

## Ecography

E7244

Locke, S. A., Levy, M. S., Marcogliese, D. J., Ackerman, S. and McLaughlin, J. D. 2012. The decay of parasite community similarity in ring-billed gulls *Larus delawarensis* and other hosts. – *Ecography* 35: xxx–xxx.

## Supplementary material

## Supplementary Table A1. Calculation of halving distances in Sorenson similarity: Notes

Calculation of similarity halving distances followed Soininen et al. (2007) with the following modifications.

- In addition to the linear and loglinear formulae for calculating halving distances provided by Soininen et al. (2007), the following were used.
  - Poulin (2003), Thieltges et al (2009), Poulin et al (in press) and the present study used  $\ln(x+1)$  or  $\log(x+1)$  similarity (rather than  $\ln(x)$  or  $\log(x)$ ). For these data, halving distances were calculated using:
    - Halving distance= $(\ln(e^{(\beta+\alpha)}+1) - \ln(2) - \alpha)/\beta$  or
    - Halving distance= $(\log(10^{(\beta+\alpha)}+1) - \log(2) - \alpha)/\beta$ , respectively.
  - Brouat and Duplantier (2007) reported the distance decay relationship in linear-log format. For this situation, the following formula was initially used to calculate the halving distance (but see also further below):
    - Halving distance= $10^{(-\alpha/2\beta)}$
- Soininen et al. (2007) used the following formula to convert Jaccard (J) to Sorenson (S):  $S=2J/(1 + J)$ 
  - In the present study, this formula was used to convert both slopes and intercepts from Jaccard to Sorenson. In contrast, Soininen et al (2007) only described the use of this formula for converting initial similarities (intercepts), not slopes.
- Slopes in Poulin (2003), Oliva and González (2007), Timi et al (2010), Poulin et al (2010) were converted to km, rather than calculating the halving distance in the original units and converting the result. This was done because the halving distance formulae provide the distance at which similarity at 1 unit of distance decreases by 50%, and thus will yield different results for different units of measurement. For example, regression parameters in Poulin (2003), Timi et al. (2010) and Poulin et al. (2010) all reflect their use of 1000 km scales; in these studies, the initial similarities will be those at 1000 km, and will differ substantially from the initial similarities at 1 km, as will the distances at which these initial similarities decrease by half.
- To verify the plausibility of calculated halving distances calculated from published regression parameters, calculated distances were compared to distance-decay figures in the original papers. Calculated halving distances appeared inconsistent for *T. murphyi* and *S. capensis* and Figure 1 of Oliva and González (2007); *M. erythroleucus* and Figure 2 of Brouat and Duplantier (2007), and also in *C. edule*, *H. ulvae* and *L. littorea* in Figure 1 of Thieltges et al. (2009). Plots of the published regression line functions confirmed these inconsistencies. In addition, Figure 2b in Thieltges et al. (2009) could not be reproduced using data from the same sources.

- It appears that the slopes for distance decay in *T. murphyi* and *S. capensis* (-0.0001, -0.0002 sim/naut. mile) were rounded. Slopes of -0.000144 and -0.000176, respectively, produced functions that were more similar to regression lines in Figure 1 in Oliva and González (2007). These adjusted slopes led to halving distances differing by 15 and 30% from those obtained from the regression line parameters reported by Oliva and González (2007).
- Application of the formula for the linear-log form ( $H.D.=10^{(-\alpha/2\beta)}$ ) to the regression parameters provided by Brouat and Duplantier (2007) led to a large halving distance (50 669 km) that was inconsistent with figure 2a in that paper. In response to inquiry, C. Brouat clarified that while the figure 2a was in linear-log form, the regression parameters were in linear-Ln form.
- One of the authors of Thieltges et al (2009) (DT) confirmed that halving distances in tables were calculated using the linear-linear form although regression parameters are all in Ln (sim+1) form. In addition, calculations of halving distances in Fig 2b of Thieltges et al (2009) did not take into account one or more of the non-equivalence of similarity measures (Jaccard versus Sorenson), and/or geographic scales (nautical miles, 1000 km, 1 km) in Poulin (2003), Fellis and Esch (2005), and Oliva and González (2007) and Thieltges et al. (2009).

