Tannins in the nutrition of wild herbivores

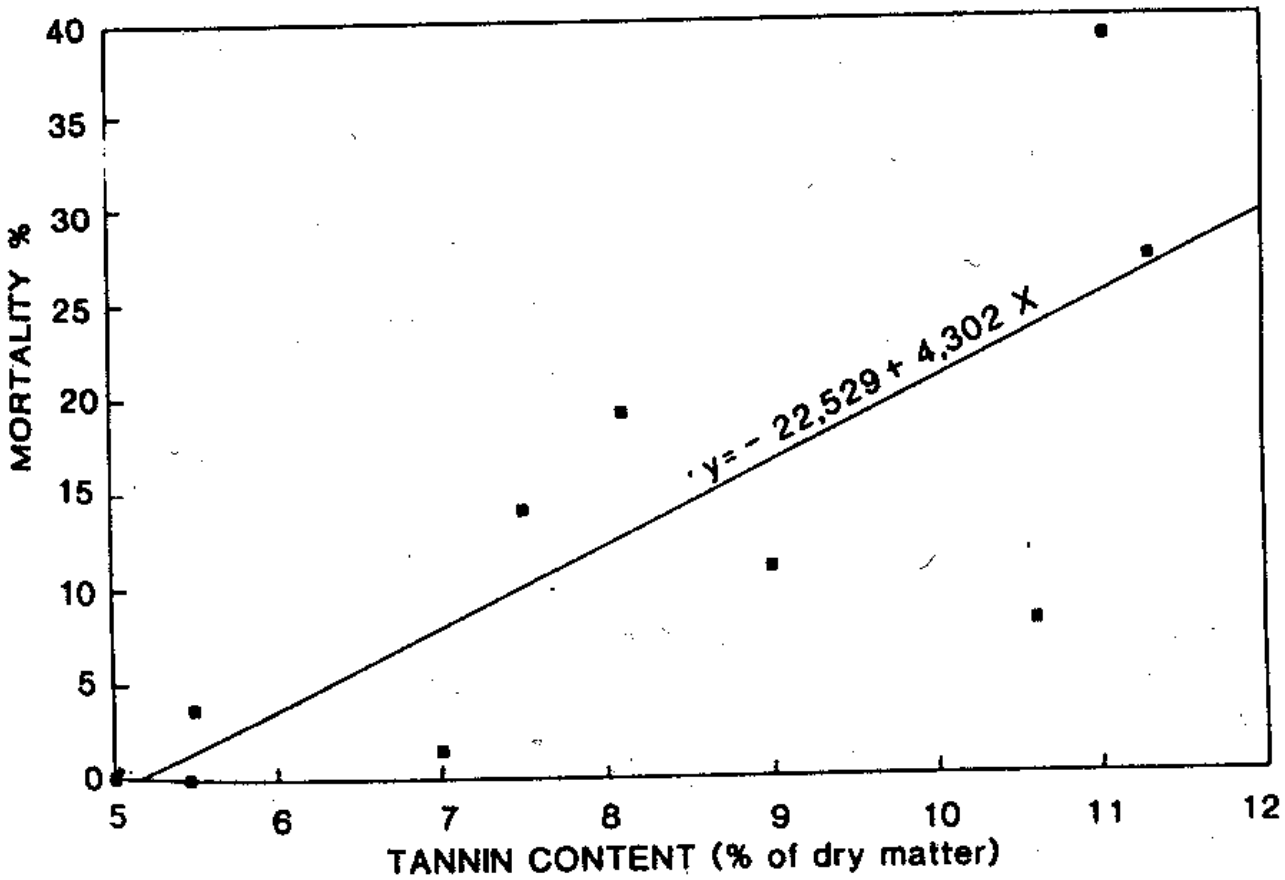
Tannins are feeding deterrents.

They occur in browse (leaves).

They deter feeding by reducing digestive efficiency and by toxicity.

Mortalities in kudu (*Tragelaphus strepsiceros*) populations related to chemical defence in trees

Wouter van HOVEN



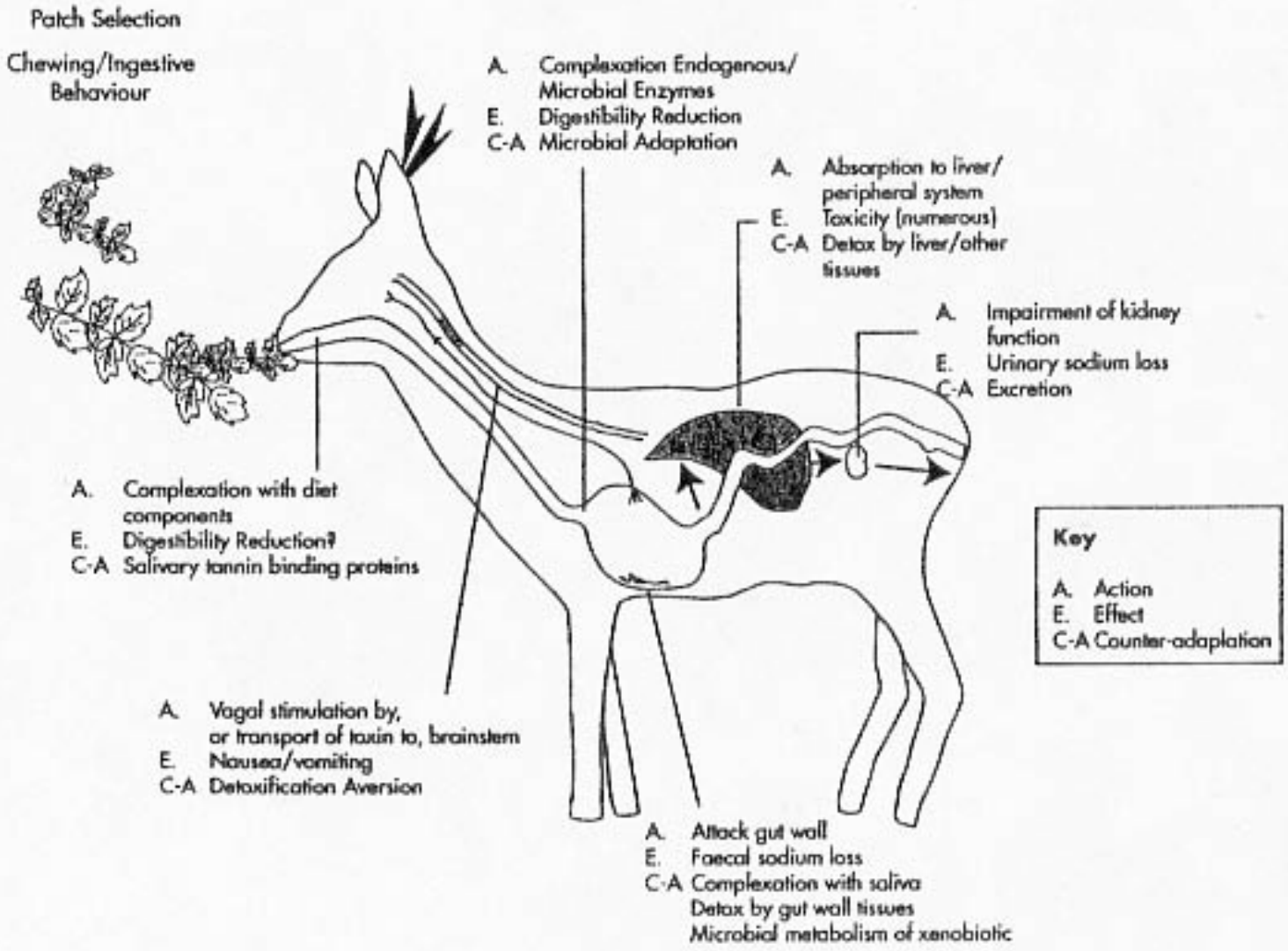


Figure 6. A summary of actions, effects, and counter-adaptations of plant secondary metabolites (PSM) in mammalian herbivores.

from Foley et al. (1999)

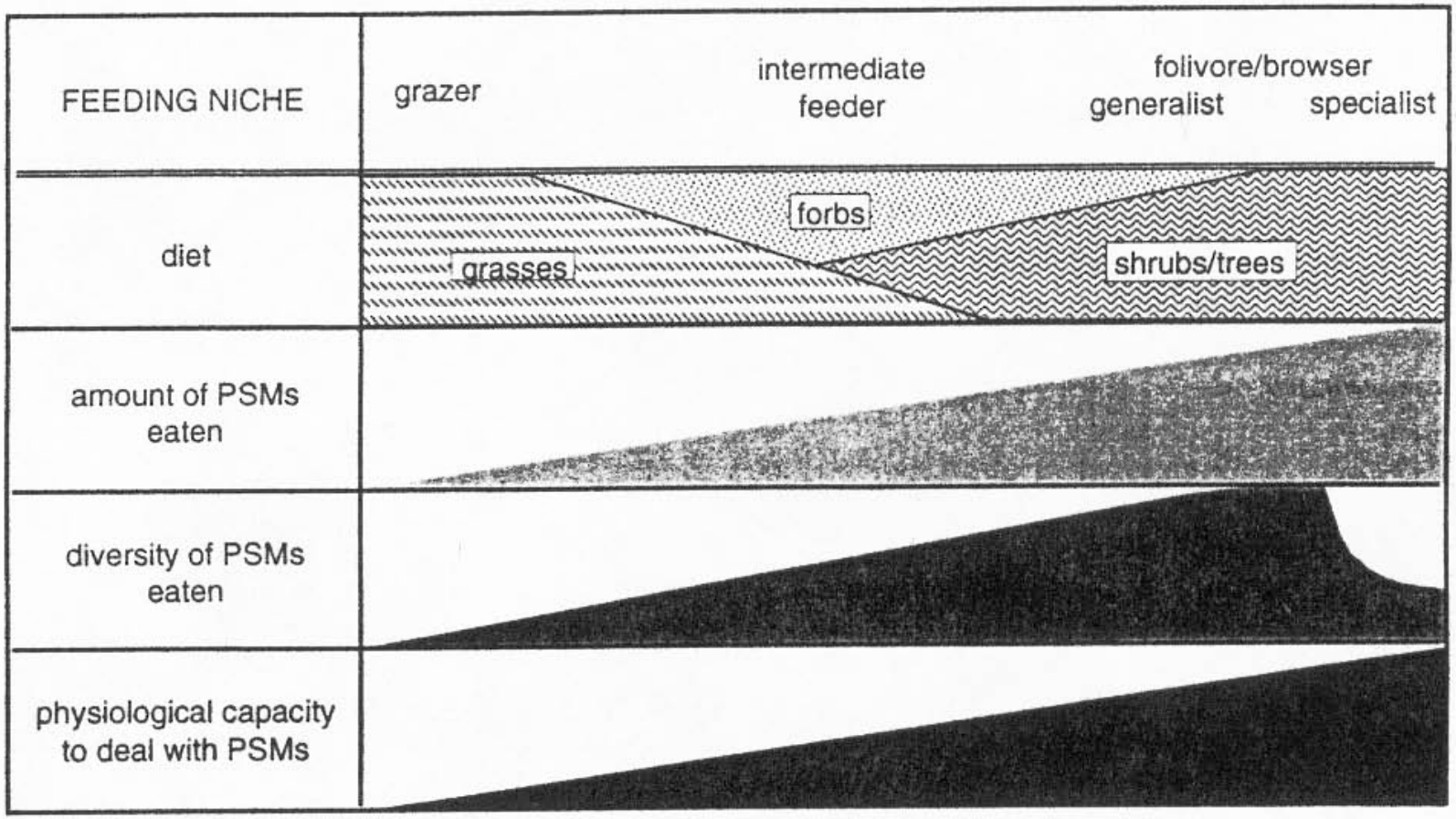


Figure 1. Relationships between feeding niche, diet, amount, and diversity of plant secondary metabolites (PSM) eaten, and the physiological capacity of the herbivore to deal with them.

from Foley et al. (1999)

How plants fight back

Eating plants is all about predators making easy meals of passive greenery—or is it? plants have evolved ways of discouraging those who would eat them

Stephen Young

Trees can communicate with each other

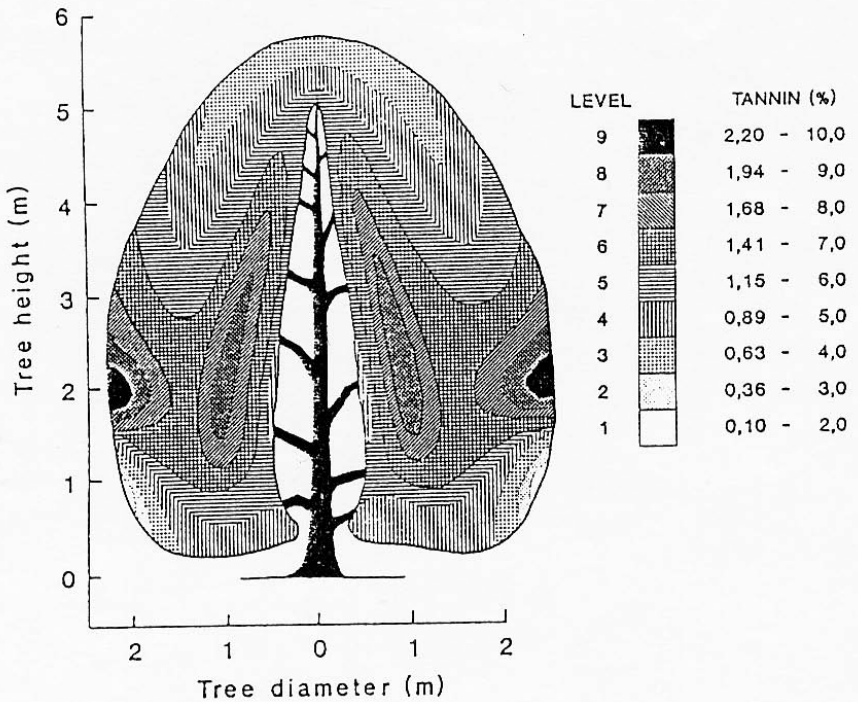
Can one tree warn another tree that it is about to be eaten? It would seem so.

