

Assessing the potential of germplasm collections for the management of genetic diversity: the case of the French National Cryobank

A part of the PhD's work of Alicia JACQUES

Avec
la contribution
financière du compte
d'affectation spéciale
développement
agricole et rural
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WHAT GENETIC RESOURCES ARE AVAILABLE IN THE CRYOBANK ?

- Cryopreserved resources can potentially be used to manage the genetic diversity of populations

⇒ **OPPORTUNITY VERY RARELY EXPLOITED**

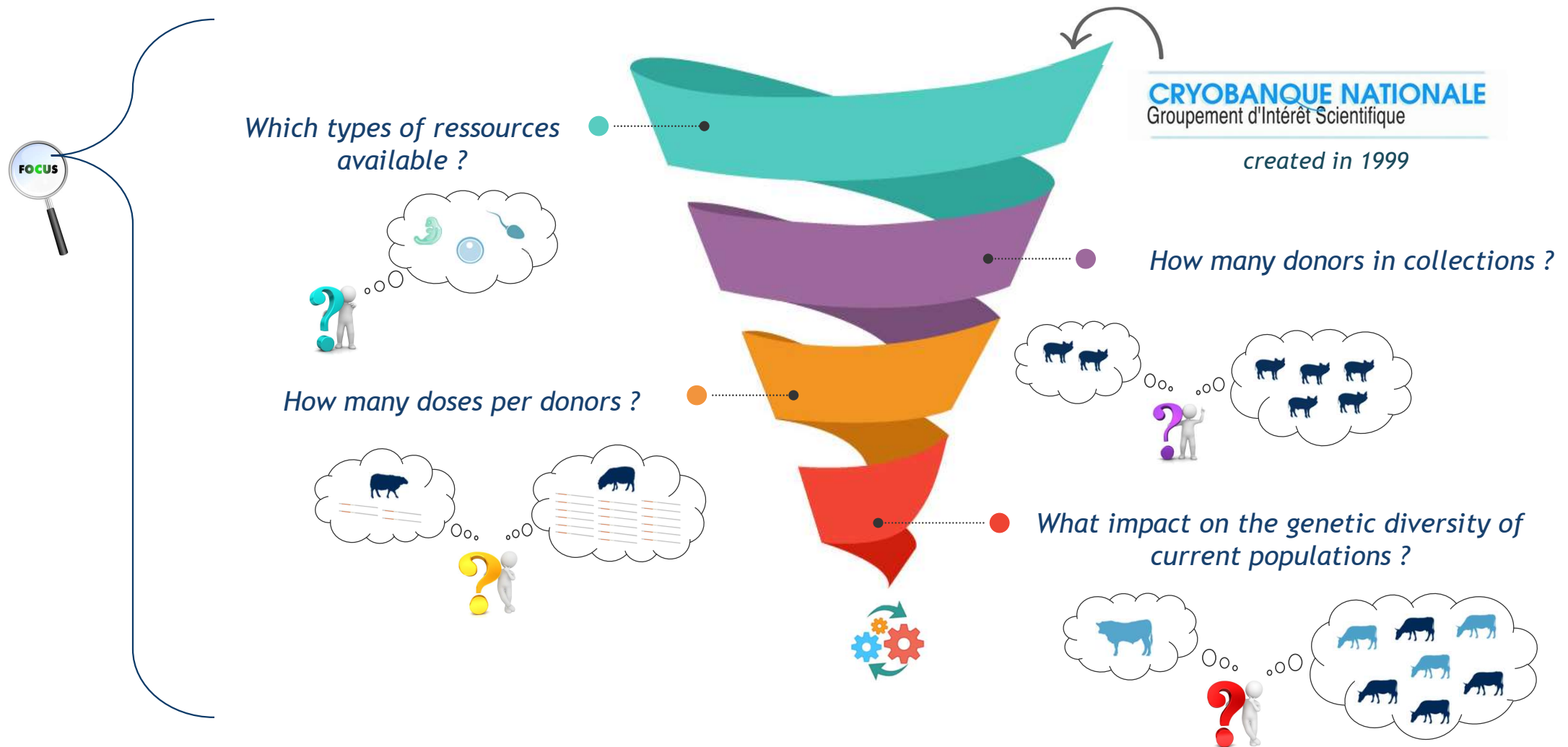
⇒ How to assess the potential of ex situ collections for managing domestic populations ?

