Average Mass of Seeds Encountered by Foraging Dabbling Ducks in Western Europe

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SHORT COMMUNICATION

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Average mass of seeds encountered by foraging dabbling ducks in western Europe

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Many dabbling ducks *Anas* spp. are largely granivorous, consuming a variety of seeds chiefly from aquatic plants. To assess the relative value and carrying capacity of wetlands for dabbling ducks, species-specific information about seed mass is needed, but it is still largely missing or scattered in the literature. By combining weights of seeds collected in the field with a literature review, we provide a reference table for seed mass of 200 western European plant taxa frequently encountered by foraging dabbling ducks. Seeds collected in the field were sampled in microhabitats and at depths at which ducks were observed to forage, and study sites represent wintering, staging as well as breeding areas within a flyway in western Europe. When combined with calorimetric data, the present reference table will aid managers and scientists in assessing the importance of seed food resources at different sites and during different parts of the annual cycle.

Key words: core sample, dabbling ducks, seed mass, waterfowl, wetland

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Many species of dabbling ducks *Anas* spp. are largely granivorous in fall and winter, and partly so in spring and summer (e.g. Cramp & Simmons 1977, Glutz von Blotzheim 1990, Del Hoyo et al. 1992). Throughout a waterfowl flyway, the relative value and the carrying capacity of wetlands may thus largely depend on the seed stock available at different sites. However, no studies have so far provided comprehensive information about the amount of energy available to seed-eating ducks. Most likely this is due to the problems of comparing different types of data. Wetland seed stocks are generally expressed as number per area unit (Grillas et al. 1993, Bonis & Lepart 1994, Thompson et al. 1997), though a few studies provide information about the actual mass of seeds per area (e.g. Tamisier 1971a, Baldassarre & Bolen 1984, Clark et al. 1986). In studies of duck diet, however, abundance of seeds in the digestive tract is expressed as either aggregate % volume, aggregate % dry weight or as frequency of occurrence (e.g. Olney 1963, Olney 1964, Tamisier 1971b, Danell & Sjöberg 1980, Pehrsson 1979, Thomas 1982, Schricke 1983, Miller 1987). Sampling also causes problems; even in large seed samples, some plant species turn out to be fairly rare, resulting in a sample size too small to calculate a reliable mean mass for the plant species in question. In effect, it is far easier and more time efficient to count seeds visually in mud samples under a microscope in the laboratory than to collect seeds in the field individually with pliers for subsequent weighing.

Thus, a serious shortcoming of expressing food abundance as the number of seeds per area unit is that this information cannot be directly translated into a measure of energy available to foraging ducks (expressed in kcal or kJ per mass unit dry weight; e.g. Sugden 1973, Paulus 1982, Baldassarre & Bolen 1984, Hoffman & Bookhout 1985, Van Eerden & Munsterman 1997). Knowing species-specific seed mass is thus crucial to bridge the gap between the present data sets, but such information is largely unavailable for European species or, if existing, is scattered in the literature. The aim of our paper is to fill this gap by providing a reference table of average mass of natural wetland seeds and crops potentially ingested by dabbling ducks in western Europe. We both present primary data and provide a compilation of values found in the literature.

Study area and methods

We sampled seeds in France and Sweden as integrated parts of research projects addressing feeding ecology, time use and microhabitat use of dabbling ducks (Schricke 1983, Guillemain et al. 2002, Legagneux 2002, Arzel et al. 2003). The French samples were obtained from five distinct geographical areas: the Camargue, close to Arles on the Mediterranean coast (43°40'N, 4°37'E), during October 2003 - July 2004, in October 2004 and in February 2005; the Brenne area, close to Mézières en Brenne (46°49'N, 1°12'E), during August - September 2002 and 2003; the Baie de Seine, close to Le Havre (49°29'N, 0°07'E), in February and March 2003 and 2004; the Baie du Mont Saint Michel

