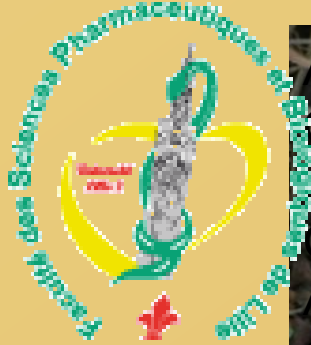


LES MORILLES

De la morphologie à l'ADN, les progrès de la taxinomie



ACGCTCGACGTGCACGACGTGCAGGCAACACGCTC
GACGTGCACGACGTGCAGGCAACCGCTCGACGTGC
ACGACGTGCAGGCAACCGCTCGACGTGCACGAGGT
GCAGGCAACCGCTCGACGTGCACGACGTGCAGGCA
ACCGCTCGACGTGCACGACGTGCAGGCAACGCTCGA
CGTGCACGACGTGCAGGCAACCGCTCGACGTGCA
GACGTGCAGGCAACGCTCGACGTGCACGACGTGC
GGCAAC ACGCTCGACGTGCACGACGTGCAGGCA
ACGCTCGACGTGCACGACGTGCAGGCAACCGCTC
ACGTGACGACGTGCAGGCAACCGCTCGACGTGCA
GACGTGCAGGCAACCGCTCGACGTGCACGACGTG
CAGGCAACCGCTCGACGTGCACGACGTGCAGGCAA
CCGCTCGACGTGCACGACGTGCAGGCAACCGCTCG
ACGTGCACGACGTGCAGGCAACCGCTCGACGTGCA



Pierre-Arthur Moreau, Régis Courtecuisse
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Jean-Michel Bellanger, Franck Richard
CEFE-CNRS
Université Montpellier 1

Lyon, 16 juillet 2015

Question 1. Qu'est-ce qu'une morille ?

Un champignon (**Fungi**) de la division des **Ascomycota**
classe des **Pezizomycetes**

ordre des **Pezizales**

famille des **Morchellaceae**

Formant des apothécies complexes



Disciotis venosa
(pézize veinée)



Verpa conica (verpe)



Mitrophora semilibera
(morillon)



Morchella sp.
(morille)

Question 2. Comment vit une morille ?

Saprotrophes ?

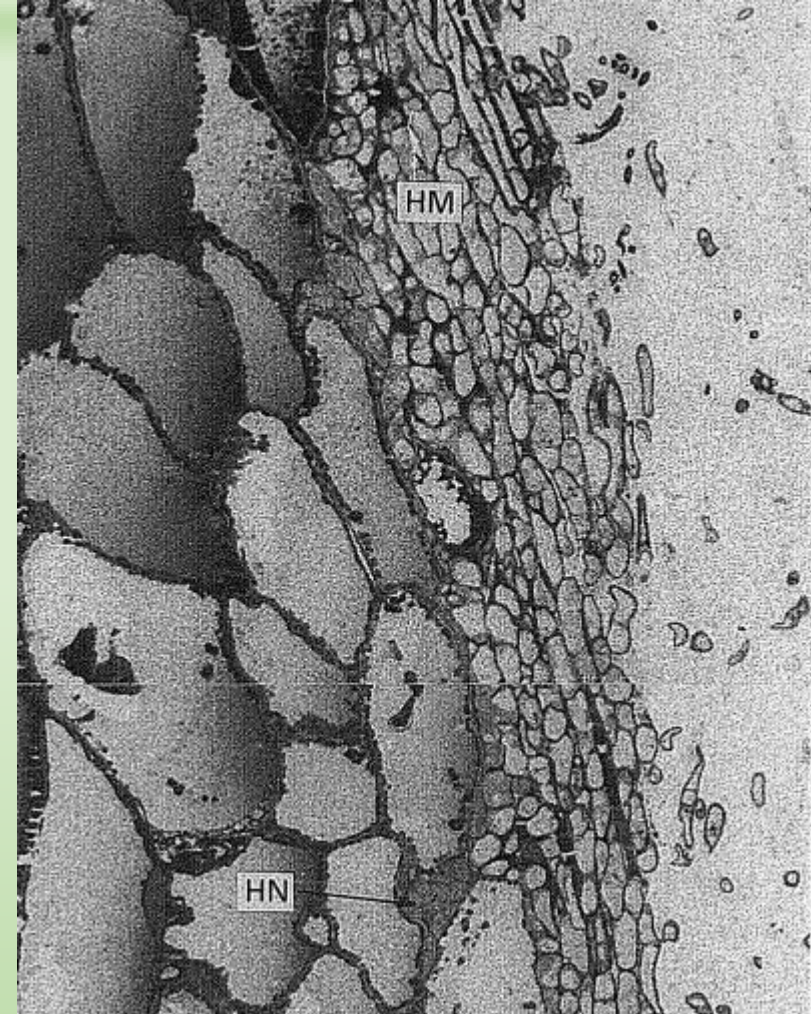
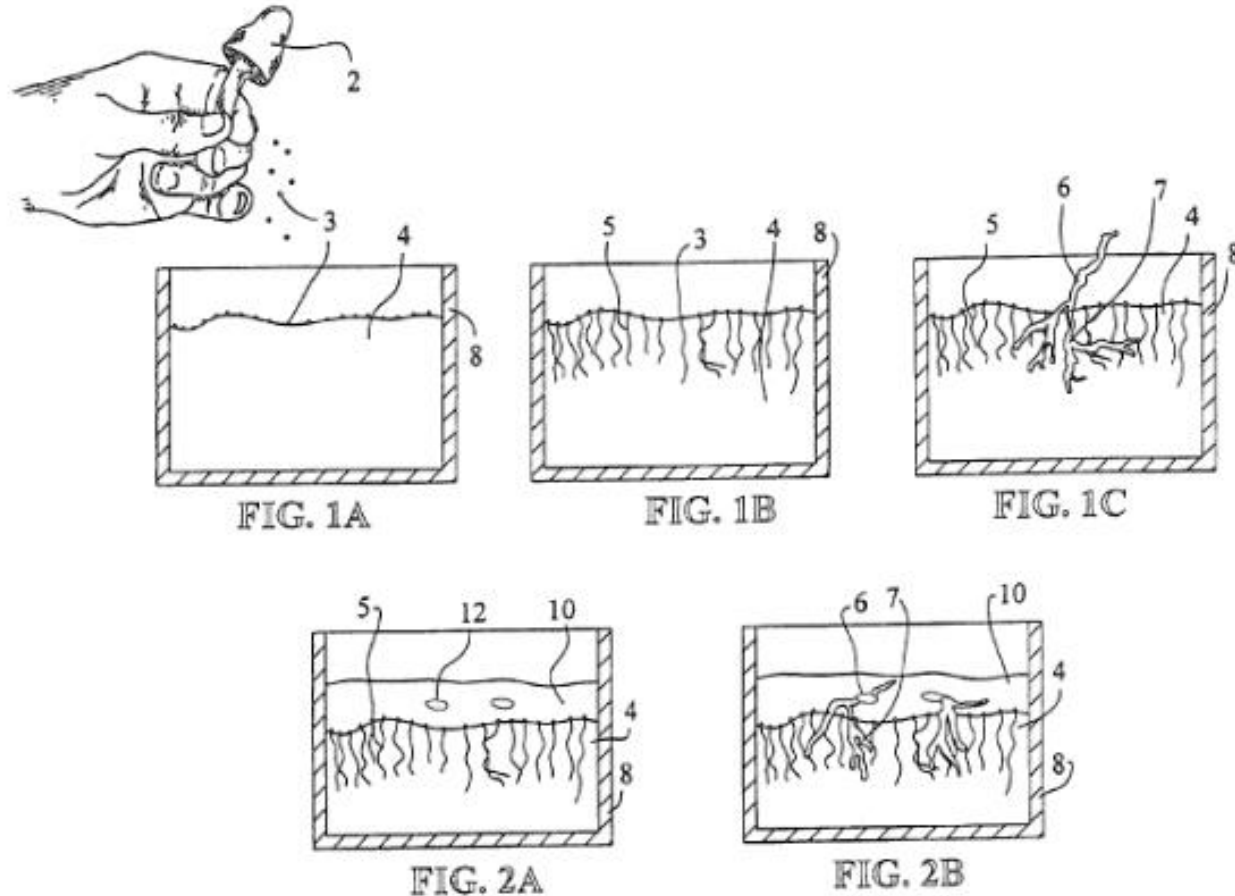


Morchella « elata »



Morchella « crassipes »

Mycorrhiziques ?



