7ème Forum de l'Apiculture Méditerranénne
Tunis, 27 novembre 2015

Abeilles, pollinisation, agriculture & biodiversité

Bernard Vaissière
INRA Pollinisation & Ecologie des Abeilles
UR 406 Abeilles & Environnement, Avignon

A quoi servent les abeilles au 21ème siècle sur le pourtour méditerranéen?

1. Abeilles & pollinisation
2. Pollinisation entomophile & biodiversité
3. Pollinisation entomophile & agriculture

Yiftach Vaknin, INRA

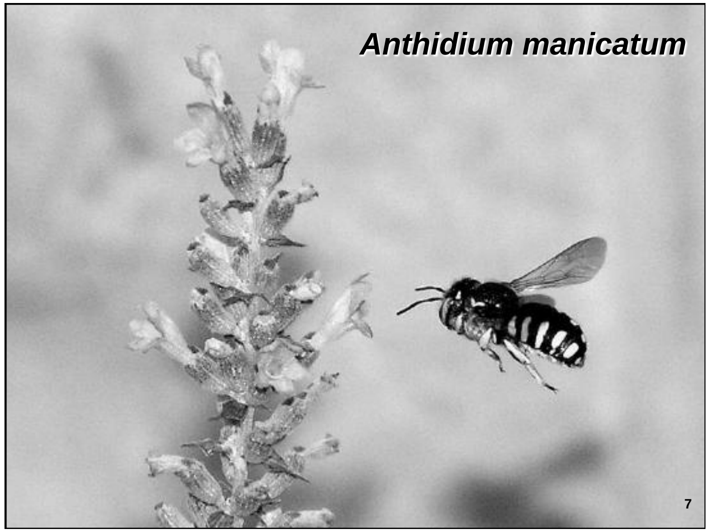
2

1. Abeilles & pollinisation

3


Abeille charpentière,
Xylocopa violacea sur sauge
5
M. El Maataoui, INRA

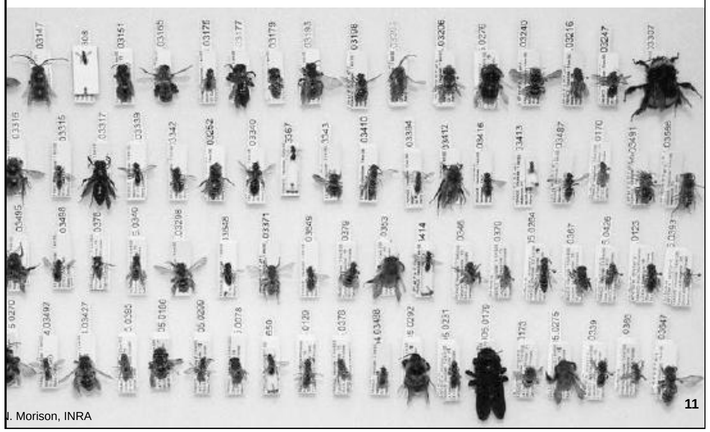

Colletes hederae
6
N. Morison, INRA


Anthidium manicatum
7


Osmie cornue, *Osmia cornuta*
8
H. Mouret, ArthropologiaA

20 070 espèces dans le monde…

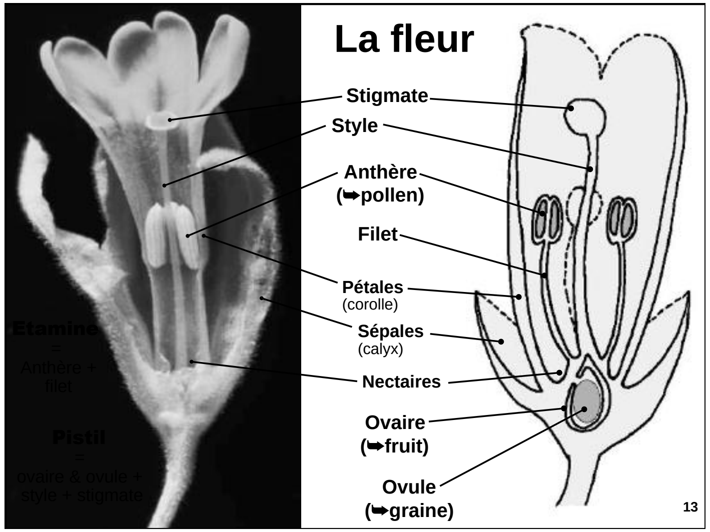
http://www.discoverlife.org/mp/20q?guide=Apoidea_species

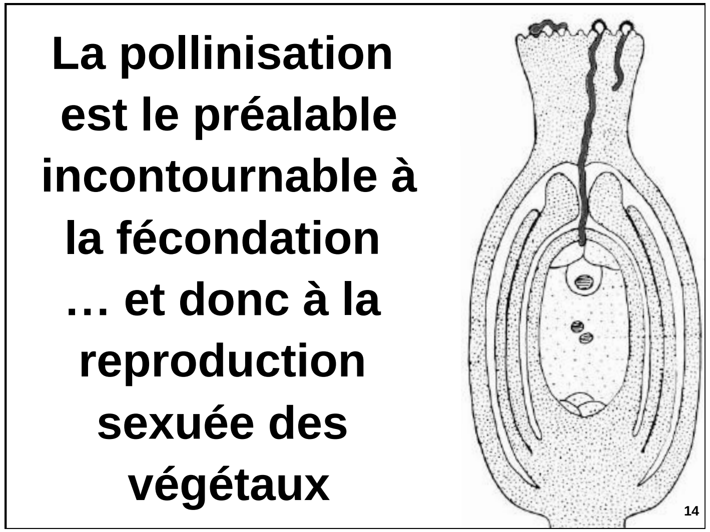


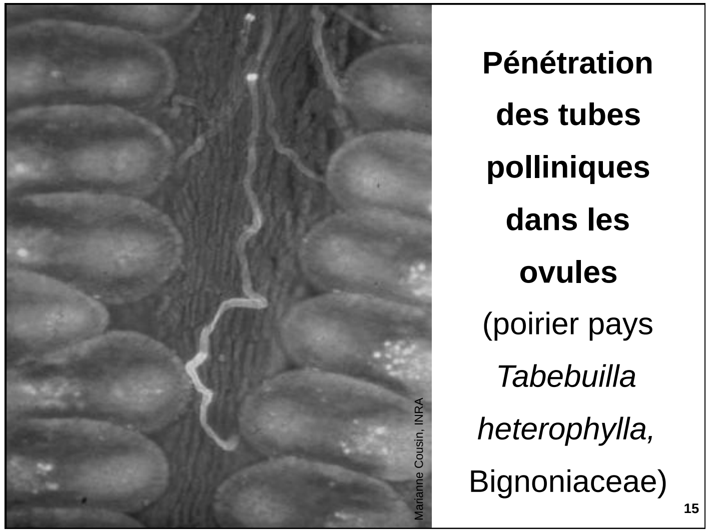
La pollinisation :

