Traits enabling woody species to persist under increased herbivory

Peter F. Scogings
Centre for Functional Biodiversity
University of KwaZulu-Natal
South Africa




What traits enable some woody species to persist under increased herbivory?

- Traits that reduce the degree of herbivory
  - – by deterring or repelling herbivores, or
  - – by reducing herbivore abundance

OIKOS 70: 322–332. Copenhagen 1994

The ecology and evolution of plant tolerance to herbivory

Sharon Y. Strauss and Anurag A. Agrawal

TREE vol. 14, no. 5 May 1999

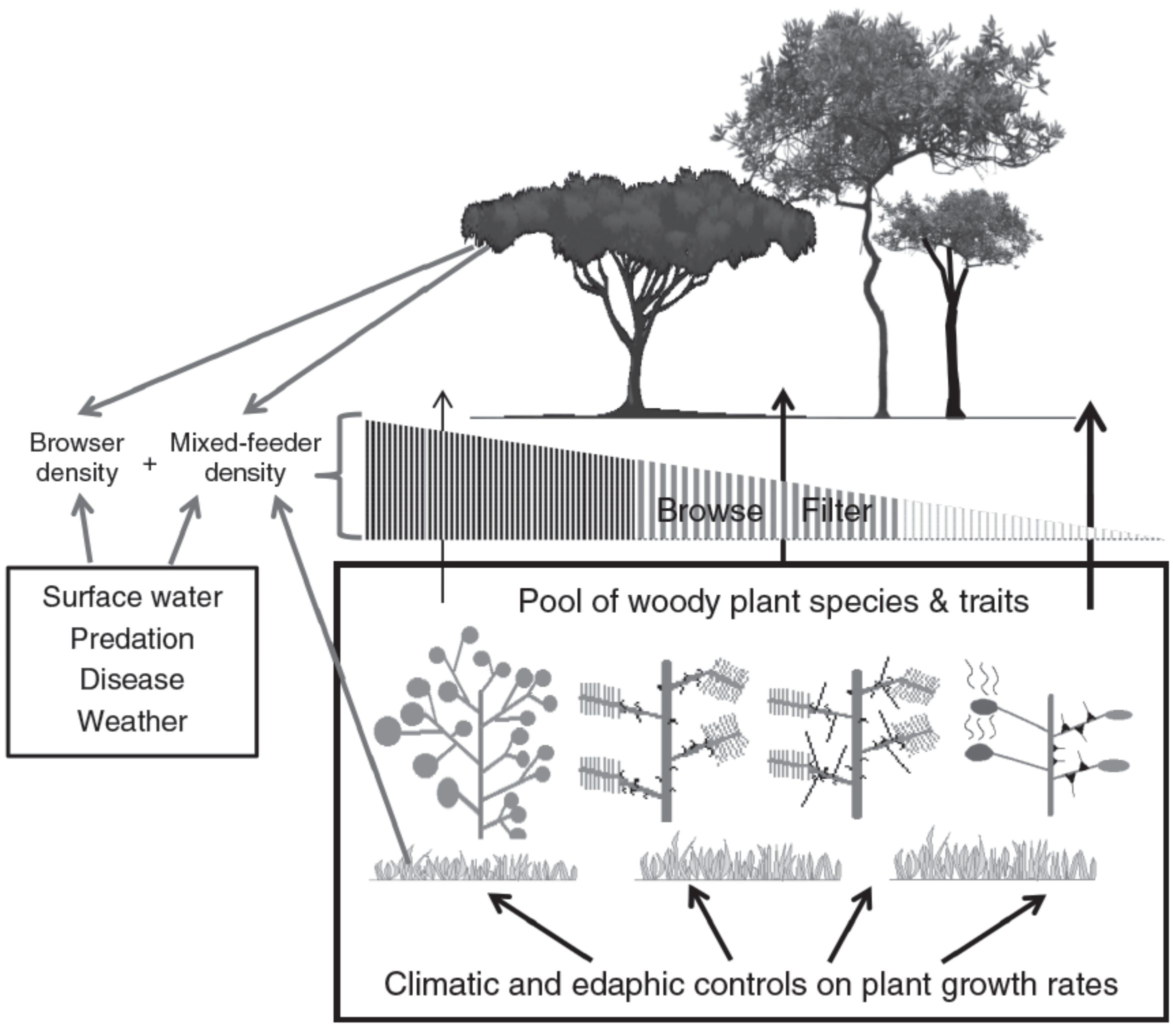
Should a plant always signal its defence against herbivores?

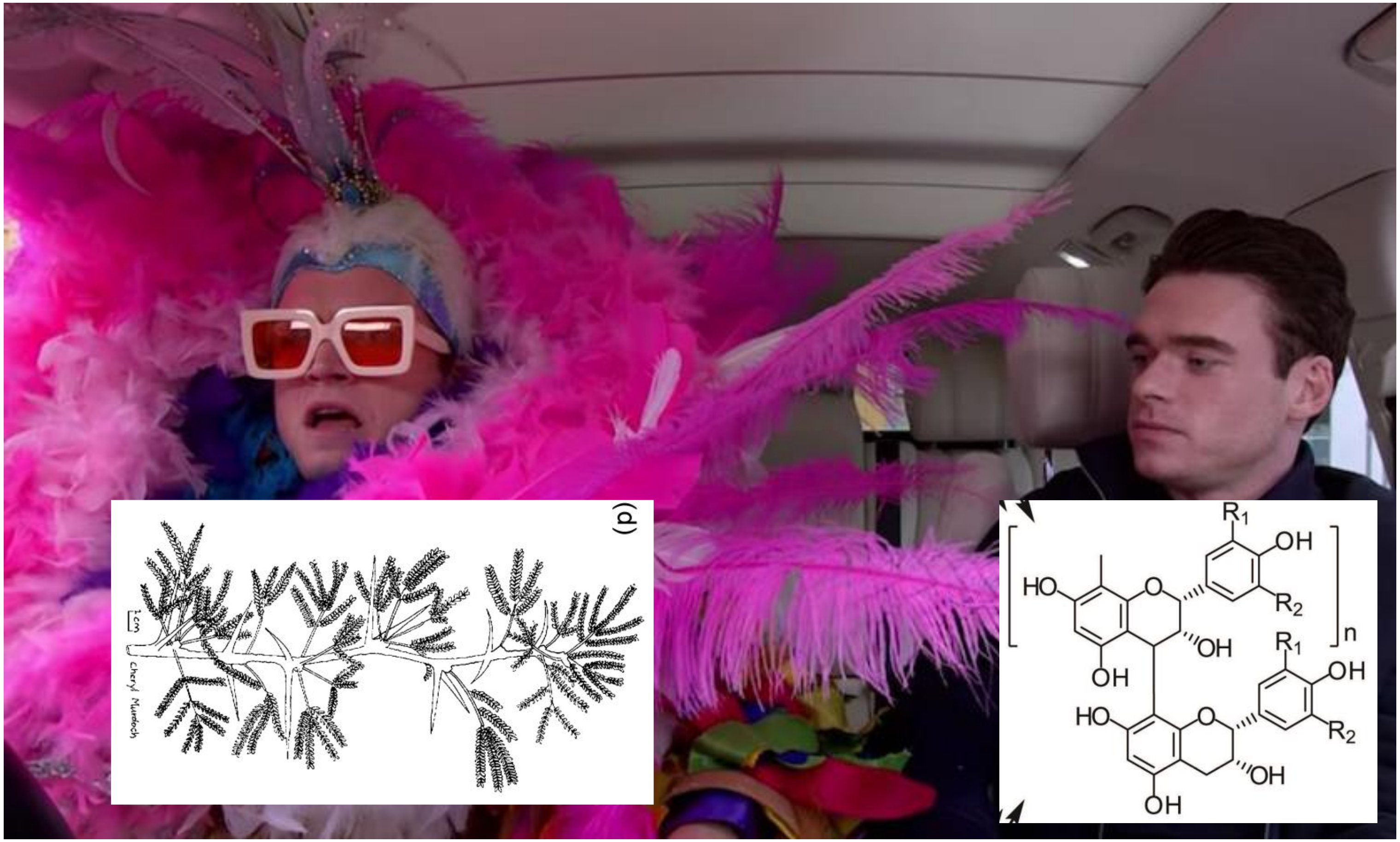
Magnus Augner

Mesobrowser Abundance and Effects on Woody Plants in Savannas

David J. Augustine[1], Peter Frank Scogings[2], and Mahesh Sankaran[3,4]

Savanna Woody Plants and Large Herbivores, First Edition. Edited by Peter Frank Scogings and Mahesh Sankaran.




