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Insects involved in ecological processes are simultaneously friends, foes and models

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Abstract: The terms 'friends', 'foes' and 'models' suit very well human relationships but have nothing to do with nature, especially the first two. When a medical doctor performs experiments with *Yersinia pestis* bacillus by injecting *Galleria mellonella* (Lepidoptera: Pyralidae; the greater wax moth) larvae, the insect is a [friend and model]. If at a later time the doctor is diagnosed with plague then the insect becomes [foe]. In ecology, there are four principal types of interactions between species, namely competition, predation, mutualism, and commensalism which can be further divided or subcategorized. All these interactions can be observed at the population level in the processes involving insects and humans. The matter is greatly complicated in cases where insects play several roles in the conservation actions of threatened plants, as the *Zelkova abelicea* on Crete Isl. [friends and foes], or transmittance of diseases and feeding on valuable human tissues such as the hematophagous mosquitoes. The solution to all such situations is indicated by insects. For instance, the phytophagous insect guild on oaks shows a thin and precise partitioning of ecological time and space. In this way, they exploit efficiently the trophic substrate and simultaneously relax the competition among species [models]. First, many insects protect the *Z. abelicea* tree [friends] by predating on phytophagous insects [foes]. Second, many invasive phytophagous insects [foes], as a rule, unknown as image, habitat dwellers and odor sources (kairomones) to local predators, are perfect prey items to them [friends]. Also, in heavily grazed Cretan plateaus like Omalos, Chania and Katharo, Lasithi, the insects protecting *Z. abellicea* plant are more abundant in the plots fenced to exclude grazing animals. This indicates that natural habitats are a prerequisite for the process of protection of certain species by excluding many grazing animals.

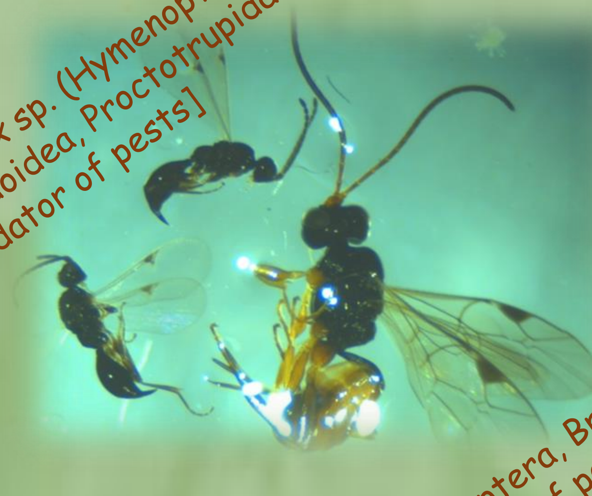
Larvae found inside the swollen filaments of the male flowers on *Zelkova abelicea* trees (May 2017) [9,10]. (credit: Fazan and Kozlowski)

A	A	A	A	A	T	C	A	A	A	A	T	A
A	T	C	A	A	A	A	A	A	T	G	A	A
C	T	C	C	T	G	C	T	A	A	A	A	T
A	T	A	G	A	T	C	A	A	A	C	A	A
T	A	T	A	T	T	T	A	A	T	A	T	A

T	C	A	A	A	C	A
T	T	A	A	T	A	T
G	C	A	A	T	A	T

Several attempts to identify this insect (*e.g.* with barcoding by sequencing COI gene base pairs) indicated that this is a new species, and also inquilines found on *Z. abelicea*, are new species too.

Normal male flowers on a branch, and fallen male flowers found on the ground under a flowering *Zelkova abelicea* tree (a Cretan endemic which(May 2017) [9,10] (credit: Fazan and Kozlowski)



Exallonyx sp. (Hymenoptera, Chalcidoidea, Proctotrupidae) [predator of pests]

Hymenoptera, Braconidae [predator of pests]

a foe for Z. abelicea

The aphrophorid (Hemiptera, Auchenorrhyncha) species found on the leaves of *Z. abelicea* is a potential carrier of *Xylella fastidiosa* . A severe damaging factor of olive trees, citrus trees, and vineyards (credit F. Samaritakis)

a foe for beehives

5th instar larva

Galleria melonella (Lepidoptera, Pyralidae) [great wax moth]

