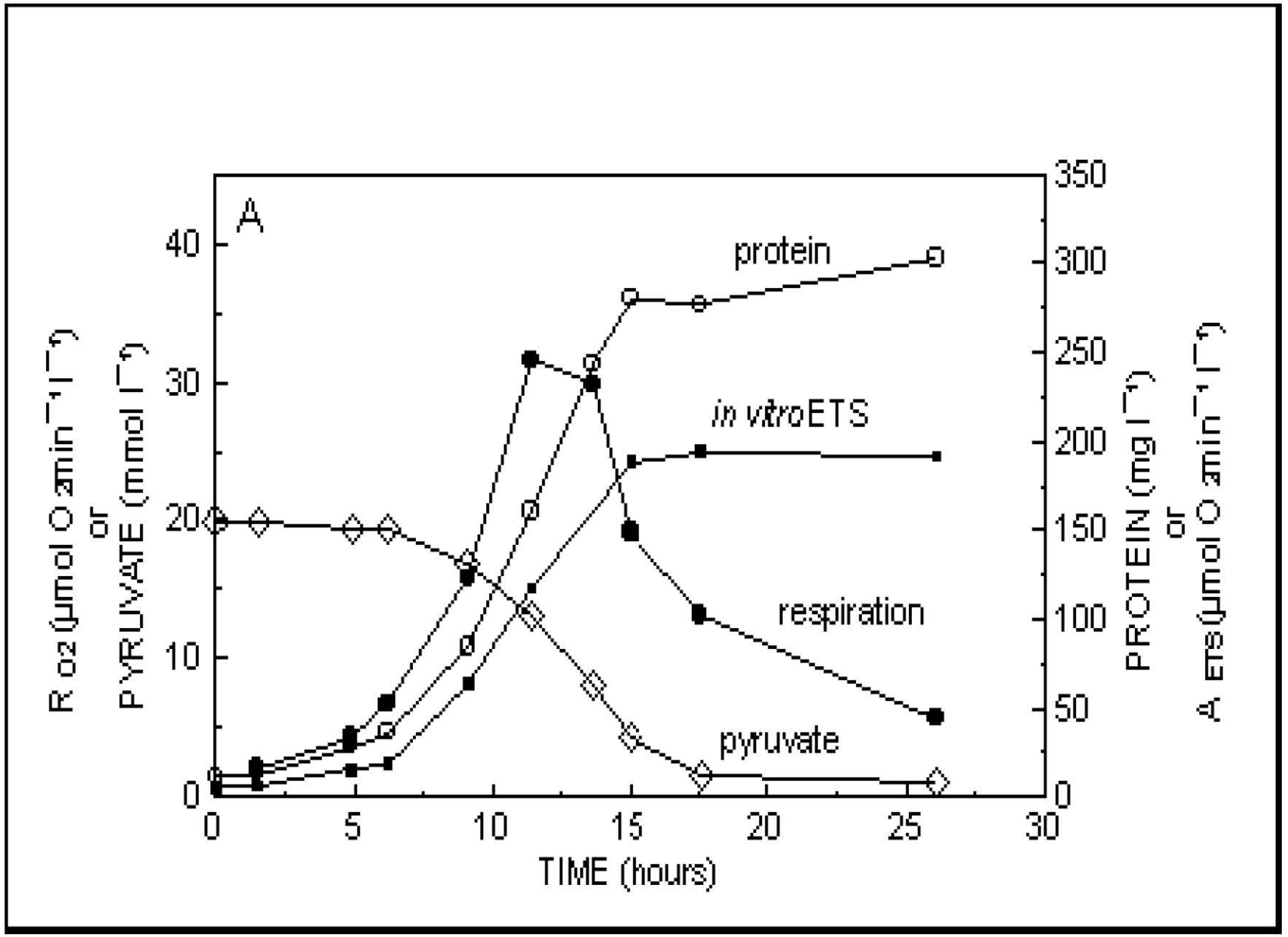
GDH ASSAY



Let’s start from the beginning!

Our first investigation was in batch cultures of marine bacteria.



