In this section of *Resonance,* we invite readers to pose questions likely to be raised in a classroom situation. We may suggest strategies for dealing with them, or invite responses, or both. "Classroom" is equally a forum for raising broader issues and sharing personal experiences and viewpoints on matters related to teaching and learning science.

Learning Foodchain with *Calotropis Procera*

Dilip Amritphale and
Santosh Sharma
Institute of Environment Management & Plant Sciences
Vikram University
Ujjain 456 010, MP, India.
Email:
dilipamritphale@yahoo.co.in

A food chain is generally described as a chain of eating and being eaten that connects consumers to their ultimate plant food. A generalized chain might be: *Plant → insect herbivores → insect carnivores → insectivorous birds→ large predatory bird.* A parallel concept of *food web* is necessary because many kind of plants live side by side, and because most animals can eat more than one kind of food. For example, spiders can eat several kinds of prey such as bees, butterflies and others so that they must be part of several food chains. In reality, no *consumer-resource* pair (predator-prey, parasite-host or grazer-plant) exists in isolation. Each is a part of a complex web of interactions with other predators, parasites, food resources, and competitors within its community. The result is a web of interlocking food chains (*Figure* 1). Since the food web for most communities is very complex involving hundreds or thousands of kinds of organisms, one useful simplification is to group organisms into categories known as *trophic levels* based on their position in the food chain (*Figure* 2).

Undoubtedly, generalizations as above are quite fundamental to concept building. However, it is equally important to provide students with specific examples in order to initiate them in the

Keywords
Calotropis procera, consumer-resource relationship, food chain/food web.

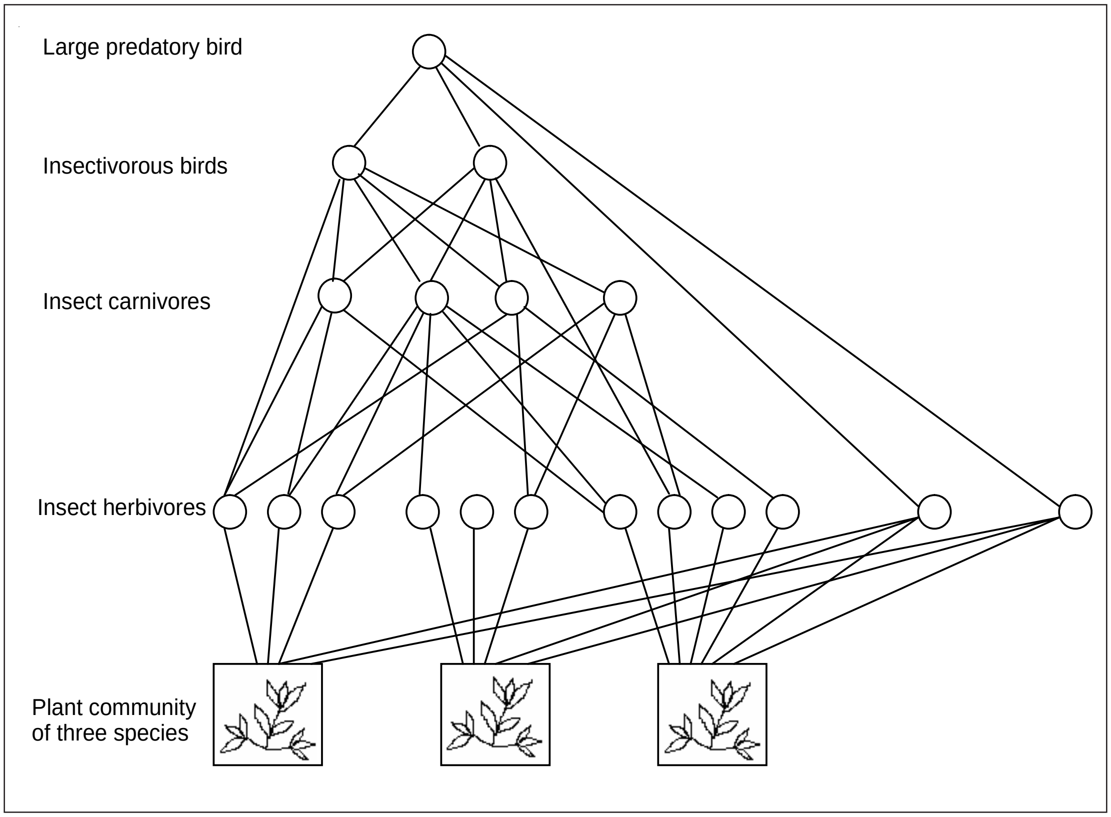


Figure 1. A hypothetical food web based on three species of plants, ten species of insect herbivores, four species of insect carnivores, two species of bird herbivores, two species of bird insectivores, and one species of large predatory bird. There is an initial diversity introduced by the numbers of plants. This diversity is multiplied at the herbivore level. At each subsequent level the diversity is reduced as the food chains converge.

