Campagne 2020 Contrats Doctoraux Instituts/Initiatives

Proposition de Projet de Recherche Doctoral (PRD)

Appel à projet ISVI - Intitiative Sces du vivant ses interfaces 2020

Intitulé du Projet de Recherche Doctoral : Test of the "flexible stem hypothesis" in drosophilids

Directeur de Thèse porteur du projet (titulaire d'une HDR) :

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Unité de Recherche :
Intitulé : Laboratoire de Biologie du Développement
Code *(ex. UMR xxxx)* : UMR7622

Ecole Doctorale de rattachement de l'équipe & d'inscription du doctorant : **ED515-Complexité du Vivant**

Doctorants actuellement encadrés par le directeur de thèse (préciser le nombre de doctorants, leur année de 1ere inscription et la quotité d'encadrement) : 0

Co-encadrant :

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Unité de Recherche :
Intitulé : Laboratoire Evolution, Génomes, Comportement et Ecologie
Code *(ex. UMR xxxx)* : UMR9191

Ecole Doctorale de rattachement : **Choisissez un élément :** Ou si ED non Alliance SU : **ED577 - SDSV**

Doctorants actuellement encadrés par le co-directeur de thèse (préciser le nombre de doctorants, leur année de 1ere inscription et la quotité d'encadrement) : 1, 2019, 100%

Cotutelle internationale : ☒ Non ☐ Oui, précisez Pays et Université :

Description du projet de recherche doctoral *(en français ou en anglais)*

3 pages maximum – interligne simple – Ce texte sera diffusé en ligne

Détailler le contexte, l'objectif scientifique, la justification de l'approche scientifique ainsi que l'adéquation à l'initiative/l'Institut.
Le cas échéant, préciser le rôle de chaque encadrant ainsi que les compétences scientifiques apportées. Indiquer les publications/productions des encadrants en lien avec le projet.
Préciser le profil d'étudiant(e) recherché.

Summary
Phenotypic plasticity describes the property of a given genotype to produce distinct phenotypes in response to distinct environmental conditions. It is widely observed in the wild and is thought to facilitate evolution. In particular, it was proposed that ancestral plasticity could lead to the emergence of robust and distinct phenotypes, a process called the "*flexible stem hypothesis*". It is known that plasticity can evolve, but the flexible stem hypothesis needs to be tested in a phylogenetic framework. The project aims at testing it using abdominal pigmentation in drosophilids, a highly evolvable trait showing phenotypic plasticity in some species (temperature sensitivity).

Main question

Phenotypic plasticity describes « *the property of a given genotype to produce different phenotypes in response to distinct environmental conditions* ». It has major implications in medicine, animal husbandry or agronomy, but has often been neglected in developmental biology laboratories were standardized environmental conditions are commonly used to focus on genetic factors. However, phenotypic plasticity is widely observed in the wild and is often an adaptation to fluctuating environmental conditions such as seasonal variations. Phenotypic plasticity is thought to facilitate evolution. Indeed, it was proposed, under the "*flexible stem hypothesis*", that, in some cases, an ancestral plastic species could be at the origin of daughter species with divergent and robust phenotypes obtained by the genetic assimilation of the alternative morphs present in this ancestral species (West-Eberhard 2003 *Developmental Plasticity*, Sinauer). Several empirical examples have shown that phenotypic plasticity can evolve and support these modes of evolution but analyses of a wide range of taxa within a well-defined phylogenetic context remains lacking [P1].

The model

Abdominal pigmentation in drosophilid flies represents an interesting model to test the flexible stem hypothesis and analyse how plasticity evolves. Drosophilidae abdominal pigmentation evolves rapidly [C1] and its underlying genetic basis of melanin synthesis is well characterized. Furthermore, this trait is temperature sensitive in several drosophilid species, flies being darker when they develop at low temperature. The analysis of abdominal pigmentation thermal plasticity in the model species *Drosophila melanogaster* showed that temperature modulates the expression of the pigmentation enzyme coding genes *tan*, *yellow* and *Ddc* in abdominal epidermis [P2, P3]. This is at least partly the consequence of temperature sensitive expression of *bab* genes encoding transcription factors that repress them [P4], but other transcription factors are also likely to be involved according to our unpublished data. In other *Drosophila* species, pigmentation is very weakly plastic and pigmentation variation has essentially pure genetic base [C2, C3]. The phylogeny of Drosophilidae is relatively well known [C4], which is a prerequisite to reconstruct ancestral characters.

