The protozoa *Pleistophora* sp., *Nosema* sp. (Microsporida: Nosematidae) and *Mattesia* sp. (Neogregarinida: Ophryocystinae) were isolated from larger grain borer in Central America (Burde, 1988). Two species of Neogregarinida (*Mattesia* sp., *Farinocystis* sp.), one Eugregarinida (*Ascogregarina bostrichidorum*) and three Microsporida were isolated from the pest in Tanzania (Laborius, 1990b; Purrini & Keil, 1989); inconsistencies in the classification of the microsporidians remain to be resolved. In the Tanzania samples, pathogens affected 6% of larvae and 1% of adults (Laborius, 1990b). Laboratory studies showed that *Mattesia* sp. infection could kill up to 90% of first instar larger grain borer larvae and reduced the egg production of adult females, without affecting the predator *T. nigrescens* (Leliveldt, 1990; Laborius, 1990b). Trials of the practical application of protozoa for control of larger grain borer in rural maize stores are currently being carried out in Togo (Laborius, 1990a).

Concerns have been expressed as to the ability of natural enemies to sustain themselves in situations where there is at least some pesticide use and to contain damage within acceptable levels. Certainly, populations of *T. nigrescens* so far tested are highly susceptible to the pyrethroids currently recommended for larger grain borer control and, as noted above, there is evidence that larger grain borer can reach damaging levels, even in the presence of co-adapted natural enemies within the pest's area of origin. Probably pesticides will, at least for the immediate future, remain the preferred means of protecting farm-stored maize, where suitable products are available and socio-economic conditions permit. Biological control may be expected to complement pesticide use by reducing larger grain borer populations outside the maize storage system, where they are not subject to pesticide treatment, and in providing some relief from the present disastrous damage levels for those farmers who do not apply pesticides. In the longer term, it is to be hoped that biological control can be combined with other compatible methods to provide a more complete and environmentally-sound solution to the pest problem.

Varietal resistance

Host plant resistance to storage insects could be of immense value in rural storage systems as a factor which would complement other pest control measures of all types. Laboratory studies already mentioned (Howard, 1983, 1984; Li, 1988) demonstrated that varietal differences, especially relating to grain hardness and size, can considerably affect the bionomics of the larger grain borer. Inter-varietal differences were also noted (Segura, 1988) or

specifically investigated in a number of field and laboratory studies in Mexico (Aguilera, 1985b, 1987a & b; Melgarejo, 1986; Silva, 1981; Silva *et al.*, 1981; Tena, 1985b, 1988a & b), though the results in most cases were variable or inconclusive. It is widely assumed, though rarely demonstrated quantitatively, that land races selected by farmers over the centuries, in the presence of storage pests, will tend to be more resistent to damage than new varieties selected by breeders, mainly on the basis of higher yield. It is also possible that the tendency of small-scale farmers in Mexico and Central America to use "criollo" varieties, which have presumably co-evolved to some extent with larger grain borer, may be a factor contributing to the lower damage levels experienced in the region. Certainly some improved varieties widely grown in Africa, such as SR52 selected in Zimbabwe, suffer particularly severe damage from larger grain borer (Keil, 1988).

More recently, storage characteristics have received specific attention from plant breeders. Possible methods of screening for resistance to storage pests were suggested by Horber (1989) and some results of a screening program for high protein maizes were reported by Segura and Mihm (1991). Mechanisms of resistance to *Sitophilus* spp. are better understood than those relating to *P. truncatus* (Philogène *et al.*, 1989); however, in the case of *P. truncatus*, the phenolic acid content, especially that of para-coumaric acid, has been shown to be important (Conilh de Beyssac, 1990). If specific factors conferring resistance to storage pests can be identified, these may be more readily included in breeding programs than those which involve more general changes, for instance in grain hardness or endosperm type. With this in mind, García and Ibarra (1989) propose the incorporation into maize of protease inhibitors.

Selection criteria relating to pre-harvest production characteristics will continue to be given more emphasis in breeding programs than post-harvest storeability, since even highly-susceptible hybrids can be protected from storage insects in well-managed bulk grain stores. However, maize breeding programs targeted to help small-scale farmers in developing countries should give priority to incorporating resistance to larger grain borer and other storage pests into improved high-yielding varieties. Even if levels of resistance were not sufficient by themselves to protect the grain adequately, reduced susceptibility of the grain could contribute significantly to the effectiveness of chemical control, biological control or other management practices which are themselves only partially effective.