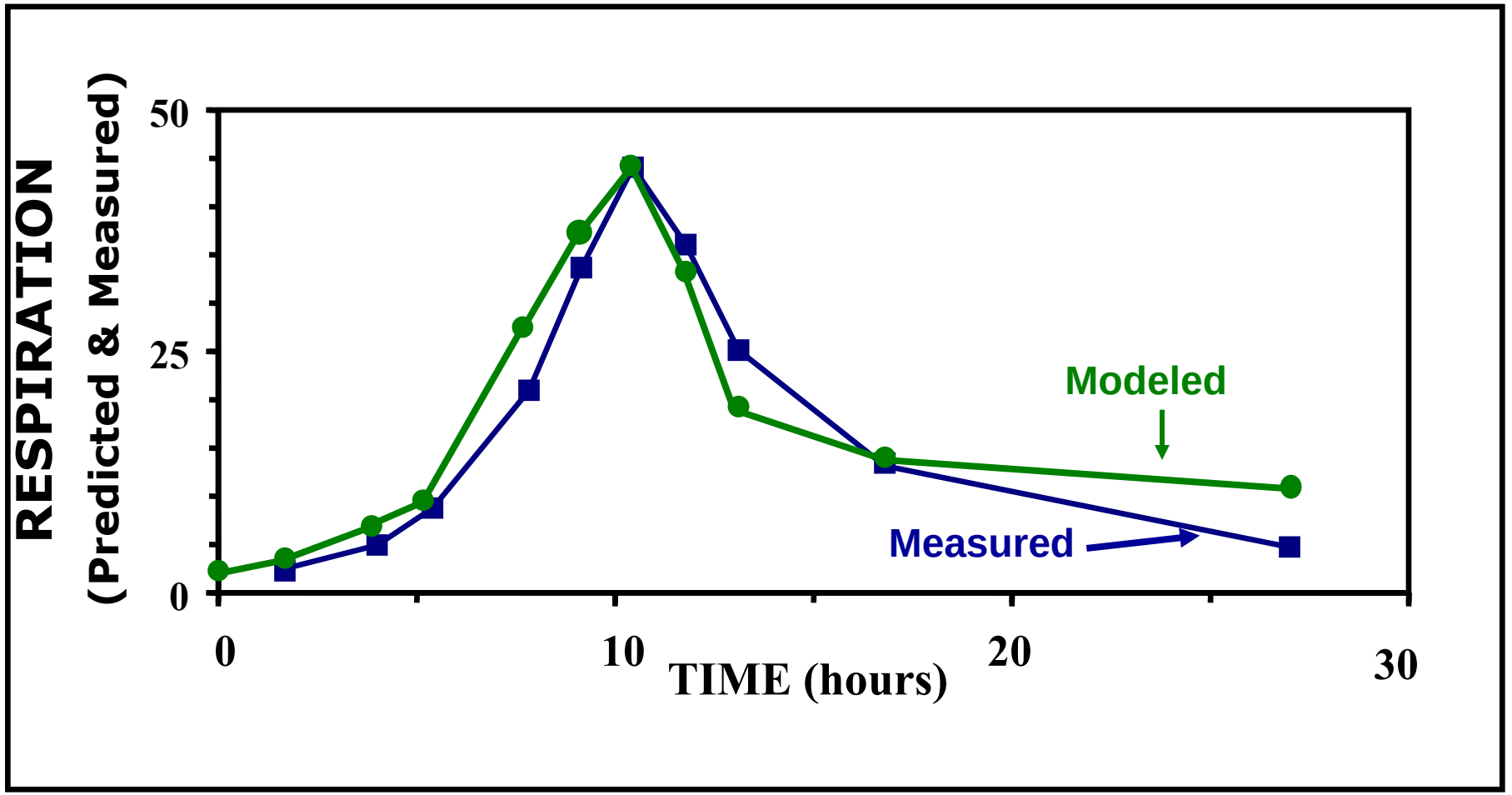

A
protein
in vitro ETS
respiration
pyruvate
TIME (hours)
R o2 (µmol O2 min⁻¹ l⁻¹)
or
PYRUVATE (mmol l⁻¹)
PROTEIN (mg l⁻¹)
or
A ETS (µmol O2 min⁻¹ l⁻¹)
0
10
20
30
40
0
5
10
15
20
25
30
0
50
100
150
200
250
300
350

