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Current situation

September 2024 – Today: **Associate Professor** (section 68)
at La Rochelle Université, LIENSs, UMR 7266, France

Grants

2024: **Travel grant** from the SEB (300€) to attend the SEB conference in Prague, Czev Republic.

2023

- **Research grant** from the Nils Olof Berggren Foundation (€11k).
- **Travel grant** from the Royal Physiographical Society of Lund to take part in the SEB centenary conference (€1k).
- **Research grant** from the Längmanska Cultural Fund Foundation (€1.7k).
- **Research grant** from the Lars Hierta Foundation (€2.6k).

2022: **Research grant** from the Helge Ax:son Johnson Foundation (€1.7k).

2020: **Travel grant** from the France Canada Research Fund (€3.4k).

2019

- **Travel grant** from the French Group of Bioenergetics (grant from the GDR Photosynthèse, Labex Graal, BBA Journal) to attend the 20th GFB congress in Autrans, France.
- **Travel grants** from the Company of Biologists (230€) and the SEB (300€) to attend the SEB conference in Seville, Spain.
- **Travel grant** from the BioEnvis Research Federation (300€).

2018: **Ministerial research grant** for a doctoral contract, French Ministry of Higher Education and Research.

Educational background

- 2018 – 2021: PhD en Ecophysiology, Université Claude Bernard Lyon 1
- 2017 – 2018: 2nd year of Master's degree « Cardiovascular, metabolic and nutritional regulation», Université Claude Bernard Lyon 1
- 2016 – 2017: 1st year of Master's degree « Integrative Biology and Physiology », Université Claude Bernard Lyon 1
- 2013 – 2016: Bachelor's degree in Biology, Physiology speciality, Université Claude Bernard Lyon 1

Collaborations

2020 (1 month): Collaboration with Dr. Julie Nati and Dr. David J. McKenzie, UMR MARBEC, Palavas-Les-Flots, France.

Funding: MC Julie NATI grant, INDITOL Project
Research topic: Relationship between hypoxia tolerance, individual metabolic rate and cardiac and hepatic metabolism in sea bass.

2020 (2 ½ months): Collaboration with Dr. Jean-Michel Weber, University of Ottawa, Canada.

Funding: France Canada Research Fund
Research topic: Effects of lactate on carbohydrate metabolism in rainbow trout.

2019 (3 weeks): Collaboration with Dr. Karine Salin, IFREMER, LEMAR UMR 6539, Brest, France.

Funding: BioEnvis Research Federation
Research topic: Concomitant fluctuations in temperature and oxygen and consequences for mitochondrial efficiency in producing energy in sea bass.

Professional experiences

July 2022 – July 2024: **Postdoctoral Researcher** at Lund University, Department of Biology, Sweden

Supervisor: Dr. Andreas Nord
Research themes: Thermal and dietary fluctuations and their consequences on energetic metabolism and thermoregulation in Japanese quail *Coturnix japonica*.

October 2021 – July 2022: **Temporary teaching and research assistant** (ATER) at Université Claude Bernard Lyon 1, LEHNA UMR 5023, France

Supervisors: Pr. Yann Voituron and Pr. François-Xavier Dechaume-Moncharmont
Research themes: Temporal changes in heart metabolism during a heat wave in apron of Rhône *Zingel asper*; Relationship between personality and metabolic rate in apron of Rhône and round goby *Neogobius melanostomus*; Analysis of mitochondrial metabolism thanks to muscle biopsies and consequences on swimming performance in goldfish *Carassius auratus*.

