Diet and Feeding Habitats of Camargue Dabbling Ducks: What Has Changed since the 1960s?

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Abstract.—In the Camargue (southern France), drastic changes in wetlands have occurred (notably extension of agriculture and salt extraction) since the 1960s, which affect the resources available to migratory waterbirds. Winter diets of Mallard (Anas platyrhynchos) and Teal (A. crecca) in 2006-2008 were assessed by analyses of gullet contents. Using PCA-based methods, duck diets were described and the main feeding habitats used by each duck species were then determined with a typology analysis. The same four food items were most important (in terms of occurrence and average dry weight) in the diet of Mallard and Teal: Oryza sativa (rice), Echinochloa sp., Scirpus maritimus and Potamogeton pusillus seeds. However, Teal diet was more diversified, with eleven feeding habitat types, compared to only five in Mallard. Both species were found to be dependent on ricefields and ricefield-like habitats. Compared to previous studies in the same area between 1964 and 1981, permanent freshwater habitats now appear to be used more intensively by Mallard and Teal, while temporary marshes are used to a lesser extent. Since the 1960s, temporary marshes have been partially replaced by permanent freshwater in order to attract more ducks, mostly for hunting. The flexibility of duck diet in response to changing food availability may explain why duck populations have not decreased in the Camargue or in Europe despite changes in land use.

Key words.—Diet comparison, feeding habitat, habitat use, land use, Mallard, Teal.
management has involved dividing marshes into smaller units and inputs of freshwater, resulting in a decrease in water salinity and a lengthening of flooding duration (Tamisier and Grillas 1994). Increased area and permanence of marshes led to increases in biomass and changes in species composition of aquatic vegetation (Aznar et al. 2003), making the Camargue more attractive to waterbirds, despite changes in water management having a negative impact on the diversity of plants and invertebrates (Tamisier and Grillas 1994).

A better understanding of the relationship between ducks and their habitat will facilitate wetland management and allow prediction of the effects of future global change (Perry et al. 2007). In this study, we identified the current diet of the two most common wintering dabbling ducks in the Camargue, Mallard (Anas platyrhynchos) and Common Teal (A. crecca, hereafter Teal), by analyzing gullet contents. Owing to their nocturnal foraging, it was not practical to determine habitat use by direct monitoring of duck distribution over the Camargue. Therefore, we used the gullet contents to identify the feeding habitat types used by the ducks. Finally, we compared current diet descriptions with previous studies in 1979-81 (hereafter c.1980) for Mallard and in 1964-66 (hereafter c.1965) for Teal (Pirot 1981 and Tamisier 1971, respectively). The aim of this comparison was to assess how land use change in the Camargue has resulted in changes in the diet of these two species.

**Methods**

**Study Area and Species**

The Camargue encompasses approximately 145,000 ha, with 60,000 ha of natural wetlands and 85,000 ha of artificial habitats (Tamisier 1990). The surface area of the main types of habitats in the Camargue has changed since the 1940s, with expansion of salt pans, agricultural areas and industrial/urban areas at the expense of natural wetlands. Rice (Oriza sativa) is the primary crop of the Camargue. Protected areas represent 14% of the whole Camargue and 24% of the wetland area, salt pans included (Tamisier and Dehorter 1999). Hunting is permitted in all other wetland areas. Tens of thousands of Mallard and Teal winter in the Camargue from August to March (annual peak counts ranging from 30,000 to 60,000 for each of the two species; Kayser et al. 2008). These species represent 20 to 30% of the total Camargue wintering duck population (Tamisier and Dehorter 1999). Because they are highly regarded as game, these ducks are among the principal drivers of wetland management for private hunting estates and nature reserves.

**Sample Collection and Analysis**

To avoid food items being subjected to physical breakdown in the gizzard, diet was inferred only from the contents of the esophagus and proventriculus (hereafter ‘gullet’), as recommended by Swanson and Bartonek (1970).

Mallard and Teal gullets were collected from hunters at eight sites (Fig. 1) during the hunting seasons 2006-7 and 2007-8 (Table 1). Most ducks were shot in the early morning, when flying out of wetland feeding sites towards roosting sites, so that their gullet would likely contain food items consumed during the night (Tamisier and Dehorter 1999). In most cases (86%), the gullet was removed 1-7 h after the duck was shot (the remaining 13% were removed the day after, with the duck kept in the fridge meanwhile). Gullet samples were then frozen in a plastic bag until examination. After excluding those empty of food items (57 Mallard and 60 Teal gullets), a total of 119 Mallard and 302 Teal gullets were analysed in the laboratory, where samples were washed through a 63-μm sieve. The retained material was sorted under a binocular microscope. The content of each gullet was separated into invertebrates, ‘seeds’ (i.e. achenes, oogonia and proper seeds) and plant vegetative parts. As the latter represented less than 0.2% of the average relative dry weight of the gullet contents in both duck species (Table 2), they were discarded from the statistical analyses. Invertebrates were identified using Tachet et al. (2000) or local specialists, to the family level in most cases. Seeds were mostly identified to genus or species using Campredon et al. (1982), Cappers et al. (2006), and a local reference collection. Invertebrates and seeds (hereafter “food items”) in small numbers were counted individually, whereas the number of abundant food items was esti-

**Figure 1.** The Camargue showing the eight collection sites for gullet samples (black symbols) and the five main protected areas.
Table 1. Number of gullet samples collected each month during the winters 2006-07 and 2007-08 for Mallard and Teal. Empty gullets are excluded.

<table>
<thead>
<tr>
<th></th>
<th>Mallard 2006-07</th>
<th>Mallard 2007-08</th>
<th>Teal 2006-07</th>
<th>Teal 2007-08</th>
</tr>
</thead>
<tbody>
<tr>
<td>September</td>
<td>6</td>
<td>35</td>
<td>17</td>
<td>41</td>
</tr>
<tr>
<td>October</td>
<td>12</td>
<td>16</td>
<td>32</td>
<td>30</td>
</tr>
<tr>
<td>November</td>
<td>8</td>
<td>8</td>
<td>34</td>
<td>13</td>
</tr>
<tr>
<td>December</td>
<td>10</td>
<td>11</td>
<td>24</td>
<td>41</td>
</tr>
<tr>
<td>January</td>
<td>7</td>
<td>6</td>
<td>34</td>
<td>36</td>
</tr>
<tr>
<td>TOTAL</td>
<td>43</td>
<td>76</td>
<td>141</td>
<td>161</td>
</tr>
</tbody>
</table>

Table 2. Average relative dry weight (Rw) expressed in percentage of the main food types (invertebrates, seeds and vegetative parts of plants) and main food items according to %PCA diet analysis (see Methods: ‘PCA-based analyses’ section and Results), for both Mallard (n = 119) and Teal (n = 302).

