

TABLE A. FULL SOL DATA SET FOR OBSERVED SPECIMENS

Species	SOL (mm)	Species	SOL (mm)	Species	SOL (mm)
<i>Echonetes</i>		<i>E (T.) clarksvillensis</i>	23	<i>L. richmondensis</i>	32
(<i>Thaerodonta</i>)		<i>E (T.) clarksvillensis</i>	23	<i>L. richmondensis</i>	32
<i>clarksvillensis</i>	16	<i>E (T.) clarksvillensis</i>	23	<i>L. richmondensis</i>	32
<i>E (T.) clarksvillensis</i>	16	<i>E (T.) clarksvillensis</i>	23	<i>L. richmondensis</i>	32
<i>E (T.) clarksvillensis</i>	18	<i>E (T.) clarksvillensis</i>	24	<i>L. richmondensis</i>	32
<i>E (T.) clarksvillensis</i>	18	<i>E (T.) clarksvillensis</i>	24	<i>L. richmondensis</i>	32
<i>E (T.) clarksvillensis</i>	18	<i>E (T.) clarksvillensis</i>	24	<i>L. richmondensis</i>	32
<i>E (T.) clarksvillensis</i>	18	<i>E (T.) clarksvillensis</i>	24	<i>L. richmondensis</i>	32
<i>E (T.) clarksvillensis</i>	19	<i>E (T.) clarksvillensis</i>	24	<i>L. richmondensis</i>	33
<i>E (T.) clarksvillensis</i>	19	<i>E (T.) clarksvillensis</i>	24	<i>L. richmondensis</i>	33
<i>E (T.) clarksvillensis</i>	19	<i>E (T.) clarksvillensis</i>	25	<i>L. richmondensis</i>	33
<i>E (T.) clarksvillensis</i>	19	<i>E (T.) clarksvillensis</i>	25	<i>L. richmondensis</i>	33
<i>E (T.) clarksvillensis</i>	20	<i>E (T.) clarksvillensis</i>	25	<i>L. richmondensis</i>	33
<i>E (T.) clarksvillensis</i>	20	<i>E (T.) clarksvillensis</i>	25	<i>L. richmondensis</i>	33
<i>E (T.) clarksvillensis</i>	20	<i>E (T.) clarksvillensis</i>	25	<i>L. richmondensis</i>	33
<i>E (T.) clarksvillensis</i>	20	<i>E (T.) clarksvillensis</i>	26	<i>L. richmondensis</i>	34
<i>E (T.) clarksvillensis</i>	20	<i>E (T.) clarksvillensis</i>	26	<i>L. richmondensis</i>	34
<i>E (T.) clarksvillensis</i>	20	<i>E (T.) clarksvillensis</i>	26	<i>L. richmondensis</i>	34
<i>E (T.) clarksvillensis</i>	21	<i>E (T.) clarksvillensis</i>	26	<i>L. richmondensis</i>	34
<i>E (T.) clarksvillensis</i>	21	<i>E (T.) clarksvillensis</i>	26	<i>L. richmondensis</i>	34
<i>E (T.) clarksvillensis</i>	21	<i>E (T.) clarksvillensis</i>	27	<i>L. richmondensis</i>	34
<i>E (T.) clarksvillensis</i>	21	<i>E (T.) clarksvillensis</i>	27	<i>L. richmondensis</i>	35
