Introducing Complex Numbers into Basic Growth Functions (6) : Hypothetic Breakdown of '1' into Complex Numbers and Application to Definite Integral of exp(t) Expanded into Infinite Series

Shimojo, Masataka
Laboratory of Animal Feed Science, Division of Animal Science, Department of Animal and Marine Bioresource Sciences, Faculty of Agriculture, Kyushu University

Ikeda, Kentarou
Research Fellow, Faculty of Agriculture, Kyushu University

Asano, Yoki
Employed Research Scientist, Miyazaki University

Ishiwaka, Reiko
Research Fellow, Faculty of Agriculture, Kyushu University

他

https://doi.org/10.5109/4654

出版情報：九州大学大学院農学研究院紀要. 50 (2), pp.407-414, 2005-10-01. Faculty of Agriculture, Kyushu University
バージョン：
権利関係：

J. Fac. Agr., Kyushu Univ., **50** (2), 407–414 (2005)

Introducing Complex Numbers into Basic Growth Functions – (VI) Hypothetic Breakdown of '1' into Complex Numbers and Application to Definite Integral of exp(t) Expanded into Infinite Series –

Masataka SHIMOJO*, Kentarou IKEDA[1], Yoki ASANO[2], Reiko ISHIWAKA[1], Hiroyuki SATO[3], Yutaka NAKANO[4], Manabu TOBISA[5], Noriko OHBA[6], Minako EGUCHI[7] and Yasuhisa MASUDA

Laboratory of Animal Feed Science, Division of Animal Science, Department of Animal and Marine Bioresource Sciences, Faculty of Agriculture, Kyushu University, Fukuoka 812–8581, Japan
(*Received June 30, 2005 and accepted July 26, 2005*)

The definite integral of exp(t) expanded into infinite series included two sets of '1+(–1)' in the calculation of growth, and each of '1' and '–1' was described using the product of eight complex numbers. The present study was designed under hypotheses to leave complex numbers by the breakdown of product form in the complex representation of '1', where a minus sign was given to each of even-numbered pieces of complex number out of eight in order to conserve the value of '1'. This was followed by inserting them into the calculation of growth using exp(t). The results obtained were as follows. The value of '1' was constructed by the product of complex numbers that were different in part from those used in the primary description, which was caused by giving a minus sign to each of even-numbered (2, 4, 6, 8) pieces of complex number. The hypothetic breakdown of product form in the complex representation of '1' left zero, two or four sorts of complex numbers. The complex numbers were left in more pieces when a minus sign was given to each of the four pieces of complex number than when given to each of the two, six or eight pieces. Inserting complex numbers that were left into exp(t) did not influence the calculation of growth, suggesting that the definite integral of exp(t) expanded into infinite series was accompanied hypothetically by pair appearances and pair disappearances of complex numbers with their opposites.

INTRODUCTION

There are some attempts where the complex number [$\exp(\boldsymbol{i}\theta)=\cos\theta+\boldsymbol{i}\sin\theta$] was applied to descriptions of some aspects of ruminant agriculture; (1) a rough relationship between light extinction and leaf inclination in forage canopy (Shimojo, 1998), (2)

[1] Research Fellow, Faculty of Agriculture, Kyushu University
[2] Employed Research Scientist, Miyazaki University, Miyazaki 889–2192, Japan
[3] Laboratory of Animal Feed Science, Division of Animal Science, Department of Animal and Marine Bioresource Sciences, Graduate School of Bioresource and Bioenvironmental Sciences, Kyushu University
[4] University Farm, Faculty of Agriculture, Kyushu University
[5] Faculty of Agriculture, Miyazaki University, Miyazaki 889–2192, Japan
[6] Research Student, School of Agriculture, Kyushu University
[7] Technical Official, School of Agriculture, Kyushu University
* Corresponding author (E-mail: mshimojo@agr.kyushu-u.ac.jp)