<table>
<thead>
<tr>
<th>Food item</th>
<th>Mallard</th>
<th>Teal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Invertebrates</td>
<td>6.2</td>
<td>15.6</td>
</tr>
<tr>
<td>Seeds</td>
<td>93.7</td>
<td>84.3</td>
</tr>
<tr>
<td>Oryza sativa</td>
<td>35.1</td>
<td>8.5</td>
</tr>
<tr>
<td>Echinoheloa sp.</td>
<td>22.2</td>
<td>14.0</td>
</tr>
<tr>
<td>Scirpus maritimus</td>
<td>5.8</td>
<td>17.3</td>
</tr>
<tr>
<td>Potamogeton pusillus</td>
<td>7.2</td>
<td>7.9</td>
</tr>
<tr>
<td>Potamogeton nodosus</td>
<td>4.1</td>
<td>—</td>
</tr>
<tr>
<td>Triticum aestivum</td>
<td>5.4</td>
<td>—</td>
</tr>
<tr>
<td>Chara spp.</td>
<td>—</td>
<td>6.0</td>
</tr>
<tr>
<td>Staurastrum sp.</td>
<td>—</td>
<td>3.6</td>
</tr>
<tr>
<td>Vegetative parts</td>
<td>&lt;0.1</td>
<td>0.2</td>
</tr>
</tbody>
</table>

We assumed that the hunting of ducks in Camargue is equivalent to random sampling in a large population. Data were presented as two distinct matrices in each species for the number and the dry weight of each food item type, respectively. Let O = [o_{ij}] be the n × m matrix for one duck species with o_{ij} the number of occurrences of the jth food item (columns, 1 ≤ j ≤ m, with m the total number of food items) in the ith gullet (rows, 1 ≤ i ≤ n) and W = [w_{ij}] the n × m matrix for one duck species with w_{ij} the dry weight of the jth food item (columns, 1 ≤ j ≤ m) in the ith gullet (rows, 1 ≤ i ≤ n). Two statistics were used to summarize the contribution of food items to the diet of each duck species: (i) R_0 the relative frequency of occurrence of the jth food item (1 ≤ j ≤ m) in gullets, \( (R_0 = n^{-1} \sum_{i=1}^{n} o_{ij}) \) i.e. the mean number of occurrences of the jth food item among gullets, expressed as percentage (see Table S1); (ii) Rw the average relative dry weight of the jth food item (1 ≤ j ≤ m) among gullets \( (Rw = n^{-1} \sum_{i=1}^{n} p_{ij} w_{ij}) \) with \( p_{ij} = w_{ij} / \sum_{j=1}^{m} w_{ij} \), i.e. calculated by dividing the dry weight of each food item in each gullet by the total dry weight of all food items in the same gullet, then taking the average over all individuals, expressed as percentage (see Table S1 and S2).

**PCA-based analyses**

Let P = [p_{ij}] be the n × m matrix of row profiles for one duck species with \( p_{ij} = w_{ij} / \sum_{j=1}^{m} w_{ij} \) the proportion (0 ≤ p_{ij} ≤ 1) of the jth food item (columns, 1 ≤ j ≤ m) in the ith gullet (rows, 1 ≤ i ≤ n). For both duck species, the matrices P were analyzed by performing a column-centered principal component analysis (%PCA, sensu de Crespin de Billy et al. 2000). We analyzed diet composition by examining the first two principal components of the column-centered PCA on distance biplots (see Storms et al. 2008 for details). Specific interpretation rules arise from the compositional nature of the P matrix (see de Crespin de Billy et al. 2000; Storms et al. 2008).

We performed separate %PCAs for Mallard and Teal. We tested for a winter (i.e. year) effect on diet composition using a between-class %PCA and its associated randomization test (see Storms et al. 2008 for details), and found no biologically relevant effect for Mallard (between-class inertia to total inertia ratio \( R = 0.0073, P = 0.5 \)) nor for Teal (\( R = 0.0068, P = 0.022 \)). We therefore decided to pool data from both winters for each duck species for subsequent analyses.

We tested for a seasonal effect (early winter: September and October; late winter: November to January) on diet composition. These two periods correspond to the first two periods (out of three) of the duck “wintering strategy” in the Camargue (restoring, pairing and fattening periods) during which feeding time budgets differ (Tamisier et al. 1995). We found some statistical evidence for a seasonal effect in both species, with comparable effect sizes (\( P = 0.033 \) and 0.000001, \( R = 0.020 \) and 0.025 for Mallard and Teal, respectively). Although the size of the effect was small, we decided to perform separate %PCAs for early and late winter for both species, as feeding times and habitat selection may change between these two periods of the winter (Tamisier et al. 1995), hence potentially influencing duck diet and feeding habitats. Computations and graphical displays were performed using the ‘ade4’ package for R (Chessel et al. 2004).

**Food item typology analysis**

For establishing stable typologies, we had to make the matrices W less sparse (a sparse matrix contains a high proportion of zeros) than they were initially. Hence, in a first step, for each species we derived a n × m matrix \( Z = [z_{ij}] \) from \( W = [w_{ij}] \), where \( z_{ij} = 1 \) if \( w_{ij} > 0 \), and \( z_{ij} = 0 \) otherwise. We sorted the columns (food items) by decreasing order of proportion of 1s (by referring to the total number of 1s in the matrix), and we kept the columns until we reached a cumulative sum of 85%. We thus obtained a n × m’ matrix \( Z' \) (m’ < m). We followed the same procedure for the rows (gullets) of \( Z' \).
for a cumulative sum up to 95%, removing gullets that contained ≤ 1 food item, i.e. 12% and 15% of Mallard and Teal gullets, respectively. Except for four Mallards and two Teal that specialised on one food item (mean seed number per gullets: 142 and 123 for Mallard and Teal respectively), all other gullets contained less than 18 seeds. We obtained an \(n' \times m'\) matrix \(W'\) (\(n'<n, m'<m\)), maintaining about 80% of the values \(w_{ij} > 0\) (81% for Mallard and 82% for Teal) and increasing considerably the filling rate of the matrices (from 2% to 16% for Mallard, and from 5% to 19% for Teal). In a second step, we used hierarchical agglomerative clustering, with chi-squared distance between the column profiles (e.g. Lebart et al. 2000) as the underlying distance function, and the Ward method (e.g. Legendre and Legendre 1998) to determine distances between clusters. In calculating the Ward criterion, we employed its generalized formula (e.g. Lebart et al. 2000), using the weights of the column profiles (i.e. the \(R_w j = \sum w_{ij}\), \(1 \leq j \leq m\)). We obtained a dendrogram for each species, which was truncated (the level of truncation was chosen visually), leading to a partition of the food items into \(k\) clusters (or classes). In a third step, we computed (i) the centroids of the classes (the food items were weighted as previously), (ii) the chi-square distances between the centroids of the classes, and (iii) the chi-square distance between each food item and the centroid of its class (which allows identification of the food items most characteristic of each class). To improve visibility, all the chi-square distances hereafter mentioned were multiplied by 10,000.