Buscot F. & Kotkke I. 1990.

The association of *Morchella rotunda* with roots of *Picea abies*. New Phytol. 116, 425-430

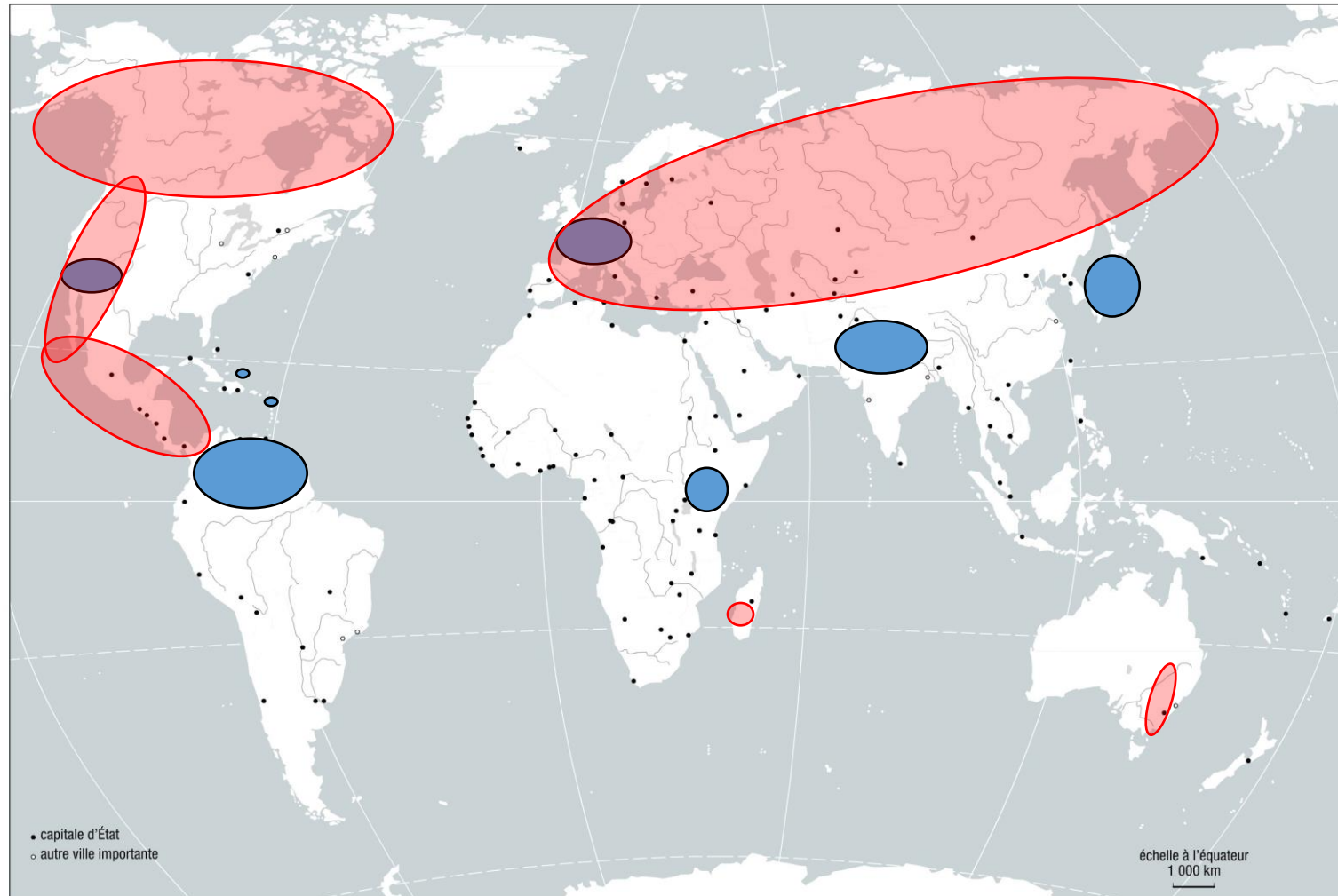
Miller S.C. 2002.

“Cultivation of *Morchella*”. Patent **US 6951074 B2**

Carbonicoles ?



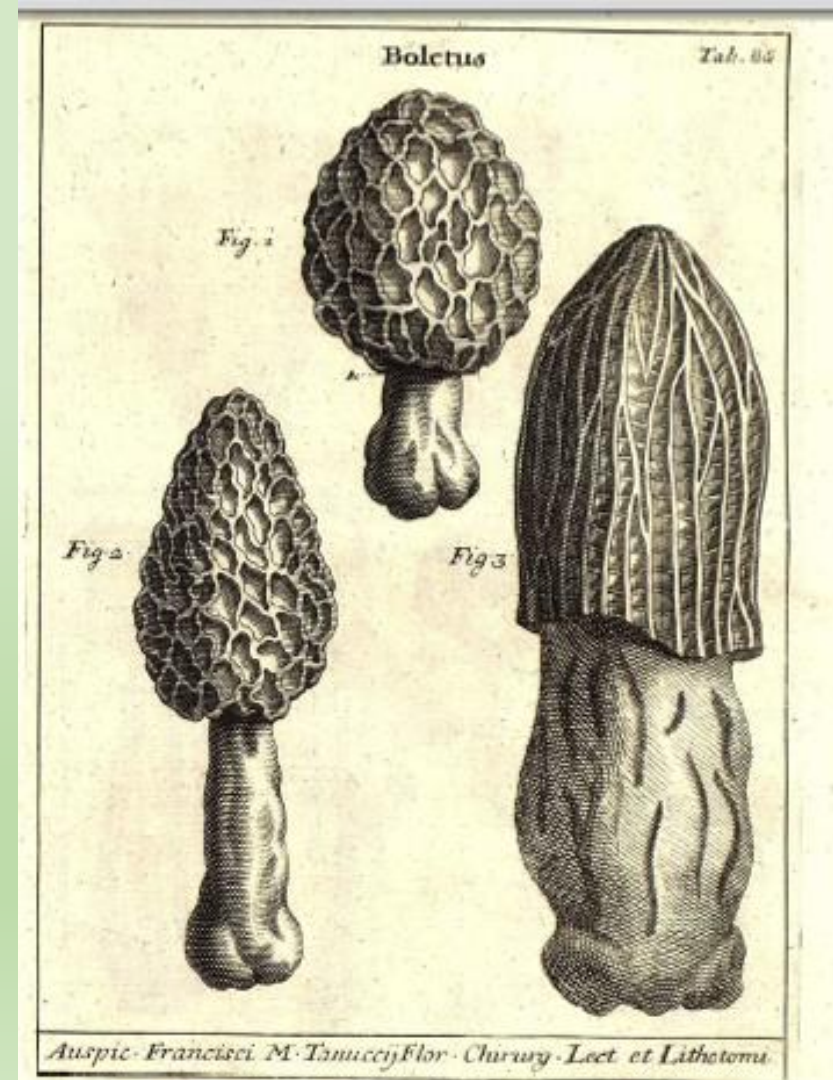
Question 3: où trouve-t-on les morilles ?



Citations de
Morchella crassipes
et
Morchella elata
dans la littérature

Planisphère : fleuves et principales villes

La VRAIE question : combien y a-t-il d'espèces de morilles ?