digestibility changes with forage growth expressed on the complex plane (Shimojo *et al.*, 1998a, b), (3) rotation properties of $\exp(\boldsymbol{i}\theta)$ for describing the cycling of matter in field–forage–ruminant relationships (Shimojo *et al.*, 2003a, b), (4) rotating the axis of $\exp(\boldsymbol{i}t)$ to give $\exp(t)$ used for growth functions (Shimojo *et al.*, 2003c), (5) hypothetic spiral properties of $\exp(\boldsymbol{i}\theta)$ similar to micro–structures in living things (Shimojo *et al.*, 2003d), (6) philosophy in the use of complex representation of ruminant agriculture (Shimojo *et al.*, 2003e), (7) a hypothetic way to derive complex numbers from the complex representation of '$0=(-1)+1$' where both '-1' and '1' were described using the product of eight complex numbers (Shimojo *et al.*, 2004b), and (8) introducing complex numbers into the differentiation and definite integral of $\exp(t)$ expanded into infinite series (Shimojo *et al.*, 2004c, d, e, f, 2005). Although these reports include many trials and errors, the complex number that is known as Euler's formula seems to have a potential, through speculations under hypotheses, for giving rough images of some aspects of ruminant agriculture (Shimojo *et al.*, 2004a).

Two reports (Shimojo *et al.*, 2004d, e) showed that the definite integral of $\exp(t)$ expanded into infinite series included two sets of '$(-1)+1$'. The complex representation of '-1' was given more attention than that of '1', because the hypothetic breakdown of product form in the eight complex numbers constructing '-1' left odd–numbered pieces of complex number (Shimojo *et al.*, 2004b, d, e, f, 2005). At first we did not consider that complex numbers were left in the case of '1' (Shimojo *et al.*, 2003e, 2004b, c, d, e, f, 2005), but we have noticed that there might be ways to leave complex numbers from the breakdown of complex representation of '1'. This is explained as follows. Giving a minus sign to each of even–numbered pieces of complex number does not influence the value of '1', and the hypothetic breakdown of product form might be expected to leave complex numbers.

This study was designed under hypotheses to leave complex numbers by the breakdown of product form in the complex representation of '1', followed by inserting them into the calculation of growth using the definite integral of $\exp(t)$ expanded into infinite series.

HYPOTHETIC BREAKDOWN OF COMPLEX REPRESENTATION OF '1' TO LEAVE COMPLEX NUMBERS

Giving a minus sign to each of even–numbered pieces of complex number out of eight constructing '1'

The complex representation of '1' (Shimojo *et al.*, 2003e, 2004b, c, d, e, f, 2005) is given by

$$1=\exp(\boldsymbol{i}\theta)\cdot\boldsymbol{i}\exp(-\boldsymbol{i}\theta)\cdot\boldsymbol{i}\exp(\boldsymbol{i}\theta)\cdot(-\exp(-\boldsymbol{i}\theta))\cdot(-\exp(\boldsymbol{i}\theta))\cdot(-\boldsymbol{i}\exp(-\boldsymbol{i}\theta))\cdot(-\boldsymbol{i}\exp(\boldsymbol{i}\theta))\cdot\exp(-\boldsymbol{i}\theta). \quad (1)$$

Equation (1) is composed of four different pairs of a complex number and its opposite, and in addition, eight complex numbers are related through phase shifts. This is the primary description that forms one group, namely ${}_8C_0=1$, where no complex number is given an additional minus sign.

Giving a minus sign to each of the two complex numbers out of eight

The combination of two from eight is given by

$$ {}_8C_2 = 28. \tag{2} $$

The 28 cases are divided into two groups; (i) the group composed of a complex number from each of the two different pairs, (ii) the group composed of a pair of complex number and its opposite.