Objectives

In this project, the PhD candidate will test the flexible stem hypothesis using abdominal pigmentation in Drosophilidae and dissect the mechanisms of phenotypic plasticity evolution. Phenotypic plasticity of abdominal pigmentation will be characterised in 20 Drosophilidae species with sequenced genomes to construct robust phylogenies. Ancestral characters will be inferred to test whether plasticity is ancestral or derived in particular lineages. Four species will then be chosen, 2 very plastic

(including *D. melanogaster* for which we have already data for comparison), 2 with reduced plasticity to analyse the genetic basis of these differences of plasticity. Transcriptomes of abdominal epidermis from two developmental stages (mid-pupae and young adults) at two temperatures will be analysed by RNAseq to identify genes whose expression is modulated by temperature. We will use these two developmental stages, as genes involved in pigmentation are not all expressed at the same stage. This will allow us to measure the level of transcriptional plasticity of pigmentation enzyme coding genes and transcription factors. Functional tests will be performed in these drosophila species using transgenesis via the piggyBac transposon or Crispr mutagenesis, both efficient in many Drosophilidae species (reporter transgenes for the activity of particular regulatory sequences at particular temperature as we did previously [P2-P4], effect of gain of function and loss of function of a regulatory gene on the expression of a potential target). This will allow reconstructing the gene networks mediating the low or high pigmentation plasticity observed in these species.

Correspondence of the project to the 12LS initiative and its multidisciplinary aspects

This project fits perfectly the initiative 12LS, integrating two of its major objectives, namely "evolution" and "plasticity in response to changing environments". The evolutionary transcriptomic analysis will also help unravelling the "dynamics of biological networks" at the molecular and developmental levels. It links two distinct fields or biology: Developmental molecular genetics and evolution. Jean-Michel Gibert is an expert in the molecular mechanisms of pigmentation development, variation and phenotypic plasticity in the model species *Drosophila melanogaster*. Amir Yassin is an expert in Drosophilidae phylogenetic systematics and evolutionary genomics, with a particular interest in studying pigmentation evolution. Thus their expertise is complementary for this project.

PhD candidate profile

The PhD candidate should have strong interest in developmental and evolutionary biology. He/she should have a good background in genetics. Previous knowledge on Drosophila is not a prerequisite but would be advantageous.

Publications of the PhD supervisors in relation to the project

Jean-Michel Gibert (main supervisor):

P1. Gibert J-M (2017) The flexible stem hypothesis: evidence from genetic data. Dev Genes Evol. 227: 297–307.

P2. Gibert J-M, Mouchel-Vielh E, De Castro S, Peronnet F (2016) Phenotypic Plasticity through Transcriptional Regulation of the Evolutionary Hotspot Gene *tan* in *Drosophila melanogaster*. PLoS Genet. 12: e1006218.

P3. Gibert J-M, Mouchel-Vielh E, Peronnet F (2017) Modulation of *yellow* expression contributes to thermal plasticity of female abdominal pigmentation in *Drosophila melanogaster*. Sci Rep. 7: 43370.

P4. De Castro S, Peronnet F, Gilles J-F, Mouchel-Vielh E, Gibert J-M (2018) *bric à brac* (*bab*), a central player in the gene regulatory network that mediates thermal plasticity of pigmentation in *Drosophila melanogaster*. PLoS Genet. 2018;14: e1007573.

Amir Yassin (co-supervisor):

C1. Al-Sayad, Yassin A (2019) Quantifying the extent of morphological homoplasy: A

phylogenetic analysis of 490 characters in *Drosophila*. *Evol. Letters* 3:286-298.
C2. Yassin A, Bastide H, Chung H, Veuille M, David JR, Pool JE (2016) Ancient balancing selection at *tan* underlies female colour dimorphism in *Drosophila erecta*. Nat Commun. 7: 10400.
C3. Yassin A*, Delaney EK*, Reddiex AJ, Seher TD, Bastide H, Appleton NC, et al. (2016) The *pdm3* Locus Is a Hotspot for Recurrent Evolution of Female-Limited Color Dimorphism in *Drosophila*. Curr Biol. 26: 2412–2422 (*equal contributions).
C4. Yassin A (2013) Phylogenetic classification of the Drosophilidae Rondani (Diptera): the role of morphology in the postgenomic era. Syst Entomol. 38: 349–364.