Supplemental Material for: Fisher et al., 2020, Locating large insects using automated VHF radio telemetry with a multi-antennae array

To employ a similar system:

To employ a similar system, investigators will need to calculate their own constants for each of the formulae provided in this paper. Similar methods to those described should be utilized to understand the relationship between angle and power, the relationship between distance and power, as well as, any random effects of the towers, antennae, receivers, and field site locations.

The following is included to provide a glimpse into the effort required to install and calibrate the receiving towers. The first time towers were augured into the ground, a full day of work was required; a gas- powered augur (BT 45 Earth Auger; Stihl; Waiblingen, Germany) proved useful. If holes and augers were already installed, it took approximately 45 minutes to erect one tower; four towers were on and functioning within four hours. When towers were left fully installed, but turned off overnight, it took approximately one hour to turn on all of the towers and ensure they were functioning. Distance, angle, and random location data collection could be completed within 2-3 weeks.

Category	Criteria	Setting
Scan Settings	GPS clock enabled	Enabled
	Scan Time	6 seconds
Frequency and Channels	Tag Type	Beeper
	BPM Window	36 $\pm$ 20
Antenna Configuration	SRX800D Antenna Switch	Enabled
	Antenna Order	1, 2, 3, 4
	Gain	65
	Radio master options	Not using a master
Filter settings	Filter Type	No Filter
Sensors	Code Set	No Sensors

Table ST1: Receiver settings. SRX800-D receiving units have the ability to collect power readings from more than one transmitter. However, it would decrease the temporal data resolution to include more than one transmitter at a time because the receiver would cycle through all Yagi antennae for one transmitter and then cycle through all Yagi antennae for the second transmitter; while it is recording one transmitter, it is not able to detect power from another transmitter.

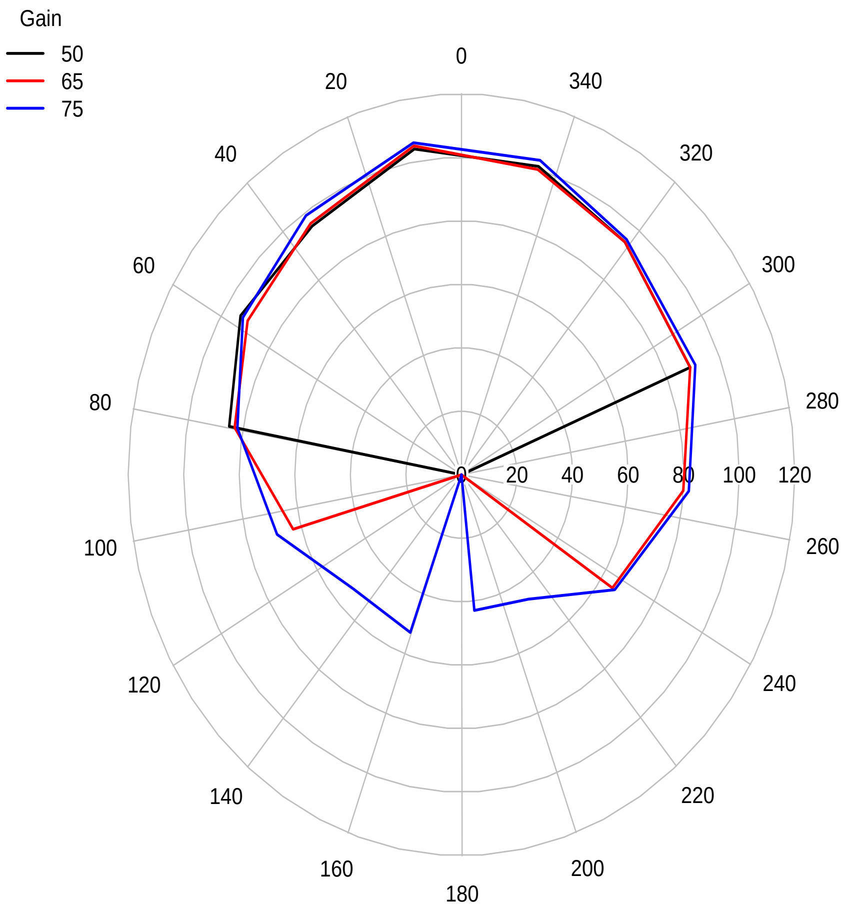

Figure S1: Power was recorded at 13 locations along a 100 m circle surrounding one receiving station at three gain settings: 50, 65, and 75. Zero values indicated when no power was detected. Based on these power-angle relationships, all gain settings provided similar information around the front of the antenna, but the gain setting of 65 exhibited limited potential "back-lobe" interference. This information provided justification to set the receiver gain to 65 for this study.

