

Ecology and Evolut

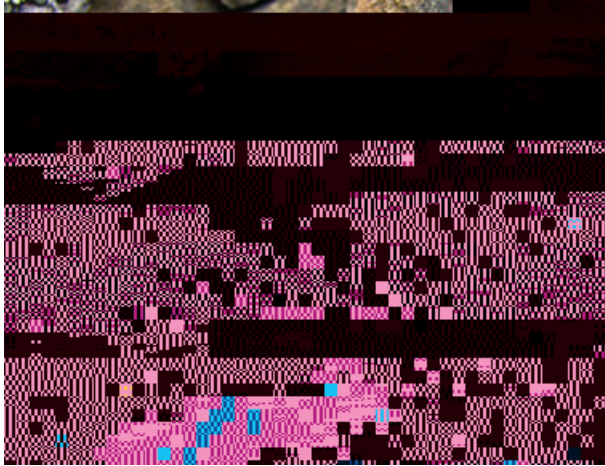
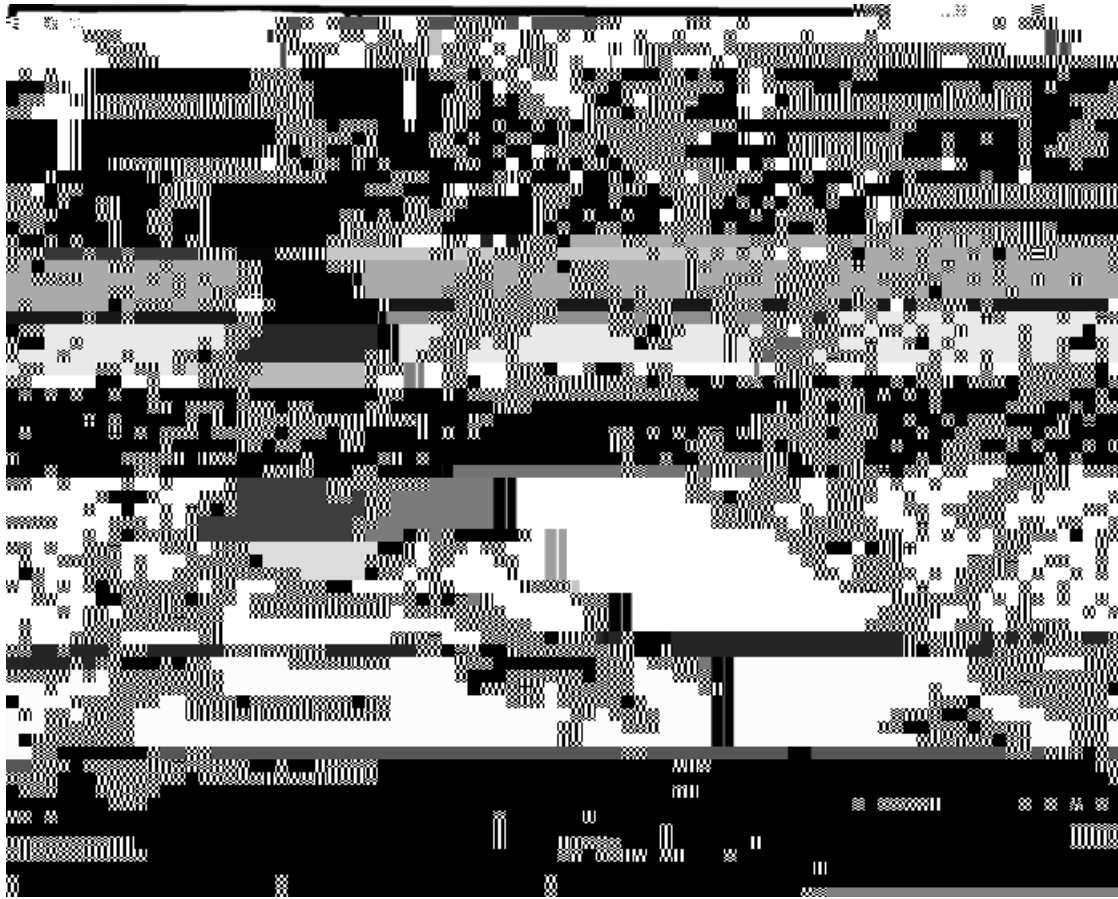