(d)
1 cm
Cheryl Murdoch
R1
OH
HO
O
R2
OH
n
R1
OH
OH
HO
O
R2
OH
OH

Oecologia (Berlin) (1986) 68:446–455

Effects of plant spinescence on large mammalian herbivores

Susan M. Cooper and Norman Owen-Smith

OIKOS 77: 279–284. Copenhagen 1996

Spines of *Acacia tortilis*: what do they defend and how?

Juan Haridas Gowda

Austral Ecology (2004) **29**, 278–286

Leaf chemistry of woody plants in relation to season, canopy retention and goat browsing in a semiarid subtropical savanna

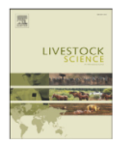
PETER F. SCOGINGS,[1]* LUTHANDO E. DZIBA[2] AND IAIN J. GORDON[3]

Livestock Science 144 (2012) 96–102

Contents lists available at SciVerse ScienceDirect

Livestock Science

journal homepage: www.elsevier.com/locate/livsci



Effect of shoot morphology on browse selection by free ranging goats in a semi-arid savanna

A. Sebata [a,*], L.R. Ndlovu [b]

Functional Ecology 2017, **31**, 1710–1717 doi: 10.1111/1365-2435.12876

The architectural design of trees protects them against large herbivores

Tristan Charles-Dominique*,[1], Jean-Francois Barczi[2], Elizabeth Le Roux[3] and Simon Chamaillé-Jammes[4]

Journal of Arid Environments 55 (2003) 150–158

The effect of plant spinescence on the foraging efficiency of bushbuck and boergoats: browsers of similar body size

S.L. Wilson*, G.I.H. Kerley

Small Ruminant Research 47 (2003) 17–30

Effects of season and breed on browse species intake rates and diet selection by goats in the False Thornveld of the Eastern Cape, South Africa

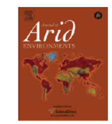
L.E. Dziba [a,*], P.F. Scogings [a], I.J. Gordon [b], J.G. Raats [a]

Journal of Arid Environments 74 (2010) 1281–1286

Contents lists available at ScienceDirect

Journal of Arid Environments

journal homepage: www.elsevier.com/locate/jaridenv



Effect of leaf size, thorn density and leaf accessibility on instantaneous intake rates of five woody species browsed by Matebele goats (*Capra hircus* L) in a semi-arid savanna, Zimbabwe

A. Sebata [a,*], L.R. Ndlovu [b]

Woody Plant Architecture and Effects on Browsing Herbivores in Savannas

Tristan Charles-Dominique[1], Jean-Francois Barczi[2], and Simon Chamaillé-Jammes[3]

Savanna Woody Plants and Large Herbivores, First Edition. Edited by Peter Frank Scogings and Mahesh Sankaran.

Oecologia (1991) 86:70–75

Thorns as induced defenses: experimental evidence

A.V. Milewski*, Truman P. Young**, and Derek Madden***

Oecologia (1998) 115:508–513

Truman P. Young · Bell D. Okello

Relaxation of an induced defense after exclusion of herbivores: spines on *Acacia drepanolobium*

OIKOS 101: 171–179, 2003

Effects of natural and simulated herbivory on spine lengths of *Acacia drepanolobium* in Kenya

Truman P. Young, Maureen L. Stanton and Caroline E. Christian

OIKOS 102: 3–14, 2003

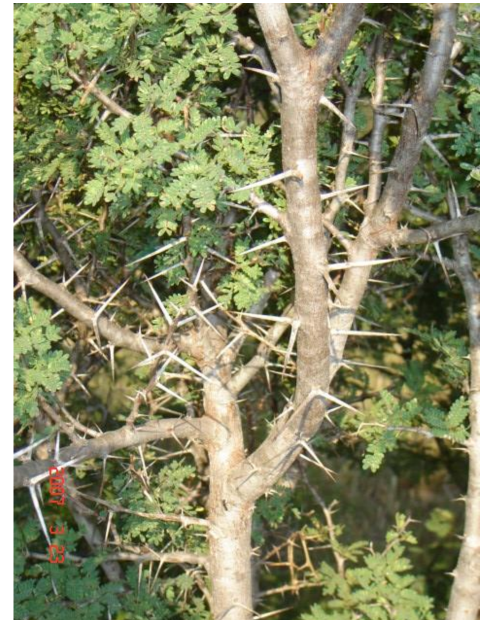
Growing tall vs growing wide: tree architecture and allometry of *Acacia karroo* in forest, savanna, and arid environments