(i) The group composed of a complex number from each of the two different pairs

The number of cases in group (i) is given by

$$ ({}_4C_2)\cdot({}_2C_1)\cdot({}_2C_1) = 24. \tag{3} $$

An example is given by

$$ \begin{aligned} 1 = &(-\exp(\boldsymbol{i}\theta))\cdot\boldsymbol{i}\exp(-\boldsymbol{i}\theta)\cdot\boldsymbol{i}\exp(\boldsymbol{i}\theta)\cdot(-\exp(-\boldsymbol{i}\theta)) \\ &\cdot(-\exp(\boldsymbol{i}\theta))\cdot(-(-\boldsymbol{i}\exp(-\boldsymbol{i}\theta)))\cdot(-\boldsymbol{i}\exp(\boldsymbol{i}\theta))\cdot\exp(-\boldsymbol{i}\theta). \end{aligned} \tag{4} $$

The hypothetic breakdown of product form in (4) gives

$$ \begin{aligned} &(-\exp(\boldsymbol{i}\theta)) + \boldsymbol{i}\exp(-\boldsymbol{i}\theta) + \boldsymbol{i}\exp(\boldsymbol{i}\theta) + (-\exp(-\boldsymbol{i}\theta)) \\ &+ (-\exp(\boldsymbol{i}\theta)) + (-(-\boldsymbol{i}\exp(-\boldsymbol{i}\theta))) + (-\boldsymbol{i}\exp(\boldsymbol{i}\theta)) + \exp(-\boldsymbol{i}\theta) \\ &= -2\exp(\boldsymbol{i}\theta) + 2\boldsymbol{i}\exp(-\boldsymbol{i}\theta). \end{aligned} \tag{5} $$

(ii) The group composed of a pair of complex number and its opposite

The number of cases in group (ii) is given by

$$ {}_4C_1 = 4. \tag{6} $$

An example is given by

$$ \begin{aligned} 1 = &\exp(\boldsymbol{i}\theta)\cdot\boldsymbol{i}\exp(-\boldsymbol{i}\theta)\cdot(-\boldsymbol{i}\exp(\boldsymbol{i}\theta))\cdot(-\exp(-\boldsymbol{i}\theta)) \\ &\cdot(-\exp(\boldsymbol{i}\theta))\cdot(-\boldsymbol{i}\exp(-\boldsymbol{i}\theta))\cdot(-(-\boldsymbol{i}\exp(\boldsymbol{i}\theta)))\cdot\exp(-\boldsymbol{i}\theta). \end{aligned} \tag{7} $$

The hypothetic breakdown of product form in (7) gives

$$ \begin{aligned} &\exp(\boldsymbol{i}\theta) + \boldsymbol{i}\exp(-\boldsymbol{i}\theta) + (-\boldsymbol{i}\exp(\boldsymbol{i}\theta)) + (-\exp(-\boldsymbol{i}\theta)) \\ &+ (-\exp(\boldsymbol{i}\theta)) + (-\boldsymbol{i}\exp(-\boldsymbol{i}\theta)) + (-(-\boldsymbol{i}\exp(\boldsymbol{i}\theta))) + \exp(-\boldsymbol{i}\theta) \\ &= 0. \end{aligned} \tag{8} $$

Equation (8) shows that choosing a pair does not make changes due to the exchange between plus and minus signs [$\boldsymbol{i}\exp(\boldsymbol{i}\theta) \to -\boldsymbol{i}\exp(\boldsymbol{i}\theta)$; $-\boldsymbol{i}\exp(\boldsymbol{i}\theta) \to \boldsymbol{i}\exp(\boldsymbol{i}\theta)$], namely nothing occurs.

Giving a minus sign to each of the four complex numbers out of eight

The combination of four from eight is given by

$$ {}_8C_4 = 70. \tag{9} $$

The 70 cases are divided into three groups; (i) the group composed of a complex number from each of the four different pairs, (ii) the group composed of a pair and a complex number from each of the two different pairs out of the remaining three, (iii) the group composed of two different pairs.

