CORRECTION FOR DRAG OF A FLIGHT MILL, WITH AN EXAMPLE FOR *AGROTIS ORTHOGANIA* MORR. (LEP. NOCTUIDAE)

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Quaestiones entomologicae
7 : 253-254 1971

A method of measuring the drag-speed relationship for an insect flight mill system is reviewed. Compensated free flight speeds and ranges for Agrotis orthogonia *Morrison are given for Jacobson's (1965) data.*

Compte rendu du rapport resistance-vitesse pour insectes montés sur un manège. De plus, je propose pour les données de Jacobson (1965) un facteur de correction pour la vitesse de vol en liberté et pour les distances de Agrotis orthogonia *Morrison.*

The use of insect flight mills as described by Hocking (1953) necessitates a consideration of mill drag. The additional drag of the device substantially lowers flight speed, and should be corrected for as follows.

The difference between power required to maintain a mill alone, and a mill loaded with a dead insect at a constant speed, is the power required to overcome drag on the insect alone at that speed. Free flight speed would be the speed at which power to overcome drag on the insect alone would equal power to overcome drag on the mill-insect combination at the observed mill speed. Correction for this requires the measurement of drag-speed relationships for the mill itself and for the insect.

I tested the mill used by Jacobson (1965). It is similar to those described by Hocking (1953), but gives a flight circumference of 0.893 meters. With the mill pivoted on a steel needle, the mill tip sweeps out a horizontal circle. Following Hocking's (1953) procedure, about the glass stem I wound two natural silk threads, passed these over light weight pulleys on either side of the glass stem, and attached a series of weights to their opposite ends. By measuring the terminal tip speed for each pair of weights the drag at this speed can be obtained from the following relationships:

$$d = \frac{2Wrg}{R} \qquad \text{and} \qquad P = \frac{dc}{t} = \frac{2Wgrc}{Rt}$$

where,

d = equivalent drag on the system at the arm tip at terminal speed (kg m sec^{-2})
W = weight on each thread (kg) r = radius of the glass stem (m)
g = acceleration due to gravity (9.8 m sec^{-2}) R = length of the mill arm (m)
P = power to maintain a terminal tip speed (Joules sec^{-1})
c = circumference swept out by the insect mount on the mill arm (m)
t = time for one revolution (sec)

I used the means of two readings taken in each direction of rotation at each loading to plot drag-speed relationships (Fig. 1). For speeds too high for counting by eye I used Hocking's photocell system.

I plotted power against terminal speed for the insect and for the mill with a dead insect, without wings or legs, mounted on it in flight attitude. The appropriate drag value, i.e. that on the insect alone or that on the insect plus 'tip equivalent drag' for the mill, multiplied by the tip speed gives the power values. As suggested by Hocking (1953) by comparison of the mill mounted insect speed to the free insect speed at equal power, the free flight speed can be estimated. The dotted lines on Fig. 1 illustrate this procedure. Free flight speeds estimated, a proportional correction can also be made to equivalent flight ranges. An example using Jacobson's (1965) data follows.

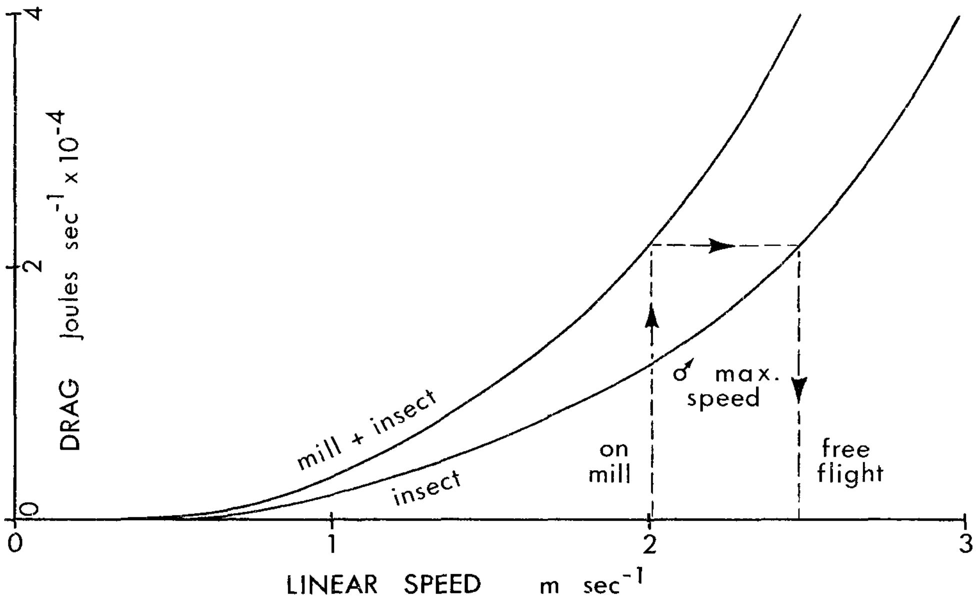

Fig. 1. The drag-speed relationships for *A. orthogonia* and Jacobson's (1965) flight mill.

The maximum mill speed of male *Agrotis orthogonia* Morrison is given at 4.5 mph or 2.01 m sec^{-1}. From Fig. 1 the equivalent free speed is found by the projection at equal drag from the insect-mill curve to the free flight curve (dotted lines). The equivalent free flight speed is 2.47 m sec^{-1} or 5.5 mph. The mean free flight speed of the male is 20% faster than the mill speed, and the equivalent flight range is then 17.6 miles.

Equivalent Free Flight Speeds and Ranges of *A. orthogonia*

	Mill values		Free flight values	
	male	female	male	female
Mean speed (mph)	2.5	1.8	3.0	2.1
Max. speed (mph)	4.5	4.8	5.5	5.9
Max. range (miles)	14.7	3.5	17.6	4.1

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