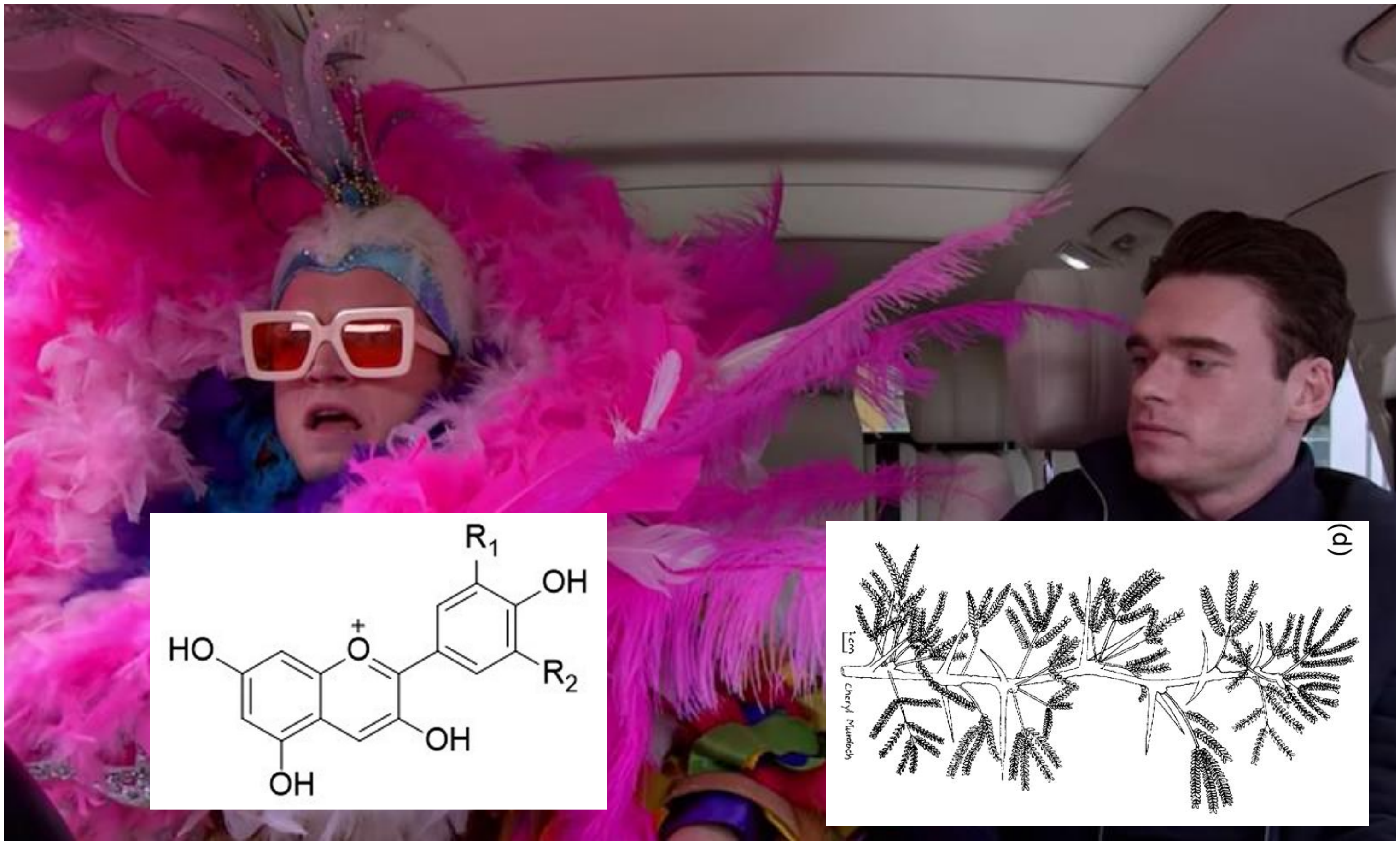
Sally Archibald and William J. Bond

Ecology Letters, (2012) doi: 10.1111/j.1461-0248.2012.01784.x

Top-down determinants of niche structure and adaptation among African Acacias

A. Carla Staver,[1,2,*] William J. Bond,[2] Michael D. Cramer[2] and Julia L. Wakeling[2]

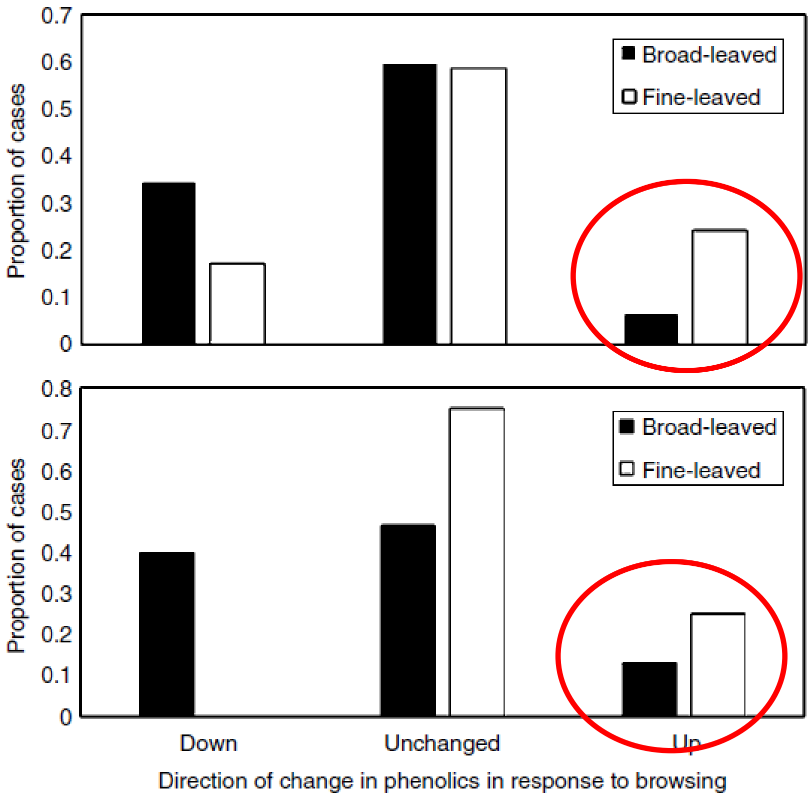



R1
OH
HO
R2
OH
OH
(d)

Browsing Herbivore–Woody Plant Interactions in Savannas

Peter Frank Scogings[1] and Juan H. Gowda[2]

Savanna Woody Plants and Large Herbivores, First Edition. Edited by Peter Frank Scogings and Mahesh Sankaran.



Condensed tannin or total phenolic content increased in ~15% of all cases (top, n=61) or cases of short-term experiments (bottom, n=27).

Ecology, 68(1), 1987, pp. 98–107

ROLE OF TANNINS IN DEFENDING PLANTS AGAINST RUMINANTS: REDUCTION IN PROTEIN AVAILABILITY[1]

C. T. Robbins
Program in Wildlife Biology, Washington State University, Pullman, Washington 99164-4220 USA

T. A. Hanley
United States Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station, Forestry Sciences Laboratory, P.O. Box 909, Juneau, Alaska 99802 USA

A. E. Hagerman
Department of Chemistry, Miami University, Oxford, Ohio 45056 USA

O. Hjeljord
Institute of Nature Conservation, Agricultural University of Norway, P.O. Box 39, N-1432 Ås-NLH, Norway

D. L. Baker
Colorado Division of Wildlife, 317 West Prospect, Fort Collins, Colorado 80526 USA

C. C. Schwartz
Alaska Department of Fish and Game, P.O. Box 3150, Soldotna, Alaska 99669 USA

and

W. W. Mautz
Institute of Natural and Environmental Resources, University of New Hampshire, Durham, New Hampshire 03824 USA

Ecology, 68(6), 1987, pp. 1606–1615

ROLE OF TANNINS IN DEFENDING PLANTS AGAINST RUMINANTS: REDUCTION IN DRY MATTER DIGESTION?[1]

C. T. Robbins
Program in Wildlife Biology, Washington State University, Pullman, Washington 99164-4220 USA

S. Mole
Department of Biochemistry, Purdue University, West Lafayette, Indiana 47907 USA

A. E. Hagerman
Department of Chemistry, Miami University, Oxford, Ohio 45056 USA

and

T. A. Hanley
United States Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station, Forestry Sciences Laboratory, P.O. Box 909, Juneau, Alaska 99802 USA

"If tannins are major determinants of protein digestion in wild ruminants, virtually all past ecological statements regarding the role of plant protein in cervid foraging would require reevaluation. Similarly, future studies of ruminant diet selection and plant defensive strategies would require the routine quantification of tannins."

– Robbins *et al*. (1987, p. 99)

Eur J Wildl Res (2007) 53:100–111
DOI 10.1007/s10344-006-0071-1

ORIGINAL PAPER

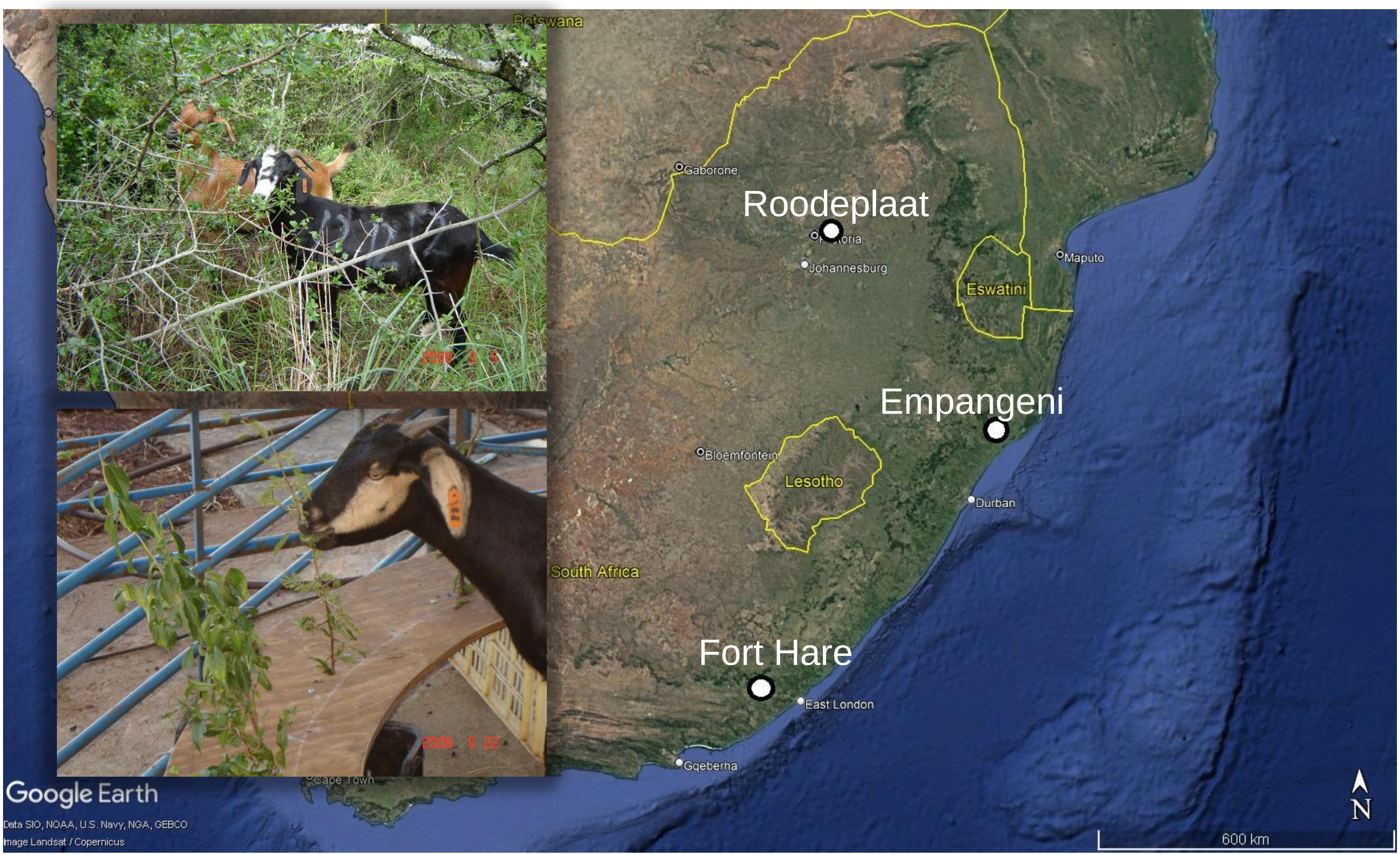
Nutritional content of savanna plant foods: implications for browser/grazer models of ungulate diversification