Trees' secret warning system against browsers

Prof. Wouter van Hoven
University of Pretoria

Condensed tannin as anti-defoliate agent against browsing by giraffe (*Giraffa camelopardalis*) in the Kruger National Park

D. Furstenburg and W. van Hoven



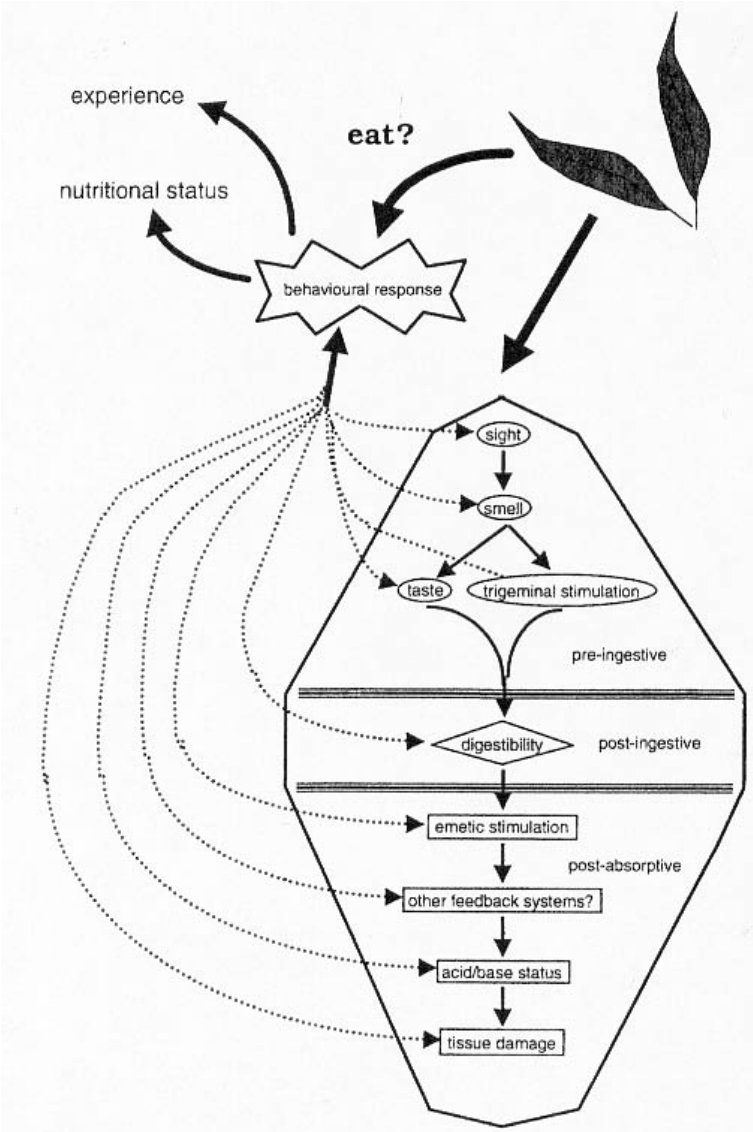


Figure 5. Proposed series of steps in a mammalian herbivore that may enable feedback leading to a decision to either eat or not eat a particular plant food.

from Foley et al. (1999)

Ecological Studies

Duiker	do not seem to avoid tannins	Müller et al. (1998)
Duiker	do not avoid tannins	Faurie and Perrin (1993)
Roe deer	do not avoid tannins	Tixier et al. (1997)
Mule deer and b lack -tailed deer	do not avoid tannins	McArthur et al. (1993)
Greater kudu	avoid tannins	Cooper and Owen -Smith (1985), Cooper et al. (1988)
Giraffe	avoid tannins	Furstenburg and van Hoven (1994)
Impala	avoid tannins	Cooper and Owen -Smith (1985) , Cooper et al. (1988)
Goat	avoid tannins	Cooper and Owen -Smith (1985)
Cattle	avoid tannins	Wilkins et al. (1953), Donnelly (1954)
African buffalo	avoid tannins	Field (1976)

Mouse lemur	avoid tannins	Ganzhorn (1988)
Greater dwarf lemur	do not avoid tannins	Ganzhorn (1988)
Brown lemur	do not avoid tannins	Ganzhorn (1988)
Eastern woolly lemur	do not avoid tannins	Ganzhorn et al. (1985)
Indri	do not avoid tannins	Ganzhorn (1988)
Howler monkey	avoid tannins	Glander (1981)
Marmosets	avoid tannins	Simmen (1994)
Vervet monkey	avoid tannins	Wrangham and Waterman (1981)
Rhesus monkey	avoid tannins	Marks et al. (1987)
Baboons	avoid phenolics	Barton and Whiten (1994)
Guereza	avoid tannins	Oates et al. (1977)
Black colobus monkey	avoid tannins	McKey et al. (1981)
Orangutan	avoid tannins	Leighton (1993)
Gorilla	do not avoid tannins	Calvert 1985
Chimpanzees	avoid tannins	Wrangham and Waterman (1983)

Ecological Studies

Duiker	do not seem to avoid tannins	Müller et al. (1998)
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Goat	avoid tannins	Cooper and Owen -Smith (1985)
Cattle	avoid tannins	Wilkins et al. (1953), Donnelly (1954)
African buffalo	avoid tannins	Field (1976)

All these animals will try to minimize tannin intake. However, most cannot avoid them completely!

Mouse lemur	avoid tannins	Ganzhorn (1988)
Greater dwarf lemur	do not avoid tannins	Ganzhorn (1988)
Brown lemur	do not avoid tannins	Ganzhorn (1988)
Eastern woolly lemur	do not avoid tannins	Ganzhorn et al. (1985)
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Orangutan	avoid tannins	Leighton (1993)
Gorilla	do not avoid tannins	Calvert 1985
Chimpanzees	avoid tannins	Wrangham and Waterman (1983)

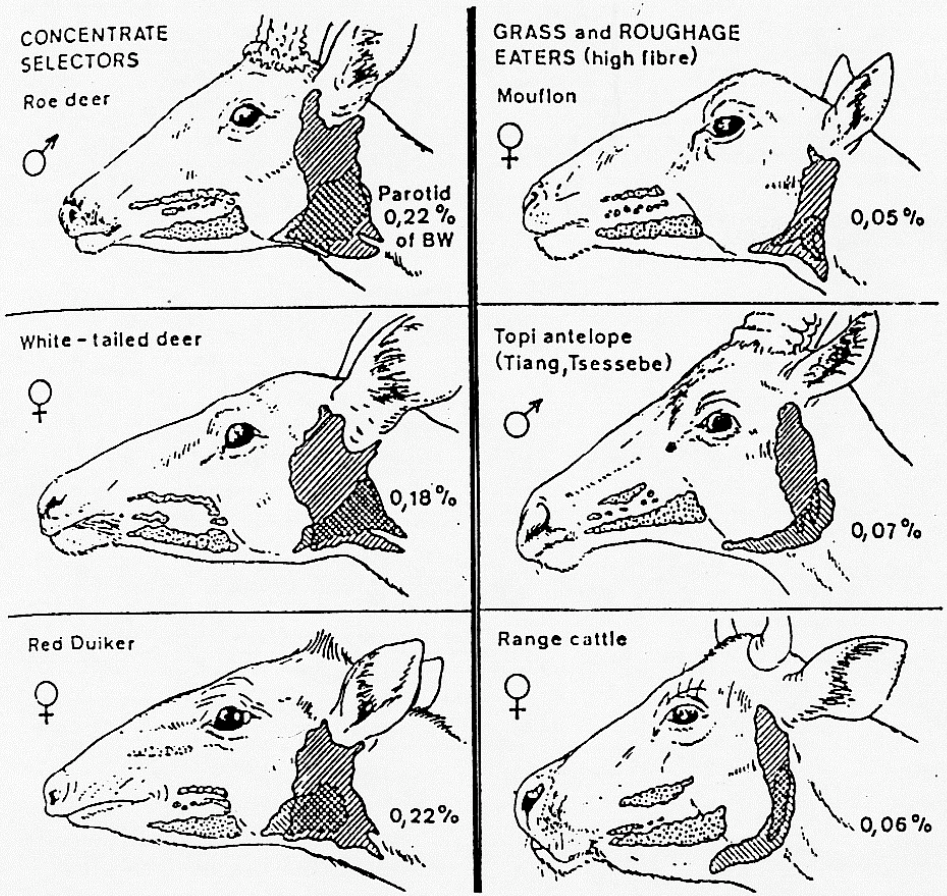
Tannins are part of the natural diet of many animals.

TANNIN-BINDING PROTEINS IN SALIVA OF DEER AND THEIR ABSENCE IN SALIVA OF SHEEP AND CATTLE

PAUL J. AUSTIN,[1] LISA A. SUCHAR,[1] CHARLES T. ROBBINS,[2] and ANN E. HAGERMAN[1]

Evolutionary steps of ecophysiological adaptation and diversification of ruminants: a comparative view of their digestive system*,**

