SUPPLEMENTAL TEXT

HOW ATLATL DARTS BEHAVE: BEVELED POINTS AND THE RELEVANCE OF CONTROLLED EXPERIMENTS

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Experiments with beveled dart points followed two parameters: flight tests to determine if beveled points would rotate a dart in air, and penetration tests to determine if beveled points would rotate darts through solid targets. A number of flight tests were undertaken resulting in 100 recorded throws with various darts and tips. Detailed results are presented in Table 1. Penetration tests to determine if beveled points would rotate darts in solid targets were made on a number of consistent target media, including foam, layered cardboard, a type of ballistics gel called Perma-gel, and cantaloupes. Of these, only cantaloupes worked in our tests to induce rotation. Perma-gel was found to be a poor stand-in for flesh when testing darts and arrows, since these projectiles had only shallow penetration into the gel. This is a highly resistive medium that is meant to stop bullets. Penetration tests were then carried out on bone, and finally on a fresh hog carcass, where rotation was also visible. It is not necessary to cover the penetration tests further since the methods and results are discussed in detail in Pettigrew's (2015) thesis. All filming for the experiments was accomplished with a Casio EX-F1 at 300 and 600 fps.

Seven darts and four atlatls were used in the flight tests. Three of these darts (cane #4, cane #5, and willow #1) were used in the carcass experiment and produced lethal wounds on the hog with various tips. Three of the atlatls (Great Basin Inspired, Broken Roof Cave, and Clovis) were also used in the carcass experiment. The willow dart (# 1) and Broken Roof Cave atlatl are

close replicas of a Basketmaker atlatl and dart from northeastern Arizona (Garnett 2011; Pettigrew 2015). The rest of the atlatl equipment were systems that the authors were comfortable with and had used in competition. Six experimental tips (Table 2) were fitted tightly over the tips of the darts and could be interchanged. Four of these (Stone and Wood 1; Figure 5e in text) were made by Whittaker and were the primary test points. Two more (Wood 2) were later made by Pettigrew for fletchless dart tests and are closely based on Whittaker's.

Two filming techniques were used to capture darts in flight: filming over the thrower's shoulder from behind, and setting the camera up between the thrower and a target. Filming over the thrower's shoulder allows observation of the entire flight of a dart, but the camera must be zoomed in to capture any detail of the dart, and it can be challenging to keep the dart in the frame. The second method is to zoom in close on a target with the camera situated on a tripod between the thrower and the target, just a short distance to the side of the flight path. This provides more detail of a dart later in the throw, and with the added benefit that flight is observed at a known distance. In both methods, a background that contrasts with the dart is helpful. Hunting with atlatls is best preformed at close range (Cattelain 1997), so in our tests the targets were set at 20 m.

In Table 1, a dart's rotation is noted from observation of the videos. Darts have dynamic flight characteristics that are determined by their spine and oscillation, as well as the motion of the throw. Over-the-shoulder filming captured more of the flight, and the darts can often be seen to change the direction of rotation or to stop or start rotating at various points in flight. A dart's flight is typically most dynamic directly after it leaves the spur of the atlatl and its oscillation is at its peak. Fletching may start to affect the characteristics of dart flight once oscillation has decreased. The fletchless darts were characterized by less patterned rotation later in their flight.

Without feathers or exaggerated wooden points as visual aids, the characteristics of fletchless darts without points attached were difficult to determine at distance with the over-the-shoulder filming technique, even with the shaft marked with contrasting stripes. Filming them at the 20 m distance was more productive. In short, Table 1 shows that darts rotate in different directions even when beveled points are attached.

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