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A Note on Searching Digits of Circular Ratio and Napier's Number for Numerically Expressed Information on Ruminant Agriculture

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The present study was conducted to search 200 million digits of π and 1 million digits of *e* for some pieces of numerically expressed information on ruminant agriculture. The results obtained were as follows. Pieces of numerically expressed information that were found in digits of π were as follows: (1) a string of data on weather condition, (2) a string of data on forage production related to growth days, (3) a string of data on correlation analysis between digestibility and lignin content of forages, (4) a string of data on digestibility improvement by ammonia treatment, (5) a string of data on silage fermentation characteristics of forages, (6) a string of data on forage protein degradation in the rumen, (7) a string of data on basic growth analysis of ruminants, (8) a string of data on economic aspects of ruminant agriculture, (9) a string of data on complementary bases related to DNA structure, (10) a string of data on bases for primers related to the detection study on rumen microbes. Pieces of numerically expressed information that were found in digits of *e* were as follows: (11) a string of data on bases encoding amino acids. It was suggested that some pieces of numerically expressed information on ruminant agriculture were found in digits of π and *e*.

INTRODUCTION

The basic growth analysis of ruminants and forages are conducted using exponential functions with base *e* (Brody, 1945; Watson, 1952; Radford, 1967; Hunt, 1990). There may exist Euler's formula, $\exp(\boldsymbol{i}x)=\cos(x)+\boldsymbol{i}\sin(x)$, at the back of exponential functions with base *e*. When $x=\pi$, it leads to $[\exp(\boldsymbol{i}\pi)=-1]$ or $[\exp(\boldsymbol{i}\pi)+1=0]$, giving beautiful relationships among basic numbers (e, π, $\boldsymbol{i}$, 0, −1, 1). The above expressions are, therefore, considered a great treasure (Feynman *et al.*, 1965) and a jewel (Yoshida, 2000), forming fundamental relationships with many things in nature (Yoshida, 2000). There were attempts to apply Euler's formula to analyses of some aspects of ruminant agriculture, suggesting hypothetic descriptions of: (1) matter circulation coming from field–forage–ruminant relationships (Shimojo *et al.*, 2003a, 2003b), (2) spiral structures showing topological resemblances to micro structures in ruminants and forages on condition that coordinate axes were eliminated to prevent wave interferences in the combination of spirals (Shimojo *et al.*, 2003c).

Not only useful but also mysterious properties have been shown for both *e* (Maor, 1994; Yoshida, 2000) and π (Yoshida, 2000; Kanada, 2003; Posamentier and Lehmann, 2004). Those reports also showed that *e* and π are transcendental numbers that have the infinite sequence of digits after the decimal point, a treasury that contains many kinds of numerical information. Therefore, these attractive properties allow people to search digits of π for numerically expressed information on various things (Posamentier and Lehmann, 2004), an expectation that π is closely related to describing natural phenomena. The same expectation may also be applied to the infinite sequence of digits of *e*.

The present study was designed to search digits of π and *e* for some pieces of numerically expressed information on ruminant agriculture.

SEARACHING π AND *e* FOR NUMERICALLY EXPRESSED INFORMATION ON RUMINANT AGRICULTURE

Searching digits of π for numerically expressed information on ruminant agriculture

In this section, we used the first 200 million digits of π published on the Web by Anderson (2006), allowing us to search for given strings of digits. Searching digits of π for the numerically expressed information is based on the following process: (i) the information is expressed numerically, (ii) forming all digits in a string, (iii) finding the string in digits of π, namely
(Numerically expressed information)→(A string of digits)→[The string in digits of π]. (1)

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The position in digits of π at which the string occurs is also shown.

(A) Weather condition

The forage production, which is indispensable to ruminant production, is affected by weather condition. We used data, adapted from Fukuoka District Meteorological Observatory (2006), on month, average monthly temperature and monthly precipitation of the average year.