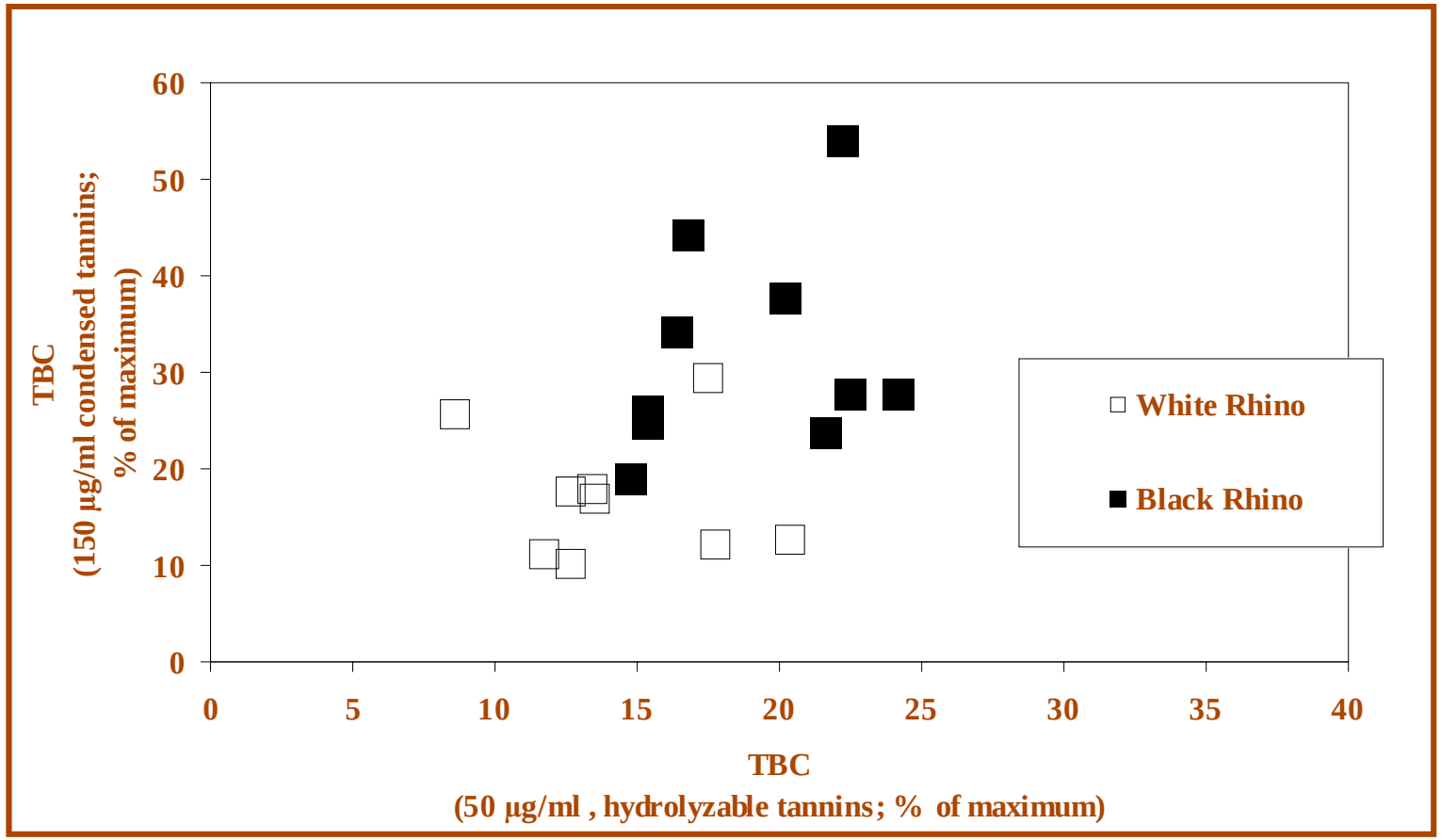
R.R. Hofmann



Salivary tannin-binding proteins

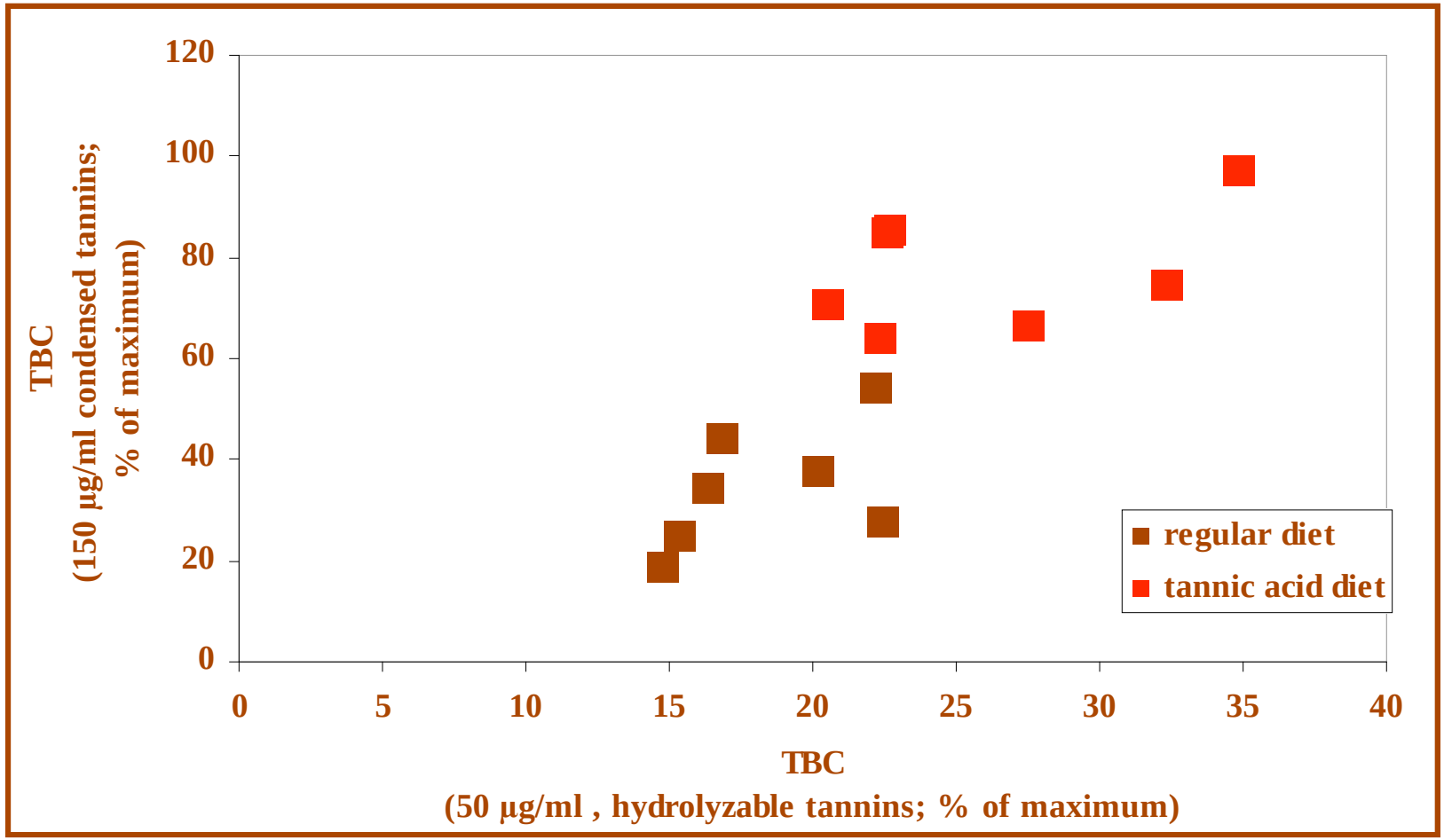
Species	Source
Swamp wallabies (*W bicolor*)	McArthur et al. (1995)
Pademelon (*Thylogale thetis*)	McArthur et al. (1995)
Humans (*Homo sapiens*)	McArthur et al. (1995), Charlton et al. (1996), Bacon and Rhoades (1998)
Mouse (*Mus musculus*)	Mehansho et al. (1985), Asquith et al. (1985)
Rat (*Rattus norvegicus*)	Mehansho et al. (1983), Jansman et al. (1994)
Root vole (*Microtus oeconomus*)	Juntheikki et al. (1996)
Beaver (*Castor canadensis*)	Hagerman and Robbins (1993)
Pika (*Ochotona princeps*)	Dearing (1997)
Rabbit (*Oryctolagus c uniculus*)	Mole et al. (1990)
Mountain hare	McArthur et al. (1995)
Hare (*Lepus timidus*)	Mole et al. (1990)
Black bear (*Ursus americanus*)	Hagerman and Robbins (1993)
Camel (*Camelus dromedarius*)	Schmidt-Witty et al. (1994)
Roe deer (*Capreolus capreolus*)	Fickel et al. (1998)
White-tailed deer (*Odocoileus virginianus*)	Robbins et al. (1987b), Mole et al. (1990)
Mule deer (*Odocoileus hemionus*)	Austin et al. (1989), Robbins et al. (1987b), Hagerman and Robbins (1993)
Moose (*Alces alces*)	Hagerman and Robbins (1993), Juntheikki (1996)

Salivary tannin-binding proteins in rhinos



from Clauss et al. (subm.)

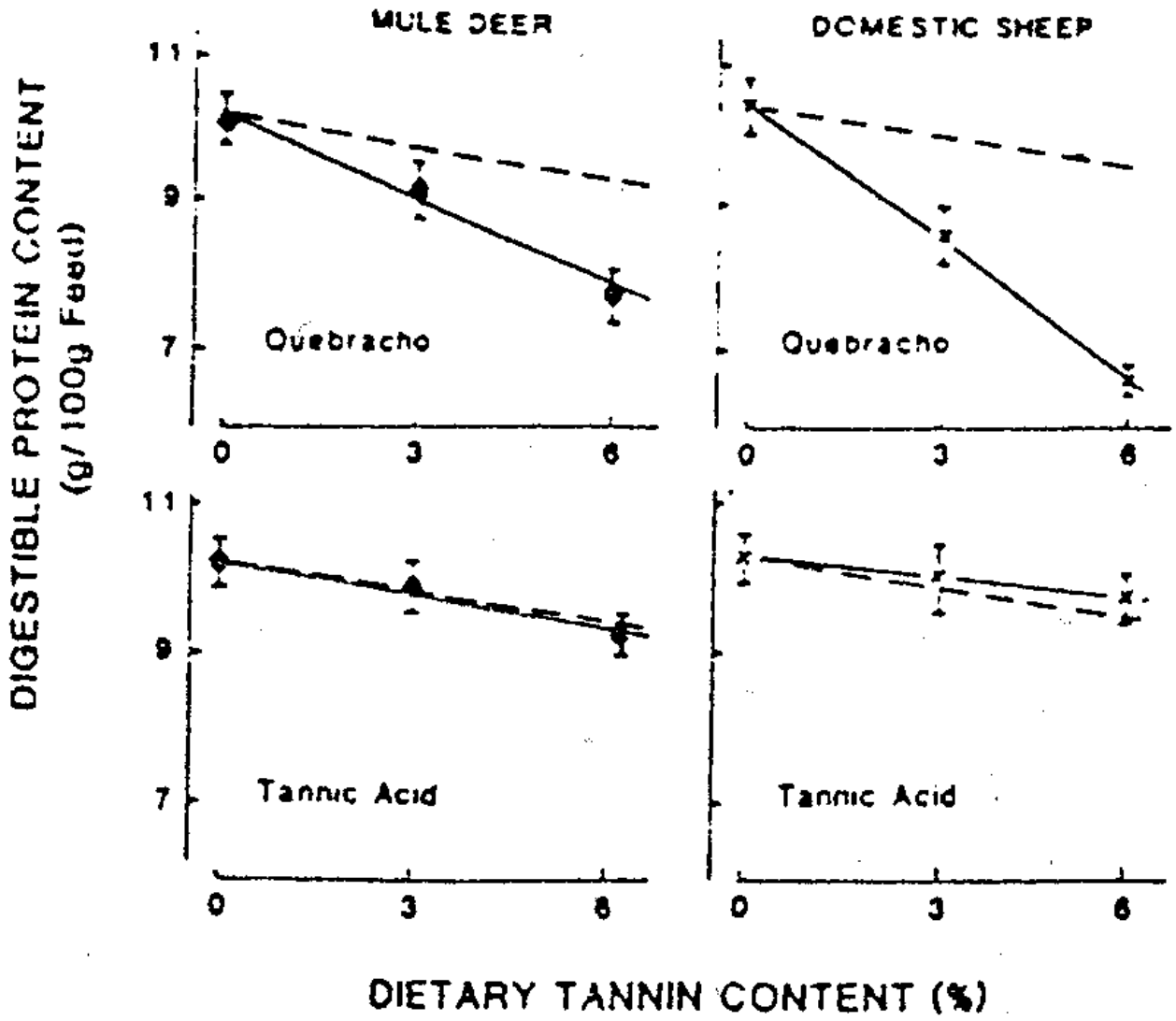
Salivary tannin-binding proteins in black rhinos



from Clauss et al. (subm.)

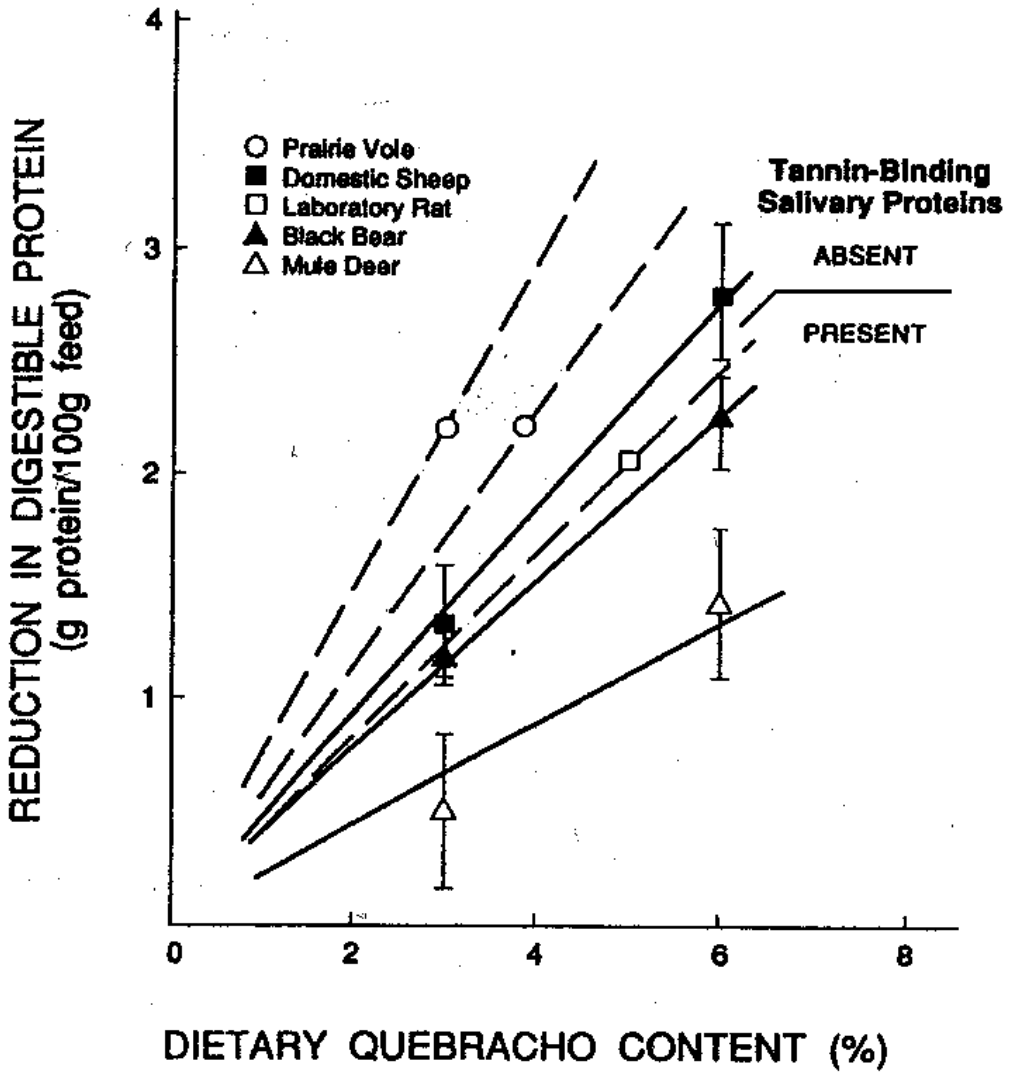
Tannin chemistry in relation to digestion

ANN E. HAGERMAN, CHARLES T. ROBBINS, YOHAN WEERASURIYA, THOMAS C. WILSON, CLARE MCARTHUR



VARIATION IN MAMMALIAN PHYSIOLOGICAL RESPONSES TO A CONDENSED TANNIN AND ITS ECOLOGICAL IMPLICATIONS

C. T. Robbins, A. E. Hagerman, P. J. Austin, C. McArthur, and T. A. Hanley



Medical Hypotheses (1999) 52(5), 479–481
© 1999 Harcourt Brace & Co. Ltd
Article No. mehy.1997.0686

Flavonoids and tannins: plant-based antioxidants with vitamin character

A. Hässig, W. X. Liang, H. Schwabl, K. Stampfli

Wld Rev. Nutr. Diet., vol. 24, pp. 117–191
(Karger, Basel 1976)

The Flavonoids. A Class of Semi-Essential Food Components: Their Role in Human Nutrition

Joachim Kühnau

Flavonoid Intake and Long-term Risk of Coronary Heart Disease and Cancer in the Seven Countries Study

Michaël G. L. Hertog, PhD; Daan Kromhout, PhD; Christ Aravanis, MD; Henry Blackburn, MD; Ratko Buzina, MD; Flaminio Fidanza, MD; Simona Giampaoli, MD; Annemarie Jansen, RD; Alessandro Menotti, MD; Srecko Nedeljkovic, MD; Maija Pekkarinen, PhD; Bozidar S. Simic, MD; Hironori Toshima, MD; Edith J. M. Feskens, PhD; Peter C. H. Hollman, MSc; Martijn B. Katan, PhD

Tea Consumption. Relationship to Cholesterol, Blood Pressure, and Coronary and Total Mortality[1]

Inger Stensvold, M.Sc.,*,2 Aage Tverdal, Ph.D.,* Kari Solvoll, B.Sc,† and Olav Per Foss, M.D.‡

Dietary antioxidant flavonoids and risk of coronary heart disease: the Zutphen Elderly Study

Michaël G L Hertog, Edith J M Feskens, Peter C H Hollman, Martijn B Katan, Daan Kromhout

Flavonoid intake and coronary mortality in Finland: a cohort study

Paul Knekt, Ritva Järvinen, Antti Reunanen, Jouni Maatela

Association of Serum Lipoproteins and Health-Related Habits with Coffee and Tea Consumption in Free-Living Subjects Examined in the Israeli CORDIS Study[1,2]

Manfred S. Green, M.D., Ph.D.,[3] and Gil Harari, B.Sc.

