The importance of grazing livestock for farmland biodiversity

Pierre Jay-Robert

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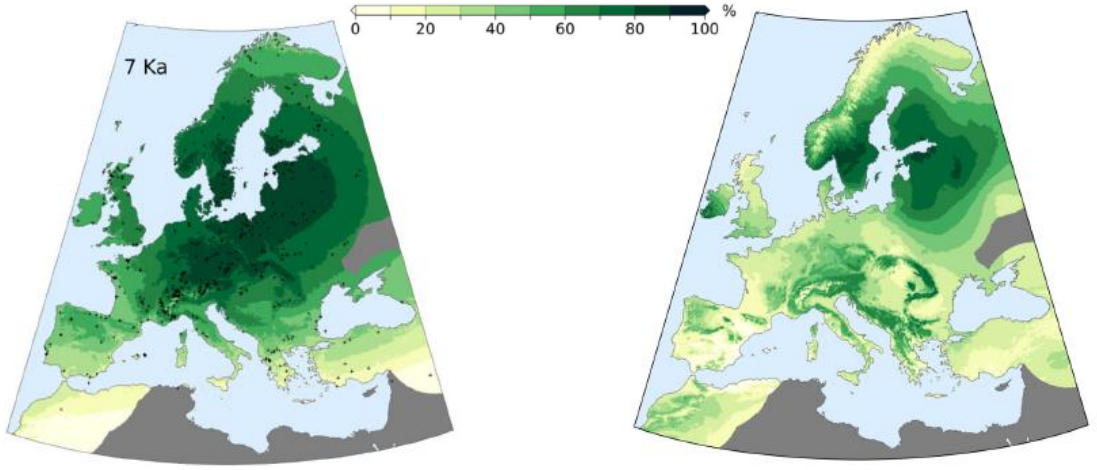
WORKSHOP ON LIVESTOCK AND BIODIVERSITY IN EUROPE – NATURE AS SOLUTION IN GRAZING SYSTEMS?

A short history

Europe before agriculture

forest cover reconstruction
(pollen data)



7 000 BP

present

Front. Plant Sci. 9:253. doi: 10.3389/fpls.2018.00253

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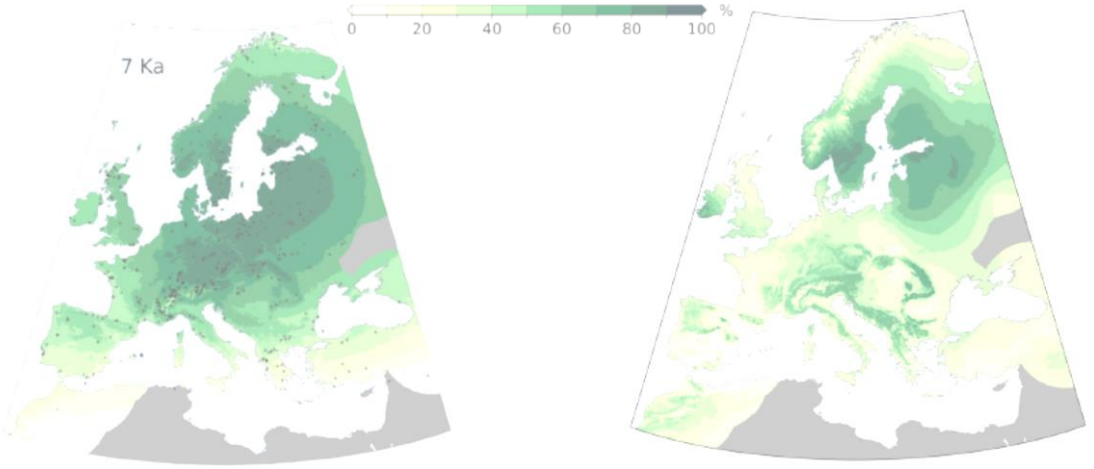

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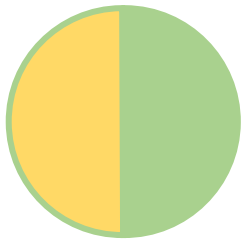
« *Sans engrais point de récolte, sans bestiaux pas d'engrais* » Instruction de la Convention Nationale, 1794
"Without manure no harvest, without cattle no manure"

ploughed



meadow (50% to 75% = grazed)

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Histoire des agricultures du monde – Mazoyer Roudart 2002

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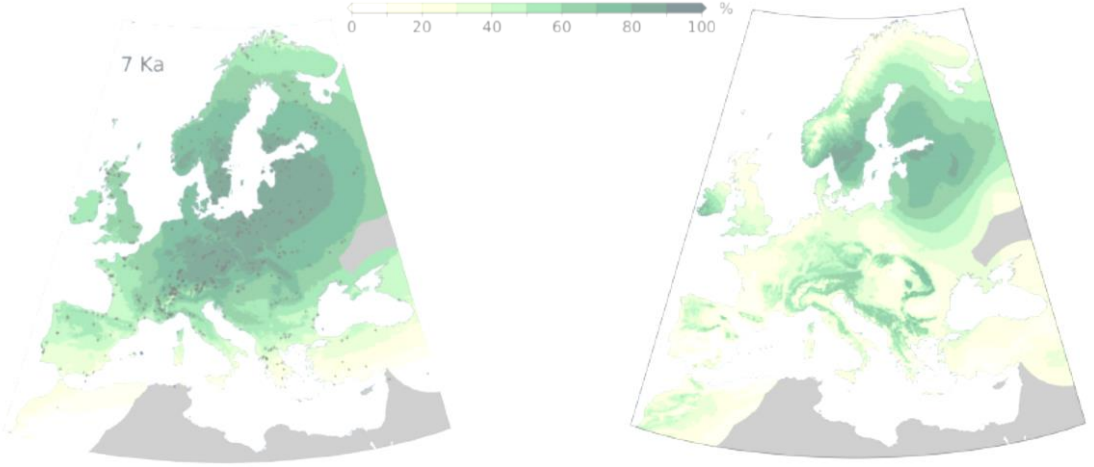

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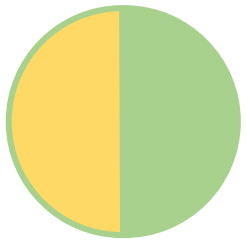

meadow (50% to 75% = grazed)

- ✓ from light to heavy plough → Q(manure)*7.5
- ✓ end of common grazing land
  & development of artificial meadow → Q(manure)*2

⇨ ↗ fertilization ↗ population ↘ forest

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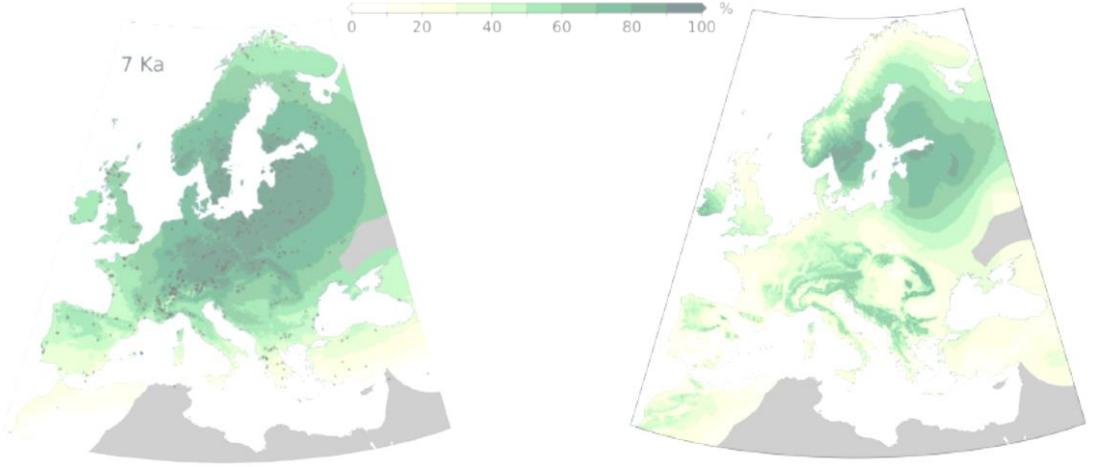

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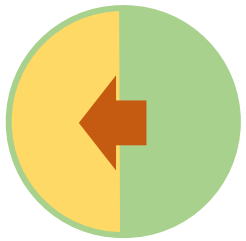

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Livestock = manure & traction
Production of arable land depends on animals fed with grass.

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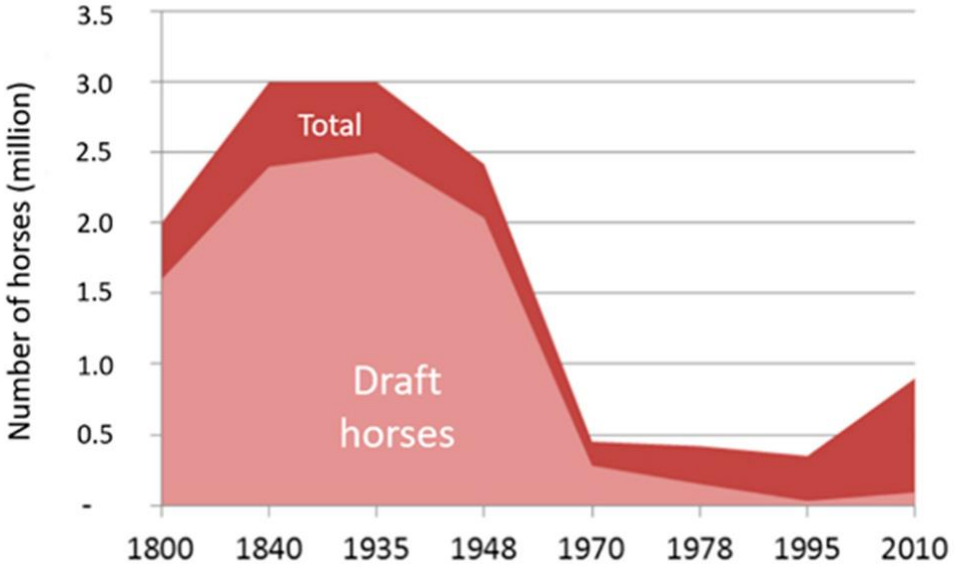
Histoire des agricultures du monde – Mazoyer Roudart 2002

European agriculture with chemicals and motors

1870-1914 : sheep population *0.5 in France, *0.2 in Germany

- ✓ useless for manure, useless for traction
- ✓ specialization of regional productions (meat, cheese…)



Evolution of the horse population in France from 1800 to 2010

Animals 2020, 10, 106; doi:10.3390/ani10010106

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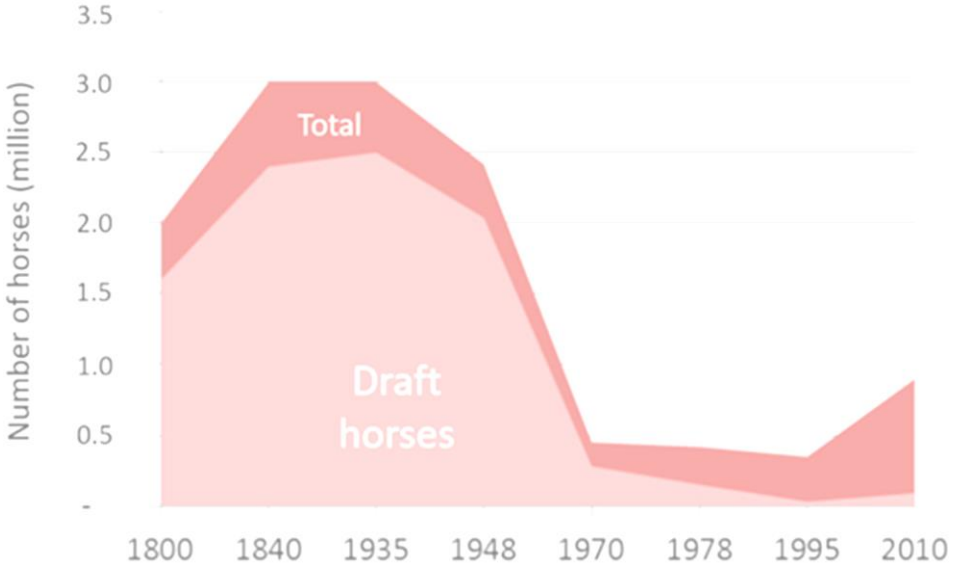
dependency reversal:

up to now: grazing lands → livestock → crops

now: fertilizer → crops → livestock



Evolution of the horse population in France from 1800 to 2010

Early 20th: hay (15Kg per day) → 1 dairy cow → 2000 L milk per year

Late 20th: feed (15Kg per day) + hay (5Kg per day) → 1 dairy cow → 10 000 L milk per year

↗ break-even point → ↗ livestock/farm

Animals 2020, 10, 106; doi:10.3390/ani10010106

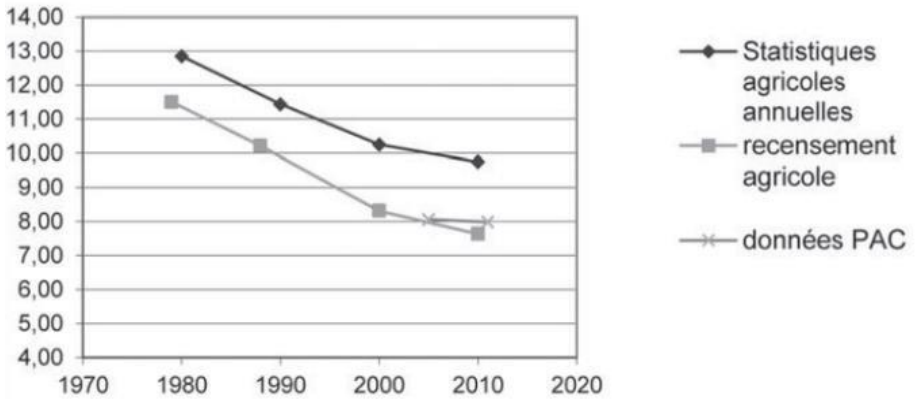
Histoire des agricultures du monde – Mazoyer Roudart 2002

Historically:

- grazing was widespread (highly connected plots), periodic (rotation), rarely intensive.
- meadows were abundant (haymaking).
- forests were overused (firewood) and partly grazed.
- manure was exported to cropping.

Now:

- landscape is a patchwork with fixed uses (culture vs breeding vs forest).
- intensification & eutrophication go hand in hand.
- natural meadows rarefied while forests are sanctuarised.



Permanent meadows / France (millions ha)

Historically:

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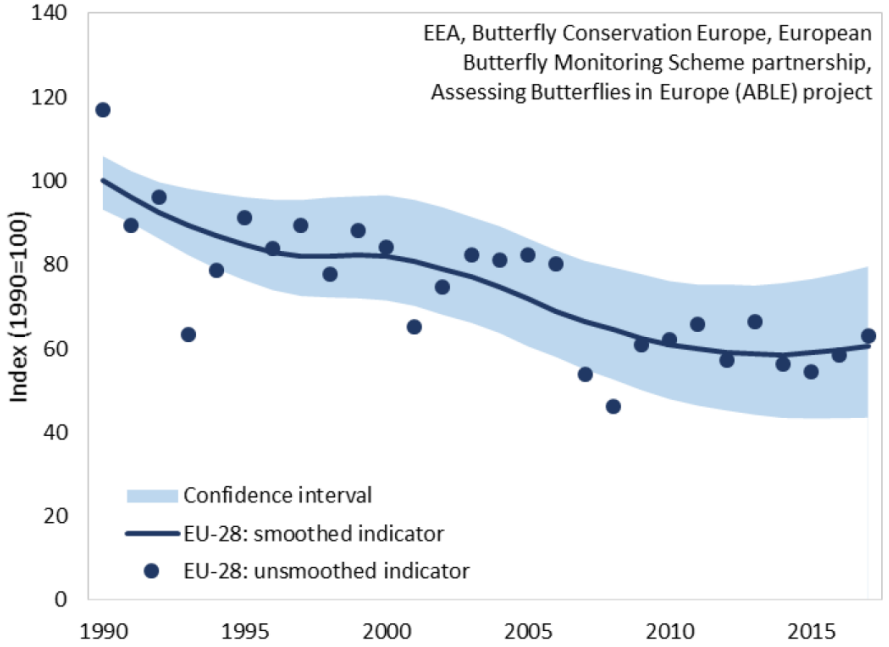


What ecological effects?

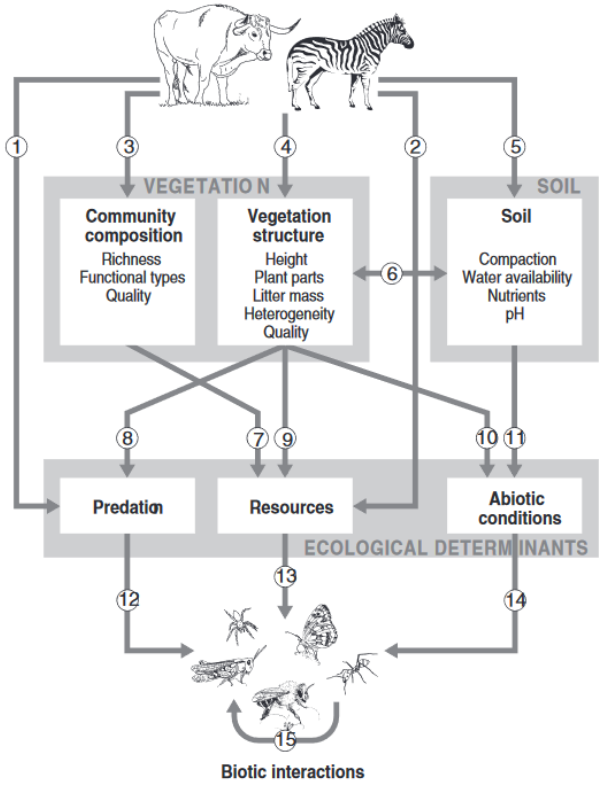
✓ Rarefaction of permanent natural meadows → habitat loss for herbaceous plants & associated species

✓ Permanency in local use → stability in habitat location

✓ Eutrophication → advantage for (the few) species able to monopolize the resource

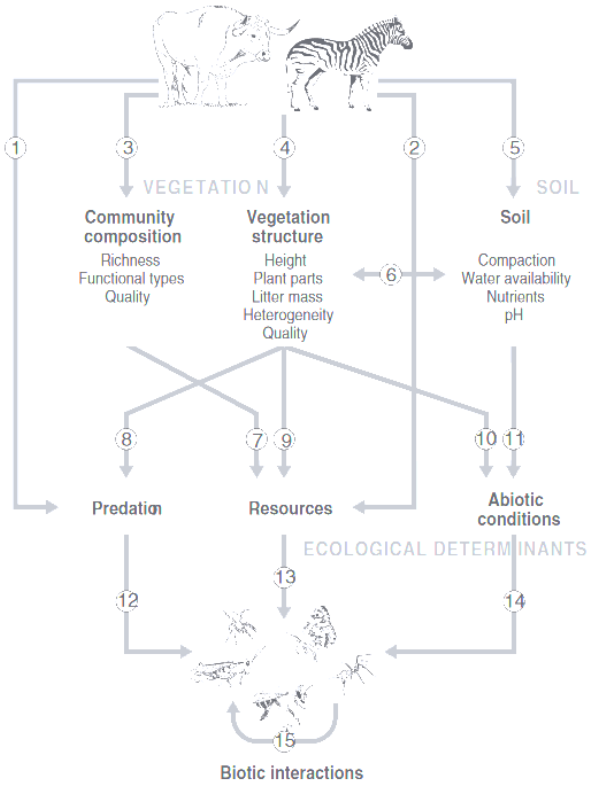
The EU Butterfly Indicator for Grassland species: 1990-2017: Technical Report. Butterfly Conservation Europe.