(July, 26.9 ˚C, 266.4 mm)→ (72692664)→ [•••98810 **72692664** 80171•••]. (2)

The string **72692664** in (2) occurs at position 99,699,399 counting from the first digit after the decimal point of π.

(B) Forage production related to growth days

We used data, adapted from Shimojo *et al.* (1997), on regrowth days and dry matter weight for rhodesgrass (tropical grass) and for greenleaf desmodium (tropical forage legume).

(B–1) Rhodesgrass

(35 days, 225.56 g/m^2) → (3522556) → [•••10455 **3522556** 30965•••]. (3)

The string **3522556** in (3) occurs at position 5,336,151 counting from the first digit after the decimal point of π.

(63 days, 515.00 g/m^2) → (6351500) → [•••37307 **6351500** 67247•••]. (4)

The string **6351500** in (4) occurs at position 7,233,755 counting from the first digit after the decimal point of π.

(B–2) Greenleaf desmodium

(35 days, 190.00 g/m^2) → (3519000) → [•••13186 **3519000** 29084•••]. (5)

The string **3519000** in (5) occurs at position 30,872,350 counting from the first digit after the decimal point of π.

(63 days, 315.28 g/m^2) → [6331528] → [•••08574 **6331528** 60308•••]. (6)

The string **6331528** in (6) occurs at position 22,677,818 counting from the first digit after the decimal point of π.

(C) Forage digestion related to lignin content

We used data, adapted from Shimojo and Goto (1987), on correlation analysis between organic matter digestibility (OMD) and content of acetyl bromide lignin (ABL) for a group of rhodesgrass (topical grass), siratro (tropical forage legume) and greenleaf desmodium (tropical forage legume). The data on negative correlation between OMD and ABL are shown in (7), and it is divided into two parts: regression equation in (8) and significance test in (9).

OMD (%)＝88.55–2.86•ABL (%); r＝－0.941 (P＜0.01). (7)

(OMD＝88.55–2.86•ABL) → (8855286) → [•••19618 **8855286** 94533•••]. (8)

The string **8855286** in (8) occurs at position 13,641,433 counting from the first digit after the decimal point of π.

(r＝–0.941 (P＜0.01)) → (0941001) → [•••60168 **0941001** 35837•••]. (9)

The string **0941001** in (9) occurs at position 66,662 counting from the first digit after the decimal point of π.

(D) Forage digestion improvement by ammonia treatment

We used data, adapted from Shimojo and Goto (1990), on ammonia treatment of green panic (tropical grass). The data are NH_3 addition rate, storage period, percent unit increase in the content of crude protein (CP), that in acetyl bromide lignin digestibility (ABLD), and that in dry matter digestibility (DMD).

(3% NH_3, 4 weeks, 5.9% unit increase in CP, 21% unit increase in ABLD, 17.6% unit increase in DMD) → (345921176) → [•••87988 **345921176** 37019•••]. (10)

The string **345921176** in (10) occurs at position 9,884,305 counting from the first digit after the decimal point of π.

(E) Fermentation quality of silage

We used data, adapted from Tobisa *et al.* (2005), on the fermentation quality of silage made from a mixture of Saikai 203 (rice plant) and phasey bean (tropical forage legume) in the ratio of 1:1 (fresh weight basis). The data are pH, lactic acid content, VBN/TN (volatile basic nitrogen / total nitrogen) and V–SCORE.

(pH＝4.6, lactic acid＝3.1 (% DM), VBN/TN＝7.8%, V–SCORE＝94.2)
→ (463178942) → [•••44641 **463178942** 97505•••]. (11)

The string **463178942** in (11) occurs at position 189,481,453 counting from the first digit after the decimal point of π.

(F) Forage protein degradation in the rumen

The degradability of forage protein in the rumen using nylon bag technique (Ørskov, 1982) is estimated by

$$P = a + b\cdot(1-\exp(-c\cdot t)), \qquad (12)$$

where P＝degradability of protein, a＝soluble fraction or fraction that disappears rapidly, b＝degradable fraction, c＝degradation rate of b, t＝time.