(i) The group composed of a complex number from each of the four different pairs

The number of cases in group (i) is given by

$$({}_2C_1)\cdot({}_2C_1)\cdot({}_2C_1)\cdot({}_2C_1)=16. \tag{10}$$

An example is given by

$$\begin{aligned}1=&(-\exp(\boldsymbol{i}\theta))\cdot\boldsymbol{i}\exp(-\boldsymbol{i}\theta)\cdot(-\boldsymbol{i}\exp(\boldsymbol{i}\theta))\cdot(-\exp(-\boldsymbol{i}\theta))\\&\cdot(-\exp(\boldsymbol{i}\theta))\cdot(-(-\boldsymbol{i}\exp(-\boldsymbol{i}\theta)))\cdot(-\boldsymbol{i}\exp(\boldsymbol{i}\theta))\cdot(-\exp(-\boldsymbol{i}\theta)).\end{aligned} \tag{11}$$

The hypothetic breakdown of product form in (11) gives

$$-2\exp(\boldsymbol{i}\theta)+2\boldsymbol{i}\exp(-\boldsymbol{i}\theta)-2\boldsymbol{i}\exp(\boldsymbol{i}\theta)-2\exp(-\boldsymbol{i}\theta). \tag{12}$$

(ii) The group composed of a pair and a complex number from each of the two different pairs out of the remaining three

The number of cases in group (ii) is given by

$$({}_4C_1)\cdot({}_3C_2)\cdot({}_2C_1)\cdot({}_2C_1)=48. \tag{13}$$

An example is given by

$$\begin{aligned}1=&(-\exp(\boldsymbol{i}\theta))\cdot(-\boldsymbol{i}\exp(-\boldsymbol{i}\theta))\cdot\boldsymbol{i}\exp(\boldsymbol{i}\theta)\cdot(-\exp(-\boldsymbol{i}\theta))\\&\cdot(-(-\exp(\boldsymbol{i}\theta)))\cdot(-\boldsymbol{i}\exp(-\boldsymbol{i}\theta))\cdot(-(-\boldsymbol{i}\exp(\boldsymbol{i}\theta)))\cdot\exp(-\boldsymbol{i}\theta).\end{aligned} \tag{14}$$

The hypothetic breakdown of product form in (14) gives

$$-2\boldsymbol{i}\exp(-\boldsymbol{i}\theta)+2\boldsymbol{i}\exp(\boldsymbol{i}\theta). \tag{15}$$

(iii) The group composed of two different pairs

The number of cases in group (iii) is given by

$${}_4C_2=6. \tag{16}$$

An example is given by

$$\begin{aligned}1=&(-\exp(\boldsymbol{i}\theta))\cdot(-\boldsymbol{i}\exp(-\boldsymbol{i}\theta))\cdot\boldsymbol{i}\exp(\boldsymbol{i}\theta)\cdot(-\exp(-\boldsymbol{i}\theta))\\&\cdot(-(-\exp(\boldsymbol{i}\theta)))\cdot(-(-\boldsymbol{i}\exp(-\boldsymbol{i}\theta)))\cdot(-\boldsymbol{i}\exp(\boldsymbol{i}\theta))\cdot\exp(-\boldsymbol{i}\theta).\end{aligned} \tag{17}$$

The hypothetic breakdown of product form in (17) gives

$$0. \tag{18}$$

Choosing two different pairs causes the exchange between plus and minus signs in each pair, resulting in that nothing occurs.

Giving a minus sign to each of the six complex numbers out of eight

The combination of six from eight is given by

$${}_8C_6=28. \tag{19}$$

The 28 cases are divided into two groups; (i) the group composed of two different pairs and a complex number from each of the remaining two different pairs, (ii) the group composed of three different pairs.