A short history **Let's focus on dung…**



- ✓ Herbivory
- ✓ Trampling
- ✓ Restitution

Biol. Rev. (2015), 90, pp. 347–366. doi: 10.1111/brv.12113



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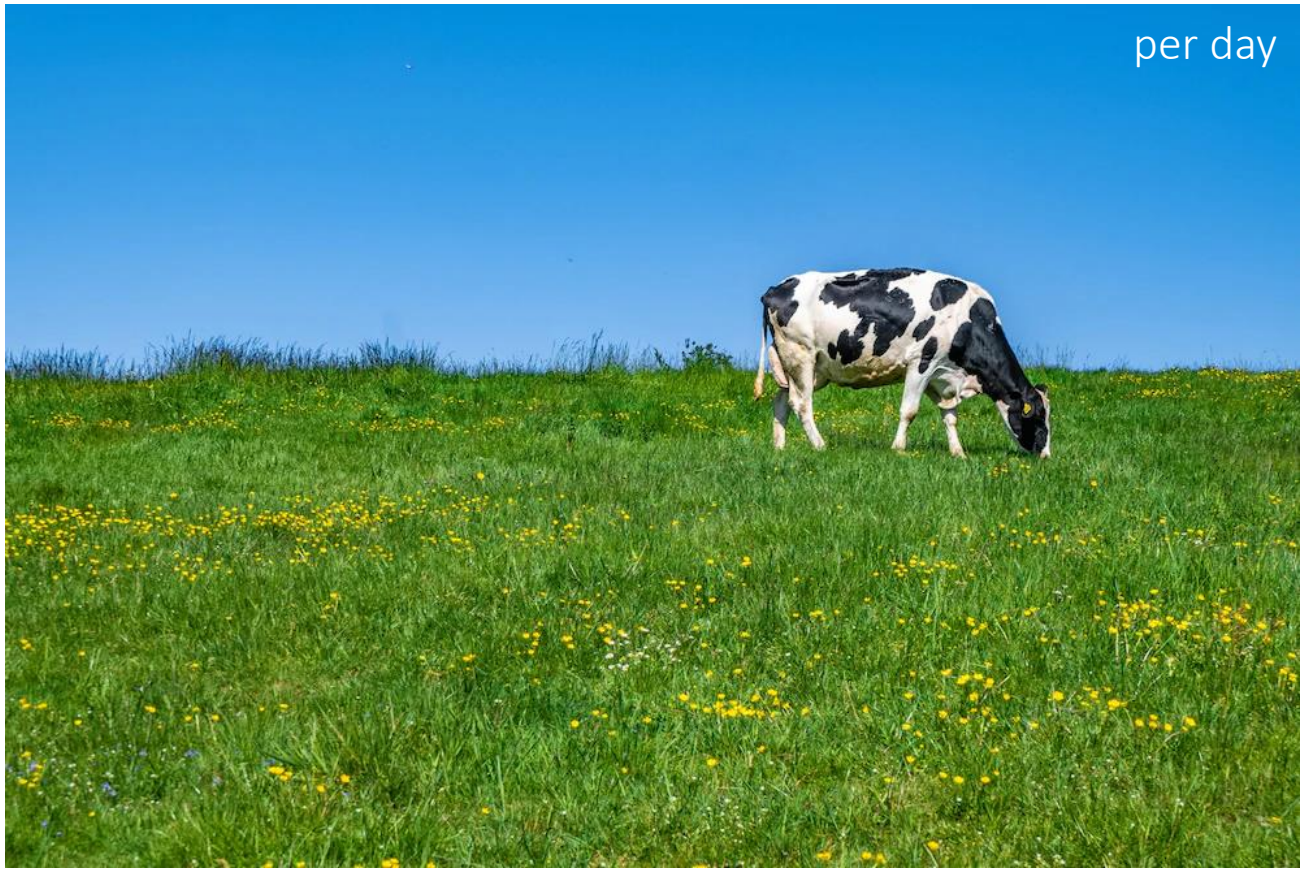

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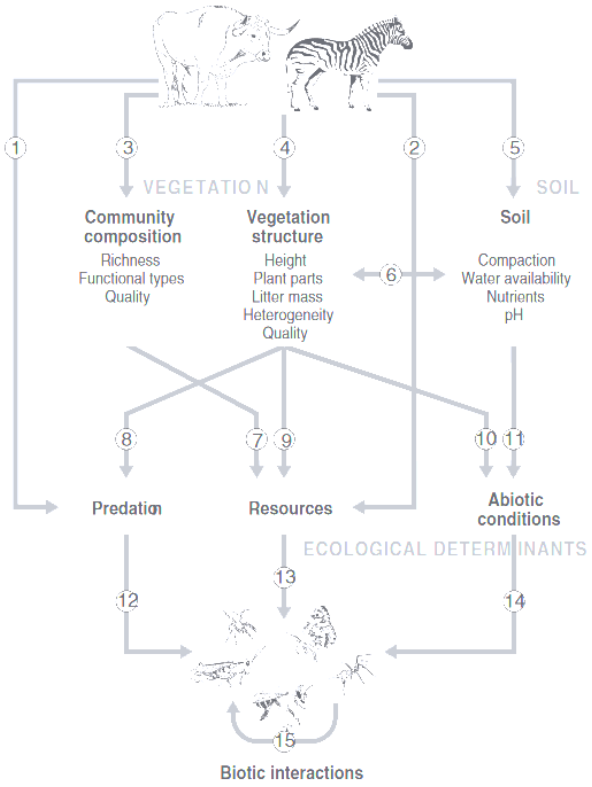
INRA Prod. Anim., 2012, 25 (1), 45-56



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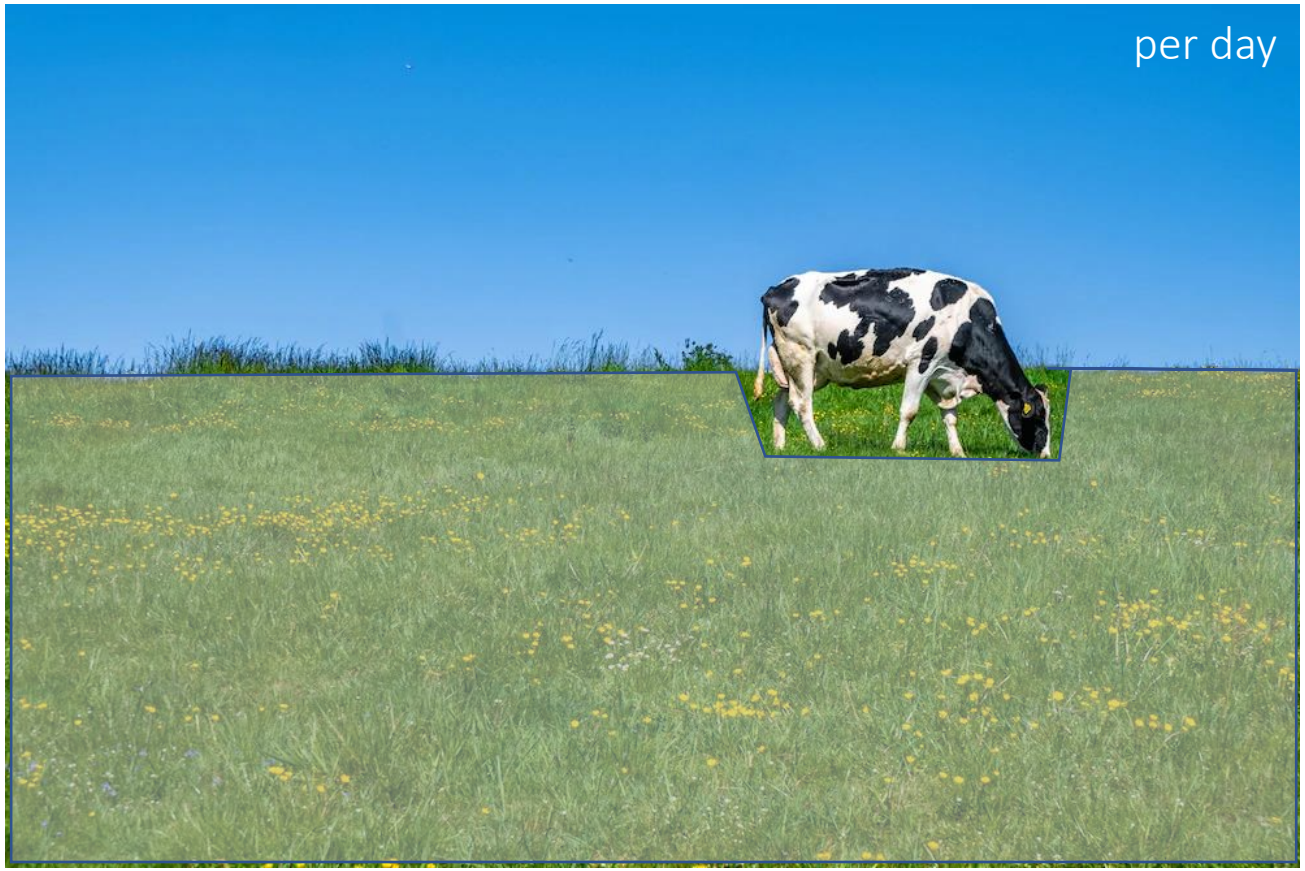

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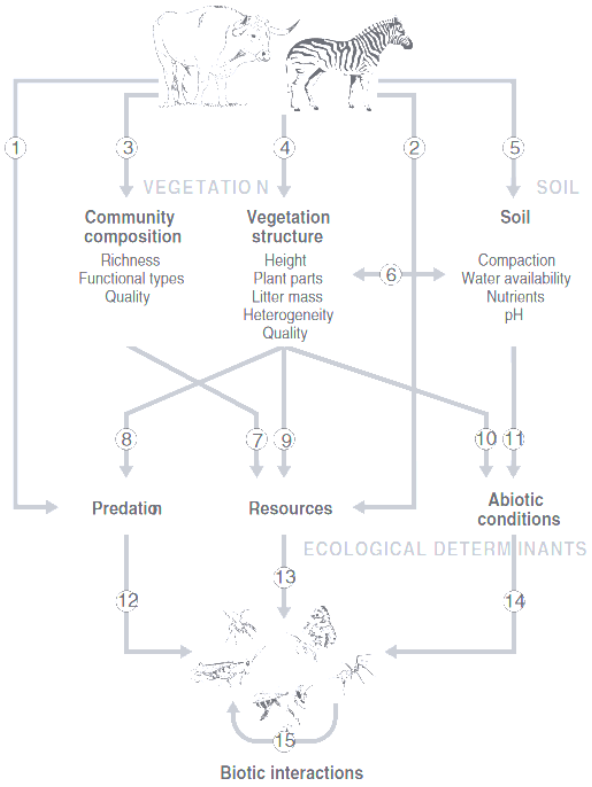

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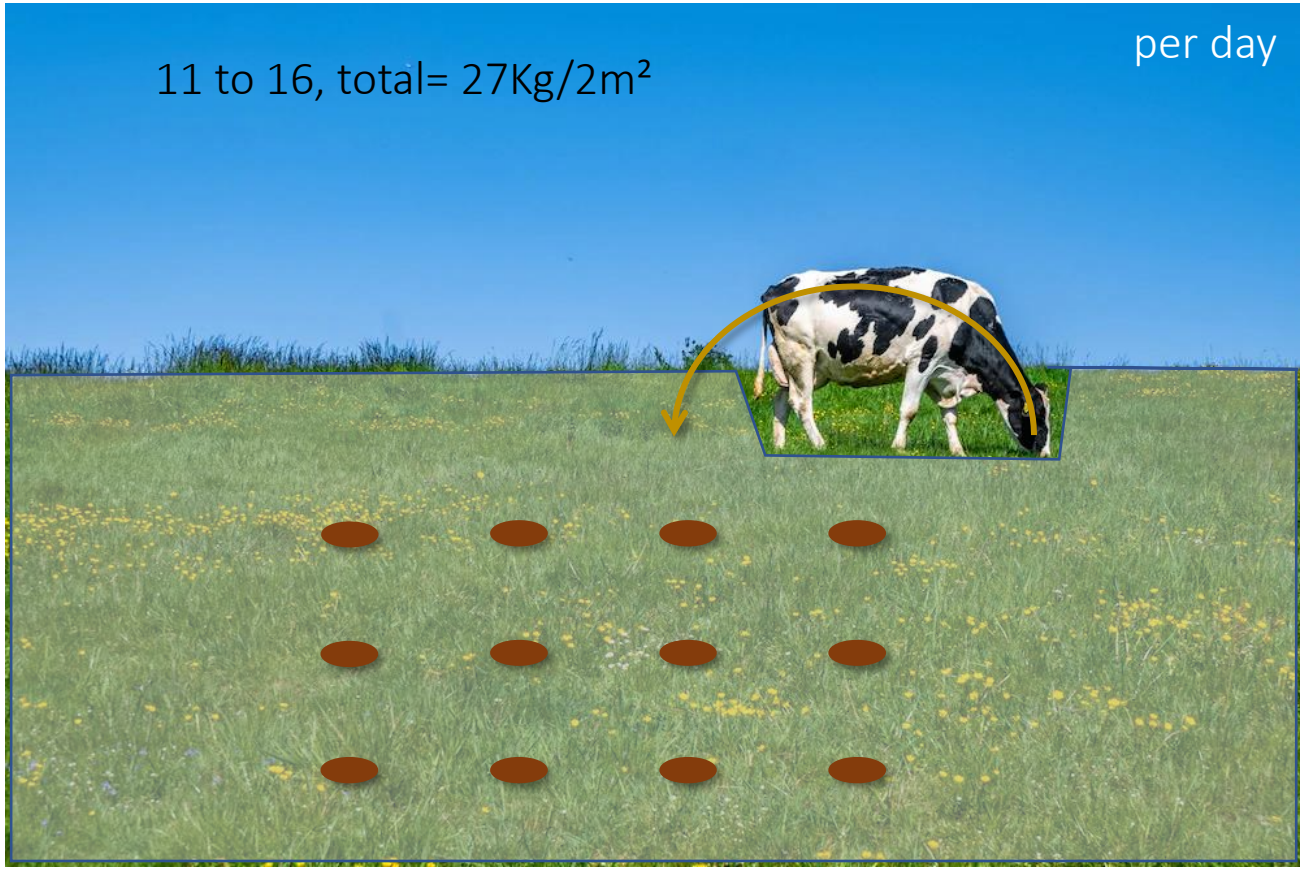

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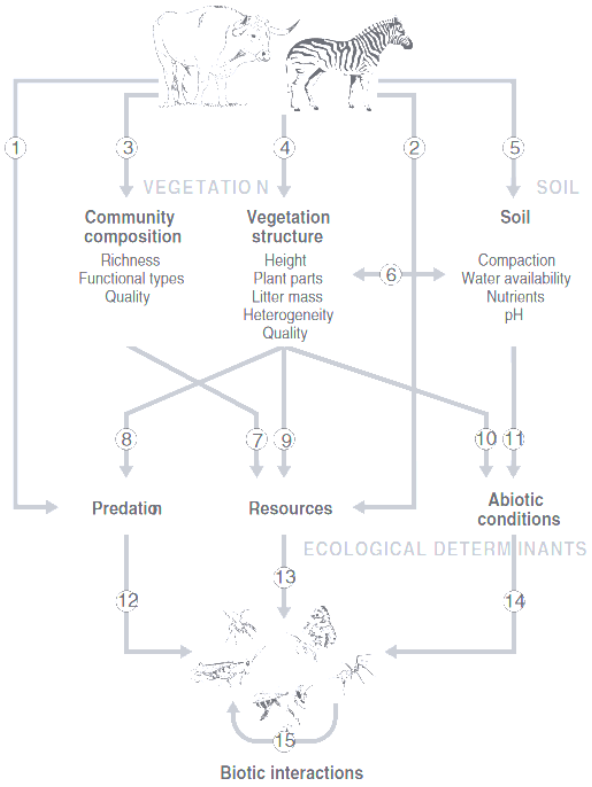

