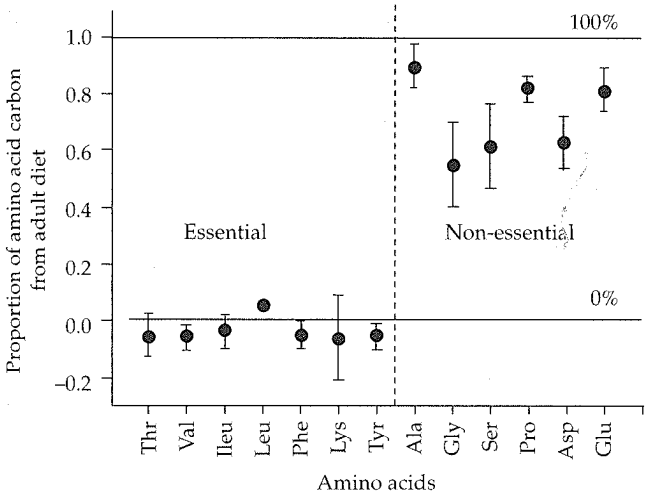

Figure 2.16 Proportion of amino acid carbon derived from the adult diet in eggs of the hawkmoth *Amphion floridensis*, measured using stable isotopes.

Note: Data are for eggs laid on day 12, when carbon isotopic composition has stabilized (see O'Brien *et al.* 2000). All essential amino acids are within measurement error of zero, indicating their exclusive origin in the larval diet.

Source: O'Brien *et al.* (2002). *Proceedings of the National Academy of Sciences of the USA* **99**, 4413–4418. © 2002 National Academy of Sciences, U.S.A.

reared gypsy moth larvae, *Lymantria dispar* (Lymantriidae) through several instars with differing access to two artificial diets, and found that an initial preference for high protein content shifted to one for high lipid content, especially in male larvae. Males need lipid for flight fuel, but female moths do not fly. Neither sex feeds as adults and there is no need to search for adult food plants. Moths eclose with mature eggs (1300 per female under laboratory conditions) which contain 50 per cent of the nitrogen assimilated by the larvae (Montgomery 1982). Incidentally, it is Lepidoptera with this type of life history that are most likely to reach outbreak densities in homogeneous food plant environments (Miller 1996). Spring-feeding forest Lepidoptera in the Geometridae and Lymantriidae exhibit a high incidence of wing reduction in females, although Hunter's (1995) phylogenetic analysis showed no statistically significant increase in fecundity.

Flight polymorphism

Polyphenisms or developmental switches are irreversible changes in phenotype in response to environmental information during a critical phase of development; as in the castes of social insects or the wet and dry seasonal phenotypes of some butterflies. Aphids exhibit a complex sequence of generations with different phenotypes, and it is commonly accepted that the development of winged aphids is a result of poor nutritional quality of their host plants, although this hypothesis is only partially supported by the accumulated evidence (Müller *et al.* 2001). All insect polyphenisms are likely to be controlled by changes in endocrine physiology (Nijhout 1999), and the best evidence for endocrine control comes from wing polymorphism in crickets. This arises from a combination of genetic and environmental variation, and is controlled by elevated titres of juvenile hormone which block the development of wings and flight muscle during a critical period of development (Zera and Denno 1997). The term polymorphism is often used when there is a genetic component to the morphological differences. However, the terms polymorphism, polyphenism, and phenotypic plasticity are sometimes not carefully distinguished (see Section 5.2.1 for discussion of terminology).

Wing polymorphism is a commonly studied dispersal polymorphism because it involves discontinuous variation in flight capability, and wing morphs are easily recognized (reviewed by Zera and Denno 1997). The winged morph usually has fully developed, functional flight muscles and lipid stores for flight fuel, while the flightless morph has short wings, non-functional flight muscles and reduced lipid stores. In some species a second flightless morph is derived from long-winged adults by histolysis of flight muscles (although this morph was not distinguished from flight-capable morphs in earlier studies). Flightless