Daryl Codron · Julia A. Lee-Thorp · Matt Sponheimer · Jacqui Codron

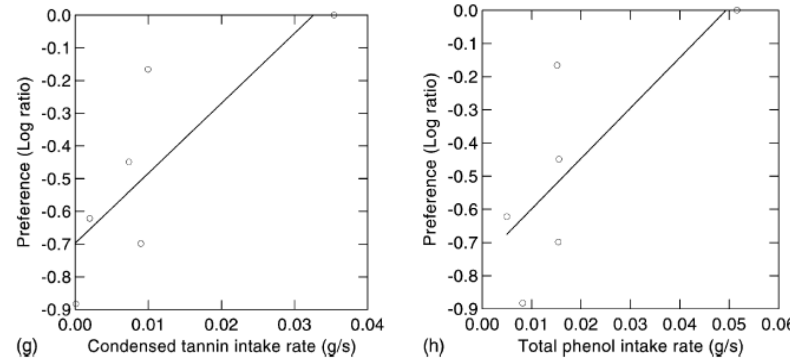
"Our findings are in agreement with several other studies depicting relatively poor digestibility of browse (tree foliage and fruit) compared to grass. Reference to browse as high quality foods is therefore misleading, and models of herbivory that rest on this assumption require revision."

– Codron *et al*. (2007. p. 100)

Plant traits affecting diet selection: structural or chemical?



L.E. Dziba et al. / Small Ruminant Research 47 (2003) 17–30



Small Ruminant Research 47 (2003) 17–30

Effects of season and breed on browse species intake rates and diet selection by goats in the False Thornveld of the Eastern Cape, South Africa

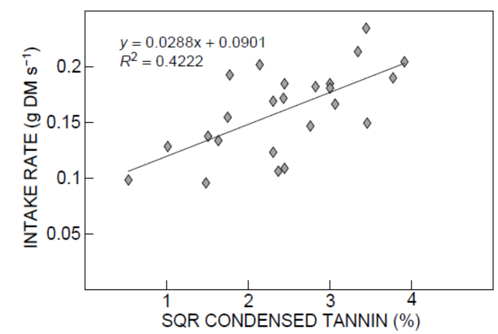
L.E. Dziba [a,*], P.F. Scogings [a], I.J. Gordon [b], J.G. Raats [a]

African Journal of Range & Forage Science 2011, 28(1): 29–34

AFRICAN JOURNAL OF RANGE & FORAGE SCIENCE
ISSN 1022–0119 EISSN 1727–9380
doi: 10.2989/10220119.2011.571809

Season and plant species influence foraging efficiency of Nguni goats in pens

NR Mkhize[1,2*], PF Scogings[1], LE Dziba[2,3] and IV Nsahlai[4]

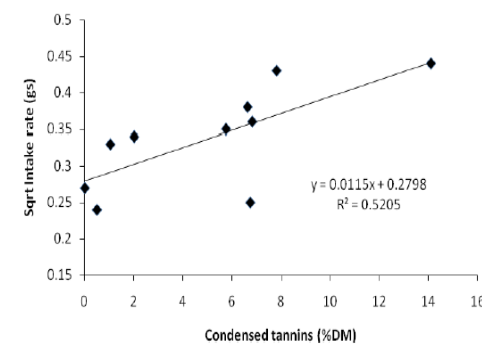


African Journal of Range & Forage Science 2015, 32(3): 193–201

AFRICAN JOURNAL OF RANGE & FORAGE SCIENCE
ISSN 1022-0119 EISSN 1727-9380
http://dx.doi.org/10.2989/10220119.2014.951072

Seasonal variations in diet selection of Nguni goats: effects of physical and chemical traits of browse

Sylvester W Fomum[1], Peter F Scogings[2], Luthando Dziba[3] and Ignatius V Nsahlai[1*]



Small Ruminant Research 102 (2012) 163–171
Contents lists available at ScienceDirect
Small Ruminant Research
journal homepage: www.elsevier.com/locate/smallrumres

ELSEVIER

Diet selection of Nguni goats in relation to season, chemistry and physical properties of browse in sub-humid subtropical savanna

N.A.D. Basha [a,d,*], P.F. Scogings [b], L.E. Dziba [c], I.V. Nsahlai [a]

Received: 3 April 2012 Revised: 7 August 2012 Accepted article published: 28 August 2012 Published online in Wiley Online Library: 26 September 2012

(wileyonlinelibrary.com) DOI 10.1002/jsfa.5895

Effects of season, browse species and polyethylene glycol addition on gas production kinetics of forages in the subhumid subtropical savannah, South Africa†

Nasreldin AD Basha,[a*] Peter F Scogings[b] and Ignatius V Nsahlai[a]

Applied Animal Behaviour Science 169 (2015) 33–37

Contents lists available at ScienceDirect

Applied Animal Behaviour Science

journal homepage: www.elsevier.com/locate/applanim

Condensed tannins reduce browsing and increase grazing time of free-ranging goats in semi-arid savannas

Ntuthuko R. Mkhize[a,b,*], Ignas M.A. Heitkönig[a], Peter F. Scogings[c], Luthando E. Dziba[d], Herbert H.T. Prins[a,c], Willem F. de Boer[a]

Small Ruminant Research 166 (2018) 28–34

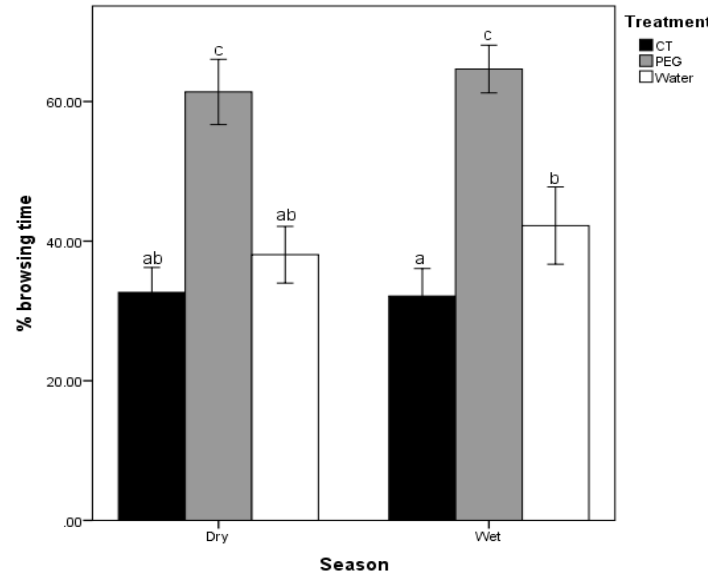
Contents lists available at ScienceDirect

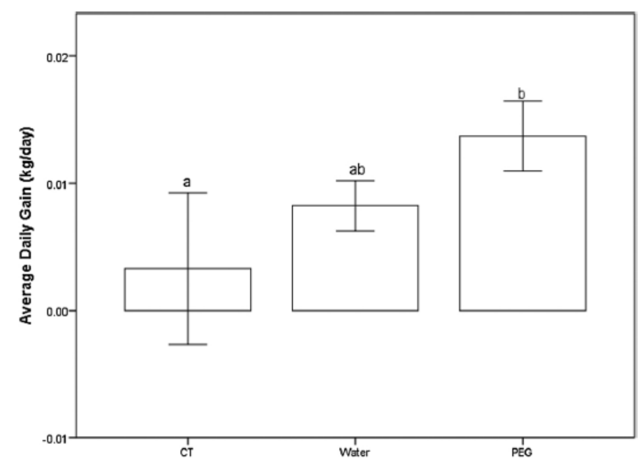
Small Ruminant Research

journal homepage: www.elsevier.com/locate/smallrumres

Effects of condensed tannins on live weight, faecal nitrogen and blood metabolites of free-ranging female goats in a semi-arid African savanna