Antioxidant flavonols and ischemic heart disease in a Welsh population of men: the Caerphilly Study[1–3]

Michaël GL Hertog, Peter M Sweetnam, Ann M Fehily, Peter C Elwood, and Daan Kromhout

Coffee and tea consumption and the prevalence of coronary heart disease in men and women: results from the Scottish Heart Health Study

C A Brown, C Bolton-Smith, M Woodward, H Tunstall-Pedoe

Wine, alcohol, platelets, and the French paradox for coronary heart disease

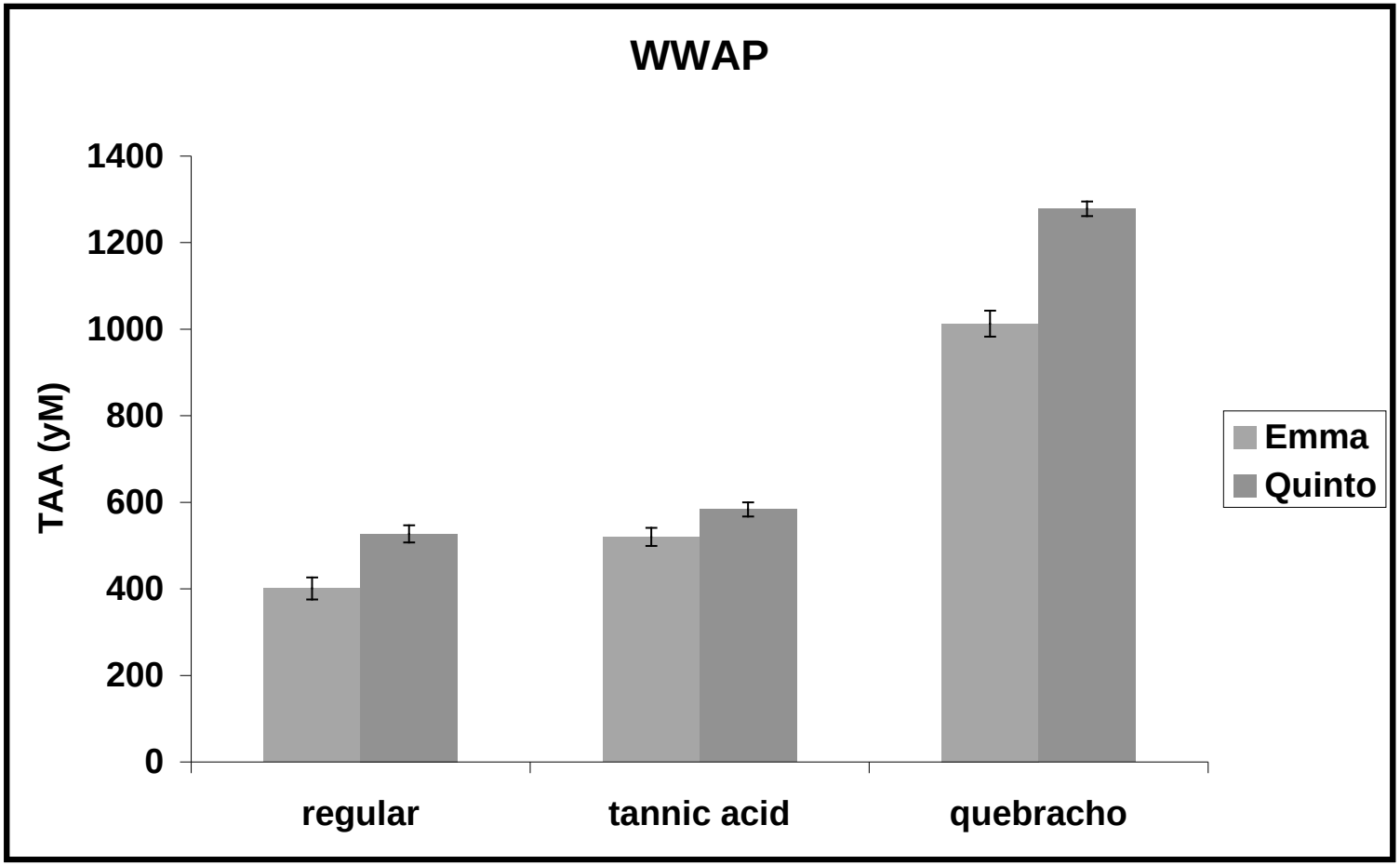
S. Renaud M. de Lorgeril

Tannins can function as antioxidants.

Phenolic substance can be absorbed from the gut and support other antioxidants within the body.

Even if not absorbed, phenolic substances can protect other antioxidnts from being oxidized in the gut and thereby increase their availability.

Black rhino feeding trials



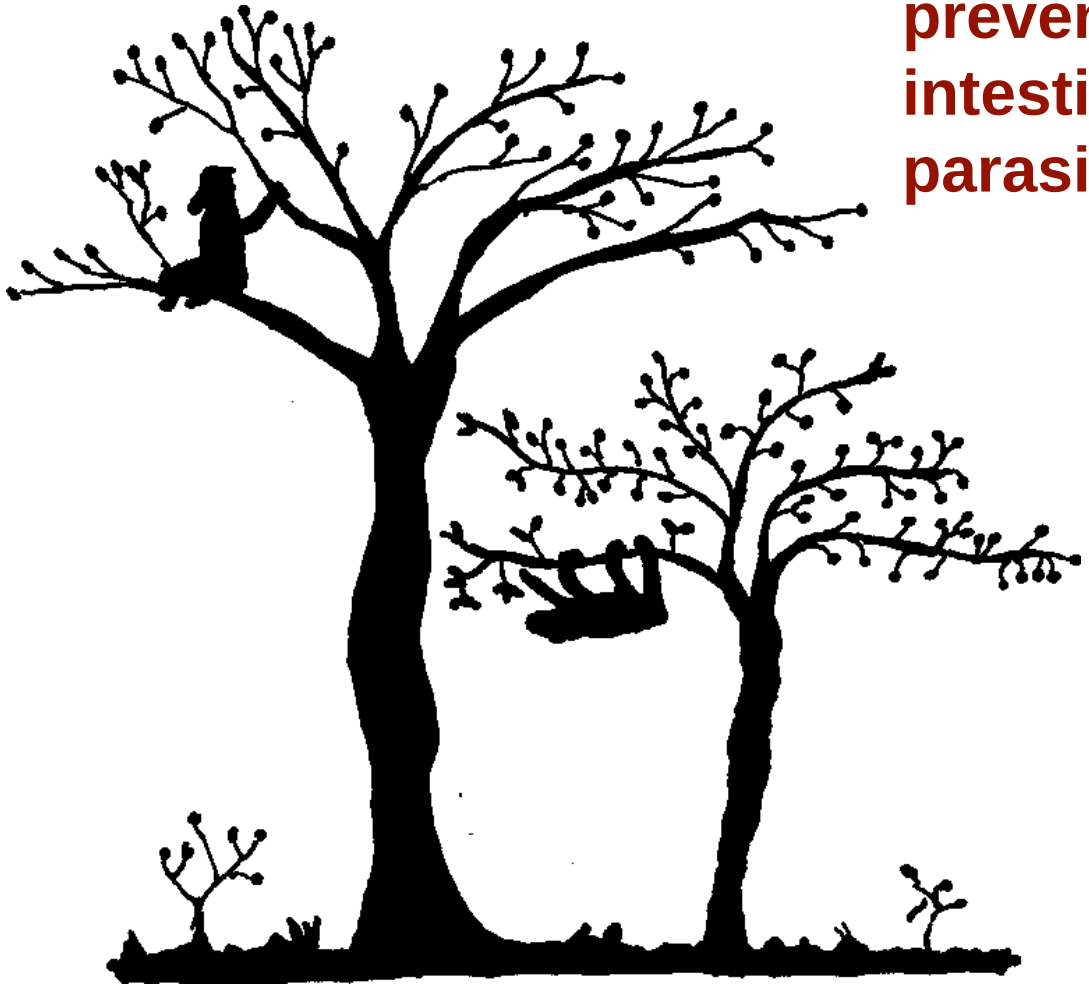
from Clauss et al. (in prep.)

In several captive animal species, low antioxidant status has been reported.

Roe deer have been suspected to be dependent on vitamin C intake in captivity. Enteritic disorders in roe deer have been cured by high dosages of vitamin C alone.

Tannins prevent bloat.

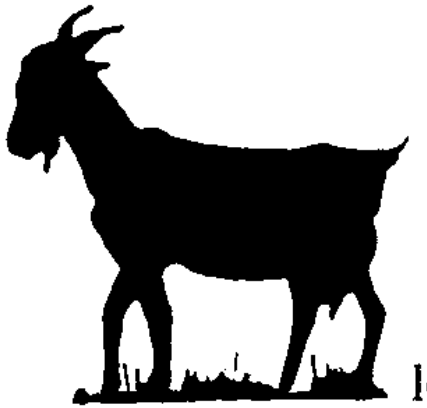
Do foregut-fermenting arboreal folivores depend on tannins to prevent bloat and control intestinal bacteria and parasites?



Tannins have anthelmintic properties.

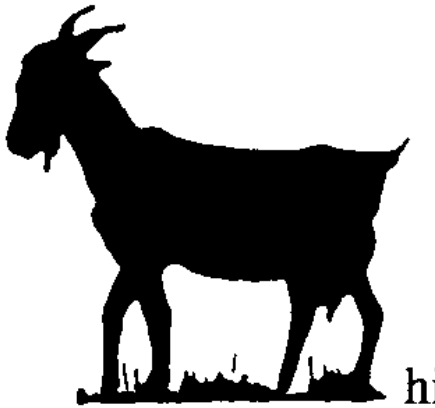
Antiparasitic Effect of Tannins

tannin-containing
browse



low fecal
egg count

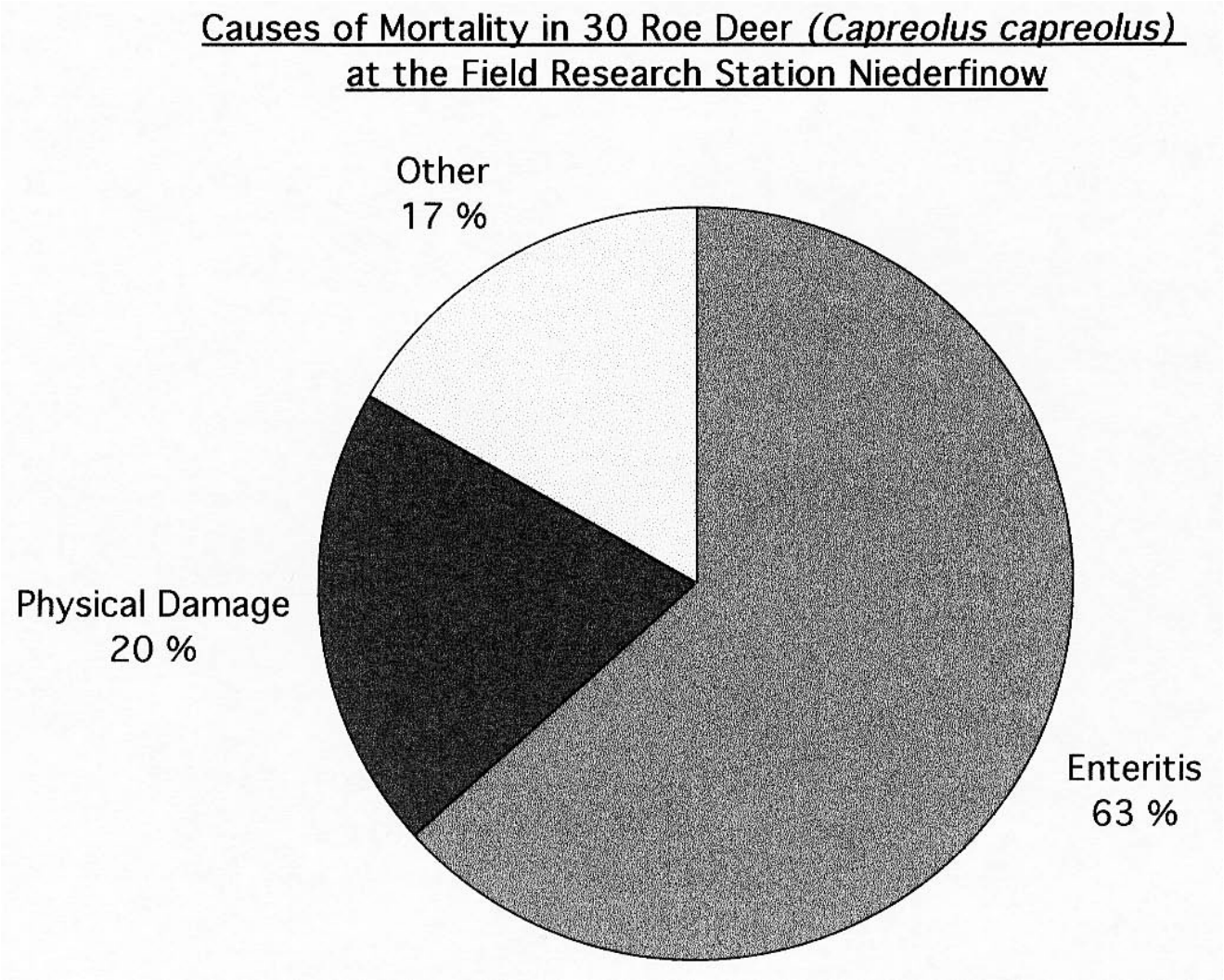
tannin-containing
browse +
tannin-inactivating
PEG