October 2018 – October 2021: **PhD in Ecophysiology** at Université Claude Bernard Lyon 1, LEHNA UMR 5023, France

Title: Plasticity of aerobic performance and muscle bioenergetics in fish in response to variations in environmental parameters.
Research themes: Endurance training and hypoxia: consequences on the energy metabolism and swimming performance of goldfish; Consequences of simultaneous variations in oxygen availability and temperature on the mitochondrial efficiency to produce energy in the sea bass *Dicentrarchus labrax*; Effects of successive heat waves on the muscular metabolism of the zebrafish *Danio rerio*.
PhD directors: Pr. Damien Roussel et Dr. Loïc Teulier
Examination jury: Pr. Yann Voituron (President), Pr. Christel Lefrançois (Opponent), Pr. Pierre Blier (Opponent) et Dr. Karine Couturier (Examiner).
Date of defence: November 8, 2021

January 2018 – June 2018: **Research project – 2nd year of Master's degree** at LEHNA (UMR 5023) and IFREMER (Palavas-Les-Flots), France

Directors: Dr. Loïc Teulier and Dr. Claire Saraux
Research themes: Metabolic consequences of concomitant fluctuations in food availability and temperature in the European sardine *Sardina pilchardus*.

January 2017 – July 2017 : **Research projects** (1st year of Master's degree and voluntary projects) at LEHNA (UMR 5023) and IFREMER (Palavas-Les-Flots), France

Directors: Dr. Loïc Teulier and Dr. Claire Saraux
Research themes: Influence of hypo-osmotic water on the muscular metabolism of zebrafish; Comparison of the muscular metabolic phenotype of the gilthead sea bream *Sparus aurata* and the European sardine; Oceanographic campaign and study of small pelagics in the Mediterranean Sea.

Published articles

13. **Thoral E**, Dawson N J, Bettinazzi S, Rodríguez E (2024) **An evolving roadmap: using mitochondrial physiology to help guide conservation efforts**. *Cons. Phys.* Volume 12, Issue 1, https://doi.org/10.1093/conphys/coae063.

12. **Thoral E**, García-Díaz C C, Persson E, Chamkha I, Elmér E, Ruuskanen S, Nord A (2024) **The relationship between mitochondrial respiration, resting metabolic rate and blood cell count in great tits.** *Biol. Open*. bio.060302. doi:10.1242/bio.060302.

11. **Thoral E**, Dargère L, Medina-Suárez I, Clair A, Averty L, Sigaud J, Morales-Montaron A, Salin K, Teulier L (2024) **Non-lethal sampling for assessment of mitochondrial function does not affect metabolic rate and swimming performance.** *Phil. Trans. R. Soc. B.* 379: 20220483. doi:10.1098/rstb.2022.0483.

10. Nord A, Persson E, Tabh J K R, **Thoral E** (2024) **Shrinking body size may not provide meaningful thermoregulatory benefits in a warmer world.** *Nat. Ecol. Evol.* 379: 20220483. doi:10.1038/s41559-023-02307-2.

9. Talarico G G M, **Thoral E**, Farhat E, Teulier L, Mennigen J A, Weber J-M (2023) **Lactate signaling and fuel selection in rainbow trout: mobilization of energy reserves.** *Am. J. Physiol. Regul. Integr. Comp. Physiol*. 325: R556–R567. doi:10.1152/ajpregu.00033.2023.

8. Metcalfe N, Bellman J, Bize P, [...], **Thoral E**, Westerterp KR, Westerterp-Plantenga MS, Wojciechowski MS, Monaghan P (2023) **Solving the conundrum of intra-specific variation in metabolic rate: A multidisciplinary conceptual and methodological toolkit.** *BioEssays*. 2300026, doi:10.1002/bies.202300026.

7. **Thoral E**, Roussel D, Gasset E, Dutto G, Queiros Q, McKenzie D J, Bourdeix J-J, Metral L, Saraux C, Teulier L (2023) **Temperature-dependent metabolic consequences of food deprivation in the European sardine.** *J. Exp. Biol.* 226, jeb244984. doi:10.1242/jeb.244984.

6. **Thoral E**, Teulier L, McKenzie D J (2023) **Energetics of fish swimming.** *Chapter in Encyclopedia of Fish Physiology*, 2nd Edition. doi: 10.1016/B978-0-323-90801-6.00083-5.

5. **Thoral E**, Roussel D, Quispe L, Voituron Y and Teulier L (2022) **Absence of mitochondrial responses in muscles of zebrafish exposed to several heat waves.** *Comp. Biochem. Physiol. Part A Mol. Integr. Physiol.* 274, 111299. doi: 10.1016/j.cbpa.2022.111299.