(i) The group composed of two different pairs and a complex number from each of the remaining two different pairs

The number of cases in group (i) is given by

$$({}_4C_2)\cdot({}_2C_1)\cdot({}_2C_1)=24. \tag{20}$$

An example is given by

$$1=(-\exp(\boldsymbol{i}\theta))\cdot(-\boldsymbol{i}\exp(-\boldsymbol{i}\theta))\cdot(-\boldsymbol{i}\exp(\boldsymbol{i}\theta))\cdot(-\exp(-\boldsymbol{i}\theta))$$
$$\cdot(-(-\exp(\boldsymbol{i}\theta)))\cdot(-(-\boldsymbol{i}\exp(-\boldsymbol{i}\theta)))\cdot(-\boldsymbol{i}\exp(\boldsymbol{i}\theta))\cdot(-\exp(-\boldsymbol{i}\theta)). \tag{21}$$

The hypothetic breakdown of product form in (21) gives

$$-2\boldsymbol{i}\exp(\boldsymbol{i}\theta)-2\exp(-\boldsymbol{i}\theta). \tag{22}$$

(ii) The group composed of three different pairs

The number of cases in group (ii) is given by

$${}_4C_3=4. \tag{23}$$

An example is given by

$$1=(-\exp(\boldsymbol{i}\theta))\cdot(-\boldsymbol{i}\exp(-\boldsymbol{i}\theta))\cdot(-\boldsymbol{i}\exp(\boldsymbol{i}\theta))\cdot(-\exp(-\boldsymbol{i}\theta))$$
$$\cdot(-(-\exp(\boldsymbol{i}\theta)))\cdot(-(-\boldsymbol{i}\exp(-\boldsymbol{i}\theta)))\cdot(-(-\boldsymbol{i}\exp(\boldsymbol{i}\theta)))\cdot\exp(-\boldsymbol{i}\theta). \tag{24}$$

The hypothetic breakdown of product form in (24) gives

$$0. \tag{25}$$

This shows that choosing three different pairs causes the exchange between plus and minus signs in each pair, namely nothing occurs.

Giving a minus sign to each of the eight complex numbers out of eight

The combination of eight from eight is given by

$${}_8C_8=1. \tag{26}$$

This case is given by taking four different pairs,

$${}_4C_4=1. \tag{27}$$

Therefore,

$$1=(-\exp(\boldsymbol{i}\theta))\cdot(-\boldsymbol{i}\exp(-\boldsymbol{i}\theta))\cdot(-\boldsymbol{i}\exp(\boldsymbol{i}\theta))\cdot(-(-\exp(-\boldsymbol{i}\theta)))$$
$$\cdot(-(-\exp(\boldsymbol{i}\theta)))\cdot(-(-\boldsymbol{i}\exp(-\boldsymbol{i}\theta)))\cdot(-(-\boldsymbol{i}\exp(\boldsymbol{i}\theta)))\cdot(-\exp(-\boldsymbol{i}\theta)). \tag{28}$$

The hypothetic breakdown of product form in (28) gives

$$0. \tag{29}$$

Choosing four different pairs causes the exchange between plus and minus signs in each pair, resulting in that nothing occurs.

COMBINING HYPOTHETIC BREAKDOWN OF '1' INTO COMPLEX NUMBERS WITH DEFINITE INTEGRAL OF exp(t) EXPANDED INTO INFINITE SERIES

Definite integral of exp(t) expanded into infinite series

As shown by Shimojo *et al.* (2004d, e), the definite integral of exp(t) expanded into infinite series is given by

$$\begin{aligned}\exp(t_2)\text{-}\exp(t_1) &= \int_{t_1}^{t_2} \exp(t)dt \\ &= \int_{t_1}^{t_2} \left(1+\frac{t}{1!}+\frac{t^2}{2!}+\cdots+\frac{t^n}{n!}+\cdots\right)dt \\ &= \left[\frac{t}{1!}+\frac{t^2}{2!}+\cdots+\frac{t^n}{n!}+\cdots\right]_{t_1}^{t_2} \\ &= \left[\left(1+\frac{t}{1!}+\frac{t^2}{2!}+\cdots+\frac{t^n}{n!}+\cdots\right)-1\right]_{t_1}^{t_2} \\ &= \left[\frac{t}{1!}+\frac{t^2}{2!}+\cdots+\frac{t^n}{n!}+\cdots\right]_{t_1}^{t_2}+\{1+(-1)\}-\{1+(-1)\}. \end{aligned} \tag{30}$$

Equation (30) gives a kind of growth calculation. It goes, however, without saying that the growth function takes the form of exp($r \cdot t$) where r shows relative growth rate of forages or ruminants.

