*Discussion*

This study was successful in tracking CRB to cryptic breeding sites at two locations on the island of Guam. The two areas where CRB were tracked differed both in topography and vegetation and the effective location of tagged beetles in these different environments shows promise for the applicability of this technique in the varied habitats were CRB infestations may occur.

The use of radio telemetry to monitor flying species is generally constrained by the weight of radio transmitters. Monitoring through radio telemetry must balance the need for devices that are long-lived, long-ranged, and light-weight (Robinson *et al.* 2009, Cochran *et al.* 2004, Thorup *et al.* 2007). This limitation is especially true when monitoring flying insects since a small increase in weight may severely hinder flight behavior. In recent years, though, the gradual miniaturization of transmitters has circumvented this obstacle allowing for more precise monitoring of flying insects (Sato Maharbiz 2010). One of the factors determining the feasibility of this study was whether or not adult CRB could fly undisturbedly with the attached radio transmitters. Adult CRB are excellent fliers and can exert force much larger than their body weight when fighting and boring, so it was reasonable to expect that the miniature radio transmitters would have little or no effect on CRB flight capability.

As expected, the flight capability of CRB was seemingly unaffected by the extra weight of radio transmitters. Each radio transmitter amounted to between 5.04% and 9.72% of the CRB weight at the time of release, and there was no correlation between the increased percentage weight and the single flight distance of CRB (R2=0.0484) indicating that CRB could fly carry the extra burden of the radio transmitters. It is also important to note that the 14 CRB that flew out of range did present not statistically significant differences in the radio transmitter percentage weights compared to the CRB that stayed in range. These observations are consistent with other studies monitoring members of the Dynastinae family which found that transmitters did not noticeably effect giant rhinoceros beetle, sp. name, flight (McCollough 2006). Without the miniaturization of radio transmitters, monitoring of CRB through radio telemetry would remain unfeasible, and although smaller radio transmitters come with shorter battery lives, the duration of commercially available radio transmitters (10-14 days) is appropriate for this type of CRB monitoring. However, the battery life of the transmitters must guide monitoring protocol timelines. CRB should be pinpointed to a final location within 2-3 days after initial release to prevent the loss of CRB due to transmitter failure. Therefore, CRB monitoring and eradication efforts using radio telemetry would be more effective when conducted in short, regular intervals rather than longer-lasting, continuous efforts. Monitoring and eradication periods would be intense and of a relatively short duration.

Another important factor to consider is the distance over which CRB can be monitored. Radio telemetry monitoring typically covers only short to medium displacement distances usually limiting the applications of the technology (Robinson *et al.*2009). The radio devices employed in this study had a maximum range of 1000 meters, but the effective range of localization varied with topological and vegetation conditions. The range detection was appropriate for CRB monitoring since the overall flight distance from release sites to ending sites ranged from 52.8 meters to 564.6 meters (Mean= 244 m, Median=234 m). This range also roughly delineates a radius for breeding site discovery from released CRB; the detector CRB must be released no further than approximately 500 meters from breeding sites. This might present difficulties for eradication teams since the breeding sites in question occur in cryptic locations presumably unknown to those searching for them. The relatively short detection radius of the radio devices obligates teams to close in on the cryptic sites through other investigative means. In order to effectively estimate possible locations of CRB breeding site, visual monitoring of damage and trapping should assess the presence of CRB populations. Once visual monitoring and trapping indicates the existence of CRB in a particular location, the detector CRB would be released in the vicinity to pinpoint the exact location of the breeding sites. Stats about monitoring and visual in Guam and HI This combination of monitoring methods would ease the control and eradication of CRB, and since traps and visual monitoring are already widespread, it would not be complicated to craft an integrated strategic plan.

One of the most important accomplishments of this study was the localization of the majority of the released CRB. Out of 33 released CRB, a total of 19 were retrieved either as an individual or as a fallen radio transmitter. This comparatively high retrieval rate required an input of approximately 1 hour per CRB immediately after release and at least the same amount of time on the following day. The tracking of CRB to an approximate location during the night followed by a more precise pinpointing during the daytime proved to greatly facilitate the retrieval of released CRB. Although a majority of the released CRB were successfully tracked to discrete locations, a rather large proportion of CRB were lost, presumably due to out-of-range flights. Interestingly, those CRB that flew out of range had statistically significantly lower percent emergence weights than those that stayed within the detection range of the radio devices. All other variables had no statistical significance.

This monitoring method greatly benefits from the fact that the problem of CRB loss can be easily addressed by controlling a single variable. Prior to release, CRB must be well-fed to ensure that the individuals will remain within the detection radius.

Finally, %EW have a strong association with the microhabitats in which tagged CRB were found. Of the 19 retrieved CRB, 11 landed in palm crown microhabitats whereas 8 landed in ground microhabitats. The CRB that landed in the crown microhabitats had a statistically significantly lower percent emergence weight than those CRB that landed on the ground microhabitats (p-value=0.0006). It is reasonable to hypothesize that heavier CRB landed on lower microhabitats due to the comparative inability to reach higher altitudes than the ones reached by lighter CRB. However, all of the released CRB flew several meters vertically into the air before displacing horizontally. If heavier CRB had hindered vertical displacement in comparison to lighter CRB, then takeoff would have notably different between these two groups. It has been noted that adult CRB spend their time either feeding on the palm crown or breeding on the ground (Zelazny 1975). As CRB alternate between these microhabitats, individuals fluctuate in their percent emergence weight making it possible to determine the behavioral pattern that CRB will engage in from noting their percent emergence weight (Source). CRB at a higher percentage of their emergence weight will very likely refrain from further feeding and fly in search of breeding sites whereas CRB at a lower percentage of their emergence weight will likely forage in search for food. Therefore, it is not coincidental that the CRB that landed in the ground microhabitats, associated with breeding, had statistically significantly higher percentage emergence weights than those that landed in palm crowns, associated with feeding sites. This particularity of the CRB life cycle makes method much more specific and controllable. In order to have CRB fly directly to breeding sites, the individuals must be fed to high percentage of their emergence weight. In doing so, monitoring and eradication teams can ensure that the released CRB will not lead them to feeding sites rather than breeding sites and will increase the effectiveness of the CRB control methods.

Effectiveness (% of beetles caught)

Previous lit (how we compare)

Our results (dist., %EW, locations) mention particularly the fact that no beetles entered traps (get number of traps at each location) mention recommendation for tracking (high %EW)

Locations CRB found

Advantages/disadvantages vs. other breeding site detection methods (get budget for dogs from Aubrey) (ease of use, cost, knowledge of local area)