the Fregate island beetle of the Seychelles, which is considered critically endangered, and the British field cricket, of which fewer than 100 remain in the wild. In the next 30 years, scientists predict that more than 1,100 mammals and 1,000 bird species will become extinct.

Not all the samples will be stored at the Natural History Museum. Part of the project will involve the creation of a database that holds worldwide information on DNA and tissue samples. As an insurance against damage or loss of the frozen samples, duplicates will be kept in chosen institutions around the world.

The Frozen Ark is possibly the best chance of being able to ensure that, even if certain species are wiped out in the coming decades, they may not be lost for ever, says Rainbow. “It may sound depressing that we feel we have to do this, but it would be even worse if we did nothing,” he said.

“Natural catastrophes apart, the current rate of animal loss is the greatest in the history of the earth and the fate of animal species is desperate,” says Rainbow. “Progress in molecular biology has been so fast that we cannot predict what extraordinary things may be possible in the next few decades. For future biologists and conservationists and for the animals they seek to protect this global network will be of immeasurable value.”

Losing out: The scimitar-horned oryx has been declared extinct in the wild last year. Its only hopes are captive breeding projects and a new plan to store DNA and tissue samples for future use. (Picture: Photolibrary. com.)

Quick guide

Tribolium

Martin Klingler

Not to be confused with.. *Tribolium castaneum*, the red flour beetle, is often confused with *Tenebrio molitor*, the common ‘meal worm’ found in pet shops. Although morphologically similar to *Tenebrio*, *Tribolium* is much smaller and even easier to breed. That’s why this beetle was used by population geneticists for decades before it was rediscovered as a system in which embryonic development, and other biological phenomena such as pesticide resistance, can be genetically analysed. The ease with which it can be manipulated, its taxonomic position, and the fact that it is a representative of the largest animal order, were the main reasons why last October *Tribolium* was selected by NHGRI to be included in its list of species that will have their genomes sequenced in the near future.

Where does it come from? As a major pest of stored grains and grain products, *Tribolium* spread around the world with human agriculture. Dead beetles found in ancient Egyptian tombs are indicative of an Old World origin, but beyond that little is known about its place of origin or natural habitat. The strains used by *Tribolium* geneticists are derived from farms and commercial storages around the world. Their ability to live on dry food alone — metabolic water is the main source for their bodily juices — hints that these beetles evolved in a dry environment, but their original food source is unknown!

A better insect model system? *Tribolium* has become a prominent subject for studies of the evolution of development (‘evo-devo’) because its mode of development is more ‘insect-typical’ than that of the classical system *Drosophila*. While both are holometabolous — they go through a pupal stage — *Tribolium* embryos display ancestral features such as extensive extraembryonic membranes (largely reduced in *Drosophila*), well-formed legs (which in *Drosophila* arise postembryonically) and a normal insect head (which in *Drosophila* larvae is modified beyond recognition). Moreover, *Tribolium* develops according to the short germ mode where many segments are added one-by-one at the posterior end of the germ band — as seen in spiders, centipedes, crustaceans and basal insect orders, but unlike the long germ *Drosophila* which forms all its segments simultaneously in the blastoderm. That *Drosophila* is a very derived insect is also evident at the molecular level: many *Tribolium* genes seem more similar to their vertebrate than their *Drosophila* homologues.

What have we learned from* Tribolium *so far? An early contribution to developmental genetics was the finding that the beetle genome contains a single homeotic complex, whereas in *Drosophila* the *Hox* complex has been split into two. It was also shown that absence of all homeotic gene products in a *Tribolium* segment results in a 'default state' of antennal identity, which differs from the more

An adult *Tribolium* beetle. (Photo taken by G. Bucher.)

complex and probably derived situation in *Drosophila*. Other 'evo-devo' discoveries include the finding that the morphogen Bicoid is absent from the *Hox* complex in *Tribolium*, and that its function is apparently fulfilled by the homologues of the *Drosophila* gap genes *orthodenticle* and *hunchback*. But the gap genes and pair-rule genes do function during segmentation in the short germ *Tribolium* embryo, a non-trivial result as it had been difficult to identify pair-rule patterns in more basal arthropods. The precise roles of segmentation genes in *Tribolium* still need to be elucidated, however. Work on dorso-vental patterning and limb development in *Tribolium* is in early stages, but has already illuminated some aspects of short germ development. Outside development, one striking discovery was the genetic identification of maternal effect 'selfish' genes; the molecular analysis of these *Medea* elements may yield new tools in the war against insect pests.

What genetic tricks are available? As with more established genetic model species, the strength of *Tribolium* is that biological questions can be approached starting from phenotypes rather than molecules, thus avoiding the bias of most current comparative studies which focus on a few highly conserved gene families. About 100 developmental mutants have been identified so far, including homeotic and segmentation mutants, as well as mutants affected in limb or dorso-ventral patterning. The use of lethal mutants is somewhat limited at present by the expense of stock keeping — requiring identification of mutant carriers in every generation, so twice per year — as balancer chromosomes are available for just 30% of the genome so far. *Tribolium* can, however, be genetically transformed at very high efficiency using the *piggyBac* and *Minos* transposons. Based on this, schemes for insertion mutagenesis are currently being tested for large-scale transposon

Tribolium larvae, like the larvae of most typical insects, have a head, head appendages and legs (top); this is not true of *Drosophila* larvae.

screens. Visible markers will tag such insertional mutants, making them easy to maintain and the affected genes easy to identify. Moreover, incorporation of the Gal4–*UAS* system should result in a wide variety of enhancer trap Gal4 driver lines that can be used to test the effects of ectopically expressing developmental genes in defined patterns. The development of a site-specific recombination system will also allow the synthesis of defined chromosomal rearrangements, including deletions and balancer chromosomes. Together, these prospects should bring to the beetle most of the genetic magic now only found with *Drosophila* and *Caenorhabditis elegans*.

What about RNAi? In addition to forward genetics, reverse genetics via RNA interference (RNAi) is possible in *Tribolium*, with the added advantage relative to *Drosophila* that embryonic phenotypes can be generated by injecting the mother (parental RNAi). This makes RNAi particularly easy to use and helps avoiding injection artefacts. The high efficiency of this method in fact makes the prospect of genome-wide RNAi screens a realistic option once the ongoing genome project yields the complete set of *Tribolium* genes. The combination of forward and reverse genetics should make *Tribolium* a very valuable system not only for questions relating to the evolution of development, but for studying any basic problem in insect biology.

Where can I find out more?
http://www.tribolium.net

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