subject. Unfortunately, books or other resource materials citing case studies and examples of indigenous origin are not generally available to a large cross section of school/college-going students in India. Several commonly available books feed them on stereotypic food chains involving, for example, something like a field rat and a cobra (few bother to put a rat snake instead!). Or, there are books of foreign origin citing plant and animal species with which an average student is generally not familiar. For example, a typical food chain in some of the foreign titles is: *Oak leaf → caterpillar → scarlet tanager → Cooper's hawk*. Obviously, it is such kind of treatment that makes biology in general and ecology in particular, a dead science. That is what prompted us to share some of our (admittedly) simple but interesting observations on *Calotropis procera* (Ait.) R. Br. (Asclepiadaceae) and the life associated with it. We feel it is necessary to clarify the following points before initiating a study in food chains with

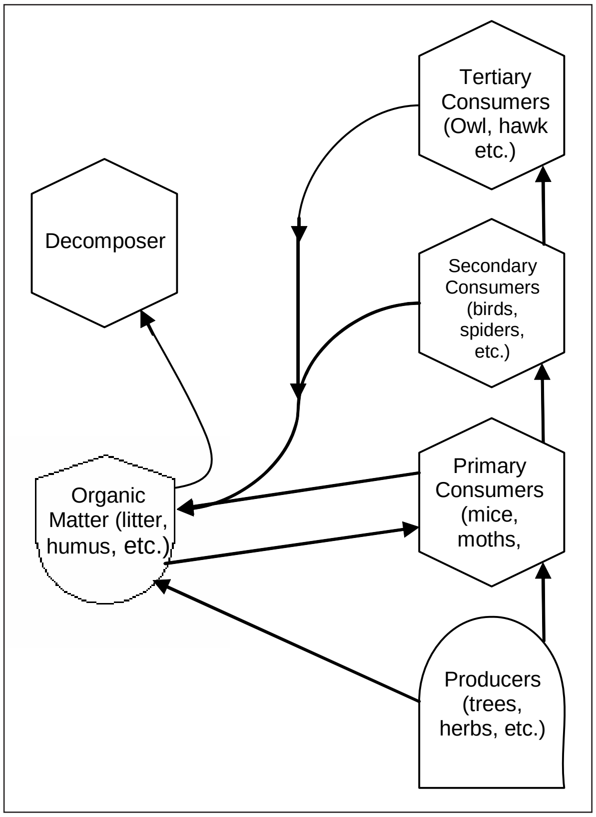


Figure 2. Species grouped into trophic levels. All of the photosynthetic plants are in one trophic level, the producer level; all the animals that consume mainly plants are in the primary consumer trophic level, and so on. Organisms that use dead plants and animals and organic matter derived from them are in the decomposer level.

C. procera: (1) the species is certainly not something unique with reference to food chain studies. In fact, any suitable plant species based on availability in a given region can serve the purpose, (2) the life associated with *C. procera* may differ among regions. While this is of little consequence in terms of the principles and concepts involved, it may require making region-specific relevant changes with respect to the composition of associated species, and (3) it may be noted that *C. procera* is only one (albeit important) of the numerous constituent species of the waste land plant community in this region, for example, *Acacia leucophlea*, *Calotropis gigantea*, *Ipomoea fistulosa*, *Lantana camara*, several members of Poaceae and others. Therefore, what is being discussed represents only a small part of the food web functioning in the degraded ecosystem.

Following are some mundane reasons that render *C. procera* a

Class	Order and number of species	Most common taxon
Insecta	Odonata-2, Orthoptera-2, Mantodea-10, Isoptera-2, Hemiptera-8, Homoptera-5, Coleoptera-8, Diptera-7, Lepidoptera-13, Hymenoptera-12	*Brachythemis contaminata, Poekilocerus pictus, Empussa sp., Microtermes obesi, Spilostethus pandurus, Aphis nerii, Cheilomenes sexmaculata, Paramecops sp., Dacus persicus, Danaus chrysippus, Apis spp., Xylocopa sp., Camponotus sp., Crematogaster sp.*
Arachnida	Araneae – 7	*Thomisus sp.*
Reptilia	Squamata – 1	*Calotes versicolor*
Aves	Passeriformes – 1	*Nectarinia asiatica*

Table 1. Fauna visiting/associated/dependent on Calotropis procera.

