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Food habits of the coypu, *Myocastor coypus*, and its impact on aquatic vegetation in a freshwater habitat of NW Italy

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A b s t r a c t . From September 1994 to August 1995 we studied the diet of coypus, *Myocastor coypus*, in a freshwater habitat located in the Ticino regional park (NW Italy). Adult and young coypus were directly observed foraging in and near water. Aquatic macrophytes (81.8%) represented the staple food all year round. Common reeds (*Phragmites australis*) and *Elodea* spp. were the main components of the overall diet. A complementary seasonal consumption of submersed/floating-leaved macrophytes and emergent macrophytes was observed, the former ones reaching the highest value in summer (65.7%) when the latter ones were at their minimum (16.2%). Differences in diet composition of adult and young coypus were recorded in summer, when adults consumed more submersed/floating-leaved plants (mainly *Callitriche stagnalis* and *Myriophyllum spicatum*) and young coypus more terrestrial plants, predominantly black locust *Robinia pseudoacacia* leaves. Terrestrial vegetation was a usual integrative resource of the coypu diet all year round, particularly for young coypus in summer. Slight damage to the plant community was observed in small areas over-grazed by coypus. Nevertheless, 7 out of 12 threatened Italian hygrophilic species were eaten by coypus, suggesting that particularly sensitive aquatic plants could suffer from long–term foraging. Selective control of coypus in natural ecosystems of particular conservation concern is suggested, in order to limit damage to native plant communities of freshwater habitats.

Key words*: Myocastor coypus*, food habits, aquatic macrophytes, freshwater habitat, Italy

Introduction

The coypu, *Myocastor coypus* Molina, 1782, is a large semi-aquatic rodent (suborder Caviomorpha) native to South America (G o s l i n g & B a k e r 1991), but it is now widespread throughout North America, Europe, Asia, South Africa and Japan (C a r t e r & L e o n a r d 2002). This expansion is linked to escapes or releases of animals from fur farms which started from the 1920s (G o s l i n g & S k i n n e r 1984). Coypus rapidly colonized wetlands and marshes and where populations have not been successfully controlled, damage to crops, drainage systems, and native flora and fauna have been recorded (e.g. M o r t o n et al. 1978, W i l l n e r 1982, R o s o u x 1985, V e r h e y d e n & A b b a s 1996). The coypu is considered a pest species in most of the countries where it has been introduced. Thus, it has been included in the list of the 100 World's Worst Invasive Alien Species (ISSG 2000).

In Italy the species was introduced at the end of the 1950s (V e l a t t a & R a g n i 1991), considerably increasing both in numbers and range in the last 20 years (C o c c h i & R i g a 2001). It has become very common in northern Italy, especially throughout the Po plain, where control operations are commonly carried out (P r i g i o n i & G a r i b o l d i 2001).

The coypu diet has been widely studied in a certain number of countries (e.g. England, France and United States) where the species was introduced several decades ago (W a r k e n t i n 1968, G o s l i n g 1974, B o o r m a n & F u l l e r 1981, C h a b r e c k

et al. 1981, Abbas 1988, 1991, Llewellyn 1993). In Italy, where its wide expansion is more recent, its food habits have been only partially investigated (Reggiani et al. 1993, Scaravelli & Martignoni 1994, Gariboldi 1993).

Coypus are predominantly herbivorous and hygrophilic plants represent their main food items both in their native range and in countries where feral populations have recently settled (e.g. Woods et al. 1992, Reggiani 1999). This feeding pattern also occurs when a high availability of terrestrial plants, such as cereal crops bordering the banks of watercourses, is present (e.g. D'Adamo et al. 2000, Borgnia et al. 2000).

In the present study we analysed the foraging behaviour of coypus in a freshwater habitat, in order to define i) the overall diet in a semi-natural habitat, ii) seasonal variations in the consumption of aquatic and riparian/terrestrial plants and iii) age-related differences of trophic niche breadth. In addition, having examined the impact of coypus on the native plant community, we suggested a management strategy aimed at preventing possible damage to threatened Italian species.