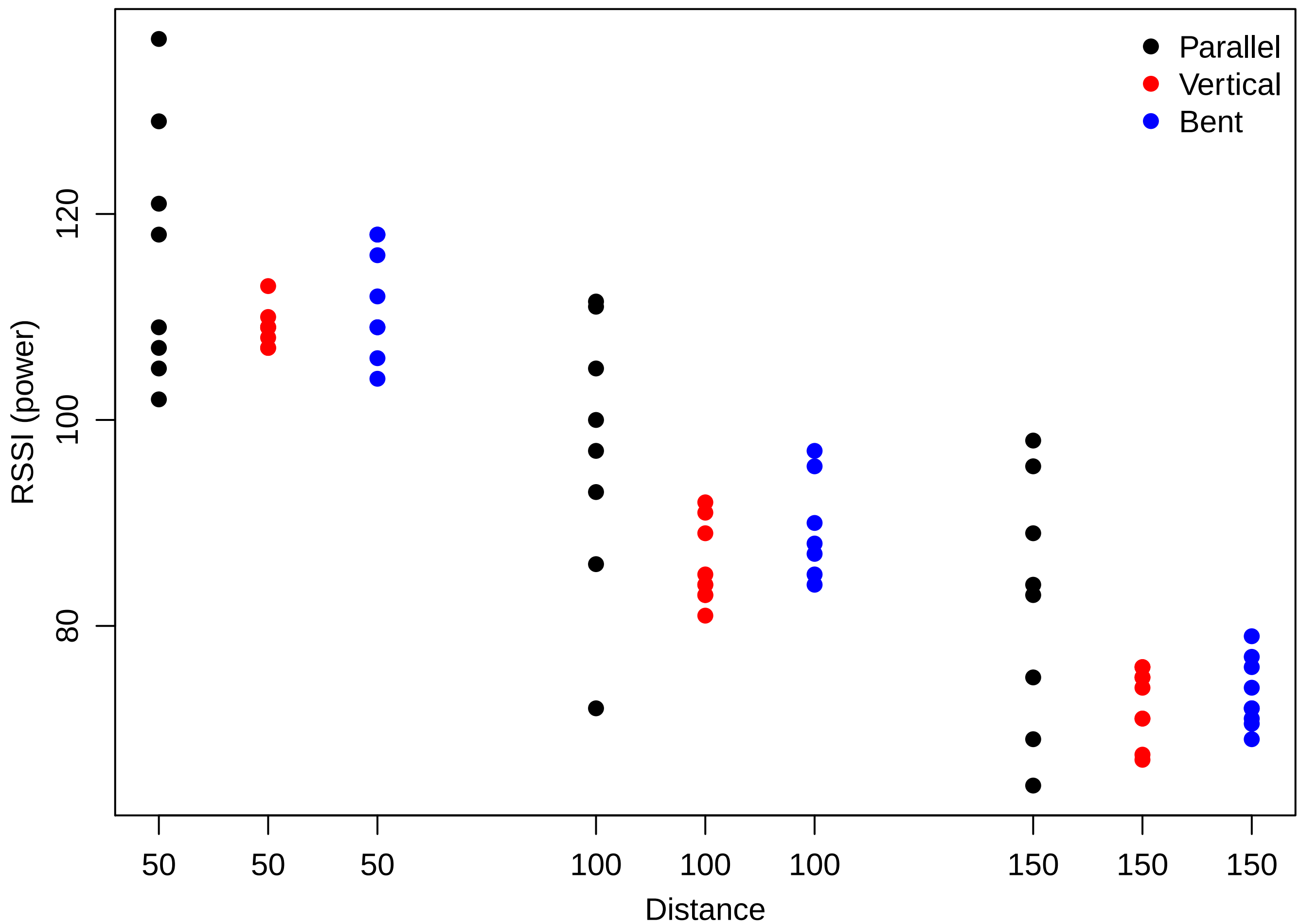

Figure S2: Variability in power for three configurations of transmitting antenna: parallel to the ground (horizontal orientation), straight up (vertical orientation), and bent so the electronics were horizontal but the transmitting antenna was vertical. For each antenna type and distance, power was recorded when the transmitter was oriented 8 directions, spaced 