Supplementary Table A1 (part 1). Calculation of halving distances.  $\beta$  = slope,  $\alpha$ =intercept

Original study				Halving distance (H.D.) in Sorenson similarity (km)	Host	Source <sup>†</sup>
Similarity <sup>†</sup>	Distance	$\beta$	$\alpha$			
Ln (J+1)	1000 km	-0.048	0.223	$\beta_{\text{Sor/km}} = 2(-0.048)/(1 + -0.048) \times 1/1000 \text{ km} = -0.00096$ $\alpha_{\text{Sor}} = 2(0.223)/(1 + 0.223) = 0.36477$ H.D. = $(\text{Ln}(e^{(\beta+\alpha)}+1) - \text{Ln}(2) - \alpha)/\beta$ H.D. = 1728	<i>P. flavescens</i>	1
Ln (J)	1000 km	-0.383	-0.896	$\beta_{\text{Sor/km}} = 2(-0.383)/(1 + -0.383) \times 1/1000 \text{ km} = -0.000766$ H.D. = $1 - \text{Ln}(2)/\beta$ H.D. = 906	<i>E. lucius</i>	1
Ln (J)	1000 km	-0.485	-0.902	$\beta_{\text{Sor/km}} = 2(-0.485)/(1 + -0.485) \times 1/1000 \text{ km} = -0.00097$ H.D. = $1 - \text{Ln}(2)/\beta$ H.D. = 715	<i>P. lotor</i>	1
Ln (J)	1000 km	-0.520	-0.579	$\beta_{\text{Sor/km}} = 2(-0.520)/(1 + -0.520) \times 1/1000 \text{ km} = -0.0001041$ H.D. = $1 - \text{Ln}(2)/\beta$ H.D. = 667	<i>C. latrans</i>	1
S	1 km	-0.0003	0.6642	H.D. = $(\beta - \alpha) / 2 \beta$ H.D. = $(-0.0003 - 0.6642) / 2 (-0.0003)$ H.D. = 1108	<i>L. machrochirus</i>	2
BC (p/a)	1 nmi	-0.0001	0.691	$\beta_{\text{Sor/km}} = -0.0001 \times 1/1.852 = -0.00054$ H.D. = $(-0.0001 - 0.691) / 2 (-0.0001)$ H.D. = 6399 But see above: $\beta_{\text{Jacc/km}}$ is closer to -0.000144, and H.D. = 4444	<i>T. murphyi</i>	3

Supplementary Table A1 (part 2)

Similarity <sup>†</sup>	Distance	$\beta$	$\alpha$	Halving distance (H.D.) in Sorenson similarity (km)	Host	Source <sup>†</sup>
BC (p/a)	1 nmi	-0.0003	0.8039	$\beta_{\text{Sor/km}} = -0.0003 \times 1/1.852 = -0.000162$ H.D. = $(-0.000162 - 0.8039) / 2 (-0.000162)$ H.D. = 2482	<i>M. gayi</i>	3
BC (p/a)	1 nmi	-0.0002	0.7393	$\beta_{\text{Sor/km}} = -0.0002 \times 1/1.852 = -0.000108$ H.D. = $(-0.0002 - 0.7393) / 2 (-0.0002)$ H.D. = 3423 But see above: $\beta_{\text{Jacc/km}}$ is closer to -0.000176, and H.D. = 3890	<i>S. capensis</i>	3
S	Ln (km)	-0.09	0.85	H.D. = $e^{(-\alpha/2\beta)}$ H.D. = $e^{(-0.85/2(-0.09))}$ H.D. = 112 (but see above)	<i>M. erythroleucus</i>	4
Ln (J+1)	1 km	-0.000083	0.4658	$\beta_{\text{Sor/km}} = 2(-0.000083)/(1 + -0.000083) = -0.000166$ $\alpha_{\text{Sor}} = 2(0.4658)/(1 + 0.4658) = 0.63556$ H.D. = $(\text{Ln}(e^{(\beta+\alpha)}+1) - \text{Ln}(2) - \alpha)/\beta$ H.D. = 1616	<i>C. edule</i>	5
Ln (J+1)	1 km	-0.00014	0.3189	$\beta_{\text{Sor/km}} = 2(-0.00014)/(1 + -0.00014) = -0.000280$ $\alpha_{\text{Sor}} = 2(0.3189)/(1 + 0.3189) = 0.483585$ H.D. = $(\text{Ln}(e^{(\beta+\alpha)}+1) - \text{Ln}(2) - \alpha)/\beta$ H.D. = 761	<i>H. ulvae</i>	5
Ln (J+1)	1 km	-0.000192	0.5219	$\beta_{\text{Sor/km}} = 2(-0.000192)/(1 + -0.000192) = -0.000384$ $\alpha_{\text{Sor}} = 2(0.5219)/(1 + 0.5219) = 0.685853$ H.D. = $(\text{Ln}(e^{(\beta+\alpha)}+1) - \text{Ln}(2) - \alpha)/\beta$ H.D. = 743	<i>L. littorea</i>	5