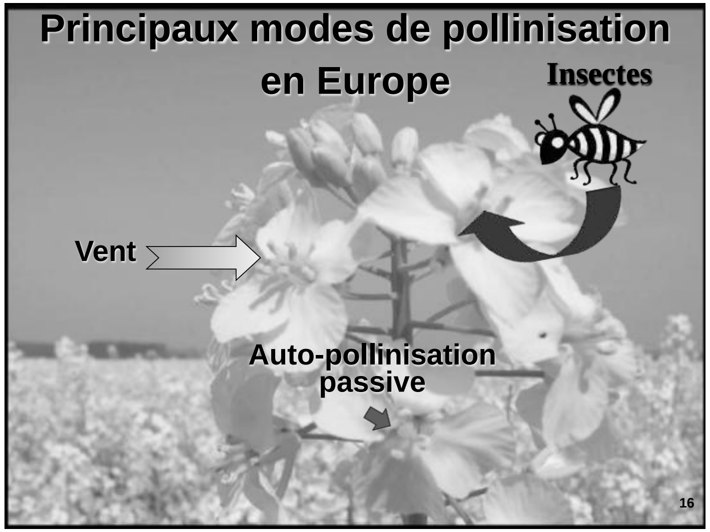
le transfert du pollen des étamines productrices aux stigmates

vecteur(s)


La fleur
Stigmate
Style
Anthère
(➥pollen)
Filet
Pétales
(corolle)
Sépales
(calyx)
Nectaires
Ovaire
(➥fruit)
Ovule
(➥graine)
Etamine
=
Anthère +
filet
Pistil
=
ovaire & ovule +
style + stigmate
13


La pollinisation
est le préalable
incontournable à
la fécondation
… et donc à la
reproduction
sexuée des
végétaux
14


Marianne Cousin, INRA
Pénétration
des tubes
polliniques
dans les
ovules
(poirier pays
Tabebuilla
heterophylla,
Bignoniaceae)
15

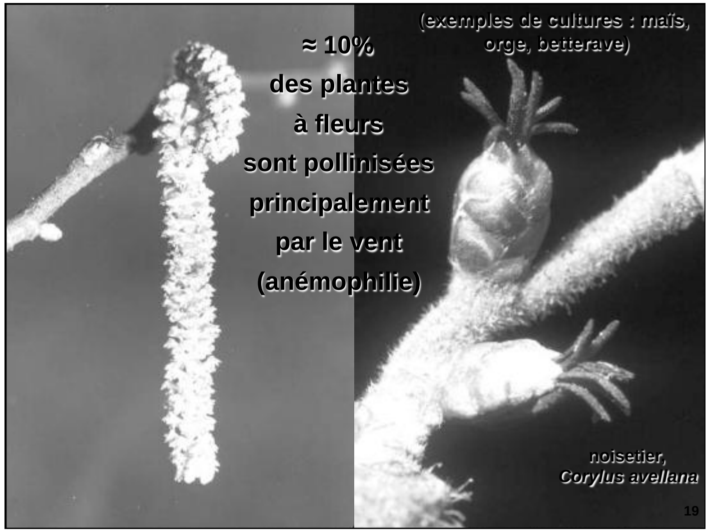

Principaux modes de pollinisation
en Europe
Insectes
Vent
Auto-pollinisation
passive
16

Auto-pollinisation passive

La pollinisation par le vent (anémophilie)

Pluie de pollen chez les conifères

Adaptation morphologique des pollens, dotés de sacs aérifères (augmentation de la surface portante, diminution de la densité).

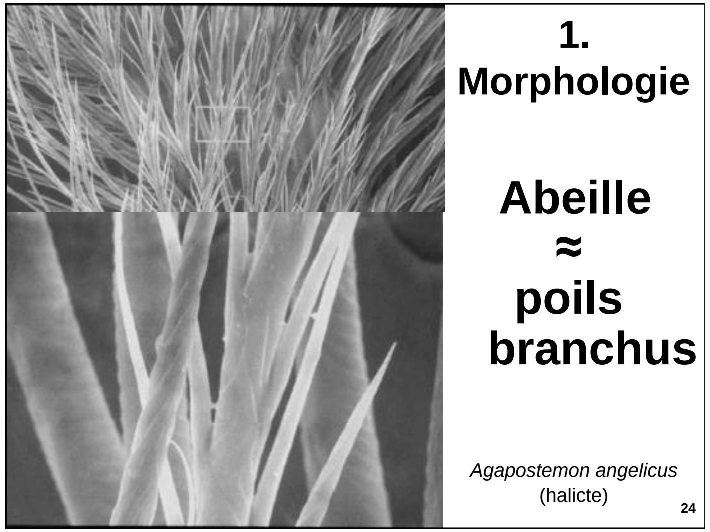


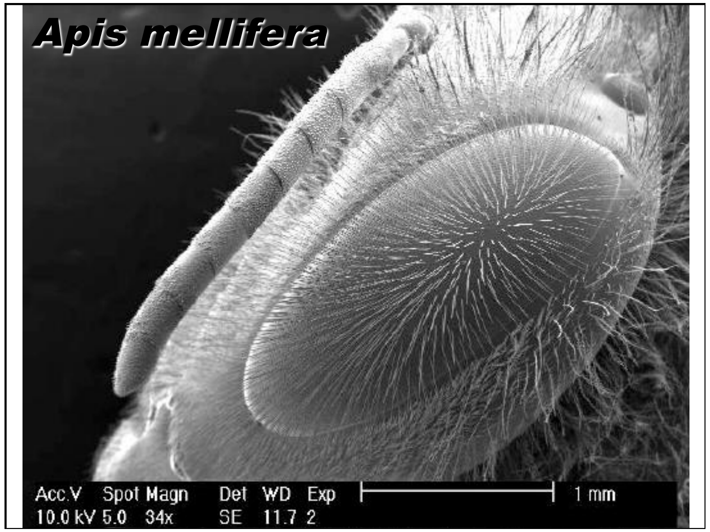
Pollinisation entomophile
(= par les insectes)


