

PHD PROPOSAL FOR THE DOCTORAL SCHOOL «Ecologie, Géosciences, Agronomie, ALimentation»

GENERAL INFORMATION

Thesis title: Plasticity and heritability of tolerance to hot and cold temperature extremes in the cereal aphid guild on a climatic gradient in two continents
Acronym: PLASTHER
Disciplinary field 1: Ecology Disciplinary field 2: Agronomy
Three keywords: adaptation to climate change; climatic gradient; thermotolerance
Research unit : UMR-CNRS 6553 ECOBIO and Institute of Plant Protection-Chinese Academy of Agricultural Science
Name of the thesis director: VAN BAAREN Joan Email address of the thesis director : joan.van-baaren@univ-rennes1.fr Name of the thesis co-supervisor 1 (if applicable): MA CHUNSEN Email address of the thesis co-supervisor 1 (if applicable): machunsen@caas.cn Name of the thesis co-supervisor 2 (if applicable): LE LANN Cécile Email address of the thesis co-supervisor 2 (if applicable): cecile.lelann@univ-rennes1.fr Name of the thesis co-supervisor 3 (if applicable): MA GANG Email address of the thesis co-supervisor 3 (if applicable): magang@caas.cn
Thesis grant (funding origin and amount): Institute of Plant Protection (Chinese grant, 1300 euros per month during the 18 months in France)
Contact(s) (mailing address and E-mail): Chun-Sen MA PhD Professor Institute of Plant Protection Chinese Academy of Agricultural Sciences. Yuan-Ming-Yuan West Road No.2. Beijing, 100193 China Joan van Baaren UMR 6553 ECOBIO Université de Rennes I Campus de Beaulieu Avenue du Général Leclerc 35 042 Rennes cedex France
Recruitment process: <input type="checkbox"/> Doctoral school contest <input type="checkbox"/> Interview <input checked="" type="checkbox"/> Other (indicate) : Financier with its own recruitment rules

ED EGAAL

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SCIENTIFIC DESCRIPTION OF THE PhD PROJECT

Socio-economic and scientific context : (10 lines)

One of the challenges of ecology is to understand the mechanisms by which environmental stresses (in particular those related to climate change) influence the individual responses of organisms and the consequences of these individual responses on the dynamics of populations, the structure of communities and the functioning of ecosystems. The objective of this research project is to link the ability of different species of the same guild of insects to resist and adapt (by plasticity or genetically) to extremes of hot and cold temperatures (which are increasingly more frequent), to the dynamics of the populations of each species, and therefore to the evolution of their relative abundances within this guild. This research is being carried out on the Cereal Aphid Guild (3 species). These aphids, originating in Europe, also exist in China and are vectors of various viruses including that of barley dwarf yellows, causing significant reductions in cereal yield (Zhang et al., 1983; Seabloom et al., 2009, 2013). The rate of virus transmission depends on the relative abundances of the aphid species, each species having its own characteristics in the spread of the virus. Field observations already carried out in China and Brittany for several years show that climate change strongly affects the relative abundances of these 3 species, in both countries, and these modifications seem to be linked to the differences in thermotolerance in these species.

Assumptions and questions (8 lines)

The objective of this thesis is to link the thermotolerance, measured at the individual level, to the dynamics of the populations of each species of the guild (evolution of the relative proportions of the 3 species), and that on a climatic gradient of severity of winters, in the two continents (Europe: from Brittany to the Czech Republic and on an East-West gradient in China). Understanding how the response of aphids to temperatures on two continental gradients will ultimately make it possible to predict the risks of damage linked to cereal virus diseases according to the evolution of climates and consequently to highlight the areas most at risk and on which specific agricultural policies must be prioritized. This in a context where neonicotinoids have been banned on cereals for two years, increasing the risk of loss of yields linked to aphids, on wheat, but also on other crops (beets, for example).