Les « réducteurs »

Seaver (1932): 3 espèces

Moser (1963): 5 espèces

Dennis (1978): 3 espèces

Breitenbach & Kränzlin (1983):
4 espèces

Clowez (1986): 4 espèces

Les « éclateurs »

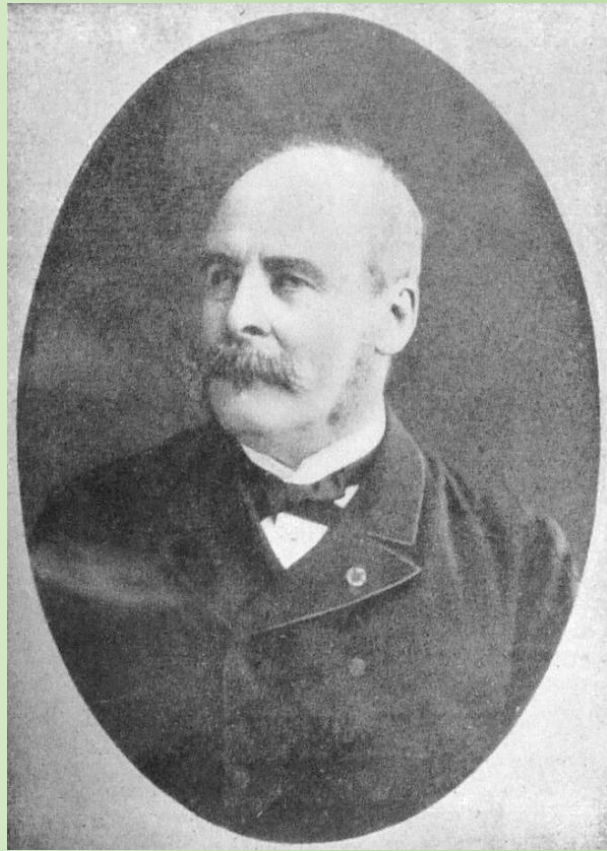
Fries (1823): 8 espèces

Krombholz (1856): 11 espèces

Boudier (1897): 20 espèces

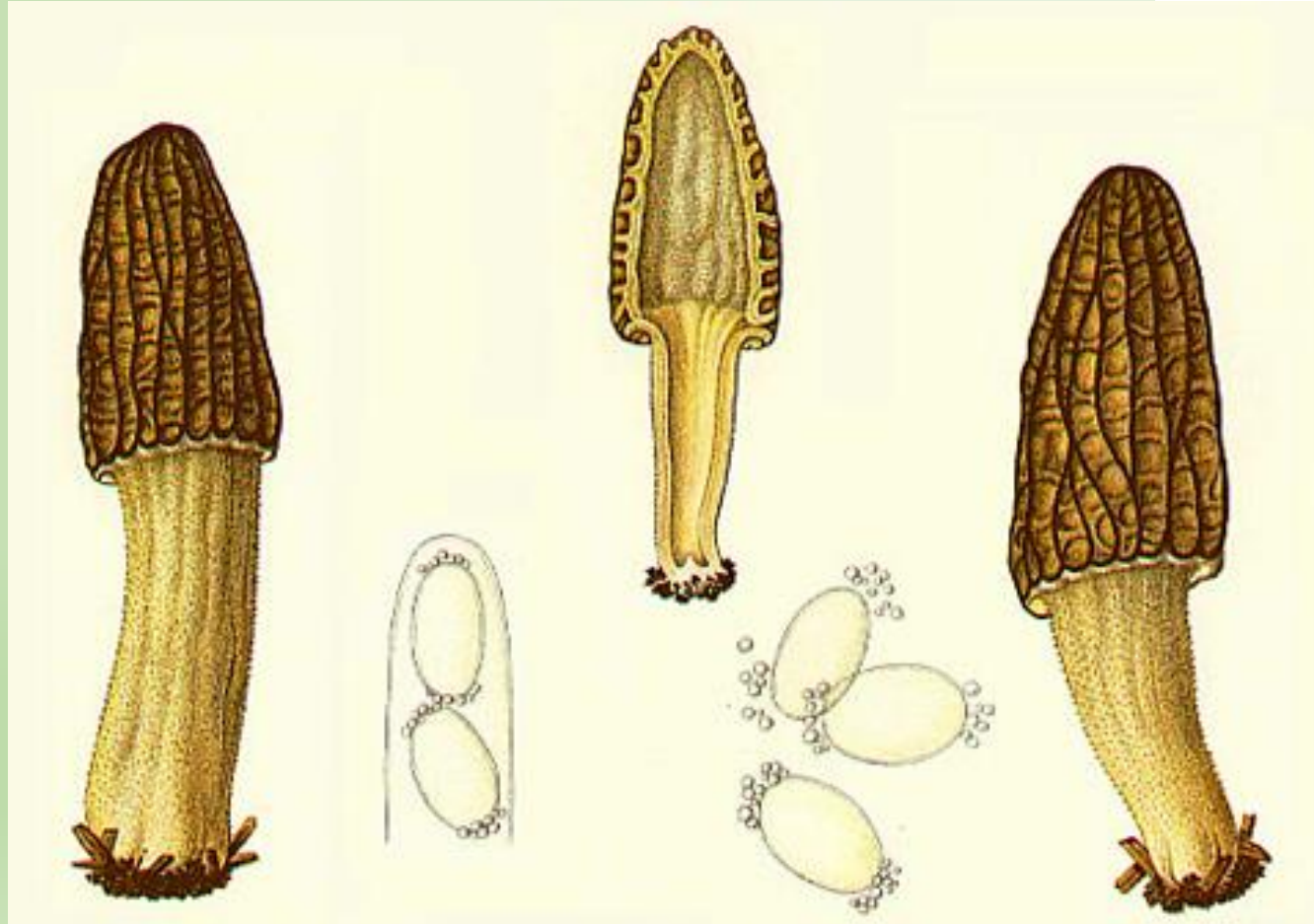
Jacquetant (1984): 30 espèces

Clowez (2012): 34 espèces



Jean-Louis-Emile Boudier (1828-1920)