OBJECTIVE :

Development of a methodology for characterizing cryopreserved collections at different hierarchical levels (species, breeds, individuals).



WHAT GENETIC RESOURCES ARE AVAILABLE IN THE CRYOBANK ?



WHAT TYPE OF GENETIC RESOURCES ARE AVAILABLE IN THE CRYOBANK ?

SEMEN



Resource most commonly found in collections for many species



Most widespread use in farmed species



7%

93%



➔ Focus on 6 mammal species likely to use frozen semen in breeding programs



21 breeds



48 breeds



10 breeds



2 breeds



19 breeds

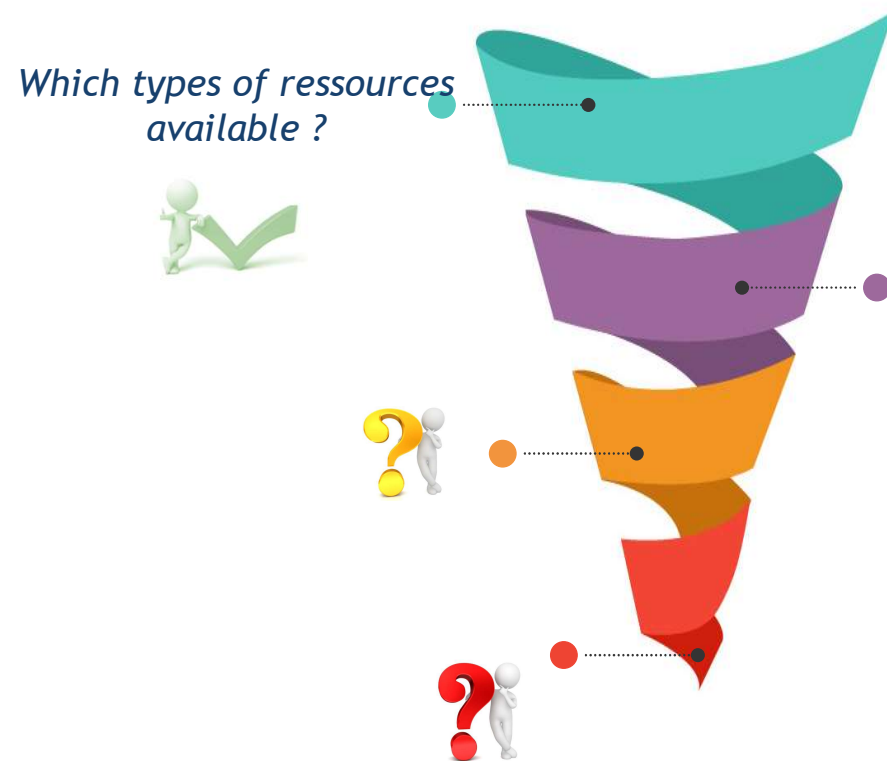


15 breeds / lines

➔ Factors likely to influence collection composition :
Species, Breed use and distribution, Reason for entering collection, Age of donors

WHAT GENETIC RESOURCES ARE AVAILABLE IN THE CRYOBANK ?

NUMBER OF DONORS PER BREED IN COLLECTIONS ?









→ Application of biodiversity indices, adapted to cryopreserved collections

- Number of breeds/lines present in the collection (**R**) without taking into account the relative abundance of each (number of donors)
- Number of donors in collection (**N**) (with semen doses)
- Gini-Simpson index (E): equitability index that measures the probability that two individuals drawn at random from collections of the same species belong to different breeds.