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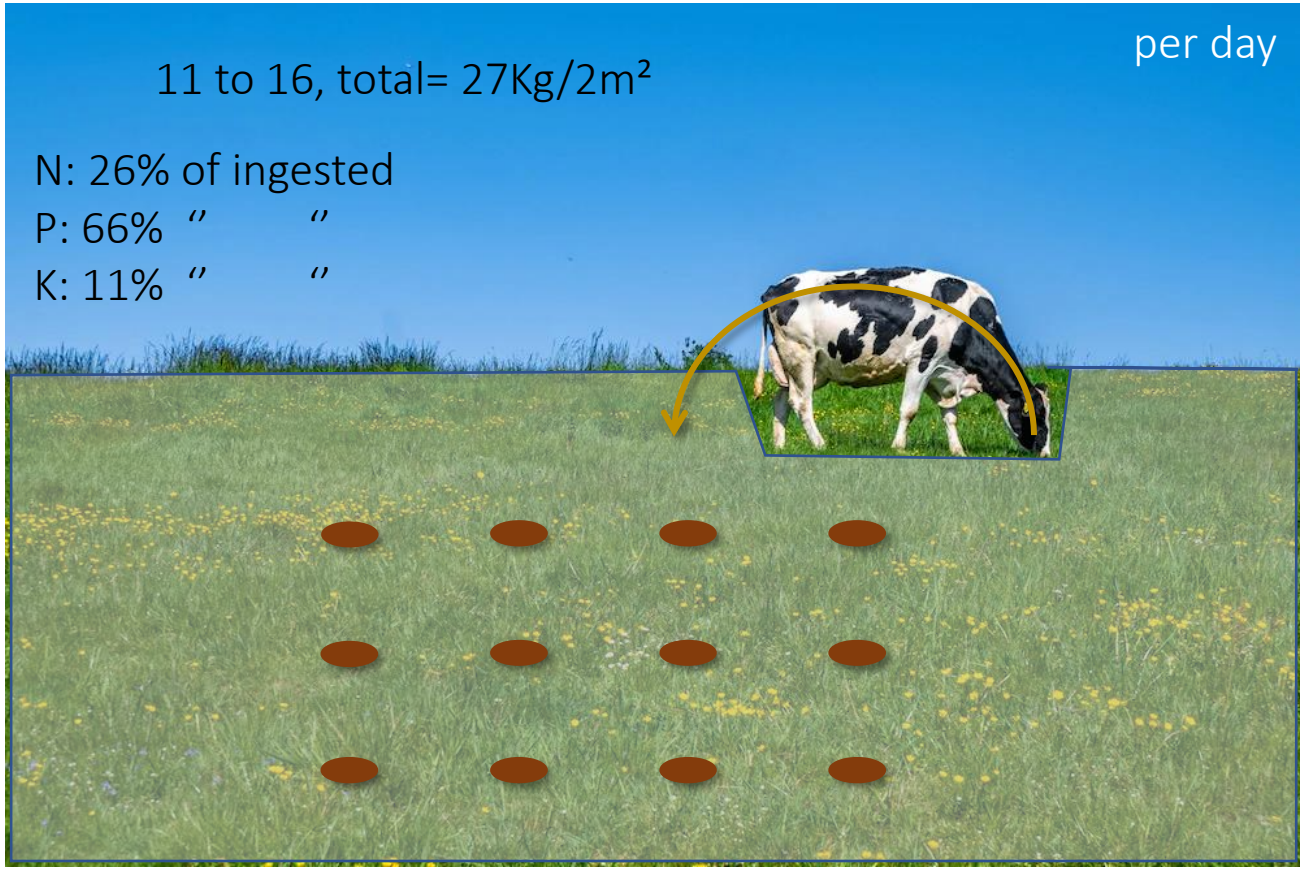

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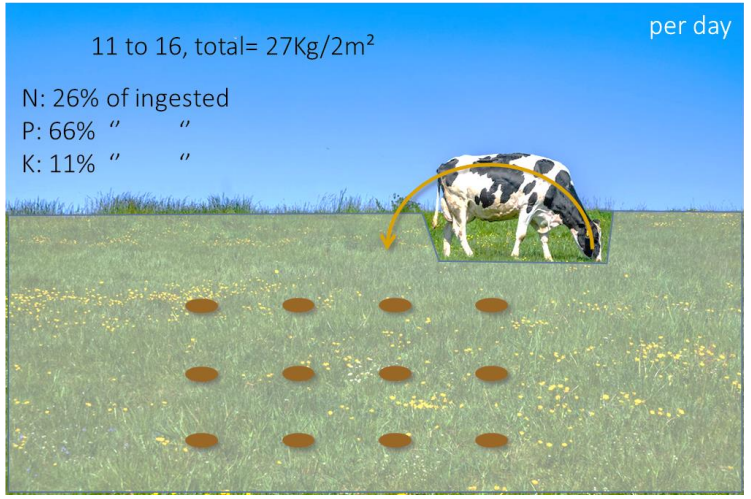

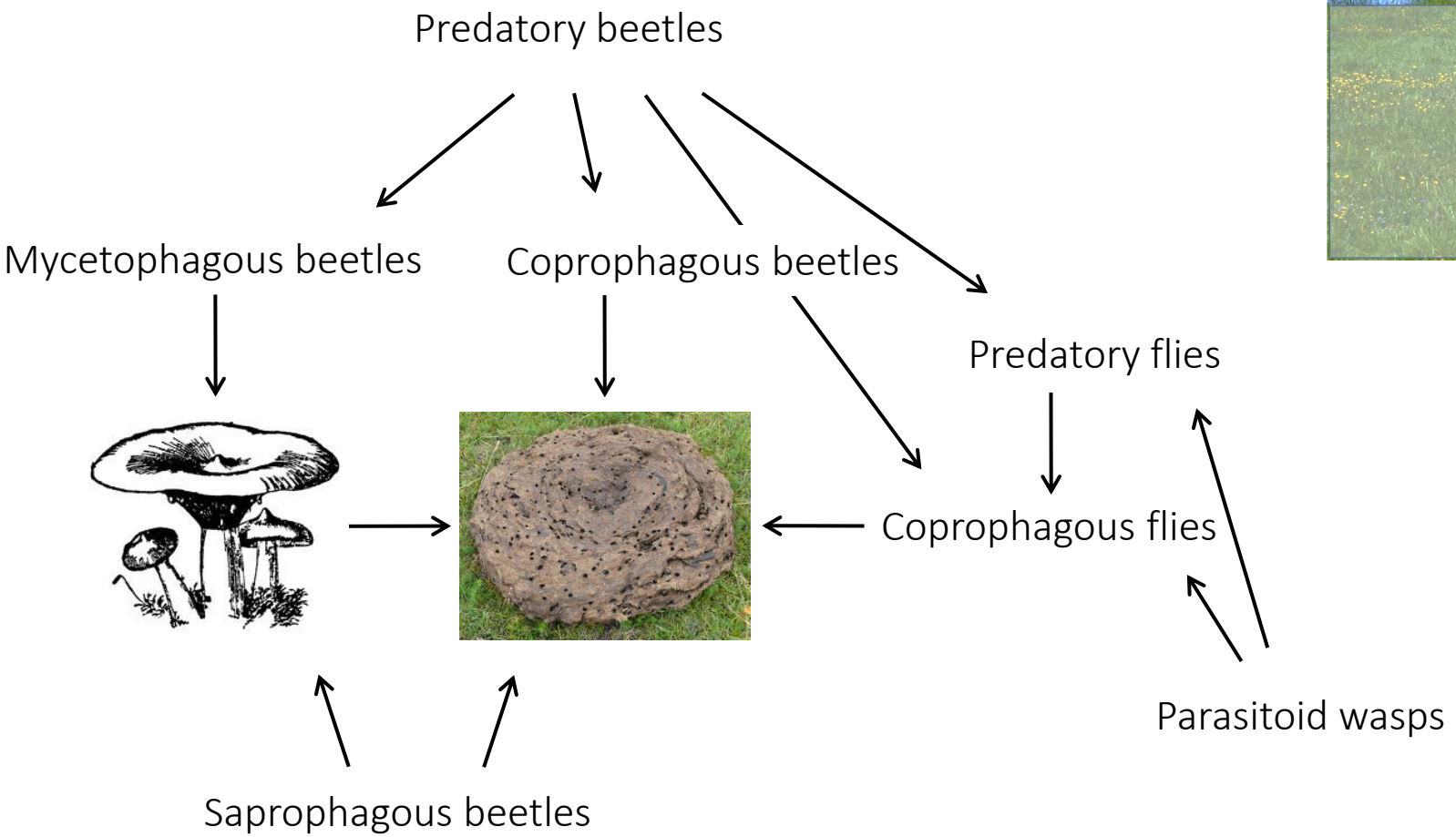

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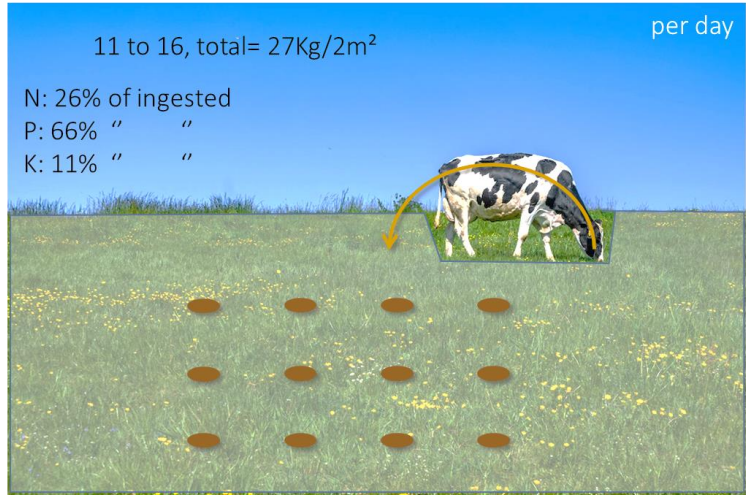


Predatory beetles

Mycetophagous beetles

Coprophagous beetles

Predatory flies

Coprophagous flies

Parasitoid wasps

Saprophagous beetles

in biomass per year (England)

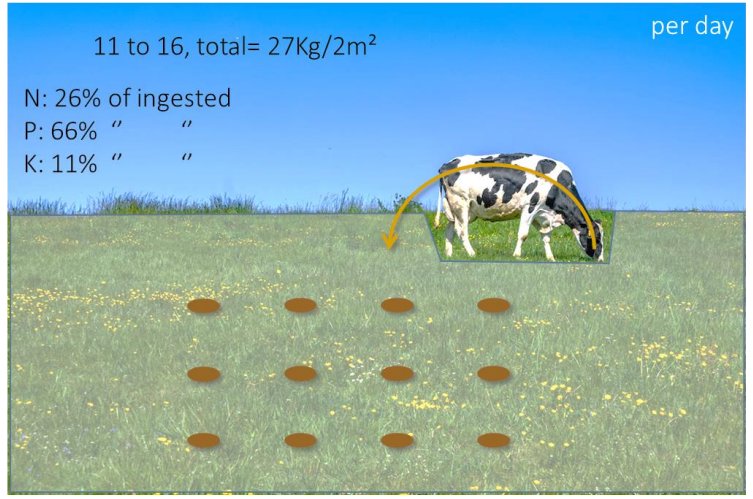
dung= 19*cow

fly larvae= 0.2*cow

(> 2 millions individuals/cow)

INRA Prod. Anim., 2012, 25 (1), 45-56

Journal of Animal Ecology , 1954, 23 (2), 234-260



Predatory beetles

e.g.
Histeridae
Staphylinidae

e.g.
Scarabaeidae
Staphylinidae

Mycetophagous beetles

e.g.
Geotrupidae

Coprophagous beetles

Predatory flies

e.g.
Muscidae

Coprophagous flies

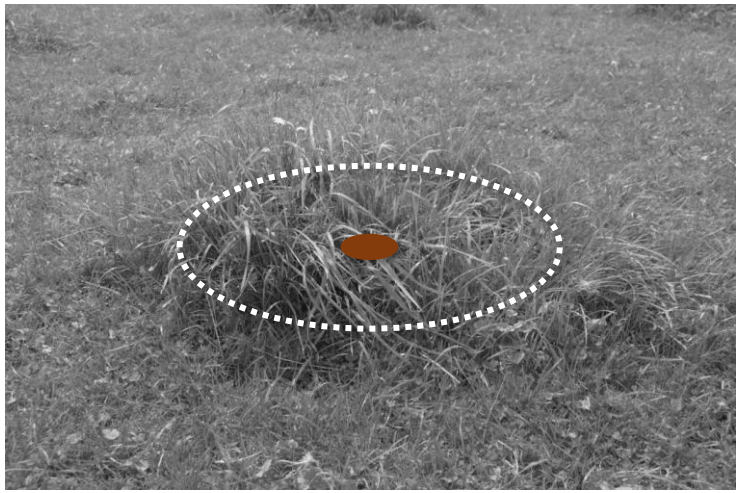
e.g.
Muscidae
Sepsidae

Parasitoid wasps

e.g.
Braconidae
Ichneumonidae

Saprophagous beetles

e.g.
Staphylinidae



(Ireland)

high sward islet

0.75*surface

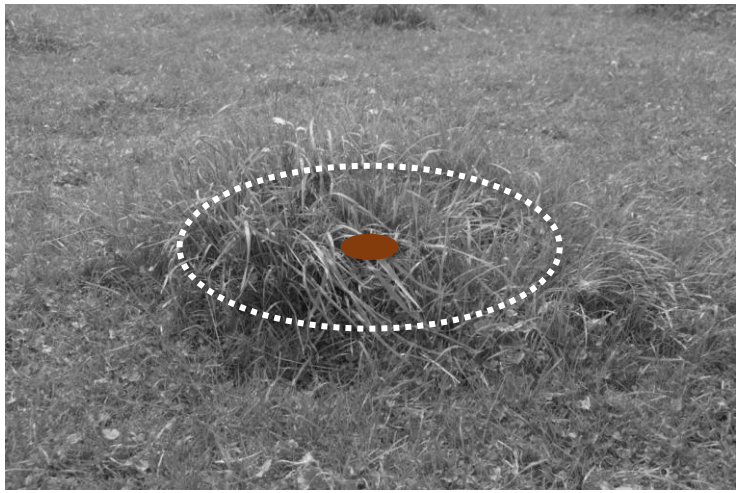
0.25*surface

Aranae
Coleoptera
Diptera
Hemiptera
Hymenoptera

0.43-0.52*abund.

- micro-habitat
- presence of dung
- no grazing perturbation

Insect Cons. & Div., 2010, 3 (4), 291-301



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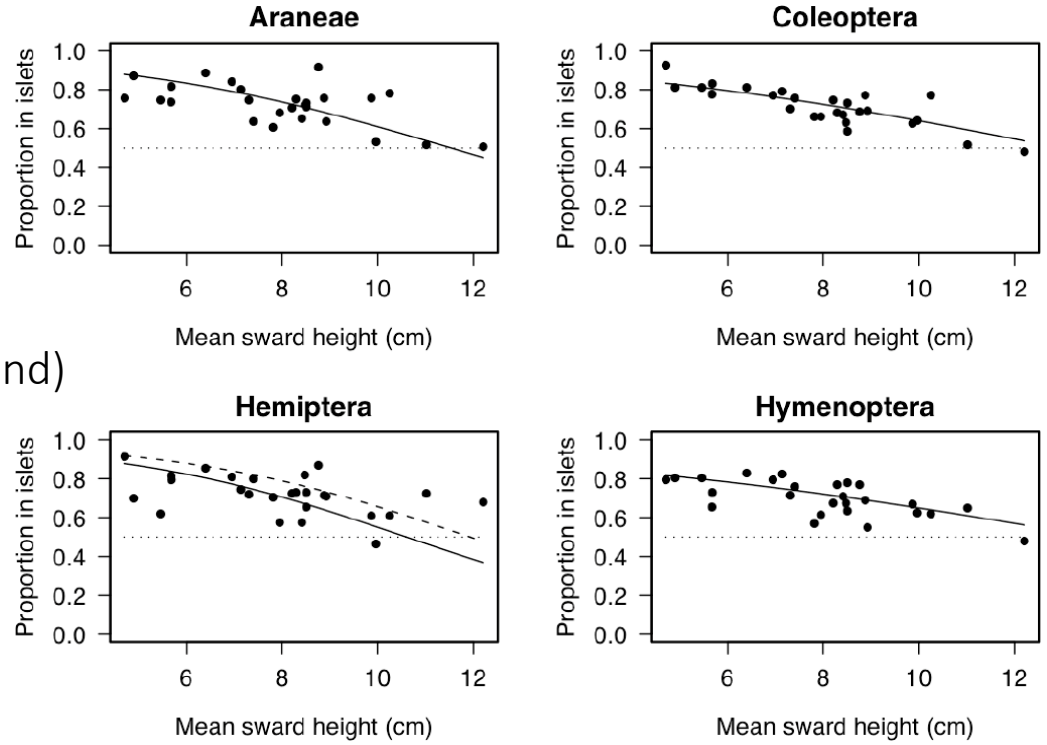
Proportion of abundance=
f(contrast between islets and sward around)



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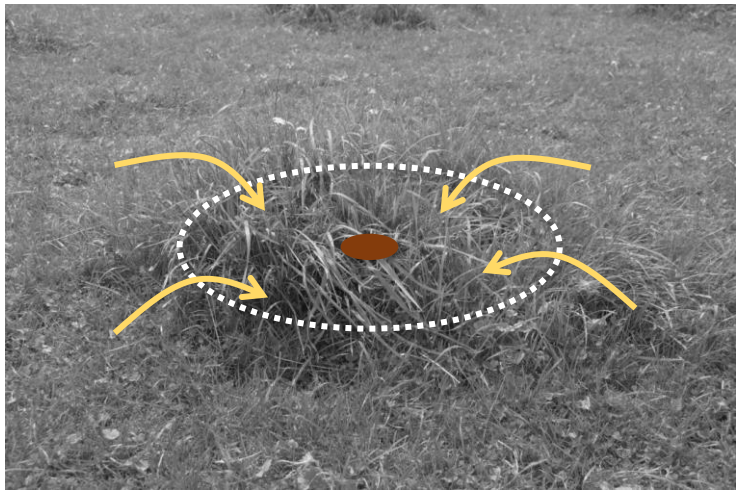

(Ireland)

refuge, except for Diptera

Proportion of abundance=
f(contrast between islets and sward around)