ICES Journal of Marine Science Advance Access published February 13, 2008

Exploring a first-principles-based model for zooplankton respiration

Ted T. Packard and May Gómez

Modelling respiration



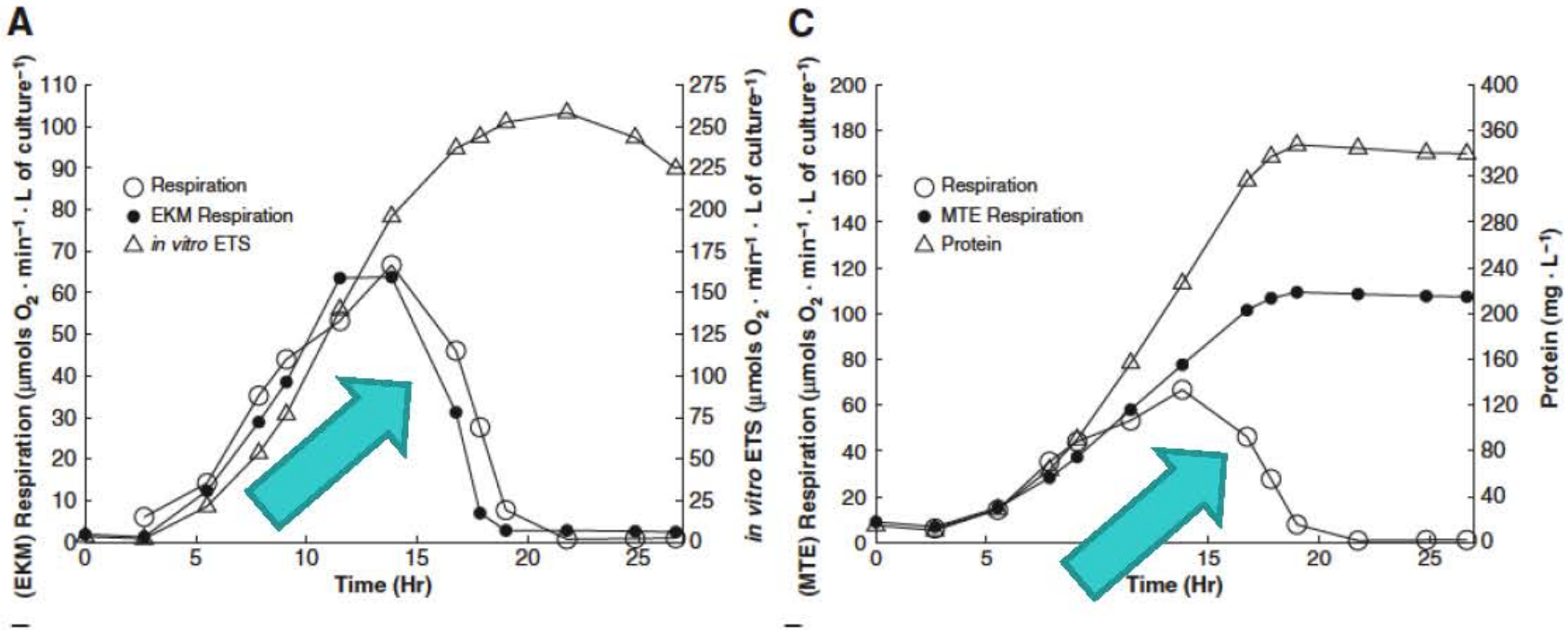
Contents lists available at SciVerse ScienceDirect

Journal of Experimental Marine Biology and Ecology

journal homepage: www.elsevier.com/locate/jembe

Respiration predicted from an Enzyme Kinetic Model and the Metabolic Theory of Ecology in two species of marine bacteria

Borja Aguiar-González [a,*], Ted T. Packard [b,c,e], Elisa Berdalet [c], Sylvie Roy [d], May Gómez [b]

