CENOZOIC MIGRATION RATES, EXINCTION RATES, AND DIVERSITY PATTERNS IN NORTH AMERICAN MAMMALS: STABILITY IN THE FACE OF STOCHASTIC MIGRATION

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Woodburne recently has published a master list of 158 mammalian genera that successfully migrated to North America during the Cenozoic. This made it possible to test hypotheses concerning the impact of migrants on the native continental fauna, as summarized in my compilation of 3745 faunal lists. First, the lists were corrected to account for 578 published genus-level synonymies and 3652 species-level synonymies and new combinations. Second, the timing of origination, immigration, and extinction events was estimated by placing the lists into 176 stratigraphic sections; subjecting them to appearance event ordination; and then calibrating the resulting combined genus- and species-level event sequence to absolute time using 115 geochronologic age estimates. Finally, the data were binned into 1.0 m.y. intervals, this figure being conservative according to several independent quantitative optimality criteria. The calibrated events define standing diversity at the start of each interval, i.e., the number of taxa that were extant at that time. Genus-level data are presented because this is the level of resolution in Woodburne's list.

The null models, tested by bootstrapping, were that migration rates (M) and native origination rates (O) are indistinguishable in terms of temporal variance, serial correlation, and correlation with either standing diversity (D) or extinction rates (E; all rates are totals per m.y.). Bootstrap proportions (p) represent the fraction of 10,000 trials in which test statistics for the migration events were more extreme than those for bootstrapped replicate data sets drawn from 986 native origination events.

The results are: (1) Migration is more clumped through time than origination, with each migration burst lasting a few million years. M and O have similar variance ($p = 0.06$), but M is serially correlated ($r = +0.43$), whereas O is not ($r = 0.00$; $p < 0.001$). (2) High diversity supresses native origination rates, conforming with the equilibrial "ecological crowding" model, but has no impact on migration ($p = 0.005$). M shows a positive correlation with D that may be a sampling effect ($r = +0.18$), but O shows a negative correlation that cannot be (r -0.11), and the difference is likely real. (3) Like origination, migration is apparently unrelated to extinction ($p = 0.38$). M shows just as weak a positive correlation with E ($r = +0.07$) as does O ($r = +0.04$). The same results for all these tests were obtained by using per-taxon rates instead of total rates; including the migrant genera in the "native" pool; substituting native species for native genera; or separately treating the 52 carnivorous and 106 non-carnivorous migrants.

In summary, migration comes in bursts, presumably because of global climate or tectonic changes, and is independent of both native diversity levels and extinction rates. Surprisingly, diversity maintains a steady-state by modulating origination, irrespective of migration bursts and low, nearly constant rates of extinction. There are important implications for both biogeography and conservation: the MacArthur-Wilson ecological (migration/extinction-forced) equilibrium model does not apply at the continental scale, despite the fact that diversity maintains an evolutionary (origination-forced) equilibrium; and the moderate migration rates seen in the fossil record provide no analogue for the large-scale ecological disruptions that have been caused by the rapid introduction of exotic species in the Recent.