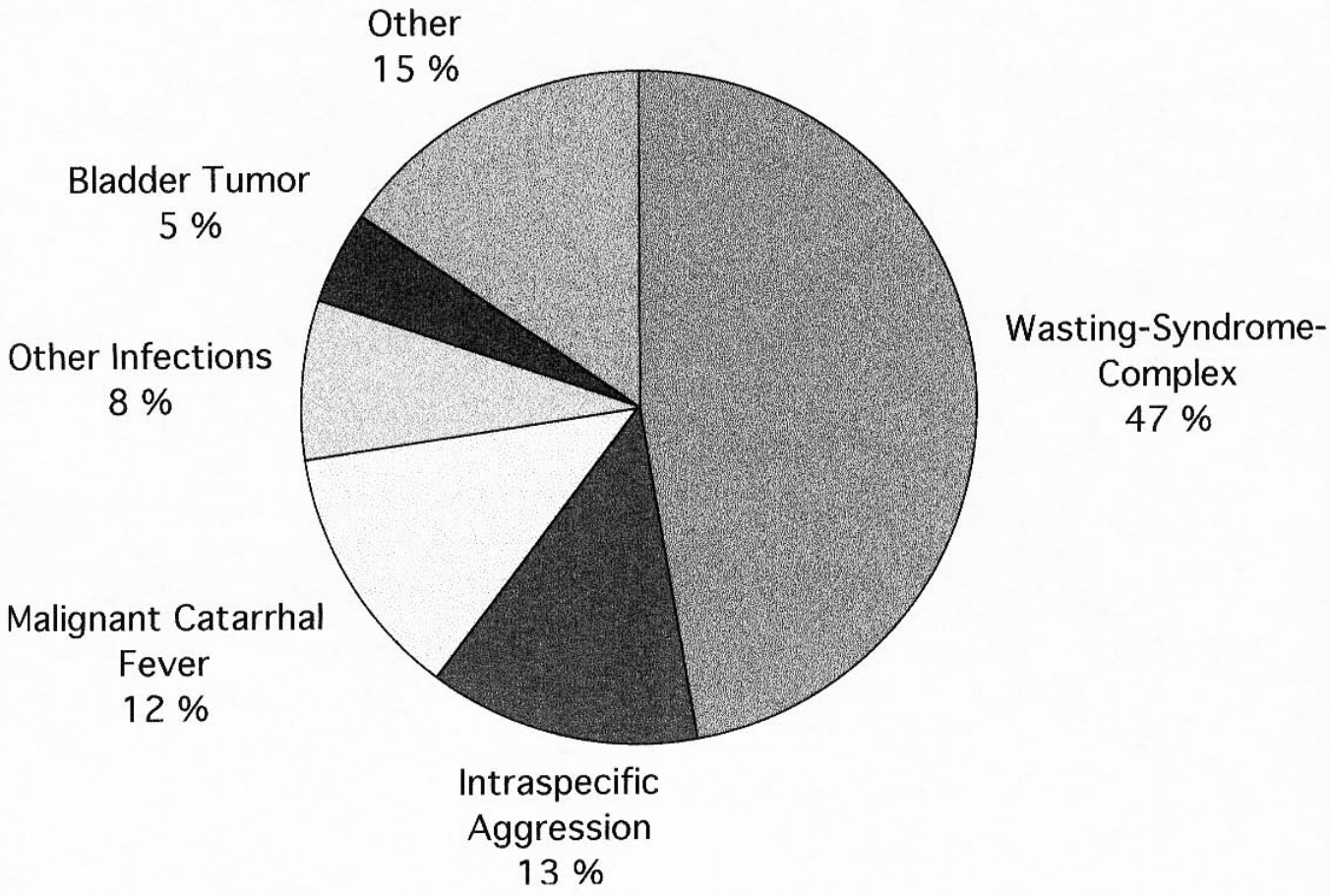
high fecal
egg count

from Kabasa et al. (1999)

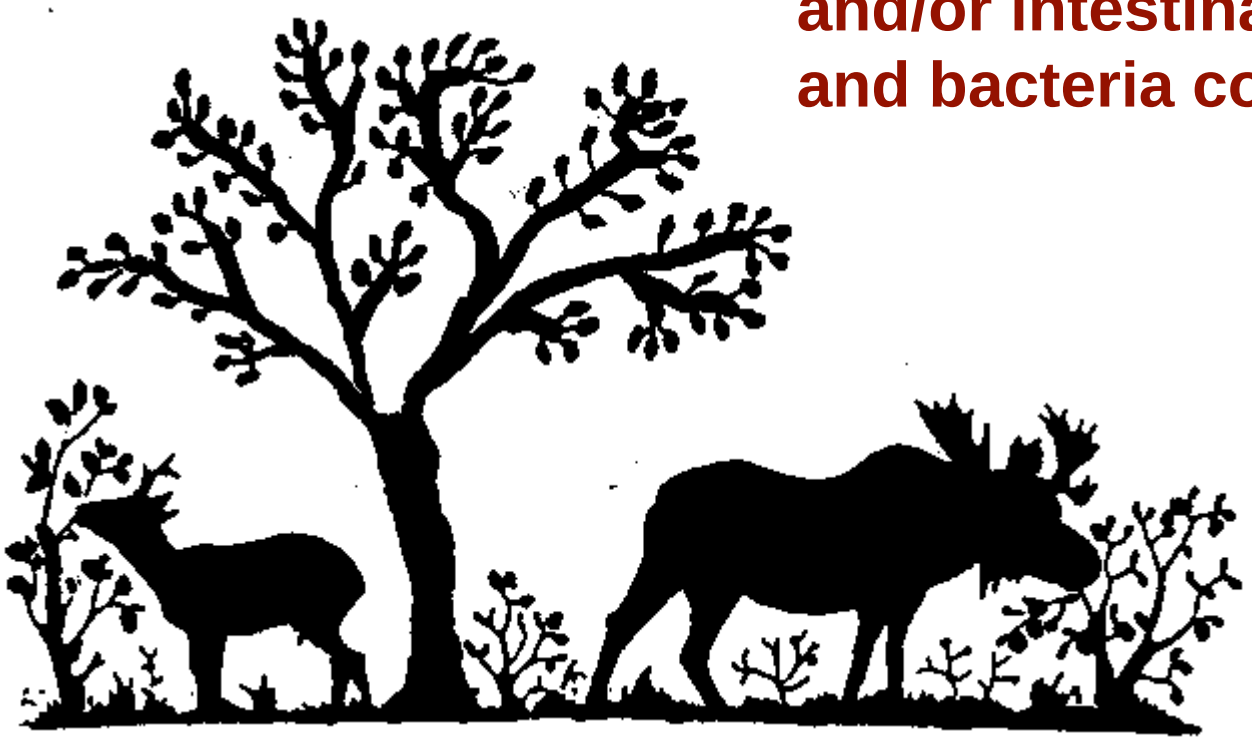
Tannins have antibacterial properties against a wide range of bacteria, including potential gastrointestinal pathogens.


Causes of Mortality in 30 Roe Deer (Capreolus capreolus)
at the Field Research Station Niederfinow
Other
17 %
Physical Damage
20 %
Enteritis
63 %

Causes of Mortality in 131 Moose *(Alces alces)* in German Zoos & Wildlife Parks



Are browsing ruminants dependent on phenolic plant substances for their antioxidant supply and/or intestinal parasite and bacteria control?



If so, by what mechanisms did grazing ruminants become independent of phenolic plant substances?

Tannins reduce the availability of dietary iron.

Zoo Biology 8:239–251 (1989)

Pathogenesis of Hemosiderosis in Lemurs: Role of Dietary Iron, Tannin, and Ascorbic Acid

Lucy H. Spelman, Kent G. Osborn, and Marilyn P. Anderson

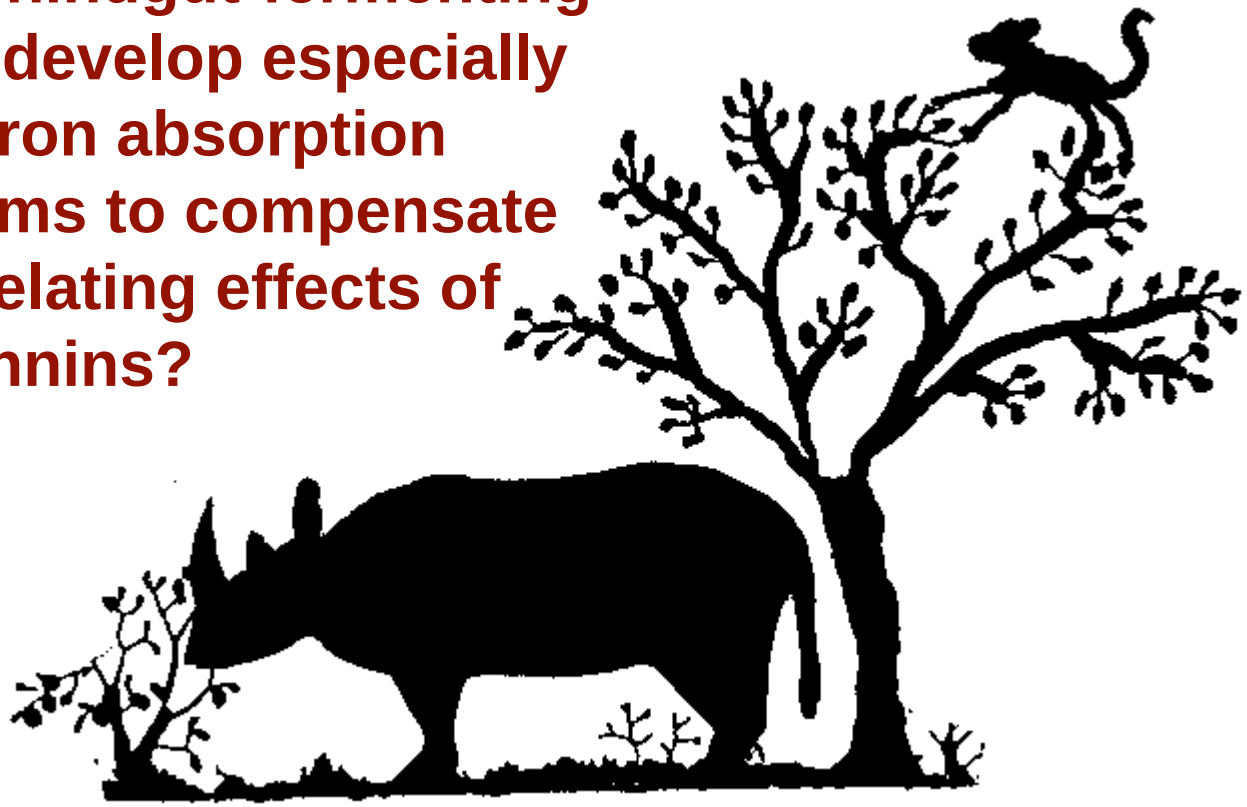
Department of Pathology, Center for Reproduction of Endangered Species, Zoological Society of San Diego, San Diego, California

ROLE OF CHRONIC IRON OVERLOAD IN MULTIPLE DISORDERS OF CAPTIVE BLACK RHINOCEROSES *(Diceros bicornis)*

Donald E. Paglia, MD[1] and Pam Dennis, DVM[2]*

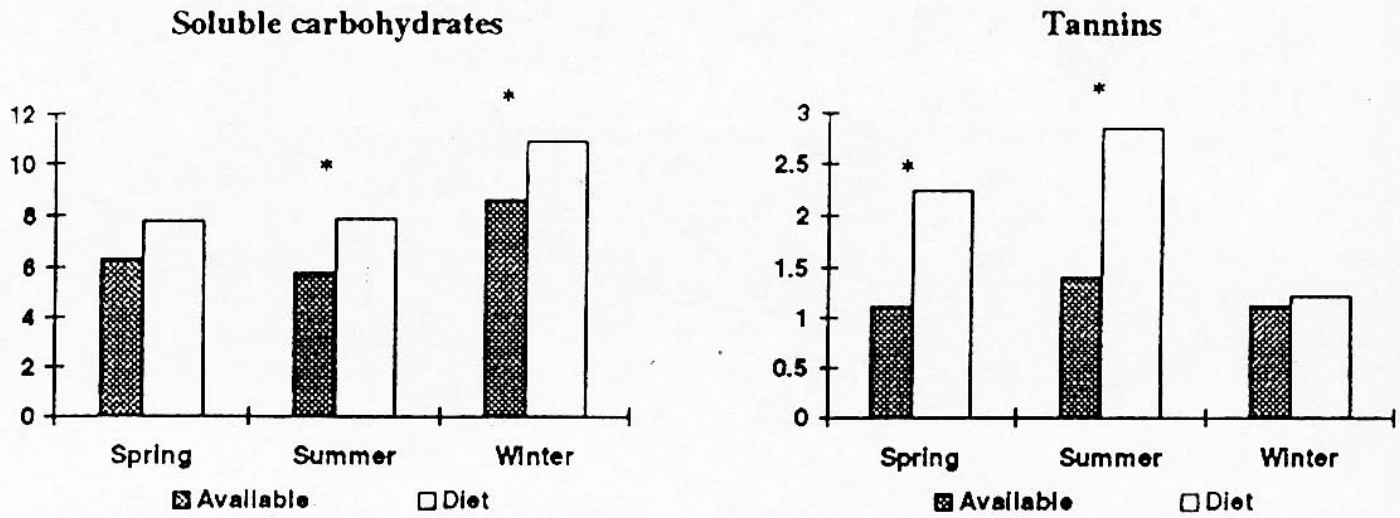
[1]Hematology Research Laboratory, Department of Pathology & Laboratory Medicine, UCLA School of Medicine, 10833 LeConte Avenue, Los Angeles CA 90095-1732 USA; [2]Department of Wildlife and Zoological Medicine, University of Florida College of Veterinary Medicine, PO Box 100126, Gainesville FL 32610 USA

Did some hindgut-fermenting browsers develop especially effective iron absorption mechanisms to compensate for the chelating effects of dietary tannins?