We used data, adapted from Zhao *et al.* (1993), on parameters estimating degradability of protein of green panic (tropical grass) suspended in the rumen of goats fed alfalfa haycubes at maintenance level. The equation reported by Zhao *et al.* (1993) was

$$P = 21.7 + 70.8\cdot(1-\exp(-0.037\cdot t)). \qquad (13)$$

(a＝21.7, b＝70.8, c＝0.037) → (2177080037) → [••• 13033 **2177080037** 26374•••]. (14)

The string **2177080037** in (14) occurs at position 162,972,204 counting from the first digit after the decimal point of π.

(G) Growth analysis of ruminant animals

We conducted two kinds of numerical simulations.

(G–1) Growth analysis using relative growth rate (RGR)

The growth analysis of a ruminant animal using RGR (Brody, 1945) is given by

$$W = W_0\cdot\exp(\mathrm{RGR}\cdot t), \qquad (15)$$

where t＝time, W_0＝weight at time 0, W＝weight at time t.

If an animal increases its weight from 81 kg to 87 kg in 7 days, then RGR=0.010. This is expressed as follows,

$87=81\cdot\exp(0.010\cdot7)$. (16)

(87 kg, 81 kg, 0.010, 7 days) → (878100107) → [･･･52282 **878100107** 91046･･･]. (17)

The string **878100107** in (17) occurs at position 57,697,615 counting from the first digit after the decimal point of π.

(G–2) Growth analysis using absolute growth rate (AGR)

The growth analysis of a ruminant animal using AGR (Brody, 1945) is given by

$W=W_0+\mathrm{AGR}\cdot t$, (18)

where t=time, W_0=weight at time 0, W=weight at time t.

If an animal weighing 494 kg shows an average AGR of 0.7 kg for 50 days, then it becomes 529 kg. This is expressed as follows,

$529=494+0.7\cdot50$. (19)

(529 kg, 494 kg, 0.7 kg/day, 50 days) → (5294940750) → [･･･11831 **5294940750** 60229･･･]. (20)

The string **5294940750** in (20) occurs at position 73,988,175 counting from the first digit after the decimal point of π.

(H) Economic aspects of ruminant agriculture

We used data, adapted from Fukuoka Office of Kyushu Agricultural Administration Bureau (2006), on the number of Wagyu cattle slaughtered in Fukuoka prefecture and the wholesale price of carcass of them at the central wholesale market of Fukuoka city in Japan in 2005.

(26,447 head, 1,904 yen/kg) → (264471904) → [･･･67719 **264471904** 05060･･･]. (21)

The string **264471904** in (21) occurs at position 81,172,829 counting from the first digit after the decimal point of π.

(I) Base sequence

Ruminant animals digest plant fibers by the action of rumen microbes in order to supply meat and milk to humans. Proteins in ruminant products and rumen microbes are composed of amino acids that are encoded by nucleic acids, DNA and RNA. Therefore, we would like to take up bases in DNA here. Each of four kinds of bases in DNA is given two digits: 1 and 5 for adenine (A), 2 and 6 for thymine (T), 3 and 7 for guanine (G), 4 and 8 for cytosine (C). Actually, each base is given either number.

(I–1) An example related to DNA structure

We used data, adapted from Watson *et al*. (1987a), on complementary bases that were investigated in order to show right–handed double helix in DNA. Complementary bases are shown in (22) and (23).

(GGTATACC) → (33212144) → [･･･82100 **33212144** 38750･･･]. (22)

(CCATATGG) → (44121233) → [･･･96332 **44121233** 45900･･･]. (23)

The string **33212144** in (22) and its complementary string **44121233** in (23) occur at position 156,193,425 and 5,157,708, respectively, counting from the first digit after the decimal point of π. DNA shows complementary oligonucleotides, but they are located at different places in digits of π when expressed numerically, a problem that is out of solving.