45 degrees around the circle. When the transmitter was held in horizontal orientation, power readings were more variable than when the transmitter was held in vertical orientation or when the transmitting antenna was bent.

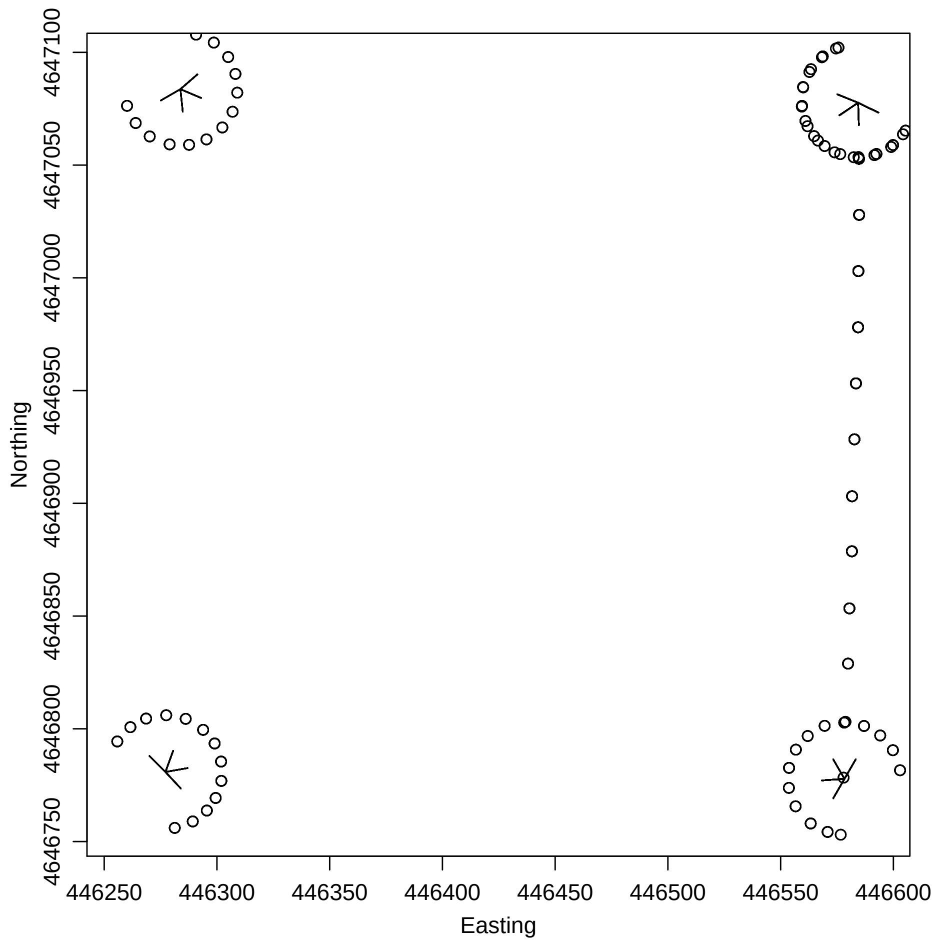

Figure S3: Locations used to calibrate the model for power as a function of distance and angle from the transmitter to the receiving antenna.