Relative importance of the food item classes

After the typology was built and characterized, we were interested in identifying the classes involving the most individuals (i.e. most gullets). For the \(i\)th individual (\(1 \leq i \leq n\)), we calculated the total dry weight for the \(j\)th class of food items, which was then divided by the total dry weight of the \(k\) classes, leading to the proportion \(p_{ij}(0 \leq p_{ij} \leq 1)\). By repeating for \(1 \leq j \leq k\) we obtained the row profile \(t_i = [p_{i1}, p_{i2}, \ldots, p_{ik}]\). In the hypothetical case where a gullet \(i\) was full of the food items of one unique class \(j (j = 1, 2, \ldots, k)\), then the corresponding row profile would be, respectively:

\[
\begin{align*}
\ell_1 &= [1,0,\ldots,0], \\
\ell_2 &= [1,0,\ldots,0], \\
\ell_3 &= [0,0,\ldots,0].
\end{align*}
\]

Hence, we computed the chi-square distances between the \(i\)th row profile \(t_i (1 \leq i \leq n)\) and the hypothetical row profiles \(\ell_1, \ell_2, \ldots, \ell_3\), and the \(i\)th individual was assigned to the closest class \(j\). Finally, we calculated the percentages of individuals assigned to each of the \(k\) classes.

Diet diversity

Diet diversity was measured by calculating Simpson’s index of diversity for each gullet as, \(S_i = 1 - \sum p_{ij}\) with Simpson’s index \(S = \sum \frac{p_{ij}}{k}\) (see Storms et al. 2008 for interpretation). For each species (Mallard / Teal) and each period (early winter / late winter), we estimated the sampling distribution of the mean diet diversity by bootstrapping (e.g. Efron and Tibshirani 1993). We used 100 bootstrap samples to accurately estimate the sampling distributions in each of the four groups (Mallard / early winter, Mallard / late winter, Teal / early winter, Teal / late winter). The four sampling distributions were plotted together (Fig. 2).

RESULTS

Mallard Diet

A total of 69 food item types were recorded in Mallard diet (see Table S1). %PCA diet analysis (based on \(R_w\)) was based on the examination of the first two axes, accumulating 51% and 59% of total inertia in early and late winter, respectively, and showed food items and gullets simultaneously (distance biplot on Fig. 3). According to Fig. 3, Mallard diet was mainly composed, in decreasing order of importance, of \(O. sativa\), \(E. crus-galli\), \(P. esculentus\), \(S. maritimus\) and \(P. nodosus\) in early winter (Fig. 3a), and by \(O. sativa\), \(E. crus-galli\) sp., \(T. aestivum\) (wheat) and \(S. maritimus\) in late winter (Fig. 3b). For clarity, only the most important food items were labelled on the distance biplots. The six most consumed items represented almost 80% of diet by \(R_w\) over the whole winter period (Table 2). The sum of

Figure 2. Sampling distributions of the mean diet diversity (Simpson’s index of diversity) estimated by bootstrapping for the four groups: Mallard / early winter, Mallard / late winter, Teal / early winter, Teal / late winter (see Methods: ‘Diet diversity’ section and Results).
O. sativa and Echinochloa sp. accounted for more than 57% of Rw, with these seeds being found in 69% of gullets (Ro). Seeds of T. aestivum and P. nodosus were consumed in large quantities, but by a relatively small proportion of Mallards (Ro 8 and 10% respectively). Other cultivated species were also found in Mallard gullets, but at lower abundance and occurrence: Sunflower Helianthus annuus (Ro 0.8%, Rw < 0.1%), Millet Milium sp. (Ro 3%, Rw 0.4%), Sorghum Sorghum sp. (Ro 3%, Rw 0.7%), Maize Zea mays (Ro 2%, Rw 0.9%) and Grape Vitis vinifera (Ro 0.8%, Rw < 0.1%). Plant seeds from brackish habitats, such as Salicornia sp. (Ro 0.8%, Rw 0.8%) and Suaeda sp. (Ro 3%, Rw 0.2%), had low frequencies and abundance in Mallard gullets. We also observed exotic seed species, such as Ludwigia peploides (Rw 0.7%), Eleusine indica (Rw < 0.1%), Paspalum distichum (Rw < 0.1%) and Heteranthera reniformis (Rw < 0.1%). Although Mallard diet was dominated by seeds, in terms of Ro, gastropods were found globally in 45% (N = 54) of gullets (Ro 25%, 31% and 8% for Physidae, Planorbidae and other unidentified gastropods, respectively).

In the food item typology analysis, five classes were obtained (Table 3). O. sativa, P. nodosus, Echinochloa sp., Polygonum sp. and T. aestivum were the most characteristic food items of these classes (for class 1 to 5, respectively). The Chi-square distance matrix between barycentres of each class showed that classes characterised by O. sativa, Echinochloa sp. and T. aestivum were very close to each other (Chi-square distance: 25.86 between O. sativa and Echinochloa sp. classes, 38.09 between O. sativa and T. aestivum classes, and 39.37 between Echinochloa sp. and T. aestivum classes; all other Chi-square distances > 103.67). Fifty six percent of sampled Mallard were assigned to the O. sativa class, 27% to the Echinochloa sp. class and 10% to the P. nodosus class. Class 4 represented 1% of ducks and corresponded to a few Mallards having consumed one main food item (Polygonum sp.) in large quantities, plus some other less numerous food items. Class 5 represented 6% of ducks and corresponded to a few Mallards having consumed one main food item (T. aestivum) in large quantities, plus some other less numerous food items.