Supplementary Table A1 (part 3)

Similarity <sup>†</sup>	Distance	$\beta$	$\alpha$	Halving distance (H.D.) in Sorenson similarity (km)	Host	Source <sup>†</sup>
Ln (J)	1000 km	-0.182	-0.352	$\beta_{\text{Sor/km}} = 2(-0.182)/(1 + -0.182) \times 1/1000 \text{ km} = -0.000364$ H.D. = $1 - \text{Ln}(2)/\beta$ H.D. = 1905	<i>P. brasiliensis</i>	6
Log (J)	1 km	-0.000359		$\beta_{\text{Sor/km}} = 2(-0.000359)/(1 + -0.000359) = -0.000718$ H.D. = $1 - \text{Log}(2)/\beta$ H.D. = 420	<i>G. morhua</i> (North Sea)	7
Log (J)	1 km	-0.000694		$\beta_{\text{Sor/km}} = 2(-0.000694)/(1 + -0.000694) = -0.001389$ H.D. = $1 - \text{Log}(2)/\beta$ H.D. = 218	<i>G. morhua</i> (Baltic Sea)	7
Log (J)	1 km	-0.00235		$\beta_{\text{Sor/km}} = 2(-0.00235)/(1 + -0.00235) = -0.004711$ H.D. = $1 - \text{Log}(2)/\beta$ H.D. = 65	<i>L. limanda</i> (Baltic Sea)	7
Log (J)	1 km	-0.000439		$\beta_{\text{Sor/km}} = 2(-0.000439)/(1 + -0.000439) = -0.000878$ H.D. = $1 - \text{Log}(2)/\beta$ H.D. = 344	<i>P. flesus</i> (Baltic Sea)	7
Log (J+1)	1000 km	-0.026	0.06	$\beta_{\text{Sor/km}} = 2(-0.026)/(1 + -0.026) \times 1/1000 \text{ km} = -0.000052$ $\alpha_{\text{Sor}} = 2(0.06)/(1 + 0.06) = 0.113208$ H.D. = $(\text{Log}(10^{(\beta+\alpha)}+1) - \text{Log}(2) - \alpha)/\beta$ H.D. = 1018	Freshwater <i>G. aculeatus</i> Eurasia	8
Log (J+1)	1000 km	-0.055	0.102	$\beta_{\text{Sor/km}} = 2(-0.055)/(1 + -0.055) \times 1/1000 \text{ km} = -0.000110$ $\alpha_{\text{Sor}} = 2(0.102)/(1 + 0.102) = 0.185118$ H.D. = $(\text{Log}(10^{(\beta+\alpha)}+1) - \text{Log}(2) - \alpha)/\beta$ H.D. = 753	Freshwater <i>G. aculeatus</i> NE N America	8

Supplementary Table A1 (part 4)