N.R. Mkhize[a,b,c,*], I.M.A. Heitkönig[a], P.F. Scogings[c], L.E. Dziba[d], H.H.T. Prins[a], W.F. de Boer[a]





Ecosystems (2009) 12: 534–547
DOI: 10.1007/s10021-009-9240-x
ECOSYSTEMS

Plant Toxicity, Adaptive Herbivory, and Plant Community Dynamics

Zhilan Feng,[1] Rongsong Liu,[1] Donald L. DeAngelis,[2]* John P. Bryant,[3] Knut Kielland,[3] F. Stuart Chapin III,[3] and Robert K. Swihart[4]

Oikos 124: 796–805, 2015
doi: 10.1111/oik.01671

Subject Editor: Thorsten Wiegand. Editor-in-Chief: Dris Bonte. Accepted 15 December 2014

A plant toxin mediated mechanism for the lag in snowshoe hare population recovery following cyclic declines

Donald L. DeAngelis, John P. Bryant, Rongsong Liu, Stephen A. Gourley, Charles J. Krebs and Paul B. Reichardt

Ecology, 90(5), 2009, pp. 1400–1411

Summer dietary nitrogen availability as a potential bottom-up constraint on moose in south-central Alaska

Scott H. McArt,[1,4] Donald E. Spalinger,[1] William B. Collins,[2] Erik R. Schoen,[3,5] Timothy Stevenson,[1] and Michele Bucho[1]

Ecology, 90(3), 2009, pp. 711–719

The effects of plant defensive chemistry on nutrient availability predict reproductive success in a mammal

Jane L. DeGabriel,[1,2,4] Ben D. Moore,[2,3] William J. Foley,[1] and Christopher N. Johnson[2]

Rangeland Ecol Manage 64:264–275 | May 2011 | DOI: 10.2111/REM-D-10-00078.1

Effects of Plant Secondary Compounds on Nutritional Carrying Capacity Estimates of a Browsing Ungulate

Steve K. Windels[1] and David G. Hewitt[2]

Ecological Modelling 244 (2012) 79–92
Contents lists available at SciVerse ScienceDirect
Ecological Modelling
journal homepage: www.elsevier.com/locate/ecolmodel
ELSEVIER

Plant toxins and trophic cascades alter fire regime and succession on a boreal forest landscape

Zhilan Feng[a], Jorge A. Alfaro-Murillo[a], Donald L. DeAngelis[b,*], Jennifer Schmidt[c], Matthew Barga[d], Yiqiang Zheng[a], Muhammad Hanis B. Ahmad Tamrin[a], Mark Olson[c], Tim Glaser[c], Knut Kielland[c], F. Stuart Chapin III[c], John Bryant[c]

Oikos 123: 298–308, 2014
doi: 10.1111/j.1600-0706.2013.00727.x

Subject Editor: Regino Zamora. Accepted 2 July 2013

Translating nutritional ecology from the laboratory to the field: milestones in linking plant chemistry to population regulation in mammalian browsers

Jane L. DeGabriel, Ben D. Moore, Annika M. Felton, Jörg U. Ganzhorn, Caroline Stolter, Ian R. Wallis, Christopher N. Johnson and William J. Foley

Ecological Modelling 332 (2016) 8–18
Contents lists available at ScienceDirect
Ecological Modelling
journal homepage: www.elsevier.com/locate/ecolmodel
ELSEVIER

Incorporating secondary metabolites, tannin-binding proteins, and diet breadth into carrying-capacity models for African elephants

Melissa H. Schmitt*, David Ward[1], Adrian M. Shrader

Why are correlations between diet preference and phenolic content not what we expected?

(The problem with general assays of condensed tannins and total phenolics)