Teal Diet

A total of 103 food item types were recorded in Teal diet (see Table S1). %PCA diet analysis (based on average relative dry weight) was based on the examination of the first two axes, accumulating 42 and 32% of total inertia in early and late winter, respectively, and showed food items and gullets simultaneously (distance biplot on Fig. 4). According to Fig. 4, Teal diet was principally composed, in decreasing order, of S. maritimus, Chara spp., P. pusillus and O. sativa in early winter (Fig. 4a), and by Echinochloa...
sp., \textit{S. maritimus}, \textit{O. sativa}, \textit{Suaeda} sp. and \textit{P. pusillus} in late winter (Fig. 4b). For clarity, only the most important food items were labelled on the distance biplots. The six most consumed items represented almost 60\% of diet by \textit{Rw} over the whole wintering period (compared to 80\% in Mallard; Table 2). With the exception of \textit{Suaeda} sp., each of these food items contributed more than 5\% to \textit{Rw} over the whole wintering period. \textit{S. maritimus}, \textit{Echinochloa} sp., and \textit{O. sativa} seeds alone accounted for about 40\% of \textit{Rw}. \textit{Chara} spp. were very frequent in Teal diet with a \textit{Ro} of 36\%. However, only 4\% of Teal consumed this food item in large quantities, i.e. with more than 16,000 \textit{Chara} oogonia in the gullet. In 56\% of cases, \textit{Chara} spp. were associated with a large number of \textit{Echinochloa} sp. seeds in the gullets. \textit{Suaeda} sp. was among the main food items, although \textit{Ro} of this taxon was only 13\%. However, this taxon was consumed in large quantities (with more than 2,000 seeds in the gullets) by a few Teal (2\% of gullets). \textit{Suaeda} sp. was more frequently present in smaller numbers and in association with seeds of \textit{Chara} spp., \textit{Zannichellia} sp. (\textit{Rw} 0.5\%), and \textit{Phragmites australis} (\textit{Rw} 0.8\%). \textit{E. palustris} was not a major food item for Teal, but represented 20\% of \textit{Ro} and 3\% of \textit{Rw}. Other seed species, such as \textit{H. reniformis} (\textit{Ro} 12\%, \textit{Rw} 0.4\%), \textit{L. pellioles} (\textit{Ro} 13\%, \textit{Rw} 2\%), \textit{Zannichellia} sp. (\textit{Ro} 14\%, \textit{Rw} 0.5\%), \textit{Schoenoplectus mucronatus} (\textit{Ro} 14\%, \textit{Rw} 1\%) and \textit{Najas} spp. (\textit{Ro} 28\%, \textit{Rw} 2\%), did not contribute much to the average diet in terms of dry weight, but occurred relatively frequently. As for Mallards, cultivated species other than \textit{O. sativa} and

### Table 3. Results of food item typology analysis for Mallard (the row in the Table S1, preceded by “r”, is given in brackets). Chi-square distance (\(\times 10^4\)) of each food item from the centroid of that class is given (see Methods: ‘Food item typology analysis’ section). The food item in bold is the closest to the centroid.

<table>
<thead>
<tr>
<th>Class</th>
<th>Food item</th>
<th>Distance between a food item and centroid of its class</th>
<th>% individuals per class</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1. \textit{Oryza sativa} (r86)</td>
<td>0.5</td>
<td>55.7</td>
</tr>
<tr>
<td></td>
<td>\textit{Chara} sp. (r46)</td>
<td>54.4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>\textit{Physidiae} (r35)</td>
<td>57.8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>\textit{Coleoptera} (adult and larvae) (r14)</td>
<td>73.9</td>
<td></td>
</tr>
<tr>
<td></td>
<td>\textit{Schoenoplectus mucronatus} (r61)</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>\textit{Odonata} (larvae) (r33)</td>
<td>90.6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>\textit{Scirpus maritimus} (r62)</td>
<td>90.8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>\textit{Planorbidaceae} (r36)</td>
<td>108.1</td>
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<td>\textit{Gasteropoda} (r37)</td>
<td>153.1</td>
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<td>\textit{Najas indica} (r73)</td>
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<td>\textit{Najas minor} (r75)</td>
<td>158.7</td>
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<td>\textit{Cyathura carinata} (r6)</td>
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<td></td>
<td>\textit{Potamogeton pectinatus} (r107)</td>
<td>451.9</td>
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<tr>
<td></td>
<td>\textit{Myriophyllum spicatum} (r66)</td>
<td>967.2</td>
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</tr>
<tr>
<td>2</td>
<td>\textit{Potamogeton nodosus} (r106)</td>
<td>477.7</td>
<td>10.3</td>
</tr>
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<td></td>
<td>\textit{Potamogeton pusillus} (r108)</td>
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<td></td>
<td>\textit{Ludwigia pellioles} (r77)</td>
<td>567.8</td>
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<td>\textit{Oryza sativa} (receptacles) (r86)</td>
<td>1228.8</td>
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<tr>
<td>3</td>
<td>\textit{Echinochloa} sp. (r80)</td>
<td>0.5</td>
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<td></td>
<td>\textit{Polygonum lapathifolium} (r100)</td>
<td>59.4</td>
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<td>\textit{Setaria verticillata} (r92)</td>
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<td>\textit{Eleocharis palustris} (r59)</td>
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<td>4</td>
<td>\textit{Polygonum} sp. (r102)</td>
<td>1.6</td>
<td>1.0</td>
</tr>
<tr>
<td>5</td>
<td>\textit{Triticum aestivum} (r95)</td>
<td>0.4</td>
<td>6.2</td>
</tr>
<tr>
<td></td>
<td>\textit{Polygonum persicaria} (r101)</td>
<td>128.3</td>
<td></td>
</tr>
</tbody>
</table>
T. aestivum were found in Teal diet: *Milium* sp. (Rw 2%) and *Sorghum* sp. (Rw 1%). Finally, Teal were less granivorous and more dependent on invertebrates than Mallards. Gastropods represented 9% of Rw, Diptera, while contributing only 4% of Rw, contributed 34% of Ro (see Table S1 for details).

Based on food item typology analysis, eleven classes were obtained (Table 4). The most characteristic food items of these classes (for class 1 to 11, respectively) were *Suaeda* sp., *Ceratopogonidae*, *H. reniformis*, *P. distichum*, *Chara* spp., *Najas minor*, Physidae, *Echinochloa* sp., *O. sativa*, *Salicornia* sp., and *T. aestivum*. The Chi-square distance matrix between barycentres of each class showed that *Suaeda* sp., *Echinochloa* sp., and *O. sativa* classes were the closest, compared to the others (Chi-square distance: 36.89 between *Suaeda* sp. and *Echinochloa* sp. classes, 39.45 between *Echinochloa* sp. and *O. sativa* classes, and 45.83 between *Suaeda* sp. and *O. sativa* classes; all others Chi-squares > 54.21).

55% of sampled Teal were assigned to the *O. sativa* class, 18% to the *Echinochloa* sp. class and 8% to the Physidae class. Classes gathering less than 5% of ducks corresponded to few Teal having consumed only one main food item, but in very large quantities, plus some other less numerous food items.

### Diet Diversity

Diet diversity analyses (Fig. 2) showed that mean diet diversity differed between seasons for Teal, but not for Mallard (peaks in mean diversity overlapping with each other). The mean diet diversity differed significantly between species but diversity was significantly greater for Teal in early winter, while there was no significant difference in late winter.

### Discussion

The same four food items were most important (in terms of frequency of occurrence Ro and average dry weight Rw) in the current diet of Mallard and Teal, though in a different order of importance: *O. sativa*, *Echinochloa* sp., *S. maritimus* and *P. pusillus* seeds. Combined, they represented 70% of Mallard average diet by Rw but only 48% for Teal. The two former items dominate the diet of Mallard, and the two latter the diet of Teal. Among these principal items, *O. sativa* is a cultivated species and *Echinochloa* sp. and *S. maritimus* are the two most common rice weeds in the Camargue (Marnotte et al. 2006). The importance of these four food items in both duck diet reflects the extreme dependence of both species on cultivated habitats in the Camargue, although *S. maritimus* is also common in brackish marshes (Molinier and Tallon 1974).