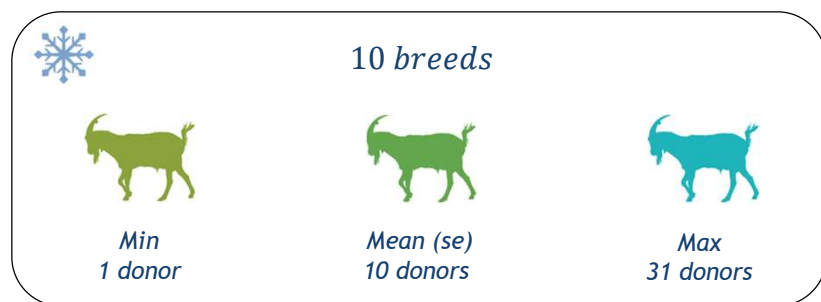
$$E = 1 - \sum_{breed=1}^R (n_{breed}/N)^2 \quad \text{with} \quad \begin{array}{l} n_{breed} = \text{nb of donors of the breed} \\ N = \text{total nb of donors of the specie} \end{array}$$

HOW BREEDS ARE DISTRIBUTED IN THE COLLECTIONS ?

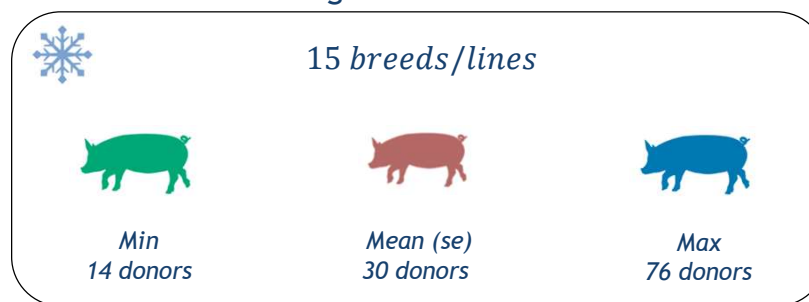
Collections considered	Cattle 	Sheep 	Goat 	Pig 	Horse 	Donkey 
Number of officially recognized breeds	54	59	14	39	54	8
Number of breeds/lines in collections (R)	21	48	10	15	19	2
Total number of donors	977	1177	98	451	175	10
Gini-Simpson index (E)	0.87	0.91	0.83	0.91	0.82	0.18
E_equipartition Maximum possible : 1-(1/R)	0.95	0.98	0.90	0.93	0.95	0.5
Ratio E/E_épartition	91.7 %	93.1 %	91.8 %	97.8 %	86.5 %	36.0 %

→ *Some examples:*

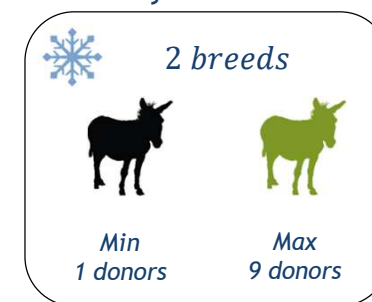
Goat collections



Pig collections



Donkeys collections



WHAT INTRA-BREED DIVERSITY IS AVAILABLE ?

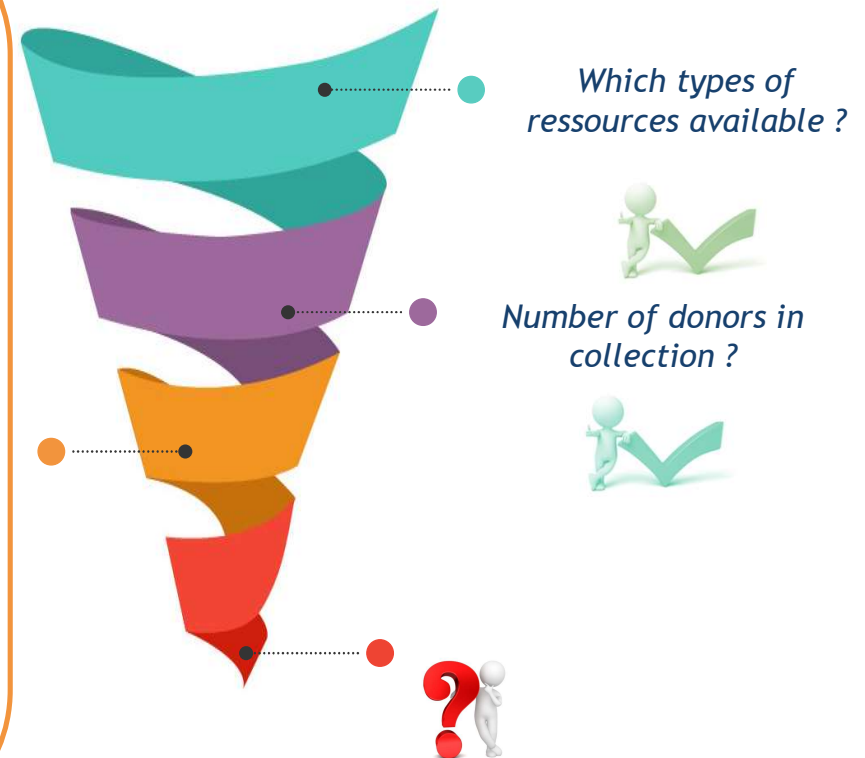
NUMBER OF DOSES PER DONOR IN COLLECTION ?