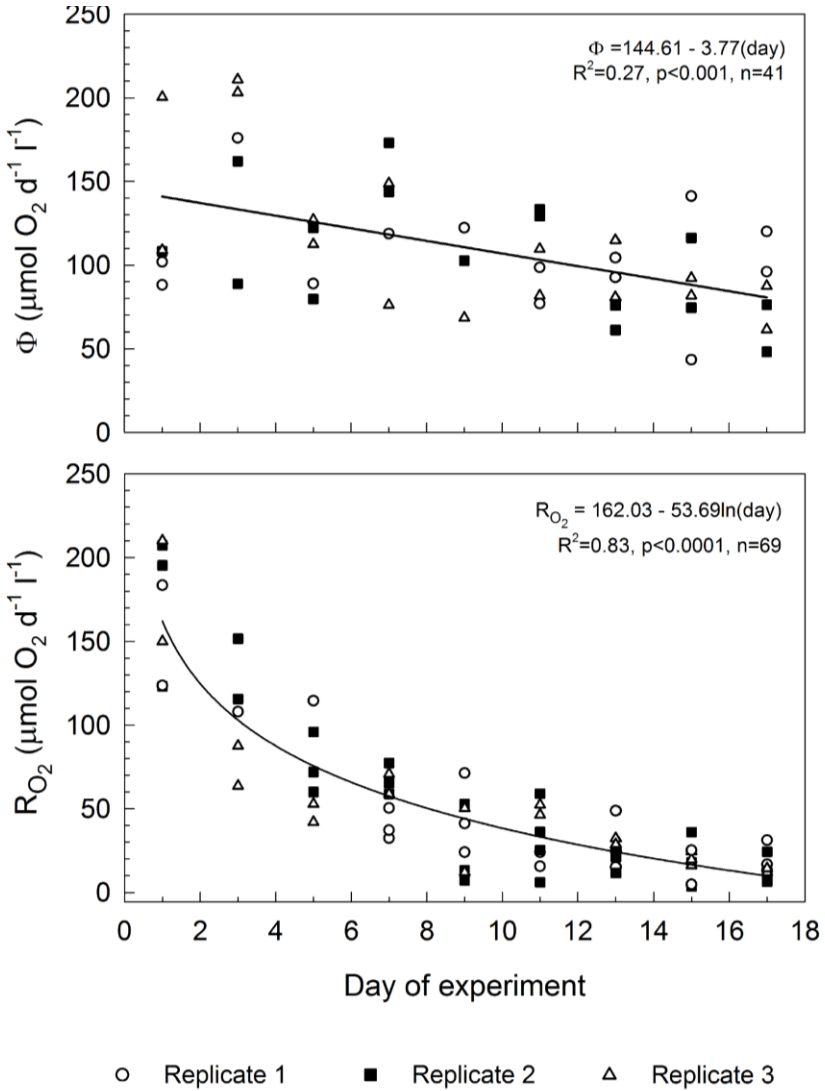


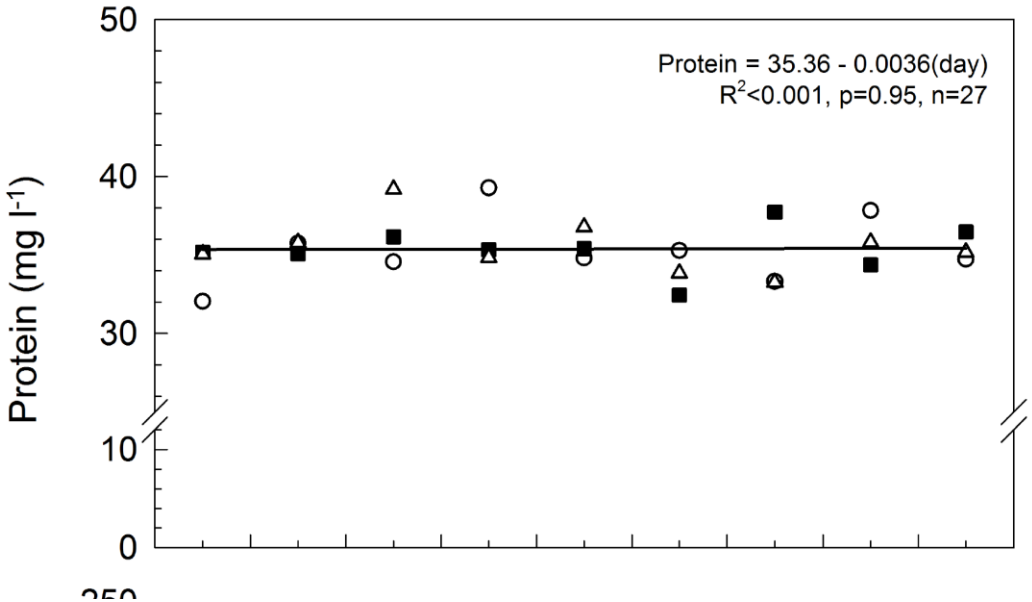
The EKM predicts respiration under starvation conditions and MTE doesn't

Can we see the same patterns in marine eukaryotes?

Respiratory metabolism and pyridine nucleotides levels in the marine dinoflagellate *Oxyrrhis marina* during starvation.