<i>E (T.) clarksvillensis</i>	21	<i>E (T.) clarksvillensis</i>	27	<i>L. richmondensis</i>	35
<i>E (T.) clarksvillensis</i>	21	<i>E (T.) clarksvillensis</i>		<i>L. richmondensis</i>	35
<i>E (T.) clarksvillensis</i>	21	<i>Leptaena</i>		<i>L. richmondensis</i>	36
<i>E (T.) clarksvillensis</i>	21	<i>richmondensis</i>	23	<i>L. richmondensis</i>	36
<i>E (T.) clarksvillensis</i>	21	<i>L. richmondensis</i>	27	<i>L. richmondensis</i>	36
<i>E (T.) clarksvillensis</i>	21	<i>L. richmondensis</i>	28	<i>L. richmondensis</i>	36
<i>E (T.) clarksvillensis</i>	21	<i>L. richmondensis</i>	28	<i>L. richmondensis</i>	37
<i>E (T.) clarksvillensis</i>	21	<i>L. richmondensis</i>	29	<i>L. richmondensis</i>	37
<i>E (T.) clarksvillensis</i>	21	<i>L. richmondensis</i>	29	<i>L. richmondensis</i>	37
<i>E (T.) clarksvillensis</i>	21	<i>L. richmondensis</i>	29	<i>L. richmondensis</i>	37
<i>E (T.) clarksvillensis</i>	22	<i>L. richmondensis</i>	29	<i>L. richmondensis</i>	38
<i>E (T.) clarksvillensis</i>	22	<i>L. richmondensis</i>	30	<i>L. richmondensis</i>	38
<i>E (T.) clarksvillensis</i>	22	<i>L. richmondensis</i>	30	<i>L. richmondensis</i>	38
<i>E (T.) clarksvillensis</i>	22	<i>L. richmondensis</i>	30	<i>L. richmondensis</i>	38
<i>E (T.) clarksvillensis</i>	22	<i>L. richmondensis</i>	30	<i>L. richmondensis</i>	39
<i>E (T.) clarksvillensis</i>	22	<i>L. richmondensis</i>	30	<i>L. richmondensis</i>	40
<i>E (T.) clarksvillensis</i>	22	<i>L. richmondensis</i>	30	<i>L. richmondensis</i>	40
<i>E (T.) clarksvillensis</i>	22	<i>L. richmondensis</i>	31	<i>L. richmondensis</i>	41
<i>E (T.) clarksvillensis</i>	22	<i>L. richmondensis</i>	31	<i>L. richmondensis</i>	42
<i>E (T.) clarksvillensis</i>	22	<i>L. richmondensis</i>	31	<i>L. richmondensis</i>	42
<i>E (T.) clarksvillensis</i>	23	<i>L. richmondensis</i>	31	<i>Strophomena</i>	
<i>E (T.) clarksvillensis</i>	23	<i>L. richmondensis</i>	31	<i>planumbona</i>	25
<i>E (T.) clarksvillensis</i>	23	<i>L. richmondensis</i>	31	<i>S. planumbona</i>	38
<i>E (T.) clarksvillensis</i>	23	<i>L. richmondensis</i>	31	<i>S. planumbona</i>	38