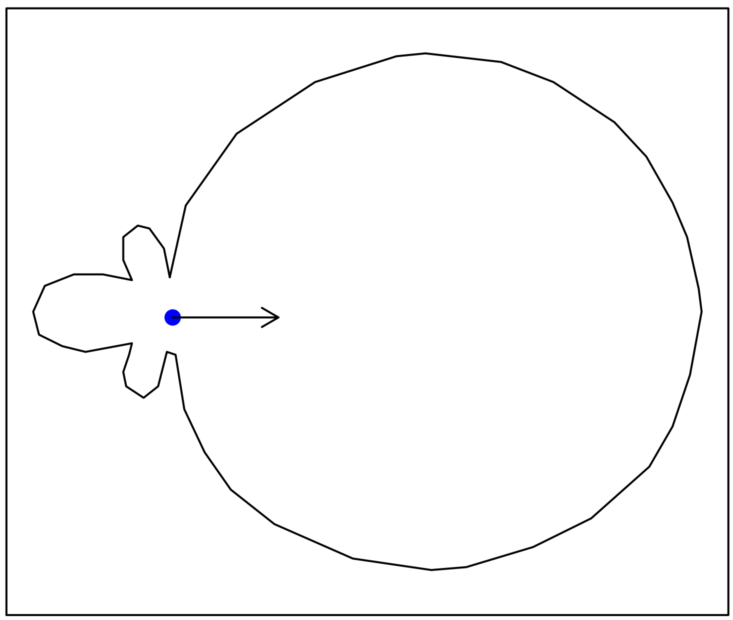

Figure S4: Theoretical power vs angle from a 3 element Yagi antenna pointing in the indicated direction. Redrawn from data shown in 3el_Yagi-Uda.pdf at yagi-uda.com (last accessed 9 April 2020, domain name expired 11 April 2020)