N. Osma, I. Fernández-Urruzola, M. Aristizabal T.T. Packard, M. Gómez





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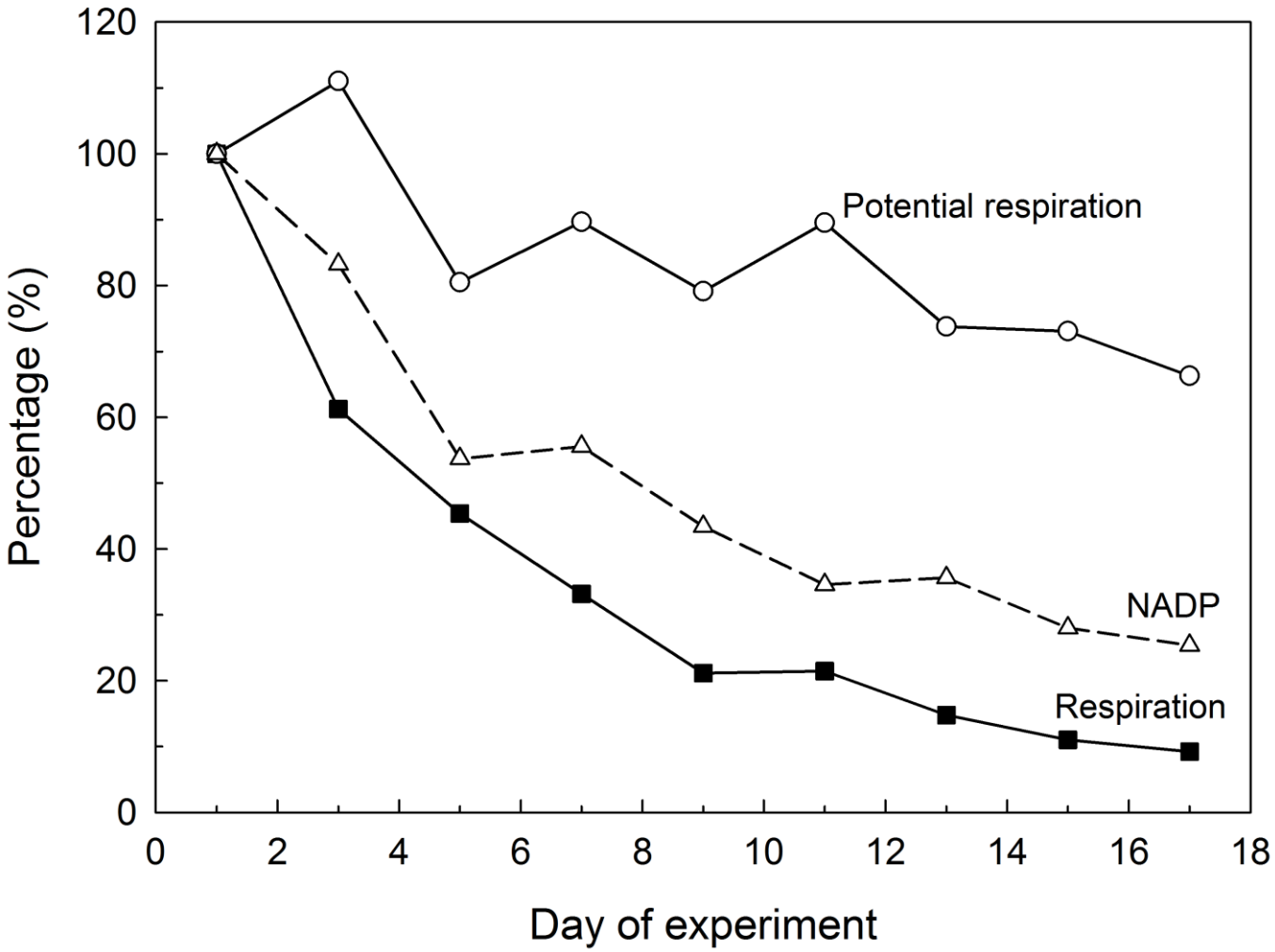

First time Pyridine nucleotides have been measured in plankton

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Effect of starvation and feeding on respiratory metabolism in *Leptomysis lingvura* (G.O. Sars, 1866)

A. Herrera [a,*], T. Packard [a], A. Santana [b], M. Gómez [a]

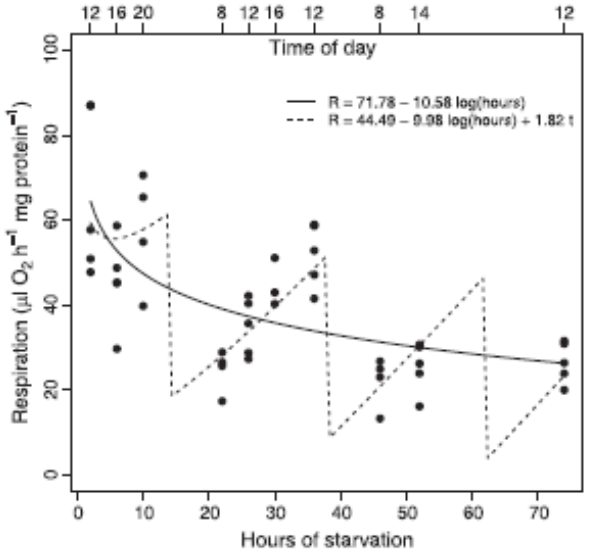


Fig. 1. Relationship between R (μ_l O_2 h^{-1} mg $prot.^{-1}$) and starvation period (h), $R^2 = 0.44$, $n = 45$ (solid line); and relationship between R, starvation period and time of day (t), $R^2 = 0.64$, $n = 45$ (dotted line). The dark period started at 20:00 h.

