**Evolution of Cooperation: The Analysis of the Case Wherein a Different Player Has a Different Benefit and a Different Cost**

Letters on Evolutionary Behavioral Science

Shun Kurokawaa,b \*

aGraduate School of Agriculture, Kyoto University, Oiwake-cho, Kitashirakawa, Sakyo-ku, Kyoto 606-8502, Japan

bInstitute of Zoology, Chinese Academy of Sciences, Datun Road, Chaoyang, Beijing 100101, P. R. China

\*Author for correspondence (kurokawa@kais.kyoto-u.ac.jp)

**Supplementary file**

**Appendix A**

*Proof for (1)*

We consider the game between a (*c*1, *b*1, *f* (*l*), 0) and (*c*2, *b*2, *f* (*l*), 0). We define *x* as the expected total payoff by an individual playing a (*c*1, *b*1, *f* (*l*), 0) in a game with two (*c*1, *b*1, *f* (*l*), 0)s and *y* as the expected total payoff by an individual playing a (*c*2, *b*2, *f* (*l*), 0) in a group consisting of one (*c*1, *b*1, *f* (*l*), 0) and one (*c*2, *b*2, *f* (*l*), 0).

We can then determine the condition under which a (*c*1, *b*1, *f* (*l*), 0) is an ESS against an invasion of (*c*2, *b*2, *f* (*l*), 0); we can show that the ESS condition will hold only if

. (A. 1)

Now after algebraic calculations (see Sigmund, 2010), we have

(A. 2)

(A. 3)

Using (A. 1)–(A. 3), the ESS condition will hold only if (1). This is the end of the proof.

**Appendix B**

We consider the case wherein the game is played by individuals whose error rates are different in what follows.

Here, we consider the game between (*c*, *b*, *f* (*l*), ) and (*c*, *b*, *f* (*l*), ). In this case, after algebraic calculation (see Sigmund, 2010), we can know that when an (*c*, *b*, *f* (*l*), ) player encounters (*c*, *b*, *f* (*l*), ), (*c*, *b*, *f* (*l*), ) gets

(B. 1)

Similarly, when an (*c*, *b*, *f* (*l*), ) player encounters (*c*, *b*, *f* (*l*), ), (*c*, *b*, *f* (*l*), ) gets

(B. 2)

Using (B. 1) and (B. 2), we can know that the condition under which (*c*, *b*, *f* (*l*), ) is stable against an invasion of (*c*, *b*, *f* (*l*), ) is given as

(B. 3)

Assuming that ,

(B. 4)

where

This means that when the error rate is smaller than the critical value (), a strategy which has a smaller error rate than the resident strategy can invade, while when the error rate is larger than the critical value (), a strategy which has a larger error rate than the resident strategy can invade. Thus, the error rate goes to 0 or 1, which depends on the initial state. This result can be regarded similar with special case 3. Note that when is met, holds true; hence, the error rate goes to 1, irrespective of the initial state.

**References**

Sigmund, K. (2010). The calculus of selfishness. Princeton: Princeton University Press. (doi: 10.1515/9781400832255)