POTENTIALLY DEFENSIVE PROTEINS IN MATURE SEEDS OF 59 SPECIES OF TROPICAL LEGUMINOSAE

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Abstract—A survey of 59 species of tropical legume seeds revealed high interspecific variation in proteinaceous capacity to inhibit bovine trypsin (a digestive enzyme) and to agglutinate human (type B, Rh positive) and laboratory rabbit red blood cells. The legume subfamily Mimosoideae was conspicuous for the absence of seeds with very weak trypsin inhibition. Congers sometimes differed strongly from each other with respect to both trypsin inhibition and phytohemagglutination. Half the species of seeds displayed no hemagglutinating capacity with one or the other kinds of red blood cells, and in only 27% of the 30 cases where there was some activity did the same species of seed actively agglutinate both species of red blood cells. A species of seed that had hemagglutinating capacity was almost invariably associated with moderate to high levels of trypsin inactivation. While it has been long known that a great diversity of small toxic and potentially defensive molecules occur in legume seeds and that one species of seed often contains several of them, we now feel that it is reasonable to consider legume seeds as also containing a high diversity of potentially toxic protein molecules. A single seed is likely to contain, at the least, three to four classes of defensive compounds, any or all of which, or some in combination, may be the cause of a seed being rejected by a potential seed predator.

Key Words—Seed predation, seed chemistry, lectins, protease inhibitors, phytohemagglutins, Costa Rica, seed defenses, Leguminosae.

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INTRODUCTION

A seed is a bag lunch for a seedling. However, there has been strong selection for seed traits that lower the probability that the seed will become lunch for a seed predator. Since seeds are rich in nutrients of value to a wide variety of animals, we expect that natural selection will have led to each species of seed having a variety of defenses, some of which function against certain potential seed predators, and others that function against others. Some seed proteins, e.g., lectins or phytohemagglutinins (Liener, 1979; Rudiger, 1984; Janzen, 1981) and proteinase inhibitors (Ryan, 1979), are among these potential defense traits (e.g., Janzen, 1977, 1978, 1981; Janzen et al., 1976; Lee, 1979; Olsnes and Pihl, 1973; Laskowski and Kato, 1980; Gatehouse et al., 1979; Adam 1974; Stripe et al., 1976; Warsy et al., 1974; Jayne-Williams and Burgess, 1974; Tannous and Ullah, 1969; Pearch et al., 1979).

One important step in understanding the defenses of a seed is identifying the potentially toxic compounds in that seed. This is less simple than it would appear for three major reasons. First, “toxicity” is a dosage- and animal-specific trait, although, of course, certain classes of compounds (e.g., alkaloids, cyanogenic glycosides) have a higher chance of being toxic than do others. This means that simply identifying a compound in a seed does not disclose the seed’s toxicity to animals (although some quite educated guesses are possible). Second, a given phytochemist tends to be specialized with respect to identification of a certain class of compounds. It is therefore almost impossible for the ecologist to send a bag of seeds to a single phytochemist and ask for a profile of all the potentially defensive compounds in that seed. Third, there are two major groups of potentially defensive compounds in seeds.

There are relatively small molecules that are generally straightforward to describe, identify, and isolate. Their mode of action on animal systems in generally very specific, and these compounds have a long tradition of examination by pharmacologists; caffeine, strychnine, L-dopa, canavanine, and cyanogenic glycosides are some well-known examples. If seed defenses were constituted only of compounds such as these, we would undoubtedly understand seed relationships with seed predators much better than we do. However, seeds also contain large molecules made up of repeating patterns of sugars, phenols, and amino acids. These carbohydrates, tannins, lignins, phytohemagglutinins (lectins), and protease inhibitors (to name but a few) are difficult to describe, identify, and isolate. Their mode of action on animal systems is often generalized (e.g., one may be a “digestion inhibitor,” another “inhibit uptake of amino acids by the intestine,” etc.). These large molecules have been known for a very long time in a general sort of way; tanning leather with polyphenols so as to prevent access to collagen by bacterial enzymes, and boiling beans to denature toxic phytohemagglutinins may be just as ancient to humans as is chewing plants for alkaloid pain-killers and mashing rotenone-rich foliage into streams.