→ Setting up the **number of effective donors (De)** in collections

→ an indicator linked to the distribution of the number of standard doses among donors within a breed

$$De = \frac{1}{\sum_{i=1}^{Nb\ donors} (Nb\ doses_i / Nb\ doses\ tot)^2}$$

→ Represents the number of donors in a collection if all donors had the same number of doses



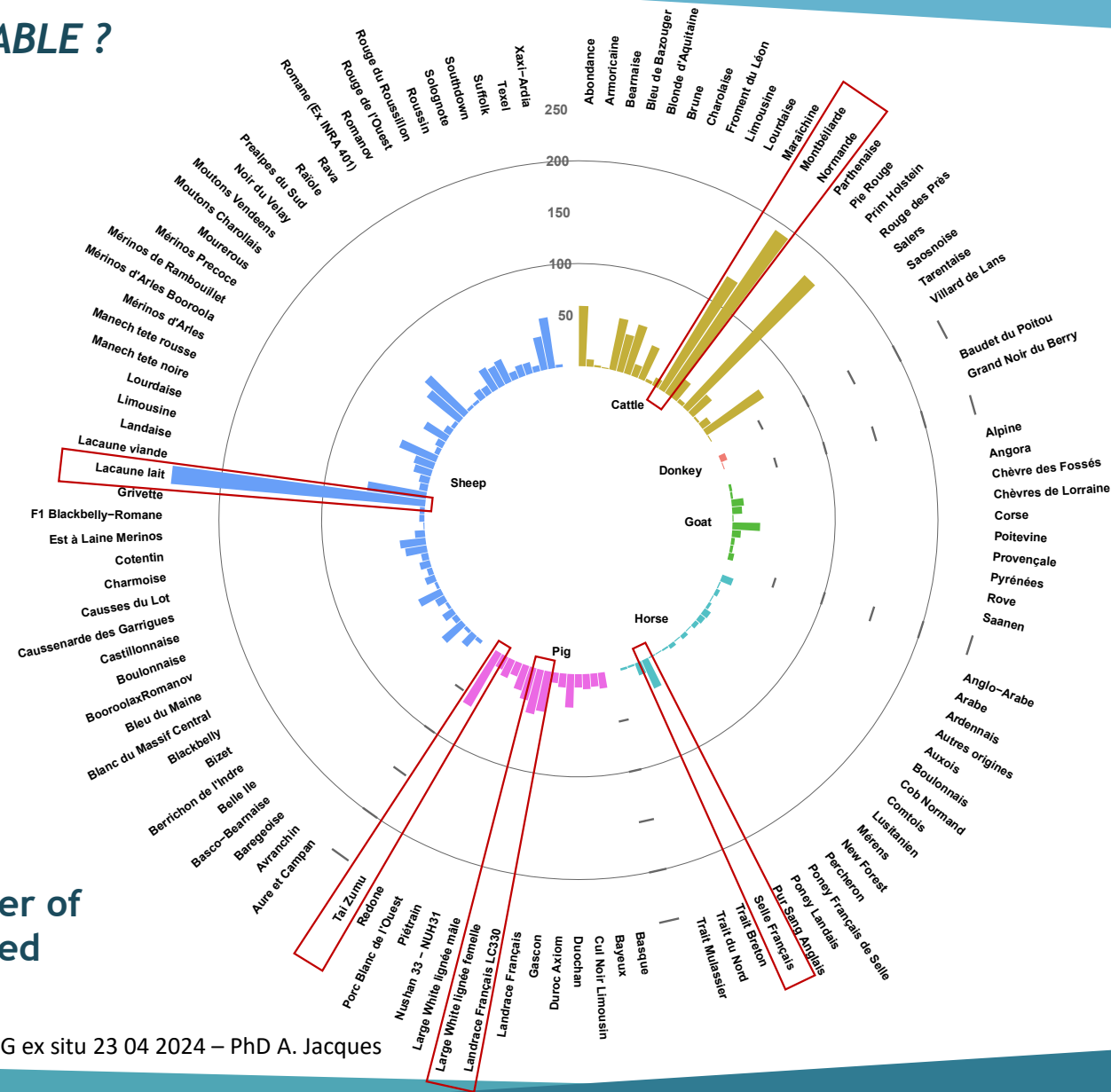
WHAT INTRA-BREED DIVERSITY IS AVAILABLE ?