The main steps of the thesis and scientific procedure (10-12 lines)

The major hypothesis is that the species and populations which have the greatest integrated adaptive capacity (by heritability and / or plasticity) will exhibit the highest relative abundances, particularly in regions where climate change (winter warming) is occurring, the most marked. Specifically, both in China and in Brittany, we observe a strong decline of the aphid species *Sitobion avenae*, for which an absence of heritability of thermotolerance to high temperatures has been demonstrated for a Chinese population. This declining species is replaced by the *Rhopalosiphum padi* species in China (for which heritable thermotolerance has been demonstrated) and by the species *Metopolophium dirhodum* in Brittany. We hypothesize that *Sitobion avenae* has less adaptive capacity than the other two species on both continents and that the reduction in its relative proportion will be related to regions where temperature extremes will be strongest and / or regions, where winters get warmer on average faster, inducing continuous aphid activity throughout the year. - Analysis of a climatic gradient (4 points per continent) in Europe and China, locating in each continent comparable areas from the point of view of winter temperatures. - Analysis of the heritability and plasticity of resistance to hot and cold stresses on individuals collected from the field in winter and spring. Measurement of genetic variability.

Methodological and technical approaches considered (4-6 lines)

- Climate data analysis. Laboratory heritability measurements.
- Analysis of life traits as a function of temperature in the laboratory (plasticity).

Scientific and technical skills required by the candidate

Evolutionary biology, interest in entomology, quantitative genetics, plasticity. 18 months in China, 18 months in France. Interest in teamwork. This thesis will be closely linked to the LANDYIELD thesis.

THESIS SUPERVISION¹

Unit name: UMR-CNRS 6553 ECOBIO	Team name: NA
Unit director name: Joan van BAAREN	Team director name:
Mailing address of the unit director: Joan.van-baaren@univ-rennes1.fr	Mailing address of the team director:
Thesis director Surname, first name: VAN BAAREN Joan Position: Professor Obtained date of the HDR (Habilitation thesis to supervise research): 2001 Employer: University of Rennes 1 Doctoral school affiliation: EGAAL Rate of thesis supervision in the present project (%): 40% Total rate of thesis supervision in ongoing theses (supervisions and co-supervisions) (%): PhD Armando Alfaro-Tapia (30%), end July 2021 ; PhD Jeniffer Alvarez-Baca (30%), end September 2021, Sacha Roudine (40%), end December 2022. Number of current thesis supervisions/co-supervisions: 3 (2 will be ended in 2021)	
Thesis co-supervisor 1 (if applicable) Surname, first name: MA CHUNSEN Position: Professor Habilitation thesis to supervise research <input type="checkbox"/> yes <input type="checkbox"/> no If yes, date diploma received: Employer: Institute of Plant Protection. CAAS China Doctoral school affiliation: Graduate School of Chinese Academy of Agricultural Sciences Rate of thesis supervision in the present project (%): 30% Total rate of thesis supervision in ongoing theses (supervisions and co-supervisions) (%): PhD Xuejing Wang (40%), end September 2021, MS Mingzhu Yuan (20%), end May 2021, PhD Yuanjie Li (30%), end September 2023 Number of current thesis supervisions/co-supervisions: 3 (2 will be ended in 2021)	
Thesis co-supervisor 2 (if applicable) Surname, first name: LE LANN Cécile	

¹ In EGAAL Doctoral School, if only one scientist in thesis supervision = 100% of supervision rate; if 2 people involved in thesis supervision = from 50% to 70% of supervision rate for the director; if 3 people involved in thesis supervision = 40% / 30% / 30% of supervision rate distribution among supervisors.

Position: MC

Habilitation thesis to supervise research yes no If yes, date diploma received:

Employer: University of Rennes 1

Doctoral school affiliation: EGAAL

Rate of thesis supervision in the present project (%): 30%

Total rate of thesis supervision in ongoing theses (supervisions and co-supervisions) (%): PhD Armando Alfaro-Tapia (30%), end July 2021 ; PhD Jeniffer Alvarez-Baca (30%), end September 2021, Sacha Roudine (40%), end December 2022.

Number of current thesis supervisions/co-supervisions: 3 (2 ended in 2021)

Thesis co-supervisor 3 (if applicable)

Surname, first name: MA GANG

Position: researcher

Habilitation thesis to supervise research yes no If yes, date diploma received:

Employer: Institute of Plant Protection

Doctoral school affiliation:

Rate of thesis supervision in the present project (%): 0%

Total rate of thesis supervision in ongoing theses (supervisions and co-supervisions) (%):

Number of current thesis supervisions/co-supervisions:

Private partner (if CIFRE funding, private funding,...)