<u>Species</u>	<u>SOL (mm)</u>	<u>Species</u>	<u>SOL (mm)</u>	<u>Species</u>	<u>SOL (mm)</u>
<i>S. planumbona</i>	39	<i>S. planumbona</i>	54	<i>R. alternata</i>	75
<i>S. planumbona</i>	40	<i>S. planumbona</i>	54	<i>R. alternata</i>	75
<i>S. planumbona</i>	41	<i>S. planumbona</i>	55	<i>R. alternata</i>	75
<i>S. planumbona</i>	43	<i>S. planumbona</i>	55	<i>R. alternata</i>	76
<i>S. planumbona</i>	44	<i>S. planumbona</i>	55	<i>R. alternata</i>	76
<i>S. planumbona</i>	45	<i>S. planumbona</i>	55	<i>R. alternata</i>	76
<i>S. planumbona</i>	45	<i>S. planumbona</i>	55	<i>R. alternata</i>	76
<i>S. planumbona</i>	45	<i>S. planumbona</i>	55	<i>R. alternata</i>	78
<i>S. planumbona</i>	46	<i>S. planumbona</i>	56	<i>R. alternata</i>	78
<i>S. planumbona</i>	46	<i>S. planumbona</i>	57	<i>R. alternata</i>	78
<i>S. planumbona</i>	46	<i>S. planumbona</i>	57	<i>R. alternata</i>	78
<i>S. planumbona</i>	47			<i>R. alternata</i>	79
<i>S. planumbona</i>	47	<i>Rafinesquina</i>		<i>R. alternata</i>	79
<i>S. planumbona</i>	48	<i>alternata</i>	60	<i>R. alternata</i>	79
<i>S. planumbona</i>	49	<i>R. alternata</i>	62	<i>R. alternata</i>	79
<i>S. planumbona</i>	49	<i>R. alternata</i>	63	<i>R. alternata</i>	80
<i>S. planumbona</i>	49	<i>R. alternata</i>	64	<i>R. alternata</i>	80
<i>S. planumbona</i>	49	<i>R. alternata</i>	65	<i>R. alternata</i>	80
<i>S. planumbona</i>	50	<i>R. alternata</i>	65	<i>R. alternata</i>	80
<i>S. planumbona</i>	50	<i>R. alternata</i>	67	<i>R. alternata</i>	80
<i>S. planumbona</i>	50	<i>R. alternata</i>	68	<i>R. alternata</i>	81
<i>S. planumbona</i>	50	<i>R. alternata</i>	68	<i>R. alternata</i>	81
<i>S. planumbona</i>	50	<i>R. alternata</i>	68	<i>R. alternata</i>	81
<i>S. planumbona</i>	50	<i>R. alternata</i>	68	<i>R. alternata</i>	81
<i>S. planumbona</i>	51	<i>R. alternata</i>	68	<i>R. alternata</i>	83
<i>S. planumbona</i>	51	<i>R. alternata</i>	69	<i>R. alternata</i>	84
<i>S. planumbona</i>	51	<i>R. alternata</i>	70	<i>R. alternata</i>	85
<i>S. planumbona</i>	51	<i>R. alternata</i>	70	<i>R. alternata</i>	86
<i>S. planumbona</i>	52	<i>R. alternata</i>	70	<i>R. alternata</i>	86
<i>S. planumbona</i>	52	<i>R. alternata</i>	70	<i>R. alternata</i>	86
<i>S. planumbona</i>	52	<i>R. alternata</i>	71	<i>R. alternata</i>	94
<i>S. planumbona</i>	52	<i>R. alternata</i>	71	<i>R. alternata</i>	94
<i>S. planumbona</i>	53	<i>R. alternata</i>	74	<i>R. alternata</i>	99
<i>S. planumbona</i>	53	<i>R. alternata</i>	74	<i>R. alternata</i>	105
<i>S. planumbona</i>	53	<i>R. alternata</i>	74	<i>R. alternata</i>	109
<i>S. planumbona</i>	54	<i>R. alternata</i>	74		
<i>S. planumbona</i>	54	<i>R. alternata</i>	75		