Here, we focus on our results for seeds, since these food items were usually identi-
Table 4. Results of food item typology analysis for Teal (the row in the Table S1, preceded by “r”, is given in brackets). Chi-square distance ($\times 10^000$) of each food item from the centroid of that class is given (see Methods: ‘Food item typology analysis’ section). The food item in bold is the closest to the centroid.

<table>
<thead>
<tr>
<th>Class</th>
<th>Food items</th>
<th>Distance between a food item and centroid of its class</th>
<th>% individuals per class</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Suada sp. (r53)</td>
<td>0.1</td>
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<tr>
<td></td>
<td>Psychodidæ (larvae) (r18)</td>
<td>45.4</td>
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<td></td>
<td>Phragmites australis (r89)</td>
<td>48.4</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Ceratopogonidae (larvae) (r15)</td>
<td>13.9</td>
<td>2.9</td>
</tr>
<tr>
<td></td>
<td>Ostracoda (r9)</td>
<td>104.2</td>
<td></td>
</tr>
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<td>Heteranthera reniformis (r105)</td>
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<td>0.4</td>
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<td>Paspalum distichum (r88)</td>
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<td>5</td>
<td>Charas sp. (r46)</td>
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<td>2.9</td>
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<td>Cladocera (ephippia) (r5)</td>
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</tr>
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<td></td>
<td>Juncus sp. (r67)</td>
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<td></td>
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<td>6</td>
<td>Najas minor (r75)</td>
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<td>0.4</td>
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<td>Physidae (r35)</td>
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<td>Polygonum lapathifolium (r100)</td>
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<td>Ludwigia peploides (r77)</td>
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<td>Inula sp. (r35)</td>
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<td>Hydrachnellae (r1)</td>
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</tr>
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<td></td>
<td>Schoenoplectus mucronatus (r61)</td>
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<td>Polygonum persicaria (r101)</td>
<td>68.7</td>
<td></td>
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<tr>
<td></td>
<td>Diptera (adult, nymph and larvae) (r24)</td>
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<td></td>
</tr>
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<td></td>
<td>Gasteropoda (r37)</td>
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<td>Anisoptera (larvae) (r31)</td>
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</tr>
<tr>
<td></td>
<td>Oryza sativa (embases) (r86)</td>
<td>216.8</td>
<td></td>
</tr>
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<td></td>
<td>Coleoptera (adult and larvae) (r14)</td>
<td>226.4</td>
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</tr>
<tr>
<td>9</td>
<td>Oryza sativa (r86)</td>
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<td>Planorbidae (r36)</td>
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<td>Najas indica (r73)</td>
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<td></td>
<td>Odonata (larvae) (r33)</td>
<td>86.3</td>
<td></td>
</tr>
</tbody>
</table>
fied to the species level, permitting identifi-
cation of more precise feeding habitat, con-
trary to invertebrate taxa which could mostly
be identified at the family level. The pres-
ence in duck diets of rice and typical rice
weeds (e.g. *E. palustris*, *Polygonum lapathifo-
lium*, *Polygonum persicaria*, *Cyperus dif-
formis*, and *S. mucronatus*; Marnotte et al.
2006) either in isolation, mixed together, or
sometimes also mixed with hydrophyte seeds,
which are typical of permanent (*Potamogeton
pectinatus*, *Myriophyllum spicatum*) and
semi-permanent (*P. nodosus*, *P. pusillus*) fresh-
water marshes, may also result from different
hunting management strategies. Baiting is a
common strategy used by hunters in the Ca-
margue. Bait can be composed of rice, rice
weeds or both, depending on whether bait
comes from unsorted or sorted har-
vest or from harvest waste. The presence of *P.
pec-
tinatus* in Mallard diet and *P. pusillus* in Teal
diet, mixed with other species character-
istic of ricefield habitat, may result from rice bait
being spread in pondweed marshes (au-
thors' personal obse-
rvation). Alternatively,
The presence of rice in duck diet could also
reflect the exploitation of post-harvest rice
weeds or both, depending on whether bait
is naturally flooded by rain or specif-
ically managed as freshwater habitat in order
to attract waterfowl (Ephlick and Oring 1998;
Tourang et al. 2001). These two management
strategies are both practiced in the Camargue and
represent part of the habitat change there, but
they could not be differentiated by duck diet
analysis alone. Wheat in duck diet was also
likely to be from hunting bait, since this spe-
cies is not cultivated during winter in the Ca-
margue, and wheat seeds rot rapidly when
moist (authors' personal observation). The
association of wheat with other plant species
in the same typology class may result from the
use of wheat in freshwater marshes. Besides the four most num-
berous food items, important differences were
observed between the current diets of the
two duck species, such as the heavy con-
sumption of *Chara oogonia* by Teal and

Table 4. (Continued) Results of food item typology analysis for Teal (the row in the Table S1, preceded by "r", is given in brackets). Chi-square distance (×10 000) of each food item from the centroid of that class is given (see Methods: ‘Food item typology analysis’ section). The food item in bold is the closest to the centroid.

<table>
<thead>
<tr>
<th>Class</th>
<th>Food items</th>
<th>Distance between a food item and centroid of its class</th>
<th>% individuals per class</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1 2 3 4 5 6 7 8 9 10 11</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td><em>Scirpus maritimus</em> (r62)</td>
<td>95.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Chironomidae (larvae)</em> (r16)</td>
<td>144.7</td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Potamogeton pusillus</em> (r108)</td>
<td>211.8</td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Eleocharis palustris</em> (r59)</td>
<td>223.89</td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Hydrophilidae (larvae)</em> (r12)</td>
<td>224.1</td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Cyperus difformis</em> (r58)</td>
<td>418.7</td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Myriophyllum spicatum</em> (r66)</td>
<td>699.9</td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Ranunculus sp.</em> (r109)</td>
<td>765.1</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td><em>Salicornia sp.</em> (r51)</td>
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<td>1.2</td>
</tr>
<tr>
<td>11</td>
<td><em>Triticum aestivum</em> (r95)</td>
<td>2.8</td>
<td>5.7</td>
</tr>
<tr>
<td></td>
<td><em>Zannichellia sp.</em> (r116)</td>
<td>139.3</td>
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</table>
of *P. nodosus* seeds by Mallard. Overall, a greater diversity of food items was observed in Teal. Mallard are known to select larger food items on average than Teal, although both use a broad range of seed sizes (Guillemain *et al.* 2002; Brochet *et al.* 2012). Pöysä (1987) suggested the diverse use made by Teal of habitats in the horizontal dimension was associated with a varied diet. Conversely, the restricted use of shorelines by Mallards was associated with a less variable diet (see also Nummi 1993). Furthermore, in our study Teal also seemed to be less dependent on ricefields than Mallard, but more dependent on semi-permanent freshwater marshes. Mallard appeared to largely specialize on rice and associated plant species (57% of the average Mallard diet by *Rw* is composed by *O. sativa* and *Echinochloa* sp.). In the Ebro delta, northern Spain, rice was also found to be more frequent in the diet of Mallard than of Teal (Mateo *et al.* 2000).