Surname, first name:

Position:

Employer:

Rate of thesis supervision in the present project (%):

Total rate of thesis supervision in ongoing theses (supervisions and co-supervisions) (%):

Number of current thesis supervisions/co-supervisions:

International partner (if Cotutelle thesis) This thesis will be done in international co-direction between ECOBIO and CAAS (China)

Surname, first name:

Position:

Employer:

Rate of thesis supervision in the present project (%):

Total rate of thesis supervision in ongoing theses (supervisions and co-supervisions) (%):

Number of current thesis supervisions/co-supervisions:

Professional status of previous PhD students supervised by both director and co-supervisors (from 5 years)

Please provide the following information for each PhD students supervised

Surname, first name: TOUGERON Kevin

Date of PhD beginning and PhD defence: 2014-2017

Thesis supervision: Joan van Baaren, Jacques Brodeur (Univ Montréal), Cécile Le Lann

Professional status and location: post-doc Univ Louvain La Neuve (3 years)

Contract profile (post-doc, fixed-term, permanent): post-doc

List of publications from the thesis work:

Tougeron K, van Baaren J, Burel F, Alford L. (2016) Comparing thermal tolerance across contrasting landscapes; first steps towards understanding how landscape management could modify ectotherm thermal tolerance. **Insect Conservation and Diversity** 9 (3): 171-180. doi: 10.1111/icad.12153.

Tougeron K., Le Lann C., Brodeur J. & van Baaren J. 2017. Are aphid parasitoids from mild winter climates losing their winter diapause? **Oecologia** **183**:(3), 619-629.

Tougeron K, Hraoui G, Le Lann C, van Baaren J & Brodeur J. 2017. Competition for hosts induces offspring summer diapause in aphid parasitoids. **Insect Science**, 00, 1–9, DOI 10.1111/1744-7917.12491

Alford L, Tougeron K, Pierre JS, Burel F, van Baaren J. 2018. The effect of landscape complexity and microclimate on the thermal tolerance of a pest insect. **Insect Science** **25** (5): 905-915. DOI

10.1111/1744-7917.12460

Tougeron K, van Baaren J, Brodeur J, Llopis S, Ridet A, & Le Lann C. 2018. Disentangling plasticity from local adaptations in diapause expression of parasitoids from and within contrasted thermal environments. **Biological Journal of the Linnean Society** 124(4): 756-764. DOI:

10.1093/biolinnean/bly079

Tougeron K, Damien M, Le Lann C, Brodeur J & van Baaren J. 2018. Changes in host-parasitoid communities over the years in cereal crops of Western France: Does climate warming matters? **Frontiers in Ecology and Evolution-Population and Evolutionary Dynamics**”. 6:173. doi: 10.3389/fevo.2018.00173

Tougeron K, Le Lann C, & van Baaren J., Brodeur J. 2019. Diapause expression in a Quebec population of the parasitoid *Aphidius ervi* (Hymenoptera: Braconidae). **The Canadian Entomologist** 151: 345–349.

Tougeron K., Brodeur J., van Baaren J., Renault D. and Le Lann C. 2019. Sex makes them sleepy: host reproductive status induces diapause in a parasitoid population experiencing harsh winters. bioRxiv 371385, ver. 6 peer-reviewed and recommended by **PCI Ecology**. doi: **10.1101/371385**

Tougeron K, Brodeur J, Le Lann C, van Baaren J. 2019. How climate changes affect parasitoids' seasonal ecology? **Ecological Entomology** **45**, 167-181. DOI: 10.1111/een.12792

van Baaren J., Wist T, Soroka J, Tougeron K. 2020. Host-parasitoids network in extreme conditions: the case of cereal aphids in wheat crops in Saskatchewan, Canada. **Entomologia generalis** 40 (1): 63-77.

[10.1127/entomologia/2019/0807](https://doi.org/10.1127/entomologia/2019/0807). [hal-02530838](https://hal.archives-ouvertes.fr/hal-02530838)

Tougeron K, Devogel M, van Baaren J, Le Lann C, Hance T. 2020. Trans-generational effects on diapause and life-history-traits of an aphid parasitoid. **Journal of Insect Physiology**. **121**. 104001.

<https://doi.org/10.1016/j.jinsphys.2019.104001>

Tougeron K., van Baaren J., Town J., Nordin, D., Dumonceaux T. & Wist T. 2021. Body-color plasticity of the English grain aphid in response to light in both laboratory and field conditions. **Evolutionary Ecology** 35 (1): 163-163 [Oct, 10.1007/s10682-020-10088-4](https://doi.org/10.1007/s10682-020-10088-4), 2020).