Study Area

The research was carried out in the southern part of the Ticino Park (Lombardy region, NW Italy), where a high coypu density has been estimated (De Ciechi & Prigioni 1998). The park is crossed by the River Ticino (100 km in length), characterized by a meandering course with several small tributaries, oxbow lakes, canals, reservoirs and fish-ponds. Most of the river flood plain is flat, mainly cultivated with rice, maize or poplar plantations. Riparian woods are mainly of oak (*Quercus robur*), alder (*Alnus glutinosa*), poplars (*Populus alba* and *P. nigra*) and willows (*Salix* spp.). A detailed description of forest systems is found in Sartori (1990).

The climate is temperate. During the study period mean temperatures ranged between 7°C in winter and 23.5°C in summer, and mean annual rainfall was 850 mm. Population density varied from about 100 to over 1000 inhabitants km^{-2}. The Ticino Valley is an important Italian wintering site for wildfowl (Prigioni & Galeotti 1989).

Fieldwork was carried out along a natural canal (300 m in length, 1–10 m in width and 0.5–1 m in depth) and an adjacent pond (0.3 ha with a depth of 1–2 m) with slow and stagnant water, respectively. Water levels kept fairly constant during the study period. Water was covered by several macrophytic species (Table 1) and surrounded by tall herbs and riparian woods.

Methods

Data were collected from September 1994 to August 1995 during monthly samplings, uniformly distributed from the sunrise to sunset, in order to draw a faithful picture of the coypu's feeding habits. Thirty two samplings were carried out, corresponding to 4147 minutes (54% of the total time of observation) of monitoring of animals' feeding activity. Observations were performed from vantage points and macrophytes consumed by coypus were identified in 220 occurrences (2240 minutes), using a 8x40 binocular and by exploring the foraging location. Results were expressed as: i) percentage of relative frequency, %RF = (number of occurrences of a food item compared with the total number of recorded items) x 100, ii) percentage of relative time, %RT = (minutes spent consuming a food item compared with the total time of observation) x 100. During the study period, a total of 15–25 coypus were present in the area.

Young coypus were detected almost exclusively in summer and autumn (young/adults ratio: 0.75 in summer and 1.2 in autumn; De Ciechi & Prigioni 1998). They were distinguished from adults from their smaller size (weight < 2 kg; Reggiani et al. 1993).

Trophic niche breadth was calculated using the normalized B Levins index (Feinsinger et al. 1981):

$$B = \frac{1}{R\sum_{i=1}^{n} p_i^2}$$

where R is the number of food items used (25) and *pi* is the proportion of use of the *i*th item expressed as relative frequency (RF). B varies from 1/R (only one item used) to 1 when all items are equally used.

Data were grouped annually and seasonally (winter: I–III; spring: IV–VI; summer: VII–IX; autumn: X–XII), in order to investigate time variations. Seasonal changes in diet between adult and young coypus were evaluated in summer and autumn. Food items consumed by coypus were grouped in the following general categories: terrestrial plants, emergent aquatic macrophytes and submerged or floating-leaved macrophytes. Variations in the use of these groups or plant species in the overall and seasonal diets were analysed by χ^2 tests as well as the difference in dietary composition between adults and young. Because of repeated tests on related data, the level of significance was calculated as ratio between $\alpha = 0.05$ and the number of tests run (Rice 1989). The relationship between %RF and %RT was tested by Spearman rank correlation (r_s).

Table 1. List of aquatic macrophytes recorded in the study area. Macrophytes in bold were consumed by coypus.

Vegetation group	Species
Emergent aquatic macrophytes	***Nasturtium officinale***, ***Glyceria maxima***, ***Phragmites australis***, *Sparganium erectum*, *Schoenoplectus lacustris*, *Polygonum* spp., ***Lysimachia vulgaris***, ***Iris pseudacorus***, *Rorippa amphibia*, *Myosotis scorpioides*, *Juncus effusus*, ***Rumex* spp.**, ***Carex* spp.**, *Stachys palustris*, *Typha latifolia*, *Lythrum salicaria*, *Gratiola officinalis*, *Plantago major*, *Oenothera biennis, Stachys palustris, Alisma plantago-aquatica, Pteridium aquilinum,* ***Nuphar lutea, Scirpus sylvaticus***
Submersed and floating-leaved macrophytes	***Ranunculus* spp.**, *Potamogeton pectinatus*, *P. natans*, ***Vallisneria spiralis***, *Ceratophyllum demersum*, ***Callitriche stagnalis***, ***Elodea canadensis***, ***E. densa***, *Apium nodiflorum*, *Veronica anagallis-aquatica*, ***Myriophyllum spicatum***, *Salvinia natans*, ***Lemna* spp.**, ***Nymphoides peltata***, *Sagittaria sagittifolia, Azolla caroliniana*