Fig. 1. Common gecko (*W. maculata*) at Turakirae Head, south coast of North Island, New Zealand. Photo by Andrew Blayney.

comprise a complex of at least 11 cryptic species based on extensive genetic studies (Hitchmough 1997; Nielsen et al. 2011;



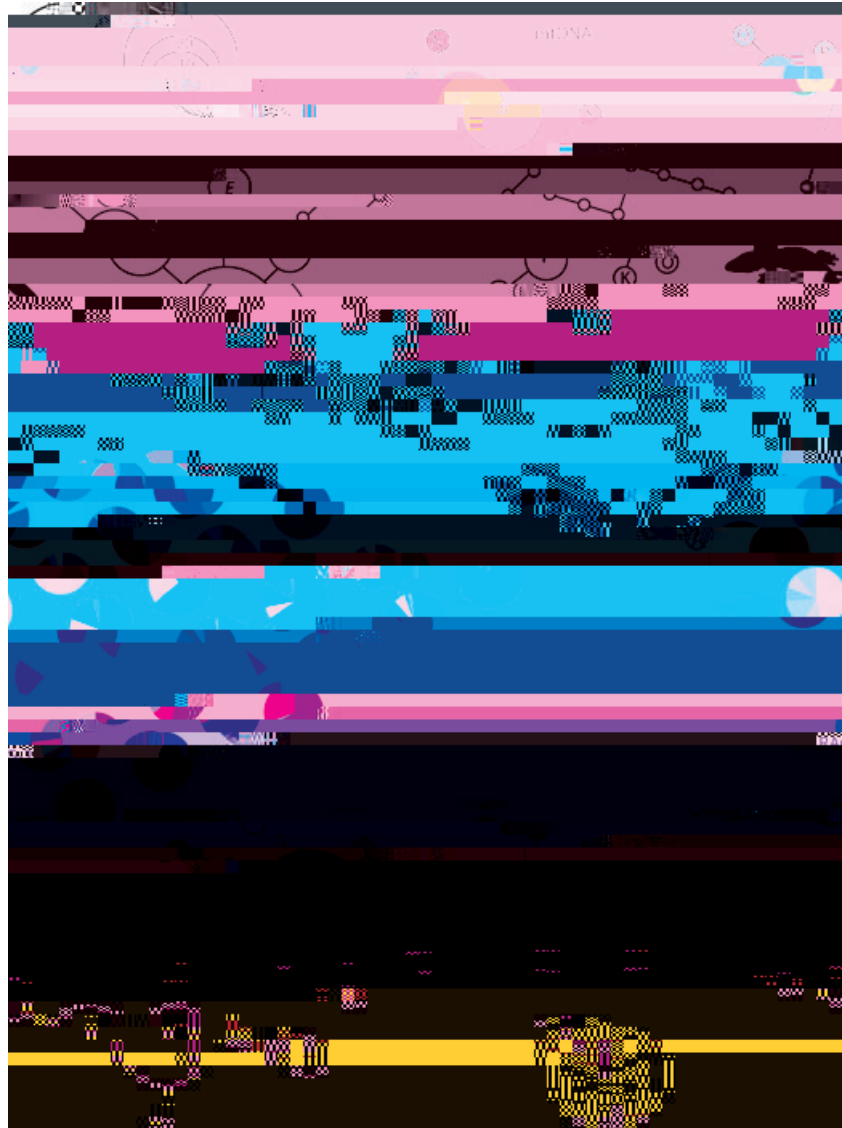
-2. Sampling locations for the gecko *W. maculata*

was approved by the Massey University Animal Ethics committee (protocol No. 08/63), and authority to study the geckos was provided by the New Zealand Department of

expectations using χ^2 tests. Evidence of isolation-by-distance was sought using a mantel test of the correlation of pairwise geographic distances and pairwise F_{ST} (or Φ_{ST} for mtDNA) with 1000 permutations in GENEPOP 4.0.10. Each locus was

a 2. Observed allele frequencies for three nuclear loci at six sites across a cline for body-size in coastal geckos *Woodworthia maculata*.