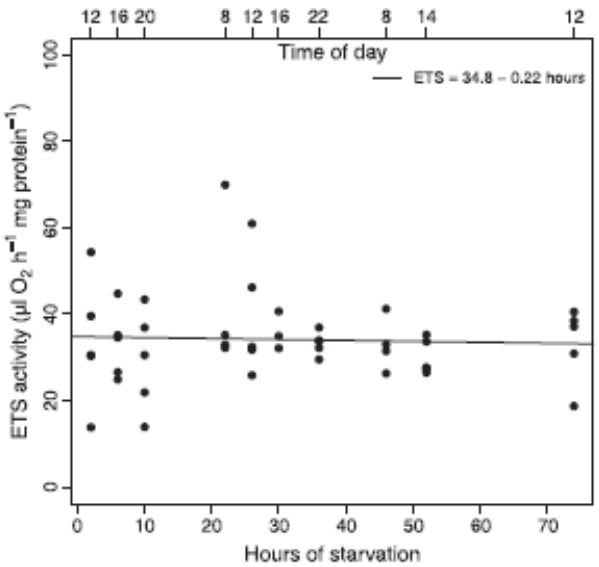


Fig. 2. Relationship between (μ_l O_2 h^{-1} mg $prot.^{-1}$) and starvation period (h), $R^2 = 0.021$, $n = 45$.

Respiration decreases during food-limitation by a third and displays a circadian rhythm.

ETS activity is constant during food-limitation.

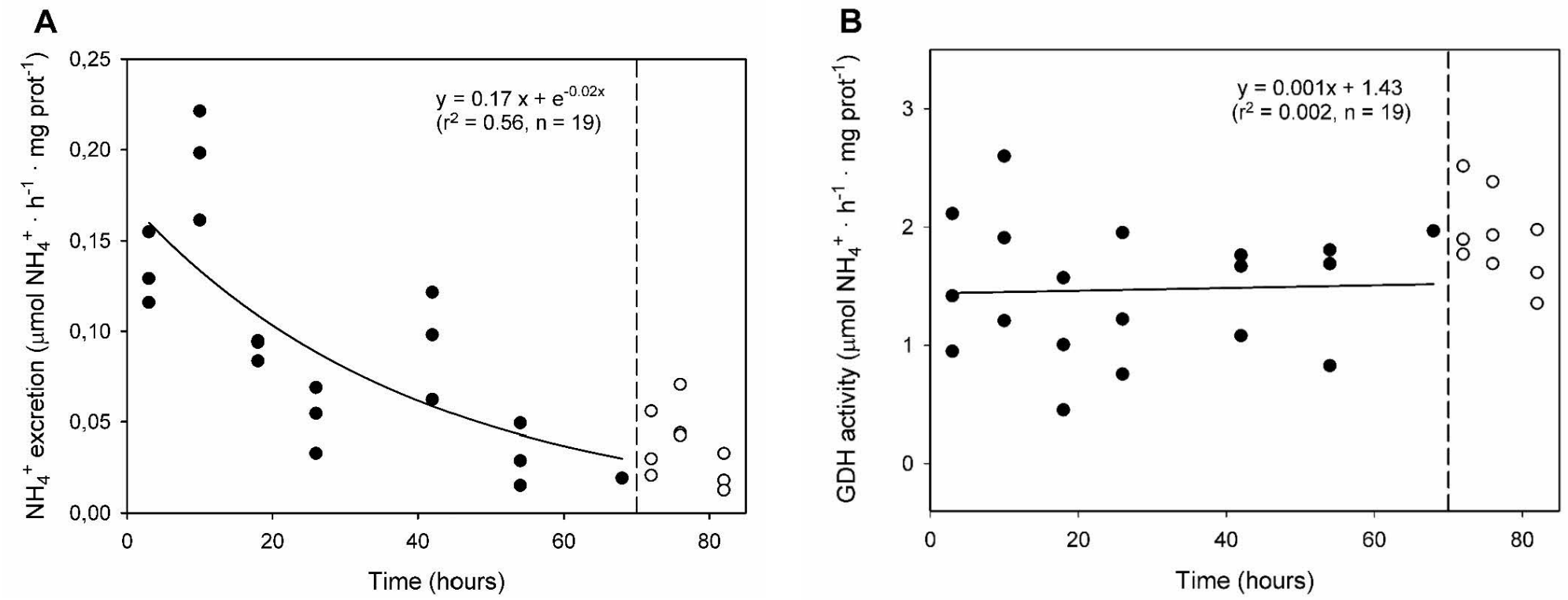
Contents lists available at ScienceDirect

Journal of Experimental Marine Biology and Ecology

journal homepage: www.elsevier.com/locate/jembe

GDH activity and ammonium excretion in the marine mysid, *Leptomysis lingvura*: Effects of age and starvation

I. Fernández-Urruzola *, T.T. Packard, M. Gómez



Starvation causes NH4+ excretion to decrease however GDH activity remains constant.