4. **Thoral E**, Farhat E, Roussel D, Cheng H, Pamenter M, Weber J-M, Teulier L (2022) **Different patterns of chronic hypoxia lead to hierarchical set of adaptative mechanisms in goldfish metabolism.** *J. Exp. Biol.* 225, jeb243194. doi: 10.1242/jeb.243194.

3. **Thoral E**, Queiros Q, Roussel D, Dutto G, Gasset E, McKenzie D J, Romestaing C, Fromentin J-M, Saraux C, Teulier L (2021) **Changes in foraging mode caused by a decline in prey size have major bioenergetic consequences for a small pelagic fish.** *J. Anim. Ecol.,* 00, 1-13. doi: 10.1111/1365-2656.13535.

2. **Thoral E**, Roussel D, Chinopoulos C, Teulier L, Salin K (2021) **Low oxygen levels can help to prevent the detrimental effect of acute warming on mitochondrial efficiency in fish.** *Biol. Letters* 17. doi: 10.1098/rsbl.2020.0759.

1. Teulier L, **Thoral E**, Queiros Q, McKenzie D J, Roussel D, Dutto G, Gasset E, Bourjea J, Saraux C (2019) **Muscle bioenergetics of two emblematic Mediterranean fish species: Sardina pilchardus and Sparus aurata.** *Comp. Biochem. Physiol. Part A Mol. Integr. Physiol.* 235, 174–179. doi: 10.1016/j.cbpa.2019.06.008.

Evaluation and edition activities:

- Member of the editorial board of the *Journal of Thermal Biology* since November 2022.

- Participated in the evaluation of 9 manuscripts for 8 international peer-reviewed journals: *Journal of Experimental Biology, Journal of Thermal Biology, STOTEN, PeerJ, Frontiers in Ecology and Evolution, Frontiers in Physiology, Ethology, Ecology and Evolution*.

Oral communications

Invited oral presentations

a. **Thoral E**, Roussel D, Chinopoulos C, Teulier L, Salin K. **Low oxygen levels can help to prevent the detrimental effect of acute warming on mitochondrial efficiency in fish**. Rank Symposium "*Variation in Metabolic Rate: Where Does It Come From and Does It Matter?"*, 2022, *Grasmere, United Kingdom*. Award for the best oral presentation (380€).

b. **Thoral E**. **Similar challenges but different consequences: how climate change shapes metabolic strategies in endotherms and ectotherms.** Society for Experimental Biology (SEB) Conference, 2024, *Prague, Czec Republic*.

Oral presentations in international congresses

c. Teulier L, **Thoral E**, Queiros Q, McKenzie DJ, Dutto G, Gasset E, Bourjea J, Saraux C. **Bioenergetics of two Mediterranean fish species are related to their swimming behavior.** 56th Annual Meeting of the Canadian Zoology Society (CSZ), 2017, *Winnipeg, Canada*.

d. **Thoral E**, Queiros Q, Roussel D, Dutto G, Gasset E, McKenzie DJ, Romestaing C, Fromentin J-M, Saraux C, Teulier L. **Food quality affects muscle bioenergetics of small pelagic fish**. SEB Conference, 2019, *Seville, Spain*.

e. **Thoral E**, Farhat E, Roussel D, Cheng H, Pamenter M, Weber J-M, Teulier L. **Long-term exposure to constant and intermittent hypoxia induce different metabolic adjustments depending on the level of integration in goldfish.** SEB Conference, 2021, *online*.

f. **Thoral E**, J.J.H. Nati J.J.H, Quéméneur J-B, Lozac'h L, Salou G, Vergnet A, Besson M, Allal F, McKenzie D.J, Salin K, Teulier L**. Is intraspecific variation in metabolism and hypoxia tolerance related to individual mitochondrial function in fish?** 14th International Congress on the Biology of Fish (ICBF), 2022, *Montpellier, France*.