(48°38'N, 1°30'W) during August - September 1980-1982; the Marais de Rochefort (45°53'N, 01°05'W) during October 1996 - March 1997, in October 1999 and in August 2004. The Swedish samples were collected from three distinct geographical areas: on the island of Öland in the Baltic Sea (56°42'N, 16°42'E) in April 2003; in the vicinity of Kristianstad in the very south of Sweden (56°01'N, 14°09'E) in April 2003 and 2004; and near Umeå in north-central Sweden (63°49'N, 20°16'E) during May - July in 2003 and 2004. Sampled habitats included temporary wetlands, coastal meadows, coastal lagoons, fluvial meadows and lakes ranging from eutrophic to oligotrophic. As part of more extensive research programmes, the foraging behaviour of dabbling ducks was studied regularly at most sites as part of the daily routine before we sampled food resources. Therefore, samples were generally taken in macro- and microhabitats where dabbling ducks were actually seen foraging, or where faeces, footprints and feathers indicated recent foraging activity. In this way, we ensured that samples were representative of seeds encountered by foraging dabbling ducks. Although we did not strive to include every occurring seed-producing plant species, we assumed that the long sampling periods, the wide geographical coverage and the variety of habitats included provided a very good representation of important forage seeds available to ducks at wintering, spring staging and breeding sites within this flyway.

Core sample volume varied among sites (within 63-407 cm^3) as did the number of samples (10-30/site/sampling day), but as we did not intend to analyse seed abundance, we do not consider these methodological differences a problem. Seeds in the Baie du Mont Saint Michel, in the Brenne area and in western France in August 2004 were hand-picked directly from plants instead of core-sampled. Seeds were hand-sorted under a binocular microscope after the cores of plant litter and sediment had been sieved. Sieve mesh size was 300 μm; hence, all seeds down to this size were considered as long as they were not empty or otherwise obviously unviable. Indeed, the minimum size of food items that a duck can effectively capture is determined by the spaces between the bill lamellae, ranging from 0.3 mm in teal *Anas crecca* and northern shoveler *Anas clypeata* to 1 mm in mallard *Anas platyrhynchos*, with all other European dabbling duck species falling between these values (Thomas 1982, Nudds & Bowlby 1984, Tolkamp 1993). We used Beijerinck (1947), Berggren (1969, 1981), Anderberg (1994) and the internet resources http://www.bioimages.org.uk/ and http://www.dijon.inra.fr/malherbo/hyppa/hyppa-f/hyppa_f.htm to identify seeds. We also used the nomenclature adopted by these sources. We oven-dried seeds at 60°C until desiccation, i.e. for at least 24 hours (Thomas 1982). In cases where seeds of the same plant species were collected at more than one location (e.g. by Matthieu Guillemain in Camargue, Pierre Legagneux in Brenne and Céline Arzel in Sweden), average seed mass was calculated based on the total sample (i.e. samples from different sites were pooled).

Results and discussion

We provide data on average seed mass of 200 taxa (of which 168 were identified to species and 32 to genus) belonging to 43 families (Table 1). *Chara* oogons were included because they sometimes constitute a large share of the diet of granivorous dabbling ducks (Tamisier 1971a, Campredon et al. 1982). Seed mass differed markedly among species, ranging from 0.0077 mg in whorled leaf water milfoil *Myriophyllum verticillatum* to 21.90 mg in caley pea *Lathyrus hirsutus* (disregarding acorns and heavy seeds from agricultural plants such as maize *Zea mays* and barley *Hordeum vulgare*).

The sample size of some species is rather small (e.g. < 5 seeds in annual seablite *Suaeda maritima*, grey sedge *Carex divulsa*, field bindweed *Convolvulus arvensis* and water mannagrass *Glyceria fluitans*), but considering the very small amount of data available elsewhere, the information provided here still makes a valuable contribution. Intraspecific variation in seed mass can be substantial (Susko & Lovett-Doust 2000), and mass data based on small sample sizes must be used with caution. We hope to see future additions to our present reference table, especially more data for species from which limited samples were obtained, and studies addressing intraspecific spatio-temporal variation in seed size are needed.