Species A

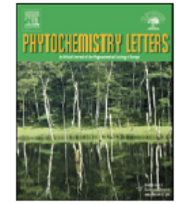
Species B

Phytochemistry Letters 5 (2012) 329–334

Contents lists available at SciVerse ScienceDirect

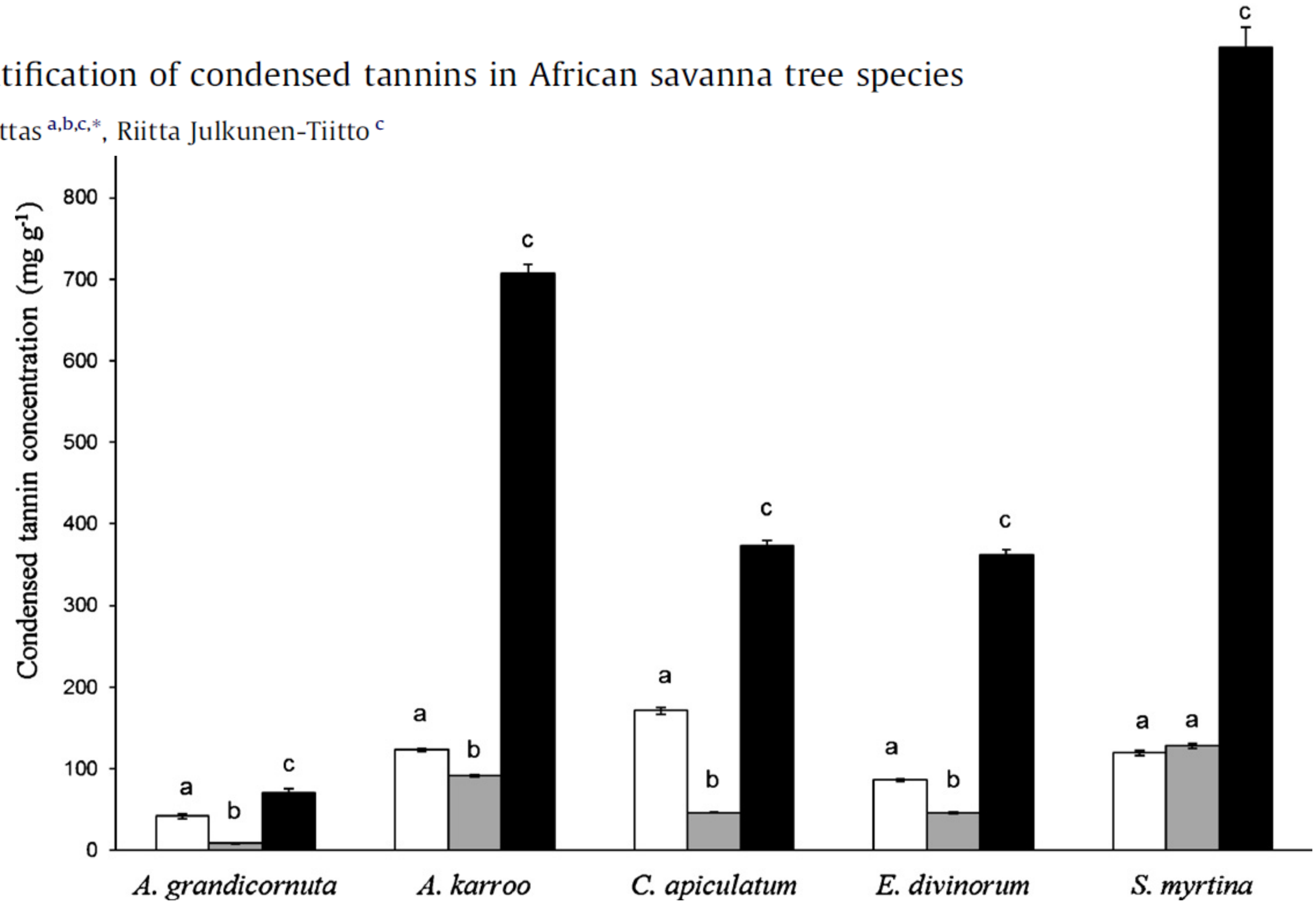
Phytochemistry Letters

journal homepage: www.elsevier.com/locate/phytol



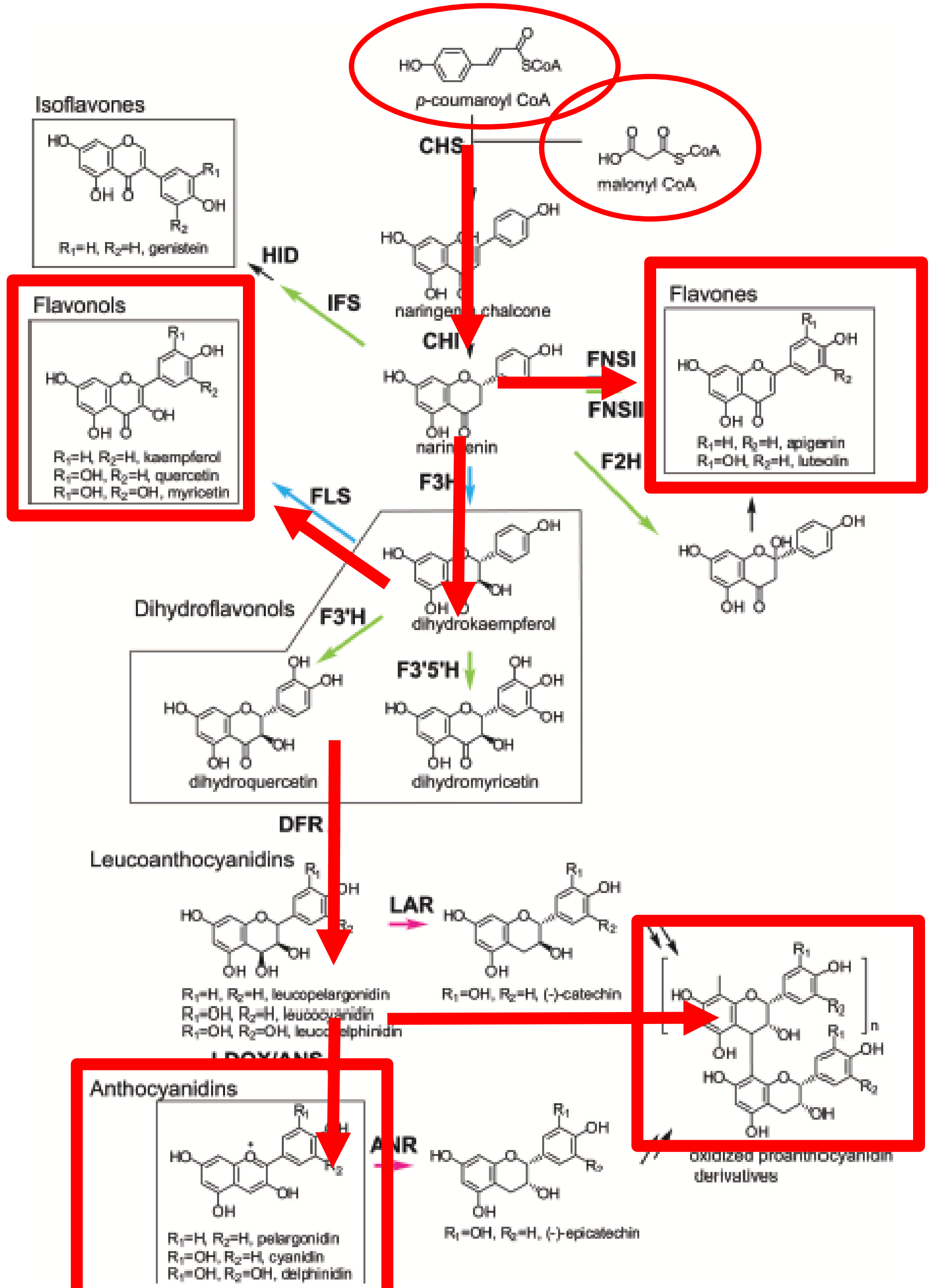
The quantification of condensed tannins in African savanna tree species

Dawood Hattas [a,b,c,*], Riitta Julkunen-Tiitto [c]



Flavonols

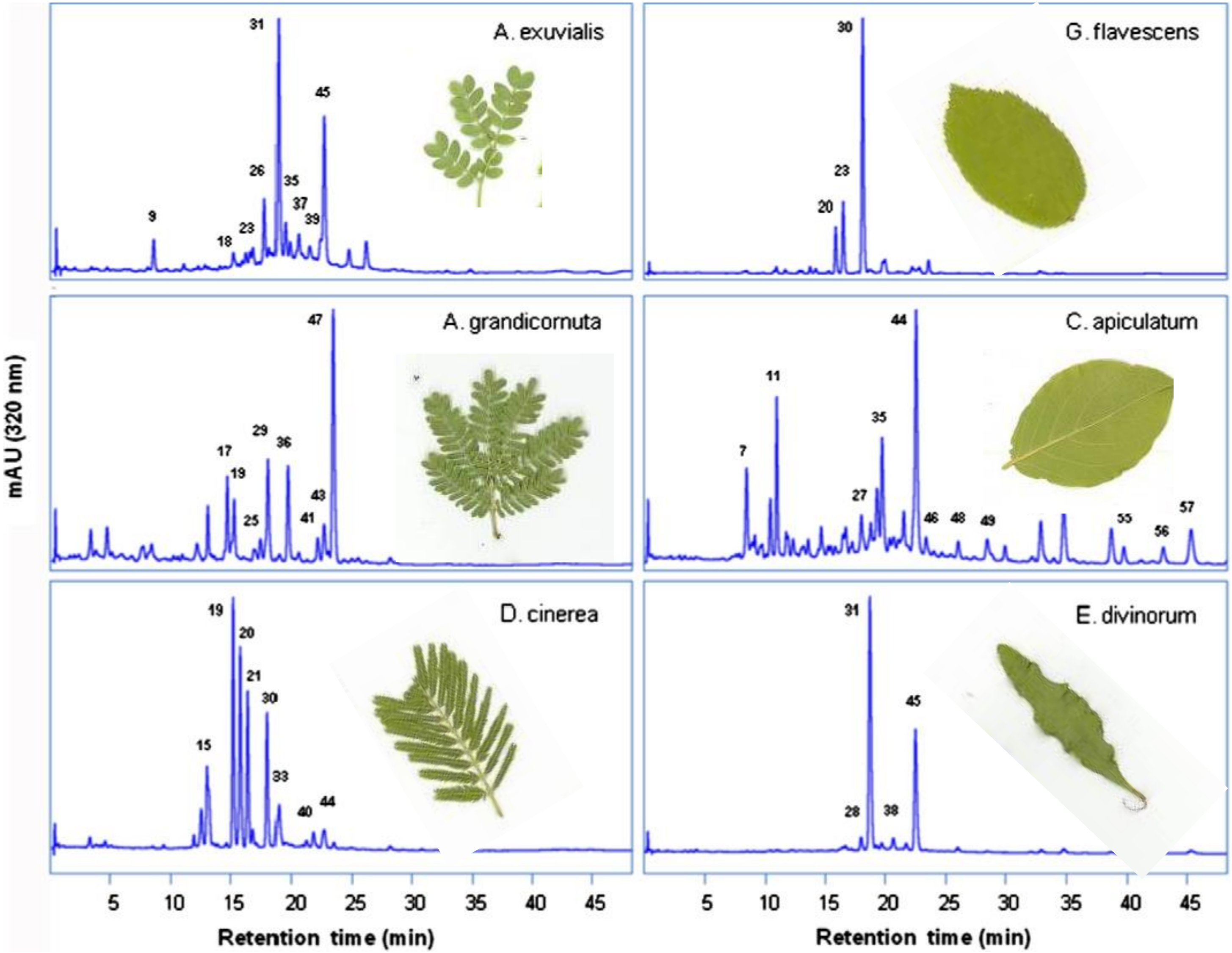
Flavones



Flavan-3-ol polymers (condensed tannins)

Pigments

Keiko Yonekura-Sakakibara, Yasuhiro Higashi and Ryo Nakabayashi* Frontiers in Plant Science August 2019 | Volume 10 | Article 943



Hattas *et al*. 2011. *Phytochemistry* 72: 1796-1803

Phytochemistry 72 (2011) 1796–1803

Contents lists available at ScienceDirect

Phytochemistry

journal homepage: www.elsevier.com/locate/phytochem

Differential phenolic profiles in six African savanna woody species in relation to antiherbivore defense

Dawood Hattas [a,*], Joakim Hjältén [b], Riitta Julkunen-Tiitto [c], Peter F. Scogings [d], Tuulikki Rooke [e]

Table 2
Tannins, total HPLC phenolics and flavonoid concentration in *A. exuvialis*, *A. grandicornuta*, *C. apiculatum*, *D. cinerea*, *E. divinorum* and *G. flavescens* ($n = 3$). Values are mean ± SE, and values in brackets are percentage contribution to total HPLC phenolics; ND = not detected.

