MixNet application to a food web network

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The food web under study is made of chalcid wasps from the *Tetramesa* species feeding on different grass species [2, 3]. Among the Eurytomidae, many are true herbivors, many are parasitoids, and some are parasitic at early larval stages and herbivorous in later stages. Therefore, the food web 5 levels of organization: plants, herbivores, parasitoids, hyperparasitoids and hyper-hyperparasitoids.

The original article points out that there is a dissymetry among the specificity of the different trophic levels : while the lower two trophic levels (herbivores and primary parasitoids) are characterized by extreme host specificity, the top two trophic levels (hyperparasitoids and hyperhyperparasitoids) comprise more generalized omnivores.

This example has recently been used by [1] to illustrate a method based on hierarchical clustering. Hierarchy seems to be a good way to summarize this kind of network, since the host-parasitoid relationship is hierarchical by essence. The results provided by [1] have the advantage of showing different degrees of precision, with the highest degree reflecting specific herbivore-parasite communities. This can be linked to the capacity of MixNet to give different degrees of summary with different number of classes, and model-based strategies have one main advantage : they allow for the construction of theoretical criteria to assess the number of clusters, which may be difficult in the case o hierarchical clustering. Another criticism that can be made to hierarchical clustering in general is that it will find hierarchy even if the data are not structured hierarchically. Furthermore, the hierarchical framework hampers the use of edge orientation, seeing the network as a non-directed network, whereas it is directed by definition, the orientation of the links giving the trophic relationship between organisms.

3 Classes. A first summary is given by a MixNet result with 3 classes (ICL). This criterion is the best trade-off between a good quality of fit of the model to the data given the clustering objective of the study. Three groups gives a simplified version of the network but gives also some clues about the nodes that structure the network (Figures 1 and 2). MixNet results suggest that the network is structured around 3 hubs which are 2 hyper-parasitoids (*Eupelmus atropurpureus*, *Macroneura vesicularis*) and 1 hyperhyper-parasitoid (*Mesopolobus graminum*), which show the highest out-degree of the network (Table 1). This structure was already observed in the original article, and can be explained by the non-specificity of the higher-order parasites. The other groups are made of herbivors for group 1, and group 2 is made of a mix of trophic levels that do not exhibit any particuliar connectivity structure pattern at this resolution level.

7 classes. Another criterion gives 7 classes. Interestingly, *Macroneura vesicularis* and *Mesopolobus graminum* still consitute hubs that have different targets (Figure 3). The organization of trophic

relationships is well summarized when studying classes 1-2-3-6-7 (Figure 3). Class 1 is made of herbivores that are infected by *Macroneura vesicularis* (Class 6) and *Mesopolobus graminum* (Class 7). Then this class of herbivores is connected to the class of grass (Class 3). The low specificity of hyperparasitoids can be seen from MixNet results, as the hub *Macroneura vesicularis* is connected to parasites as well as herbivores. This is also illustrated by the connections of *Mesopolobus graminum* (Class 7) to herbivores (Class 1) but also to class 4 which has no specific pattern in terms of trophic levels (Figure 3). Actually *Mesopolobus graminum* creates a partitioning of the network, since cluster 4 is formed by nodes that connects together or with the hub, but not with other parts of the network (Figure 4). A last interesting feature is given by Class 5 which is made of a community centered around the herbivore *Tetramesa petiolata*.

Acknowledgements

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References

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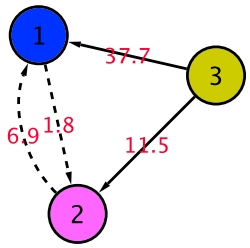
[2] Dawah H.A., Hawkins B.A., and Claridge M.F. Structure of the parasitoid communities of grass-feeding chalcid wasps. *Journal of animal ecology*, 64:708–720, 1995.

[3] Martinez N.D., Hawkins B.A., Dawah H.A., and Feifarek B.P. Effects of sampling effort on characterization of food-web structure. *Ecology*, 80(3):1044–1055, 1999.

	1	2	3
1	.	1.8	.
2	6.9	.	.
3	37.7	11.5	.
alpha	15.7	80.3	4.0



	1	2	3
grass	0	8	0
herbivore	12	3	0
hyperhyperparasitoid	0	1	1
hyperparasitoid	0	9	2
parasitoid	0	39	0
mean In degree	5.25	0.83	0
mean Out degree	1.08	1.10	11.33

Figure 1: MixNet parameters for the food web network with $Q = 3$ classes. Connections ($\times 100$) lower than 1% are not represented. Middle : graphical summary of MixNet results. Bottom: Repartition of trophic levels among MixNet Classes.