(I–2) Primer for specific detection in the study of rumen bacteria

We used data, adapted from a review by Tajima and Nagamine (2004), on primer for detection study on *Prevotella ruminicola* in the rumen. Since we notice that long strings are impossible to find in 200 million digits of π, they should be divided into some parts and given either number in order to succeed in finding. Thus,

Forward primer (GGTTATCTTGAGTGAGTT)→(GGTTATCTT)+(GAGTGAGTT)
→(332212422)+(313231322)→(332656866)+(717271322)
→[･･･90927**332656866**77585･･･]+[･･･85809 **717271322** 54505･･･]. (24)

The first string **332656866** and second string **717271322** in (24) occur at position 6,281,476 and 18,130,419, respectively, counting from the first digit after the decimal point of π.

Reverse primer (CTGATGGCAACTAAAGAA) → (CTGATGGCA)+(ACTAAAGAA)
→(423123341)+(142111311)→(423123341)+(542551715)
→[･･･28869**423123341**47337･･･]+[･･･84000 **542551715** 83173･･･]. (25)

The first string **423123341** and second string **542551715** in (25) occur at position 82,090,974 and 109,544,178, respectively, counting from the first digit after the decimal point of π.

Searching digits of *e* for numerically expressed information on bases encoding amino acids

In this section, we used the first 1 million digits of *e* published by Nemiroff and Bonnell (1994). We have to find the position in digits of *e* at which a string occurs, because the 1 million digits of *e* that we use here do not have an automatic searching system. Therefore, we focus on very short strings of digits that express information on bases numerically.

(A) Three bases encoding an amino acid

This section deals with sequences of bases encoding amino acids (Watson *et al*., 1987b). As shown in the preceding section, each of four kinds of bases in DNA is given two digits: 1 and 5 for adenine (A), 2 and 6 for thymine (T), 3 and 7 for guanine (G), 4 and 8 for cytosine (C). In RNA that is required for the synthesis of proteins using amino acids, thymine (T) is replaced by uracil (U) that is given 0 and 9. T and U can be given the same numbers, but we deal with T and U differently in the numerical expression.

Five amino acids are chosen here: glutamic acid (Glu), serine (Ser), lysine (Lys), methionine (Met) and phenylalanine (Phe). There are several combinations of bases in RNA that encode an amino acid, but one combination is chosen: GAG for Glu, UCA for Ser, AAA for Lys, AUG for Met and UUC for Phe. Each amino acid has eight combinations of digits ($2^3=8$), because each base has two digits. In this attempt, we would like to find two places in digits of e for each set of numerically expressed bases encoding an amino acid.

(A–1) GAG for Glu

(GAG) → (353) → [•••452 **353** 602•••]. (26)

(GAG) → (713) → [•••874 **713** 526•••]. (27)

The string **353** in (26) and string **713** in (27) occur at position 17 and 26, respectively, counting from the first digit after the decimal point of e.

(A–2) UCA for Ser

(UCA) → (045) → [•••459 **045** 235•••]. (28)

(UCA) → (945) → [•••475 **945** 713•••]. (29)

The string **045** in (28) and string **945** in (29) occur at position 13 and 80, respectively, counting from the first digit after the decimal point of e.

(A–3) AAA for Lys

(AAA) → (115) → [•••190 **115** 738•••]. (30)

(AAA) → (551) → [•••069 **551** 702•••]. (31)

The string **115** in (30) and string **551** in (31) occur at position 200 and 301, respectively, counting from the first digit after the decimal point of e.

(A–4) AUG for Met

(AUG) → (107) → [•••437 **107** 539•••]. (32)

(AUG) → (197) → [•••238 **197** 068•••]. (33)

The string **107** in (32) and string **197** in (33) occur at position 283 and 607, respectively, counting from the first digit after the decimal point of e.