What happen to the R/Q during starvation?

MARINE ECOLOGY PROGRESS SERIES

Vol. 519: 47–59, 2015
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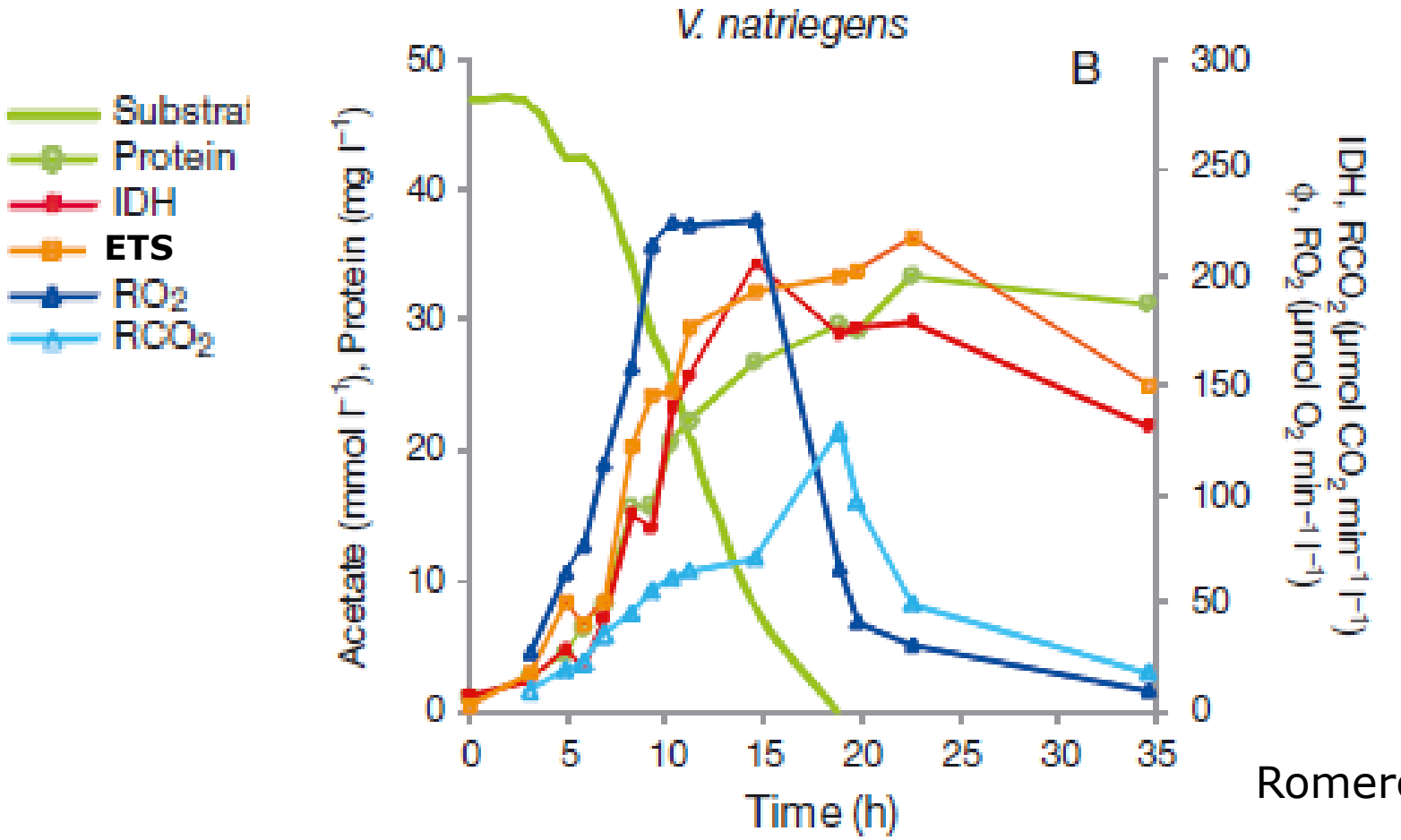
Published January 20