Beaucoup
d’ insectes
floricoles
ne SONT PAS
des pollinisateurs
21


Les
principaux
insectes
pollinisateurs
sont
22

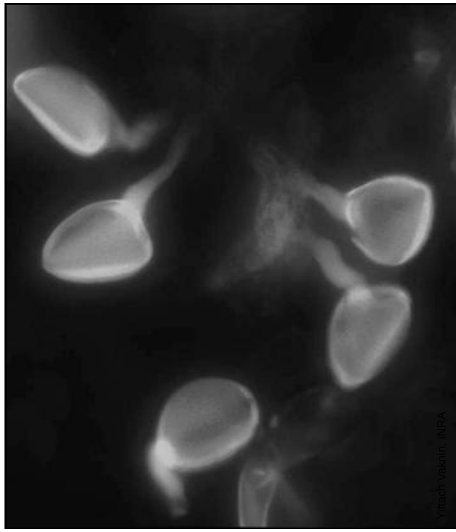

N. Morison, INRA
23


1.
Morphologie
Abeille
≈
poils
branchus
Agapostemon angelicus
(halicte)
24



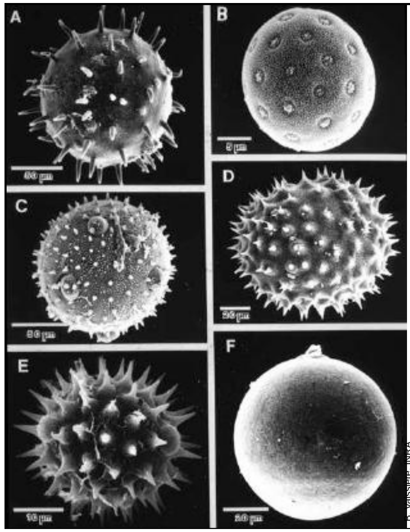
3. Constance à une espèce végétale lors d'un voyage

27



4. Le pollen transporté demeure viable pendant plusieurs heures

28



B. Vaissière, INRA

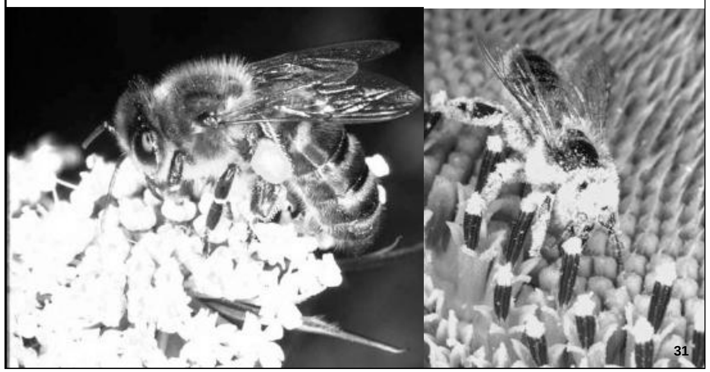
Co-évolution entre les abeilles et les plantes depuis le début du Crétacé

[Crepet WL. 1984. Ann. Missouri Bot. Gard. 71:607-630; Poinard & Danforth 2006 Science 314:614]

Biodiversité des plantes à fleurs…

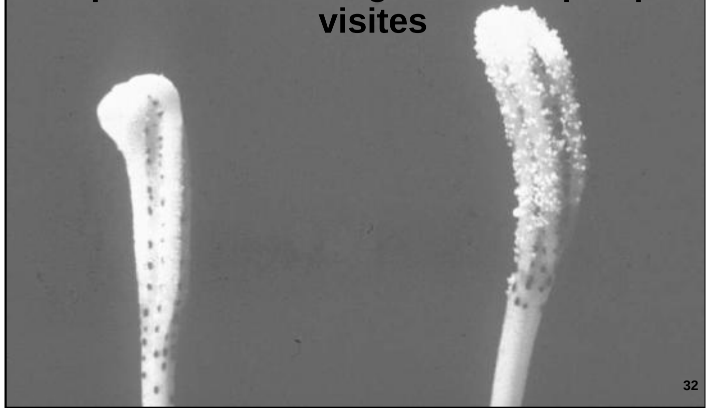
29

Mutualisme, mais acte de pollinisation <u>involontaire</u>



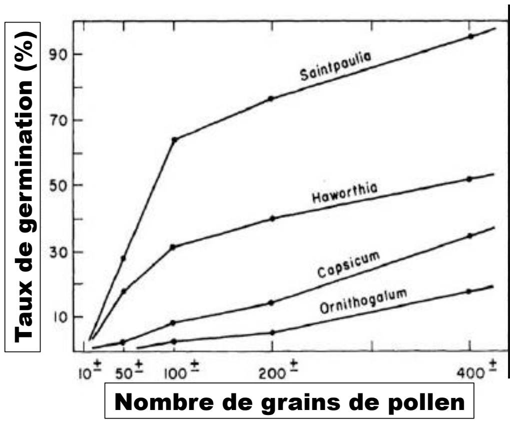
31

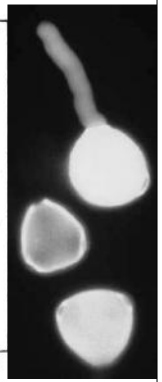
Sur le plan quantitatif, les abeilles peuvent déposer de grandes quantités de pollen sur les stigmates en quelques visites



32

Relation entre effectif de grains de pollen et taux de germination dans 20 µl de milieu de culture

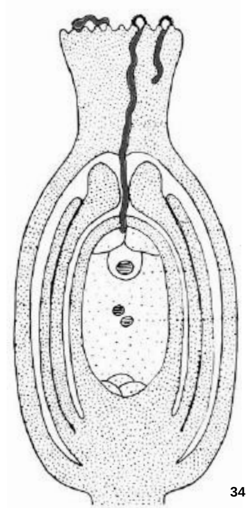




Brewbaker 1963 Amer. J. Bot. 50:863

33

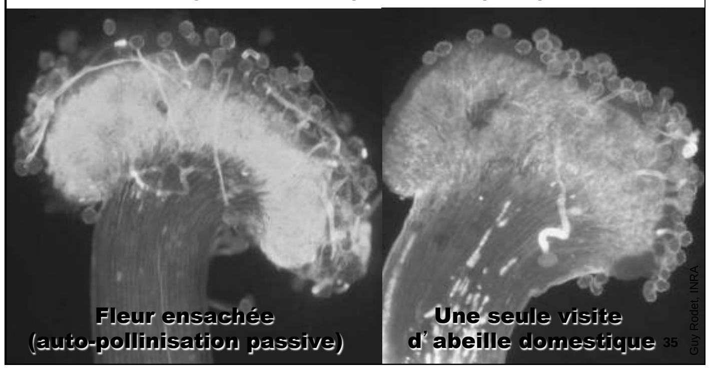
La croissance du tube pollinique est un parasitisme : l'accession à l'ovule dépend des relations qui auront pu s'établir, ou non, entre le grain de pollen et le pistil