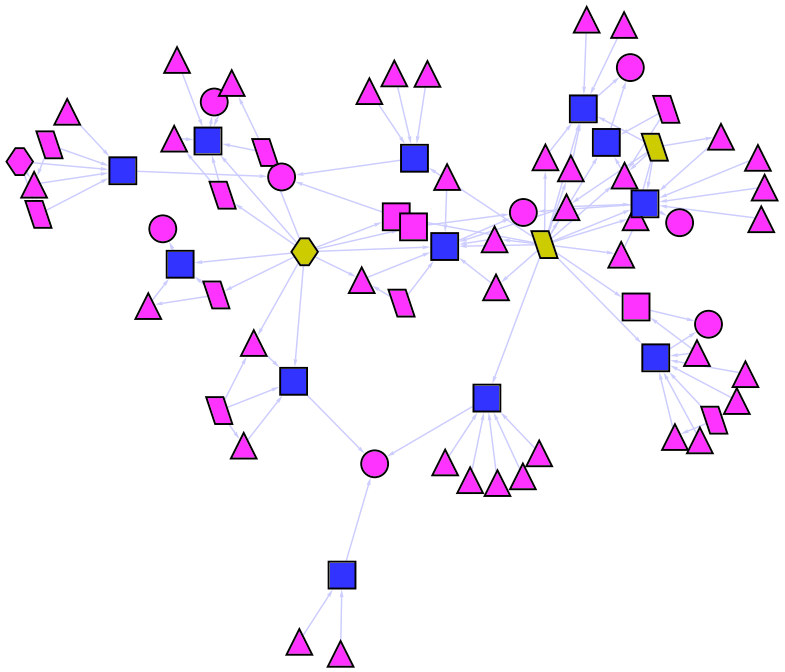
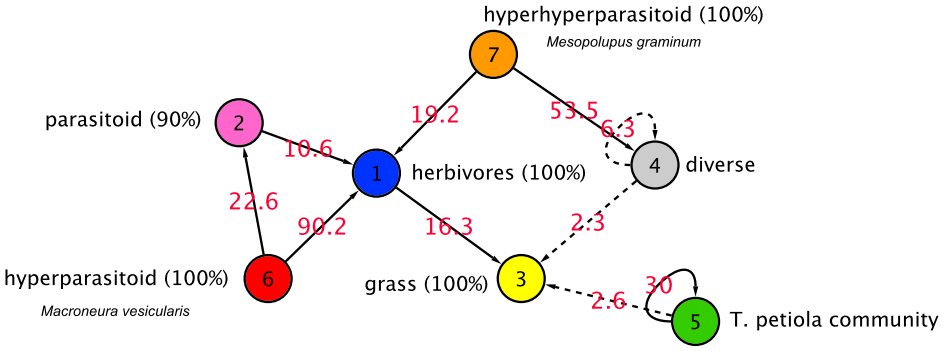


Figure 2: Grassland food web network displayed with colors for each MixNet class.

	1	2	3	4	5	6	7
1	.	.	16.3	.	.	.	.
2	10.6	.	.	.	.	.	.
3	.	.	.	.	.	.	.
4	.	.	2.3	6.3	.	.	.
5	.	.	2.6	.	30.0	.	.
6	90.2	22.6	.	.	.	.	.
7	19.2	.	.	53.5	.	.	.
alpha	14.0	44.4	8.6	22.3	8.0	1.3	1.3



	1	2	3	4	5	6	7
grass	0	0	6	2	0	0	0
herbivore	10	0	0	4	1	0	0
hyperhyperparasitoid	0	0	0	0	1	0	1
hyperparasitoid	0	4	0	4	2	1	0
parasitoid	0	30	0	7	2	0	0
Mean In degree	4.90	0.41	2.33	1.59	1.50	0	0
Mean Out degree	1.10	1.29	0	1.17	1.66	17	11

Figure 3: Top : MixNet parameters for the food web network with $Q = 7$ classes. Connections ($\times 100$) lower than 1% are not represented. Middle : graphical summary of MixNet results. Bottom: Repartition of trophic levels among MixNet Classes.

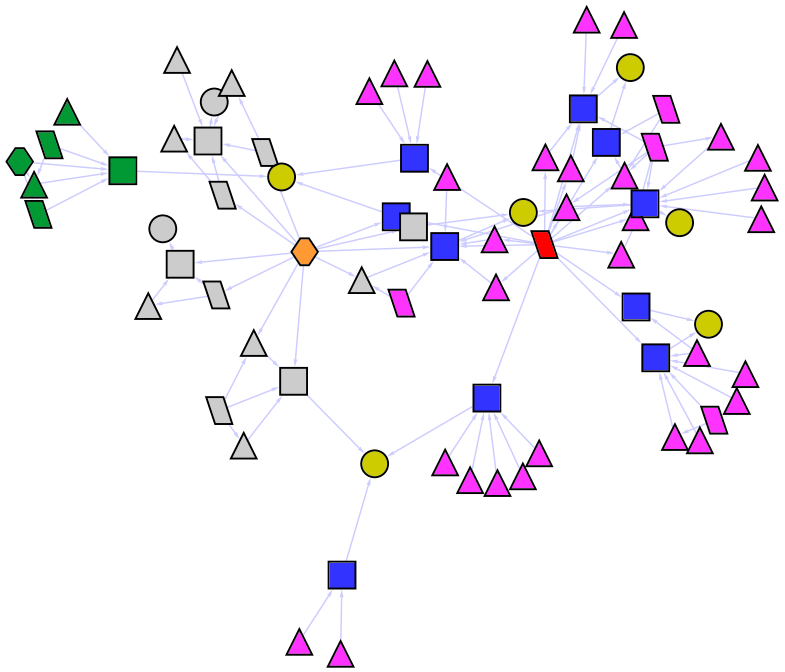


Figure 4: Grassland food web network displayed with colors for each MixNet class.