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Technical Comments

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Comment on "Low-Aspect-Ratio Wing Aerodynamics at Low Reynolds Numbers"

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IN their paper[1] Torres and Mueller venture into the aeromodelers' (and micro-unmanned air vehicle makers') low-Reynolds-number world with gratifying results. They show that the center of pressure (c.p.) of thin wings with zero camber moves aft with increasing angle of attack. However, they do not mention an important consequence of this. There is a substantial range of center of gravity positions for which such wings are longitudinally stable in flight—either way up.

The stability of little, uncambered "flying planks" of 8-in. span and 2-in. chord, made of mica 0.003 in. thick, was noted by Lanchester in 1909,[2] but few modelers know of the stable c.p. travel or that it affects the flight of their models—including those with tails.

I investigated the stability of little, uncambered, flying-plank gliders in the early 1980s, calling the effect "superstability."[3,4] In one series of experiments the wing, of balsa wood, was 1/16 in. thick, 3 in. in chord, and 4, 8, or 36 in. in span. Leading and trailing edges were sharpened in the 8-in. wing, square at first in the others. The same fuselage and fin were used with all wings.

With the 4-in. wing the c.g. range for stable flight was 21.8–35.3% of the chord. Moving the c.g. too far back made the model pull up and stall. Evidently the center of pressure had stopped moving aft with increasing angle of attack. Moving the c.g. too far forward made the model dive, implying that the c.p. had, at the least, stopped moving forward with reduction in angle of attack. With the 8-in. wing the stable c.g. range was 21.4–36%, and the 36-in. span gave 20.5–36.7%.

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Sharpening the leading and trailing edges of the 4- and 36-in. wings made no great difference.

With the 8-in. wing the model weighed 7 g, and the Reynolds number ranged from 1.5×10^4 with the c.g. at the aft limit to 2.9×10^4 with it at the forward limit.

The c.g. positions are probably accurate to a percent or so of the chord, Reynolds number to several percent.

The aft c.g. limit in my experiments agrees quite well with the aft limit in c.p. travel found by Torres and Mueller. My forward c.g. limit coincides roughly with sloping plateaux in the Torres and Mueller c.p. data for rectangular wings. At lower angles of attack their cp vs angle of attack curves steepen again. My experiments did not find the fast, stable glide that this part of the Torres–Mueller data would predict.

I doubt that Torres and Mueller are correct in saying that the rearward shift of the c.p. with rising angle of attack results from vortex lift. They say the shift is steepest in low-aspect-ratio wings, but their data in fact have the opposite trend.

Torres and Mueller predict that were their experiment repeated with a wing of aspect ratio 10, there would be no rearward march of the c.p. with rising angle of attack; however, my wing of aspect ratio 12 showed a march even a little longer than that at low aspect ratios.

Following Schmitz's drawings of flow around a flat-plate wing at various angles of attack,[5] I ascribed the aft movement of the c.p. to a progressive change in the effective camber of the wing from negative to positive caused by a separation bubble on its top surface. The bubble stretches aft from the leading edge, and its thickness and length both increase with rising angle of attack.

References

[1]Torres, G. E., and Mueller, T. J., "Low-Aspect-Ratio Wing Aerodynamics at Low Reynolds Numbers," *AIAA Journal*, Vol. 42, No. 5, 2004, pp. 865–873.

[2]Lanchester, F. W., *Aerodynamics*, 2nd ed., Constable, London, 1909, pp. 231–233.

[3]McCutchen, C. W., "Superstability," *Model Builder*, Oct. 1982, p. 52, and Nov. 1982, p. 46.

[4]McCutchen, C. W., "Superstability—Or Why Your Chuck Glider Has Two Personalities," *Nineteenth Annual Symposium of the National Free Flight Society*, National Free Flight Society, Lake Charles, LA, 1986, pp. 49–53.

[5]Schmitz, F. W., *Aerodynamik des Flugmodells*. C. J. E. Volkmann Nachf. E. Wette, Berlin, 1942; available in translation from the National Technical Information Service, Springfield, VA, as Index No. N70-39001, p. 45 of the translation.

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