Invisible trophic links? Quantifying the importance of non-standard food sources for key intertidal avian predators in the Eastern Atlantic

Pedro M. Lourenço*, Teresa Catry, Ricardo J. Lopes, Theunis Piersma, José P. Granadeiro

*Corresponding author: p.m.g.lourenco@gmail.com

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Figure S1: Sensitivity analysis on the effects of changing isotope trophic discrimination factors in estimates of the relative contribution of different food sources to the diet of shorebirds in the four study areas. Colours (and the z-axis) in each graphic indicate the proportion contribution of each potential food sources, as estimated by SIAR mixing models, with varying values of trophic discrimination for nitrogen (y-axis; 2.4 to 4.4‰ $\delta^{15}\text{N}$) and carbon (x-axis; -0.9 to 1.7‰ $\delta^{13}\text{C}$). Each page presents a different shorebird species/site. Taxa included in each food source group are listed in Table S1.

Ruddy turnstone (*Arenaria interpres*), Tejo estuary

Sanderling (*Calidris alba*), Tejo estuary

Intertidal invertebrates

Saltpan invertebrates

Biofilm

Dunlin (*Calidris alpina*), Tejo estuary

Intertidal invertebrates

Saltpan invertebrates

Biofilm

Red knot (*Calidris canutus*), Tejo estuary

Intertidal invertebrates

Saltpan invertebrates

Biofilm

Little stint (*Calidris minuta*), Tejo estuary

Intertidal invertebrates

Saltpan invertebrates

Biofilm

Ringed plover (*Charadrius hiaticula*), Tejo estuary

Intertidal invertebrates

Saltpan invertebrates

Biofilm

Black-tailed godwit (*Limosa limosa*), Tejo estuary

Intertidal invertebrates

Saltpan invertebrates

Biofilm

Grey plover (*Pluvialis squatarola*), Tejo estuary

Intertidal invertebrates

Saltpan invertebrates

Biofilm

Redshank (*Tringa totanus*), Tejo estuary

Intertidal invertebrates

Saltpan invertebrates

Biofilm

Sanderling (*Calidris alba*), Sidi-Moussa

Intertidal invertebrates

Saltpan invertebrates

Biofilm

Seagrass rhizomes

Dunlin (*Calidris alpina*), Sidi-Moussa

Intertidal invertebrates

Saltpan invertebrates

Biofilm

Seagrass rhizomes

Little stint (*Calidris minuta*), Sidi-Moussa

Intertidal invertebrates

Saltpan invertebrates

Biofilm

Seagrass rhizomes

Ringed plover (*Charadrius hiaticula*), Sidi-Moussa

Intertidal invertebrates

Saltpan invertebrates

Biofilm

Seagrass rhizomes

Grey plover (*Pluvialis squatarola*), Sidi-Moussa

