Temporal host-parasite relationships of the wild rabbit, *Oryctolagus cuniculus* (L.) as revealed by stable isotope analyses

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Introduction

Natural abundances of stable isotopes are effectively an integrated record of assimilated elements such as C and N, and as such, are a better representation of the recent biochemical and dietary past of an organism than traditional snapshot methods, e.g. gut content analyses. Changes in the ratios of $^{13}C/^{12}C$ and $^{15}N/^{14}N$ (expressed as $\delta^{13}C$ and $\delta^{15}N$) in animal tissue are indicative of dietary sources and trophic grouping, respectively. Although parasites are an integral component of any trophic system, their inclusion in foodweb studies is infrequent (Marcogliese & Cone, 1997). Similarly, the utilisation of stable isotope techniques in host-parasite studies is rare. Using stable isotopes, initial data from Boag *et al*. (1998) suggested that different trophic relationships existed between parasitic intestinal nematodes and parasitic cestodes and their host, the European rabbit.

Aim

The objective of this study is to report for the first time, the temporal trophic dynamics of a host-parasite system using the natural abundances of $\delta^{13}C$ and $\delta^{15}N$.

Material and Methods

Ten wild rabbits were captured using box traps from a study site located in the Scottish Borders on six separate occasions (January, March, May, July, September and November) during a 12-month period. Samples of fur, muscle, stomach contents and faeces were collected from the rabbits and when present, parasitic cestodes (*Mosgovoyia pectinata* and *Cittotaenia denticulata*) and parasitic nematodes (*Graphidium strigosum, Passalurus ambiguus* and *Trichostrongylus retortaeformis*). Samples were processed and analysed by continuous-flow isotope ratio mass spectrometry (CF-IRMS) as described by Boag *et al*. (1998).

Results

$\delta^{15}N$

Muscle and stomach content $\delta^{15}N$ varied little (p=0.365 and p=0.829, respectively) during the sampling period (Fig. 1a, c). In contrast, faeces, fur and vegetation $\delta^{15}N$ exhibited statistically significant temporal trends (Figs. 1b, d and 2a). Vegetation showed the greatest temporal variation (p=0.021). Faeces (p=0.045; Fig. 1b) and fur (p=0.000; Fig. 1d) also exhibited significant ^{15}N temporal variability.

The three species of intestinal nematode were only found on the first three sampling dates indicative of their known biology when their intensity is greatest (e.g. *G. strigosum*) or when they are prevalent. Consequently, it was not possible to statistically test any observed isotopic temporal differences.

Intestinal parasitic nematode $\delta^{15}N$ exhibited discordant temporal patterns (Table 1). The *cestode C. denticulata* (p=0.988) exhibited no $\delta^{15}N$ temporal patterns whereas *M. pectinata*, exhibited significant (p=0.013) temporal variation in $\delta^{15}N$ (Fig. 2b).

$\delta^{13}C$

Muscle (p=0.000), faeces (p=0.000), vegetation (p=0.000) and stomach content (p=0.036) $\delta^{13}C$ varied temporally during the sampling period (Figs. 1a-c and 2a). In contrast, fur $\delta^{13}C$ was uniform throughout the sampling period (Fig. 1d).

Both cestode species became less ^{13}C-depleted during the sampling period (p=0.000) although the temporal trend of both species differed (Fig. 2b). During the period January-May, intestinal nematode $\delta^{13}C$ showed no obvious temporal trends (Table 1).

Table 1.
Mean $\delta^{13}C$ (‰) and $\delta^{15}N$ (‰) values for three intestinal nematodes recorded from the European rabbit (*Oryctolagus cuniculus*). Values in parentheses are standard errors.