Results

The diet of coypus was based on aquatic macrophytes (%RF = 81.8%) with a preponderance of submersed and floating-leaved plants (%RF = 50.9%; $\chi^2 = 35.93$, df = 2, $P < .005$); emergent macrophytes and terrestrial plants represented 30.9% and 18.2%, respectively. Coypus used 9 (37.5%) out of the 24 emergent macrophytes and 8 (43.7%) out of the 16 submersed or floating-leaved macrophytes that were found in the study area (Table 1).

Common reeds (*Phragmites australis*) and *Elodea* spp. were the main components of the overall diet followed by *Callitriche stagnalis*, *Myriophyllum spicatum* and *Robinia pseudoacacia*, of which coypus consumed only leaves (Table 2). In addition, coypus used to a certain

Table 2. Overall coypu diet in the study area. Total number of occurrences: 220; total time: 2240 minutes; n: number of occurrences of each item; %RF: percentage of relative frequency; %RT: percentage of relative time.

Plant species	n	%RF	%RT
Hydrocharitaceae	5	2.3	2.8
Vallisneria spiralis	5	2.3	2.8
Graminaceae	54	24.5	24.6
Phragmites australis	42	19.1	18.2
Glyceria maxima	4	1.8	3.7
Graminaceae unidentified	8	3.6	2.7
Cyperaceae	4	1.8	4.2
Scirpus sylvaticus	3	1.4	3.7
Carex spp.	1	0.45	0.5
Lemnaceae	37	16.8	20.4
Lemna spp.	12	5.4	3.7
Elodea spp.	25	11.4	16.6
Iridaceae	1	0.45	0.7
Iris pseudacorus	1	0.45	0.7
Salicaceae	3	1.4	1.2
Salix spp.	3	1.4	1.2
Urticaceae	3	1.4	1.6
Urtica dioica	3	1.4	1.6
Polygonaceae	1	0.45	0.1
Rumex spp.	1	0.45	0.1
Phytolaccaceae	1	0.45	0.2
Phytolacca americana	1	0.45	0.2
Nymphaeaceae	23	10.4	7.2
Nuphar lutea	16	7.3	5.7
Nymphoides peltata	7	3.2	1.5
Ranunculaceae	9	4.1	2.9
Ranunculus spp.	9	4.1	2.9
Cruciferae	6	2.7	1.9
Nasturtium officinale	6	2.7	1.9
Rosaceae	1	0.45	0.4
Rubus spp.	1	0.45	0.4
Leguminosae	18	8.2	10.3
Robinia pseudoacacia	17	7.7	9.6
Trifolium spp.	1	0.45	0.7
Callitrichaceae	19	8.6	7.1
Callitriche stagnalis	19	8.6	7.1
Vitaceae	1	0.45	0.4
Vitis vinifera	1	0.45	0.4
Halorrhagidaceae	19	8.6	7.1
Myriophyllum spicatum	19	8.6	7.1
Primulaceae	2	0.9	3.0
Lysimachia vulgaris	2	0.9	3.0
Bark	13	5.9	4.0

extent aquatic plants such as *Nuphar lutea* and *Lemna* spp. and bark, mostly belonging to *Salix* spp. and *Populus* spp.

The percentage relative frequency of the plant species exploited by coypus was positively correlated with the percentage of relative time spent in consuming them (r_s = 0.914, n = 25, P < .01).

The overall diet was fairly varied in spring (B = 0.22) and summer (B = 0.31), while it became narrow in the cold seasons (B = 0.15 in autumn, B = 0.11 in winter).

The consumption of submersed and floating-leaved macrophytes varied seasonally (χ^2 = 22.02, df = 3, P < .005) with a minimum (%RF = 30.2%) in spring and a maximum (%RF = 65.7%) in summer (Fig. 1). An opposite trend was recorded for emergent macrophytes (spring: 52.3%; summer 16.2%; χ^2 = 27.88, df = 3, P < .005). No significant seasonal variation was recorded for terrestrial plants (χ^2 = 1.18, df = 3, NS).