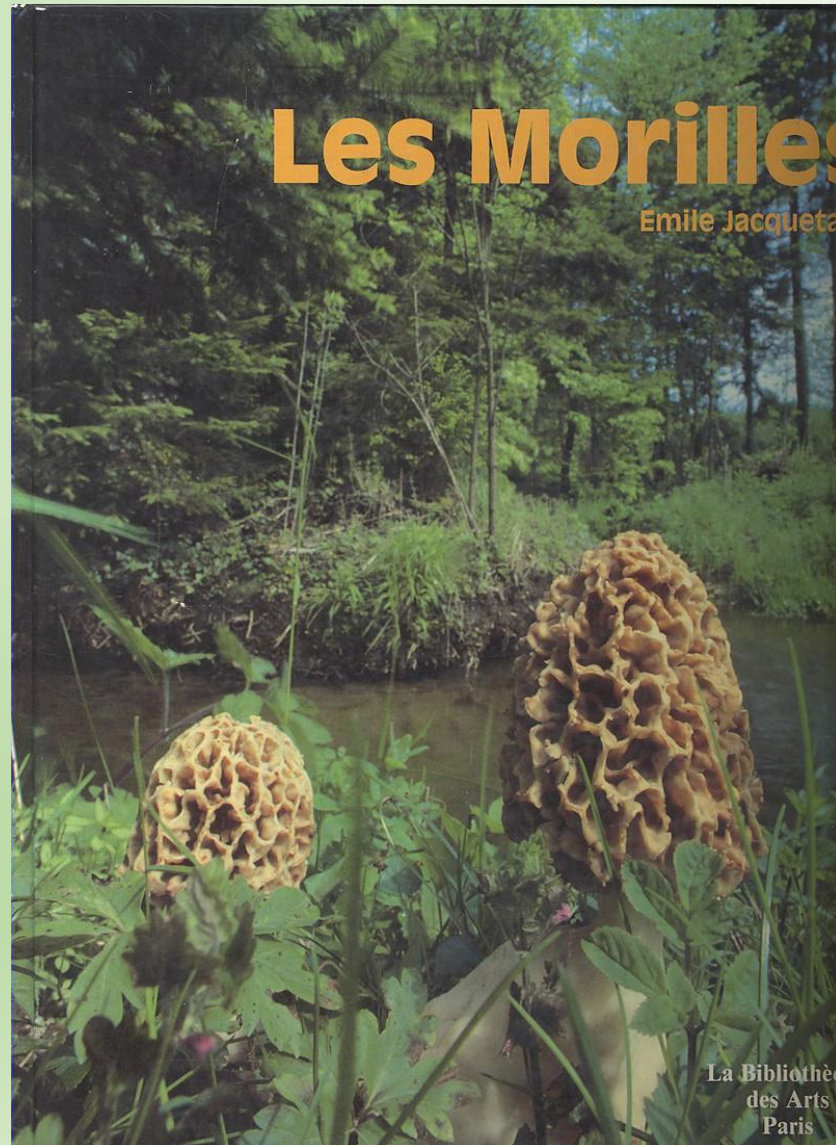
20 espèces



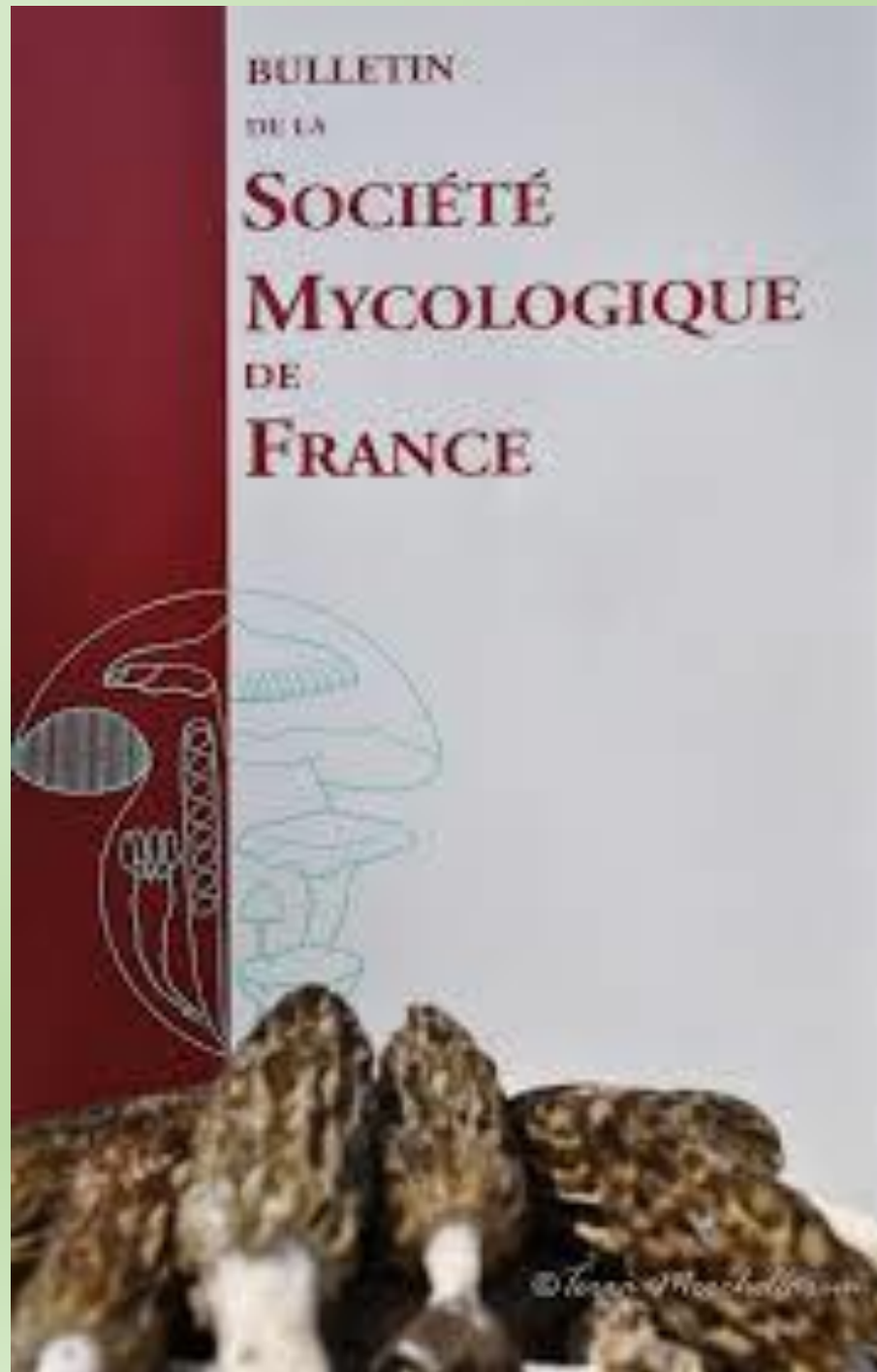


Emile Jacquetant (1923-2000)

30 espèces



Philippe Clowez (1960-)



41 espèces

Et finalement : qu'est-ce qu'une espèce de morille ?...

Au moins 22 concepts d'espèce !

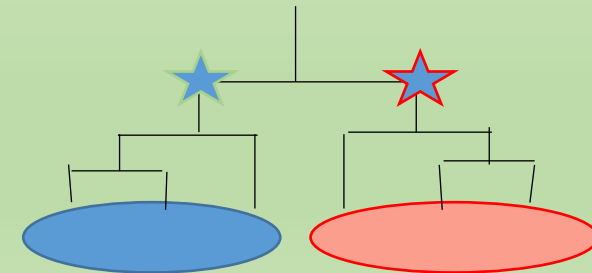
Mayden, R. L. (1997), "A hierarchy of species concepts: the denouement in the saga of the species problem", in M. F. Claridge, H. A. Dawah and M. R. Wilson (eds.), *Species: The units of diversity*, London: Chapman and Hall, 381-423.

Chaque concept dépend de l'outil de définition utilisé
(morphologie, écologie, comportement, compatibilité génétique...)

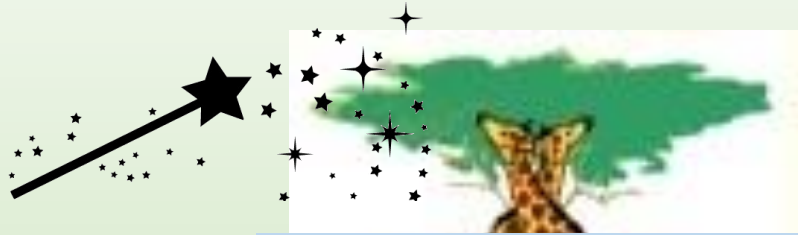
Pour Linné (1753), les espèces sont fixes (**classification linnéenne**)



Pour Darwin (1853): les espèces descendent d'un ancêtre commun
→ la classification doit retracer la « généalogie » des espèces (**classification phylogénétique**)

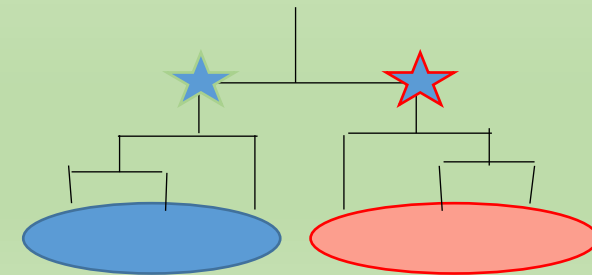


Pour Linné (1753), les espèces sont fixes (**classification linnéenne**)



Le taxinomiste recherche le Graal :
une taxinomie linnéenne sur une systématique darwinienne !

Pour Darwin (1853): les espèces descendent d'un ancêtre commun
→ la classification doit retracer la « généalogie » des espèces (**classification phylogénétique**)



L'arbitrage de la biologie moléculaire...

