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**Evolutionary and functional studies of the variability of
reproductive modes in the poplar rust fungus,
*Melampsora larici-populina***

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Evolutionary and functional studies of the variability of reproductive modes in the poplar rust fungus, *Melampsora larici-populina*



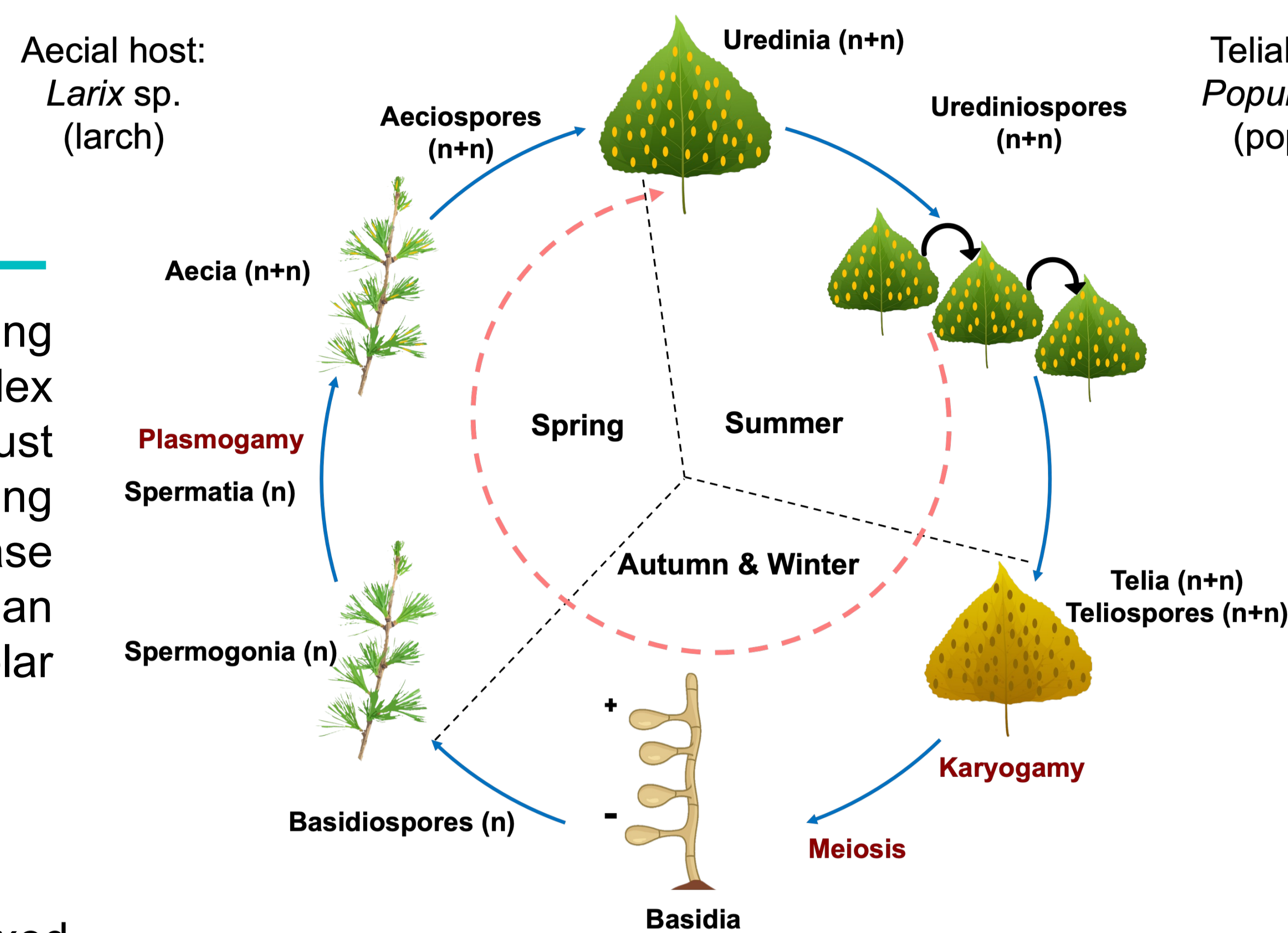
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Context

Melampsora larici-populina, causing poplar rust exhibits a complex heteroecious life cycle, typical of rust fungi (Pucciniales), alternating between a sexual reproduction phase on larch trees (*Larix* sp.) and an asexual multiplication phase on poplar trees (*Populus* sp.).

Previous population genetic study provided evidence for mixed reproductive mode, with a genetic group that shows hallmarks of long lasting asexual reproduction (Xhaard et al., 2011).