- Calculating the number of effective donors in a breed

$$De = \frac{1}{\sum_{i=1}^{Nb\ donors} (Nb\ doses_i / Nb\ doses\ tot)^2}$$

→ Represents the number of donors in a collection if all donors were represented by the same number of doses.

→ Collections with a highly variable number of effective donors, depending on the breed









WHAT GENETIC RESOURCES ARE AVAILABLE IN THE CRYOBANK ?

- Calculating the number of effective donors in a breed

→ Represents the number of donors in a collection if all donors were represented by the same number of doses.

- Ratio of the number of effective donors De to the total number of donors in a collection

$$\frac{De}{\text{Number of donors in the collection}}$$

Breed	Nb donors (N)	Total nb doses	De	De/N	Mean nb [Min – Max] doses/donor
 Alpine	6	356	2.5	42 %	59 [8 – 200]
 Trait mulassier	5	632	2.3	46 %	126 [18 – 394]
 Cul noir Limousin	27	1227	16.9	63 %	26 [1 – 50]
 Froment du Léon	12	2300	12	100 %	192 [190 – 200]
 Baudet du Poitou	9	820	6.6	73 %	91 [9 – 201]
 Vendéen	69	6209	51.2	74 %	90 [15 – 228]

→ The number of doses per donor is very balanced in some breeds BUT very unbalanced in others.

WHAT GENETIC RESOURCES ARE AVAILABLE IN THE CRYOBANK ?

Which types of
ressources available ?



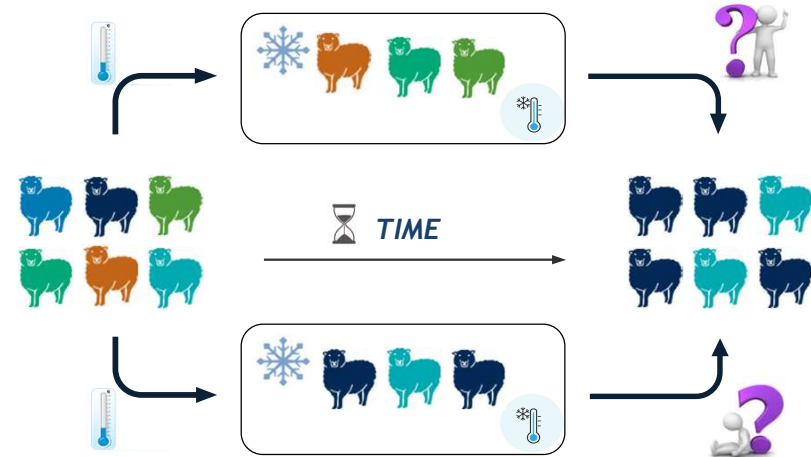
Number of doses per donor ?



Number of donors in collection ?



What impact on the genetic diversity of current
populations ?