Intertidal invertebrates

Saltpan invertebrates

Biofilm

Seagrass rhizomes

Redshank (*Tringa totanus*), Sidi-Moussa

Intertidal invertebrates

Saltpan invertebrates

Biofilm

Seagrass rhizomes

Ruddy turnstone (*Arenaria interpres*), Banc d'Arguin

Intertidal invertebrates

Symbiotic bivalves

Biofilm

Seagrass rhizomes

Sanderling (*Calidris alba*), Banc d'Arguin

Intertidal invertebrates

Symbiotic bivalves

Biofilm

Seagrass rhizomes

Dunlin (*Calidris alpina*), Banc d'Arguin

Intertidal invertebrates

Symbiotic bivalves

Biofilm

Seagrass rhizomes

Red knot (*Calidris canutus*), Banc d'Arguin

Intertidal invertebrates

Symbiotic bivalves

Biofilm

Seagrass rhizomes

Little stint (*Calidris minuta*), Banc d'Arguin

Intertidal invertebrates

Symbiotic bivalves

Biofilm

Seagrass rhizomes

Curlew sandpiper (*Calidris ferruginea*), Banc d'Arguin

Intertidal invertebrates

Symbiotic bivalves

Biofilm

Seagrass rhizomes

Ringed plover (*Charadrius hiaticula*), Banc d'Arguin

Intertidal invertebrates

Symbiotic bivalves

Biofilm

Seagrass rhizomes

Grey plover (*Pluvialis squatarola*), Banc d'Arguin

Intertidal invertebrates

Symbiotic bivalves

Biofilm

Seagrass rhizomes

Redshank (*Tringa totanus*), Banc d'Arguin

Intertidal invertebrates

Symbiotic bivalves

Biofilm

Seagrass rhizomes

Ruddy turnstone (*Arenaria interpres*), Bijagós archipelago

Intertidal invertebrates

Symbiotic bivalves

Biofilm

Sanderling (*Calidris alba*), Bijagós archipelago

Intertidal invertebrates

Symbiotic bivalves

Biofilm

Red knot (*Calidris canutus*), Bijagós archipelago

Intertidal invertebrates

Symbiotic bivalves

Biofilm

Curlew sandpiper (*Calidris ferruginea*), Bijagós archipelago

Intertidal invertebrates

Symbiotic bivalves

Biofilm

Ringed plover (*Charadrius hiaticula*), Bijagós archipelago

Intertidal invertebrates

Symbiotic bivalves

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Bar-tailed godwit (*Limosa lapponica*), Bijagós archipelago

Intertidal invertebrates

Symbiotic bivalves

Biofilm

Grey plover (*Pluvialis squatarola*), Bijagós archipelago

Intertidal invertebrates

Symbiotic bivalves

Biofilm

Redshank (*Tringa totanus*), Bijagós archipelago

Intertidal invertebrates

Symbiotic bivalves

Biofilm