Brackish habitats were represented in Teal diet by only one class characterized by *Suaeda* sp., a typical species of shallow, brackish habitats. Characteristic seed species of temporary freshwater or brackish habitats (e.g. *Ruppia* sp., *Chara* sp. or *Zannichellia* sp.), or coastal lagoon habitat (e.g. *Zostera nolitii*) may have been slightly underestimated in our duck diet study. These habitats in the Camargue correspond mainly to protected areas where management is less intensive, and marshes are more salty due to natural marine influence (most protected areas are in the South of Camargue, near the Mediterranean Sea) and some brackish and/or annual plants are more abundant there than in permanent freshwater habitats (Tamisier and Dehorter 1999). Ducks using protected areas for both feeding and resting were not represented in our analysis, as they escape hunting pressure. These individuals however likely represent a minor part of the duck population, since Camargue wintering ducks generally commute twice daily between a day-roost and a distinct nocturnal foraging area (Tamisier and Dehorter 1999).

Mallard and Teal diets were previously studied in c.1980 by Pirot (1981) and in c.1965 by Tamisier (1971), respectively. The methods used were similar to ours (diet from hunted ducks; relative dry weight of food items), except that Tamisier (1971) also used a combination of gullet and gizzard contents.

In c.1980, Pirot (1981) found that Mallard diet in the Camargue was made up by *Rw* of 46% Poaceae (*O. sativa* and *Echinochloa* sp.), 17% Cyperaceae, 17% Chenopodiaceae, 14% Characeae, and 6% Potamogetonaceae (see also Green *et al.* 2002 for a detailed summary in English of this French reference). The equivalent proportions of these food items in our results were *Rw* 57%, 7%, 1%, <0.1% and 13% respectively. According to Pirot (1981), in c. 1980, Characeae were principally consumed at the beginning of winter and Cyperaceae at the end. *O. sativa*, *Echinochloa* sp., *S. maritimus* and *P. pectinatus* made up the main diet of Mallard throughout the period, the latter two being less abundant than the former two species. In c. 1980, the animal part was less than 1% of the average Mallard diet by *Rw*, whereas this part represented 6% in our results. Therefore, compared to c.1980, Mallard diet has not changed a great deal, rice and rice weeds still being the main food items. However we did notice a shift from *P. pectinatus* to *P. nodosus*, the former changing from a *Ro* of 33% in c. 1980 to 7% currently, and the latter from 0% to 10%. We also observed a lower consumption of *Chara* spp. in our study, *Rw* <1%, compared to 14% in Pirot (1981). In both studies, Mallard was dependent on ricefield habitats. *O. sativa* and *Echinochloa* sp. represented 46% by *Rw* in Pirot (1981) and 57% in our study, but ricefield surface area has increased over time (from c. 6,000 ha in 1980 to c. 20,000 ha from 2000-2010; Marnotte *et al.* 2006).

In c.1965, Tamisier (1971) found that Teal diet in the Camargue was made up, by *Rw*, of 25% Characeae, 25% Cyperaceae seeds and 25% seeds of *O. sativa* and *Echinochloa* sp. The last 25% consisted of Chenopodiaceae, Potamogetonaceae, Ruppiaceae and *Myriophyllum* sp. seeds. The equivalent proportions of these food items in our results were *Rw* 6%, 23%, 23%, and 17% respectively. Hence, Teal diet has not changed a great deal either since c.1965. However, the proportions
of *Echinochloa* sp. and *S. maritimus* have increased over time (from 7% to 14% and from 4% to 17% respectively by *Rw*), whereas the proportions of *Characeae* and *Ruppia* have decreased (from 25% to 6% and from 4% to 0.4%, respectively, by *Rw*). Teal now seem to exploit brackish and temporary freshwater habitats to a lesser extent than they did in the 1960s: *Suaeda* sp., *Chara* spp. and *Ruppia* sp. represented 27% of Teal diet by *Rw* in Tamisier (1971), and 10% in this study. The surface area of temporary brackish marshes has greatly decreased, most being replaced by permanent and semi-permanent freshwater marshes artificially flooded (Tamisier and Grillas 1994). Conversely Teal now seem to rely more on freshwater habitats (natural or cultivated): Poaceae, Potamogetonaceae and Haloragaceae represented 29% of Teal diet by *Rw* in Tamisier (1971) and 41% in this study. Ricefield surface area reached a peak of 32,500 ha in 1962 (29,500 ha in 1965, Marnotte *et al.* 2006), but there were also more temporary freshwater habitats than nowaday. The surface area of temporary freshwater marshes declined by 60% from 1942 to 1984, and this trend continues (Tamisier and Dehorter 1999).

We also observed new food items that appeared in the diet of both ducks since c. 1965. First, we observed seeds of the exotic plants *H. reniformis* and *L. peploides*, native to the Americas, which colonized the Camargue 15 and 30 years ago, respectively (Marnotte *et al.* 2006). *H. reniformis* had a particularly high abundance in some Teal in this study, with up to 148,000 seeds in one gullet. Ducks are likely to play a role in the spread and colonization of new habitats by these plant species (Brochet *et al.* 2009, 2010). Secondly, we observed the appearance of indigenous plants such as *P. nodosus*, which was absent from previous diet studies, whereas this species was abundant and frequent in ours. *P. nodosus* was rare in the Camargue in the 1960s and known only from canals and ditches (Molinier and Tallon 1974). In the 1980s *P. nodosus* was not found in freshwater marshes (Britton and Podlejski 1981; Grillas 1990), but was still frequent in canals. *P. nodosus* was eventually found in year 2000 in freshwater Camargue marshes (Aznar *et al.* 2003), where this species is now widespread. There may be a parallel between the decline of *P. pectinatus* and the increase in both *P. nodosus* and *P. pusillus*. This switch may be due to a change in frequency of drought or drawdown (short and regular nowadays, long and irregular in the 1960s). More intensive water management developed for hunting activity (Tamisier and Dehorter 1999) may have favoured the latter two *Potamogeton* species. Conversely, we observed the disappearance of *Scirpus littoralis*, which was no longer recorded in the current Teal diet. *S. littoralis* was widespread at the beginning of the 1960s (Molinier and Tallon 1974; Britton and Podlejski 1981). Today the species is declining, with few known localities in the Camargue, likely due to intensification of marsh management, leading to eutrophication and frequent mechanical destruction of helophytes (*P. Grillas*, pers.comm.).