TABLE B. FULL SOL DATA SET FOR UDDER IMAGES

Genus	species	SOL (mm)	Genus	species	SOL (mm)
<i>Actinomena</i>	<i>orta</i>	44	<i>Moravostrophia</i>	<i>moravica</i>	39
<i>Aegiria</i>	<i>norvegica</i>	14	<i>Murinella</i>	<i>partita</i>	41
<i>Aegiomena</i>	<i>aquila</i>	32	<i>Nervostrophia</i>	<i>rockfordensis</i>	31
<i>Ahtiella</i>	<i>jaanussoni</i>	50	<i>Oepikina</i>	<i>septata</i>	28
<i>Anoptambonites</i>	<i>grayae</i>	23	<i>Petroria</i>	<i>rugosa</i>	14
<i>Bekkeromena</i>	<i>semipartita</i>	60	<i>Pholidostrophia</i>	<i>nacrea</i>	28
<i>Bellimurina</i>	<i>charlottae</i>	26	<i>Platymena</i>	<i>plana</i>	23
<i>Bilobia</i>	<i>hemispherica</i>	16	<i>Plectambonites</i>	<i>planissimus</i>	26
<i>Bimuria</i>	<i>superba</i>	27	<i>Plectodonta</i>	<i>mariae</i>	9
<i>Brachypriion</i>	<i>sp.</i>	34	<i>Protoleptostrophia</i>	<i>blainvillii</i>	43
<i>Christiania</i>	<i>subquadrata</i>	24	<i>Rafinesquina</i>	<i>alternata</i>	77
<i>Cyphomena</i>	<i>angulata</i>	20	<i>Rhipidomena</i>	<i>tennesseensis</i>	50
<i>Dactylogonia</i>	<i>geniculata</i>	26	<i>Sampo</i>	<i>hiuensis</i>	18
<i>Dicoelostrophia</i>	<i>punctata</i>	39	<i>Sericoidea</i>	<i>restricta</i>	7
<i>Douvillina</i>	<i>arcuata</i>	33	<i>Sowerbyites</i>	<i>tri septatus</i>	23
<i>Douvillinaria</i>	<i>variabilis</i>	34	<i>Strophelloides</i>	<i>reversa</i>	62
<i>Eochonetes</i>	<i>advena</i>	40	<i>Strophodonta</i>	<i>demissa</i>	57
<i>Eoplectodonta</i>	<i>praecursor</i>	17	<i>Strophomena</i>	<i>planumbona</i>	49
<i>Eostropheodonta</i>	<i>hernantensis</i>	21	<i>Taffia</i>	<i>planoconvexa</i>	24
<i>Foliomena</i>	<i>folium</i>	15	<i>Taphrodonta</i>	<i>parallela</i>	27
<i>Furcitella</i>	<i>plicata</i>	23	<i>Telaeoshaleria</i>	<i>sulcata</i>	39
<i>Glyptomena</i>	<i>sculpturata</i>	22	<i>Teratelaasma</i>	<i>neumani</i>	14
<i>Hesperinia</i>	<i>kirki</i>	32	<i>Tetraphalerella</i>	<i>cooperi</i>	68
<i>Hesperomina</i>	<i>leptellinoidea</i>	30	<i>Thaerodonta</i>	<i>clarkesvillensis</i>	22
<i>Holtedahlina</i>	<i>sulcata</i>	43	<i>Titanambonites</i>	<i>medius</i>	56
<i>Ingria</i>	<i>cloudi</i>	32	<i>Toquimia</i>	<i>kirki</i>	30
<i>Isofagma</i>	<i>ricevillense</i>	15	<i>Tufoleptina</i>	<i>tufogena</i>	11
<i>Kiaeromena</i>	<i>kjerulfi</i>	32	<i>Viruella</i>	<i>liliifera</i>	17
<i>Kjaerina</i>	<i>typa</i>	29	<i>Xenambonites</i>	<i>undosus</i>	8
<i>Kjerulfina</i>	<i>polycyma</i>	49			
<i>Leangella</i>	<i>scissa</i>	10			
<i>Leptaena</i>	<i>richmondensis</i>	33			
<i>Leptaenisca</i>	<i>concava</i>	64			
<i>Leptella</i>	<i>sordida</i>	9			
<i>Leptellina</i>	<i>tennesseensis</i>	20			
<i>Leptelloidea</i>	<i>leptelloides</i>	31			
<i>Leptestia</i>	<i>musculosa</i>	53			
<i>Leptestiina</i>	<i>oepiki</i>	17			
<i>Leptodonta</i>	<i>leblanci</i>	32			
<i>Lissostrophia</i>	<i>cooperi</i>	13			
<i>Luhaiia</i>	<i>vardi</i>	49			
<i>Maoristrophia</i>	<i>neozelanica</i>	68			
<i>Megamyonia</i>	<i>nighti</i>	20			
<i>Mesopholidostrophia</i>	<i>nitens</i>	17			
<i>Mjoesina</i>	<i>rugata</i>	20			

TABLE C. PROBABILISTIC TESTS FOR REDUCTION OF INTERSPECIFIC SOL OVERLAP

Test number	Morphospace axis sampled (mm)	p-value	Expanded morphospace axis (mm)	Morphospace expansion (%)
I*	Logarithmic on (0, ln 110)	< 0.03	(0, ln 136)	24
II*	Arithmetic on (1, 110)	< 0.01	(0, 181)	65
III [#]	Arithmetic on (1, 110)	< 0.02	(0, 125)	14

Note: Locations of all simulated species distributions chosen at random from the morphospace.

*Ranges of simulated species distributions identical to observed Liberty species distribution ranges.

[#]Endpoints for ranges of simulated species distributions chosen at random from the morphospace, with maximum range equal to half the morphospace. Sum of simulated ranges equal to sum of observed ranges.

