MONITORING THE SPREAD OF AN INVADING ALIEN ANOLE IN DOMINICA, AND ITS EFFECT ON THE ENDEMIC NATIVE SPECIES: FINAL REPORT

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Aims of the project:

1. To monitor the spread of the invading species.
2. To train Forestry Dept personnel in anole identification and establish a methodology for further regular monitoring.
3. To provide a detailed baseline against which to measure further spread.
4. To establish the nature of the interaction between the species, particularly at the current edges of the distribution of *Anolis cristatellus*.

Summary of activity:

Two MSc students, S. Kay and Elizabeth Corry, after an initial training period of two weeks in February 2003 supervised by Roger Thorpe, travelled to Dominica in May and June 2003, and Roger Thorpe travelled to Dominica in July/August 2003. Anita Malhotra did not participate in the fieldwork in the end due to pregnancy and subsequent maternity leave.

Extent to which the aims have been achieved:

1. *To monitor the spread of the invading species*

This survey was able to confirm the presence of the invading species in the Bath Estate, and also established the southern limit of its range at Loubiere (but see section 3 below). Reports from the Forestry Department of *A. cristatellus* from Salisbury and Layou were investigated but could not be confirmed. Contrary to the initial survey, females and juveniles of the endemic *Anolis oculatus* were found well within the range of *A. cristatellus*, not just at the edges of its range, so some degree of co-existence seems to be possible although it may be relatively transient.

2. *To train Forestry Dept personnel in anole identification and establish a methodology for further regular monitoring*

Both the invading *A. cristatellus* and the native *A. oculatus* are of very similar size and occupy similar habitats in SW Dominica. Moreover, in the SW of Dominica the native anole is fairly uniformly coloured and is not obviously different to the *A. cristatellus* with its subtle markings. The view that the invading species is dark and the native species light-coloured is of limited use, because both species darken under stress (metachrosis) and one can readily find light *A. cristatellus* and dark *A. oculatus*. In other parts of the island the characteristic colour pattern of *A. oculatus* may make it easier to distinguish the species. For example, on the northern Caribbean coast male *A. oculatus* tends to have easily recognised large block blotches on the trunk. It was established that the best means of identification is the dewlap. Even female and juvenile *A. cristatellus* have a dewlap (unlike the case in *A. oculatus*) and in this species it tends to have a greenish centre and reddish orange outer edge (Fig 1a). *A. oculatus* has an uniform yellow/orange dewlap (Fig 1b). From a distance, *A. cristatellus* has a

shorter head, which it holds distinctly reflexed up from the trunk ("horse-like" posture), while the native anole holds its head more gently reflexed, although still off of the substrate. Up close, *A. cristatellus* can be seen to have dark spots at the base of the enlarged scales on the tail crest (Fig 1c), whereas in *A. oculatus* they are light. Roger Thorpe organised a workshop for the Forestry Department to train them in distinguishing between the two species and to familiarize them with the current limits of the range of the invading species. The attached figures (however note that Fig 2 in this report is an updated version of the mapped range distributed to the Forestry Department) were laminated and sent to the Forestry Department to aid with their efforts to monitor the spread of the invading species.

3. *To provide a detailed baseline against which to measure further spread*

The results obtained contributed to the capture of a competitive NERC CASE studentship in association with WDNAS to further study the process of invasion of Dominica by *A. cristatellus*. Further monitoring of the spread of the invader is taking place every February. Given that this report is being submitted considerably after the Rufford-funded work was done, but that the monitoring of further spread was a central objective of the Rufford grant, we summarise the current situation (as of Feburary 2006) in Figure 2. While no *A. cristatellus* have been found yet outside the SW coast, *A. cristatellus* have spread from the former northern limit (just north of the Belfast River near the prawn farm) to the vicinity of the petrol station near Rodney's Rock (about 0.5 further north). At this location, it co-exists with *Anolis oculatus*. A more significant advance had been made at its southern limit, where it was recorded from Roseau in 2002, as far south as Loubiere in 2003 and recorded at Anse Bateaux (c. 3 miles further south) in 2005. Although it has not been found between Castle Comfort and Anse Bateaux, it is possible that it may be found in private gardens in Loubiere and St Michel. It is also worth noting that it is present at very low densities at Anse Bateaux and n fact was not seen there in February 2006. Inland, *A. cristatellus* has only advanced about 100 m further up the road to Pont Casse.