All seeds treated here were collected in duck foraging habitats, and some of the plant species indeed form the bulk of the diet of dabbling ducks in western Europe, at least seasonally (e.g. Mazzuchi 1971, Tamisier 1971a, Pehrsson 1979). To truly understand the importance of seeds as food for dabbling ducks, information about the energy content of representative species is also needed. Calorimetric data are available for some species (e.g. Hoffman &

Bookhout 1985, Joyner et al. 1987, Loesch & Kaminski 1989) and are being developed for others (P. Legagneux, unpubl. data). Combined with calorimetric data, our present reference table will make up a helpful tool for managers and scientists in assessing the relative value of foraging sites and estimating the carrying capacity of natural wetlands.

Table 1. Average mass of plant seeds collected in France and Sweden, supplied by available values from literature. N denotes the number of seeds weighed in the present study, and all values are given in mg dry weight. The literature from which data were available include: [a] Grime et al. 1988, [b] Tamisier 1971a, [c] Grillas et al. 1993, [d] Van Eerden & Munsterman 1997, [e] Campredon et al. 1982, [f] Kantrud 1996, [g] Van Wijk 1988 (average value for *P. pectinatus* was computed from this source), [h] Rhazi et al. 2004, and [i] Maranon & Grubb 1993.

Family	Species	N	Seed mass	Literature
Alismacea	*Alisma plantago-aquatica*	157	0.296	0.270[a], 0.210[b]
	Baldelia ranunculoides	62	0.177	
Apiacea	*Cicuta virosa*	35	0.691	
	Conium maculatum	3	0.400	
	Oenanthe fistulosa	9	0.511	
	Oenanthe sp.	1	16.200	
Aracea	*Calla palustris*	16	1.513	
Asteracea	*Bidens tripartitus*	22	1.491	
	Bidens sp.	25	0.576	
	Cirsium arvense			1.170[a]
	C. palustre			2.000[a]
	C. vulgare			2.640[a]
	Cirsium sp.	4	1.125	
	Gnaphalium uliginosum	195	0.011	
	Senecio jacobea			0.050[a]
	Senecio sp.			0.400[b]
	Taraxacum officinalis	20	0.545	
	Taraxacum sp.			0.640[a]
Betulacea	*Alnus glutinosa*	30	0.610	1.300[a]
	Betula alba	100	0.117	
	B. pendula	100	0.117	
	Betula sp.			0.120[a]
Brassicacea	*Brassica napus*	2376	3.623	
	Brassica sp.	50	1.332	
	Rorippa amphibia	16	0.038	
	R. palustris	47	0.659	0.070[a]
	Rorippa sp.	13	0.062	
Callitrichacea	*Callitriche palustris*	234	0.059	
	C. platycarpa	58	0.031	
	C. truncata			0,065[c]
	C. vulgaris		0.090	
	Callitriche sp.	45	0.082	
Caprifoliacea	*Sambucus nigra*	6	2.250	3.400[a]
Caryophyllacea	*Cerastium fontanum*		0.160	
	Lychnis flos-cuculi	35	0.070	
	Spergula arvensis	49	0.040	
	Spergularia marina	614	0.054	
	S. maritime			0.087[d]
	S. media	23	0.074	
	S. salina			0.053[d]
Ceratophyllaceae	*Ceratophyllum demersum*	4	9.050	
	Ceratophyllum sp.	10	9.350	
Characeae	*Chara* (small)			0.030[e]
	Chara (medium size)	626	0.137	0.150[d]
	Chara (Öland, Sweden)	511	0.010	
	Chara (Donaña, Spain)			0.025[c]

Table 1; continued...