34

Sur le plan qualitatif, elles déposent de l'allo-pollen (compatible)

e.g. trèfle blanc (*Trifolium repens*)



35

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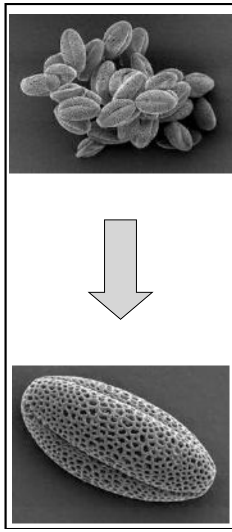
Le butinage des abeilles s'accompagne d'une mise en suspension du pollen

37



Apidologie 41 (2010) 109–115
© INRA/DIB-AGIB/EDP Sciences, 2009
DOI: 10.1051/apido/2009056

Available online at:
www.apidologie.org

Original article

Efficiency of airborne pollen released by honeybee foraging on pollination in oilseed rape: a wind insect-assisted pollination*

Jacqueline PIERRE[1], Bernard VAISSIÈRE[2], Patrick VALLÉE[3], Michel RENARD[3]

[1] INRA, UMR 1099, "BiO3P", BP 35327, 35653 Le Rheu Cedex, France
[2] INRA, UMR 406, "Abeilles et Environnement", Domaine Saint-Paul, Site Agroparc, 84914 Avignon Cedex 9, France
[3] INRA, UMR 118, Amélioration des Plantes et Biotechnologies Végétales, BP 35327, 35653 Le Rheu Cedex, France

Received 9 April 2009 – Revised and accepted 8 July 2009

Abstract – Oilseed rape (*Brassica napus* L.) is an entomophilous crop. Its pollen is covered with sticky pollenkitt and not readily released from the anthers. We investigated the role of foraging honeybees in making this pollen airborne. To assess this, six cages were laid over male-fertile (MF) and male-sterile (MS) plants; at flowering, three cages received a honeybee colony while the others served as controls. On average, approximately 25% more pollen grains were deposited on sticky slides (covered with gauze) in cages with honeybees, compared to control cages. The fruit and seed set per not-empty pod of 5 MS plants bagged under gauze to avoid bee visits were 7 times and 3.4 times higher, respectively, in the cages with honeybees than in control cages without honeybees. These results demonstrate the role of bees in releasing airborne pollen, as well as the effectiveness of this insect-assisted wind pollination: at close range, honeybees participate to pollination without touching the female flowers.

Apis mellifera / airborne pollen / pollination / *Brassica napus*

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Les relations plantes-abeilles peuvent être très étroites

39

40

2. Abeilles & biodiversité

41

Abeilles et milieux naturels

42

Oikos 120: 321–326, 2011
doi: 10.1111/j.1600-0706.2010.18644.x

Subject Editor: Anna Traveset. Accepted 22 October 2010

Forum

How many flowering plants are pollinated by animals?

Jeff Ollerton, Rachael Winfree and Sam Tarrant

J. Ollerton (jeff.ollerton@northampton.ac.uk) and S. Tarrant, School of Science and Technology, Univ. of Northampton, Avenue Campus, Northampton, NN2 6JD, UK. Present address for ST: RSPB UK Headquarters, The Lodge, Sandy, Bedfordshire, SG19 2DL, UK – R. Winfree, Dept of Entomology, Rutgers Univ., New Brunswick, NJ 08901, USA.

It is clear that the majority of flowering plants are pollinated by insects and other animals, with a minority utilising abiotic pollen vectors, mainly wind. However there is no accurate published calculation of the proportion of the ca 352 000 species of angiosperms that interact with pollinators. Widely cited figures range from 67% to 96% but these have not been based on firm data. We estimated the number and proportion of flowering plants that are pollinated by animals using published and unpublished community-level surveys of plant pollination systems that recorded whether each species present was pollinated by animals or wind. The proportion of animal-pollinated species rises from a mean of 78% in temperate-zone communities to 94% in tropical communities. By correcting for the latitudinal diversity trend in flowering plants, we estimate the global number and proportion of animal pollinated angiosperms as 308 006, which is 87.5% of the estimated species-level diversity of flowering plants. Given current concerns about the decline in pollinators and the possible resulting impacts on both natural communities and agricultural crops, such estimates are vital to both ecologists and policy makers. Further research is required to assess in detail the absolute dependency of these plants on their pollinators, and how this varies with latitude and community type, but there is no doubt that plant–pollinator interactions play a significant role in maintaining the functional integrity of most terrestrial ecosystems.

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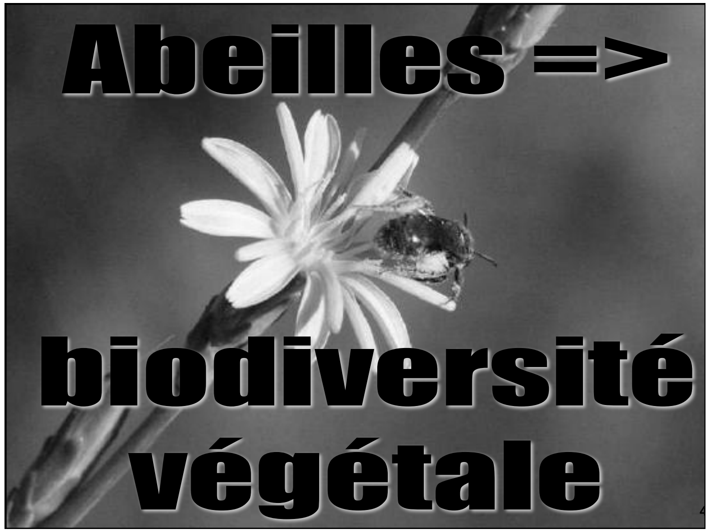
Leur activité pollinisatrice !