Table S1: $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values (mean $\pm$ SD) of potential food sources for shorebirds collected in the four study areas: Tejo estuary, Sidi-Moussa, Banc d'Arguin and Bijagós archipelago. n = number of samples analysed followed by the number of individuals included in each sample. Potential food sources are: INTINV: intertidal macroinvertebrates, SALINV: saltpan macroinvertebrates, SYMCHE: intertidal bivalves with symbiotic chemoautotrophic bacteria, BIOFIL: biofilm, SEARHI: seagrass rhizomes.

	$\delta^{15}\text{N}$ (‰)	$\delta^{13}\text{C}$ (‰)	n	Food source
Tejo estuary, Portugal				
SOM	8.05 $\pm$ 0.54	-20.82 $\pm$ 0.62	2	BIOFIL
Microalgae	13.90 $\pm$ 3.00	-16.98 $\pm$ 2.17	2	BIOFIL
<i>Scrobicularia plana</i>	15.87 $\pm$ 0.85	-16.13 $\pm$ 1.18	5 (5-25)	INTINV
<i>Hydrobia ulvae</i>	15.26 $\pm$ 0.54	-13.15 $\pm$ 0.36	6 (>25)	INTINV
<i>Hediste diversicolor</i>	15.70 $\pm$ 1.21	-13.44 $\pm$ 1.32	6(4-10)	INTINV
Chironomidae	9.51 $\pm$ 1.33	-17.73 $\pm$ 0.29	3(>20)	SALINV
Sidi-Moussa, Morocco				
SOM	6.36	-22.42	1	BIOFIL
Microalgae	7.40	-19.14	1	BIOFIL
<i>Scrobicularia plana</i>	7.91 $\pm$ 0.28	-15.59 $\pm$ 0.75	3 (5-10)	INTINV
<i>Hydrobia ulvae</i>	11.79 $\pm$ 0.65	-16.71 $\pm$ 0.27	3(>25)	INTINV
<i>Hediste diversicolor</i>	12.20 $\pm$ 1.35	-16.98 $\pm$ 1.17	4(4-10)	INTINV
Chironomidae	4.39 $\pm$ 0.16	-18.96 $\pm$ 0.12	3(>20)	SALINV
<i>Zostera noltii</i>	4.90	-6.52	1(10)	SEARHI
Banc d'Arguin, Mauritania				
SOM	4.39	-17.89	1	BIOFIL
Microalgae	5.68	-20.83	1	BIOFIL
<i>Dosinia isocardia</i>	7.07 $\pm$ 0.47	-17.06 $\pm$ 0.56	4(10-20)	INTINV
<i>Hydrobia ulvae</i>	5.00 $\pm$ 0.35	-11.75 $\pm$ 0.40	3(>50)	INTINV
<i>Ideotea chelipes</i>	4.97 $\pm$ 0.41	-8.17 $\pm$ 0.18	2(5-10)	INTINV
<i>Nereis</i> sp.	9.24 $\pm$ 4.38	-13.53 $\pm$ 4.84	3(7-20)	INTINV
<i>Glycera</i> sp.	11.16 $\pm$ 3.62	-12.50 $\pm$ 3.08	3(2-5)	INTINV
<i>Loripes lucinalis</i>	1.05 $\pm$ 0.81	-25.00 $\pm$ 0.48	9(10-20)	SYMCHE
<i>Zostera noltii</i>	0.82 $\pm$ 0.72	-8.15 $\pm$ 2.17	2(10)	SEARHI
Bijagós archipelago, Guinea-Bissau				
SOM	6.52 $\pm$ 1.19	-19.04 $\pm$ 0.97	2	BIOFIL
Microalgae	9.89	-16.69	1	BIOFIL
<i>Dosinia isocardia</i>	9.22 $\pm$ 0.41	-16.91 $\pm$ 0.45	3(5-10)	INTINV
<i>Tagelus adansonii</i>	9.29 $\pm$ 0.11	-15.90 $\pm$ 0.22	3(5-10)	INTINV
<i>Uca tangeri</i>	6.23 $\pm$ 0.29	-12.86 $\pm$ 0.42	3(2-5)	INTINV
Eunicidae	9.85 $\pm$ 0.39	-12.07 $\pm$ 0.62	2(2-5)	INTINV
<i>Glycera</i> sp.	10.23 $\pm$ 0.77	-16.72 $\pm$ 1.36	2(2-5)	INTINV
Lucinidae	-0.45 $\pm$ 0.22	-25.30 $\pm$ 0.34	3(5-10)	SYMCHE