g. Talarico G.G.M, **Thoral E**, Farhat E, Teulier L, Mennigen J.A and Weber J-M. **Lactate signaling for fuel selection: Carbohydrate and lipid mobilization in trout.** 14th ICBF, 2022, *Montpellier, France*

h. **Thoral E**, Correia M, Persson E, Chamkha I, Elmér E, Tabh J, Nord A. **Cold or hot spells: long-term consequences for mitochondrial metabolism in Japanese quail and comparison between different tissues.** SEB Animal Biology Early Career Researcher Symposium, 2022, *Tvärminne, Finland (online presentation due to COVID-19)*.

i. **Thoral E**. **How does incubation temperature affect mitochondrial thermal sensitivity and ROS production in Japanese quail embryos?** The Evolutionary Ecology Christmas meeting, 2023, *Höör, Sweden*.

j. **Thoral E**, Correia M, Langreiter M, Schött M, Breschel L C, Persson E, Chamkha I, Elmér E, Tabh J, Nord A. **How does environmental temperature during growth affect metabolism of birds in adulthood?** Nordic Oikos Conference, 2024, *Lund, Sweden*.

k. Roussel D, **Thoral E**, Voituron Y, Teulier L. **Plasticity of mitochondrial coupling efficiency: the last chance to survive in adverse environment?** 63rd Annual Meeting of the CSZ, 2024, *Moncton, Canada*.

l. Watson J, Souques C, Le Guyader J, Roussel D, Lassus R, Guillard L, Clair A, Averty L, Bastianini C, Redon L, Voituron Y, Daufresne M, Dechaume-Moncharmont FX, **Thoral E**, Teulier L. **Effects of a heatwave on**

cardiac mitochondrial respiration of a freshwater fish: the Rhône apron. 63rd Annual Meeting of the CSZ, 2024, *Moncton, Canada*.

m. Souques C, Watson J, Le Guyader J, Guillard L, Averty L, Bastianini C, Clair A, Redon L, Voituron Y, Dechaume-Moncharmont FX, **Thoral E**, Teulier L. **Facing an increasingly variable world: metabolic responses throughout an heatwave event in an endangered freshwater fish (*Zingel asper*).** 63rd Annual Meeting of the CSZ, 2024, *Moncton, Canada*.

Oral presentations in national congresses

n. **Thoral E**, Farhat E, Roussel D, Cheng H, Pamenter M, Weber J-M, Teulier L. **Chronic hypoxia acclimation and exercise enhance goldfish swimming performance.** 4th Congress of the Animal Ecophysiology (CEPA), 2019, *Rennes, France*.

o. **Thoral E**, Roussel D, Chinopoulos C, Teulier L, Salin K. **Low oxygen water concentrations can help to counteract the negative effects of warming on mitochondrial efficiency in fish.** Conference of Phenotypic Plasticity GDR, 2020, *online*.

p. **Thoral E**, Roussel D, Chinopoulos C, Teulier L, Salin K. **Low oxygen levels can help to prevent the detrimental effects of warming on mitochondrial efficiency in fish.** 25th Annual Meeting of the doctoral school EDISS, 2020, *online*. Award for the best oral presentation (200€).

q. Saraux C, Queiros Q, McKenzie DJ, Dutto G, Gasset E, **Thoral E**, Teulier L, Schull Q, Fromentin J-M. **How experimental approaches can inform us on behavioural and physiological mechanisms underlying population changes in the wild?** 5th CEPA, 2021, *Montpellier, France*

r. Dargère L, Medina-Suárez I, Clair A, Averty L, Sigaud J, **Thoral E**, Teulier L. **Muscle biopsies: consequences on muscle metabolism and swimming performance in goldfish.** 5th Congress of Societif of Physiology and Integrative Biology (SPBI), 2022, *Lyon, France*.

s. **Thoral E**, García-Díaz C C, Persson E, Chamkha I, Elmér E, Ruuskanen S, Nord A. **How blood mitochondrial metabolism can predict the whole-individual metabolic rate in great tits?** 6th Congress of SPBI, 2023, *Clermont-Ferrand, France*. Award for the best oral presentation (250€).