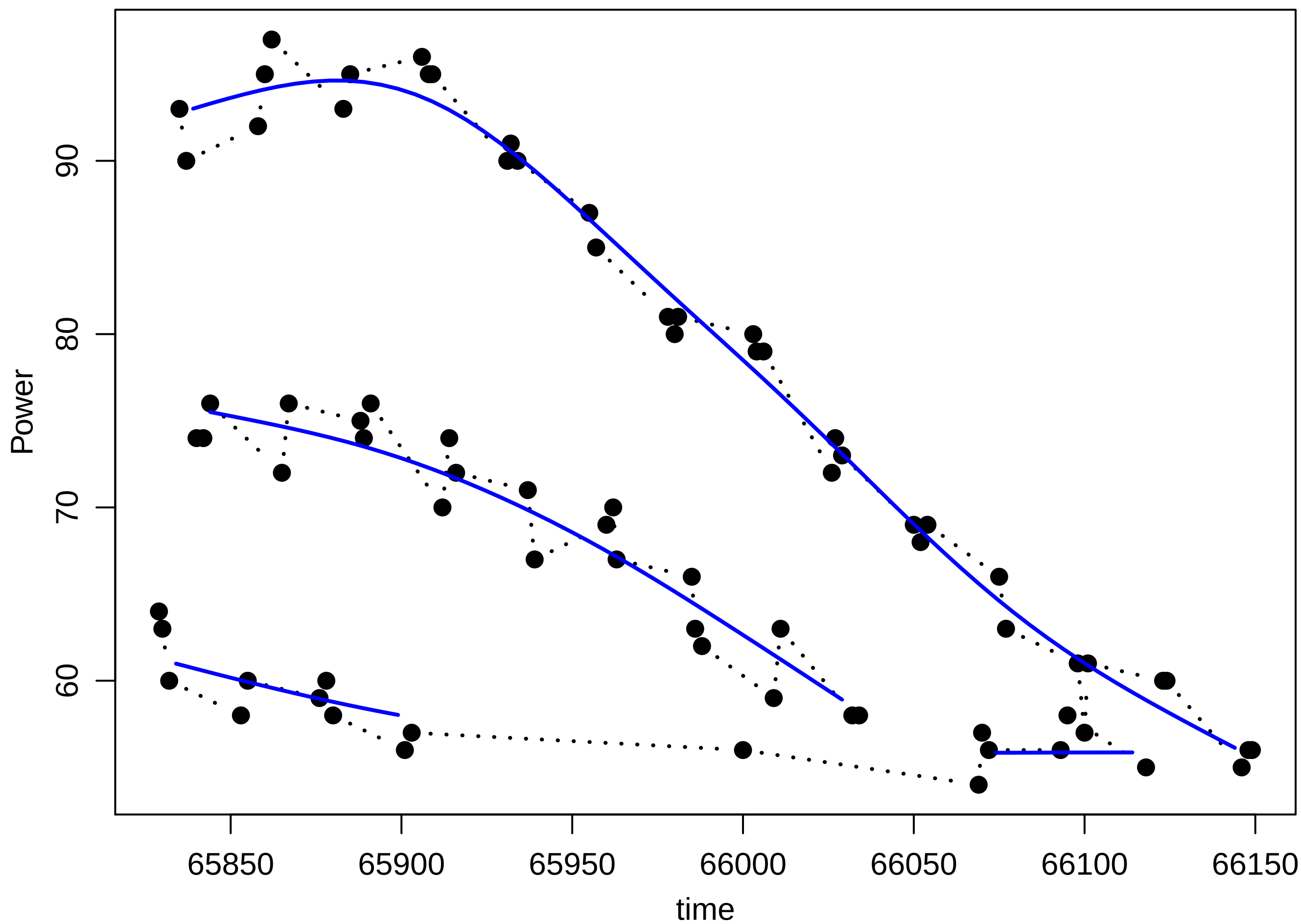

Figure S5: Using thin-plate regression smoothing provided an effective alternative to calculating the median power recorded over time. Dots and dashed lines show observed power readings readings for three antennae on one tower over time, colored lines show smoothed values. The effective degrees of freedom are 1.8, 2.0, and 4.6.