IDI, A NEW INDEX BASED ON KINSHIP COEFFICIENTS

→ **CALCULATION of IDI (Index of Diversity Impact) :**

$$IDI = \frac{\overline{\phi_{cryo-F}} - \overline{\phi_{M-F}}}{\overline{\phi_{M-F}}}$$

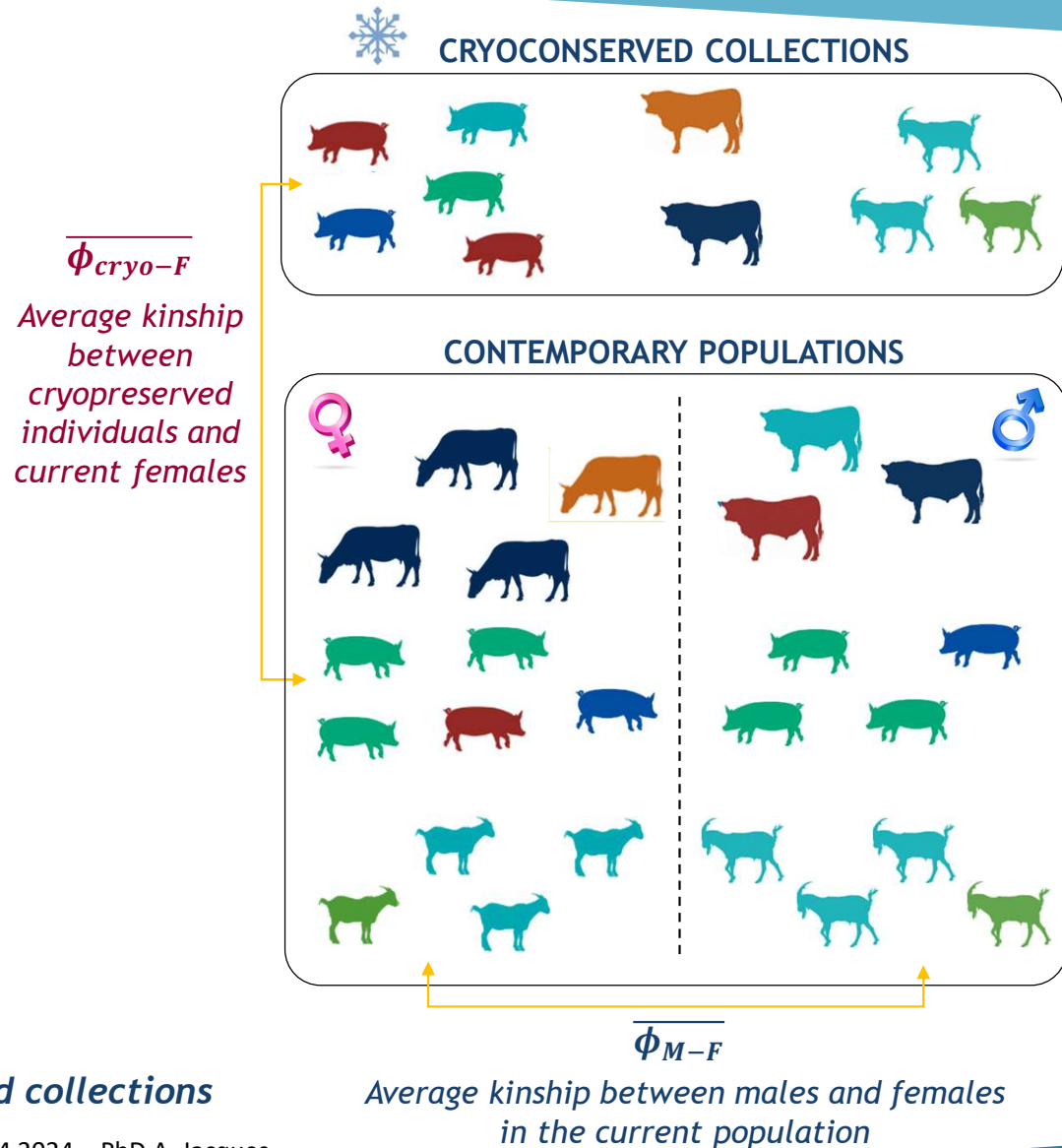
→ **OBJECTIVE :**

- Examine the potential impact on genetic diversity of using cryopreserved males with the contemporary female population







→ **SPECIAL FEATURES :**

- Takes into account the level of diversity between males and females in the current population
- Theoretical index assuming the use of all cryopreserved males or current active males with current females in random matings.