44

Pollinisation et structure des peuplements végétaux

pollinisation par le vent	pollinisation par les abeilles
Grandes populations avec densité élevée et faible diversité	**Individus isolés ou en groupes dispersés, densité souvent faible et grande diversité**
(graminées, conifères et espèces forestière à feuilles caduques comme le chêne *Quercus* spp.)	**(sauge *Salvia* dans les prairies; merisier *Prunus* dans les bois et les haies)**

46



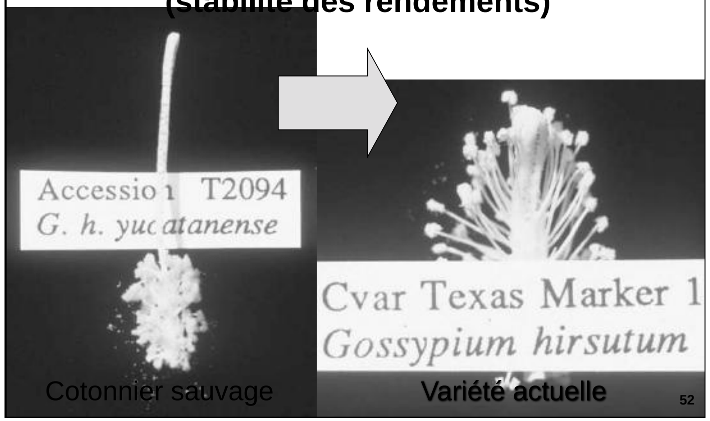
Abeilles et Environnement => BIODIVERSITE

50

3. Abeilles & agriculture

51

L'auto-pollinisation passive a été sélectionnée chez de nombreuses cultures (stabilité des rendements)



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PROCEEDINGS OF THE ROYAL SOCIETY B

Proc. R. Soc. B (2007) **274**, 303–313
doi:10.1098/rspb.2006.3721
Published online 27 October 2006

Review

Importance of pollinators in changing landscapes for world crops

Alexandra-Maria Klein[1,*], Bernard E. Vaissière[2], James H. Cane[3], Ingolf Steffan-Dewenter[1], Saul A. Cunningham[4], Claire Kremen[5] and Teja Tscharntke[1]

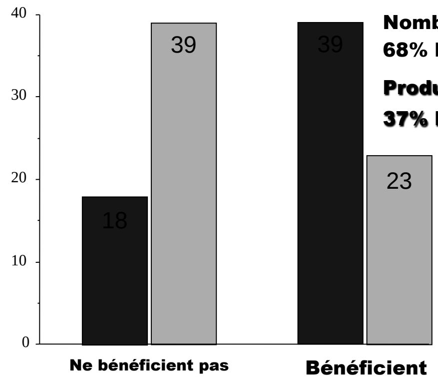
[1]*Agroecology, University of Göttingen, Waldweg 26, 37073 Göttingen, Germany*
[2]*Institut National de la Recherche Agronomique, Laboratoire de Pollinisation Entomophile, UMR 406 INRA-UAPV Ecologie des Invertébrés, 84914 Avignon Cedex 9, France*
[3]*USDA-ARS Bee Biology and Systematics Laboratory, Utah State University, Logan, UT 84322, USA*
[4]*CSIRO Entomology, Box 1700 Canberra, Australian Capital Territory 2601, Australia*
[5]*Department of Environmental Science, Policy and Management, University of California, 137 Mulford Hall no. 3114, Berkeley, CA 94720, USA*

The extent of our reliance on animal pollination for world crop production for human food has not previously been evaluated and the previous estimates for countries or continents have seldom used primary data. In this review, we expand the previous estimates using novel primary data from 200 countries and found that fruit, vegetable or seed production from 87 of the leading global food crops is dependent upon animal pollination, while 28 crops do not rely upon animal pollination. However, global production volumes give a contrasting perspective, since 60% of global production comes from crops that do not

55

Klein *et al.* 2007. **Importance of pollinators in changing landscapes for world crops.** *Proc. Royal Soc. B* 274:303-

FAO stat 2004 : => Alimentation humaine & production & > 4 million tonnes (> 94.5% total) ➡ 57 espèces



Nombre d'espèces 68% bénéficient

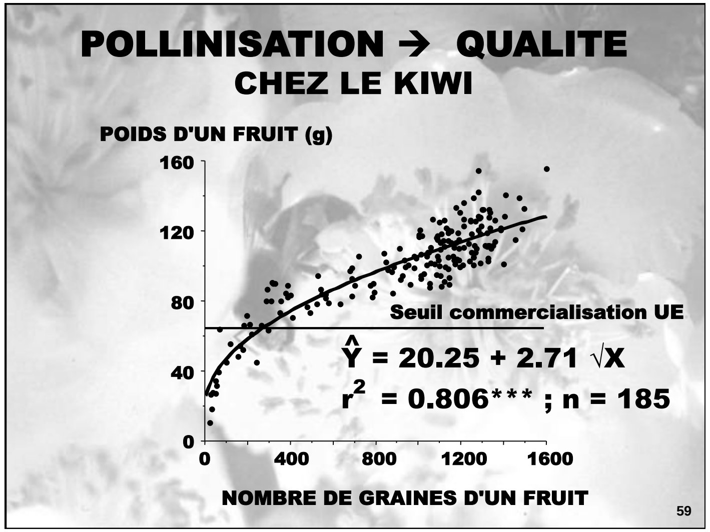
Production (10^8 tonnes) 37% bénéficient

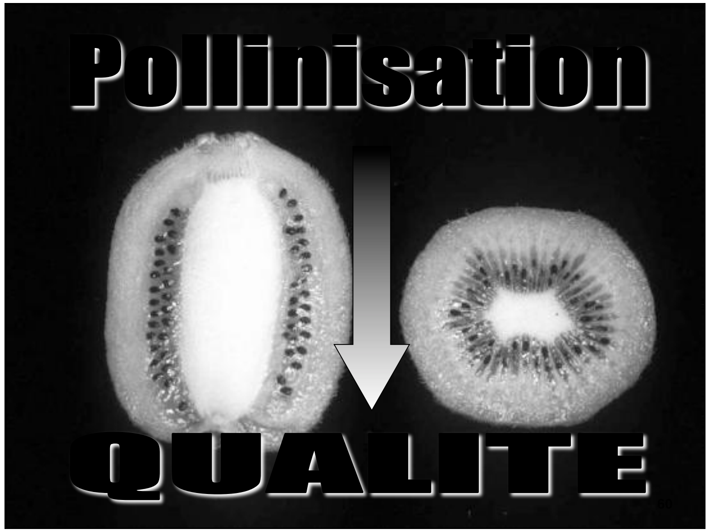
Importance des insectes pollinisateurs

56


1.Arboriculture
fruitière
57


58


POLLINISATION → QUALITE
CHEZ LE KIWI
POIDS D'UN FRUIT (g)
160
120
80
40
0
0
400
800
1200
1600
Seuil commercialisation UE
Ŷ = 20.25 + 2.71 √X
r2 = 0.806*** ; n = 185
NOMBRE DE GRAINES D'UN FRUIT
59