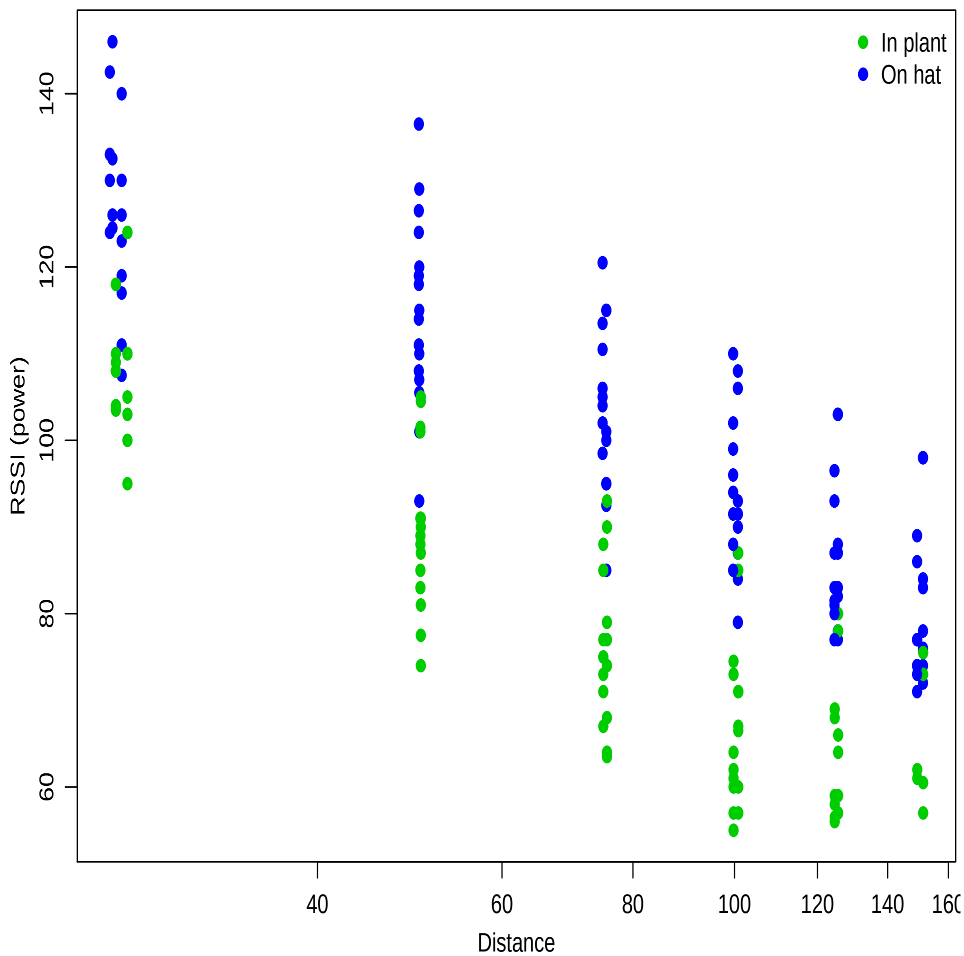

Figure S6: Received power as a function of distance for a transmitter worn by an investigator (in hat) and one mounted on a butterfly in a plant.

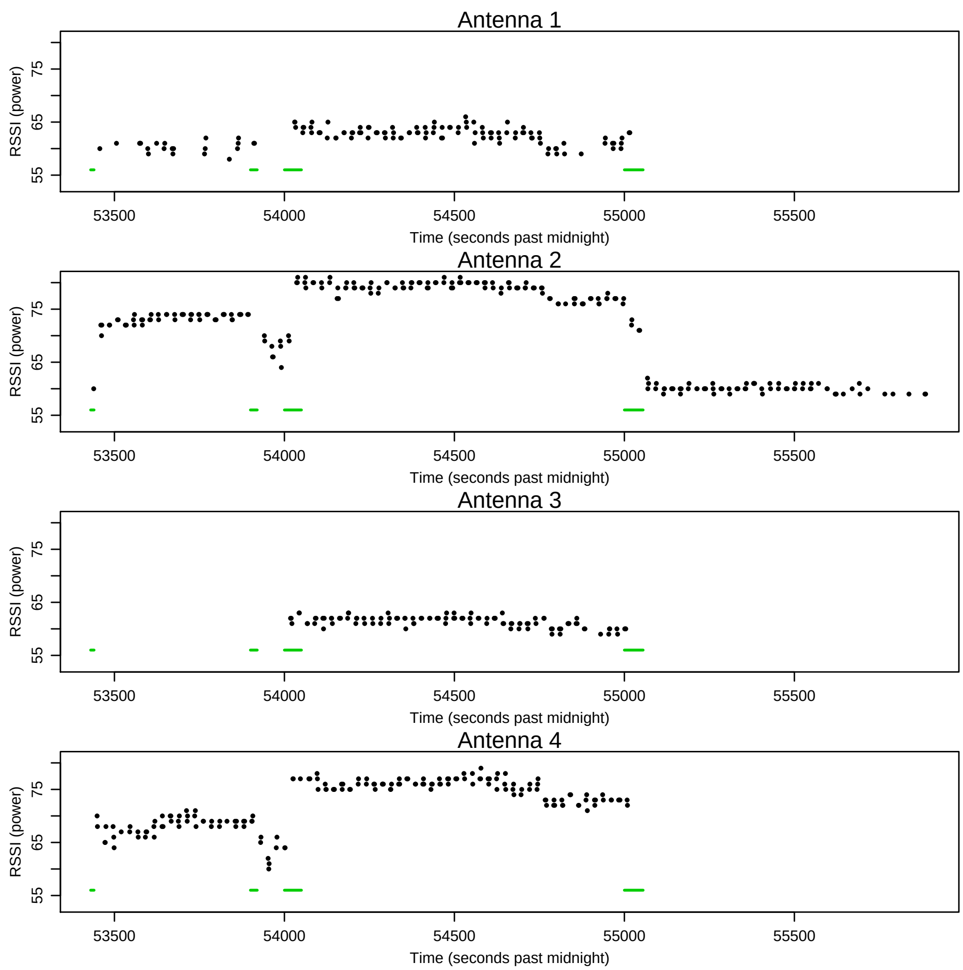

Figure S7: Received power over time at four antennae when a monarch was allowed to move freely through a field. Green segments at the bottom indicate when the butterfly was visually observed to be flying. The system could detect when the butterfly was stationary and when it was flying. At approximately 55000 seconds past midnight, the butterfly was observed to fly out of sight. The system indicates that it appears to be been stationary for approximately 12 minutes after that.