Our results indicate that the current diet of both Mallard and Teal rely essentially on cultivated species and associated plants. Most marshes of the Camargue are managed in order to attract the maximum number of waterbirds, mostly for hunting, but also partly for conservation and tourism purposes. Our results suggest that this intensive marsh management does not reach its goal, since ducks still principally exploit cultivated habitat. However, the switch from temporary to more permanent marshes has resulted in profound changes in plant species composition over the last decades, with an overall loss in plant biodiversity across the Camargue (Tamisier and Grillas 1994). This loss of natural wetland habitat does not seem to have affected Mallard and Teal abundance, since the size of their populations did not undergo a significant reduction since the 1970s, neither in the Camargue (Kayser *et al.* 2008) nor at wider scales across Europe (Delany and Scott 2006).

**Acknowledgments**

We are grateful to hunting managers who authorized us to take samples from ducks. We thank J. Fuster for help collecting gullet samples and L. Cosneau, M. Droulin and V. Pavési for help analysing gullet contents.
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**Literature Cited**


**Table S1. Relative frequency of occurrence (Ro) and average relative dry weight (Rw) of food items present in gullet (both expressed in %), for Mallard (n = 119) and Teal (n = 302) (see text: ‘Statistical analyses’ section).**

<table>
<thead>
<tr>
<th>Invertebrate</th>
<th>Abbreviation</th>
<th>Relative frequency of occurrence (%)</th>
<th>Average relative dry weight (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mallard</td>
<td>Teal</td>
</tr>
<tr>
<td>1</td>
<td>Arachnida</td>
<td>HYDRA</td>
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</tr>
<tr>
<td>2</td>
<td>Bryozoa</td>
<td>BRY(S)</td>
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<td>Crustacea</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>- Amphipoda</td>
<td>CORO</td>
<td>1.7</td>
</tr>
<tr>
<td>4</td>
<td>Gammaridae</td>
<td>CAMM</td>
<td>0.1</td>
</tr>
<tr>
<td>5</td>
<td>- Cladocera</td>
<td>CLA(E)</td>
<td>0.8</td>
</tr>
<tr>
<td>6</td>
<td>Isopoda</td>
<td>CYACAR</td>
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</tr>
<tr>
<td>7</td>
<td>Idotea sp.</td>
<td>IDESP</td>
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<td>8</td>
<td>Sphaeroma hockeri</td>
<td>SPHHOO</td>
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<td>- Coleoptera</td>
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<tr>
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<td>Noteridae (larvae)</td>
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<tr>
<td>14</td>
<td>Other Coleoptera (adult and larvae)</td>
<td>COL(A, L)</td>
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</tr>
<tr>
<td>15</td>
<td>Ceratopogonidae (larvae)</td>
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<td>Chironomidae (larvae)</td>
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<tr>
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<td>Ephydridae (larvae)</td>
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<td>Psychodidae (larvae)</td>
<td>PSY(L)</td>
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</tr>
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<td>Rhagionidae (larvae)</td>
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<td>20</td>
<td>Stratiomyidae (larvae)</td>
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<td>Syrphidae (larvae)</td>
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<td>Tabanidae (larvae)</td>
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<td>Tipulidae (larvae)</td>
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<td>Other Diptera (adult, nymph and larvae)</td>
<td>DIP(A, N, L)</td>
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<td>Corixidae (adult)</td>
<td>COR(A)</td>
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<td>26</td>
<td>Microvelia sp. (adult)</td>
<td>MIC(A)</td>
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*Introduced plant species in France, according to Marnotte et al. (2006) and Flora Europaea (Royal Botanic Garden Edinburgh 2011)*

* Cultivated plant species
Table S1. (Continued) Relative frequency of occurrence (Ro) and average relative dry weight (Rw) of food items present in gullet (both expressed in %), for Mallard (n = 119) and Teal (n = 302) (see text: ‘Statistical analyses’ section).

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Relative frequency of occurrence (%)</th>
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<td>Teal</td>
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<td>NAUC(A)</td>
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<td>ZYG(L)</td>
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<td>Other Odonata (larvae)</td>
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*introduced plant species in France, according to Marnotte *et al.* (2006) and Flora Europaea (Royal Botanic Garden Edinburgh 2011)

*b*cultivated plant species
Table S1. (Continued) Relative frequency of occurrence (Ro) and average relative dry weight (Rw) of food items present in gullet (both expressed in %), for Mallard (n = 119) and Teal (n = 302) (see text: ‘Statistical analyses’ section).

<table>
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<td>86</td>
<td>Oryza sativa (and « receptacle ») a b</td>
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<td>89</td>
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*introduced plant species in France, according to Marnotte et al. (2006) and Flora Europaea (Royal Botanic Garden Edinburgh 2011)

^cultivated plant species
Table S1. (Continued) Relative frequency of occurrence ($Ro$) and average relative dry weight ($Rw$) of food items present in gullet (both expressed in %), for Mallard ($n = 119$) and Teal ($n = 302$) (see text: ‘Statistical analyses’ section).

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Relative frequency of occurrence (%)</th>
<th>Average relative dry weight (%)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Mallard</td>
<td>Teal</td>
</tr>
<tr>
<td>90</td>
<td>Polypogon sp.</td>
<td>POLYSP</td>
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<tr>
<td>91</td>
<td>Setaria palma</td>
<td>SETPUM</td>
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<tr>
<td>92</td>
<td>Setaria verticillata</td>
<td>SETVER</td>
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<tr>
<td>93</td>
<td>Setaria viridis</td>
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<td>94</td>
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<td>ZEAMAY</td>
</tr>
<tr>
<td>97</td>
<td>Other Poaceae sp.</td>
<td>POASP</td>
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<tr>
<td>98</td>
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<td>Polygona convolus</td>
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</tr>
<tr>
<td>100</td>
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<td>POLAVI</td>
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<td>Polygonum lapathifolium</td>
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<td>102</td>
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Vegetative part

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<td></td>
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aIntroduced plant species in France, according to Marnotte et al. (2006) and Flora Europaea (Royal Botanic Garden Edinburgh 2011) 
bCultivated plant species
<table>
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<td>0.01</td>
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<td>3.96</td>
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</table>

*No mean dry weight, each food item was weighted according to a broad food item size variation

*bData from Arzel et al. (2007
Table S2. (Continued) Mean and total dry weight for each food item consumed by Mallard and/or Teal (in mg)