Is there a tannin “requirement” for certain species?

What´s in a (free-ranging) roe deer´s diet?



from Tixier et al. (1997)

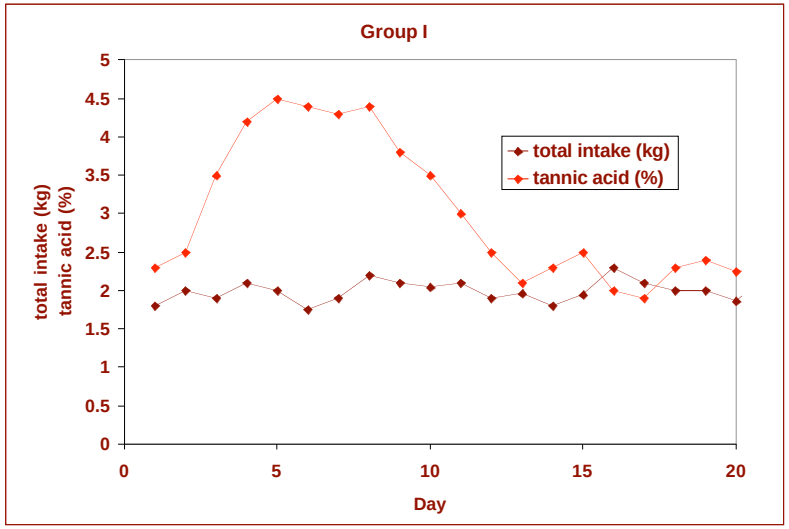
ROE DEER CHOOSE TO INCLUDE SMALL AMOUNTS OF TANNINS IN THEIR DIET

Hélène VERHEYDEN-TIXIER[1], Patrick DUNCAN[2] and Nadine GUILLON[2]

Roe deer preference trials

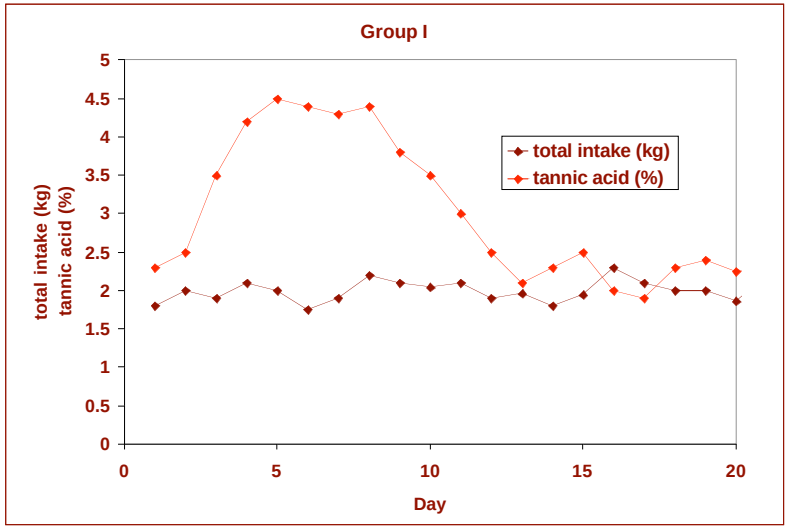
from Clauss et al. (2003)

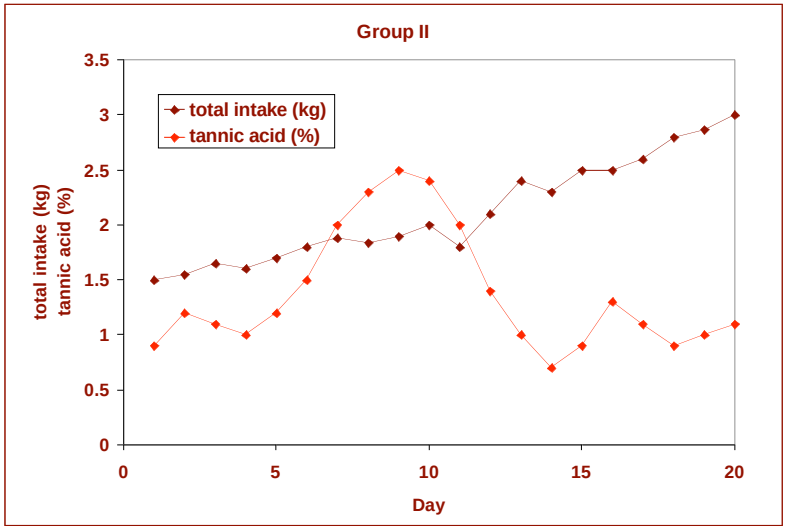
Roe deer preference trials



from Clauss et al. (2003)

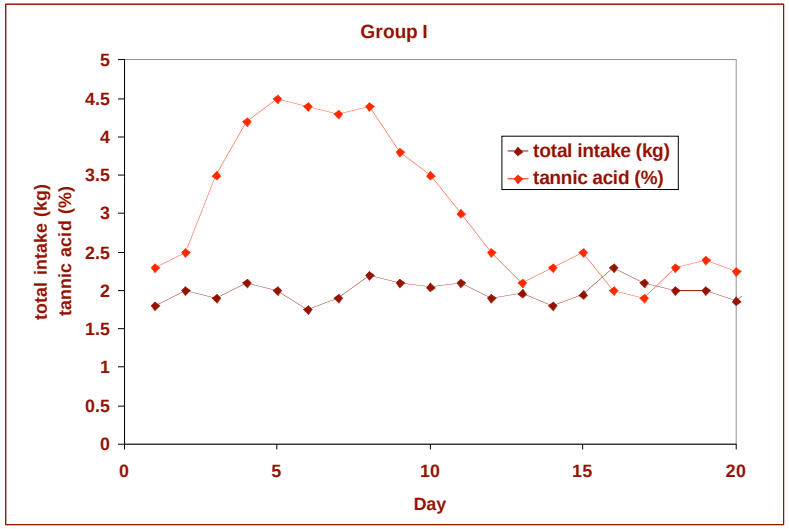
Roe deer preference trials

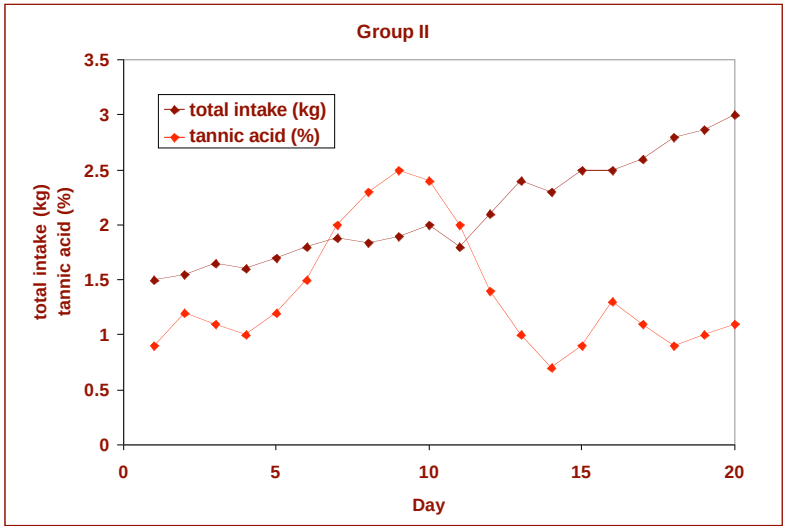


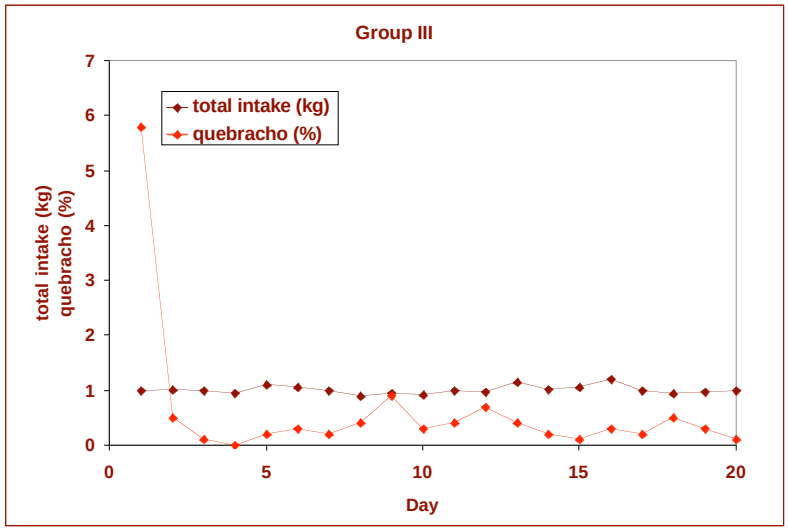


from Clauss et al. (2003)

Roe deer preference trials

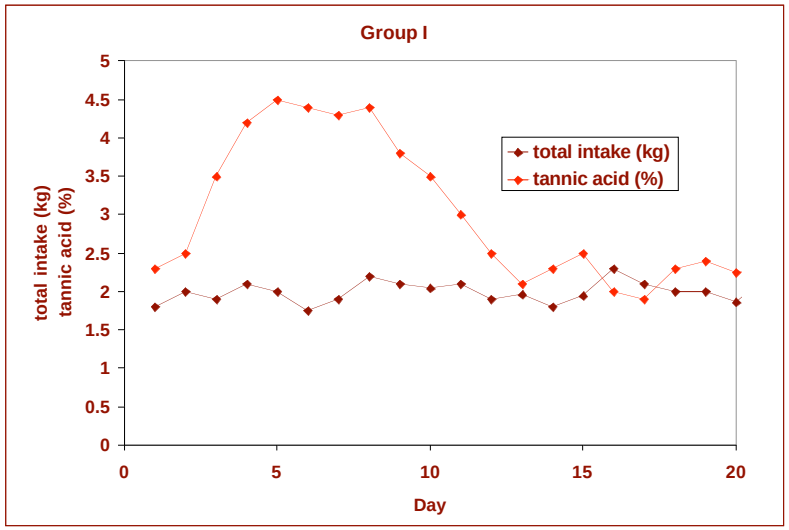


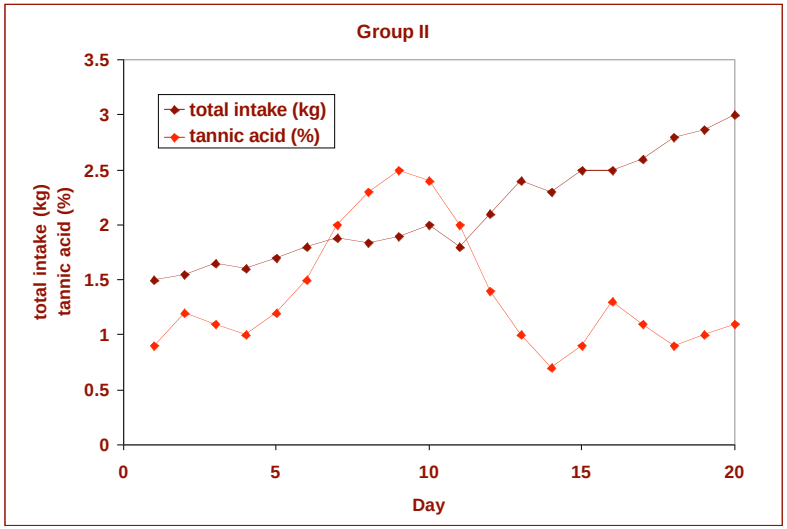


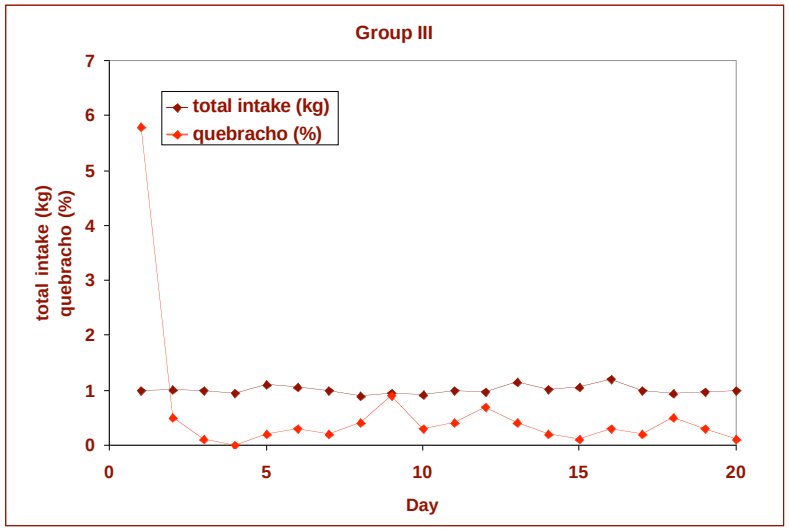


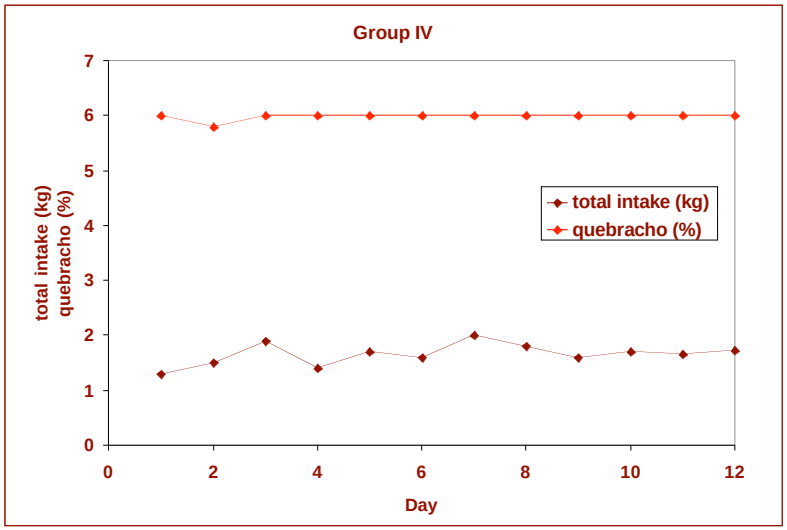
from Clauss et al. (2003)