Surname, first name: DAMIEN Maxime

Date of PhD beginning and PhD defence: 2015-2018

Thesis supervision: Joan van Baaren, Nicolas Desneux (INRAE Sophia Antipolis), Cécile Le Lann

Professional status and location: post-doc Canada (3 years)

Contract profile (post-doc, fixed-term, permanent): post-doc

List of publications from the thesis work:

Damien M, Le Lann C, Desneux N, Alford L, Al-Hassan D, Georges R, Van Baaren J. 2017. Change in plant phenology during winter increases pest control but not trophic link diversity. **Agriculture Ecosystems and Environment** 247: 418-425

Tougeron K, Damien M, Le Lann C, Brodeur J & van Baaren J. 2018. Changes in host-parasitoid communities over the years in cereal crops of Western France: Does climate warming matters? **Frontiers in Ecology and Evolution-Population and Evolutionary Dynamics** 6:173.
doi: 10.3389/fevo.2018.00173

Damien M, Barascou L, Ridel A, Van Baaren J, Le Lann C 2019. Food or host: do physiological state and flower type affect foraging decisions of parasitoids? **Behavioral Ecology and Sociobiology** 73:156.
<https://doi.org/10.1007/s00265-019-2758-9>

Damien M, Llopis S, Desneux N, Van Baaren J and Le Lann C. 2020. How does floral nectar quality affect life history strategies in parasitic wasps. **Entomologia generalis** 40(2): 147 – 156. ArtNo. ESP146004002003 DOI: 10.1127/entomologia/2020/0906

Surname, first name: JEAUVONS Emma

Date of PhD beginning and PhD defence: 2017-2020

Thesis supervision: Joan van Baaren, Cécile Le Lann, Anne Le Ralec

Professional status and location: research of post-doc

Contract profile (post-doc, fixed-term, permanent):

List of publications from the thesis work:

Jeavons E, van Baaren J, Le Lann C. 2020. Resource partitioning among a pollinator guild: 1 a case study of flower monocultures under high honeybee pressure. **Acta Oecologia** 104. 103527.
<https://doi.org/10.1016/j.actao.2020.103527>.

Jeavons E, van Baaren J, Le Ralec A, Bucharde C, Duval F, Llopis S, Postic E, Le Lann C. When resource diversification fails to enhance cereal aphid control: intraguild competition and predation matters. Resoumis apres correction J Applied Ecology.

+ 3 publications en préparation (à soumettre avant fin avril 2021)

Surname, first name: ZHU Liang

Date of PhD beginning and PhD defence: 2016-2019

Thesis supervision: Chun-Sen Ma

Professional status and location: post-doc China (2 years)

Contract profile (post-doc, fixed-term, permanent): post-doc

List of publications from the thesis work:

Zhu L, Hoffmann A, Li SM, Ma CS. 2021. Extreme climate shifts pest dominance hierarchy through thermal evolution and transgenerational plasticity. **Functional Ecology**, (in press) <https://doi.org/10.1111/1365-2435.13774>

Zhu L, Wang L, Ma CS. 2019. Sporadic short temperature events cannot be neglected in predicting impacts of climate change on small insects. **Journal of Insect Physiology**, 112: 48–56.

Five main recent publications of the supervisors on thesis subject:

Zhu L, Hoffmann A, Li SM, Ma CS. 2021. Extreme climate shifts pest dominance hierarchy through thermal evolution and transgenerational plasticity. **Functional Ecology**, (in press) <https://doi.org/10.1111/1365-2435.13774>

Ma CS, Ma G, Pincebourde S. 2021. Survive a Warming Climate: Insect Responses to Extreme High Temperatures. **Annual Review of Entomology**, 66: 163–184. <https://doi.org/10.1146/annurev-ento-041520-074454>

Le Lann C, van Baaren J & Visser B. Dealing with predictable and unpredictable temperatures in a climate change context: the case of parasitoids and their hosts 2021 **Journal of Experimental Biology** 224 Issue: Pt Suppl 1

Alford L, Louâpre P, Mougél F, van Baaren J. 2020. Measuring the evolutionary potential of a diapause-avoiding parasitic wasp to climate change. **Oecologia** 194 (1-2) 41-50. Springer Verlag, 2020, [10.1007/s00442-020-04761-2](https://doi.org/10.1007/s00442-020-04761-2). [hal-02959770](https://hal.archives-ouvertes.fr/hal-02959770).