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Coleoptera
Diptera
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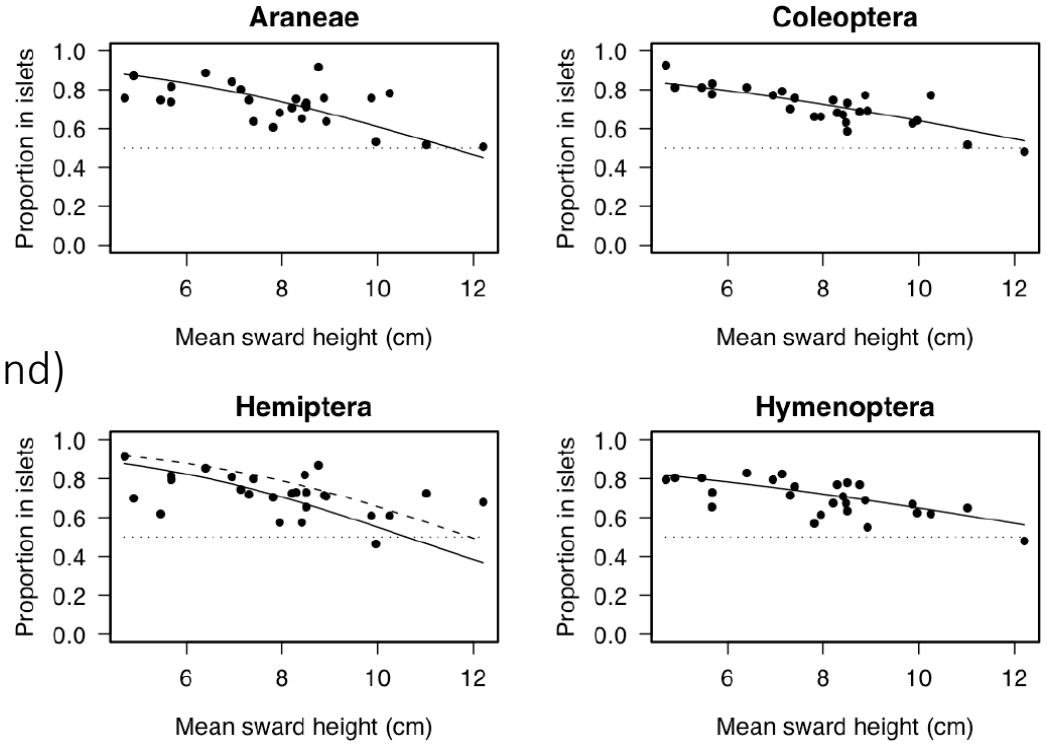

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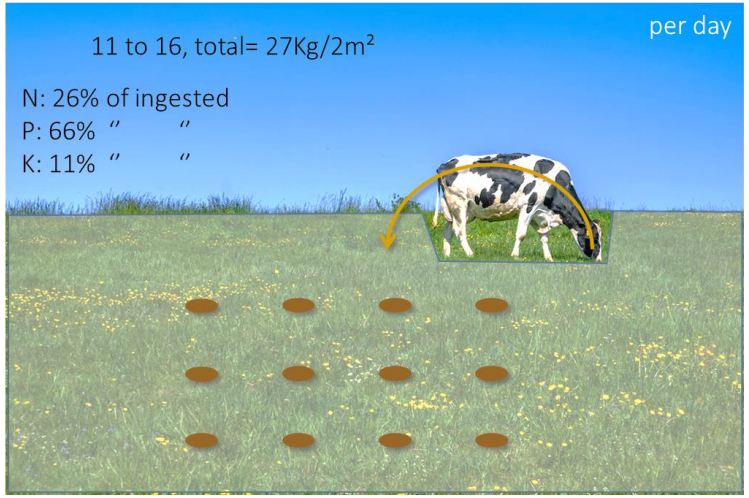

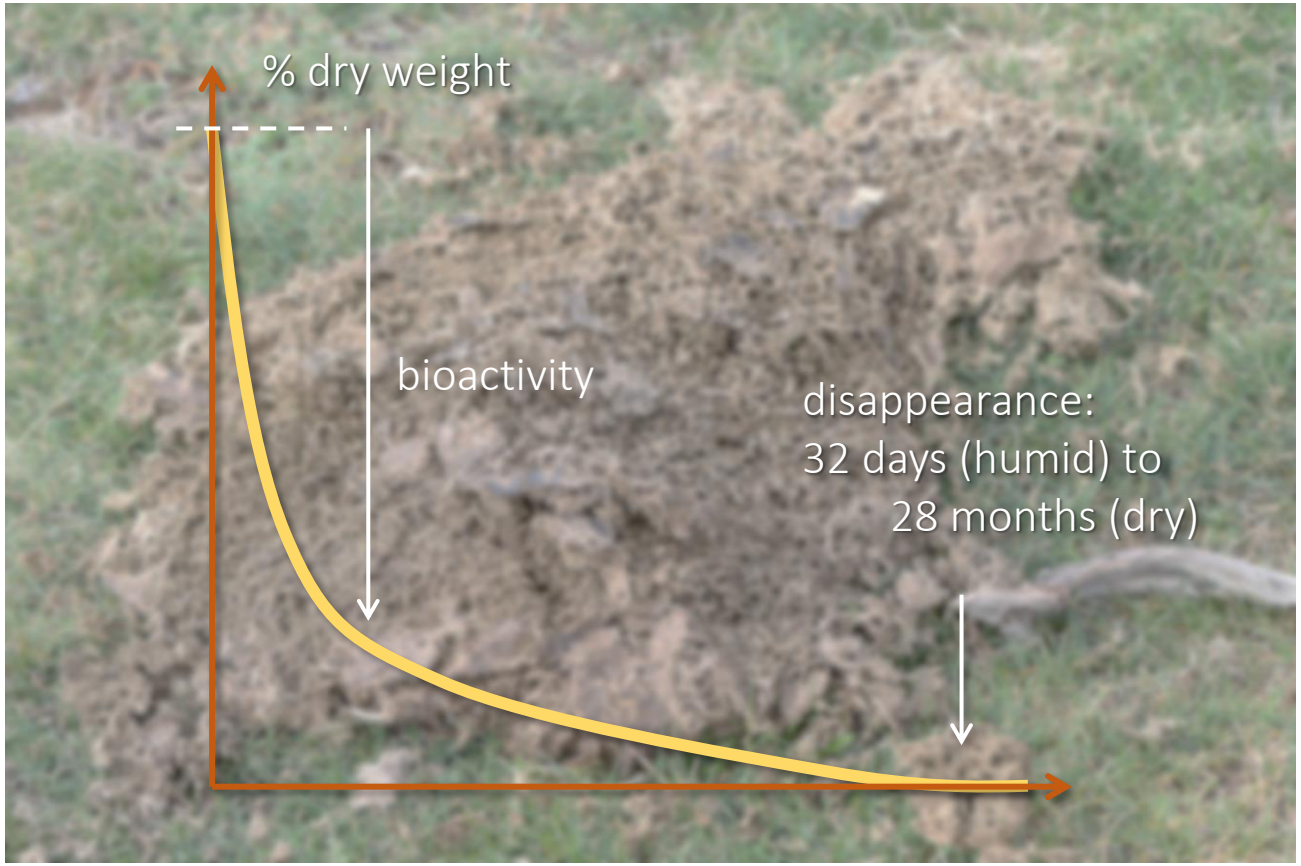

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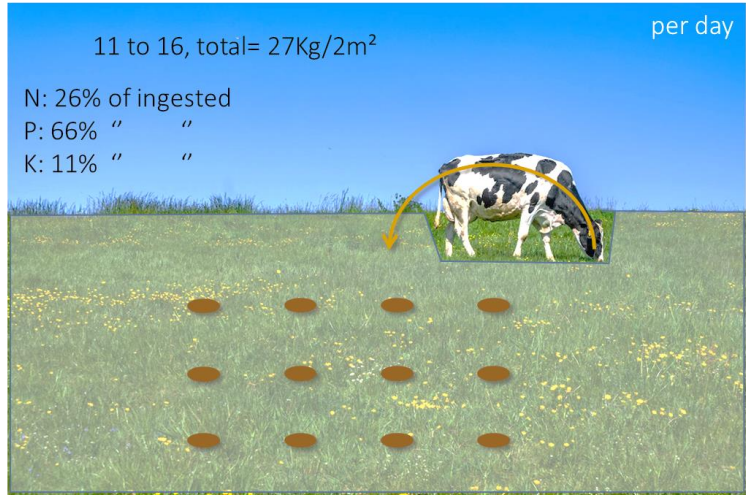
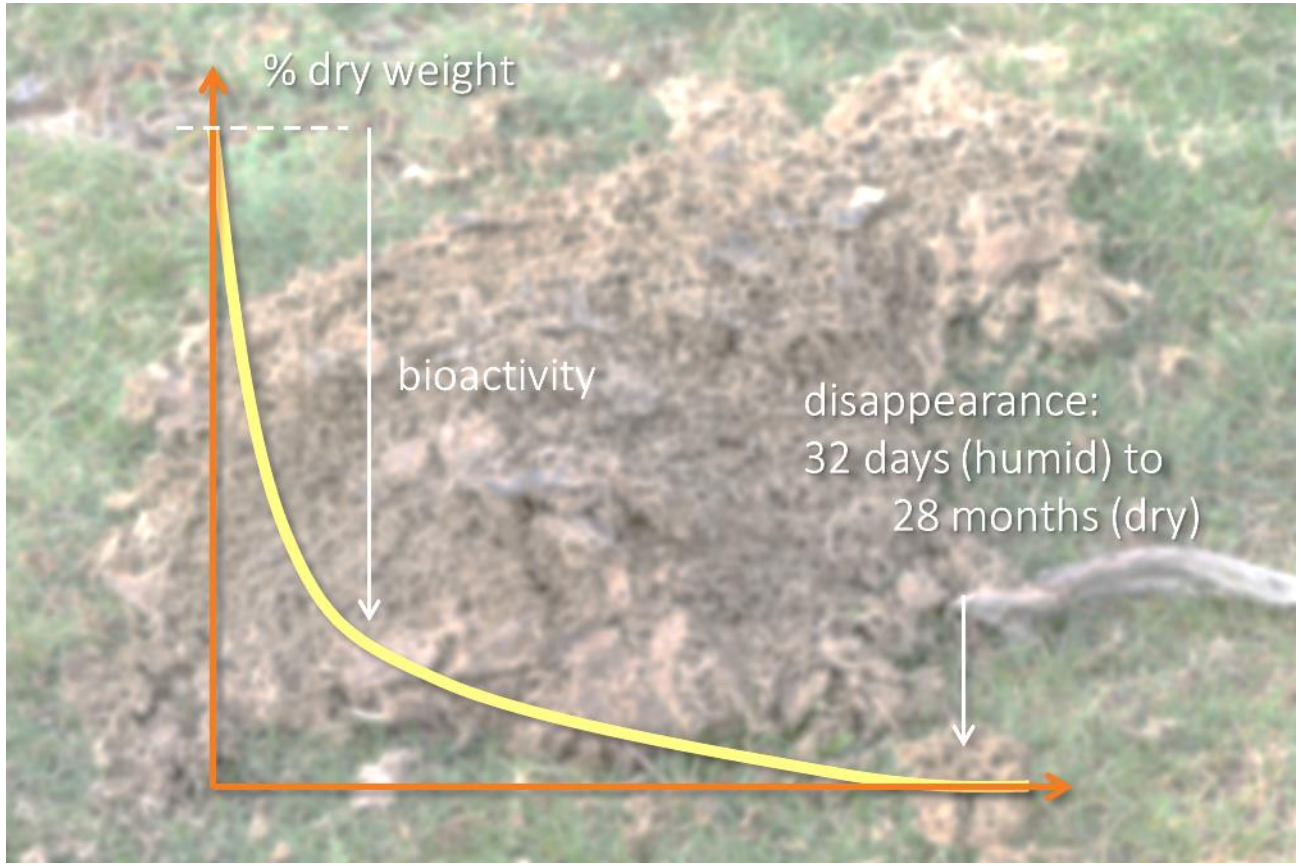
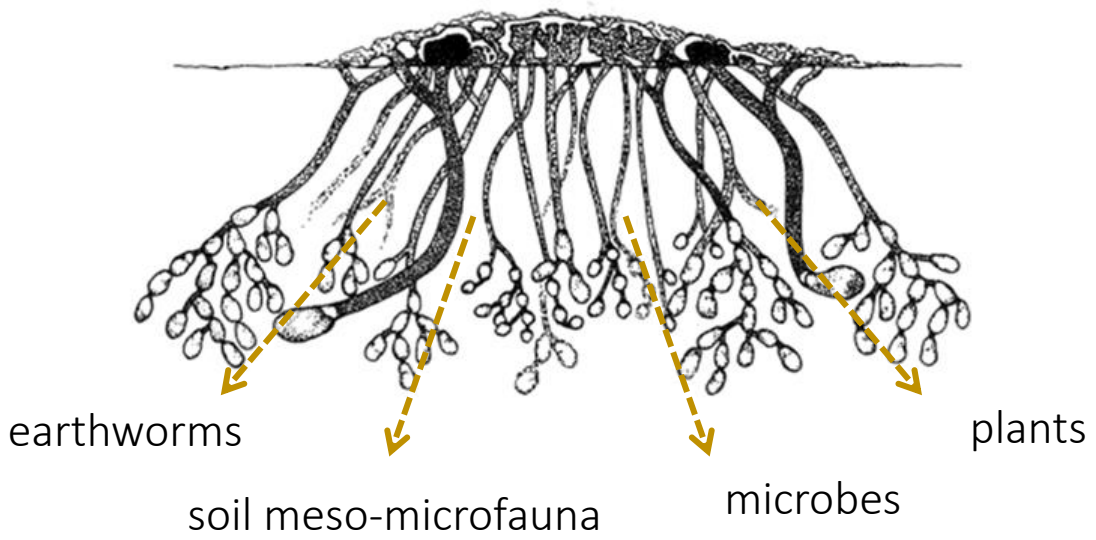


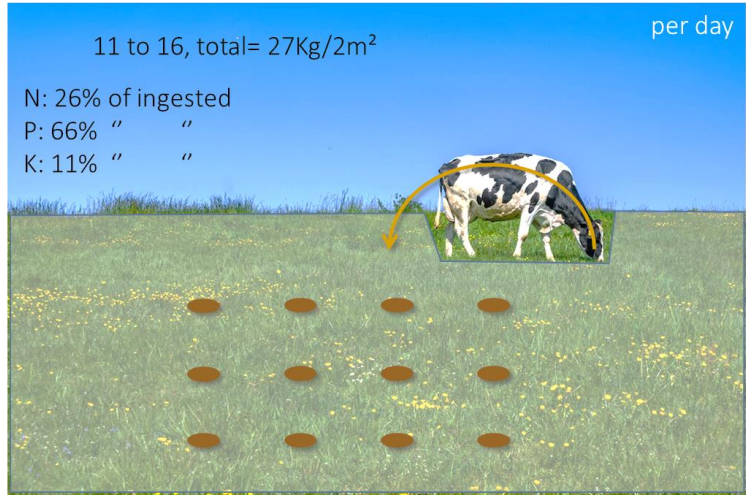


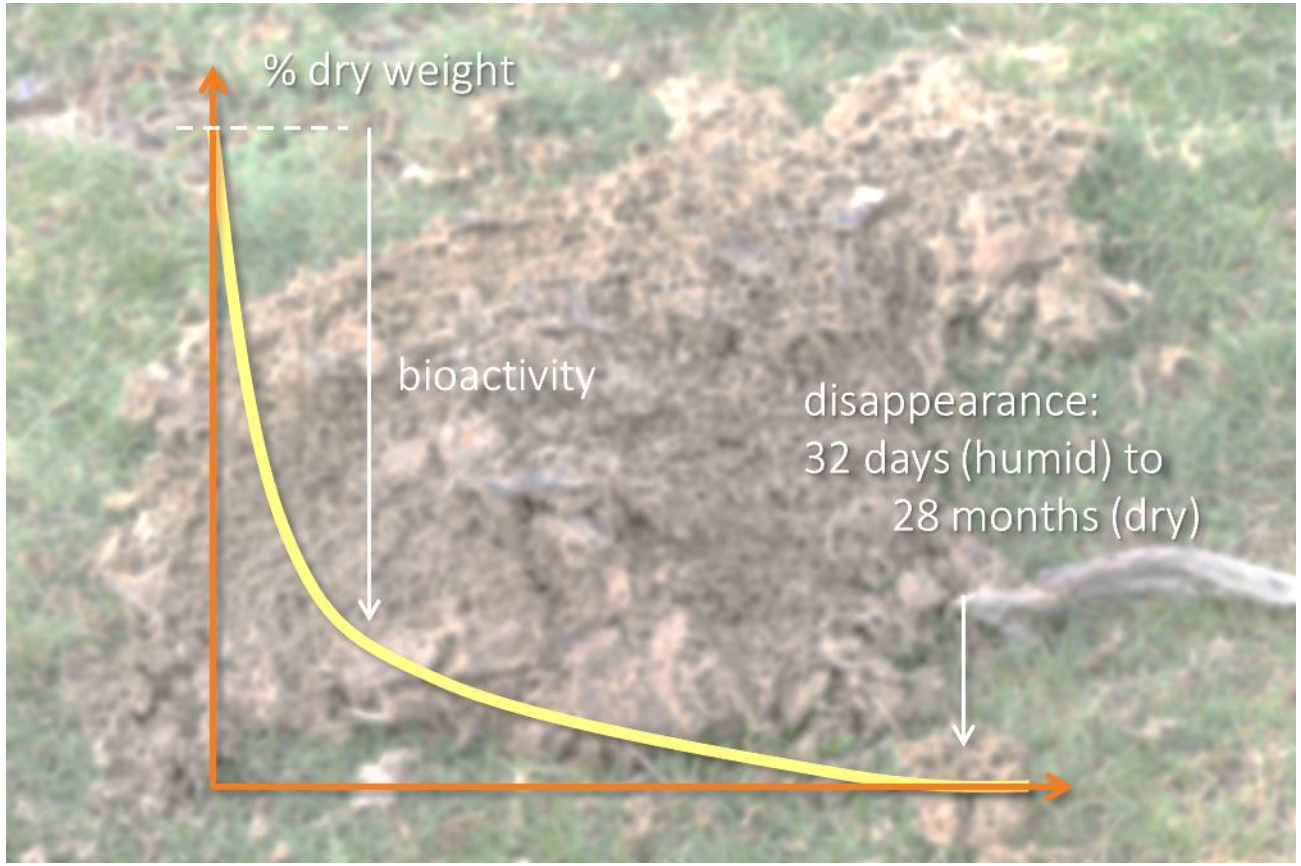


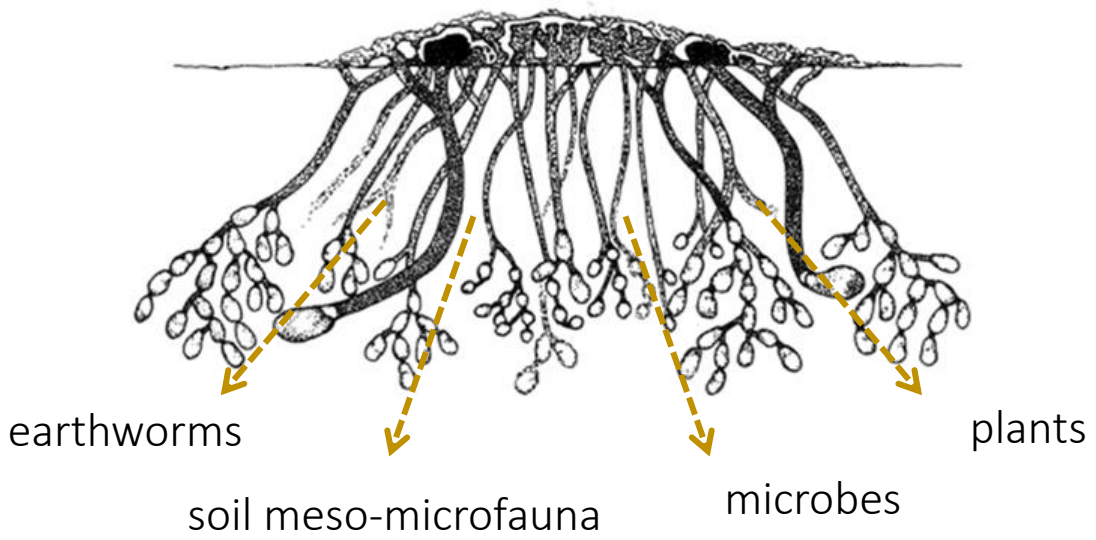
INRA Prod. Anim., 2012, 25 (1), 45-56

AMRC Review. Australian Meat Research Committee, 1976, 30, 1-30

Aphodiinae dung beetles (Denmark)
Community (13 sp.) assimilated approx. 2% of cow pat energy.







