The Veloci-Raptor: A Bicycle-Powered Model Raptor for Realistic Predator Encounter Experiments (Ei Veloci-Raptor: Un Modelo de Rapaz Movido por Bicicleta para Experimentos Realistas de Encuentros con Depredadores)

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Source: *Journal of Field Ornithology*, Vol. 72, No. 3 (Summer, 2001), pp. 399-403
Published by: Wiley on behalf of Association of Field Ornithologists
Stable URL: http://www.jstor.org/stable/4514605
Accessed: 27-05-2015 18:01 UTC

J. Field Ornithol., 72(3):399–403

THE VELOCI-RAPTOR: A BICYCLE-POWERED MODEL RAPTOR FOR REALISTIC PREDATOR ENCOUNTER EXPERIMENTS

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Abstract.—Raptor attacks in the wild can be difficult to observe and impossible to manipulate in a repeatable manner. We have developed a bicycle-driven model raptor ("Veloci-Raptor") to test prey responses to raptor attacks. Previous researchers have used wind-up toy birds or gravity-driven model raptors, which typically have low maximum velocities and often require cumbersome equipment. Our method's combination of portability, flexibility, and high maximum speed (19.4 m/s) make it superior to previous methods in many field situations.

EI VELOCI-RAPTOR: UN MODELO DE RAPAZ MOVIDO POR BICICLETA PARA EXPERIMENTOS REALISTAS DE ENCUENTROS CON DEPREDADORES

Sinopsis.—Ataques de rapaces en el estado silvestre pueden ser difíciles de observar e imposible de manipular de forma repetitiva. Hemos desarrollado un modelo de rapaz movido por bicicleta ("Veloci-Raptor") para determinar las respuestas de prensas a los ataques de rapaces. Investigadores previos han usado aves de juguete a los que se les dá cuerda o modelos de rapaces movidos por gravedad, los cuales típicamente tienen una velocidad máxima pobre y a menudo requieren equipo engorroso. Nuestro método combina facilidad de acarreo, flexibilidad, y una velocidad máxima (19.4 metros/segundo) que lo hace superior a métodos previos en muchas situaciones de campo.

Our understanding of the reaction of potential prey animals to an attacking raptor is severely limited by our ability to manipulate the events of an attack. The use of direct observations to study prey responses can be difficult or impossible because attacks near any one observer are typically infrequent. Trained raptors have been used (e.g., Kenward 1978), but are undesirable as their attacks cannot be manipulated or repeated precisely. One way to manipulate predator attacks in a repeatable manner is to control attack vector and speed using a model predator.

Previous researchers have attempted this by using wind-up toy birds shaped like raptors (Greene and Meagher 1998), and wooden or cardboard models propelled by gravity down an angled line (Hanson and Coss 1997; Kullberg et al. 1998). However, the portability, flexibility of operation, and maximum speeds of these methods can limit their utility in the field. For instance, Hanson and Coss (1997) required a 4.9-m high wooden tower to create enough incline to propel a hawk model for 30 m at an average of 5.2 m/s. The toy bird used by Greene and Meagher (1998), although portable, has a maximum speed of only 1.8 m/s. Thus, these model raptors have unrealistically slow attack speeds and/or require cumbersome equipment or slopes to generate speed.

Because of the weaknesses of these approaches, we have developed a bicycle-driven model raptor that moves along a guide line at realistic speeds over a broad range of distances, using equipment that can be transported with ease. This equipment does not rely upon gravity and can

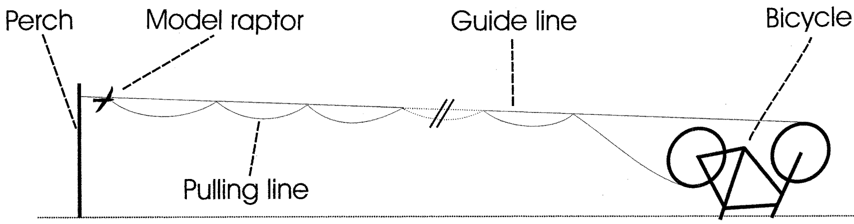

FIGURE 1. Components of the Veloci-raptor: The pulling line is attached to the guide line at 10-m intervals by small clumps of plasticine (// indicates the distance between bicycle and perch is at the discretion of the experimenter).

thus operate in flat terrain. We describe the construction of the apparatus and suggest its utility in a variety of situations.