Table S2: $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values (mean $\pm$ SD) measured in nail samples of shorebird species in the four study areas: Tejo estuary, Sidi-Moussa, Banc d'Arguin and Bijagós archipelago. n = number of individuals.

	$\delta^{15}\text{N}$ (‰)	$\delta^{13}\text{C}$ (‰)	n
Tejo estuary, Portugal			
<i>Arenaria interpres</i>	19.33 $\pm$ 1.42	-14.83 $\pm$ 0.94	10
<i>Calidris alba</i>	19.94 $\pm$ 0.32	-15.85 $\pm$ 0.32	7
<i>Calidris alpina</i>	17.29 $\pm$ 2.41	-15.73 $\pm$ 1.88	41
<i>Calidris canutus</i>	15.02 $\pm$ 2.03	-16.21 $\pm$ 1.74	17
<i>Calidris minuta</i>	14.43 $\pm$ 1.76	-16.54 $\pm$ 1.36	5
<i>Charadrius hiaticula</i>	18.61 $\pm$ 1.15	-15.12 $\pm$ 0.79	15
<i>Limosa limosa</i>	14.90 $\pm$ 3.21	-15.43 $\pm$ 1.65	10
<i>Pluvialis squatarola</i>	18.70 $\pm$ 1.39	-14.30 $\pm$ 0.88	10
<i>Tringa totanus</i>	19.41 $\pm$ 1.13	-15.10 $\pm$ 0.95	16
Sidi-Moussa, Morocco			
<i>Calidris alba</i>	11.65 $\pm$ 0.90	-17.07 $\pm$ 0.92	10
<i>Calidris alpina</i>	11.66 $\pm$ 1.58	-13.79 $\pm$ 1.07	14
<i>Calidris minuta</i>	10.26 $\pm$ 1.37	-18.56 $\pm$ 1.63	10
<i>Charadrius hiaticula</i>	11.58 $\pm$ 1.03	-17.58 $\pm$ 2.78	10
<i>Pluvialis squatarola</i>	10.95 $\pm$ 2.10	-17.56 $\pm$ 2.08	6
<i>Tringa totanus</i>	9.91 $\pm$ 0.60	-16.64 $\pm$ 1.85	16
Banc d'Arguin, Mauritania			
<i>Arenaria interpres</i>	10.26 $\pm$ 0.66	-8.91 $\pm$ 1.85	15
<i>Calidris alba</i>	9.57 $\pm$ 0.58	-8.52 $\pm$ 0.97	15
<i>Calidris alpina</i>	9.41 $\pm$ 0.63	-7.96 $\pm$ 0.77	13
<i>Calidris canutus</i>	8.92 $\pm$ 1.18	-12.95 $\pm$ 3.26	10
<i>Calidris ferruginea</i>	8.93 $\pm$ 0.54	-8.94 $\pm$ 0.83	10
<i>Calidris minuta</i>	6.09 $\pm$ 0.46	-6.05 $\pm$ 0.99	6
<i>Charadrius hiaticula</i>	8.88 $\pm$ 0.33	-8.96 $\pm$ 0.63	10
<i>Pluvialis squatarola</i>	10.39 $\pm$ 0.56	-10.81 $\pm$ 0.49	5
<i>Tringa totanus</i>	9.16 $\pm$ 0.95	-8.53 $\pm$ 1.78	10
Bijagós archipelago, Guinea-Bissau			
<i>Arenaria interpres</i>	15.25 $\pm$ 0.63	-12.79 $\pm$ 0.79	8
<i>Calidris alba</i>	13.81 $\pm$ 0.90	-11.68 $\pm$ 0.77	10
<i>Calidris canutus</i>	13.15 $\pm$ 1.02	-12.80 $\pm$ 1.47	15
<i>Calidris ferruginea</i>	12.57 $\pm$ 0.80	-11.20 $\pm$ 1.03	5
<i>Charadrius hiaticula</i>	11.49 $\pm$ 1.49	-12.80 $\pm$ 1.37	16
<i>Limosa lapponica</i>	14.56 $\pm$ 1.44	-12.21 $\pm$ 0.47	7
<i>Pluvialis squatarola</i>	11.91 $\pm$ 1.15	-11.89 $\pm$ 1.47	8
<i>Tringa totanus</i>	14.11 $\pm$ 0.90	-11.35 $\pm$ 1.11	10

Table S3: Diet composition (proportion contribution of food sources in the diet) of shorebirds at the four study areas as estimated by stable isotope mixing models. In each case we present the median and the 0.025 and 0.975 quantiles of the stable isotope mixing models results. INTINV: intertidal invertebrates, SALINV: saltpan invertebrates, SYMCHE: intertidal bivalves with symbiotic chemoautotrophic bacteria, BIOFIL: biofilm, SEARHI: seagrass rhizomes.