Similarity <sup>†</sup>	Distance	$\beta$	$\alpha$	Halving distance (H.D.) in Sorenson similarity (km)	Host	Source <sup>†</sup>
Log (J+1)	1000 km	-0.357	0.13	$\beta_{\text{Sor/km}} = 2(-0.357)/(1 + -0.357) \times 1/1000 \text{ km} = -0.000714$ $\alpha_{\text{Sor}} = 2(0.13)/(1 + 0.13) = 0.230088$ $\text{H.D.} = (\text{Log}(10^{(\beta+\alpha)+1}) - \text{Log}(2) - \alpha)/\beta$ $\text{H.D.} = 141$	Freshwater <i>G. aculeatus</i> NW N America	8
Log (J+1)	1000 km	-0.042	0.106	$\beta_{\text{Sor/km}} = 2(-0.042)/(1 + -0.042) \times 1/1000 \text{ km} = -0.000084$ $\alpha_{\text{Sor}} = 2(0.106)/(1 + 0.106) = 0.191682$ $\text{H.D.} = (\text{Log}(10^{(\beta+\alpha)+1}) - \text{Log}(2) - \alpha)/\beta$ $\text{H.D.} = 1017$	Marine <i>G. aculeatus</i> Eurasia	8
Log (J+1)	1000 km	-0.127	0.184	$\beta_{\text{Sor/km}} = 2(-0.127)/(1 + -0.127) \times 1/1000 \text{ km} = -0.000254$ $\alpha_{\text{Sor}} = 2(0.184)/(1 + 0.184) = 0.310811$ $\text{H.D.} = (\text{Log}(10^{(\beta+\alpha)+1}) - \text{Log}(2) - \alpha)/\beta$ $\text{H.D.} = 505$	Marine <i>G. aculeatus</i> NE N America	8
Log (J+1)	1000 km	-0.028	0.061	$\beta_{\text{Sor/km}} = 2(-0.028)/(1 + -0.028) \times 1/1000 \text{ km} = -0.000056$ $\alpha_{\text{Sor}} = 2(0.061)/(1 + 0.061) = 0.114986$ $\text{H.D.} = (\text{Log}(10^{(\beta+\alpha)+1}) - \text{Log}(2) - \alpha)/\beta$ $\text{H.D.} = 959$	Brackish water <i>G. aculeatus</i> Eurasia	8
Log (J+1)	1000 km	-0.072	0.098	$\beta_{\text{Sor/km}} = 2(-0.072)/(1 + -0.072) \times 1/1000 \text{ km} = -0.000144$ $\alpha_{\text{Sor}} = 2(0.098)/(1 + 0.098) = 0.178506$ $\text{H.D.} = (\text{Log}(10^{(\beta+\alpha)+1}) - \text{Log}(2) - \alpha)/\beta$ $\text{H.D.} = 557$	Brackish water <i>G. aculeatus</i> NE N America	8
S	1 km	-0.013	56.238	$\text{H.D.} = (\beta - \alpha) / 2 \beta$ $\text{H.D.} = (-0.013 - 56.238) / 2 (-0.013)$ $\text{H.D.} = 2164$	<i>L. delawarensis</i>	9

<sup>†</sup>J=Jaccard; S=Sorenson; BC p/a=Bray-Curtis on presence absence, which is equivalent to Sorenson similarity

Supplementary Table A2. Independent variables evaluated for effects on halving distances.  
Sources<sup>†</sup> in parentheses. (Ecto=ectotherm; Homeo=homeotherm)