The list is based on a preliminary study only by the authors in and around Ujjian (23°11' N; 75°43'E) and still much remains to be added.

better option over several other plant species to initiate food chain studies: (1) the plant generally occurs in waste lands almost throughout India, (2) it is a perennial shrub and can thus facilitate round-the-year field studies, (3) the plant generally grows to a maximum height of ca. 2 m, which renders it a more convenient tool compared with trees for field studies by students, (4) it does not bear spines, thorns or similar other structures (however, one should avoid latex contacting to the eyes since it may cause irritation), and (5) the plant acts as an excellent resource provider to a bewildering array of organisms (*Table* 1 and *Figure* 3).

C. procera is a ready source of food to a large number of primary consumers (herbivores) among which aphids are the most abundant. *Figure* 4 showing consumption of aphids by the predaceous larvae of a ladybird beetle is just another demonstration of the fundamental fact: that animals high on food chains are rarer than animals down. In other words, there are more primary consumers than *secondary consumers* (carnivores) and so on (also applicable to plants and primary consumers, but not always). This is what is generally known (and depicted in textbooks with stepped sides or as their cone-shaped version) as *pyramid of numbers*, sometimes referred to as the *eltonian pyramid* in the name of Charles Elton who set out the importance of food chains in his text book – *Animal Ecology* – published in 1927. A

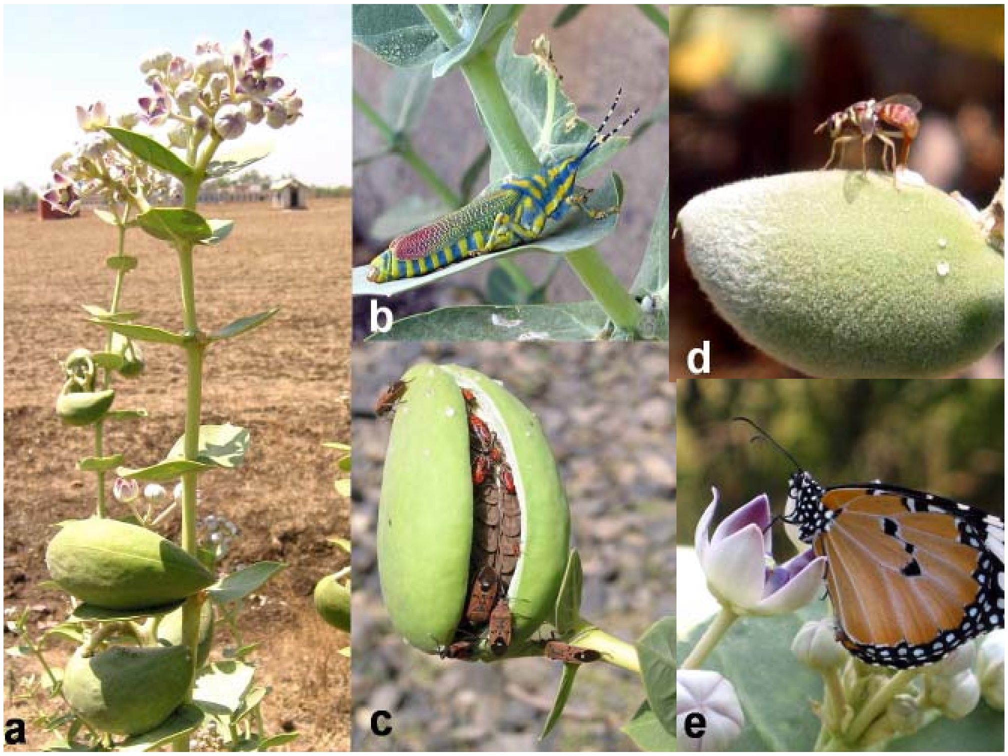


Figure 3. (a) Calotropis procera – a resource provider to a large number of organisms including (b) a grasshopper (Poekilocerus pic-tus) that primarily eats leaves, (c) nymphs and adults of a bug (Spilo-stethus pandurus) consuming seeds, (d) a female fruit fly (Dacus persicus) laying eggs in a fruit, and (e) a butterfly (Danaus chrysippus) ready to drink nectar from the flower.

(The photographs in this article are taken by the authors.)