Marqueurs moléculaires : ITS, 28S, RPB1, RPB2, Tef1

Bunyard et al. (1995): 3 European species in the 'yellow' morels (*M. esculenta*, *M. rotunda*, *M. crassipes*)

O'Donnell et al. (2011): premier concept d'espèce phylogénétique des *Morchella*



Phylogeny and historical biogeography of true morels (*Morchella*) reveals an early Cretaceous origin and high continental endemism and provincialism in the Holarctic

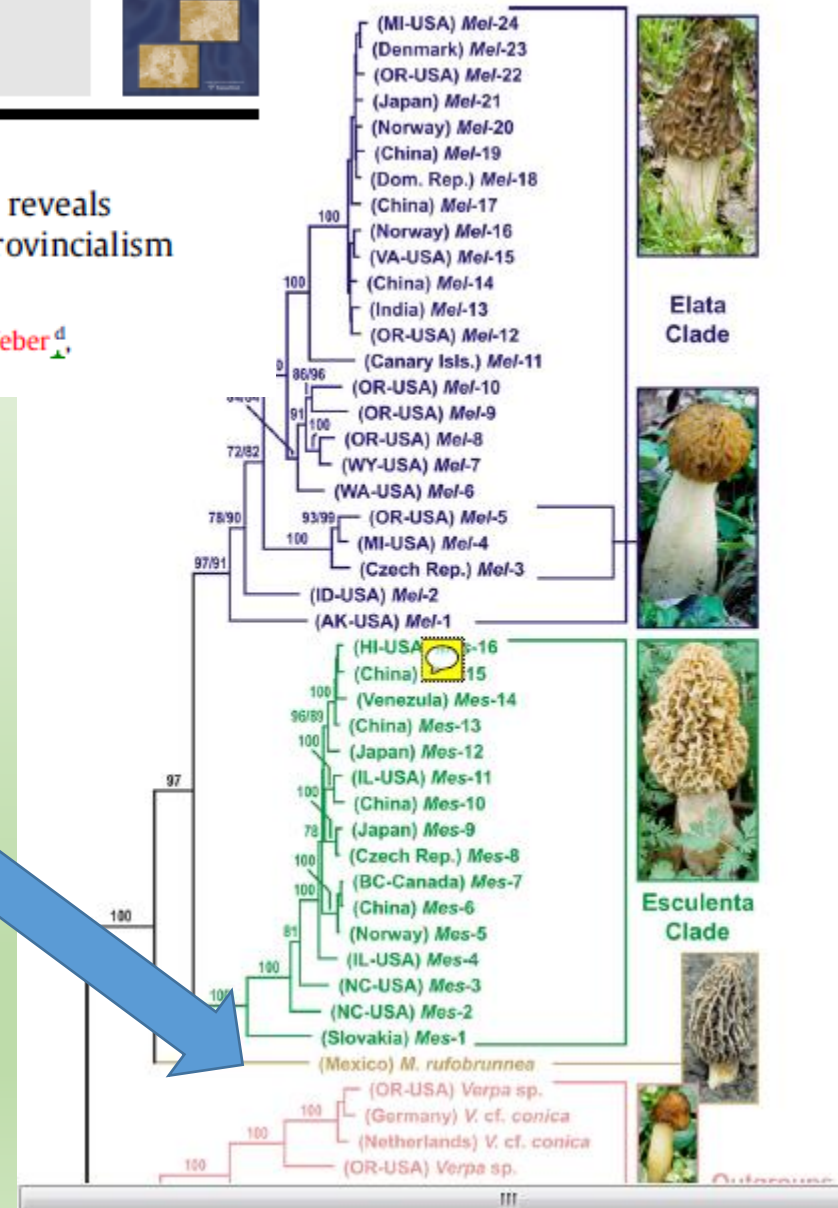
Kerry O'Donnell^{a,*}, Alejandro P. Rooney^a, Gary L. Mills^b, Michael Kuo^c, Nancy S. Weber^d, Stephen A. Rehner^e

43 « phylogenetic species »

M. rufobrunnea

Mel 1 to Mel 24

Mes 1 to Mes 18





Phylogeny and historical biogeography of true morels (*Morchella*) reveals an early Cretaceous origin and high continental endemism and provincialism in the Holarctic

Kerry O'Donnell^{a,*}, Alejandro P. Rooney^a, Gary L. Mills^b, Michael Kuo^c, Nancy S. Weber^d, Stephen A. Rehner^e

43 « phylogenetic species » *M. rufobrunnea*

Mycologia, 104(2), 2012, pp. 446–461. DOI: 10.3852/11-180

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Multilocus phylogenetic analysis of true morels (*Morchella*) reveals high levels of endemics in Turkey relative to other regions of Europe

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Saadet Büyükalacı

Department of Horticulture, Faculty of Agriculture,
Çukurova University, Adana 01330, Turkey

Karen Hansen

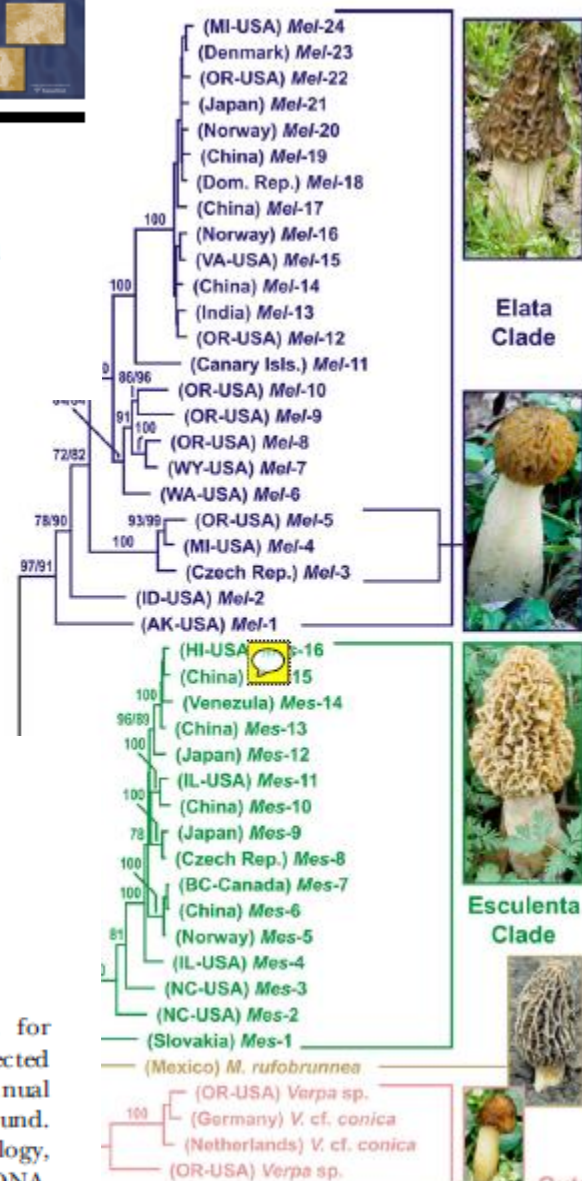
Cryptogamic Botany, Swedish Museum of Natural
History, P.O. Box 50007, SE-10405 Stockholm, Sweden

Kerry O'Donnell¹

Bacterial Foodborne Pathogens and Mycology Research

their biogeographic distribution are crucial for formulating informed conservation policies directed at preventing species loss and ensuring that annual morel harvests are sustainable and ecologically sound.

Key words: Ascomycota, conservation biology, DNA sequence, *EF-1α*, GCPSR, ITS rDNA, LSU rDNA, *RPB1*, *RPB2*, species limits



How well do ITS rDNA sequences differentiate species of true morels (*Morchella*)?

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Kerry O'Donnell¹
Bacterial Foodborne Pathogens and Mycology Research

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Agricultural Research Service, 1815 North University
Street, Peoria, Illinois 61604

Abstract: Arguably more mycophiles hunt for
morels (*Morchella*) during their brief fruiting
each spring in the northern hemisphere than for
other wild edible fungus. Concerns about

GenBank using *emerencia* and analyzed the
genetically. Three major findings emerged:
rDNA sequences were useful in identifying
(77.4%) of the known phylopecies; however,
failed to identify 12 of the 22 species within
species-rich Elata Subclade and two closely
species in the Esculenta Clade; (ii) at least 66
named *Morchella* sequences in GenBank are
identified; and (iii) ITS rDNA sequences of
putatively novel *Morchella* species were represented
GenBank. Recombination was not detected