Pollinisation
QUALITE

Oecologia (2012) 169:1025-1032
DOI 10.1007/s00442-012-2271-6

PLANT-ANIMAL INTERACTIONS - ORIGINAL RESEARCH

Insect pollination enhances seed yield, quality, and market value in oilseed rape

Riccardo Bommarco · Lorenzo Marini ·
Bernard E. Vaissière

Received: 12 July 2011 / Accepted: 23 January 2012 / Published online: 7 February 2012

Abstract The relationships between landscape intensification, the abundance and diversity of pollinating insects, and their contributions to crop yield, quality, and market value are poorly studied, despite observed declines in wild and domesticated pollinators. Abundance and species richness of pollinating insects were estimated in ten fields of spring oilseed rape, *Brassica napus* var. SW Stratos™, located along a gradient of landscape compositions ranging from simple landscapes dominated by arable land to heterogeneous landscapes with extensive cover of semi-natural habitats. In each field, we assessed the contribution of wind and insect pollination to seed yield, seed quality (individual seed weight and oil and chlorophyll contents), and market value in a block experiment with four replicates and two treatments: (1) all flowers were accessible to insects, self and wind pollination, and (2) flowers enclosed in tulle net bags (mesh: 1 × 1 mm) were accessible only to wind and self pollination. Complex landscapes enhanced the overall abundance of wild insects as well as the abundance and species richness of hoverflies. This did not translate to a higher yield, probably due to consistent pollination by honey bees across all fields. However, the pollination experiment showed that insects increased seed weight per plant by 18% and market value by 20%. Seed quality was enhanced by insect pollination, rendering heavier seeds as well as higher oil and lower chlorophyll contents, clearly showing that insect pollination is required to reach high seed yield and quality in oilseed rape. Our study demonstrates considerable and previously underestimated contributions from pollinating insects to both the yield and the market value of oilseed rape.

Keywords *Brassica napus* · Crop pollination · Honey bee · Hoverflies · Landscape heterogeneity

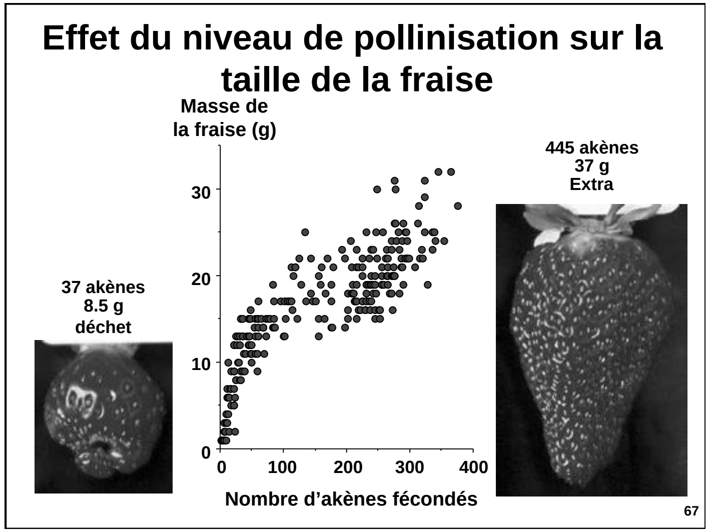
Introduction

Pollination by insects has been identified as an important and endangered ecosystem service (e.g., Allen-Wardell et al. 1998; Potts et al. 2010). Despite this, there is a lack of up to date studies on pollination of crops, and there is surprisingly little information available on the extent to

64

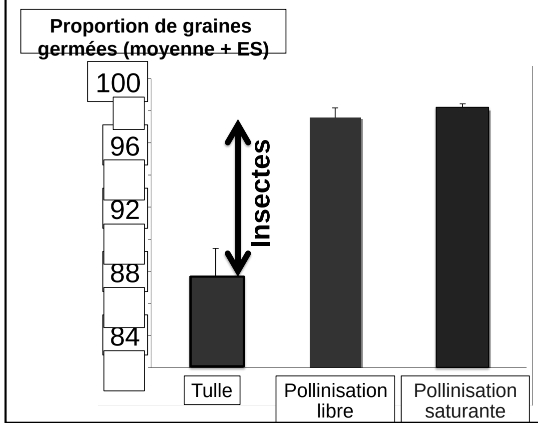

3. Maraîchage & petits fruits
65


N. Morison, INRA
N. Morison, INRA
N. Morison, INRA
66


Effet du niveau de pollinisation sur la taille de la fraise
Masse de la fraise (g)
0
10
20
30
0
100
200
300
400
Nombre d'akènes fécondés
37 akènes
8.5 g
déchet
445 akènes
37 g
Extra
67


Cultures porte-graine
68

Effet de pollinisation sur la faculté germinative des semences hybrides de tournesol (19 parcelles/ traitement ; Drôme 2007)



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Abeilles et Agriculture

=>

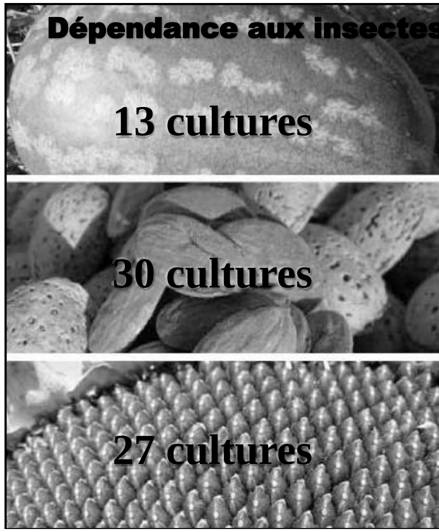
RENDEMENT & QUALITE

72

D
=
Coefficient de dépendance (agronomique) aux insectes pollinisateurs

73

Dépendance aux insectes pollinisateurs



Essentiel
(D > 90%)

Fort
(40% < D ≤ 90%)

Modeste
(10% < D ≤ 40%)

74

Dépendance aux insectes pollinisateurs

Faible
(0% < D ≤ 10%)

Nulle
(D = 0%)

75

Valeur de l'activité des pollinisateurs

=

153 milliards € en 2005

(≈ 10% chiffre d'affaire de l'activité agricole)

76

Quels insectes pour maximiser la pollinisation ?

77


Et les mouches (syrphes) ?


