CLASSICS

In 1926, based upon his studies of the deer fly, Charles Townsend suggested it can fly at speeds close to 800 miles per hour, much faster than the fastest trains of today. This was accepted as the truth, for several years, until Langmuir analyzed the flight in a classic *Science* paper, reproduced below. His analysis showed that at this speed, the air pressure would crush it. Further, the energy requirements for such flight would mean that it would have to consume 150% of its body weight as food each second. Langmuir estimated the speed to be 25 miles per hour.

K L Sebastian

The Speed of the Deer Fly

Irving Langmuir

About ten years ago, an editorial in *the New York Times*, in commenting on a new seaplane speed record of something over 300 miles per hour warned man not to be too boastful of his accomplishments, since the deer fly has a speed of 700 miles per hour. This speed, nearly that of sound, seemed to me so fantastically high that I was led to make some rough mental calculations, by dimensional reasoning, comparing the fly with a Zeppelin as to diameter and speed and fuel consumption. I found that the fly would have to consume his own weight of fuel every few minutes or so to supply the necessary power.

I was curious also regarding the source of the data and the nature of the measurements, for the methods of measuring the velocities of revolver bullets are not easily applicable to deer flies.

About a year ago there was an editorial in Sehenectaday newspaper giving the speed of the deer fly as 800 miles per hour. Since then I have met many people who have seen similar citations in various publications, so I believe the story is going the rounds over the whole country.

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I was therefore interested in a 2-page diagram in the *Illustrated London News*, January 1, 1938, giving the comparative speeds attained by man and by animals, fish, etc. The female deer fly was credited with 614 miles per hour, while for the male the record was 818 miles per hour.

On the next page there was a photograph entitled, "The speed champion of the world, capable of outstripping sound: a Deer Botfly (*Cephenomyia Pratti* Hunter)". Under this was a reference to the source of the data that I had long been hoping to find:

Writing in the Journal of the New York Entomological Society, Dr. Charles H.T. Townsend, who has studied insects, and Cephenomyia in particular, for many years, states "On 12,000 foot summits in New Mexico I have seen pass me at an incredible velocity what were certainly the males of Cephenomyia. I could barely distinguish that something had passed – only a brownish blur in the air of about the right size for these flies and without a sense of form. As closely as I can estimate, their speed must have approximated 400 yards per second."

It should be noted that the 400 yds/sec is 818 m/hr, while 300 yrds/sec is 614 m/hr. The article on "Ballistics" in the Encyclopedia Britannica, 1929 Edition, vol.2, p.1003, gives for the resisting force (drag) acting on a projectile of diameter d, moving with the velocity v:

$$R = \rho\, d^2 v^2 f$$

Where ρ is the density of air, and f is a numerical factor that depends on the shape of the projectile and on the ration v/v_o where v_o is the velocity of sound.

This factor increases rapidly when the velocity approaches that of sound. For the speed of 818 m/hr (3.7×10^4 cm/sec) $f = 0.20$, for the best projectiles with sharp points and rises to 0.50 for cylindrical projectiles with flat heads. The deer fly has a very flat head, so that if we choose $f = 0.25$ we shall certainly be taking too low a value. If we take $d = 0.5$ cm for the body of the fly and neglect the resistance of the wings we shall again be taking a lower limit. The equation thus gives:

$$R = 1.0 \times 10^5 \text{ dynes}$$

or a force to the weight of 100 grams. A check on this result was obtained from equations of entirely different form in the "*Handbuch der Physik*," vol.5, p.311 (1927).

Thus the wind pressure against the head of the fly amounts to about 8 pounds per square inch or more than half an atmosphere, probably enough to crush the fly. This force if unopposed would given an acceleration of 500 times gravity, taking the weight of the fly to be 0.20 grams (density, 1., length 1. cm, diameter 0.5 cm).

The power consumption needed to maintain this velocity of 818 m/hr would be 3.7×10^9 ergs/sec or 370 watts or about one-half horse power – a good deal for a fly!

A man weighing 200 pounds and in good training can climb about 10,000 feet in a day, but he will eat at least 3 pounds of dry food and 2 pounds of water. The man develops 1.0 horsepower-hours of work or 2.7×10^{13} ergs and the food consumption amounts to 8×10^{-11} grams per erg. The insect can not do much better than this, since even man has rather high thermodynamic efficiency.

On this basis the insect, to deliver 370 watts, must consume 0.31 grams per see or 1.5 times his own weight of food each second!

The quoted statement of Dr. Townsend is obviously a mere rough estimate, which cannot justifiably be used to establish a world record. It is of interest to determine the speed of an object the size of a deer fly which would appear as "a barely distinguishable blur in the air." For this purpose I took a short piece of solder about 1 cm long and 0.5 cm diameter and tied it about its middle to one end of a light silk thread, holding the other end in my hand. With lengths of thread from 1 to 3 feet it was easily possible to swing the weight in a circle in a vertical plane at the rate of 3 to 5 rotations per second (timed with a telechron clock). In this way speeds from 13 to 64 miles per hour were produced.

Observations in a room, with a brightly lighted white ceiling as background, showed that at 13 miles per hour (580 cm/sec) the "fly" was merely a blur – the shape could not be seen, but it could be recognized as a small object of about the correct size.

At 26 m/hr (1,150 cm/sec) the fly was barely visible as a moving object. At 43 m/hr (1920 cm/sec) it appeared as a very faint line and the direction of rotation could not be recognized. At 64 m/hr. (2,900 cm/sec) the moving object was wholly invisible.

That even a black object of this size moving at 64 m/hr should be invisible is also apparent from the fact that in $1/20^{th}$ second (about the shortest time that the eye can recognize) the object moves 150 cm, and thus if it has a length of 1. cm the average intensity of the light

along the 150 cm section of its track is decreased by only 0.7% by the presence of the object. Even under steady conditions in a photometer intensity differences of less than 1% are not distinguishable.

The description given by Dr Townsend of the appearance of the flies seems to correspond best with a speed in the neighborhood of 25 m/hr.

In the Adirondacks I have been surprised by the swift flight of insects which I have been told were deer flies. These flies often strike one's bare skin with a very noticeable impact, far greater than that of any other insect I have met. However, if the speed were 800/hr and the fly on striking should be stopped within 1. cm it would come to rest in about 55×10^{-6} sec, and during this time there would be a force of 1.4×10^{-8} dynes or 140 kg (310 pounds). It is obvious that such a projectile would penetrate deeply into human flesh.

The appearance of the moving lead weight on the thread at 25 m/hr seems to agree roughly with my recollections of the deer flies.

The power requirement of a fly at 25 m/hr (f = 0.08) would be 0.0034 watts, which would involve a food consumption of about 5% of the fly's body weight per hour, a value which could not well be greatly exceeded if the flies are to fly over 12,000 foot mountain peaks.

Thus a speed of 25 miles per hour is a reasonable one for the deer fly, while 800 miles per hour is utterly impossible.

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