

## Results from Breeding Programs

Modern animal breeding has strongly confirmed Darwin's conclusion: artificial selection can produce dramatic evolutionary change in a small number of generations and for essentially any



**Figure 1**

Contemporary comparison of (a) 1957 Control and (b) 2001 Selected broiler carcasses slaughtered at different ages (from left: 43, 57, 71, and 85 days). (Figure courtesy of G.A. Havenstein.)

trait (Hill 2008, summarizing results for many livestock species). Perhaps the most spectacular example is for traits of broiler chicken, where there are good data because unselected control populations founded from commercial breeding stock of 1957 have been maintained for over 40 years (Figure 1). For example, 8-week body weight in contemporary trials has increased from 0.81 kg to 3.14 kg over the period 1957 to 2001. About 80% of this four-fold increase is genetic (Havenstein et al. 2003), that is, a selection response of about 2.5% per year (approximately, per generation). This response shows no signs of abating: Comparisons between trials run in 1991 and 2001 show about a 26% increase in weight over this period. Other important traits such as meat yield and feed conversion efficiency also increased. Likewise, milk production in dairy cattle has increased greatly. During the 50 years starting in 1957, mean milk yield in the U.S. has more than doubled, from 5,859 to 12,043 kg year<sup>-1</sup> per cow; and BLUP analyses show that about half the change is attributable to genetic improvement (<http://aipl.arsusda.gov/eval/summary/trend.cfm>). This implies over 1% evolutionary change per generation. Again, there is no evidence of decreased response, and if anything heritability has increased in recent years (perhaps due to better recording and management). Rapid evolution under long-term artificial selection is not limited to animals: In the famed Illinois selection experiment on corn, oil content has increased by 3% per generation for 100 generations, and shows no signs of slowing down (Dudley & Lambert 2004).