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<thead>
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<td>3.40</td>
<td>279.10</td>
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<tr>
<td>32 Zygoptera (larvae)</td>
<td>ZYG(L)</td>
<td>3.40</td>
<td>34.00</td>
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<td>ODO(L)</td>
<td>3.40</td>
<td>98.60</td>
<td>752.90</td>
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<tr>
<td>34 - Bilvalvia Cerastodroma edule</td>
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<td>41.20</td>
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<tr>
<td>35 - Gasteropoda Physidae</td>
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<tr>
<td>Seeds</td>
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<td>41 Alismataceae Alisma plantago-aquatica</td>
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<td>0.30(^b)</td>
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<td>&lt;0.01</td>
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<td>0.10</td>
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<td>46 Characeae Chara sp.</td>
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<td>0.27</td>
<td>1,8829.20</td>
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<tr>
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<tr>
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<td>0.63</td>
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<tr>
<td>50 Kochia hirsuta</td>
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<tr>
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<tr>
<td>52 Salsola soda</td>
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<tr>
<td>53 Suaeda sp.</td>
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<td>106.79</td>
<td>134,290.33</td>
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<td>55 Inula sp.</td>
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<td>56 Cruciferae Brassica sp.</td>
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<td>57 Cyperaceae Carex sp.</td>
<td>CARSP</td>
<td>1.17(^b)</td>
<td></td>
<td>38.70</td>
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</tbody>
</table>

\(^a\)No mean dry weight, each food item was weighted according to a broad food item size variation
\(^b\)Data from Arzel et al. (2007)
Table S2. (Continued) Mean and total dry weight for each food item consumed by Mallard and/or Teal (in mg)

<table>
<thead>
<tr>
<th>Food item</th>
<th>Abbreviation</th>
<th>Mean dry weight</th>
<th>Total dry weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>58 Cyperus difformis</td>
<td>CYPDIF</td>
<td>0.04</td>
<td>269.14</td>
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<tr>
<td>59 Eleocharis palustris</td>
<td>ELEPAL</td>
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<td>196.97</td>
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<tr>
<td>60 Eleocharis sp.</td>
<td>ELES</td>
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<tr>
<td>61 Schoenoplectus mucronatus</td>
<td>SCHMUC</td>
<td>1.00</td>
<td>209.47</td>
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<tr>
<td>62 Scirpus maritimus</td>
<td>SCIMAR</td>
<td>3.29&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1,026.03</td>
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<tr>
<td>63 Scirpus tabernamontani</td>
<td>SCITAB</td>
<td>0.30&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.30</td>
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<tr>
<td>64 Other Cyperaceae sp.</td>
<td>CYPESP</td>
<td>0.80</td>
<td>0.80</td>
</tr>
<tr>
<td>65 Fabaceae</td>
<td>FABSP</td>
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<tr>
<td>66 Haloragaceae</td>
<td>MYRSP</td>
<td>0.97</td>
<td>20.39</td>
</tr>
<tr>
<td>67 Juncaceae</td>
<td>JUNSP</td>
<td>0.03&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.03</td>
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<tr>
<td>68 Labiatae</td>
<td>LYCEUR</td>
<td>0.16&lt;sup&gt;b&lt;/sup&gt;</td>
<td>7.41</td>
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<tr>
<td>69 Leguminosae</td>
<td>TRISP</td>
<td>0.38</td>
<td>238.87</td>
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<tr>
<td>70 Vicia sp.</td>
<td>VICS</td>
<td>2.10</td>
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<td>71 Lemnaceae</td>
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<tr>
<td>72 Malvaceae</td>
<td>ALTOFF</td>
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<td>1.80</td>
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<tr>
<td>73 Najadaceae</td>
<td>NAJIND</td>
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<tr>
<td>74 Najas marina</td>
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<td>7.79</td>
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<tr>
<td>75 Najas minor</td>
<td>NAJMIN</td>
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<td>76 Other Najas sp.</td>
<td>NAJSP</td>
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<td>77 Onagraceae</td>
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<td>78 Papaveraceae</td>
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<td>0.05</td>
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<tr>
<td>79 Poaceae</td>
<td>DIGSAN</td>
<td>6.30</td>
<td>18.90</td>
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<tr>
<td>80 Echinochloa sp.</td>
<td>ECHSP</td>
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<td>197,526.92</td>
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<tr>
<td>81 Eleusine indica</td>
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<td>2.50</td>
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<td>82 Eragrostis sp.</td>
<td>ERASP</td>
<td>0.15</td>
<td>0.45</td>
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<tr>
<td>83 Festuca arundinacea</td>
<td>FESARU</td>
<td>1.55</td>
<td>4.65</td>
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<tr>
<td>84 Leersia oxyacoides</td>
<td>LEFORY</td>
<td>0.89&lt;sup&gt;b&lt;/sup&gt;</td>
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<td>85 Milium sp.</td>
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<td>3.74&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2,054.25</td>
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<tr>
<td>86 Oryza sativa</td>
<td>ORYSAT (E)</td>
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<td>273,855.00</td>
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<tr>
<td>87 Panicum sp.</td>
<td>PANS</td>
<td>4.90</td>
<td>9.80</td>
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</table>

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<th>Abbreviation</th>
<th>Mean dry weight</th>
<th>Mallard</th>
<th>Teal</th>
</tr>
</thead>
<tbody>
<tr>
<td>88 Paspalum distichum</td>
<td>PASDIS</td>
<td>0.47</td>
<td>54.17</td>
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<td>PHRAUS</td>
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<td>144.44</td>
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<tr>
<td>91 Setaria pumila</td>
<td>SETPUM</td>
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<td>2.59</td>
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<tr>
<td>92 Setaria verticillata</td>
<td>SETVER</td>
<td>0.71</td>
<td>35.96</td>
<td>98.70</td>
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<tr>
<td>93 Setaria viridis</td>
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<td>SORS</td>
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<td>8,278.63</td>
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<td>TRIAES</td>
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<td>100,337.65</td>
<td>42,790.80</td>
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<td>96 Zea mays</td>
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<td>23,555.46</td>
<td>252.29</td>
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<tr>
<td>97 Other Poaceae sp. *</td>
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<td>16.47</td>
<td>2.53</td>
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<td>FALCON</td>
<td>3.53</td>
<td>3.53</td>
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<td>99 Polygonum aviculare</td>
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<td>1.33</td>
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<td>POLLA</td>
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<td>101 Polygonum persicaria</td>
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<td>103 Rumex sp.</td>
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<td>16.47</td>
<td>2.53</td>
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<td>191.71</td>
<td>148.83</td>
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<td>1.56</td>
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<td>ZOSNOL</td>
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</table>

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<tbody>
<tr>
<td></td>
<td></td>
<td>Mallard</td>
<td>Teal</td>
</tr>
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<td>Undetermined</td>
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</tr>
<tr>
<td>119</td>
<td>Potamogetonaceae</td>
<td>Potamogeton pectina(^a)</td>
<td>POTPEC(V)</td>
</tr>
<tr>
<td>120</td>
<td>Undetermined</td>
<td>Undetermined (^a)</td>
<td>INDV</td>
</tr>
</tbody>
</table>

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