Combining equation (30) with hypothetic breakdown of '1' into complex numbers

This is, for example, given by inserting equation (22) into equation (30). Thus,

$$\begin{aligned}\exp(t_2)\text{-}\exp(t_1) &= \int_{t_1}^{t_2} \exp(t)\, dt \\ &= \left[\frac{t}{1!}+\frac{t^2}{2!}+\cdots+\frac{t^n}{n!}+\cdots\right]_{t_1}^{t_2}+\{(-2\boldsymbol{i}\exp(\boldsymbol{i}\theta)-2\exp(-\boldsymbol{i}\theta))+(-1)\} \\ &\quad -\{(-2\boldsymbol{i}\exp(\boldsymbol{i}\theta)-2\exp(-\boldsymbol{i}\theta))+(-1)\} \\ &= \left[\frac{t}{1!}+\frac{t^2}{2!}+\cdots+\frac{t^n}{n!}+\cdots\right]_{t_1}^{t_2}+(-2\boldsymbol{i}\exp(\boldsymbol{i}\theta)-2\exp(-\boldsymbol{i}\theta)) \\ &\quad +(2\boldsymbol{i}\exp(\boldsymbol{i}\theta)+2\exp(-\boldsymbol{i}\theta)) \\ &= \left[\frac{t}{1!}+\frac{t^2}{2!}+\cdots+\frac{t^n}{n!}+\cdots\right]_{t_1}^{t_2}. \end{aligned} \tag{31}$$

Equation (31) shows that the insertion of equation (22) coming hypothetically from '1' into equation (30) does not influence the calculation.

Equations (31) suggests that the calculation of growth using the definite integral of exp(t) expanded into infinite series is accompanied hypothetically by pair appearances and pair disappearances of complex numbers with their opposites. The way of hypothetic breakdown into complex numbers for '1' is different from that for '−1' (Shimojo *et al.*, 2004d). This difference and related problems will be taken up in our following report in the same issue.

Conclusions and suggestions from the present study

Giving a minus sign to each of even-numbered pieces (2, 4, 6, 8) of complex number out of eight constructing '1' does not influence the value of '1'. The hypothetic breakdown of product form in the complex representation of '1' leaves zero, two or four sorts of complex numbers. The complex numbers are left in more pieces when a minus sign is given to each of the four pieces of complex number than when given to each of the two, six or eight pieces. Inserting complex numbers that are left into exp(t) does not influence the calculation of growth, suggesting that the definite integral of exp(t) expanded into infinite series is accompanied hypothetically by pair appearances and pair disappearances of complex numbers with their opposites.

REFERENCES

Shimojo, M. 1998 A rough image of the relationship between light extinction and leaf inclination in plant canopy. *Proc. 8th World Conf. Anim. Prod.*, Seoul, Vol. II, 506–507

Shimojo, M., T. Bungo, Y. Imura, M. Tobisa, N. Koga, S. Tao, M. Yunus, Y. Nakano, I. Goto, M. Furuse and Y. Masuda 1998a Digestibility decrease with forage growth as interpreted using complex plane. *Proc. 8th World Conf. Anim. Prod*, Seoul, Vol. II, 514–515

Shimojo, M., T. Bungo, Y. Imura, M. Tobisa, N. Koga, S. Tao, M. Yunus, Y. Nakano, I. Goto, M. Furuse and Y. Masuda 1998b Use of complex number in the analysis of increase in dry matter indigestibility with growth of forages. *J. Fac. Agr., Kyushu Univ.*, **43**: 137–142