Zhao F, Xing K, Hoffmann A, Ma CS. 2019. The importance of timing of heat events for predicting the dynamics of aphid pest populations. *Pest Management Science*, 75(7): 1866–1874.

Zhu Liang, Wang Lin, Ma Chun-Sen. 2019. Sporadic short temperature events cannot be neglected in predicting impacts of climate change on small insects. *Journal of Insect Physiology*, 112: 48–56.

Bai CM, Ma, G*, Cai WZ and Ma CS* 2019. Independent and combined effects of daytime heat stress and night-time recovery determine thermal performance. *Biology Open* 8: bio038141. doi:10.1242/bio.038141

Ortiz-Martínez S., Pierre J.S., Van Baaren J., Le Lann C., Zepeda-Paulo F., Lavandero B. 2019. Interspecific competition among aphid parasitoids: molecular approaches reveal preferential exploitation of parasitized hosts. **Scientific Reports** 9(1): 19641-19641. <https://doi.org/10.1038/s41598-019-56187-3>

Kishani Farahani H, Moghadassi Y, Alford L, van Baaren J. 2019. Effect of interference and exploitive competition on associative learning by a parasitoid wasp: a mechanism for IFD? **Animal Behaviour** 151: 157:163. <https://doi.org/10.1016/j.anbehav.2019.03.017>

Mathé-Hubert H, Kremmer L, Colinet D, Gatti JL, Van Baaren J, Delava E and Poirié M. 2019. Variation in the venom of parasitic wasps, drift or selection? Insights from a multivariate QST analysis. **Frontiers in Ecology and Evolution-Chemical Ecology**. doi: 10.3389/fevo.2019.00156

van Baaren J and Candolin U. 2018. Plasticity in a changing world: Behavioural responses to human perturbations. **Current Opinion in Insect Science**. Article sur invitation pour la section Behavioural Ecology 2018 éditée par Eric Wajnberg et Emmanuel Desouhant. <https://doi.org/10.1016/j.cois.2018.02.003>

Ma CS, Wang L, Zhang W, Rudolf V. 2018. Resolving biological impacts of multiple heat waves: interaction of hot and recovery days. *Oikos*, 127: 622–633. <https://doi.org/10.1111/oik.04699>

Ma G, Bai CM, Wang XJ, Majeed MZ, Ma CS. 2018. Behavioural thermoregulation alters microhabitat utilization and demographic rates in ectothermic invertebrates. *Animal Behaviour*, 142: 49-57. <https://doi.org/10.1016/j.anbehav.2018.06.003>

Alford L, Tougeron K, Pierre JS, Burel F, van Baaren J. 2018. The effect of landscape complexity and microclimate on the thermal tolerance of a pest insect. **Insect Science** 25 (5): 905-915. DOI 10.1111/1744-7917.12460

Cebolla R, Urbaneja A, van Baaren J, Tena A. 2018. Negative effect of global warming on biological control is mitigated by direct competition between sympatric parasitoids. **Biological Control** 122: 60-66. <https://doi.org/10.1016/j.biocontrol.2018.04.006>

Outreman Y, Andrade TO, Krespi L, Violle Cyrille, van Baaren J. 2017. Factors driving life-history traits in a community of aphid parasitoids: environmental filtering and niche partitioning. **Funct Ecol** 247: 418-425. DOI: 10.1111/1365-2435.13007

Alford L, Kishani Farahani H, Pierre JS, Burel F, van Baaren J. 2017. Why is there no impact of the host species on the physiological thermal tolerance of a generalist parasitoid? **Journal of Insect Physiol** 103: 71-77 <http://dx.doi.org/10.1016/j.jinsphys.2017.10.008>

Kishani Farahani H., Ashouri A., Zibae A., Abroon P., Alford L., Pierre JS, van Baaren J. 2017. Early life nutritional quality effects on adult memory retention in a parasitic wasp. **Behavioural Ecology**. 28 (3): 818-826

THESIS FUNDING

Origin(s) of the thesis funding: Institute of Plant Protection CAAS (China)
Gross monthly salary: 1300 euros per month the 18 months that will be spent in France (grant)
Thesis funding state : Acquired
Funding beginning date/Funding ending date: October 2021

Date: 24/03/2021

Name, signature of unit director: Julien Pétilon



Julien PÉTILLON
Directeur adjoint de l'UMR ECOBIO

Name, signature of team director:

Name, signature of thesis project director: Joan van Baaren and Ma Chunsen