Family	Species	N	Seed mass	Literature
Chenopodiacea	*Arthrocnemum glaucum*			0.200[b]
	Atriplex hastata	605	0.499	0.860[a]; 0.390[b]
	A. hortensis	300	2.156	
	Atriplex sp.	2569	0.574	
	Chenopodium album	67	0.525	1.350[a]
	C. glaucum	630	0.126	
	C. polyspermum			
	C. rubrum	12	0.142	
	Chenopodium sp.	129	0.238	
	Obione portulacoides			0.300[b]
	Salicornia dolichostachya			0.161[d]
	S. fructicosa			2.800[b]
	S. herbacea			0.050[b]
	Sarcocornia sp.	250	0.139	
	Suaeda fructicosa			0.330[b]
	S. maritime	1	0.8000	0.285[b]; 1.415[d]
Convolvulacea	*Convolvulus arvensis*	3	2.267	
Cyperacea	*Carex acuta*	15	0.993	
	C. bohemica	7	0.443	
	C. canescens	43	0.286	
	C. disticha	87	0.403	
	C. divulsa	1	1.200	
	C. elata	21	0.767	
	C. extensa	11	1.991	
	C. hirta	9	1.322	
	C. limosa	74	1.391	
	C. otrubae	64	0.586	
	C. pallescens	25	0.852	
	C. panicea	4	0.775	
	C. pseudocyperus	120	0.510	
	C. riparia	47	1.166	
	C. rostrata	600	0.746	
	C. serotina	121	0.042	
	C. vesicaria	13	1.508	
	C. vulpina	1	0.250	
	Carex sp.	17	1.171	
	Cladium mariscus	30	1.327	
	Cyperus sp.			0.006[b]
	Eleocharis acicularis	100	0.041	
	E. palustris	1114	0.568	0.960[a]; 0.540[b]
	E. uniglumis	494	0.453	
	Scirpus lacustris	905	1.601	1.660[b]; 1.191[d]
	S. litoralis			0.740[b]
	S. maritimus	412	3.293	2.350[b], 5.600[f]
	S. mucronatus			1.000[b]
	S. tabernaemontani	434	0.298	
	Scirpus sp.	14	1.029	
Fabacea	*Lathyrus hirsutus*	5	21.900	
	Lotus corniculatus	8	1.138	1.670[a]
	L. uliginosus	21	0.552	0.400[a]
	Medicago lupulina	5	1.740	2.010[a]
	Trifolium arvense	27	0.333	
	T. pratense	110	1.419	1.350[a]
	T. repens	1026	0.503	
	Trifolium sp.	153	0.376	
	Vicia cracca			14.290[a]

Table 1; continued...

Family	Species	N	Seed mass	Literature
Fagacea	*Quercus* sp.	33	3323.291	
Haloragaceae	*Myriophyllum alternifolius*			0,492[c]
	M. spicatum	167	0.747	
	M. verticillatum	13	0.008	
	Myriophyllum sp.			0.970[b]
Hippuridacea	*Hippuris vulgaris*	51	0.478	
Iridacea	*Iris pseudacorus*	1	17.300	
Isoetacea	*Isoetes setacea*			0.098[h]
Juncacea	*J. bufonius*	1000	0.021	0.020[a]
	J. bulbosus		0.022	0.030[a]
	J. compressus	665	0.022	
	J. effusus			0.011[d]
	J. gerardii	15	0.035	
	Juncus sp.	4624	0.025	
Lamiacea	*Prunella vulgaris*	13	0.215	
	Lycopus europaeus	16	0.161	
	Mentha aquatica	18	0.094	0.140[a]
Lemnacea	*Lemna minor*	4	0.200	0.600[a]
Lythraceae	*Lythrum salicaria*	4	0.063	
	Peplis portula	408	0.016	
Menyanthacea	*Menyanthes trifoliata*	7	1.771	
Naiadacea	*Naias marina*	3260	7.790	
Nympheacea	*Nymphea alba*	57	12.528	
Oenotheracea	*Epilobium hirsutum*	68	0.062	0.050[a]
	E. palustre	33	0.118	0.040[a]
	E. parviflorum			0.110[a]
	Epilobium sp.	23	0.057	
Plantaginaceae	*Plantago lanceolata*	102	1.879	
	P. major	185	0.154	0.240[a]
Poacea	*Agrostis stolonifera*	17	0.277	
	Alopecurus geniculatus	10	0.120	0.380[a]
	Alopecurus sp.	5	0.140	
	Avena barbata			2,630[i]
	Baldingera arundinacea	2	0.330	
	Bromus hordaceus			0.910[i]
	Bromus sp.	205	2.519	
	Crypsis aculeata	100	0.371	
	Cynosorus cristatus			0.700[a]
	Echinochloa crus-galli	13,240	1.446	
	Glyceria fluitans	3	0.500	1.200[a]
	G. maxima			0.740[a]
	Glyceria sp.	303	2.424	
	Hordeum vulgare	91	38.7835	
	Leerzia oryzoides	60	0.885	
	Milium sp.	229	3.735	
	Oryza sativa			15.000[b]
	Panicum crus-galli			4.000[b]
	Paspalum distichum			0.470[b]
	Poaceae sp.	37	0.063	
	Triticum vulgare	2138	32.916	
	Zea mays	89	250.590	