	<b>Study extent (km)</b>	<b>Study latitude ( DD )</b>	<b>Maximum host mass (g)</b>	<b>Host thermo-regulation</b>	<b>Maximum host dispersal (km)</b>	<b>Host trophic level</b>	<b>N host populations examined</b>	<b>Parasite species richness</b>
<i>P. flavescens</i>	2700 (1)	48 (1)	1910 (12)	Ecto	175 (18)	3.7 (12)	21 (1)	15 (1)
<i>E. lucius</i>	4050 (1)	54 (1)	28400 (12)	Ecto	78 (19)	4.4 (12)	6 (1)	14 (1)
<i>P. lotor</i>	2700 (1)	40.75 (1)	23000 (23)	Homeo	266 (17)	2.5 (31)	8 (1)	33 (1)
<i>C. latrans</i>	3000 (1)	45.25 (1)	16000 (24)	Homeo	544 (19)	3	7 (1)	20 (1)
<i>L. machrochirus</i>	1700 (2)	35 (2)	2150 (12)	Ecto	17 (22)	3.18 (12)	25 (2)	19 (2)
<i>T. murphyi</i>	3928 (3)	20.6 (3)	11000 (14)	Ecto	200 (10)	3.5 (10)	7 (3)	21 (3)
<i>M. gayi</i>	3297 (3)	26.5 (3)	17000 (14)	Ecto	200 (3)	4.26 (12)	5 (3)	30 (3)
<i>S. capensis</i>	4467 (3)	32.9 (3)	300 (13)	Ecto	10 (3)	3.5 (15)	7 (3)	15 (3)
<i>M. erythroleucus</i>	68 (26)	12 (4)	106 (27)	Homeo	7 (26)	2.25 (27)	10 (4)	11 (4)
<i>C. edule</i>	3900 (5)	51.1 (5)	10	Ecto	0.01	5 (30)	19 (5)	15 (5)
<i>H. ulvae</i>	1500 (5)	50.5 (5)	10	Ecto	0.01	5 (30)	36 (5)	44 (5)
<i>L. littorea</i>	1700 (5)	51.8 (5)	10	Ecto	0.01	5 (30)	35 (5)	10 (5)
<i>P. brasilianus</i>	3100 (6)	33 (6)	11000 (14)	Ecto	100	3.8 (12)	5 (6)	39 (6)
<i>G. morhua</i> (North Sea)	1176 (7)	58 (7)	96000 (12)	Ecto	600 (25)	3.73 (12)	9 (7)	18 (7)
<i>G. morhua</i> (Baltic Sea)	485 (7)	55 (7)	96000 (12)	Ecto	600 (25)	3.73 (12)	6 (7)	18 (7)
<i>L. limanda</i> (Baltic Sea)	350 (7)	58 (7)	1000 (12)	Ecto	200	3.29 (12)	6 (7)	13 (7)
<i>P. flesus</i> (Baltic Sea)	1054 (7)	58 (7)	14000 (12)	Ecto	300 (12)	3.19 (12)	8 (7)	27 (7)
Freshwater <i>G. aculeatus</i> Eurasia	2500 (8)	60 (8)	10 (16)	Ecto	10 (22)	3.51 (12)	37 (8)	86 (8)
Freshwater <i>G. aculeatus</i> NE N America	1400 (8)	50 (8)	10 (16)	Ecto	10 (32)	3.51 (12)	15 (8)	44 (8)
Freshwater <i>G. aculeatus</i> NW N America	375 (8)	55 (8)	10 (16)	Ecto	10 (32)	3.51 (12)	13 (8)	30 (8)
Marine <i>G. aculeatus</i> Eurasia	2500 (8)	60 (8)	10 (16)	Ecto	10 (32)	3.51 (12)	11 (8)	86 (8)
Marine <i>G. aculeatus</i> NE N America	1400 (8)	50 (8)	10 (16)	Ecto	10 (32)	3.51 (12)	17 (8)	44 (8)
Brackish water <i>G. aculeatus</i> Eurasia	2500 (8)	60 (8)	10 (16)	Ecto	10 (32)	3.51 (12)	19 (8)	86 (8)
Brackish water <i>G. aculeatus</i> NE N America	1400 (8)	50 (8)	10 (16)	Ecto	10 (32)	3.51 (12)	12 (8)	44 (8)
<i>L. delawarensis</i>	3100	49.25	700	Homeo	2600 (21)	3.9 (28)	7	37



Item A1. Helminths found in 145 ring-billed gulls (*Larus delawarensis*) in 1994-1995 in the St. Lawrence River, Quebec, Canada

Cestoda:

*Anomotaenia dominicanus*, *Aploparaxis* sp., Dilepididae gen. sp., *Diphyllobothrium* sp., *Drepanidotaenia lateralis*, *Microsomacanthus charadrii*, *Microsomacanthus ductilis*, *Ophryocotyle proteus*, *Choanotaenia porosa*, *Tetrabothrius cylindraceus*, *Wardium cirrosa*, *Wardium clavicirrus*, *Wardium stellorae*, *Wardium* spp. 1-3

Digenea:

*Apophallus brevis*, *Cardiocephalus medioconiger*, *Cotylurus platycephalus*, *Diplostomum* spp., *Echinostoma* sp., *Himasthala leptosoma*, *Maritreminoides* sp., *Mesophorodiplostomum pricei*, *Plagiorchis multiglandularis*, *Stephanoprora denticulata*

Nematoda:

*Capillaria* spp. 1 and 2; *Cosmocephalus obvelatus*, *Tetrameres* sp.