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Oikos, 1982, 39, 213-227

AMRC Review. Australian Meat Research Committee, 1976, 30, 1-30

Dung beetles (Southern France)
5 years after change in trophic resource
14,500 ind. – 43 species

resource*3

Journal of Applied Ecology, 1992, (29), 349-356

Journal of Animal Ecology , 1954, 23 (2), 234-260

Dung beetles (Southern France)
5 years after change in trophic resource
14,500 ind. – 43 species

resource*3 →

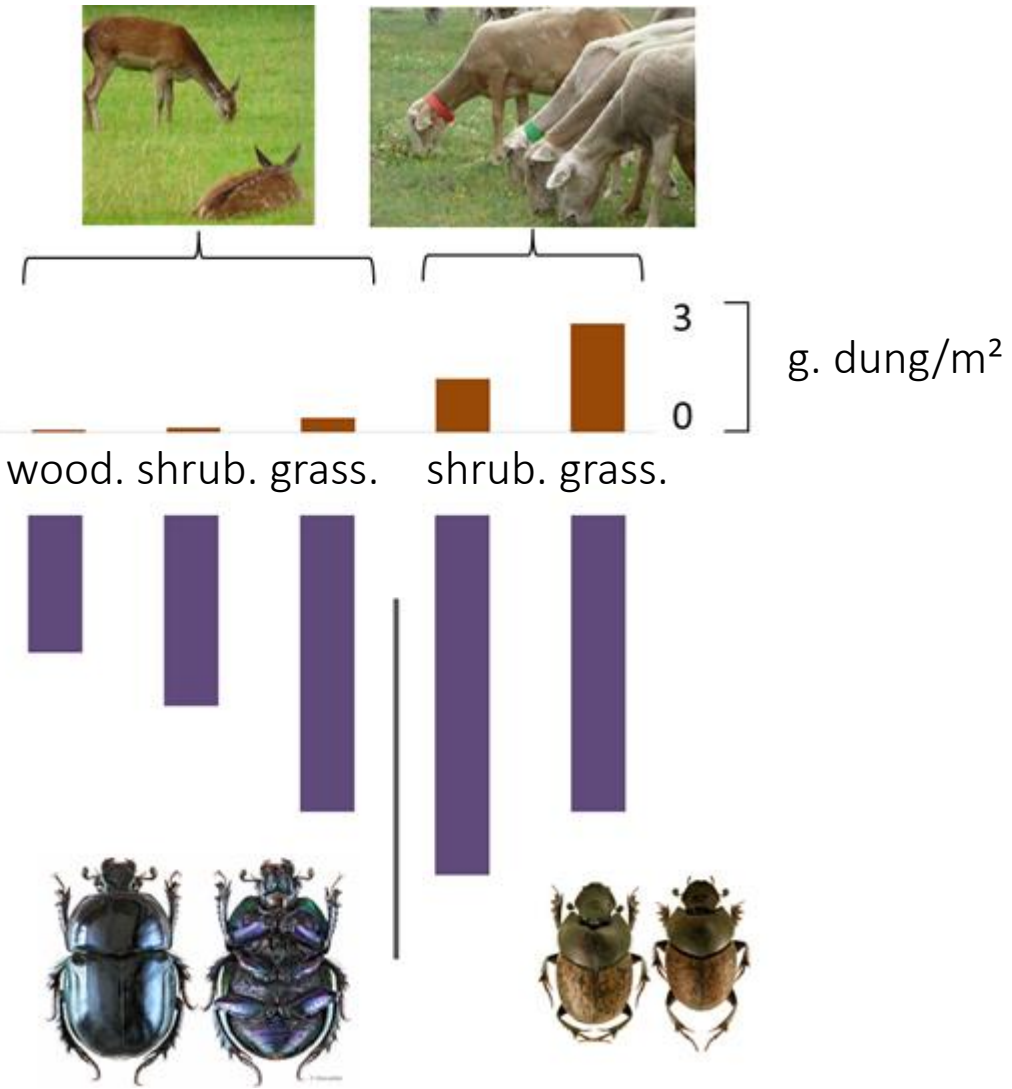
number of insects*3
no change in species-richness

% dwellers*2
41% → 83%

Journal of Applied Ecology, 1992, (29), 349-356

Journal of Animal Ecology , 1954, 23 (2), 234-260

Dung beetles (France)
7,462 ind. – 42 sp.



Biol. Conserv., 1 4 1 (2 0 0 8) 2879 –2887

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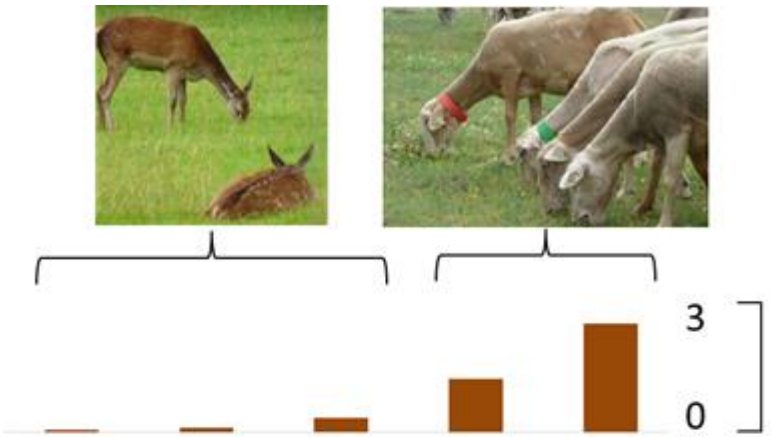
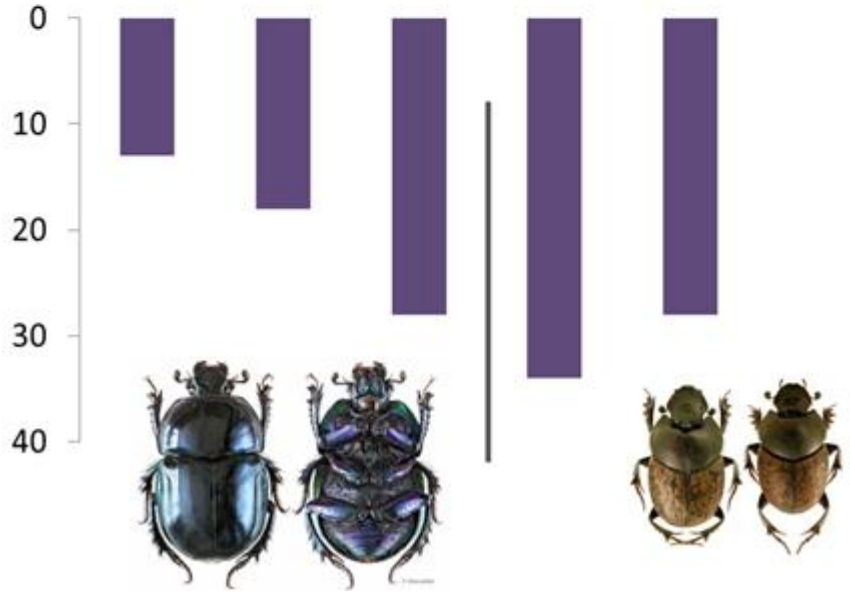
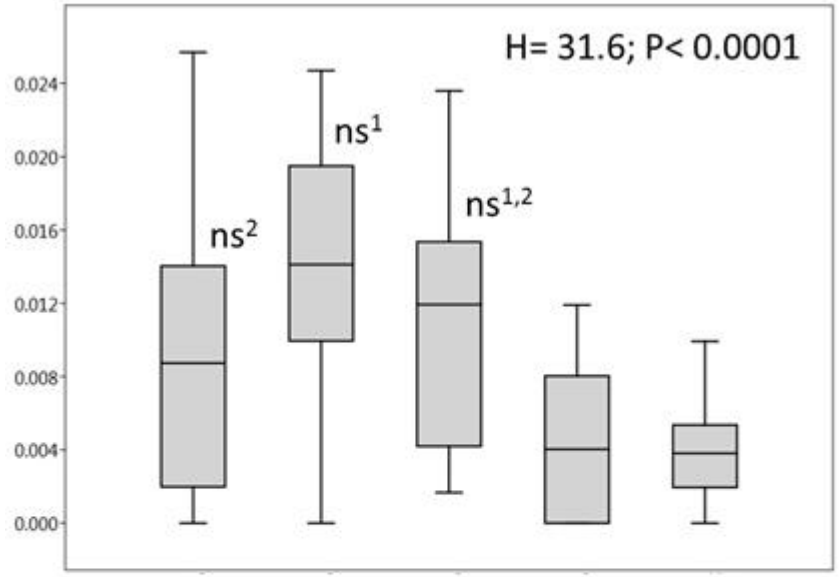
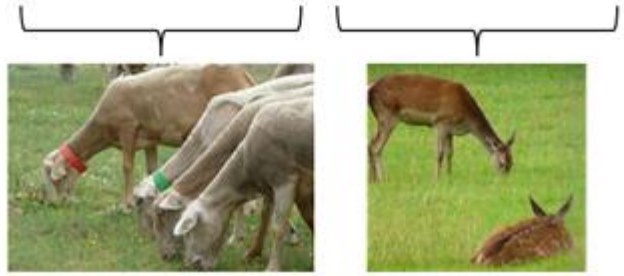




nb. species/ g dung

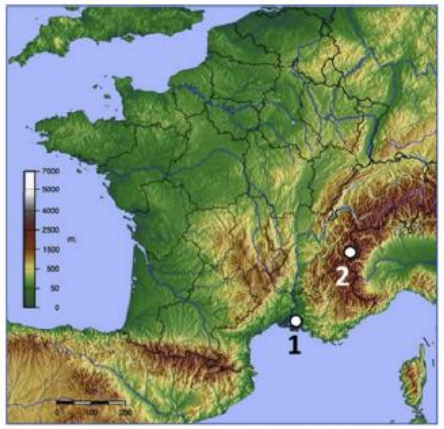


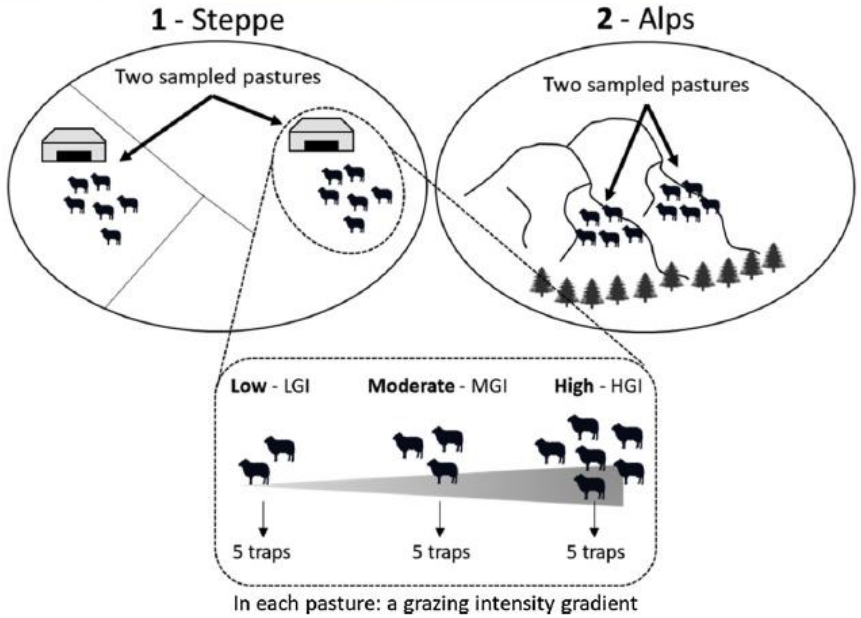
grass. shrub. grass. shrub. wood.



Biol. Conserv., 1 4 1 (2 0 0 8) 2879 –2887

Dung beetles
11,733 ind. – 52 sp. (only 4 in common)





Agriculture, Ecosystems and Environment 289 (2020) 106740

Dung beetles
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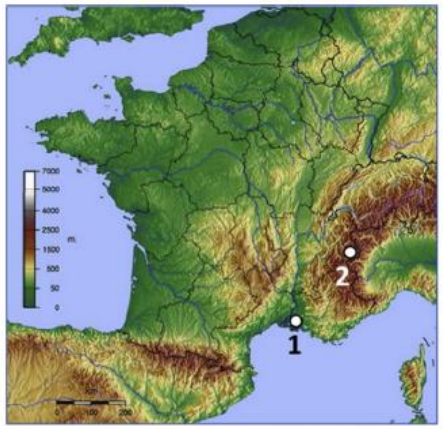
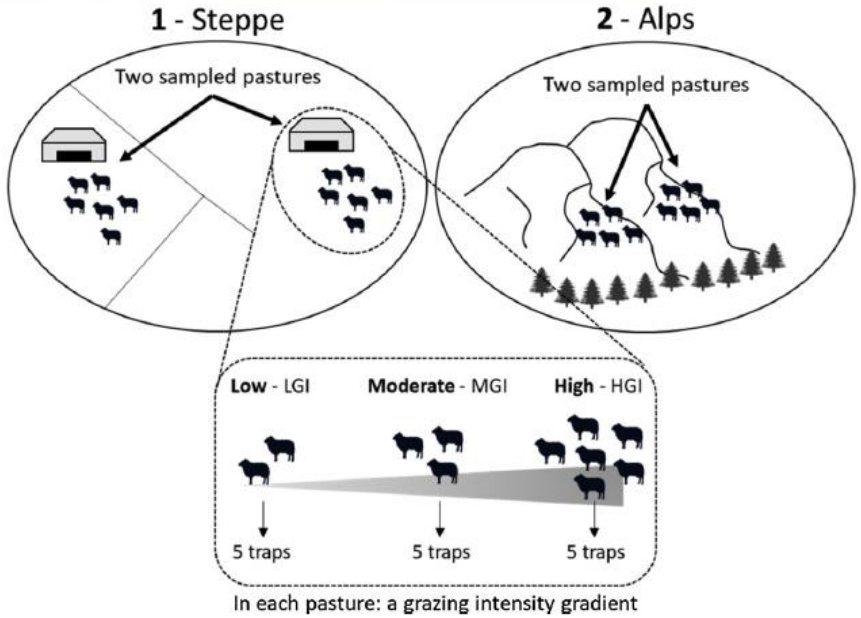
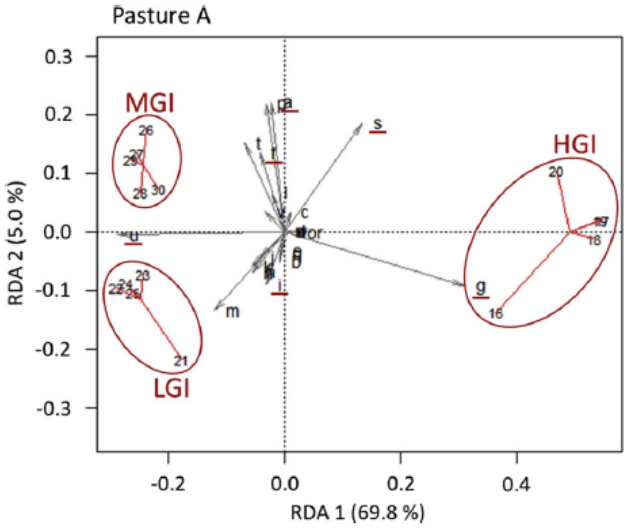
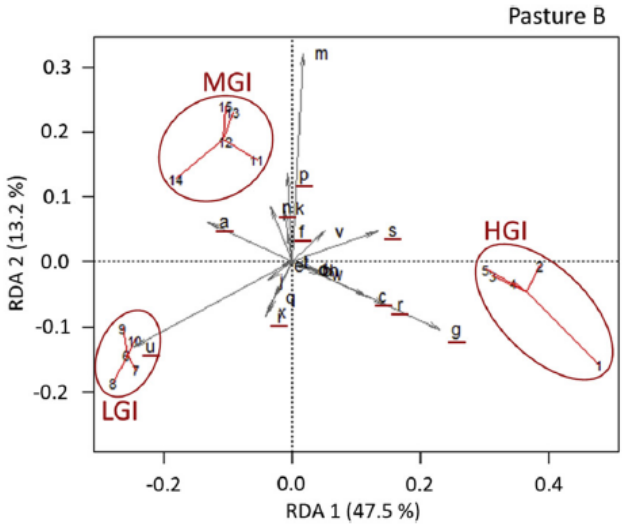