	Percentage of diet				
	INTINV	SALINV	SYMCHE	BIOFIL	SEARHI
Tejo estuary, Portugal					
<i>Arenaria interpres</i>	89.3 (68.6-98.7)	1.0 (-0.2-21.1)		0.8 (-0.1-12.9)	
<i>Calidris alba</i>	92.2 (68.3-98.6)	1.1 (-0.3-22.7)		1.8 (-0.7-18.5)	
<i>Calidris alpina</i>	74.2 (64.3-84.1)	14.5 (0.7-32.3)		11.2 (2.2-22.1)	
<i>Calidris canutus</i>	23.2 (8.5-39.1)	59.2 (34.0-84.5)		17.6 (-0.7-31.6)	
<i>Calidris minuta</i>	34.4 (12.5-52.3)	30.4 (9.5-56.0)		42.3 (15.6-64.3)	
<i>Charadrius hiaticula</i>	85.9 (73.6-95.0)	4.2 (-0.8-19.1)		0.4 (-0.2-15.5)	
<i>Limosa limosa</i>	48.1 (27.4-65.8)	36.9 (8.7-59.9)		3.3 (-1.1-27.2)	
<i>Pluvialis squatarola</i>	87.2 (74.0-97.3)	3.3 (-0.5-19.5)		1.4 (-0.3-9.4)	
<i>Tringa totanus</i>	93.9 (78.9-99.3)	0.8 (-0.2-14.1)		0.7 (-0.1-12.4)	
Sidi-Moussa, Morocco					
<i>Calidris alba</i>	45.1 (33.3-58.4)	42.5 (24.3-64.2)		2.7 (-0.2-21.2)	9.2 (2.0-16.8)
<i>Calidris alpina</i>	49.5 (31.1-63.5)	29.9 (23.3-36.9)		3.2 (-0.3-21.3)	11.3 (-0.4-26.6)
<i>Calidris minuta</i>	39.6 (20.4-57.1)	13.1 (-1.7-33.9)		40.0 (21.5-63.2)	1.3 (-0.2-11.3)
<i>Charadrius hiaticula</i>	52.6 (38.1-65.3)	41.4 (21.3-58.0)		1.5 (-0.5-17.3)	6.7 (-0.1-14.1)
<i>Pluvialis squatarola</i>	64.3 (42.3-87.7)	26.5 (10.5-47.0)		2.6 (-0.5-17.1)	9.1 (-1.2-19.8)
<i>Tringa totanus</i>	33.8 (20.9-45.9)	45.9 (24.0-67.8)		1.2 (-0.8-18.5)	17.3 (6.7-28.4)
Banc d'Arguin, Mauritania					
<i>Arenaria interpres</i>	88.9 (75.7-98.3)		0.2 (-0.4-4.9)	0.8 (-0.1-8.1)	5.7 (0.9-19.1)
<i>Calidris alba</i>	80.4 (65.9-93.7)		0.1 (-0.1-3.9)	0.9 (-0.1-9.2)	15.2 (1.9-30.4)
<i>Calidris alpina</i>	78.7 (61.6-94.8)		0.2 (-0.1-5.5)	0.9 (-0.2-12.5)	16.5 (3.3-33.9)
<i>Calidris canutus</i>	57.1 (39.6-77.6)		26.4 (1.4-46.1)	1.1 (-0.1-14.4)	10.1 (2.9-25.2)
<i>Calidris minuta</i>	58.1 (39.6-79.4)		0.9 (-0.3-9.9)	11.7 (-0.6-29.4)	28.4 (3.8-50.3)
<i>Calidris ferruginea</i>	76.8 (62.3-91.4)		0.6 (-0.1-5.6)	1.1 (-0.1-8.2)	16.5 (1.7-31.4)
<i>Charadrius hiaticula</i>	81.3 (63.4-99.2)		0.2 (-0.1-5.8)	0.7 (-0.2-7.6)	10.6 (2.1-30.5)
<i>Pluvialis squatarola</i>	81.0 (43.3-99.2)		1.0 (-0.1-3.6)	3.4 (-0.4-12.0)	10.8 (1.2-28.8)
<i>Tringa totanus</i>	81.4 (62.1-97.9)		0.8 (-0.1-8.2)	0.9 (-0.2-15.3)	10.6 (1.9-28.6)

Bijagós archipelago, Guinea-Bissau

<i>Arenaria interpres</i>	94.2 (77.3-100.1)	0.7 (-0.1-5.8)	0.7 (-0.2-10.7)
<i>Calidris alba</i>	95.6 (79.8-99.8)	0.3 (-0.1-4.8)	0.9 (-0.2-15.3)
<i>Calidris canutus</i>	92.7 (77.5-98.9)	0.6 (-0.1-5.6)	5.2 (-1.6-18.4)
<i>Calidris ferruginea</i>	88.8 (61.1-98.9)	1.0 (-0.1-8.3)	3.8 (-1.5-25.3)
<i>Charadrius hiaticula</i>	89.2 (65.4-99.6)	4.5 (-0.2-11.3)	1.7 (-1.0-20.4)
<i>Limosa lapponica</i>	94.6 (80.0-99.9)	0.3 (-0.1-6.2)	1.0 (-0.2-16.8)
<i>Pluvialis squatarola</i>	85.3 (54.4-96.9)	2.3 (-0.2-12.3)	2.8 (-0.4-29.8)
<i>Tringa totanus</i>	96.2 (81.4-99.8)	0.2 (-0.1-4.4)	1.0 (-0.1-11.5)