Supplementary Table A3.1-3.3. The three best models (minimum AICc) for explaining variation in halving distances in phylogenetically independent contrasts in Sorenson similarity of parasite communities (note: all regressions forced through the origin). DF=degrees of freedom; SE=Standard Error; P= Probability of exceeding |t| or F ratios

**Table A3.1 AICc = -29.073, R<sup>2</sup> = 0.912**

Source	DF	Sum of squares	Mean square	F ratio	P
Model	3	0.75332909	0.2511110	56.5273	<0.0001
Error	13	0.05774950	0.004442		
Total	16	0.81107860			

**Parameter Estimates**

Term	Estimate	SE	t ratio	P
Log study extent	1.1282167	0.087241	12.62	<0.0001
Log latitude	-1.405738	0.222534	-6.32	<0.0001
Log N host populations	0.3257756	0.141773	2.30	0.0388

**Table A3.2 AICc = -28.542, R<sup>2</sup> = 0.911**

Source	DF	Sum of squares	Mean Square	F ratio	P
Model	3	0.75268370	0.250895	55.8547	<0.0001
Error	13	0.05839490	0.004492		
Total	16	0.81107860			

**Parameter Estimates**

Term	Estimate	SE	t ratio	P
Log study extent	1.1559048	0.09204	12.56	<0.0001
Log latitude	-1.334819	0.215269	-6.20	<0.0001
Log body mass	-0.078228	0.034714	-2.25	0.0421

**Table A3.3 AICc = -27.562, R<sup>2</sup> = 0.886**

Source	DF	Sum of squares	Mean Square	F ratio	P
Model	2	0.72987289	0.364936	62.9157	<0.0001
Error	14	0.08120571	0.005800		
Total	16	0.81107860			

**Parameter Estimates**

Term	Estimate	SE	t ratio	P
Log study extent	1.0724992	0.095761	11.20	<0.0001
Log Latitude	-1.230652	0.238916	-5.15	0.0001

Supplementary Table A4. Summary results of studies of geographic distance decay in parasite community similarity. See Locke et al. 2011. *Ecography*. – 34: xxx-xxx for sources.

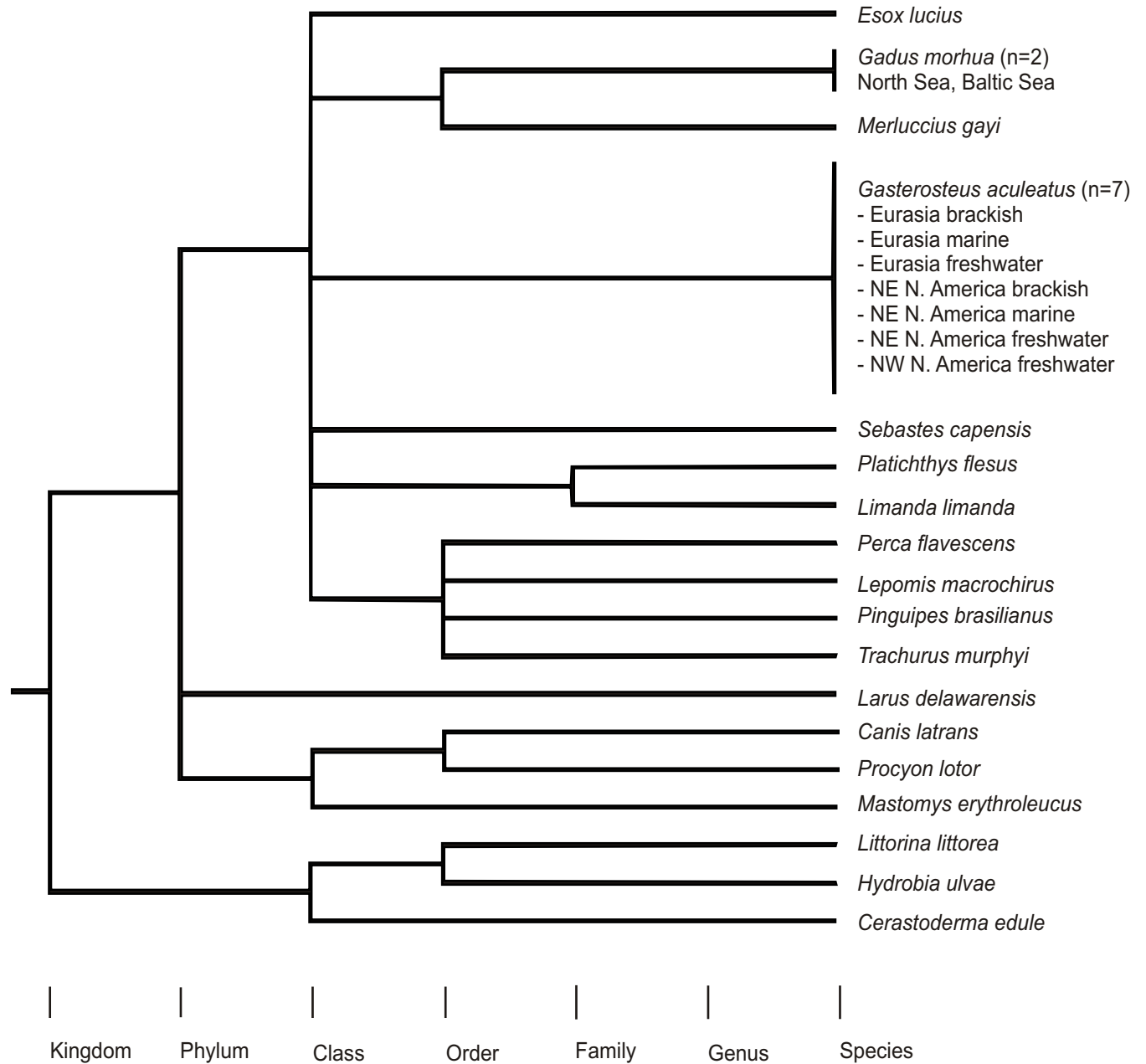
Source	Geographic distance decay in parasite community similarity	
	N significant relationships	N relationships assessed
Poulin and Morand, 1999	2	3
Poulin 2003	4	6
Krasnov et al. 2005	6	11
Brouat and Duplantier 2007	1	2
Vinarski et al. 2007	1	11
Karvonen and Valtonen 2004	1	1
Karvonen et al. 2005	1	2
Fellis and Esch 2005a, b	2	2
Oliva and González, 2005	3	4
Seifertová et al. 2008	1	1
Pérez-del-Olmo et al. 2009	1	1
Timi et al. 2010a	1	1
Thieltges et al. 2009	3	3
Thieltges et al. 2010	4	6*
Poulin et al. 2011	3	3
<b>Total:</b>	<b>34</b>	<b>57</b>