Table 1; continued...

Family	Species	N	Seed mass	Literature
Polygonacea	*Polygonum amphibium*	44	2.389	
	P. aviculare	388	1.332	1.450[a]
	P. hydropiper	83	1.474	
	P. lapathifolium	2326	1.103	
	P. minus	40	0.798	
	P. persicaria	721	1.135	2.120[a]
	Rumex acetosa	10	0.670	
	R. conglomeratus	517	0.740	
	R. crispus	5	0.680	1.330[a]
	R. hydrolapathum	14	1.971	
	R. maritimus	170	0.154	0.517[d]
	R. palustris	50	0.718	
Potamogetonacea	*Potamogeton berchtoldi*			0.650[b]
	P. gramineus	262	2.446	
	P. natans	1052	2.316	
	P. nodosus	18	2.706	
	P. obtusifolius	86	2.594	
	P. pectinatus	66	3.199	3.870[b], 4.624[g]
	Potamogeton sp.	5	2.100	
Primulacea	*Anagallis arvensis*	43	0.147	0.400[a]
	Lysimachia vulgaris	70	0.164	
Ranunculacea	*Ranunculus baudotii*			0.178[c]
	R. flammula	30	0.550	0.370[a]
	R. peltatus	19	0.247	0.250[a]
	R. repens	6	2.550	2.320[a]
	R. sardous	162	1.112	
	R. sceleratus	142	0.241	
	R. trichophyllus	878	0.301	
	Ranunculus sp.	100	0.171	0.120[b]
Rosacea	*Filipendula ulmaria*			0.990[a]
	Potentilla anserina	3	0.433	
	P. palustris	253	0.440	
	Potentilla sp.	131	0.049	
	Rubus fructicosus			2.490[a]
	Rubus sp.	1253	2.115	
Rubiacea	*Galium palustre*	52	0.462	0.910[a]
Ruppiacea	*Ruppia cirrhosa*	47	0.181	
	R. maritima	273	1.556	2.000[b]
Salsolacea	*Kochia hirsuta*			0.410[b]
Scrophulariacea	*Veronica anagallis-*	18	0.033	
Sparganiacea	*Sparganium angustifolium*	92	8.128	
	S. emersum	9	2.111	
	Sparganium sp.	225	2.309	
Urticacea	*Urtica dioica*	79	0.118	0.190[a]
Vitacea	*Vitis vinifera*	26	15.804	
Zanichelliacea	*Zanichellia palustris*	156	0.279	130[e]
	Zanichellia sp.			0.130[b], 0.146[c]

Another step in assessing the carrying capacity of a wetland is to define the true metabolisable energy (TME) of different food items (Sherfy 1999). This is because the digestibility may differ between seeds from different species, and calorimetric data may not always reflect what birds can actually metabolise (Sherfy 1999). Although TME values are essential in the end, individual seed mass remains useful for calculating and predicting TME (Sibbald 1980, Sherfy 1999).

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