- no change in species-richness along gradients
- but contrasted assemblages

eg. steppe







Agriculture, Ecosystems and Environment 289 (2020) 106740

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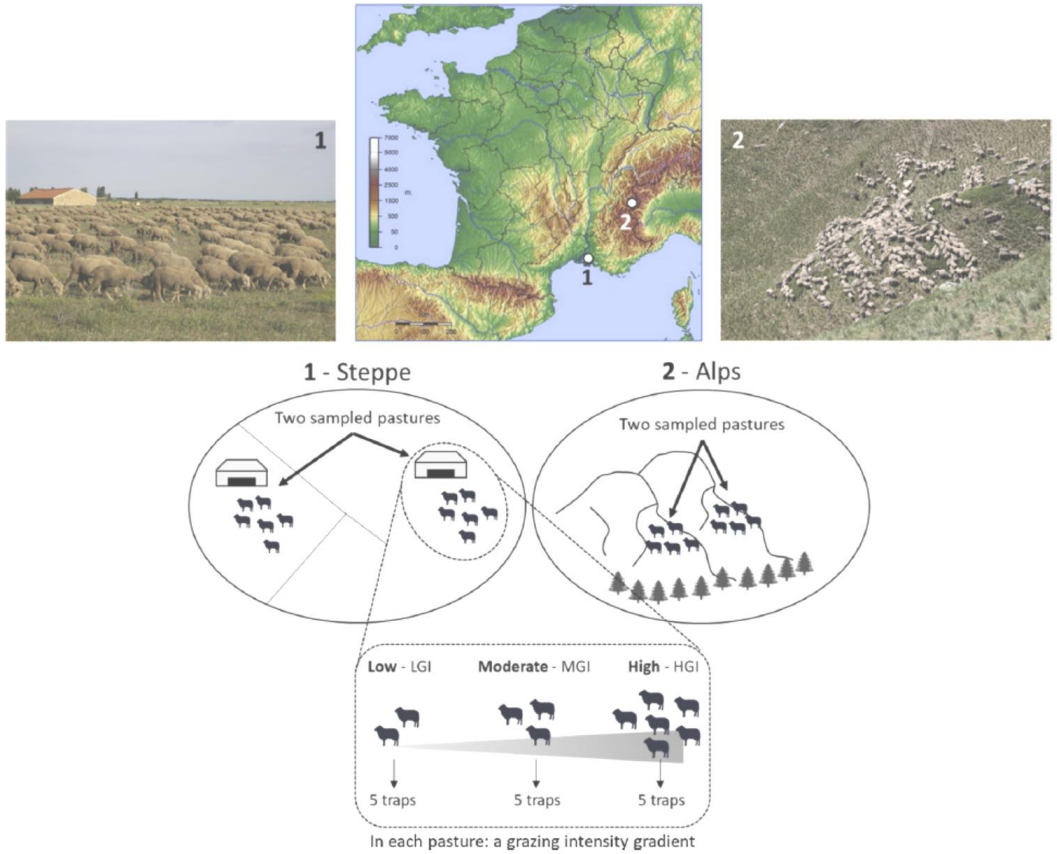
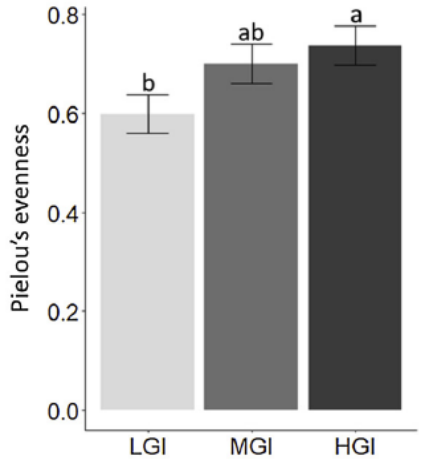
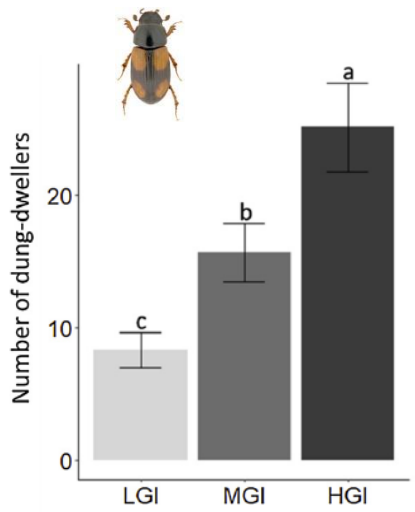
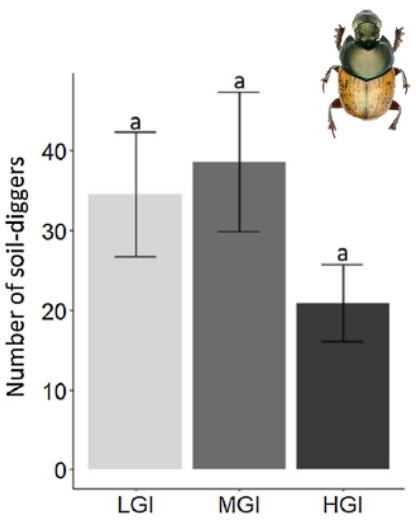


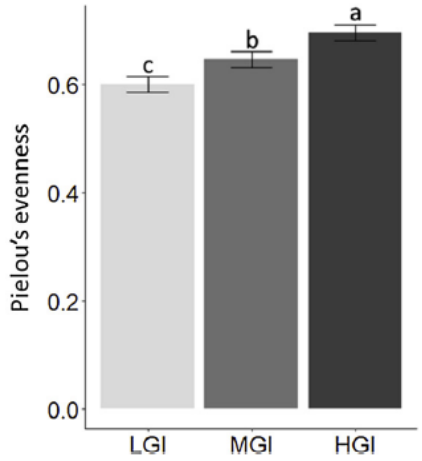
Steppe

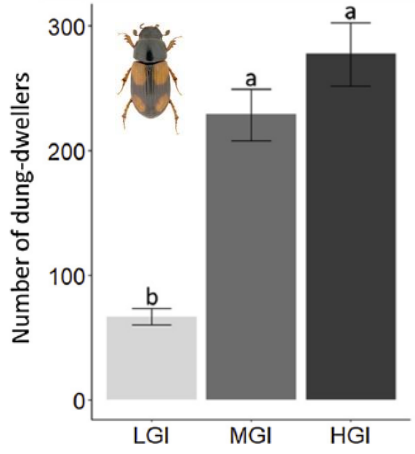


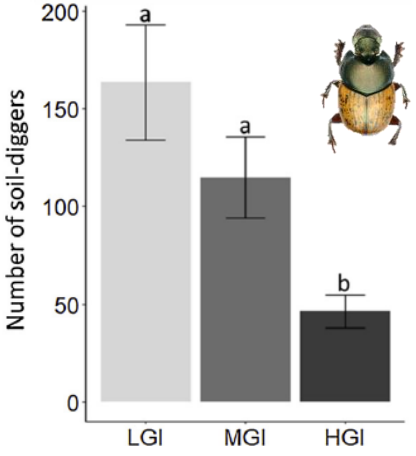




Alps





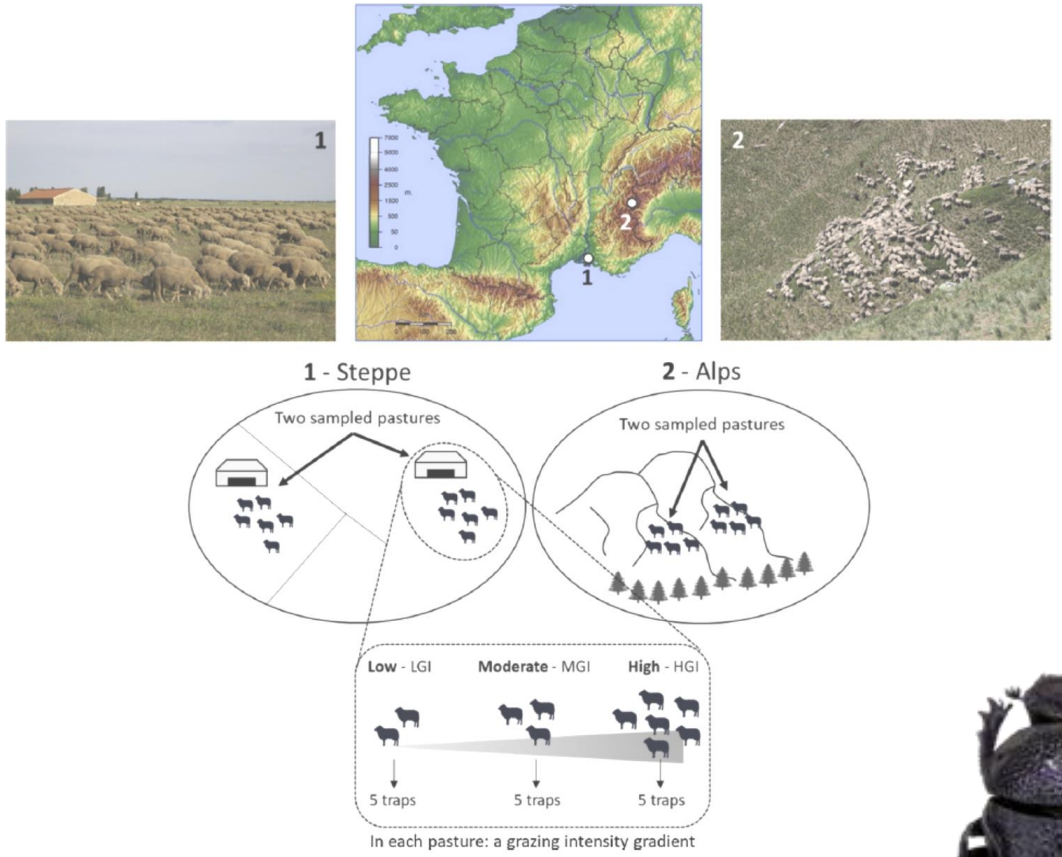


Agriculture, Ecosystems and Environment 289 (2020) 106740

Dung beetles
11,727 ind. – 50 sp.

- trait value +

biological interpretation:



- dry body mass

Ratios:

- pronotum:body length
- width:length pronotum
- back:front tibia length
- width:length front tibia

Environmental Entomology, 50(6), 2021, 1332–1343

Dung beetles
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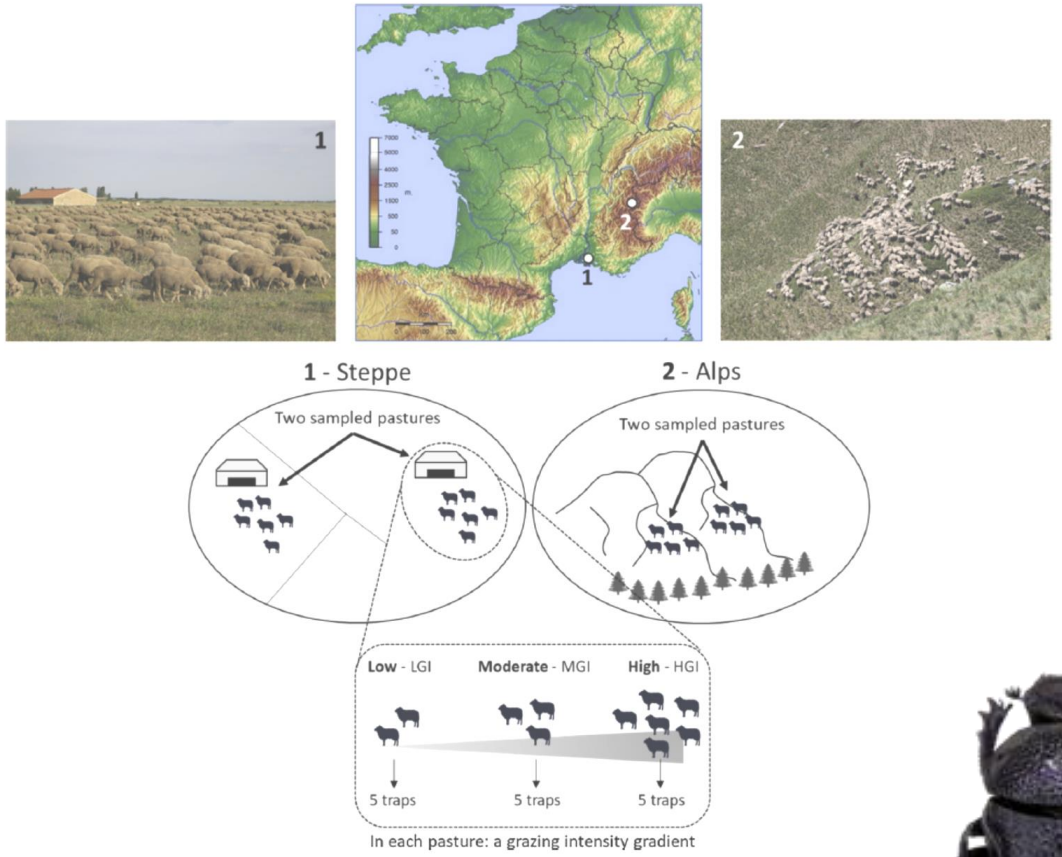

	trait value	
	biological interpretation:	
• dry body mass →		- ind. nutrition. needs +

Ratios:

• pronotum:body length →		- active mobility + + reproduction -
• width:length pronotum →		- fligth performance +
• back:front tibia length →		- capacity to move within dung + + capacity to roll ball -
• width:length front tibia →		- capacity to move within dung + + capacity to move materials -

Environmental Entomology, 50(6), 2021, 1332–1343

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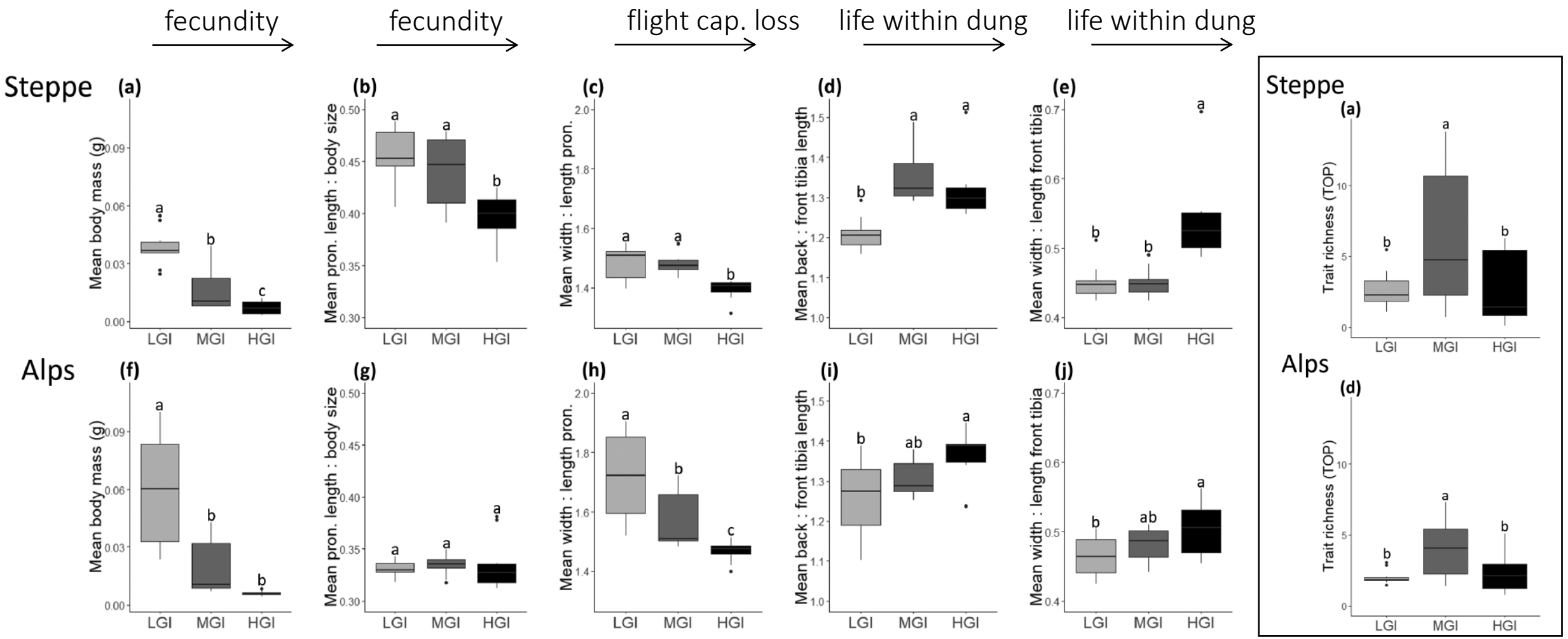