Respiration quotient variability: bacterial evidence

V. Romero-Kutzner[1,*], T. T. Packard[1], E. Berdalet[2], S. O. Roy[3], J.-P. Gagné[4], M. Gómez[1]



Romero-Kutzner et al., 2015

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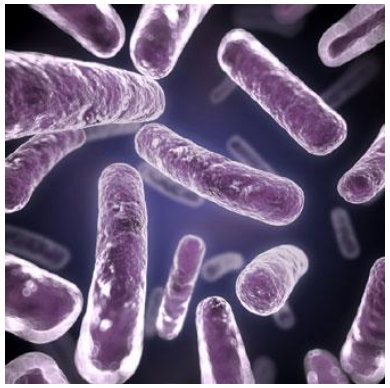
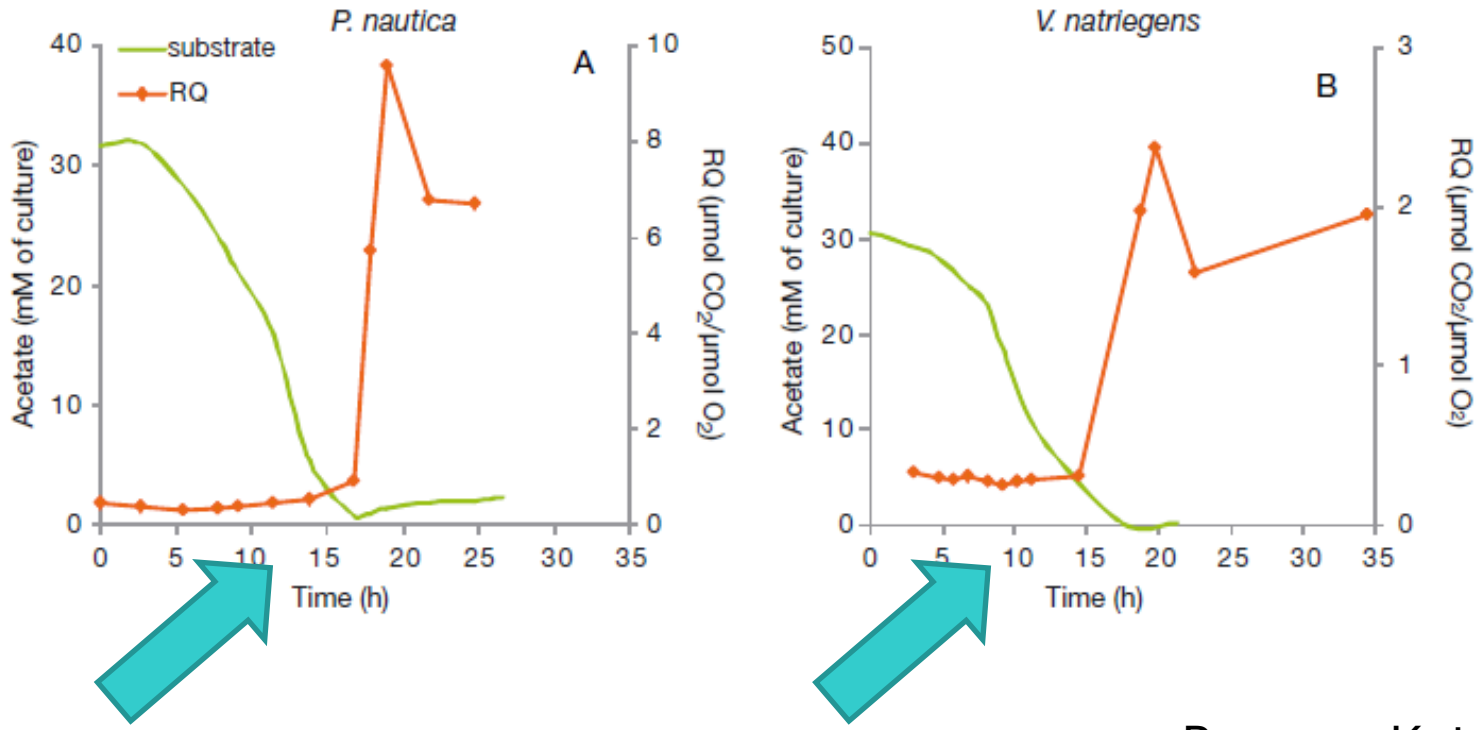
Other Uses:
RQ understanding





Romero-Kutzner et al., 2015

Conclusion:

1.- **Starvation** decreases respiration and ammonia excretion, but not their enzyme-based potentials.

2.-Metabolic Theory of Ecology can not predict respiration under conditions of **starvation**.

3.- **Starvation** decreases the energy currency molecule needed for carbón synthesis.

4.- **Starvation** can cause R/Q to increase 10-fold.

Marine Ecophysiology Group: EOMAR

Thank you!

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