METHODS AND MATERIALS

The Veloci-Raptor is based upon the premise of inverting a bicycle (originally known as a "velocipede") and using one of its wheels like a large fishing reel to pull a model raptor along a guide line (Fig. 1). The front wheel is attached to a guide line, with the wheel also acting to adjust the line's tension. The rear wheel is attached to a second line that propels the model raptor when the pedals are cranked.

Bicycle set-up.—The inverted bicycle is secured in position with the rear wheel closest to the perch (Fig. 1). Distance between the perch and the bicycle can be varied depending on the needs of the experimenter. It is important that the bicycle be secured in position firmly because of the tension exerted by the guide line. Methods for securing the bicycle include using the seat post and handle bar ends as spikes for sinking into the ground, fastening metal U-bars over the bicycle frame and into the ground, or attaching a simple frame to the bicycle that can be weighed down. Tires are removed from the wheels so that the rims can hold the lines. A bicycle speedometer, calibrated to the proper size wheels, is attached with the sensor placed on the rear wheel.

Guide line.—Fishing line (40-lb fishing line or stronger) is passed through the valve hole of the front wheel and tied to the spokes. The guide line extends to the perch and is secured there. The tension of the guide line can be increased by turning the front wheel and reeling in the line until it is taut enough to hold the weight of the model raptor at the mid-point between the perch and bicycle. When reeling in the guide line, it should first contact the top of the wheel (Fig. 2).

To maintain desired tension, the wheel can be secured by placing a rod through the spokes to rest against the bicycle forks (Fig. 2). Small clumps of plasticine ($\sim$0.5 cm^3) should be placed on the 10 m of guide line closest to the bicycle at 2–3 m intervals to aid in slowing the model raptor as it approaches the end of its flight.

The tension of the guide line is high, especially when the bicycle and perch are separated by over 100 m, so we recommend the use of work

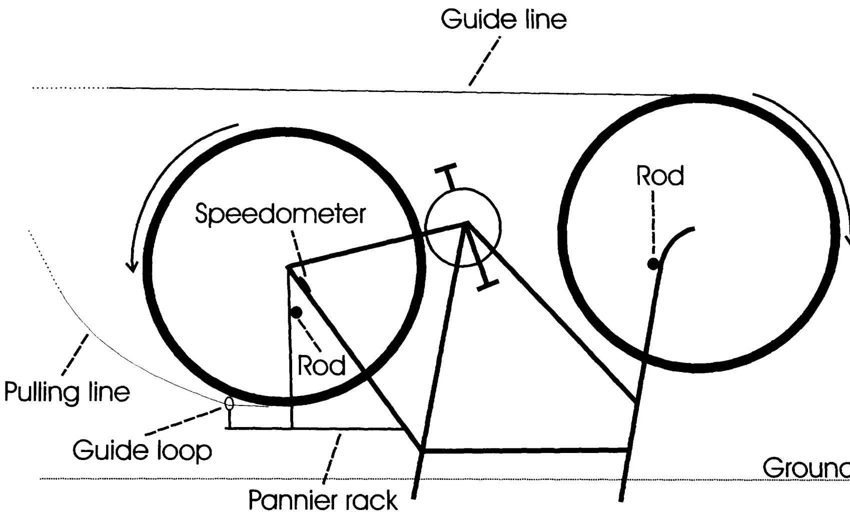

FIGURE 2. Close view of bicycle set-up: Arrows indicate direction of wheel rotation for setting of line tension (both front and rear wheels) and for reeling in pulling line (rear wheel only). Rods are placed between spokes and forks after line tension is set.

gloves and protective eyewear for the person setting up and operating the bicycle.

Pulling line and model raptor.—One end of the pulling line (10-lb fishing line) is passed through the valve hole of the rear wheel and tied to the spokes. The other end is fed out through a guide loop, as found on fishing rods, to ensure the pulling line winds around the rim as the wheel turns (Fig. 2). We used a loop attached to a pannier rack on our bicycle. In contrast to the guide line, the pulling line should first contact the bottom of the wheel when it is reeled in. The pulling line must be long enough to reach from the bicycle to the model raptor that is positioned at the perch.