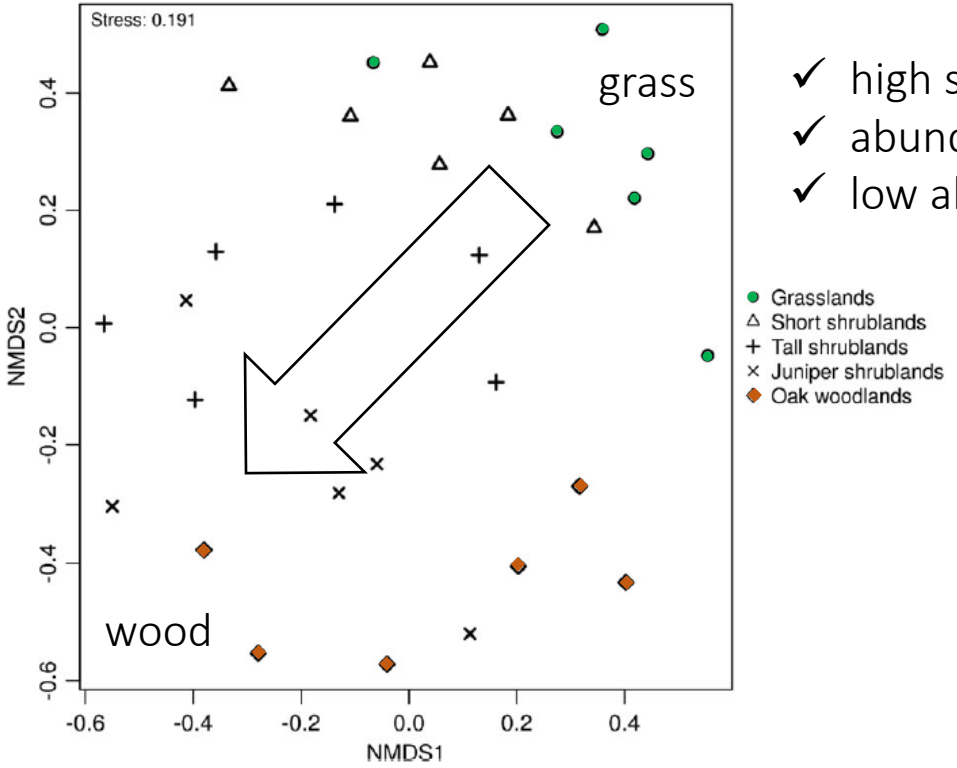
Environmental Entomology, 50(6), 2021, 1332–1343

A short history Let's focus on dung… & take a step back

Wild bees (Portugal)

	indiv.	species
Grasslands	1141	100
Short shrublands	737	70
Tall shrublands	366	58
Juniper shrublands	208	49
Oak woodlands	207	69

Σ= 157



- ✓ high species-turnover in bees
- ✓ abundant species in grassland
- ✓ low abund. species in woodland

Insect Cons. & Div., 2022, 1-12. DOI: 10.1111/icad.12562

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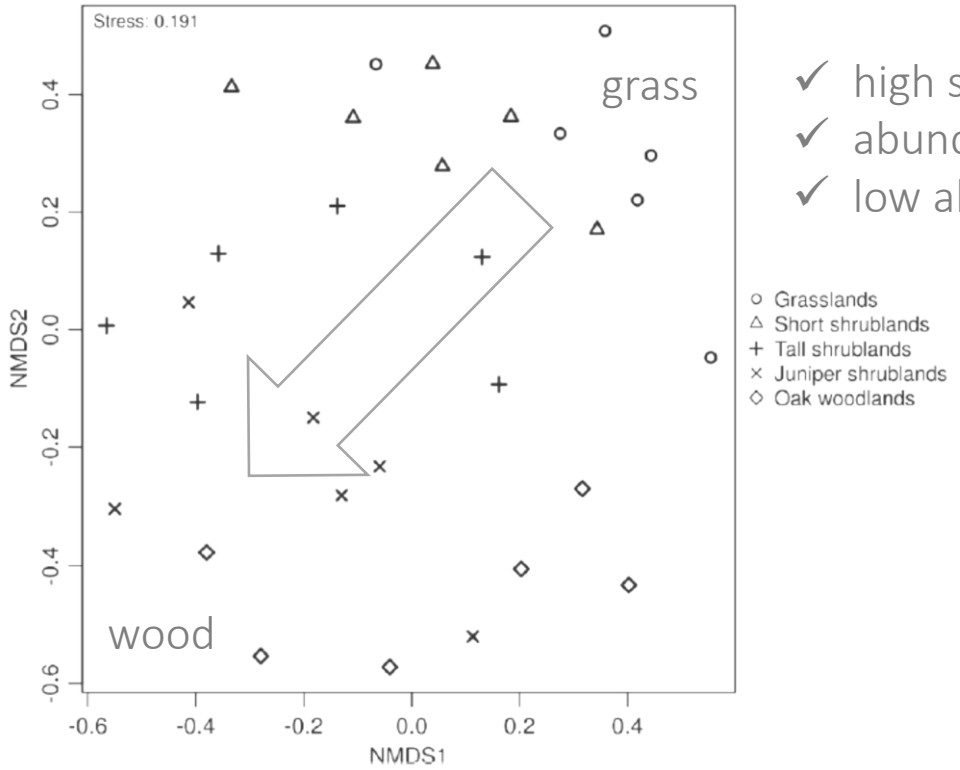

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Dung beetles (Spain)

34 sites – 42 species

"At local scale […] species richness was related to the local amount of sheep dung (27% of variance). The amount of dung in a 2-km buffer around the site accounts for 27–32% of variance in abundance and 60–65% of variance in species richness. […] the amount of dung in the surroundings seems to be more important for locally collected species than the dung effectively found in the site."

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Diversity Distrib. (2006) 12, 111–123

What ecological effects?

- ✓ Rarefaction of permanent natural meadows → habitat loss for herbaceous plants & associated species
- ✓ Eutrophication → advantage for (the few) species able to monopolize the resource
- ✓ Permanency in local use → stability in habitat location

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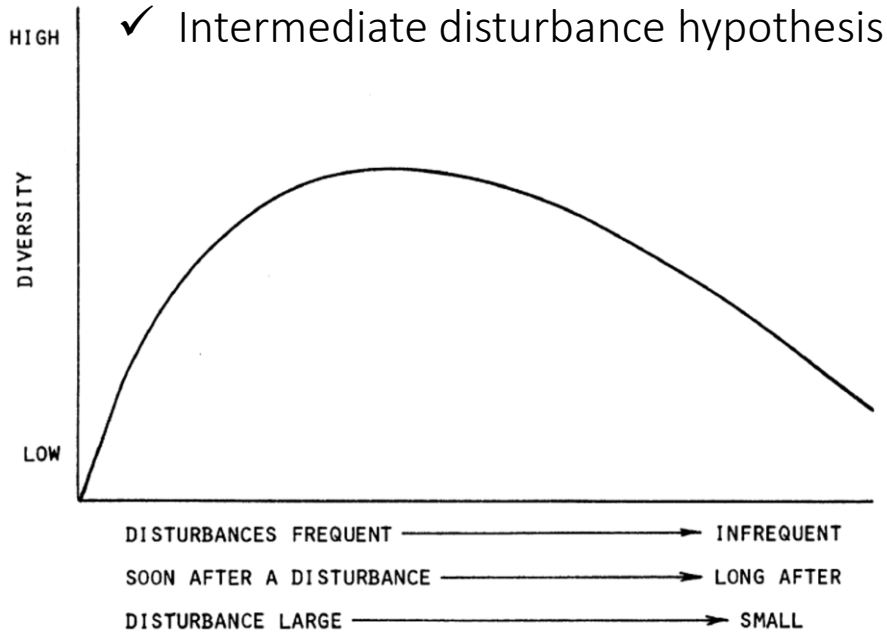
Upon what ecological theories?

- ✓ Landscape ecology (metapopulations…)
- ✓ Intermediate disturbance hypothesis



Science, 1978, Vol. 199, No. 4335, pp. 1302-1310

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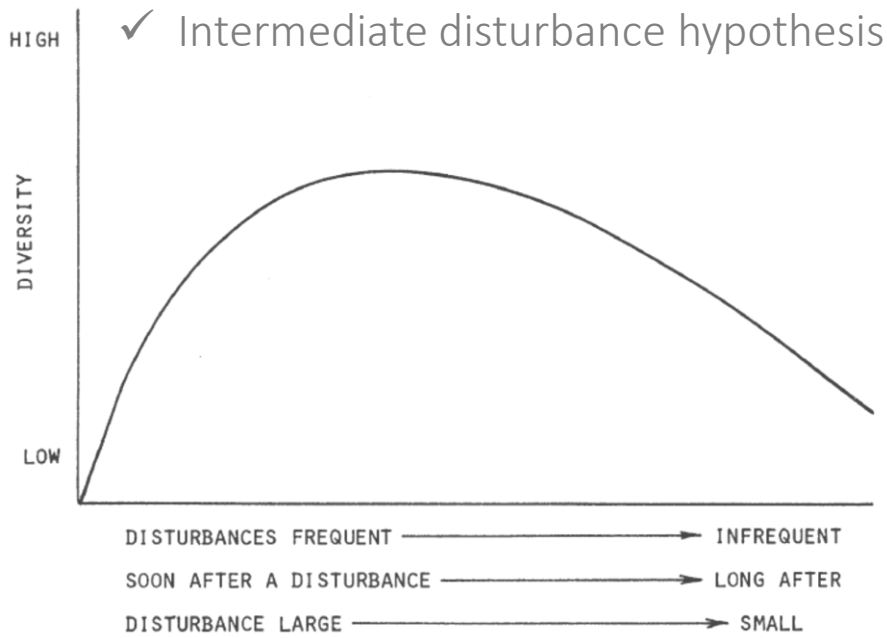
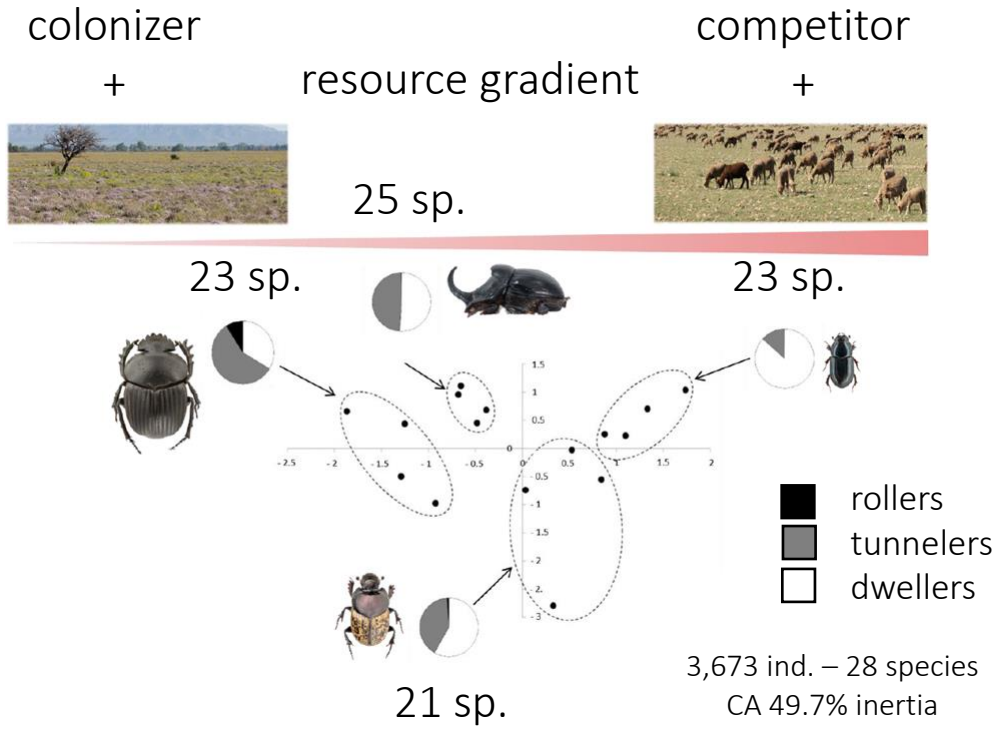


Competition-colonization trade-off



Science, 1978, Vol. 199, No. 4335, pp. 1302-1310

Unpubl.

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Competition-colonization trade-off

colonizer
+

favoured by unpredictable resource

resource gradient

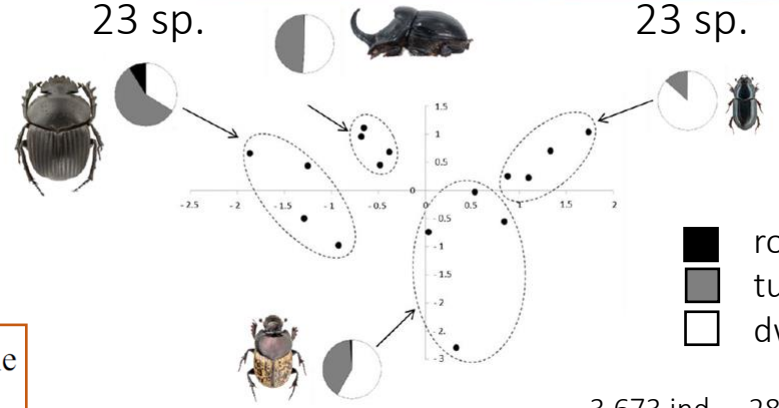
competitor
+

favoured by regular
& abundant resource

25 sp.

23 sp.

23 sp.



21 sp.

3,673 ind. – 28 species
CA 49.7% inertia

Diversity and Distributions, (Diversity Distrib.) (2007) 13, 903–919

BIODIVERSITY RESEARCH

Inferring species decline from collection records: roller dung beetles in Italy (Coleoptera, Scarabaeidae)

Decline of roller dung beetle (Scarabaeinae) populations in the Iberian peninsula during the 20th century
Biological Conservation 97 (2001) 43–50

Unpubl.