(A–5) UUC for Phe

(UUC) → (904) → [•••845 **904** 523•••]. (34)

(UUC) → (098) → [•••230 **098** 793•••]. (35)

The string **904** in (34) and string **098** in (35) occur at position 12 and 493, respectively, counting from the first digit after the decimal point of e.

DISCUSSION

In the present study, we arbitrarily chose pieces of numerically expressed information on ruminant agriculture in order to find them easily in digits of π and e. In addition, there were cases where we divided a string into two parts in order to find them more easily. These difficulties came from the limitation that the sequence of digits of π we used was not long enough to locate the position at which strings occurred, in spite of 200 million digits. It is suggested, therefore, that various pieces of numerical information on ruminant agriculture will be found in digits of π and e when they are expanded into as long sequence of digits as possible. Do we find the same numerical information in digits of irrational numbers other than π and e? This is an issue of interest, but we would like to stick to special properties of π and e: (1) π is indispensable to forming a circle and a sphere that are symmetric with respect to handling, (2) exponential functions with base e show symmetric properties with respect to differential and integral. There may be a concept of symmetries at the back of many things in nature, a reason why we have taken up π and e in the present study.

Is there a possibility that the numerically expressed base sequence of a gene or a genome is found as either a string or dispersed strings in digits of π and e? This is a dream, but seems to be very difficult to achieve. However, we wish to hope that in the distant future someone will find, in digits of π and e, many pieces of numerically expressed information on ruminant agriculture, leading to a kind of unification from molecular to ecological level.

CONCLUSIONS

It was suggested that some pieces of numerically expressed information on ruminant agriculture were found in 200 million digits of π and in 1 million digits of e.

REFERENCES

Anderson, D. G. 2006 "Pi Search." http://www.angio.net./pi/piquery

Brody, S. 1945 Time relations of growth of individuals and populations. *In* "Bioenergetics and growth – with special reference to the efficiency complex in domestic animals", Reinhold Publishing Corporation, New York, pp. 484–574

Feynman, R. P., R. B. Leighton and M. L. Sands 1965 Mechanics. *In* "The Feynman Lectures on Physics", Addison–Wesley Publishing Company, Inc., Massachusetts. (Translated into Japanese by Tsuboi, C., Iwanami Shoten Publishers, Tokyo, 2003, pp. 294–308)

Fukuoka District Meteorological Observatory 2006 http://www.fukuoka–jma.go.jp/cgi–bin/fukuoka/chosa/geppou_past/fukuoka.cgi

Fukuoka Office of Kyushu Agricultural Administration Bureau 2006 http://www.fukuoka.info.maff.go.jp/toukei/17syokuniku/17syokuniku.htm

Hunt, R. 1990 *Basic Growth Analysis*. Unwin Hyman Ltd., London.

Kanada, Y. 2003 Calculation of Circular Ratio using Computer. *J. Math. Cult.*, **1**: 72—83 (written in Japanese)

Maor, E. 1994 *e*: The Story of A Number. Princeton University Press, Princeton. (Translated into Japanese by Iri, U., Iwanami Shoten Publishers, Tokyo, 1999)

Nemiroff, R. J. and J. T. Bonnell 1994 The Number *e* to 1 Million Digits. http://antwrp.gsfc.nasa.gov/htmltest/gifcity/e.1 mil

Ørskov, E. R. 1982 Protein Nutrition in Ruminants. Academic Press, London

Posamentier, A. S. and I. Lehmann 2004 π: A Biography of the World's Most Mysterious Number. Prometheus Books. Inc. New York. (Translated into Japanese by Matsuura, S., Nikkei Business Publications, Inc., Tokyo, 2005)

Radford, P. J. 1967 Growth analysis formulae–their use and abuse. *Crop Sci.*, **7**: 171–175