→ **Provides a global view of the value of cryopreserved collections**



EXAMPLE OF IDI VALUES FOR SOME BREEDS

BREED	Cryopreserved individuals (birth year)	Selection intensity	IDI	Commentaries
 FROMENT DU LÉON 534 females 12 active males	12 bulls (1978 - 2006)	—	13.1 %	<ul style="list-style-type: none"> The use of cryopreserved males would increase the average kinship of matings (and therefore inbreeding).
 MANECH TÊTE ROUSSE 104 184 females 616 active males	48 rams (2008 - 2016)	+	0.5 %	<ul style="list-style-type: none"> Overall, the cryobank population is genetically close to the population of contemporary females. Presence in the cryobank of individuals representative of the breed's diversity (recent boars, AI bulls, etc.)
 PIETRAIN 48 503 females 401 active males	14 boars (2016 - 2017)	++	−0.6 %	
 PRIM'HOLSTEIN 5 069 731 females 10 776 active males	190 bulls (1993 - 2013)	++	−12.6 %	<ul style="list-style-type: none"> The use of cryopreserved males would reduce the average kinship of matings (and therefore inbreeding). Overall, the cryobank population is genetically distant from the population of contemporary females. Presence of old individuals in cryobanks
 MOUTON VENDÉEN 33 855 females 306 active males	69 rams (1989 - 2012)	+	−16.3 %	
 CUL NOIR LIMOUSIN 1 367 females 14 active males	27 boars (1981 - 1999)	—	−30.1 %	

TAKE-HOME MESSAGE

→ *PROPOSED FRAMEWORK FOR ANALYZING COLLECTIONS*

- Standardized approach → possible comparison with other collections
- IDI → can be used with pedigree and/or genomic data
→ applicable to breeds with less precise genealogies (local)



→ *ANALYSIS OF THE FRENCH NATIONAL CRYOBANK*

- Numerous species and breeds already in collections, although not exhaustive
- Highly heterogeneous situations in terms of donor and dose distribution
- Importance of factors: breed diffusion and semen biology (freezing)

CRYOBANQUE NATIONALE
Groupement d'Intérêt Scientifique



TO KNOW MORE

CRYOBANQUE NATIONALE
Groupement d'Intérêt Scientifique

Avec la contribution financière du compte d'affectation spéciale développement agricole et rural CASDAR
MINISTÈRE DE L'AGRICULTURE ET DE LA SOUVERAINETÉ ALIMENTAIRE
Label d'Intérêt National

The complete article is available on this link: <https://peercommunityjournal.org/articles/10.24072/pcjournal.369/>

Other articles written by Alicia:

Jacques A, Duclos Delphine, Danchin-Burge Coralie, Mercat Marie-José, Tixier-Boichard Michèle, Restoux G (2023a) Additional Files for “Assessing the potential of germplasm collections for the management of genetic diversity: the case of the French National Cryobank.” <https://doi.org/10.5281/ZENODO.8162989>

Jacques A, Duclos Delphine, Danchin-Burge Coralie, Mercat Marie-José, Tixier-Boichard Michèle, Restoux G (2023b) Data and scripts for “Assessing the potential of germplasm collections for the management Alicia Jacques et al. 21 Peer Community Journal, Vol. 4 (2024), article e13 <https://doi.org/10.24072/pcjournal.369> of genetic diversity: the case of the French National Cryobank.” <https://doi.org/10.5281/ZENODO.8163138>

Jacques A, Leroy G, Rognon X, Verrier E, Tixier-Boichard M, Restoux G (2023) Reintroducing genetic diversity in populations from cryopreserved material: the case of Abondance, a French local dairy cattle breed. Genetics Selection Evolution, 55, 28. <https://doi.org/10.1186/s12711-023-00801-6>



Thank you for your attention