We used a life-sized model of a Merlin (*Falco columbarius*) (Birdmobile Card Sculptures, North Yorkshire, England; mass = 50 g). To hang the model raptor on the guide line we used two 1.5-cm screw eyes that were screwed into the dorsal surface of the model. The model raptor must be secured at the perch, after attaching the pulling line to the anterior screw eye, to prevent it from being pulled out of the perch by the weight of the slack of the pulling line sinking to the ground. A short length of line can be attached to the model and held by a second observer until the model is reeled in, or a radio-controlled remote unit can be used to release it (e.g., Mock et al. 1999).

To keep the pulling line off the ground, small clumps of plasticine can be used to attach it to the guide line at intervals of 10–20 m. At the bicycle end, a rod should be passed through the spokes to rest against the forks to prevent the wheel from turning prematurely (Fig. 2).

Operation.—Just before operation remove the rod from the rear wheel and release the model raptor at the perch. To make the raptor move along the guide line, begin pedalling with one hand. The other hand (in a glove) should be poised above the rear wheel ready to act as a brake by grasping the rim and using friction to slow the wheel's rotation. Speed can be adjusted by either changing the rate of pedal revolutions or by changing gears on the bicycle. The current speed can be observed on the speedometer at any point as the model raptor moves along the line.

At high speeds (>50 km/h) we found that the model would revolve around the guide line. This can be prevented by adding mass to the center of the body of the model. We accomplished this with our model by pouring sand into the body cavity through a small hole in the dorsal surface, increasing the model's mass to 150 g.

RESULTS AND DISCUSSION

Three key features make our method superior to previous methods in many field situations: portability, flexibility, and realistic speed.

Portability.—Both the perch and the bicycle can be moved easily, allowing researchers to either set up at different sites or adjust the angle of flight by moving the bicycle in an arc around the central axis of the perch. The bicycle portion can be wheeled around for easy movement between sites. Full set-up typically requires only 10 min.

Flexibility.—Range of operation can be manipulated easily. We have successfully employed the method at distances ranging from 30 m to 150 m between the bicycle and perch. The apparatus can also be used in a variety of terrain, whereas gravity-driven methods require either a slope or high perches to propel a model raptor. Additionally, many possible model raptors can be used with the Veloci-Raptor to test prey responses, whereas the wind-up bird used by Greene and Meagher (1998) imitated only one class of raptor.

Speed.—We used a 10-speed road bicycle with 1.98-m circumference wheels. Given a 40:16 gear ratio in fourth gear (40 teeth on the front sprocket, 16 teeth on the rear sprocket), 4.95 m of line was wound in for each complete revolution of the pedals. This gear ratio allowed quick acceleration of the model raptor up to speeds of 13.9 m/s (50 km/h). The maximum speed, 19.4 m/s (70 km/hr), was reached using tenth gear which has a gear ratio of 50:14, allowing 7.07 m of line to be pulled in per full revolution of the pedals.

Our speeds are comparable to values of raptors attacking prey on the ground in the wild. For example, Sparrowhawks (*Accipiter nisus*) have been estimated to fly at 20–28 m/s (n = 4) (Hilton et al. 1999), while the horizontal flight of a Peregrine Falcon (*Falco peregrinus*) and a Hobby (*Falco subbuteo*) were measured at 19–23 m/s and 23.5 m/s respectively (Alerstam 1987).

Future research will benefit from the advantages of the Veloci-Raptor over other methods. Combining this apparatus with appropriate techniques for quantifying prey responses to raptor attacks (e.g., high-speed film for determination of flight initiation distance and escape speed) will greatly expand the possibilities for future field studies.

ACKNOWLEDGMENTS

We thank Kina Harrington, Jessica MacDonald, and Kyle Elliot for their assistance during field trials. We also thank Yolanda E. Morbey, Ian M. Hamilton, and two anonymous reviewers for helpful comments on the manuscript.

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Received 8 August 2000; accepted 17 November 2000.