In our paper's probabilistic overlap test ("Test I" above), we assessed among-species overlap along the ln-transform of the SOL morphological axis. We found that the sum of pairwise interspecific overlaps was unexpectedly low, corroborating the hypothesis of limiting similarity. We performed this test in the logarithmic space (Figure B) because we believed it to be the most biologically realistic and statistically conservative setting. However, little agreement has been reached as to the appropriate null model for assessing niche overlap, even in morphological spaces. Comparison of the ln-transform results with results from other null models may shed further light on the observed pattern. Here we describe the additional null models, give the results from tests of overlap analogous to our original overlap test, and justify the use of our original test in ln-transformed space. Figures A and B help to illustrate the nature of the problems at hand.

In each test, the axial overlap among four randomly generated species distributions was compared to that among the Liberty taxa. The randomly generated species were constrained to lie within the same SOL morphospace as the Liberty community (i.e., minimum SOL at 1 mm, maximum SOL at 110 mm). In addition, the sum of the ranges of the randomly generated species was constrained to be equal to that of the Liberty species. In each test, the placement of a given distribution was independent of the placement of any other distribution, constrained only by the endpoints of the morphospace. For each test, 100,000 replicates were performed in order to obtain the significance of the frequency with which the summed overlap of the Liberty taxa exceeded that of randomly generated taxa. In the case of significance $p < 0.05$, the morphospace was gradually widened until $p = 0.05$. Given the null hypothesis that the expected overlap among randomly placed distributions would be indistinguishable from that among the observed distributions, the smallest morphospace in which the null hypothesis cannot be rejected is that for which $p = 0.05$.

In the test whose results we reported in our paper (here, "Test I"), the four observed distributions were randomly relocated to locations chosen by sampling a random value from the ln-transform of the morphospace (Figure B). Test II repeated the Test I procedure in the arithmetic morphospace proper (Figure A). In Test III, distribution ranges (minimum and maximum values of each distribution) were randomized, as were distribution locations. Eight random samples from the arithmetic morphospace served as endpoints for the simulated distribution ranges, with the constraint that no simulated range could exceed half the total arithmetic morphospace. Distribution locations were then sampled as in Test II.

Each model of random species assortment gives a slightly different realized significance and range expansion value. However, all test results indicate that the observed overlap sum is unexpectedly low ($p < 0.03$). All tests further affirm that the observed overlap would still be unexpectedly small even on a null-model morphospace axis at least 13.6% longer than the observed axis. In short, alternative models of random species assortment yield results similar to those obtained from the model incorporated in our paper (Test I).

Execution of these tests on the ln-transformed morphospace axis provides for enhanced biological realism and statistical conservatism, for the following reasons:

- (1) Relocation of ln-transformed distributions preserves their normalized variance structures. That is to say, the observed scaling of species variance with species mean (see Figure A below) is maintained during relocation. Whether this scaling is justified physiologically or geometrically, it is a real and persistent pattern in nature. This scaling must therefore be incorporated into the model in order to obtain biologically relevant results. In-transformation is one straightforward way of incorporating this scaling.
- (2) Choice of new locations by sampling a random value from the ln-transform of the morphospace produces random relocation configurations similar to the observed configuration. For this reason, relocation in ln-space produces statistically conservative results. Choice of new locations from an arithmetic morphospace produces comparatively disparate and variable relocation configurations. These relocation configurations are also

strongly biased with respect to constancy among ratios between successive species means, unlike the ln-transformed relocation configurations.

- (3) Test III, whose model of randomness differs greatly from that of Tests I and II, also fails to maintain the statistical and biological relevance upheld by Test I. Its assumption that species distributions are random in both spacing and range is ecologically radical and statistically unconservative. Yet even this model produces a significant overlap result (though morphospace expansion is less than under other models).
- (4) In their call for appropriate null models for competition, Simberloff and Boecklen (1981) recommend logarithmic spaces.

Figures A and B. The observed SOL distributions in (A) arithmetic space and (B) ln-transformed space. For explanation, see Figure 1.