Vector-born diseases and parasitic issues

→ biocides dissemination

Mid-June, French Pyrenees

Thank you for your attention… and understanding

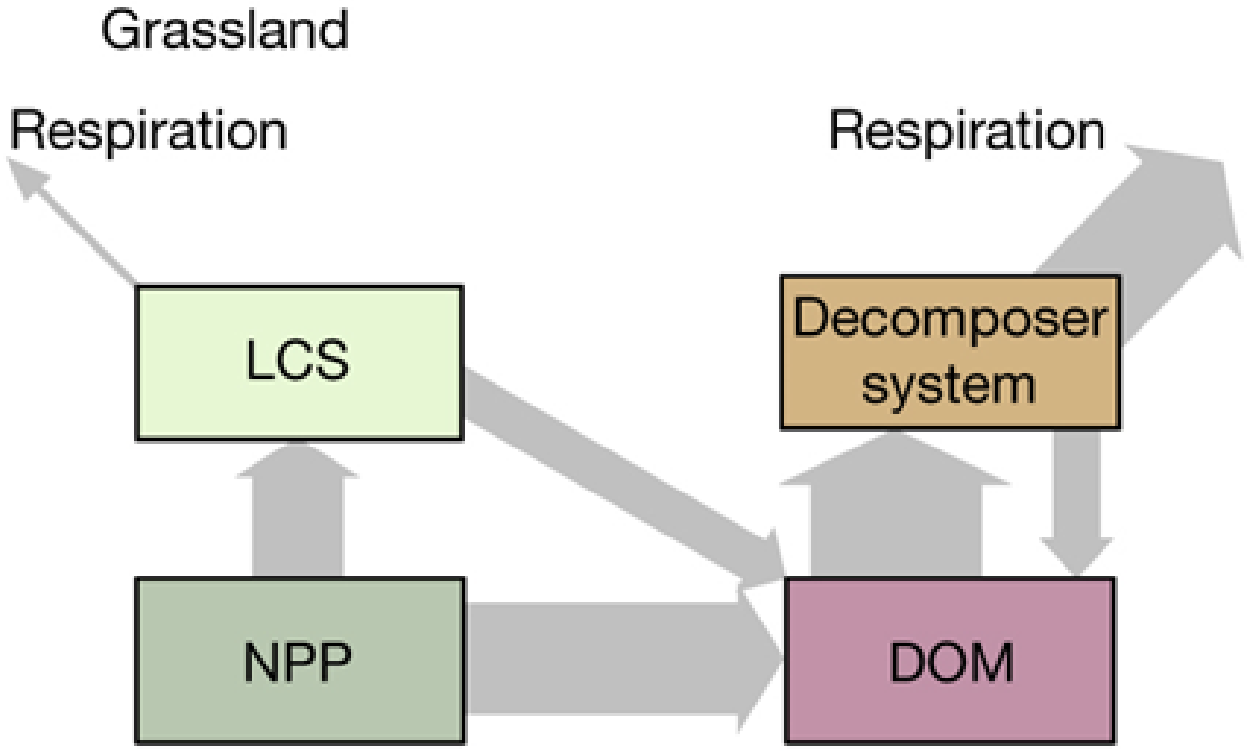
&

Camila Leandro

William Perrin

Bastien Louboutin

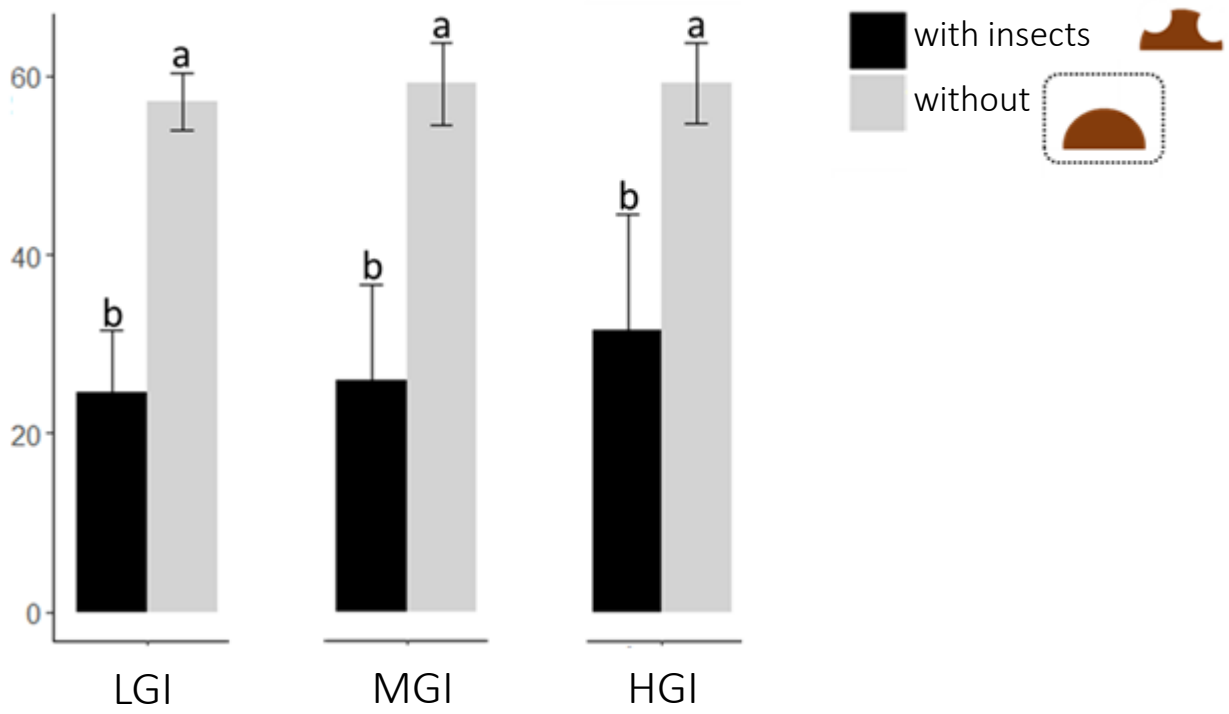
… for fruitful discussions

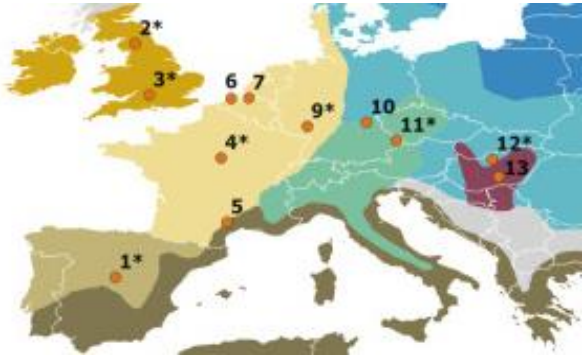


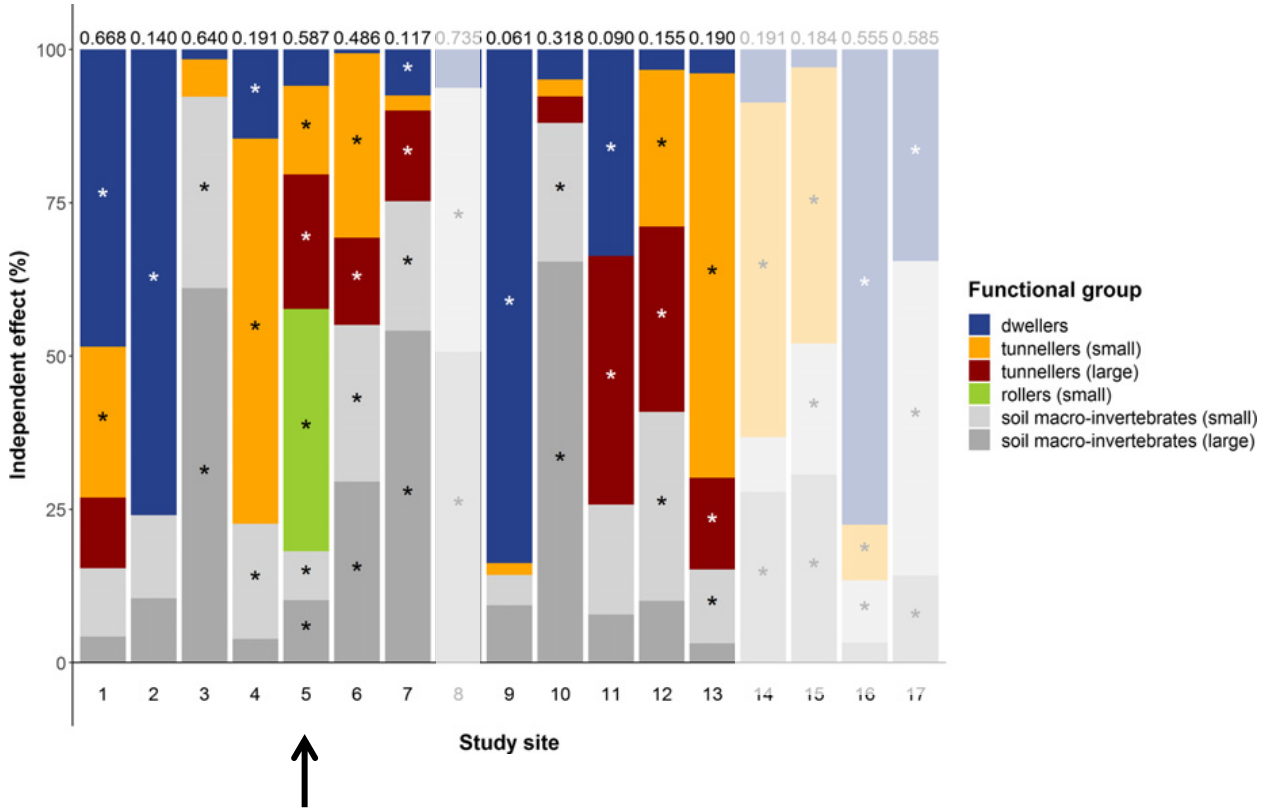
Essentials of Ecology, Blackwell

Dung beetles - Alps

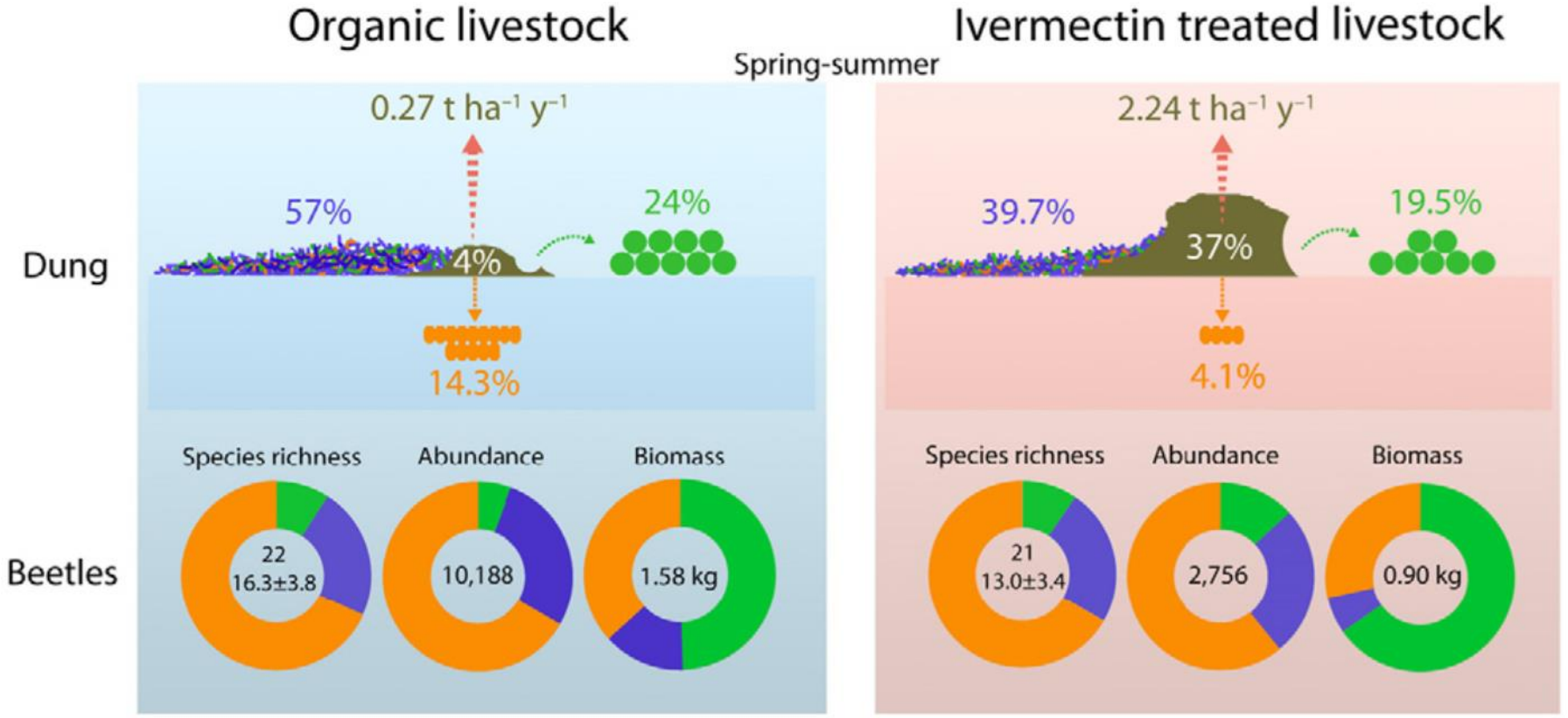
remnant sheep dung (g) after 2 weeks







Milotić et al. 2018 – J. Biogeography



Verdú et al. 2018 – Science of the Total Environment

Dung beetles

34 sites – 42 species (Central Spain)

"At local scale […] species richness was related to the local amount of sheep dung (27% of variance). The amount of dung in a 2-km buffer around the site accounts for 27–32% of variance in abundance and 60–65% of variance in species richness. […] the amount of dung in the surroundings seems to be more important for locally collected species than the dung effectively found in the site."

Dung beetles

36 sites, 15,190 ind. – 71 sp. (Southern France)

GLM (number of species):

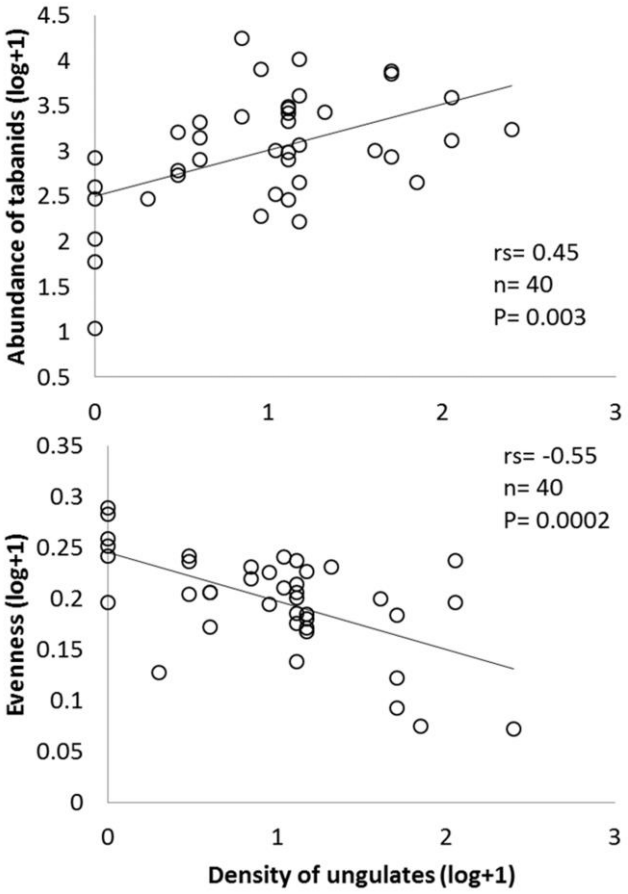
	Annual mean T°C – 1 Km	Livestock abund. – 5 Km	Forest % – 5 Km	Urban % – 5 Km
Aphodiinae 39 sp.	slp. = 0.09 p < 0.0001	slope = 0.009 p = 0.69	slp. = -0.01 p = 0.51	slp. = 0.115 p = 0.099
Scarabaeinae 26 sp.	slp. = -0.03 p = 0.25	slope = -0.01 p = 0.65	slp. = 0.04 p = 0.04	slp. = -0.15 p = 0.026
Geotrupinae 6 sp.	slp. = -0.02 p = 0.002	slope = -0.008 p = 0.38	slp. = 0.01 p = 0.02	slp. = -0.02 p = 0.2

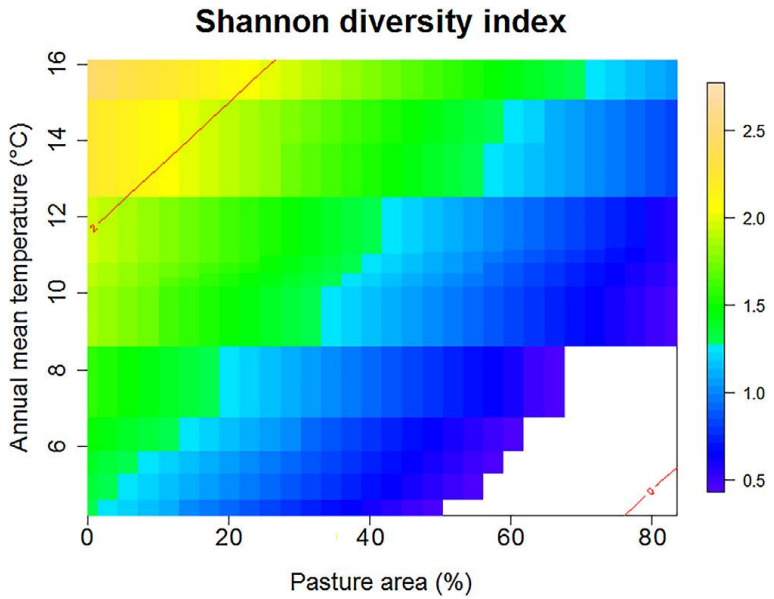
Diversity Distrib. (2006) 12, 111–123

In prep.

Tabanids

38 sites, 76,613 ind. – 79 species (Europe)





Tabanus bromius= 47%

Haematopota pluvialis= 14.5%

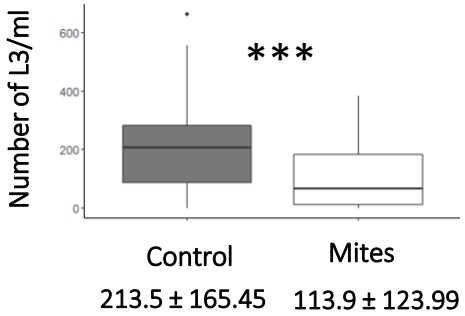
Agriculture, Ecosystems and Environment 239 (2017) 112–118.

Predation of *Haemonchus contortus* larvae by the *Macrocheles* sp. mite.
Macrocheles sp. collected on free-living dung beetles (phoretic mite).

Results & discussion

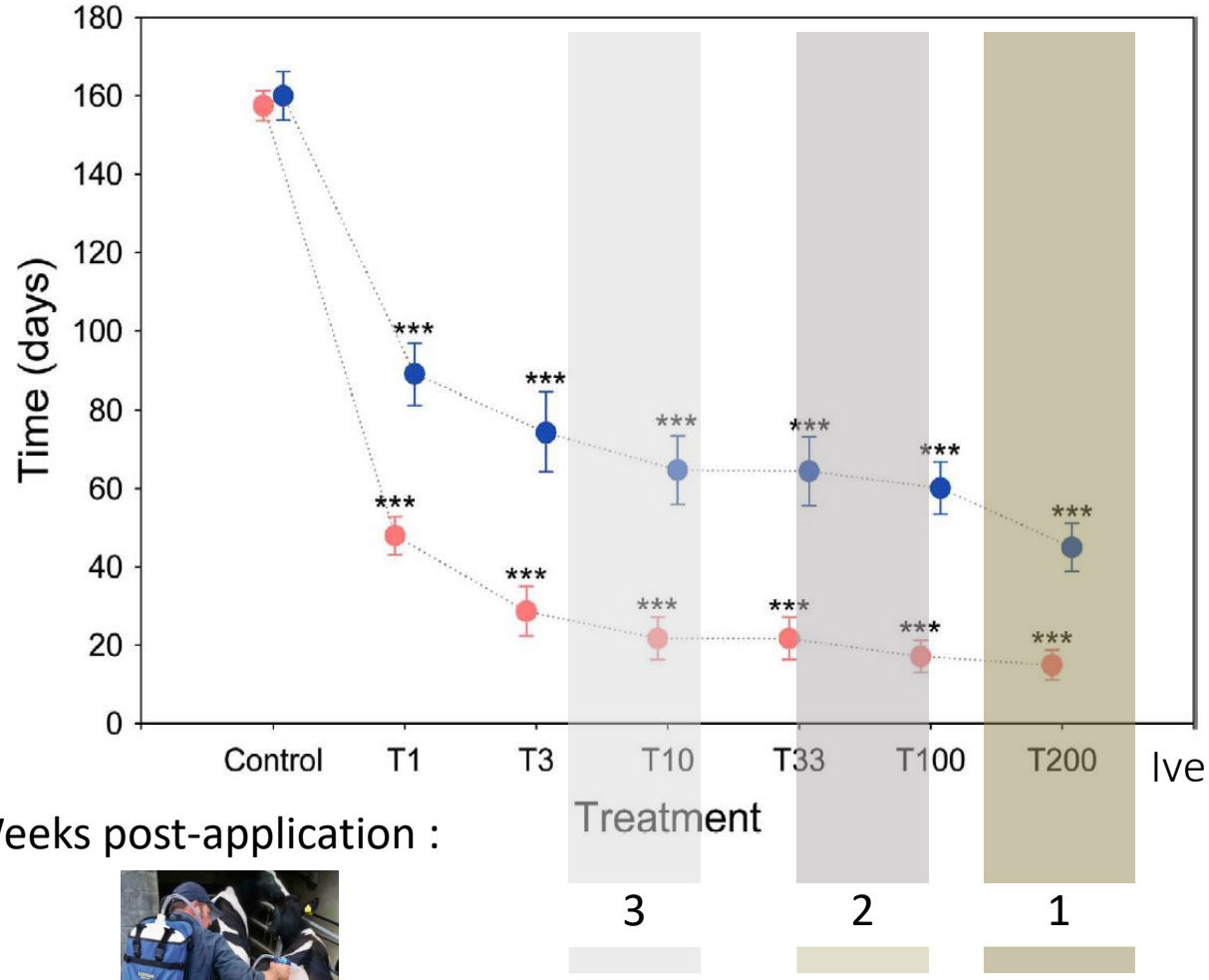
- Predatory behaviour was systematically observed : as soon as the mites have located the L3, they directly go on their prey to feed on it :

- Mites' predation (on *H. contortus*, from eggs to larvae) significantly reduced the number of L3 recovered (Mixed model) :




```
Random effects:
 Groups      Name        Variance Std.Dev.
 Code_Manip (Intercept) 0.6502   0.8063
Number of obs: 68, groups:  Code_Manip, 5

Fixed effects:
                          Estimate Std. Error z value Pr(>|z|)
(Intercept)                 4.2949     0.3956  10.855  < 2e-16 ***
Type_EchantillonTemoins     0.8761     0.2232   3.924 8.69e-05 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```



Ateuchetus cicatricosus

← death

← ataxia

Ivermectin : µg/kg

Weeks post-application :

Verdú et al. 2015 – Nature, Scientific Reports