Shimojo, M and I. Goto 1987 A study on the relation between organic matter disappearance and acetyl bromide lignin of tropical forages. *Jpn. J. Zootech. Sci.*, **58**: 750–753 (written in Japanese with English summary)

Shimojo, M and I. Goto 1990 Improvement of nutritive value of tropical grasses by physical or chemical treatment. 3. Effect of ammonia treatment on chemical composition and dry matter digestibility. *J. Japan. Grassl. Sci.*, **36**: 197–202 (written in Japanese with English summary)

Shimojo, M., Y. Imura, M. Tobisa, N. Koga, T. Bungo, Y. Nakano, T. Nishihira, I. Goto and Y. Masuda 1997 Formation of indigestible materials and increase in dry matter indigestibility in the growth of two tropical forages. *J. Fac. Agr., Kyushu Univ.*, **42**: 95–99

Shimojo, M., K. Ikeda, Y. Asano, R. Ishiwaka, T. Shao, H. Sato, M.

Tobisa, Y. Nakano, N. Ohba, Y. Yano and Y. Masuda 2003a A symbolic representation of field–forage–ruminant relationships using polar form on the complex plane. *J. Fac. Agr., Kyushu Univ.*, **47**: 359–366

Shimojo, M., Y. Asano, K. Ikeda, R. Ishiwaka, T. Shao, H. Sato, M. Tobisa, Y. Nakano, N. Ohba, Y. Yano and Y. Masuda 2003b Complex representation of field–forage–ruminant relationships using symmetric properties of Euler's formula. *J. Fac. Agr., Kyushu Univ.*, **47**: 367–372

Shimojo, M., Y. Asano, K. Ikeda, R. Ishiwaka, T. Shao, H. Sato, M. Tobisa, Y. Nakano, N. Ohba, Y. Yano and Y. Masuda 2003c A stereographic representation of Euler's formula to show spirals and topological similarities to micro–structures in ruminants and forages. *J. Fac. Agr., Kyushu Univ.*, **48**: 71–75

Tajima, K. and T. Nagamine 2004 Gene analysis of rumen microbes. *In* " New Rumen World – microbial ecology and metabolic control – ", ed. by R. Onodera and H. Itabashi, Rural Culture Association, Tokyo, pp. 151–169 (written in Japanese)

Tobisa, M., Y. Nakano, J. Paek, T. Mochizuki, M. Shimojo and Y. Masuda 2005 Fermentation quality and palatability of rice plant silages as affected by mixing with phasey bean (*Macroptilium lathyroides* (L.) Urb.). *Jpn. J. Grassl. Sci.*, **51**: 274–280 (written in Japanese with English summary)

Watson, D. J. 1952 The physiological basis of variation in yield. *Adv. Agron.*, **4**: 101–145

Watson, J. D., N. H. Hopkins, J. W. Roberts, J. A. Steitz and A. M. Weiner 1987a Molecular Biology of the Gene (4th ed.), The Benjamin/Cummings Publishing Co., Inc., California. (Translated into Japanese under the supervision of Matsubara, K., K. Nakamura and K. Miura, Tokyo Denki University Press, Tokyo, 2001, pp. 240–281)

Watson, J. D., N. H. Hopkins, J. W. Roberts, J. A. Steitz and A. M. Weiner 1987b Molecular Biology of the Gene (4th ed.), The Benjamin/Cummings Publishing Co., Inc., California. (Translated into Japanese under the supervision of Matsubara, K., K. Nakamura and K. Miura, Tokyo Denki University Press, Tokyo, 2001, pp. 431–462)

Yoshida, T. 2000 *Emotion for imaginary number*. Tokai University Press, Tokyo. (written in Japanese)

Zhao, J. Y., M. Shimojo and I. Goto 1993 The effects of feeding level and roughage/concentrate ratio on the measurement of protein degradability of two tropical forages in the rumen of goats, using the nylon bag technique. *Anim. Feed Sci. Technol.*, **41**: 261—269