Figure 4. Larvae (white-coloured) of a ladybird beetle (Coleoptera: Coccin-ellidae) consuming aphids (Aphis nerii). A few ants are also seen.

similar pattern, the *pyramid of biomass*, almost always results if dry weight is used instead of number. Both these pyramids are aspects of the structure of the community. The functional aspect of the community is best described by the *pyramid of energy* in which the rate of energy flow and/or rate of production at successive trophic levels are shown.

Yet another fact about food chains relates to the size of the predator as comapred to its prey: that there is a quantum jump in size between the animals belonging to two different trophic levels in the food chain. This is what is generally known as the *principle of food size*. Indeed, in 90% of the feeding links among the animal species in natural communities, a larger predator consumes a smaller prey. Thus, a ladybird beetle sucking on an aphid as seen in *Figure* 5 or a preying mantid devouring a honeybee as observed in *Figure* 6 conform well to this principle. The garden lizard (*Figure* 7), which is perhaps one of the largest animals using *C. procera* as shelter and hunting ground, also eats

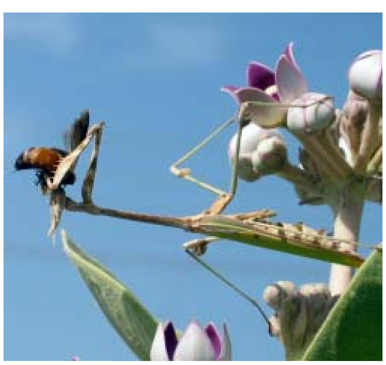


Figure 5 (top left). A ladybird beetle (Cheilomenes sex-maculata) consuming an aphid (Aphis nerii).

Figure 6 (left). A praying mantid (Empussa gutt-ula) devouring a honeybee (Apis sp.).

Figure 7 (top-right). A garden lizard (Calotes versi-color) waiting for prey.

insects and spiders that are comparatively much smaller. There are clear exceptions to the principle of food size in numerous feeding links though. For example, the spider seen preying upon the butterfly in *Figure* 8 is evidently much smaller compared to its prey.

Figure 8. A spider (Thomisus sp.-female) holding its prey – a butterfly

A food chain conventionally refers to grazer-plant or prey-predator relationship. There are many steps in the food chains, however, which do not match with this blueprint. One such step is evident in *Figures* 9a,b showing ants feeding on aphid honeydew. Such steps represent links, although partial, in a food chain since they too involve transfer of energy between one trophic level and another. The ant-aphid relationship, as depicted here, elucidates yet another important characteristic of food chains. As shown above, the ants act as secondary consumers (though not as carnivores!) when feeding on aphid honey-dew. Interestingly, they act as secondary consumers again (though this time as carnivores!) when preying on the larva of a fruit fly, which is emerging from the fruit (*Figure* 9c). On the other hand, they act as primary consumers when feeding on the nectar from flowers (*Figure* 9d).

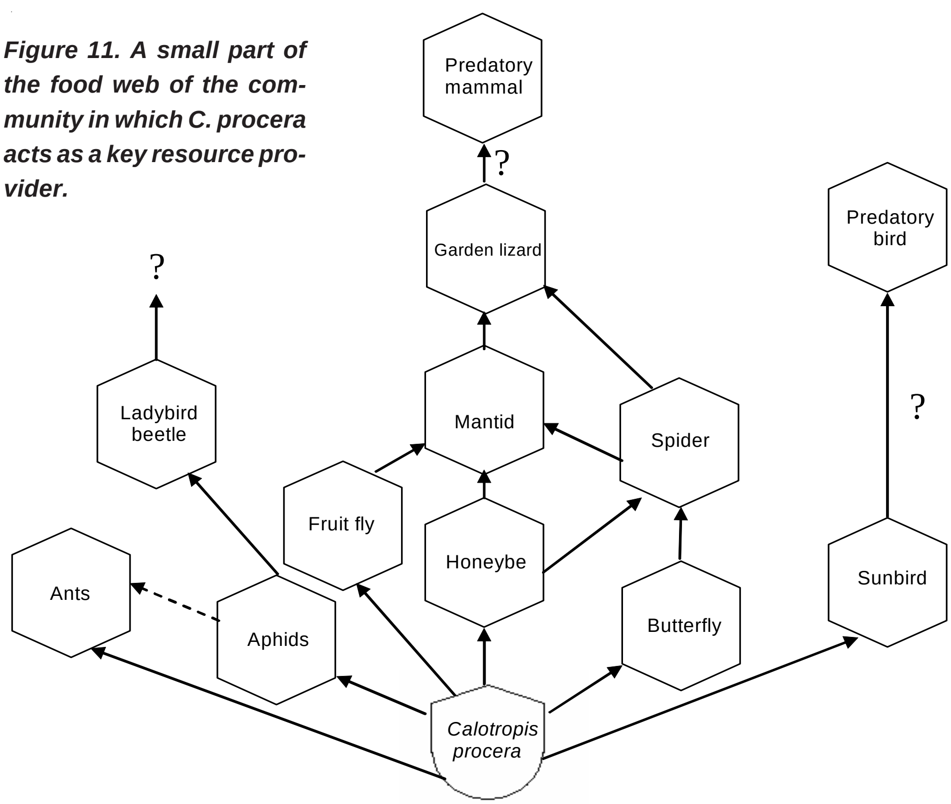
Figure 9. (a) and (b) Ants (Formicidae) consuming the honedew excreted from the siphon of an aphid (Aphis nerii). (c) and (d) Ants preying a larva (yellowish in colour) of the fruit fly (Dacus persicus) and feeding on the nectar, respectively.