\*Using only Jaccard similarity

†Sources used in Tables A1 and A3:

1) Poulin, R. 2003. The decay of similarity with geographical distance in parasite communities of vertebrate hosts. *J. Biogeogr.* – 30: 1609-1615. 2) Fellis, J. K. and Esch G. W. 2005. Variation in life cycle affects the distance decay of similarity among bluegill sunfish parasite communities. *J. Parasitol.* – 91: 1484-1486. 3) Oliva, M. E. and González, M. T. 2005. The decay of similarity over geographical distance in parasite communities of marine fishes. *J. Biogeogr.* – 32: 1327-1332. 4) Brouat, C. and Duplantier, J. M. 2007. Host habitat patchiness and the distance decay of similarity among gastro-intestinal nematode communities in two species of *Mastomys* (southeastern Senegal). *Oecologia* – 152: 715-720. 5) Thieltges, D. W. et al. 2009. Distance decay of similarity among parasite communities of three marine invertebrate hosts. *Oecologia* – 160: 163-173. 6) Timi, J. T. et al. 2010a. Similarity in parasite communities of the teleost fish *Pinguipes brasilianus* in the southwestern Atlantic: infracommunities as a tool to detect geographical patterns? *Int. J. Parasitol.* – 40: 243-254. 7) Thieltges, D. W. et al. 2010. Salinity gradient shapes distance decay of similarity among parasite communities in three marine fishes. *J. Fish Biol.* – 76: 1806-1814. 8) Poulin, R. et al. 2010. The biogeography of parasitism in sticklebacks: distance, habitat differences and the similarity in parasite occurrence and abundance. *Ecography* – 33: 1-129. Present study 10) Bertrand et al. 2004. Diel vertical behaviour, predator-prey relationships, and occupation of space by jack mackerel (*Trachurus murphyi*) off Chile. *ICES J. Mar. Sci.* – 61: 1105-1112. 11) Tam et al. 2006. Changes in the diet of hake associated with El Niño 1997-1998 in the northern Humboldt Current ecosystem. *Advances in Geosciences* – 6: 63-67. 12) www.fishbase.org 13) Chen, L-C. 1971. Systematics, Variation, Distribution and Biology of Rockfishes of the Subgenus *Sebastes* (Pisces,

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Appendix 1, Fig. A1. Phylogeny used to generate independent contrasts for the analysis of data set 3.