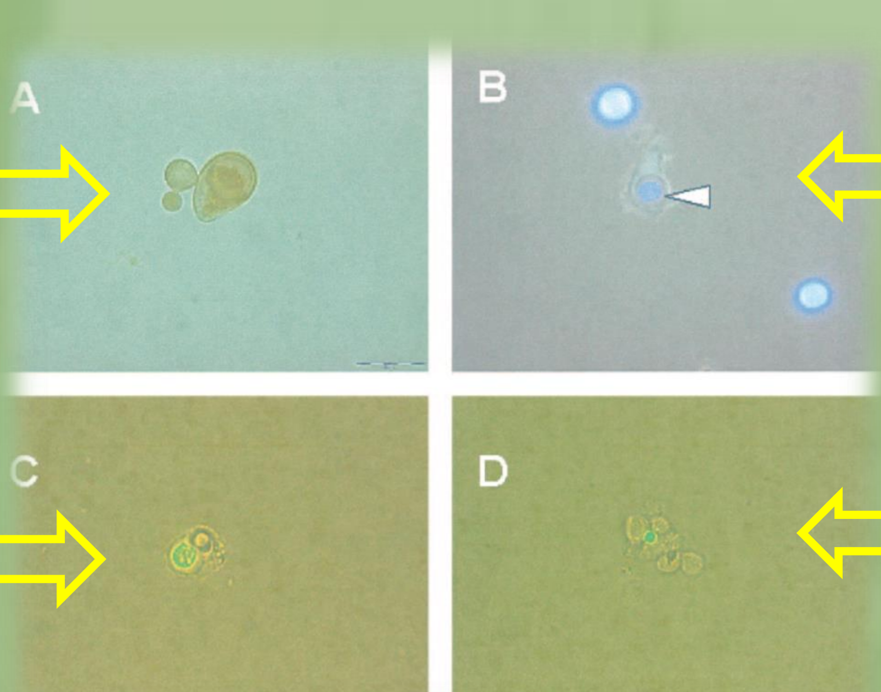
a model and friendly insect

for the study of fungi and bacteria pathogenesis

No animal model fully duplicates the human response. Existing models are expensive to maintain and train (e.g. *Rhesus macaca*, Muridae), costly maintenance of animal facilities, veterinary services approved animal protocols, and cause ethical concerns [1-7].
Insects can be used in large numbers, are easily manipulated, and are not subject to the same ethical concerns as mammalian systems [8]. Insects and mammals have many parallels with respect to microbial pathogenesis from proteinaceous integuments that require breaching before infection to similarities in their innate immune responses [1-6].

Binding of *Cryptococcus neoformans* cells (a human pathogen) by *G. mellonella* haemocytes (special cells of insect haemolymh capable to employ the superoxide pathogen killing mechanism in analogy to mammalian phagocytes [1,4,5]

Phagocytosis of *C. neoformans* cells by *G. mellonella* haemocytes (arrowhead). Stain is calcofluor white [5]



Phagocytosis of *C. neoformans* cells by *G. mellonella* hemocytes

A *C. neoformans* fungal cell (green-blue) is surrounded by layers of haemocytes in a process known as nodulation [5] or nodulization [1].

credit: Eleftherios Mylonakis and [5,4]

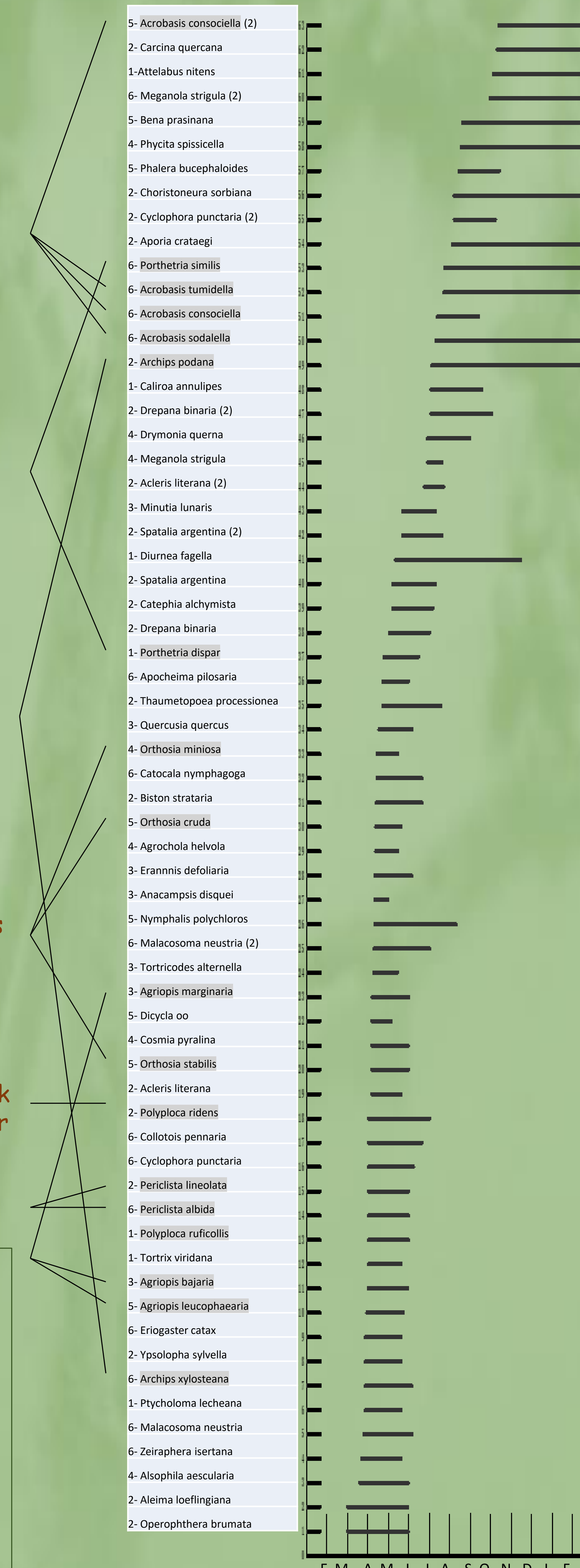
The larval periods of the insects feeding on the leaves of oaks on Mt Holomontas, Chalkidiki, Greece, are shown sorted according to the peak of their appearance.

Only presences are considered here.

Insects with two generations are shown as different species followed by the number '2'.

Numbers (1…6) are clusters on the basis of insect niche affinities.

For oaks, insects are foes. However they are also friends because they attack new coming plants and other competitors. They are also models indicating how the time can be manipulated in order not to deplete the trophic substrate.



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