Common reed (leaves, shoots and rhizomes) was the only aquatic macrophyte consumed all year round with a significant seasonal variation (%RF, min-max: 7.1% in winter – 40.6% in autumn; χ^2 = 27.58, df = 3, P < .001). The other aquatic plants were discontinuously used with peaks in different seasons: *N. lutea* (%RF = 22.2%) in spring, *Elodea* spp. (%RF = 22.5%), *C. stagnalis* (%RF = 14.4%) and *M. spicatum* (%RF = 14.4%) in summer, *Lemna* spp. (%RF = 28.1%) in autumn and *Ranunculus* spp. (%RF = 50%) in winter. Of terrestrial plants, *R. pseudoacacia* (%RF = 15.3%) was used only in summer, while bark occurred all year round, ranging in %RF between 1.8% in summer and 28.6% in winter (χ^2 = 18.23, df = 3, P < .001).

The summer diet of adult and young coypus differed significantly (χ^2 = 42.98, df = 2, P < .0001): adults consumed more submersed and floating-leaved macrophytes (χ^2 = 12.62, df = 1, P < .001), mainly *C. stagnalis* and *M. spicatum*, while young coypus ate more terrestrial plants (χ^2 = 27.30, df = 1, P < .0001), predominantly black locust leaves (Fig. 2). In contrast, autumnal diets were similar ((χ^2 = 2.96, df = 2, NS). On the whole, in summer and autumn young coypus consumed fewer plant species (10 species) than adults (20 species) and their trophic niche was narrower (B = 0.22 *vs.* 0.42 for adults).

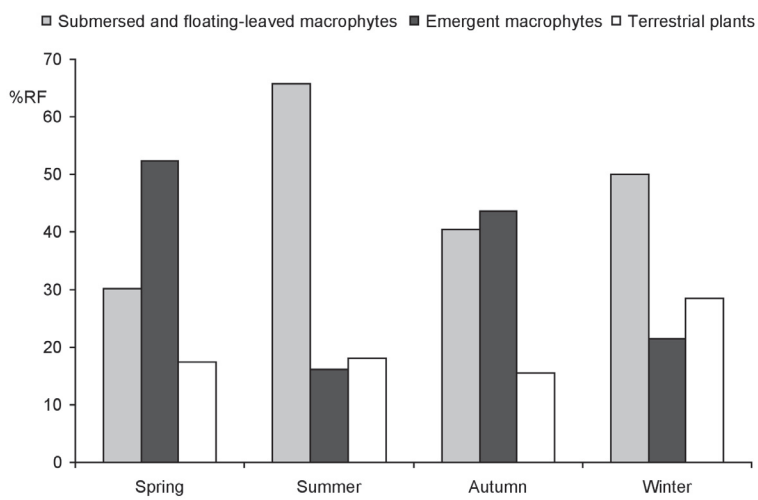

Fig. 1. Seasonal variation of the main food categories of aquatic and terrestrial plants consumed by the coypu (%RF = percentage of relative frequency).

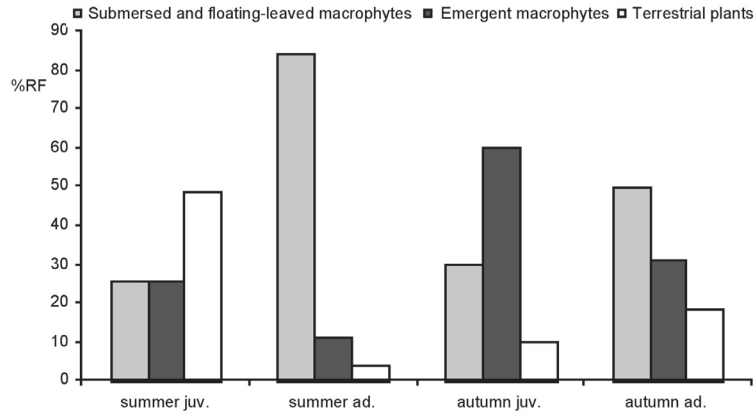

Fig. 2. Diet of adult (ad.) and young (juv.) coypus in summer and autumn (%RF = percentage of relative frequency).