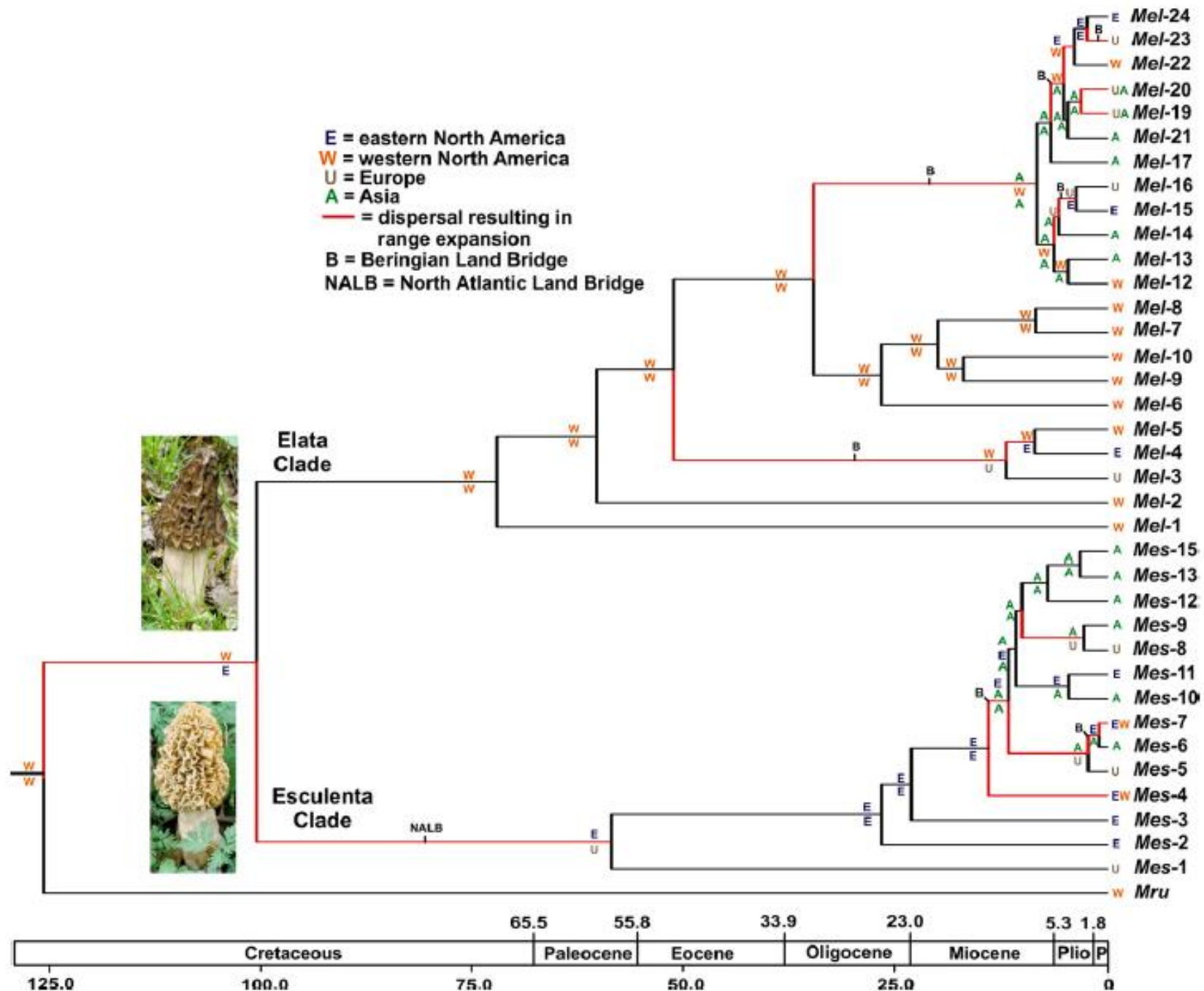
accessible reference
identification
constructed *M.
n1/morchella/
sequences and
our prior multi-
this charismatic
Key words:
phy, *emerencia*,
limits*

61 « phylogenetic species »

M. rufobrunnea

Mel 1 to Mel 33

Mes 1 to Mes 27



Associer Linné et Darwin.. (ou Clowez et O'Donnell)

C'est la ***taxinomie intégrative***
(Dayrat, 2005)

Mycologia, 107(2), 2015, pp. 359–382. DOI: 10.3852/14-166
© 2015 by The Mycological Society of America, Lawrence, KS 66044-8897

True morels (*Morchella*, Pezizales) of Europe and North America: evolutionary relationships inferred from multilocus data and a unified taxonomy

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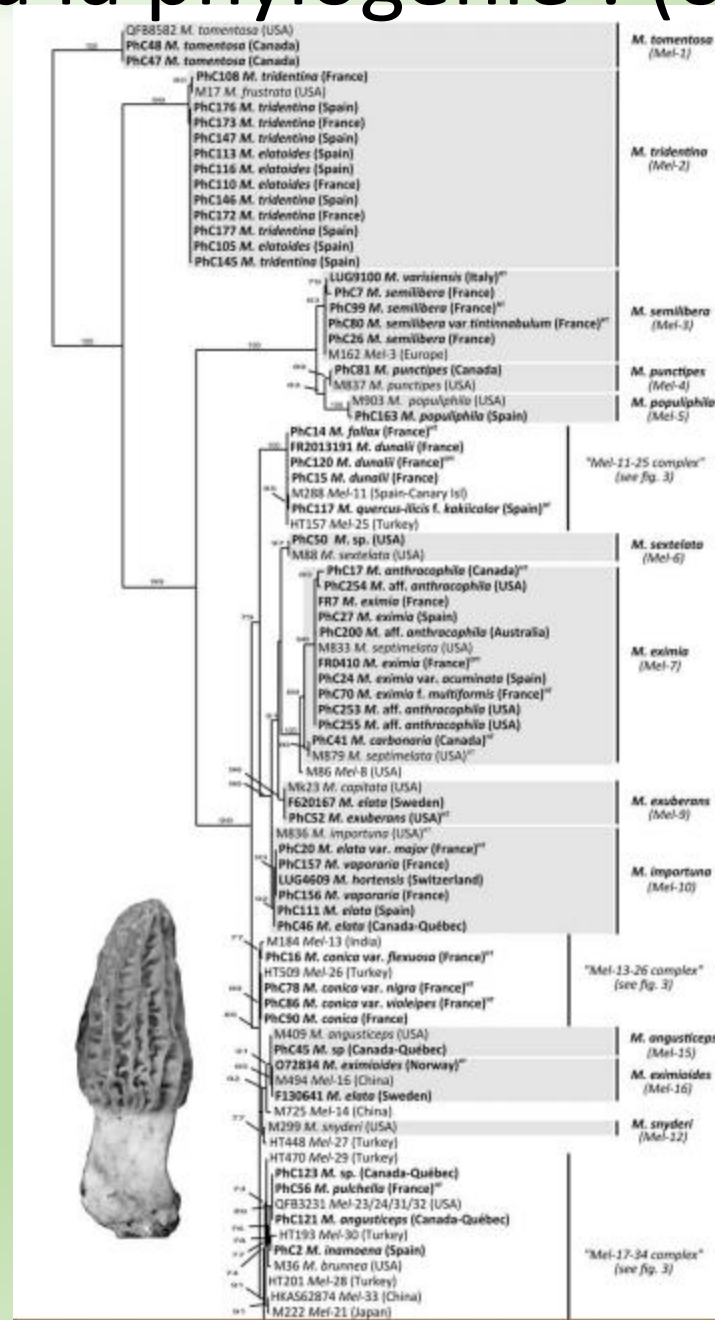
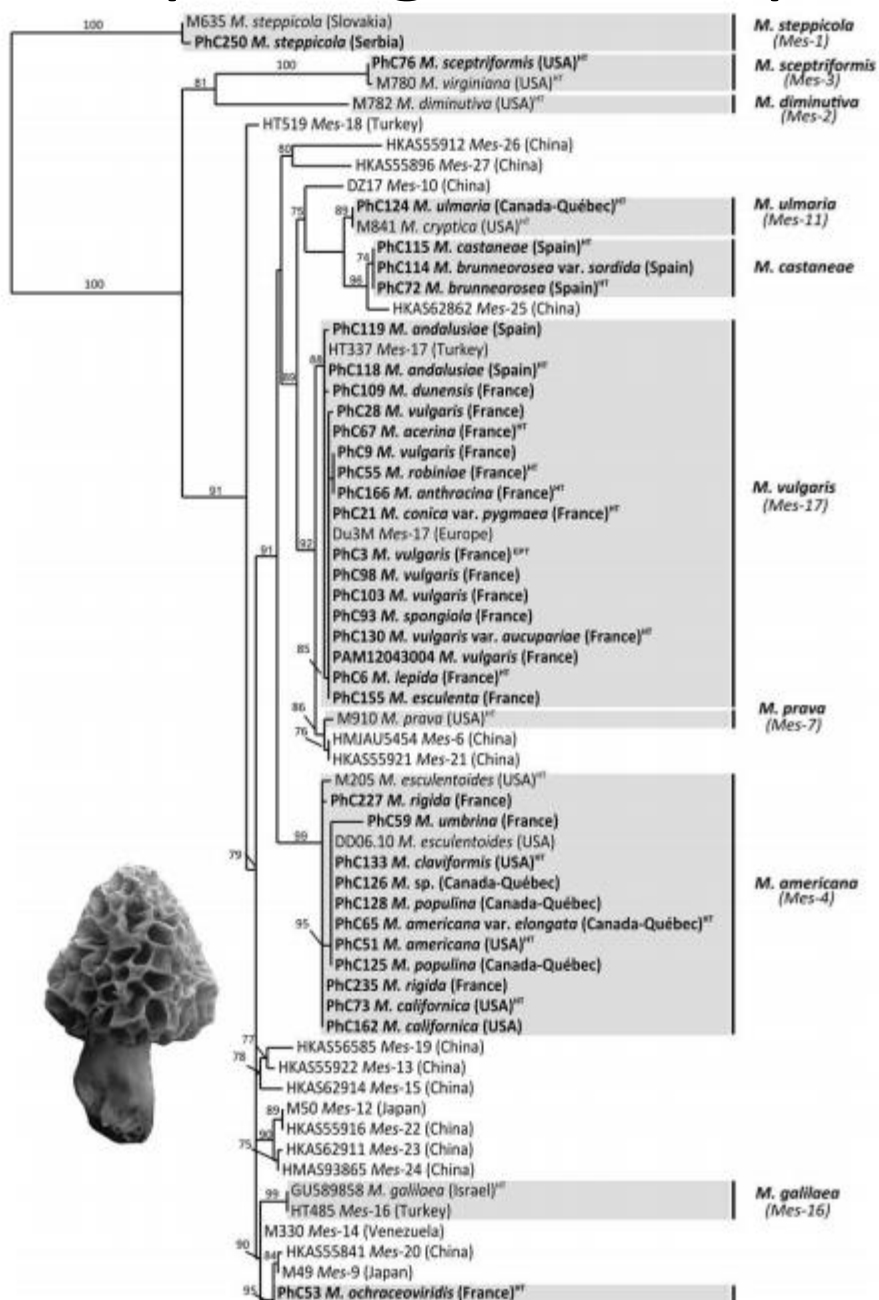
28S rDNA D1-D2 domains (28S). The 107 newly sequenced collections were from both continents, including 48 types, together with previously published sequences. Names are applied to 30 of the 65 currently recognized genealogical species. Results of the present study revealed that the number of *Morchella* species in Europe ($n = 21$) is nearly identical to that in North America ($n = 22$). Only seven species were found on both continents, consistent with previous reports of high continental endemism within the genus. Presently it is not possible to tell whether the transoceanic disjunctions were due to human activities, migration across a Bering land bridge or long-distance dispersal. In an effort to stabilize the taxonomy, due in part to the recent publication of synonyms for 11 of the species, accepted names are presented together with their corresponding later synonyms. A new subclade that includes holotypes of *M. castanea* and *M. brunneorosea* is identified in sect. *Morchella* (Esculenta Clade). Lectotypes for *Morchella deliciosa*, *M. eximia* and *M. tridentina* are designated here, as well as epitypes for *M. dunalii*, *M. eximia*, *M. purpurascens* and *M. vulgaris*. *Morchella conica* was determined to be illegitimate, and further research is required to determine the identity of *M. elata* and *M. inamoena*.