	Graphidium strigosum		*Passalurus ambiguus*		*Trichostrongylus retortaeformis*	
	$\delta^{13}C$	$\delta^{15}N$	$\delta^{13}C$	$\delta^{15}N$	$\delta^{13}C$	$\delta^{15}N$
January	-26.7 (0.42)	7.5 (0.61)	-28.7 (0.05)	9.0 (0.31)	-27.4 (0.18)	7.3 (0.36)
March	-26.6 (0.25)	8.7 (0.40)	-28.5 (0.10)	8.9 (0.25)	-27.5 (0.15)	6.8 (0.40)
May	-26.5 (0.15)	10.2 (0.19)	-27.9 (n/d)	8.9 (n/d)	-27.7 (0.29)	5.6 (0.32)
Mean	-26.6 (0.16)	9.4 (0.45)	-28.6 (0.15)	9.0 (0.25)	-27.5 (0.15)	6.8 (0.39)

n/d = not determined as n=1

Figure 3. Seasonal mean $\delta^{13}C$ vs $\delta^{15}N$ for all samples. Cd = *Cittotaenia denticulata*; Gs = *Graphidium strigosum*; Mp = *Mosgovoyia pectinata*; Pa = *Passalurus ambiguus* and Tr = *Trichostrongylus retortaeformis*. In some instances error bars are smaller than the symbols.

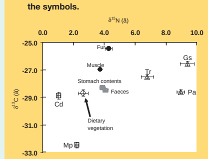


Figure 1. Temporal mean $\delta^{15}N$ (closed squares) and $\delta^{13}C$ (open circles) for A) rabbit muscle; B) rabbit faeces; C) rabbit stomach contents and D) rabbit fur.

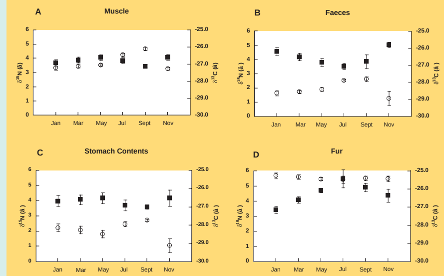
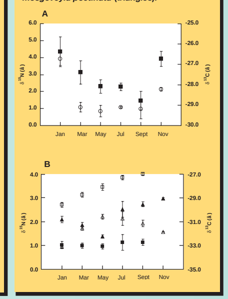


Figure 2. A) Temporal vegetation mean $\delta^{15}N$ (closed squares) and $\delta^{13}C$ (open circles) and B) Temporal mean $\delta^{15}N$ (closed symbols) and $\delta^{13}C$ (open symbols) for the parasitic cestodes, *Cittotaenia denticulata* (squares) and *Mosgovoyia pectinata* (triangles).



Trophic interactions

Both rabbit tissues, muscle and fur, were ^{15}N-enriched, respectively, relative to the host (rabbit) diet (C3-grass). Similarly, stomach contents and faeces were ^{15}N-enriched relative to dietary material (Fig. 3). Compared to rabbit muscle, levels of ^{15}N-enrichment differed among intestinal nematode species: *G. strigosum* (5.7 ‰), *P. ambiguus* (5.3 ‰) and *T. retortaeformis* (3.1 ‰)(Table 1, Fig. 3). In contrast, the parasitic cestodes were less ^{15}N-enriched than rabbit muscle and as with the nematodes this differed among cestode species, *C. denticulata* (2.7 ‰) and *M. pectinata* (1.5 ‰).

Mean faeces and stomach content $\delta^{13}C$ were similar to vegetation $\delta^{13}C$ (Fig. 3). Overall, both rabbit tissues (muscle and fur) sampled were less ^{13}C-depleted than the dietary material (Fig. 3). Unlike $\delta^{15}N$, mean $\delta^{13}C$ for *G. strigosum* and *T. retortaeformis* was similar to that for host muscle (Fig. 3). In contrast, *P. ambiguus* was more ^{13}C-depleted (Fig. 3). Similarly, both cestode species were more ^{13}C-depleted than host muscle (Fig. 3).

Conclusions

- Host faeces and stomach content were isotopically indistinct as a likely consequence of coprophagy.
- Relative to their host, parasitic nematodes were ^{15}N-enriched consistent with an increase in trophic level status.
- Conversely, cestodes were ^{15}N-depleted.
- Isotopically, each parasite reflected a species-specific relationship with their rabbit host.

References

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Marcogliese, D. J. & Cone, D. K. (1997). *Trends in Ecology and Evolution* **12**, 320-325.