On the edge of a wing

SIR—It is very striking how the wings of all species of the fruitfly *Drosophila* have a similar, elliptical shape, independent of their size. This suggests that there could be a standard growth mechanism with parameters that vary within narrow limits.

D'Arcy Thompson[1] showed that the shapes of organs of various plants and animals can be accurately described using geometric figures defined by simple equations. To characterize the variation in size and shape of *D. mediopunctata*'s wing, we tried to adjust an ellipse to its contour. When we overlayed the adjusted ellipse on a photograph of the wing, we were impressed by the nearly perfect fit (see figure).

Because the shape and size of an ellipse can be precisely described by two independent parameters (in our figure *SH* and *SI*), we can characterize the shape and size of a wing using the parameters of the adjusted ellipse. We did this when we analysed the wings of 17 females collected from the field and of 42 of their daughters raised in the laboratory, half at 16.5 °C and the other half at 20 °C. Comparing the three groups, we found no significant difference in the shape of their wings ($F=0.91$; $P>0.9$; d.f.=2, 56) although there were clear and significant differences in size ($F=18.81$; $P<0.001$; d.f.=2, 56); showing that, despite the great variation in size, there is little variation in the wing shape.

We also adjusted ellipses to the wings of a few animals of other species: *D. atrata*, *D. quadrum*, *D. hydei*, *D. mulleri*, *D. willistoni* and *D. melanogaster*. Similarly, we examined published photographs of the wings of 17 *Zygothrica*[2] species and of 16 species and 40 hybrids of the picture-winged Hawaiian *Drosophila*[3]. In all cases, there was a good fit for the adjusted ellipses.

Together with use of genetic information available for *Drosophila*, the use of ellipses opens the possibility of new experimental investigations on questions related to size and shape. These could include evolution in species of *Drosophila* and related genera, environmental and genetic factors and the effects of selection for size on shape. We suspect that the wings of other insects may also be described by simple geometric figures, although not necessarily ellipses.

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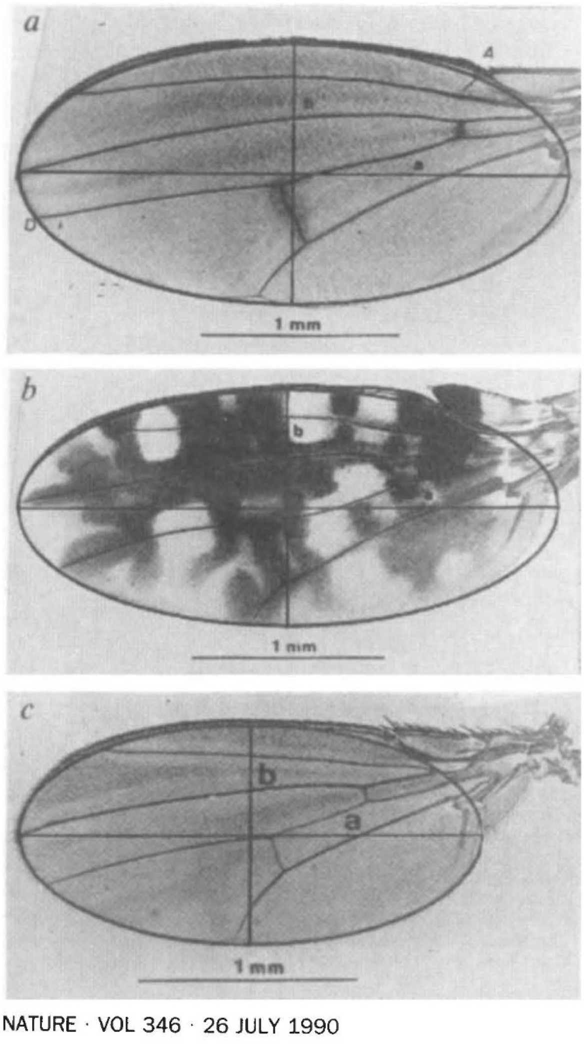

a, Wing and adjusted ellipse of *Drosophila mediopunctata* (a= 1.398 mm, b=0.653 mm, $SI=\sqrt{ab}$=0.955 mm, SH= 0.4668, r=0.9998). *b*, Wing of *D. quadrum* (a=1.4156 mm, b=0.612 mm, SI=0.931 mm, SH=0.4324, r=0.99933). *c*, Wing of *D. melanogaster* (a=1.054 mm, b=0.496 mm, SI=0.723 mm, SH=0.4707, r=0.9996). We took at least 20 points along the outline of the wing (using the internal edge of the marginal vein from A to D). We fit the general equation of the ellipse to the cartesian coordinates of these points using a least-squares procedure. Solving this equation for the x-observed values, we calculated a correlation (r) between the observed and expected y-values, and the centre and orientation of the ellipse found. Through a translation and rotation of the coordinates system, the general equation was transformed to $x^2/a^2+y^2/b^2=1$, where a and b are the radii of the two director circles of the ellipse. Their geometric mean is the size parameter ($SI=\sqrt{ab}$); the shape parameter is the proportion of the smaller to the larger radius ($SH=b/a$).

Channel hands

SIR—Calcium-binding proteins are grouped into several classes, one of which consists of intracellular transducers of calcium signals. These calcium-modulated proteins contain sequences of 29 amino acids, the EF hand which forms an α-helix, a calcium-binding loop and a second α-helix[1].

The deduced amino-acid sequences of many voltage-gated ion-channel proteins have been reported recently. Sodium-channel α_1 and dihydropyridine-sensitive calcium channel α_1 polypeptides have recognizably similar amino-acid sequences, both of which probably evolved by two gene duplications from a polypeptide resembling the *Drosophila Shaker* gene product, a voltage-gated potassium channel[2,3]. In the course of work on brain calcium-binding proteins, I found that all three calcium-channel α_1-subunit and seven of eight published sodium-channel α_1-subunit sequences contain one or more putative EF hands. The exception is the *Drosophila* DSC locus[4], but another probable *Drosophila* sodium-channel α_1-subunit which has been partially sequenced may have the conserved EF hand[3]. By contrast, none of the 10 potassium-channel sequences so far published contains apparent calcium-binding sites.

All the sodium-channel α_1-subunit sequences except the *Electrophorus* sequence contain a conserved region which scores 10 or 11 in the Tufty–Kretsinger test and all scores can be improved to 12 or 13 by allowing plausible test modifications described for other EF hands. Other criteria for calcium binding[5], such as the presence of three acidic ligands and the absence of more than one serine or threonine serving as a ligand in the calcium-binding loop, are fulfilled by these sequences. Critical positions are better conserved than are noncritical ones. Polypeptides from *Electrophorus* electric organ and rat skeletal muscle also contain a putative EF hand downstream.

The calcium channel α_1-subunit sequences score higher in the EF-hand test than do the sodium-channel sequences and they have more characteristics of EF hands, particularly the specified I, G and first E. The sequences of the rat aorta and brain calcium-channel α_1