Key words: Ascomycota, Morchellaceae, nomenclature, Pezizomycetes, taxonomy

INTRODUCTION

True morels (*Morchella*) comprise one of the most intensively collected groups of macrofungi worldwide.

La morphologie correspond bien à la phylogénie ! (ouf)

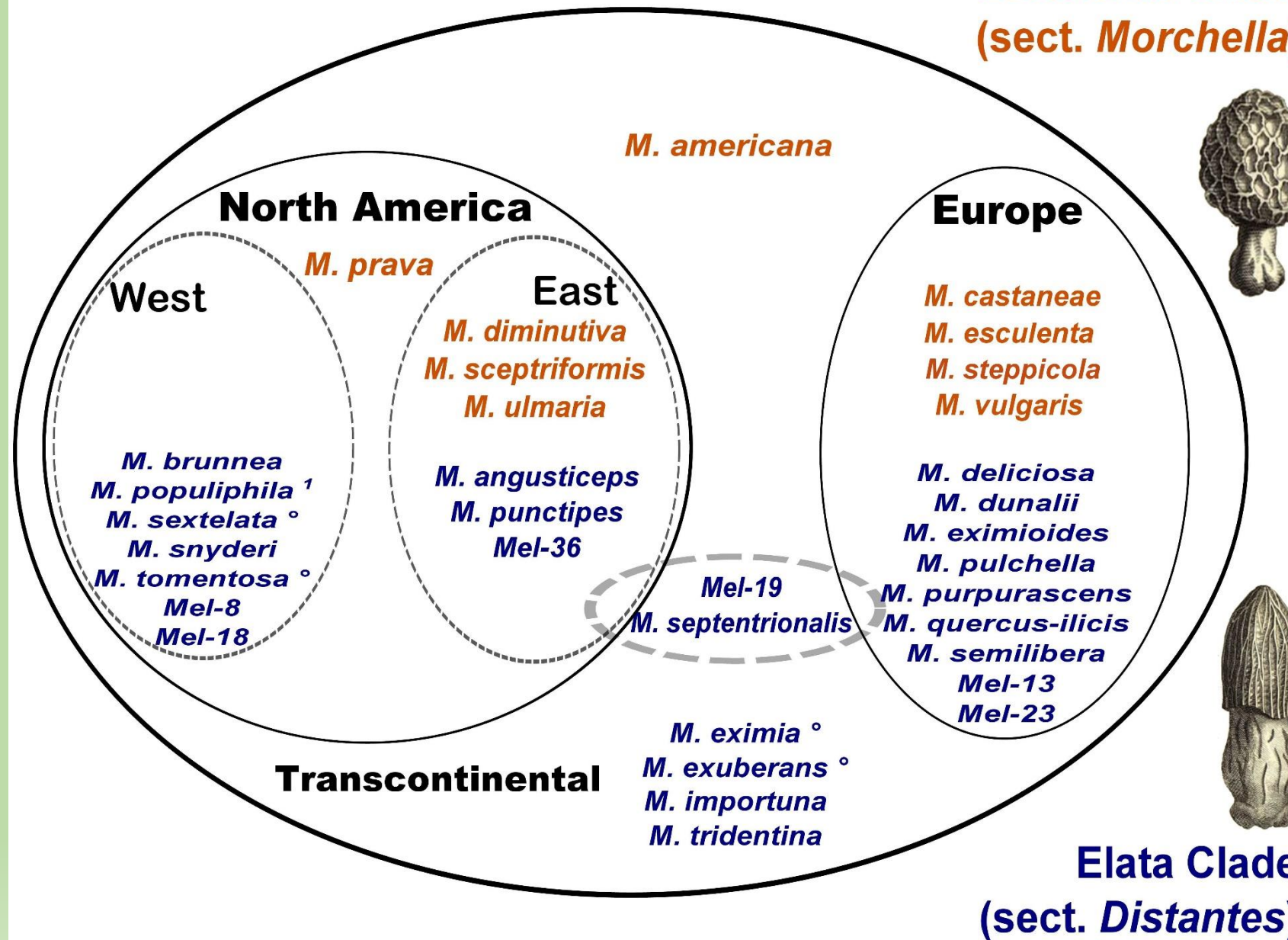


Mitrophora
semilibera
(morillon)

→ Morchella
semilibera

Le cosmopolitisme est une exception...