Locus	Allele	Site 1 <i>n</i> = 26	Site 2 <i>n</i> = 28	Site 3 <i>n</i> = 21	Site 4 <i>n</i> = 23	Site 5 <i>n</i> = 26	Site 6 <i>n</i> = 8
<i>RAG-1</i>	A	0.62	0.55	0.64	0.44	0.44	0.50
	B	0.23	0.25	0.26	0.41	0.52	0.19
	C	0.12	0.14	0.05	0.04	0.04	–
	E	0.02	0.05	–	–	–	0.19
	F	0.02	–	–	–	–	–
	G	–	–	0.02	–	–	–
	D	–	–	0.02	0.07	–	0.06
	I	–	–	–	0.02	–	–
	H	–	–	–	–	–	0.06



4. Minimum networks showing putative evolutionary relationships of DNA

a 3. Estimates of cline-centers and cline-widths for body-size and two genetic loci, in coastal geckos, *Woodworthia maculata*, on the south coast of North Island New Zealand. tanH curves fitted to cline data were used to estimate centre and width, with best log likelihoods providing support values.

Center

Confidence

Width

Confidence

has representatives of not two but three distinct haplotype clades. Identifying three clades is consistent with secondary contact (e.g., Gūbitz *et al.* 2000; Thorpe and Stenson 2003). However, our sampling of *W. maculata* is as yet too limited for complete confidence that the three clades have distinct geographical ranges that overlap only where the size cline has been identified. Although consistent with secondary contact,

putatively adjacent in the gecko genome), as would be expected if the *RAG-2* cline resulted from selection in situ. In contrast, a cline in *RAG-1* (due to linkage to *RAG-2*) would be expected to last for thousands of generations if the *RAG-2* cline were the result of secondary contact (Durrett et al. 2000).

Conclusions

We have described a body size cline in coastal geckos, the width of which is apparently not controlled by endogenous selection. There is no evidence of assortative mating or hybrid disadvantage and the cline is wide compared to the dispersal ability of the species. However, some evidence points to secondary contact being responsible for the cline formation. We found three mtDNA clades within the transect and two genetic clines. Genetic and morphological clines were neither concordant nor coincident, from which one might infer that this is an old contact zone with independent introgression and exogenous selection. Primary intergradation is difficult to distinguish from secondary contact with exogenous selection and although the allele frequency clines implicate the latter (Barton and Hewitt 1985), the presence of a cline in *RAG-2* but not *RAG-1* implicates primary intergradation (Durrett et al. 2000).

It is likely that body size is important in determining the fitness of a gecko in a particular habitat, and that the described transition from large to little coastal geckos in New Zealand may be evidence of selection resulting from an environmental gradient. There is no known physical or climatic gradient along the New Zealand coastal transect we sampled, so the role of the environment in limiting gene flow and applying differential selection pressure on these geckos is yet to be determined. Characterizing the habitat change over the transect is an important step in future work to provide a better understanding of selection factors that may be operating across the zone. In addition, sampling inland from the coast to detect parallel clines is important in discriminating the processes involved in cline formation (Johansson et al. 2008).

Due to the level of hybridization, sharing of nuclear alleles and widths of genetic clines, it is unlikely that this size cline is a barrier to gene flow. These populations are therefore not considered different species. No evidence was found of assortative mating (mate choice based on size). But it is possible that selection pressures might result in increased frequency; should such behavior arise, and this could lead to the separate populations further differentiating into different species (Wu 2001; Schluter 2009). We suggest that the cline in body size described here, and low dispersal of this gecko species current is indicative of selection acting on size variation.

Acknowledgments

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