The *Melampsora larici-populina* life cycle

This alternation of sexual and asexual reproduction exhibits some similarities with the cyclical parthenogenesis of aphids and daphnia.

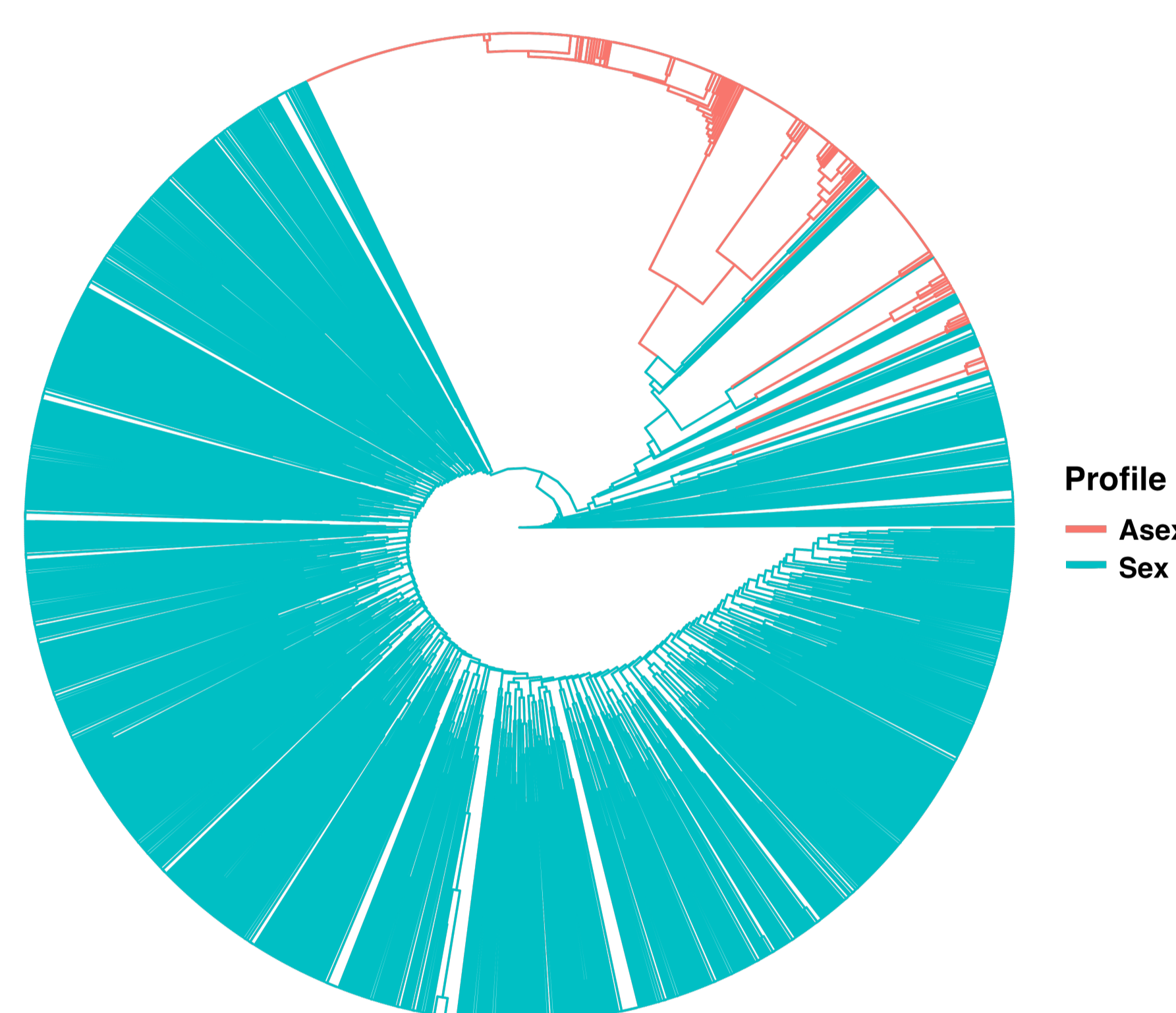
My PhD project proposes to address the issue of variability in reproductive modes and the survival through years of asexual lineages. along **three complementary axes**:

Axis 1: Evolutionary ecology

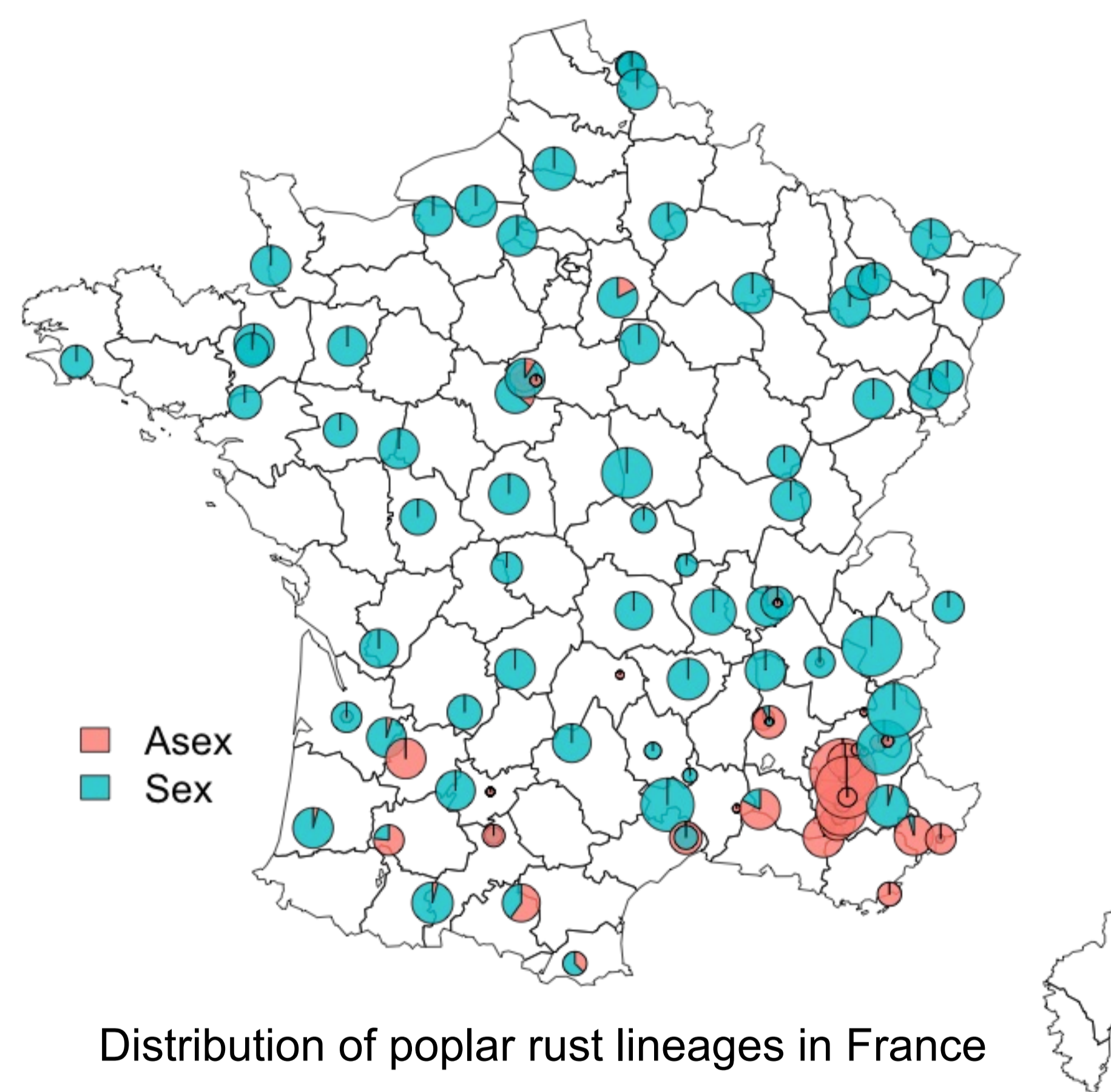
This approach will allow us to determine the geographical distribution of the asexual lineages of *M. larici-populina* using population genetics.

Table 2. Details of asexual lineages

MLL	Isolate No.	MLG No.	Year range
1	255	41	1992:2020
2	23	8	1996:2020
3	43	5	1996:2011
4	38	14	1996:2020
5	13	5	1993:2014
6	49	4	2014:2020
7	14	3	2009:2011



Neighbor Joining tree (SSR data)



Distribution of poplar rust lineages in France

Results

Sexually reproducing lineages are common throughout France, while asexual lineages are more prevalent in southern France. This difference may be influenced by various environmental and/or ecological factors, such as milder winters.