4. *To establish the nature of the interaction between the species, particularly at the current edges of the distribution of A. cristatellus.*

a> Population density estimates of adult male *A. cristatellus* were undertaken between May and June in five localities, ranging from 10 m to 142 m above sea level (Fig 2b). Three or four quadrats (ranging in size from 150 to 500 m^2) were sampled within each locality. Anoles caught were sexed using size, presence of enlarged post-anal scales in males, swollen tail base in adult males, and presence of a distinct light vertebral band in females and juvenile males. Heckel and Roughgarden's (1979) mark-resight method was used to derive a maximum likelihood estimate of population densities. . A spray-paint gun loaded with latex-based emulsion paint diluted 1:1 with water was used to mark the lizards (this is known to be non-toxic to the lizards), using a different coloured paint on each of three consecutive days. The calculated density estimates were then compared to data collected by Thorpe in 2002. Estimates of number of adult males per 100 m^2 ranged between 2-10 in Windsor Park, Jimmit, Morne Daniel, and Bellevue D'Aubigny but reached an estimated density of 21-62 on the road running inland from Deep Water Harbour. However, the latter high estimate might have resulted from violation of the assumptions underlying the calculation which can be ascribed to bad weather and flooding of the site during the census which may have affected the visibility of marked lizards. Within each site, adult *A.cristatellus* showed a preference for thicker and higher perches and large mature trees provide a focus for relatively large aggregations of individuals (up to 9 adults and several juveniles). It also appears to show an

association with urban and suburban altered habitats as within several of the sampling sites (eg the road running inland from Deepwater Harbour, which contains several factories and semi-industrial sites), they are found in abundance up to the point where relatively natural and undisturbed vegetation begins.

b> Geographic variation in *Anolis cristatellus* was examined in detail by sampling fifteen adult male lizards from each of ten sites ranging between 6 to 35 m above sea level along a transect running from the northern to southern boundaries of its range (as existed at the time the study was done). Another analysis compared two coastal sites (Jimmit and Morne Daniel) to two higher altitude sites (Roger at c. 180 m on the Canefield to Pont Casse road, and M. Daniel at c. 150 m). Thirteen morphological measurements of body proportion and scalation characteristics were made. Univariate (ANOVA/ANCOVA) and multivariate (Canonical Variate Analysis, Principal Component Analysis, nested MANOVA) analyses showed some morphological differentiation between the two locations central to the range of *A. cristatellus* (Canefield and M. Daniel) and all the remaining populations apart from Jimmit. This may suggest that the Jimmit population was established by a human-mediated dispersal process directly from the central sites, which is plausible as Jimmit is also a semi-industrial site. However, the Jimmit population also shows slight differentiation from the "central" populations. The fact that there are two quite morphologically distinct clusters of invaders in Dominica along the coast, as well as marked differences between coastal and altitudinal sites might suggest that there have been more than one independent colonisations of Dominica by *A. cristatellus.* Alternatively, the pattern may result from variations in ecological and habitat characteristics which may either directly induce morphological differentiation through the phenomenon of phenotypic plasticity, or through a genetic process of natural selection. Numerous studies on *Anolis* have shown that they can respond quickly to changes in selection pressures brought about by being moved to a new habitat. However, it might be expected that an invading population contained too little genetic variability to allow such a rapid genetic response. These alternatives can only be distinguished between with further genetic studies, and also "common garden" experiments (Thorpe et al, 2005) which are planned.

References

Heckel, DG and J Roughgarden. 1979. A technique for estimating the size of lizard populations. *Ecology* 60:966-975

Thorpe, RS, JT Reardon and A Malhotra. 2005. Common garden and natural selection experiments support ecotypic differentiation in the Dominican anole (*Anolis oculatus*). *Amer. Nat.*,165: 495-504

A.cristatellus (fem) Dewlap has greenish centre and reddish orange periphery. Note the short head

A.oculatus (male) SW ecotype. Dewlap has uniform yellow/orange background. The head is longer.

A.cristatellus tail. Note that the enlarged scales on the tail crest have a dark spot on their base.

Fig 2. Updated distribution map of endemic and invading anole species in Dominica (situation as recorded in Feb 2006) A: *Anolis cristatellus* has spread northwards to Rodney's Rock (0.5 mile), southwards (3 miles to Anse Bateaux) and inland (100 m further along the road to Pont Casse) since mapped in 2002.Original site of introduction indicated by a star, and the northern and southern limits of the range of *A. cristatellus* are indicated by empty circles. Green dots show the other sites which were surveyed for presence of *Anolis cristatellus* in 2002.
B: Assumed breeding populations of *A.oculatus*: green squares; Breeding populations of *A. cristatellus:* circles. Red filled circles indicate sites of population density estimates for *A. cristatellus,* pink circles indicate sites sampled for assessment of geographic variation and orange circles indicate sites used for both studies; empty circles indicate other sites at which *A. cristatellus* has been recorded.