Figure 10. A purple sunbird (Nectarinia asiatica – male) feeding on the nectar.

Like ants, sunbirds also seem to occupy more than one trophic level because, in addition to feeding on the nectar (*Figure* 10), they eat insects also. Clearly thus, the trophic classification is one of function and not of species as such; a given species population may occupy one, or more than one, trophic level based on the source of energy actually assimilated. The trophic-level concept is useful as a simple way of looking at ecosystems. But, due to the problems discussed above, there is a tendency these days to use a '*compartment*' approach. A compartment is a group of species in a food web that interact more with each other than with species outside that group. In the above example thus, aphids and ants may be put in the same compartment despite differences at the trophic level.

We conclude showing a few food chains (*Figure* 11) that can be connected to *C. procera* on the basis of consumer-resource pairs

Figure 11. A small part of the food web of the community in which C. procera acts as a key resource provider.



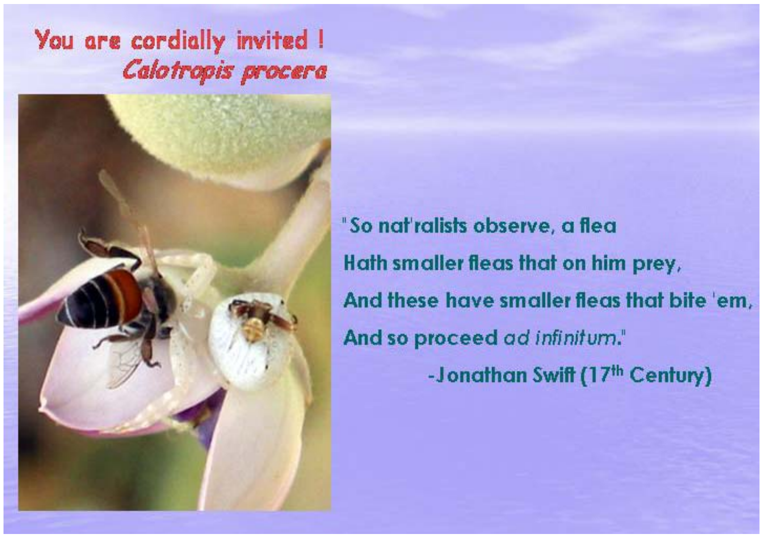


Figure 12. Photograph shows a honeybee (Apis sp.) on a flower of Calotropis procera in the hold of a female spider (Thomisus sp.). The female may, at times, return the 'love-bite' of the mate (riding on her back) by a 'death-bite'. A ditty by Jonathan Swift, a 17th century writer, mocking the idea of self-similarity in natural philosophy (not to be taken literally).

described above. Admittedly, the picture is far from complete. One just needs to accept the accompanying invitation (*Figure* 12) to take up a ride through the food web and to paint it further. The journey, besides being assuredly enjoyable, may also prove fruitful since an understanding of the structure and function of food webs is crucial to understand ecosystem functioning, including attempts to predict which communities might be more vulnerable to disturbance and therefore in more immediate need of conservation.

Acknowledgements

We are particularly grateful to K Chandrashekara, GKVK, Bangalore; H Ghate, Modern College, Pune; C Viaktamath, GKVK, Bangalore. A Freidberg, Tel Aviv Univesity, Israel; M Quinn, Texas Parks & Wildlife, Texas, USA and P Stys, Charles University, Czech Republic for their kind help in species identification.

Suggested Reading

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