Species	Life strategy/ spinescence	Condensed tannins ($mg\ g^{-1}$)	Total HPLC phenolics ($mg\ g^{-1}$)	Hydrolysable tannins ($mg\ g^{-1}$)	Myricetin conjugates ($mg\ g^{-1}$)	Quercetin conjugates ($mg\ g^{-1}$)	Kaempferol conjugates ($mg\ g^{-1}$)	Apigenin conjugates ($mg\ g^{-1}$)	Luteolin conjugates ($mg\ g^{-1}$)
A. exuvialis	Deciduous-spinescent	11.3 ± 1.3	11.3 ± 1.2	0.42 ± 0.06 (4)	1.26 ± 0.3 (11)	9.1 ± 0.9 (80)	ND	ND	ND
A. grandicornuta	Deciduous-spinescent	5.9 ± 0.8	17.6 ± 3.0	0.15 ± 0.01 (0.8)	ND	ND	ND	5.1 ± 2.0 (29)	12.3 ± 1.1 (70)
C. apiculatum	Deciduous-spineless	86.7 ± 35.6	32.0 ± 0.87	1.36 ± 0.12 (4)	ND	12.0 ± 0.1 (38)	2.04 ± 0.20 (6)	ND	ND
D. cinerea	Deciduous-spinescent	14.3 ± 6.7	25.8 ± 3.6	0.28 ± 0.08 (1)	2.1 ± 0.6 (23)	ND	ND	8.9 ± 0.7 (34)	7.4 ± 1.2 (29)
E. divinorum	Evergreen-spineless	21.3 ± 1.4	24.2 ± 3.4	ND	16.4 ± 3.7 (70)	5.7 ± 1.5 (23)	0.32 ± 0.17 (1)	ND	ND
G. flavescens	Deciduous-spineless	31.5 ± 26.3	19.6 ± 3.8	0.17 ± 0.02 (1)	0.3 ± 0.2 (2)	ND	ND	14.2 ± 3.9 (72)	3.3 ± 0.7 (17)

Flavanol polymers

Flavonols

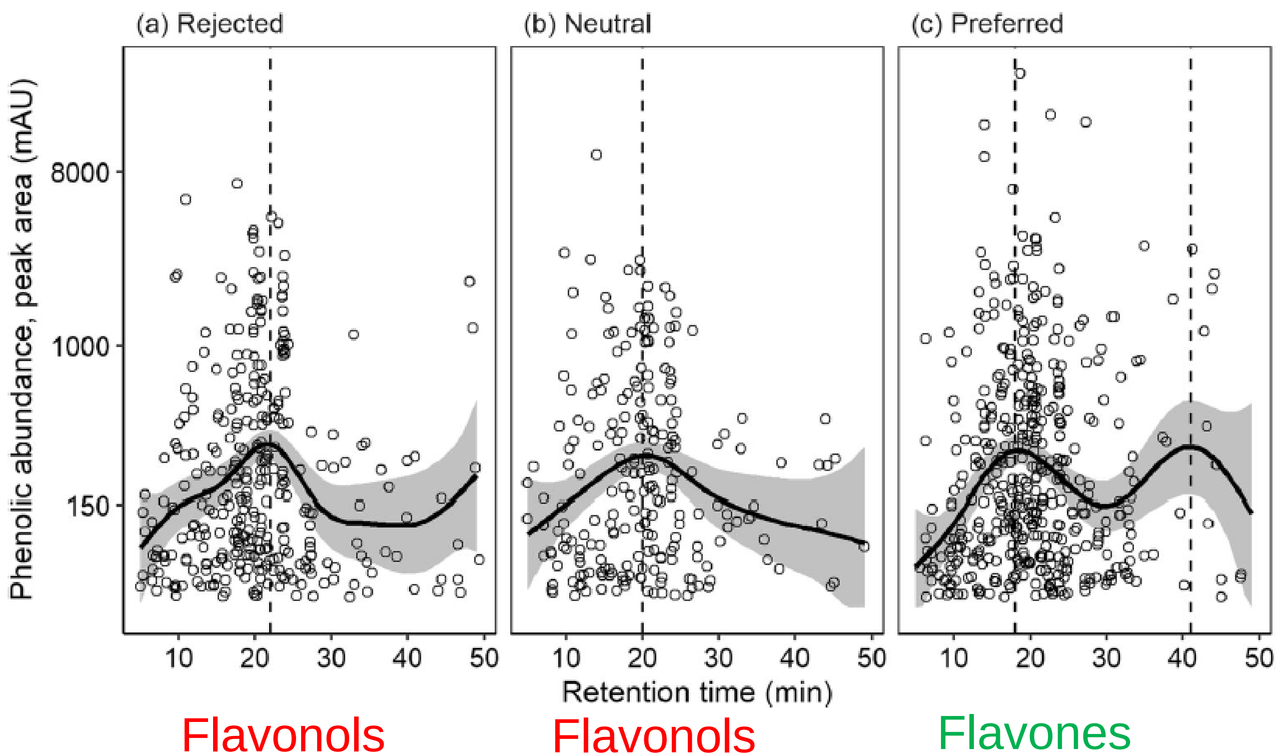
Flavones

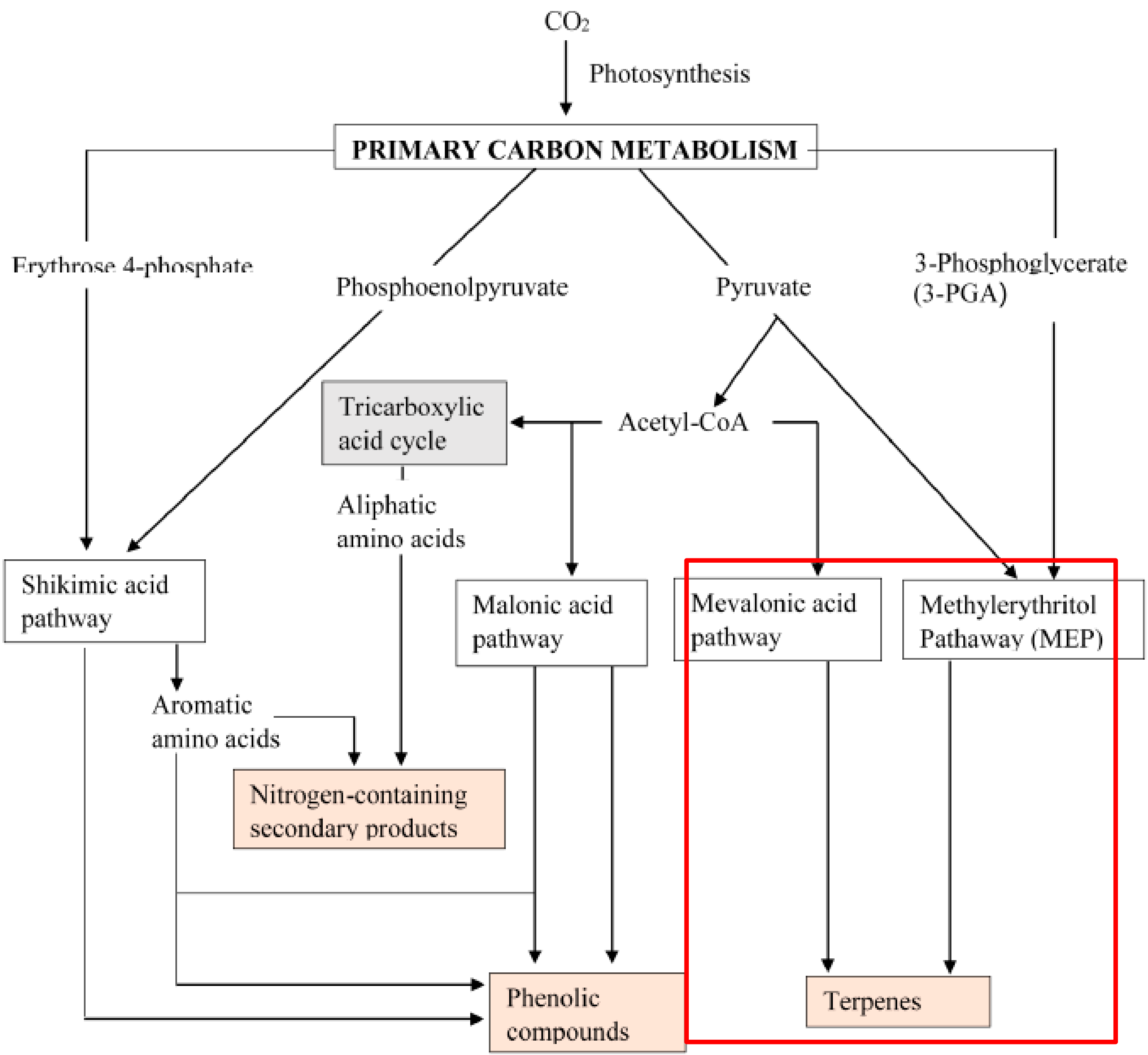
Journal of Chemical Ecology (2021) 47:322–333
https://doi.org/10.1007/s10886-021-01258-x