Jean-Pierre Sarthou

81

Les interactions interspécifiques entre les abeilles domestiques et les abeilles sauvages augmentent l'efficacité pollinisatrice des abeilles domestiques jusqu'à 5 fois

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PROCEEDINGS OF THE ROYAL SOCIETY B

rspb.royalsocietypublishing.org

Research

Synergistic effects of non-*Apis* bees and honey bees for pollination services

Claire Brittain[1,2], Neal Williams[2], Claire Kremen[3] and Alexandra-Maria Klein[1]

[1]Institute of Ecology, Ecosystem Functions, Leuphana University of Lüneburg, Lüneburg, Germany
[2]Department of Entomology, University of California in Davis, Davis, CA 95616, USA
[3]Environmental Sciences Policy and Management, University of California in Berkeley, Berkeley, CA 94720, USA

Cite this article: Brittain C, Williams N, Kremen C, Klein A-M. 2013 Synergistic effects of non-Apis bees and honey bees for pollination services. Proc R Soc B 280: 20122767.
http://dx.doi.org/10.1098/rspb.2012.2767

Received: 21 November 2012
Accepted: 12 December 2012

Subject Areas:

In diverse pollinator communities, interspecific interactions may modify the behaviour and increase the pollination effectiveness of individual species. Because agricultural production reliant on pollination is growing, improving pollination effectiveness could increase crop yield without any increase in agricultural intensity or area. In California almond, a crop highly dependent on honey bee pollination, we explored the foraging behaviour and pollination effectiveness of honey bees in orchards with simple (honey bee only) and diverse (non-*Apis* bees present) bee communities. In orchards with non-*Apis* bees, the foraging behaviour of honey bees changed and the pollination effectiveness of a single honey bee visit was greater than in orchards where non-*Apis* bees were absent. This change translated to a greater proportion of fruit set in these orchards. Our field experiments show that increased pollinator diversity can synergistically increase pollination service, through species interactions that alter the behaviour and resulting functional quality of a dominant pollinator species. These results of functional synergy between species were supported by an additional controlled cage experiment with *Osmia lignaria* and *Apis mellifera*. Our findings highlight a largely unexplored facilitative component of the benefit of biodiversity to ecosystem services, and represent a way to improve pollinator-dependent crop yields in a sustainable manner.

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Wild Pollinators Enhance Fruit Set of Crops Regardless of Honey Bee Abundance

Lucas A. Garibaldi,[1*] Ingolf Steffan-Dewenter,[2] Rachael Winfree,[3] Marcelo A. Aizen,[4] Riccardo Bommarco,[5] Saul A. Cunningham,[6] Claire Kremen,[7] Luísa G. Carvalheiro,[8,9] Lawrence D. Harder,[10] Ohad Afik,[11] Ignasi Bartomeus,[12] Faye Benjamin,[3] [illegible] Boreux,[13,14] [illegible] Smitha [illegible]hnan,[14] Yael Mandelik,[11] Margaret M. Mayfield,[24] Iris Motzke,[13,23] Theodore Munyuli,[25] Brian A. Nault,[26] Mark Otieno,[27] Jessica Petersen,[26] Gideon Pisanty,[11] Simon G. Potts,[27] [illegible] Colleen L. Seymour,[31] Christof Schüepp [illegible] [illegible]scharntke,[23] Carlos H. Vergara [illegible] [illegible]estphal,[23] Neal Williams,[37] Alexandra M. Klein[13]

Importance des insectes pollinisateurs sauvages

The diversity and [illegible] of wild insect pollinators have declined in many agricultural landscapes. [illegible] by honey bees in only 14% of the systems surveyed. Overall, wild insects pollinated crops more effectively; an increase in wild insect visitation enhanced fruit set by twice as much as an equivalent increase in hon[illegible] fruit set independently, [illegible] substituted for, pollination by [illegible] agement of both honey bees and diverse wild insect assemblages will en[illegible] global crop yields.

29 MARCH 2013 VOL 339 SCIENCE www.sciencemag.org

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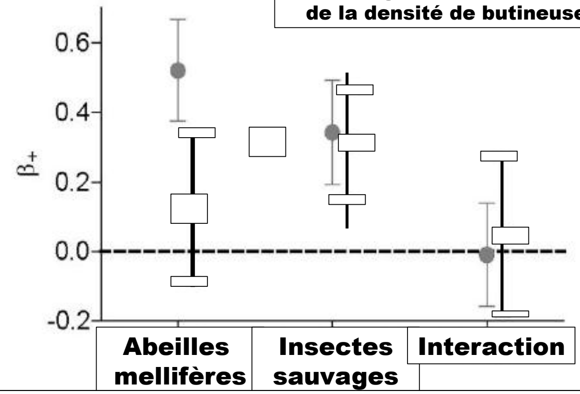
Effet des visites d'abeilles mellifères et des insectes pollinisateurs sauvages sur la pollinisation

Garibaldi & al. 2013. Science

Pente de la charge en pollen des stigmates en fonction de la densité de butineuses

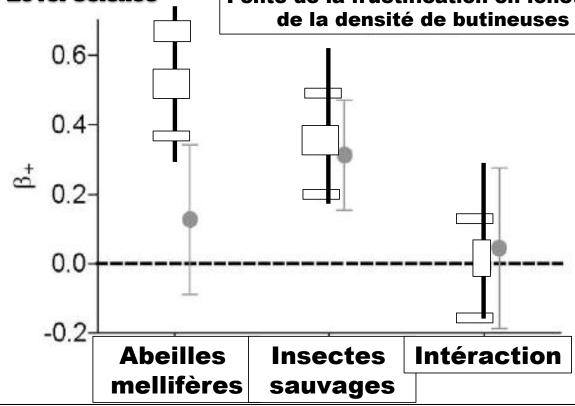


85

Effet des visites d'abeilles mellifères et des insectes pollinisateurs sauvage sur la fructification

Garibaldi & al. 2013. Science

Pente de la fructification en fonction de la densité de butineuses



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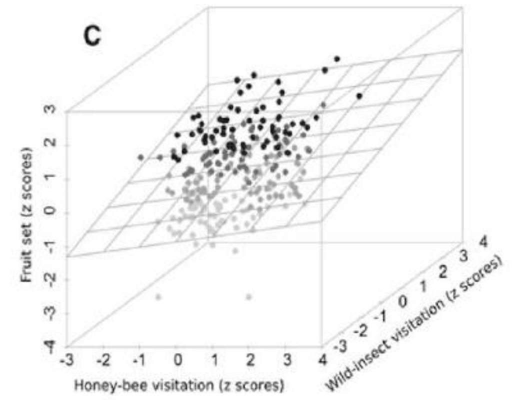
Pas d'interaction & complémentarité entre abeilles sauvages et abeilles mellifères