Discussion

As reported in previous studies (e.g. Shirley et al. 1981, Abbas 1991, Wilsey et al. 1991, Borgnia et al. 2000, Guichón et al. 2003), coypus foraged mostly on hygrophilic macrophytes. The high consumption of aquatic vegetation should assure a large amount of proteins and a wide variety of aminoacids (Hubac et al. 1984). Nevertheless, Guichón et al. (2003) found no difference in nutritional quality between hygrophilic and terrestrial plants.

Abbas (1991) recorded that coypus consumed terrestrial plants only when hygrophilic vegetation availability was scarce. In our study area, terrestrial vegetation was a usual integrative resource of the coypu annual diet, particularly for young coypus during summer. Compared to adults, young animals spent more time foraging on the ground (De Ciechi 1996), where they probably succeeded in satisfying their nutritional requirements with a lower energetic investment.

Behavioural foraging ecology and diet composition of coypus vary according to the environmental characteristics of the study area. Therefore, the comparison of our data with those of other studies should be taken with caution. Nevertheless, common reeds were a main food item in several studies (Ehrlich 1967, Chabreck et al. 1981, Gosling 1981, Reggiani et al. 1993), while our results markedly differed from those recorded by Abbas (1991) in central western France, where fodder plants (e.g. *Lolium italicum*, *Agrostis stolonifera*, *Festuca* spp.) were the staple food of coypus. The consumption of black locust leaves, mainly by young coypus in summer, and of *Urtica dioica*, which is said to be avoided by coypus (Abbas 1991), represented some peculiarities of our study area.

As expected, diet composition was particularly diversified during the vegetative period of plants, while it was more simplified in winter. In this season we could have underestimated the consumption of submersed roots or rhizomes, whose identification is problematic by direct observation. However, in France Abbas (1991) recorded a lower use of roots (5%) than that found in North and South America (Willner et al. 1979, Chabreck et al. 1981, Murua et al. 1981).

In Italy, according to Scaravelli (2002), coypus use more than one hundred plant species, of which some are of particular importance (*Trapa natans*, *Nymphoides peltata*

and *Nymphaea alba*) because classified as endangered or vulnerable species (Conti et al. 1997).

During the study period, we found only slight damage by coypus to aquatic and terrestrial vegetation, with overgrazing areas of 5–10 m^2 in size. Nevertheless, coypus ate 7 (58.3%) out of the 12 species of native aquatic plants of particular interest recorded in the study area (e.g. *Vallisneria spiralis, Iris pseudacorus, Nuphar lutea*; Furlanetto 1999).

Damage to cat-tails (Boorman & Fuller 1981) and reedswamps (Harris & Webert 1962, Willner et al. 1979, Linscombe et al. 1981) have been noticed in several countries where coypus have been introduced over a long time. On the other hand, in Italy, Reggiani et al. (1993) suggest that the grazing of coypus should delay the development of littoral aquatic plants, preventing the establishment of *Salix* associations and favouring the expansion of species such as *P. australis* and *Calamagrostis* sp., which promptly occupy overgrazed areas to the detriment of other less competitive reeds (e.g. *Typha* spp.). In the Ticino Valley, characterized by wide wet woods and wetlands, the impact of coypus on native aquatic vegetation could become evident in future, determining the decline of particular sensitive plant species rather than a reduction of reedswamps area.

Moreover, damage caused by coypus could produce a decrease of suitable nesting sites for threatened bird species (Scaravelli 2002, Tinarelli 2002), as has been observed for the little grebe (*Ixobrychus minutus*) in the Ticino Valley (Prigioni, unpublished data), due to both thinning out of aquatic vegetation and disturbance during the nesting period.

The coypu is not included in the list of Italian game species (National Law 157/92), but control or eradication programs are recommended and legally authorized, preferentially by use of cage-trapping and/or direct shooting in winter (Cocchi & Riga 2001).

In northern Italy, taking into account the wide and almost uniform distribution and the high capacity of recovery of coypus, control campaigns might first of all be carried out in natural ecosystems of particular conservation concern, in order to limit damage on native plant communities and to encourage the recovery of particularly sensitive species. In some wetlands of the Park of the Rivers Po and Orba (NW Italy), where coypu control has been carried out by cage-trapping, aquatic vegetation showed signs of recovery in a relatively short time in over-exploited areas (Bertolino et al. in press).

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