Spinescence and Total Phenolic Content Do Not Influence Diet Preference of a Critically Endangered Megaherbivore, but the Mix of Compounds Does

Peter F. Scogings[1] · Stuart Demmer[1,2] · Dawood Hattas[3]

Fig. 3 Modelled phenolic profiles of plant species across black rhino diet preference classes ((a) rejected, (b) neutral, (c) preferred). Retention time indicates the time at which phenolics were detected. Peak area indicates the amount of the phenolic that was detected. Dotted vertical lines indicate retention times where the greatest amount of phenolics were detected. Shaded regions represent 95% confidence intervals of the prediction. Note log scale applied to the y-axis





Bhekumthetho Ncube and Johannes Van Staden *Molecules* **2015**, *20*, 12698-12731;

Oecologia (2016) 182:643–651
DOI 10.1007/s00442-016-3678-2

HIGHLIGHTED STUDENT RESEARCH

Follow your nose: leaf odour as an important foraging cue for mammalian herbivores

Rebecca S. Stutz[1,3] · Peter B. Banks[1] · Nicholas Proschogo[2] · Clare McArthur[1]

DOI: 10.1111/1365-2656.12748

RESEARCH ARTICLE

Journal of Animal Ecology BRITISH ECOLOGICAL SOCIETY

Leaf odour cues enable non-random foraging by mammalian herbivores

Patrick B. Finnerty[1] | Rebecca S. Stutz[1,2] | Catherine J. Price[1] | Peter B. Banks[1] | Clare McArthur[1]

Animal Behaviour 155 (2019) 199–216

Contents lists available at ScienceDirect

Animal Behaviour

journal homepage: www.elsevier.com/locate/anbehav

ELSEVIER

Plant volatiles are a salient cue for foraging mammals: elephants target preferred plants despite background plant odour

Clare McArthur[a, *], Patrick B. Finnerty[a], Melissa H. Schmitt[b, c], Adam Shuttleworth[b], Adrian M. Shrader[b, d]

Animal Behaviour 141 (2018) 17–27

Contents lists available at ScienceDirect

Animal Behaviour

journal homepage: www.elsevier.com/locate/anbehav

ELSEVIER

African elephants use plant odours to make foraging decisions across multiple spatial scales

Melissa H. Schmitt[a, *], Adam Shuttleworth[a], David Ward[a, 1], Adrian M. Shrader[a, b]

Journal of Chemical Ecology (2019) 45:993–1003
https://doi.org/10.1007/s10886-019-01117-w

Terpenes May Serve as Feeding Deterrents and Foraging Cues for Mammalian Herbivores

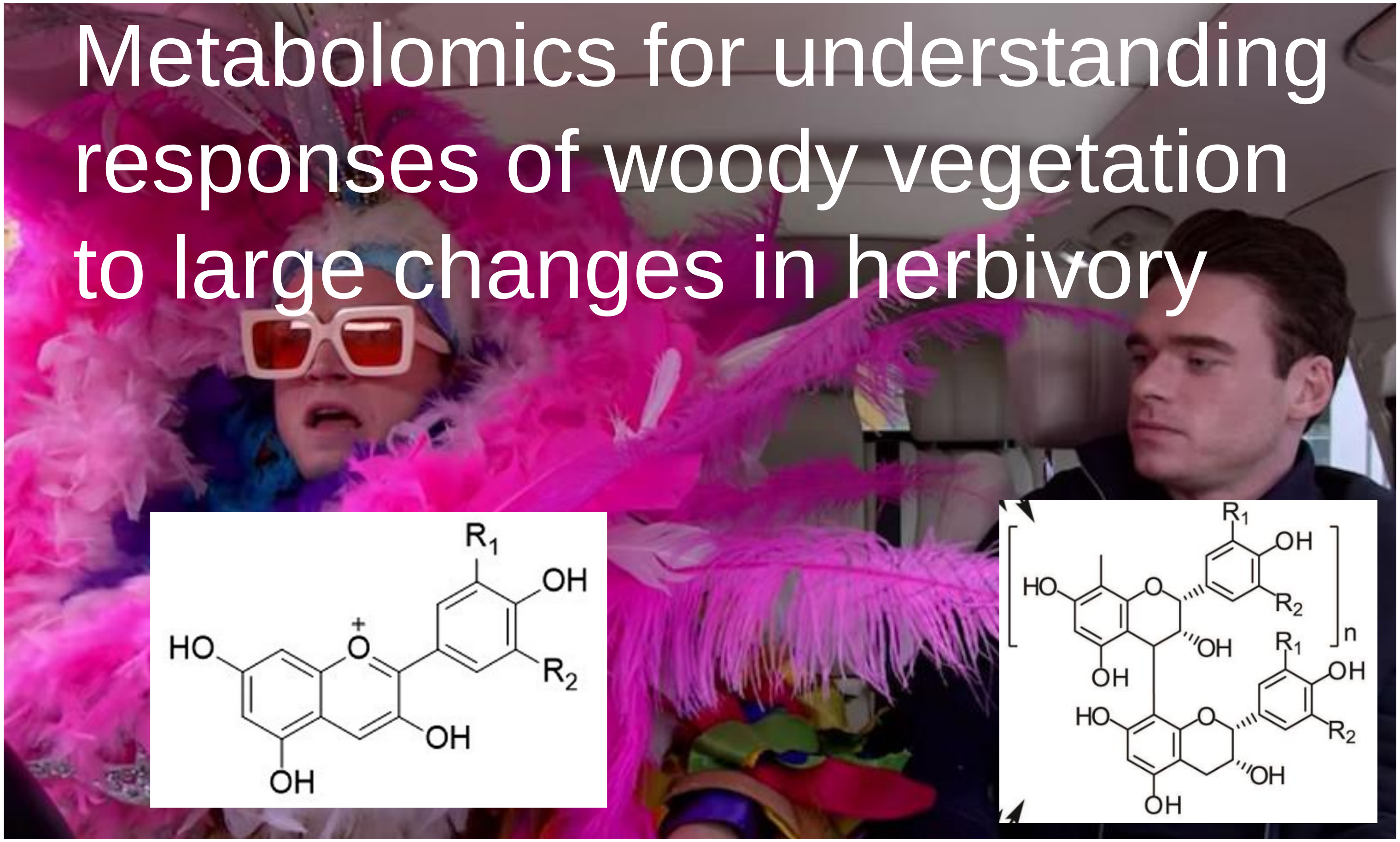
Michele M. Skopec[1] · Robert P. Adams[2] · James P. Muir[3]

Journal of Chemical Ecology (2020) 46:99–113
https://doi.org/10.1007/s10886-019-01124-x

Volatiles and Tannins in *Pistacia lentiscus* and Their Role in Browsing Behavior of Goats (*Capra hircus*)

Shilo Navon[1,2] · Jaime Kigel[2] · Nativ Dudai[3] · Ariela Knaanie[4] · Tzach Aharon Glasser[5] · Alona Shachter[3] · Eugene David Ungar[1]

Metabolomics for understanding responses of woody vegetation to large changes in herbivory




Thank you for your attention!