Posters in international congresses

t. Teulier L, Guillard L, **Thoral E**, Averty L, Clair A, Ulmann J, Romestaing C. **Bioenergetics flexibility of zebra fish muscle facing environmental constraints: chronic hypoxia vs. ion poor water acclimation.** 50 years of Hochachka Legacy - Satellite Symposium CSZ, 2017, *Winnipeg, Canada*.

u. **Thoral E**, Queiros Q, McKenzie DJ, Roussel D, Dutto G, Gasset E, Bourdeix J-H, Metral L, Saraux C, Teulier L. **Seasonal-dependent metabolic consequences of fasting in the European sardine.** ICCPB, 2019, *Ottawa, Canada*.

v. **Thoral E**, Roussel D, Quispe L, Voituron Y, Teulier. **Effects of simulated heatwaves on mitochondrial respiration in red muscle of zebrafish *Danio rerio*.** 60th Annual Meeting of the CSZ, 2021, *online*.

w. **Thoral E**, Correia M, Elmér E, Chamkha I, Nord A. **Effect of incubation temperature on mitochondrial thermal sensitivity and reactive oxygen species production during early-life development in Japanese quail.** SEB Centenary Conference, 2023, *Edinburgh, Écosse*. (Pecha Kucha and poster).

x. Teulier L, **Thoral E**, Souques C, Watson J, Clair A, Averty L, Guillard L, Morales-Montaron A, Roussel D, Dechaume-Moncharmont FX, Voituron Y. **Unlock in progress: Physiology tools in an ecological context.** 63rd Annual Meeting of the CSZ, 2024, *Moncton, Canada*.

y. **Thoral E**, Correia M, Elmér E, Chamkha I, Nord A. **Effect of incubation temperature on the thermal sensitivity of mitochondrial respiration during early-life development in Japanese quail.** 14th European Ornithologists' Union (EOU) Congress, 2023, *Lund, Sweden*. (Pecha Kucha and poster).

Poster in a national congress

z. **Thoral E**, Roussel D, Gasset E, Dutto G, Queiros Q, McKenzie D J, Bourdeix J-J, Metral L, Saraux C, Teulier L. **The seasonal-dependent metabolic consequences of fasting in the European sardine.** 20eth Congress of French Group of Bioenergetics, 2019, *Autrans, France*.

Technical and theoretical skills

Key-words: Integrative physiology, mitochondrial bioenergetics, oxygen consumption, ATP production, ROS production, muscular metabolism, swimming performance, fish, birds

Cellular metabolism:

- **Measurement of mitochondrial respiration, ROS and ATP production** in different tissues from fish and birds (muscle, liver, heart) *via* high precision respirometers Oroboros® for oxygen consumption coupled to ***magnesium green*** for ATP synthesis, or coupled to ***AmplexRed*** for the ROS production.
- **Enzymatic assays** by **spectrophotometry**
- (cytochrome c oxidase, citrate synthase, lactate dehydrogenase).

In vivo measurements:

- **Study of swimming performance** (U_{crit}) and metabolic rate with the Loligo® swim tunnels fitted with optode probe for oxygen consumption.
- **Surgery**: - Double cannulation in dorsal aorta in rainbow trout for blood samplings in parallel with the infusion of different molecules.
  - Blood collection in birds from brachial vein.
  - Tissues dissection.
- **Muscle shivering**: Insertion of an electrode in birds' muscle to measure the shivering activity of muscle, coupled to the measure of metabolic rate with the LabChart® System.

Supervising activity

- 1 BSc student: Marine Hoareau (2019)
- 5 MSc students (1st year): Océane Malvezin (2021); Laura Quispe (2021); Lilian Redon (2022); Chloé Souques (2022); Matilda Langreiter (2023)
- 2 MSc students (2nd year): Lauréliane Dargère (2022); Maria Correia (2022 - 2023)
- 2 research assistants: Maria Correia (2023); Malin Holmberg (2024)

Administrative and collective activities

June 2024 – present: Member of the steering committee of the Comparative Physiology Special Interest Group in the Scandinavian Physiology Society.

September 2023 - present: Co-organisation of the international club newspaper "EcoMito" (~30 people per month). The aim of this journal club is to give young researchers (PhD students and post-docs) the opportunity to present their recently published work in the field of mitochondrial metabolism in an ecological context.