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., K. Ikeda, Y. Asano, R. Ishiwaka, T. Shao, H. Sato, M. Tobisa, Y. Nakano, N. Ohba, Y. Yano and Y. Masuda 2003c Exponential functions with base e in growth analysis and deriving them from rotations of axes of time described using Euler's formula. *J. Fac. Agr., Kyushu Univ.*, **48**: 65–69

Shimojo, M., Y. Asano, K. Ikeda, R. Ishiwaka, T. Shao, H. Sato, M. Tobisa, Y. Nakano, N. Ohba, Y. Yano and Y. Masuda 2003d 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

Shimojo, M., K. Ikeda, Y. Asano, R. Ishiwaka, T. Shao, H. Sato, M. Tobisa, Y. Nakano, N. Ohba, Y. Yano and Y. Masuda 2003e Philosophical properties of Euler's formula in its application to symbolic representation of some aspects of ruminant agriculture. *J. Fac. Agr., Kyushu Univ.*, **48**: 77–83

Shimojo, M., Y. Asano, K. Ikeda, R. Ishiwaka, T. Shao, H. Sato, M. Tobisa, Y. Nakano and Y. Masuda 2004a Simple descriptions of some micro– and macro–structures in ruminant agriculture. *In* "Biotechnology of Lignocellulose Degradation and Biomass Utilization", ed. by K. Ohmiya, K. Sakka, S. Karita, K. Kimura, M. Sakka and Y. Onishi, Uni Publishers Co. Ltd., Tokyo, pp. 325

Shimojo, M., K. Ikeda, Y. Asano, R. Ishiwaka, T. Shao, H. Sato, M. Tobisa, Y. Nakano, N. Ohba, Y. Yano and

Y. Masuda 2004b Hypothetic incomplete pair disappearances of complex numbers forming '0=(−1)+1' in the application to complex representation of some aspects of ruminant agriculture. *J. Fac. Agr., Kyushu Univ.*, **49**: 61–67

Shimojo, M., K. Ikeda, R. Ishiwaka, H. Sato, Y. Asano, M. Tobisa, Y. Nakano, N. Ohba, M. Eguchi and Y. Masuda 2004c Introducing complex numbers into basic growth functions – (I) Applying complex representation of '1' to differentiation of exponential function with base *e* expanded into infinite series –. *J. Fac. Agr., Kyushu Univ.*, **49**: 331–335

Shimojo, M., K. Ikeda, R. Ishiwaka, H. Sato, Y. Asano, M. Tobisa, Y. Nakano, N. Ohba, M. Eguchi and Y. Masuda 2004d Introducing complex numbers into basic growth functions – (II) Applying complex representation of '(−1)+1' to definite integral of exponential function with base *e* expanded into infinite series –. *J. Fac. Agr., Kyushu Univ.*, **49**: 337–341

Shimojo, M., K. Ikeda, R. Ishiwaka, H. Sato, Y. Asano, M. Tobisa, Y. Nakano, N. Ohba, M. Eguchi and Y. Masuda 2004e Introducing complex numbers into basic growth functions – (III) Symmetry breakdown in complex representation of '0=(−1)+1' in definite integral of exponential function with base *e* expanded into infinite series –. *J. Fac. Agr., Kyushu Univ.*, **49**: 343–348

Shimojo, M., K. Ikeda, R. Ishiwaka, H. Sato, Y. Asano, M. Tobisa, Y. Nakano, N. Ohba, M. Eguchi and Y. Masuda 2004f Introducing complex numbers into basic growth functions – (IV) Hypothetic appearance of exponential function with base *e* from the complex representation of '0=(−1)+1' –. *J. Fac. Agr., Kyushu Univ.*, **49**: 349–353

Shimojo, M., K. Ikeda, R. Ishiwaka, H. Sato, Y. Asano, M. Tobisa, Y. Nakano, N. Ohba, M. Eguchi and Y. Masuda 2005 Introducing complex numbers into basic growth functions – (V) Hypothetic factors influencing increase in θ in $\exp(\theta)$ –. *J. Fac. Agr., Kyushu Univ.*, **50**: 135–139