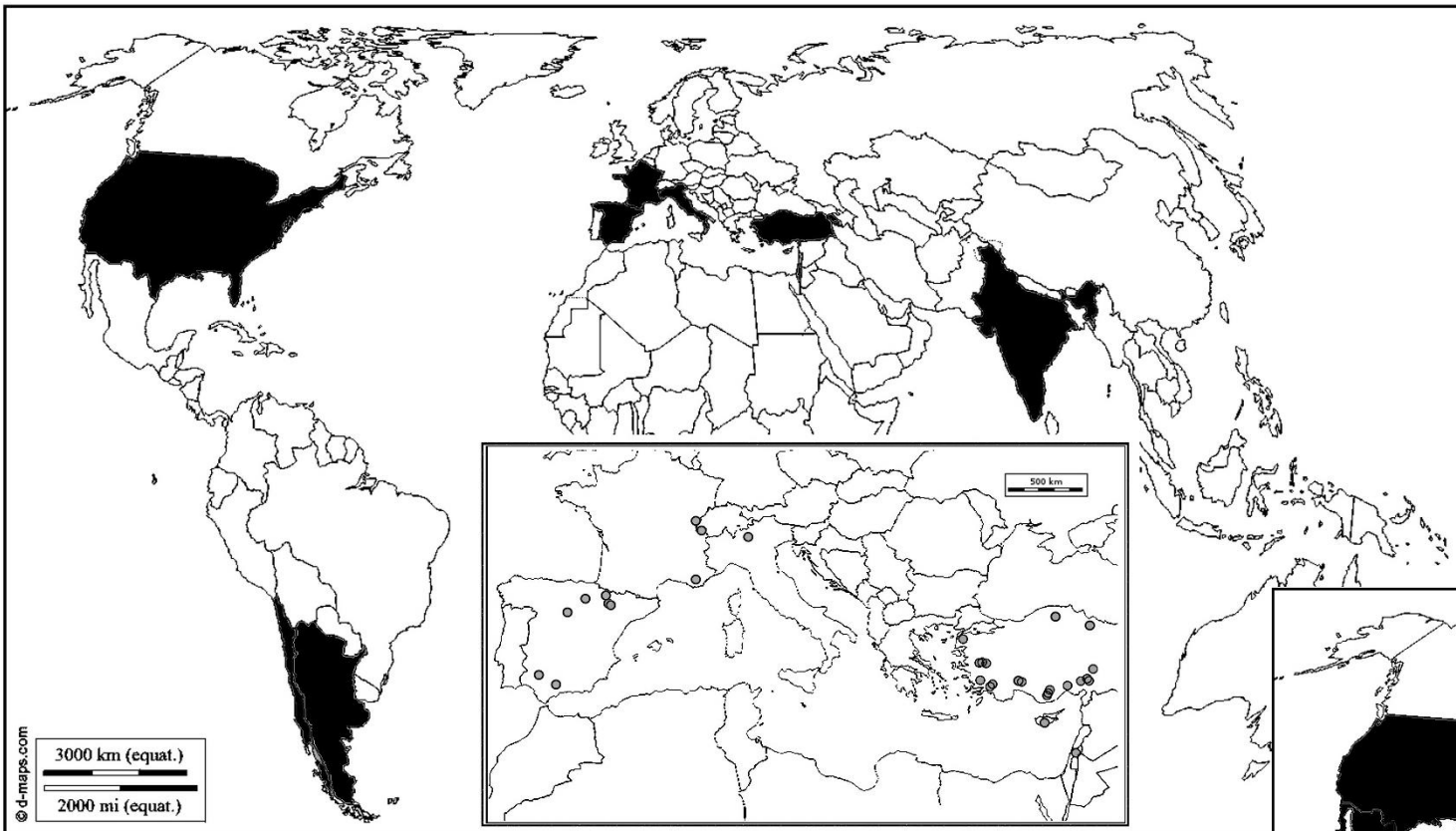
Esculenta Clade
(sect. *Morchella*)



Elata Clade
(sect. *Distantes*)

Le cosmopolitisme est une exception...

Loizides *et al.* 2015,
Mycol. Progress 14: 13

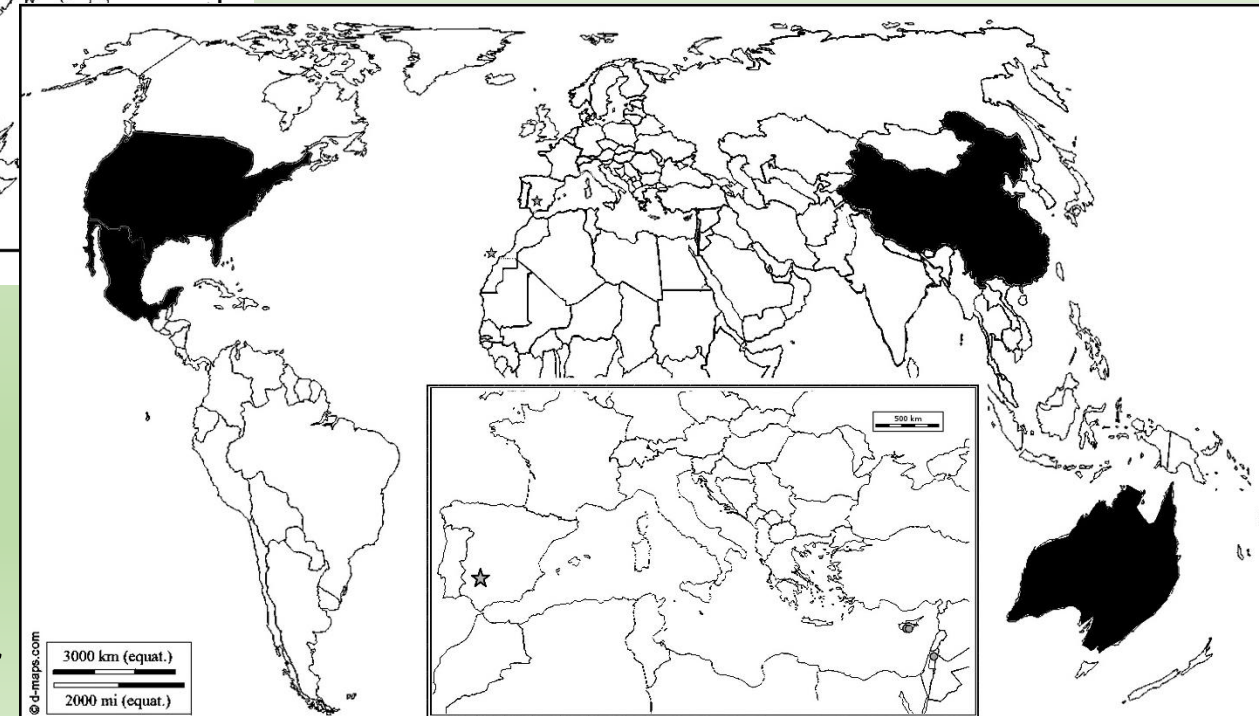


Morchella tridentina



Quelle dispersion ?

Morchella rufobrunnea
*: *M. kakiicolor*



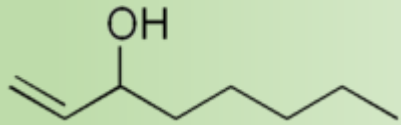
Conclusion :
Pour connaître, il faut nommer !



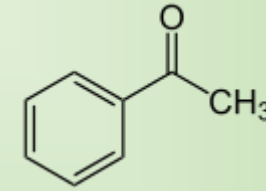
Question-bonus :

Comment bien préparer les morilles ?

1-Octen-3-ol



Acétophénone



Amount of identified molecules in the total aroma (µg/l) in *Morchella* “*esculenta*”:

	Fresh	Rehydrated
<i>l</i> -octene,3-01	1	3
2-heptanone	0	0
2-5-dimethylpyrazine	Traces	5
<i>linalool</i>	0	0
<i>acetophenone</i>	4	29
Concentration of total aroma (µg/g)	70	170

Comment bien préparer les morilles ?



Réhydratation

H₂O 60 °C, 5 min



Extraction
70-80 °C
10 min

(+ dénaturation
des hémolysines)



Préparation du solvant

Réduction
Assaisonnement
10 min



Emulsification
60 °C
10 min



Comment bien préparer les m



MERCI de votre attention



Remerciements à :

Philippe Clowez (Pont-l'Évêque), Michael Loizides (Chypre),
Kerry O'Donnell (USA), Karen Hansen (Suède), Mathieu Sauve (CEFE-CNRS)