Table 1. Population genetic characteristics

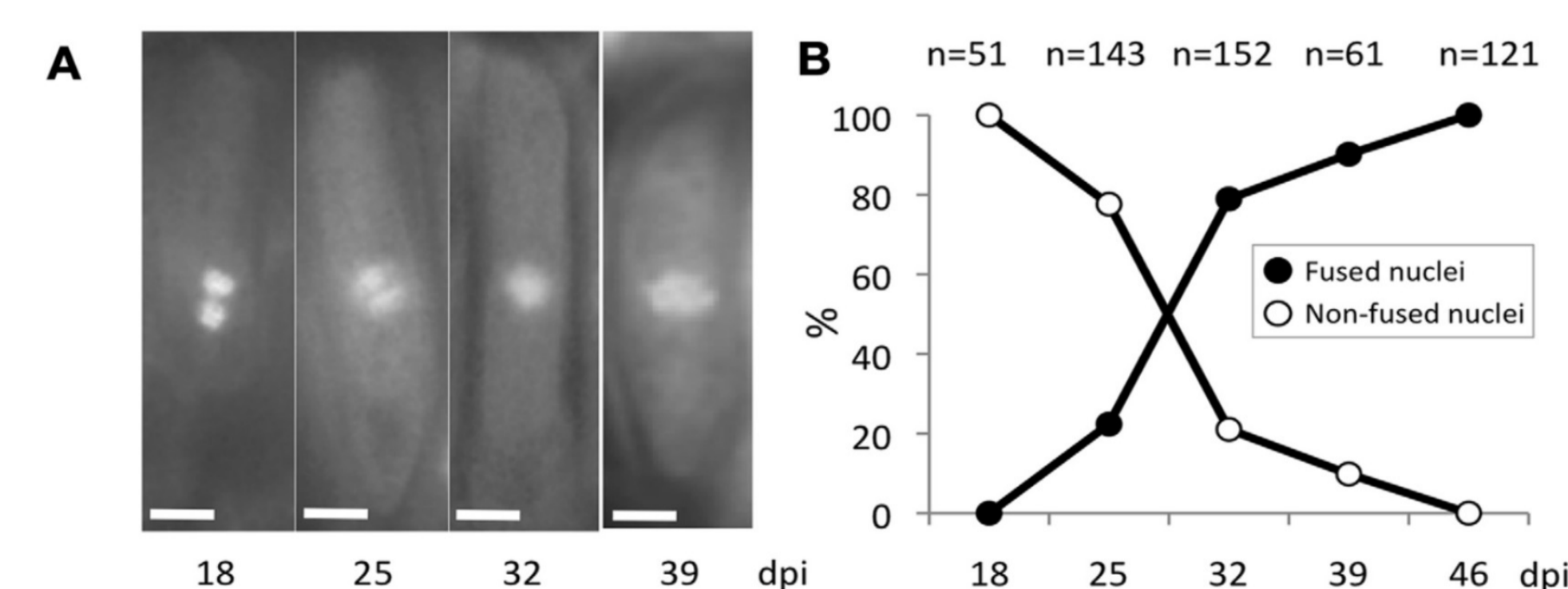
	N	G/N	Ar	Fis	(sd)	rbarD
Asex	438	0.185	4.390	-0.361	0.374	0.361
Sex	1307	0.886	8.771	0.092	0.111	0.018

Axis 2: Evolutionary transcriptomic

This approach that will aim to elucidate the functional basis of the cycle and to find the determinants of sexual vs. asexual reproductive modes.

Axis 3: Phenotypic

To evaluate whether asexual lineages can undergo karyogamy in teliospores similar to sexual lineages, using DAPI staining and a fluorescence microscope



(A) DAPI-stained teliospores nuclei during telia formation, (B) Dynamics of karyogamy. (Hacquard et al., 2013).

Conclusion and perspectives

- The existence of long lasting asexual lineages, largely found in southern France, was validated using a population genetic analysis: some of asexual lineages were repeatedly sampled across a time period of 30 years.
- Overall, this thesis aims to contribute to our understanding of the complexity of reproductive mode variability in *M. larici-populina* and how it affects the evolution and adaptation of this important phytopathogenic fungus.

References

- Xhaard, C., Fabre, B., Andrieux, A., Gladioux, P., Barrès, B., Frey, P., & Halkett, F. (2011). The genetic structure of the plant pathogenic fungus *Melampsora larici-populina* on its wild host is extensively impacted by host domestication. *Molecular Ecology*, 20(13), 2739–2755.
- Hacquard, S., Delaruelle, C., Frey, P., Tisserant, E., Kohler, A., & Duplessis, S. (2013). Transcriptome analysis of poplar rust telia reveals overwintering adaptation and tightly coordinated karyogamy and meiosis processes. *Frontiers in Plant Science*, 4: 456.