Roe deer preference trials



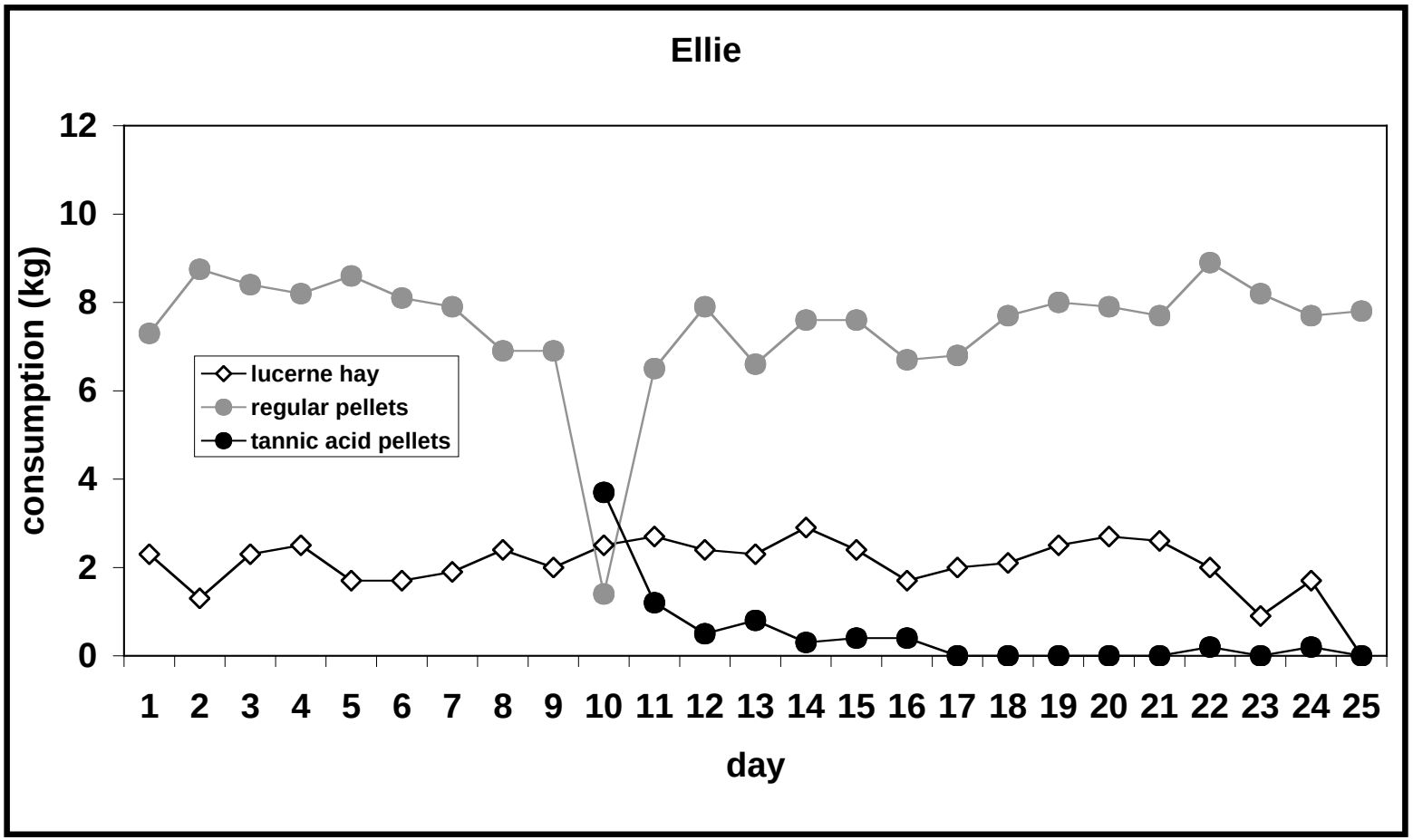






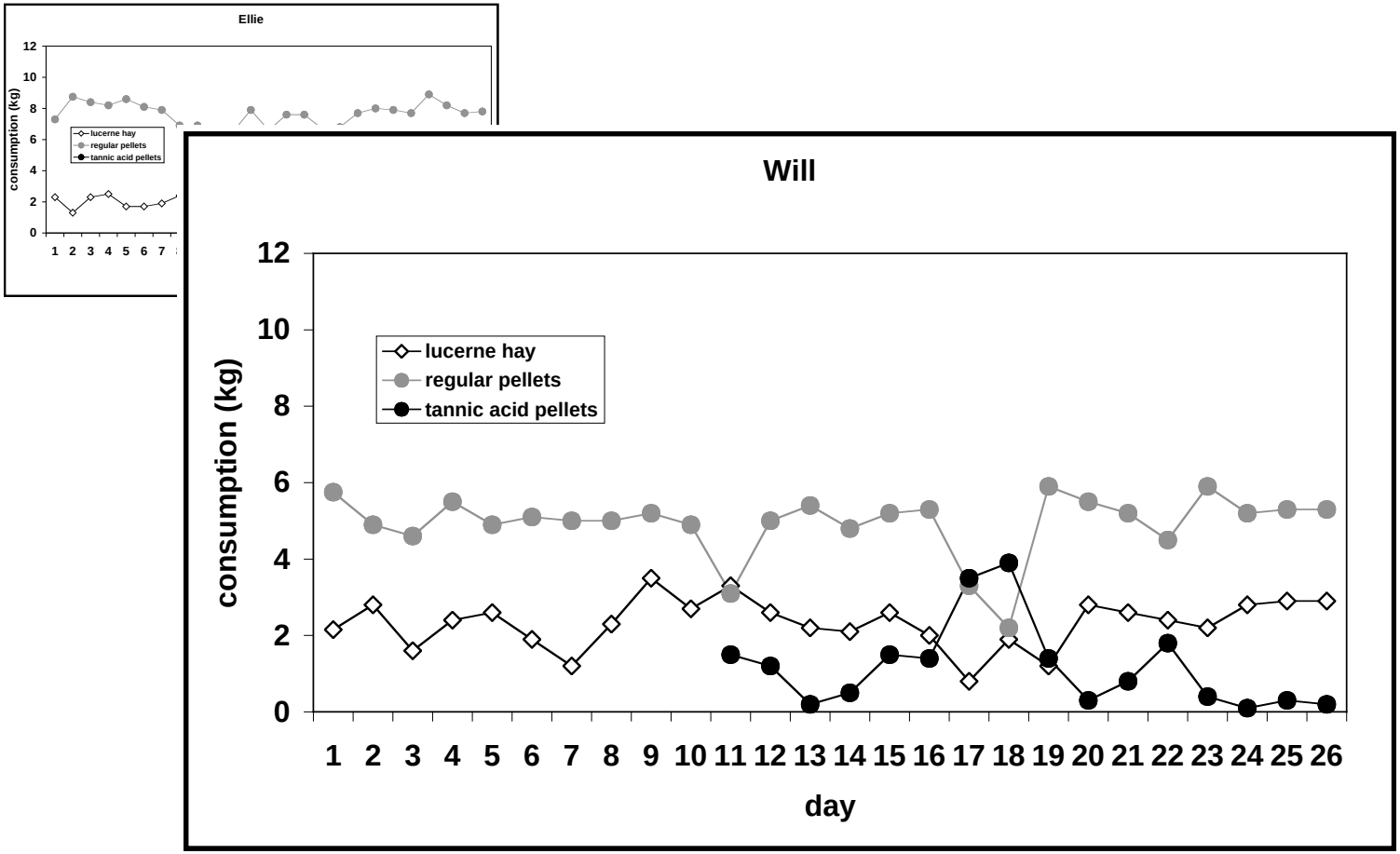
from Clauss et al. (2003)

Giraffe preference trials



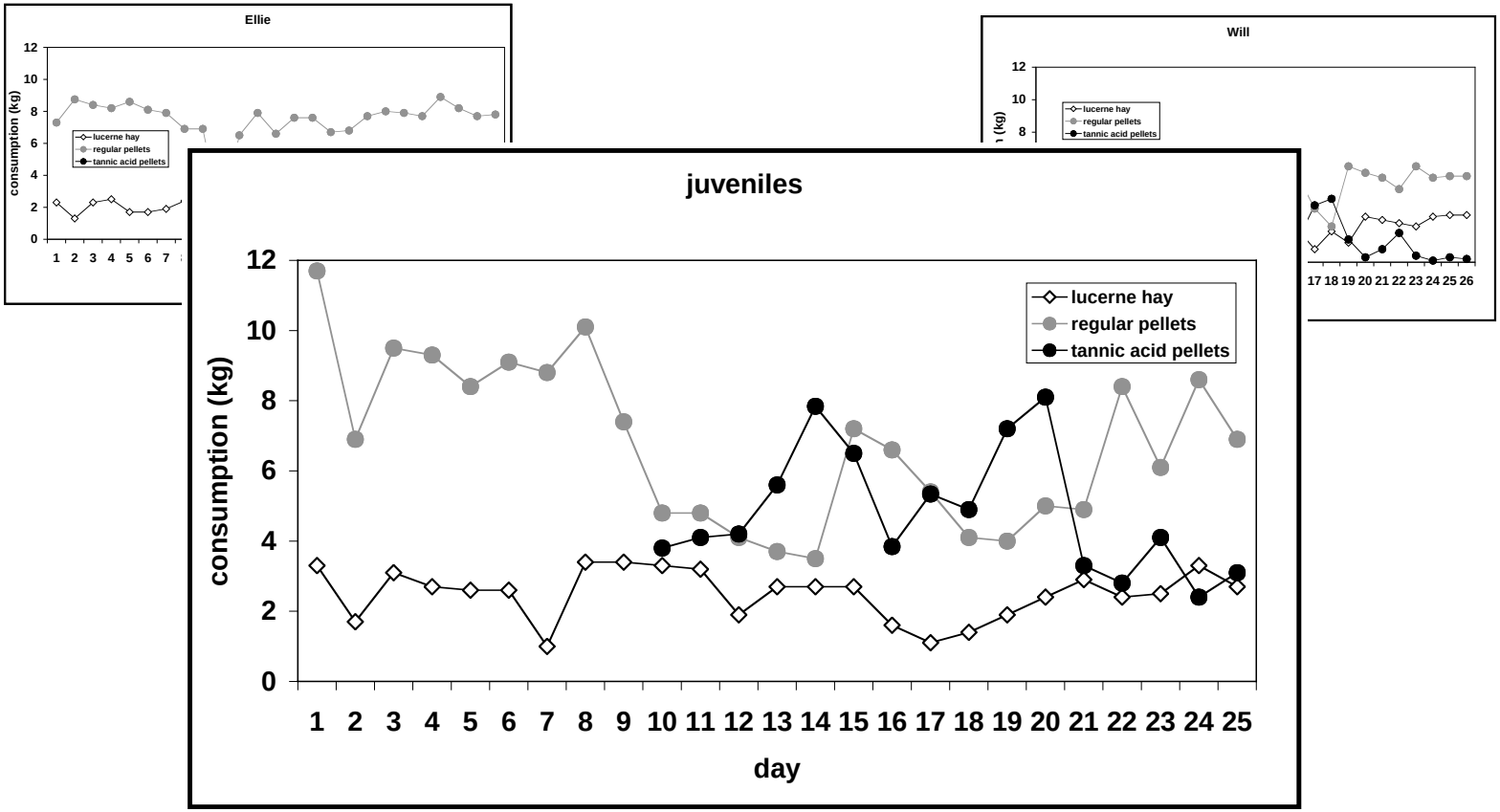
from Clauss et al. (2002)

