University of Florida Book of Insect Records
Chapter 9 *Fastest Wing Beat*

C.W. SCHERER

Department of Entomology & Nematology
University of Florida, Gainesville, Florida 32611-0620

8 May 1995

Using a beat-frequency oscillator as well as personal auditory analysis, O. Sotavalta (1953) found that a midge of the genus Forcipomyia *(Diptera: Ceratopogonidae) attained a wing beat frequency of 1046 Hz.*

Insects require enormous amounts of energy to beat their wings rapidly. To lessen the demand for energy, insects have reduced the weight of the wings, the amount of drag created during wing movement, and the overall body size and weight. Appropriately the fastest recorded wing beat was achieved by a small, lightweight ceratopogonid midge.

Methods

To locate references on wing beat frequencies, I consulted general entomology texts and keyword searched "LUIS", the University of Florida's computerized library catalog. I also searched *Biological Abstracts* on CD- ROM but it was not helpful. The most useful technique was locating citations of primary literature in published books on insect flight.

Results and Discussion

A Polish researcher, O. Sotavalta (1947,1953) published extensively on insect flight, particularly concerning flight-tone frequency. Using a beat-frequency oscillator as well as personal auditory analysis (Sotavalta had perfect pitch), Sotavalta found that a species of *Chironomous* (Diptera: Chironomidae) had a wing beat frequency between 650-700 Hz. However, a member of the genus *Forcipomyia* (Diptera: Ceratoponidae) (no species given) had most masterfully exploited its asynchronous muscle system by acheiving a wing beat frequency of 1046 cycles/sec (Hz). Through experimental manipulation of this insect (removal of most of the wing area as well as exposing it to temperatures up to 37 C) Sotavalta recorded flight tones over 2200 Hz.!!

Insect muscle systems have been categorized into two groups; synchronous and asynchronous. Most insects with synchronous muscle systems cannot produce muscle contractions greater than about 100/sec., because of delays involved in conduction of the motor nerve impulses and the activation of the contractile system of muscle fibers (Pringle 1976, Smyth 1985.) However, insects do not read our texts on physiology and biochemistry and there are currently two recorded exceptions to this limit. The tymbal muscles used in sound production in the cicada, *Chlorocysta viridis* (Homoptera:Cicadidae), have been recorded up to 224 Hz. (Young & Josephson 1983). When singing, the cone-head *Neoconocephalus robustus* (Orthoptera: Tettigoniidae) has thoracic muscle contractions of 212 Hz (Josephson & Halverson 1971).

In asynchronous muscle systems (Hymenoptera, Diptera, Coleoptera, and Hemiptera), the impulses in the motor nerves and the mechanical activity of the muscles do not occur at the same frequency (Pringle 1976.) The arrangement of muscles in the asynchronous system is antagonistic which causes cyclic deformations of the thorax (Smyth 1985). It is this asynchronous muscle system that allows some insects to pro-

duce such high muscle contraction rates.

Although these recordings are over 40 years old they seem to be the only evidence of such feats, as the most modern publications continue to cite Sotavalta's work. One advantage for rapid wing beat is the ability of the insect to remain relatively stationary in air (hover). This talent would certainly be helpful in times of mating.

Acknowledgements

I thank Drs. J.L. Nation, T.J. Walker and J.F. Butler (University of Florida, Department of Entomology and Nematology) for their suggestions of possible "champions" as well as identifying pertinent references. I also thank Jason Byrd and Doug Sieglaff for their help in locating appropriate literature.

References Cited

Josephson, R. K. & R. C. Halverson. 1971. High frequency muscles used in sound production by a katydid. I. Organization of the motor system. Biol. Bull. 141: 411-433.

Pringle, J. W. S. 1976. The muscle and sense organs involved in insect flight, pp. 107-130. *In* R.C. Rainey [ed.], Insect flight. John Wiley and Sons, New York.

Smyth, T.,Jr. 1985. Muscle systems, pp. 227-286. *In* M.S. Blum [ed.], Fundamentals of insect physiology. John Wiley and Sons, New York.

Sotavalta, O. 1947. The flight-tone (wing stroke frequency) of insects. Acta Entomol. Fenn. 4: 1-117.

Sotavalta, O. 1953. Recordings of high wing-stroke and thoracic vibration frequency in some midges. Biol. Bull. Woods Hole 104: 439-444.

Young, D. & R. K. Josephson. 1983. Mechanisms of sound-production and muscle contraction kinetics in cicadas. J. Comp. Physiol. 152: 183-195.