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Pollinisation intégrée des cultures entomophiles

Service écologique (faune sauvage)

Pratique culturale (colonies en complément)

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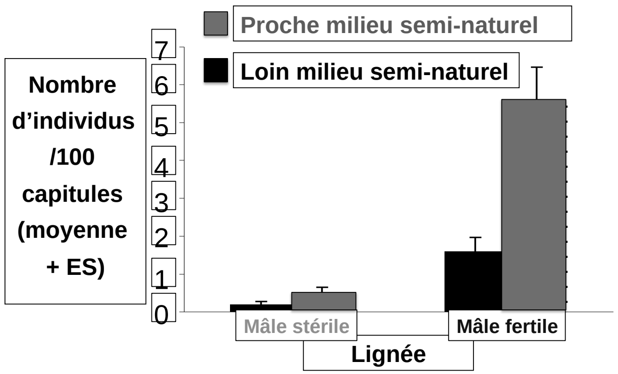
- ***Anthidium** florentinum*
- ***Bombus** hortorum*
- *Bombus humilis*
- *Bombus lapidarius*
- *Bombus pascuorum*
- *Bombus terrestris*
- ***Halictus** quadricinctus*
- *Halictus scabiosae*
- *Halictus simplex*
- *Halictus* sp.
- ***Heriades** crenulata*
- ***Lasioglossum** leucozonium*
- *Lasioglossum malachurum*
- *Lasioglossum nigripes*
- *Lasioglossum zonulum*
- ***Megachile** albisecta*
- *Megachile melanogaster*
- *Megachile melanopyga*
- ***Xylocopa** violacea*

20 espèces d'abeilles sauvages capturées au filet dans 5 parcelles de tournesol en production de semence hybride en 2009 dans la Drôme

90

Influence de la proximité de 19 parcelles au milieu semi-naturel sur l'abondance des abeilles sauvages (Drôme 2007)



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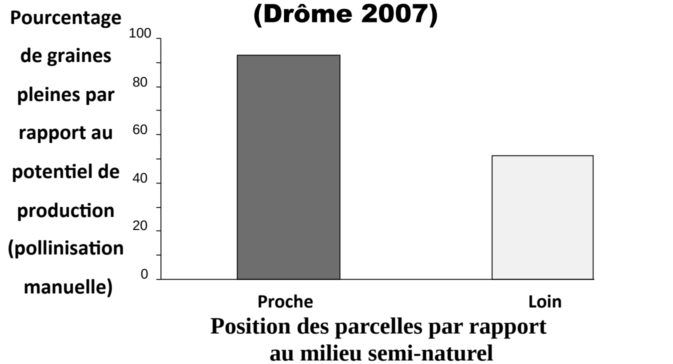
Effet de la proximité des parcelles au milieu semi-naturel sur l'efficacité de la pollinisation du tournesol en production de semence hybride (Drôme 2007)



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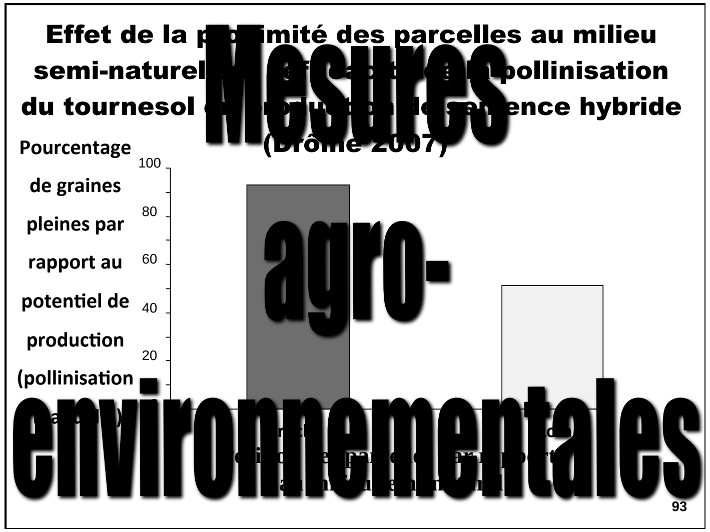

Conclusions

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Mais...
déclin des abeilles
97


Enrayer les causes du déclin ?
Augmenter les sites de nidification
98


Enrayer les causes du déclin ?
2. Parasites & prédateurs
Attention aux
espèces invasives !
Jean Haxaire
99


Enrayer les causes du déclin ?
3. Traitements phytosanitaires
- Ne pas traiter les plantes en fleurs !
- Adopter une approche de lutte intégrée
- Minimiser la lutte chimique et utiliser la lutte biologique autant que faire se peut
100

FP7 2010-2014

Status & Trends of European Pollinators

STEP

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La ville et ses abeilles

http://www.urbanbees.eu

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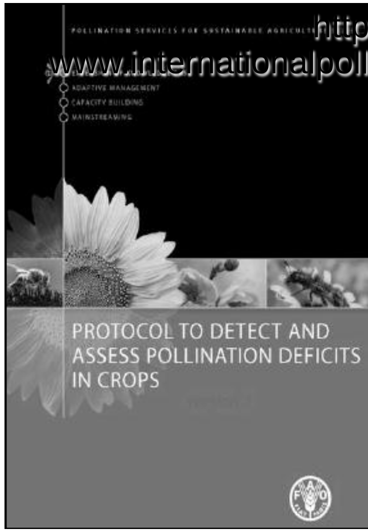
http://www.internationalpollinatorsinitiative.org/



International Pollinator Initiative

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Base de données photographiques & bibliographiques en ligne

http://www.florapis.org

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Objectifs

- **Mesurer l'activité pollinisatrice des abeilles domestiques vis-à-vis de la biodiversité végétale nationale, en particulier pour les espèces de plantes rares, protégées ou patrimoniales**
- **Mieux évaluer l'importance écologique des abeilles mellifères sur le territoire national métropolitain**

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FLORAPIS aujourd'hui

891 séries validées sur 1167 soumises

531 espèces végétales dont

51 font l'objet d'une protection

(2 niveau international

7 niveau national

34 niveau régional)

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Plan national d'actions
en faveur des insectes
pollinisateurs sauvages
10 mars 2015
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Merci de votre attention
C. Pleindoux & N. Morison, INRA Avignon
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N. Morison, INRA Avignon