Giraffe preference trials



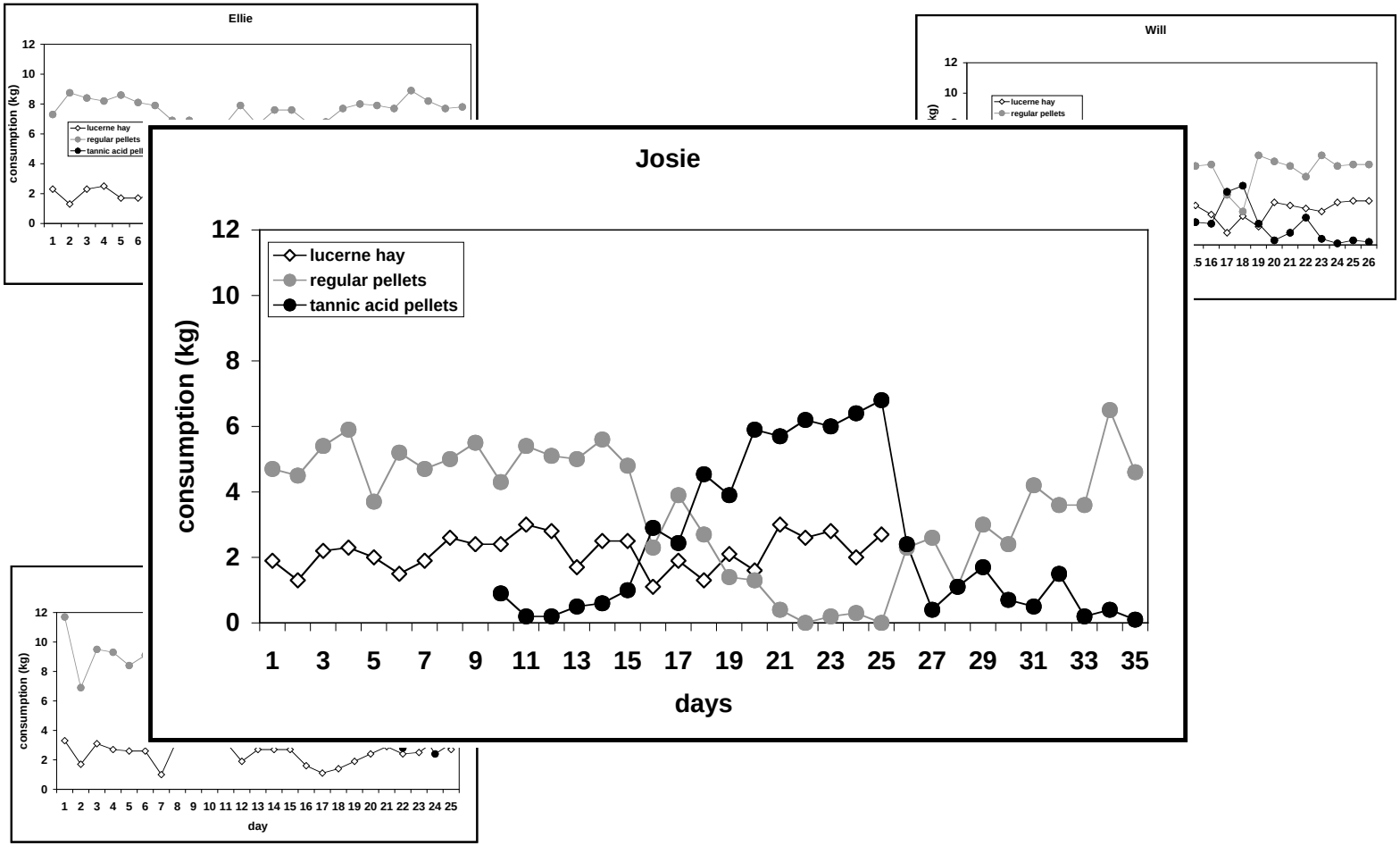
from Clauss et al. (2002)

Giraffe preference trials



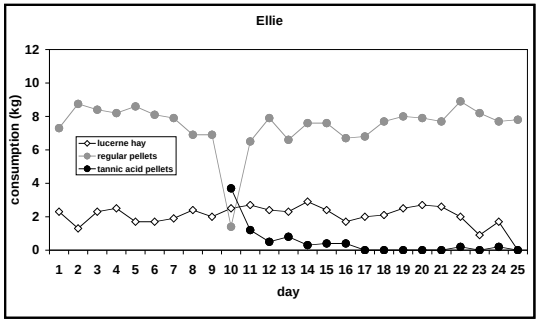
from Clauss et al. (2002)

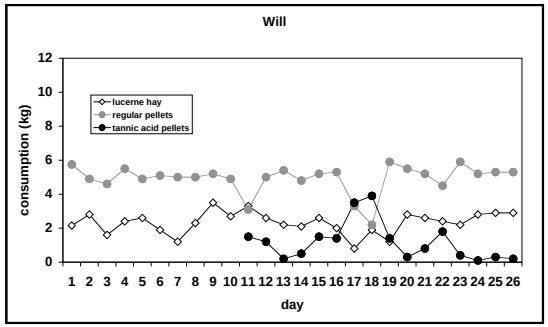
Giraffe preference trials



from Clauss et al. (2002)

Giraffe preference trials





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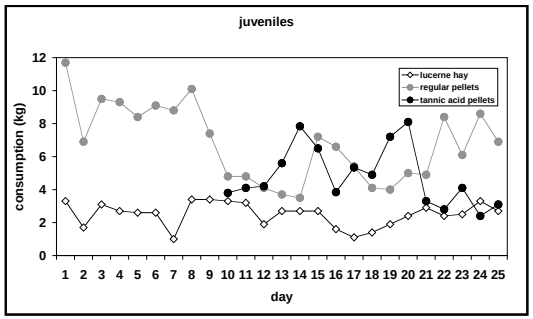
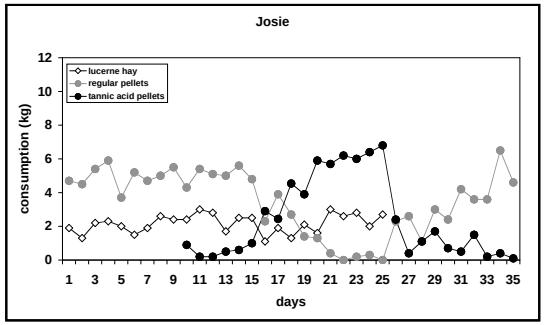


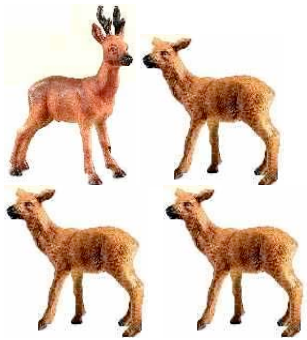


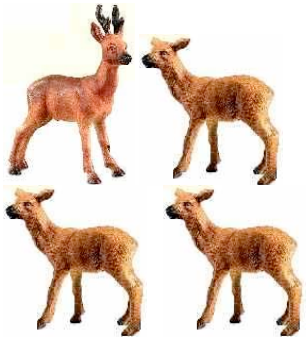
from Clauss et al. (2002)

Roe deer feeding trials

from Clauss et al. (2003)

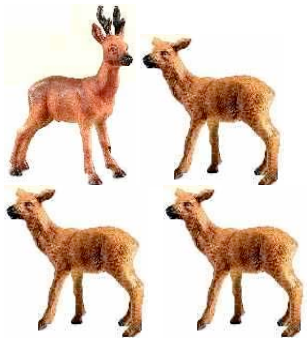
Roe deer feeding trials





from Clauss et al. (2003)

Roe deer feeding trials



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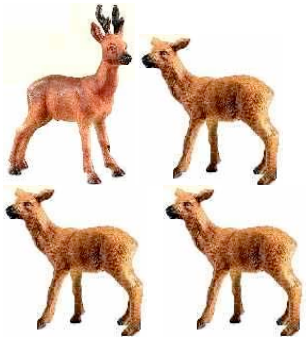
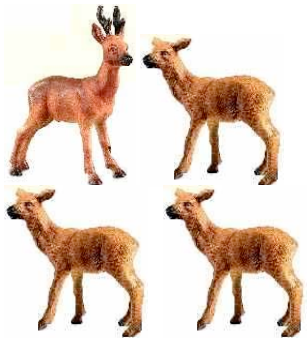


from Clauss et al. (2003)

Roe deer feeding trials



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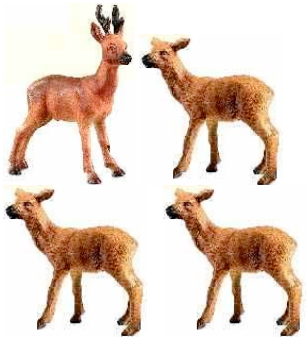
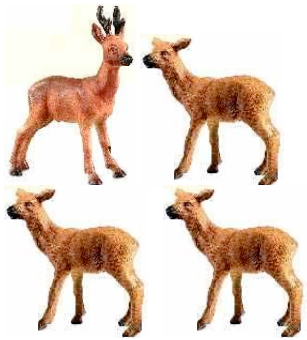


regular

3% tannic acid

from Clauss et al. (2003)

Roe deer feeding trials



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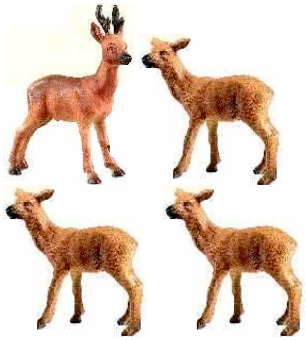
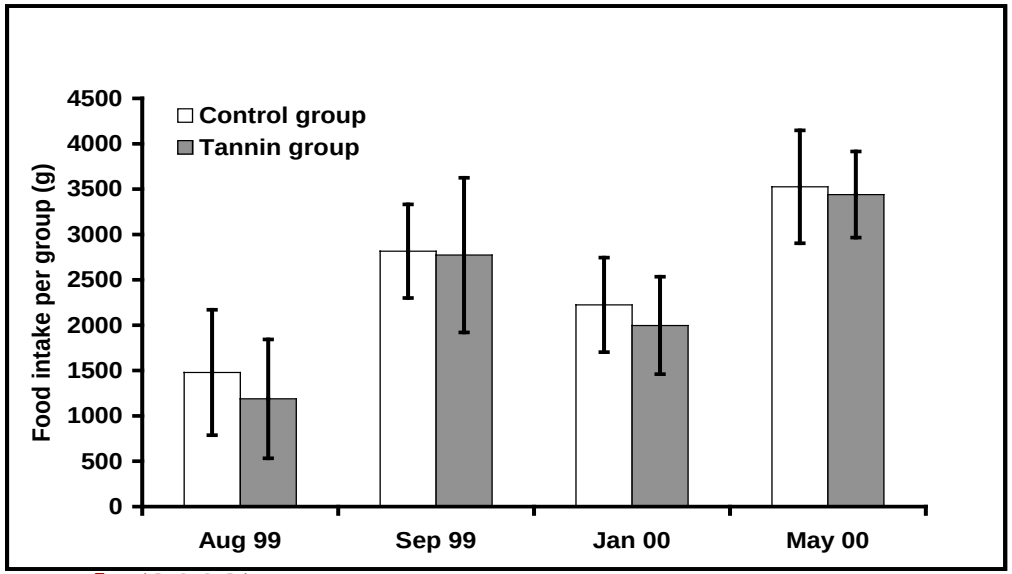


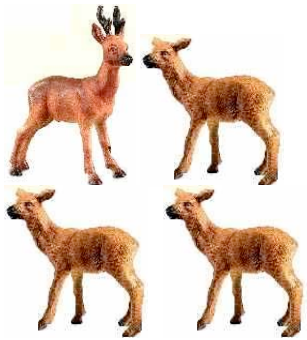
regular

3% tannic acid



from Clauss et al. (2003)

Roe deer feeding trials



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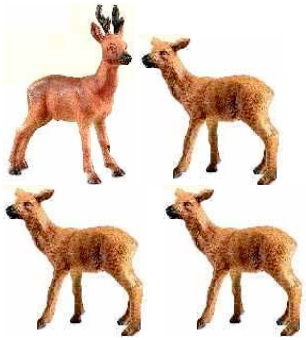

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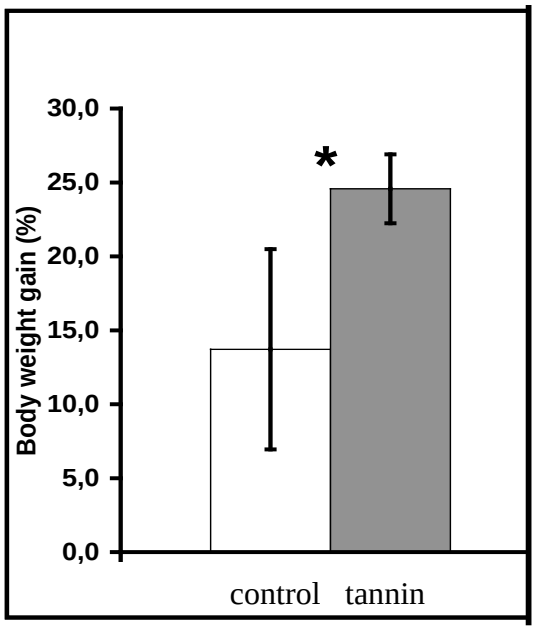

from Clauss et al. (2003)

Low levels of dietary tannins can prevent protein/carbohydrate degradation in the forestomach, thus enhancing their nutritive value for ruminants.

In sheep, Kaitho et al. (1998) even reported weight gains due to the use of tannins.

Conclusions?

- Low levels of tannins might be beneficial for many captive wild animals (based on theoretical considerations)
- Many potentially tannin-related problems in captivity could possibly be solved by a more restricted use of concentrate feeds, by an increase in fibre content, by controlled mineral levels
- As always: more research needed …

end of session