Research Paper

Fluctuating Asymmetry: An Early Warning Indicator of Environmental Stress

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Abstract

To ensure sustainable development of our environment, it is important to maintain its health. We, therefore, need indicators or markers that tell us if our environment is stressed even before actual deterioration of its quality takes place. Measuring the physico-chemical changes in an environment is one way of determining environmental quality. However, these usually do not have much meaning unless they are measured in relation to the biological health of the living organisms in that environment. Fluctuating asymmetry appears to be a good bioindicator of the state of environmental quality. This is an easy to do and inexpensive way of determining if the environment is capable of sustainable development. Preliminary data measuring the fluctuating asymmetry of the gill rakers, pelvic fins and pectoral fins of the Nile tilapia, *Oreochromis niloticus* from two lakes in the Philippines indicate that fluctuating asymmetry may indeed be a good bioindicator of the quality of an environment.

Keywords*: bioindicator, environmental quality, environmental stress, fluctuating asymmetry, Nile tilapia.*

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Introduction

Van Valen first introduced fluctuating asymmetry as a measure of environmental degradation and developmental stability in 1962. Several researchers later picked up the methodology, but it was Palmer in 1994, who really generated several researches when he came up with his primer. Very recently the group of Lens and Van Dongen (2000, 2002) contributed to refining the statistical analysis associated with the methodology. They also established the real worth of fluctuating asymmetry as a measure of environmental stress.

A group of Russians led by Zakharov (2001a, 2001b) also firmly established fluctuating asymmetry as the major morphogenetic methodology in measuring environmental stress. They also established five-grade scales for estimating the level of developmental stability and fluctuating asymmetry in several indicator organisms. They recommended that in order to get the total view of environmental stress, all aspects of homeostatic disturbance must be measured. The parameters to be measured are found in Table 1.1 next page.

What is Fluctuating Asymmetry?

There are three kinds of asymmetry, directional, antisymmetry and fluctuating. As the term implies, directional symmetry (DA) shows skewness towards either the right or the left direction. Antisymmetry (AS) on the other hand shows divergence from symmetry while fluctuating asymmetry (FA) are random differences between the left and right sides of bilaterally symmetrical characters in an organism. The asymmetry therefore fluctuates between left and right and will eventually cancel out each other.

Fluctuating Asymmetry (FA) measurement is based on the following assumptions:

- Identical sets of genes control the development of two sides of a bilaterally symmetrical organism
- Fluctuations are environmental in origin.

Table 1 Homeostatic disturbances measured to determine environmental stress (Adapted from Zakharov et al, 2001)

Parameters Measured	What It Measures
Morphogenetic homeostasis	Developmental stability
Cytogenetic homeostasis	Chromosome aberrations
Physiological homeostasis	Energy metabolism, growth, photosynthesis
Biochemical homeostasis	Oxidative stress, metabolic products
Immunological homeostasis	Blood cells, antibodies

As the level of environmental stress or instability increases, the ability of the organism to maintain homeostasis at various levels will be affected. Thus, this inability to maintain homeostasis is manifested as deviations from normal symmetry. Increase in the level of fluctuating asymmetry (FA) is therefore shown as a good indicator of environmental stress even before any decline in population number or reproduction occurs (Lens et al, 2002; Lens and Van Dongen, 2002; Oxnevad et al, 2002; Aparicio, 2000; Pelabon and Van Breukelen, 1998).

How is Fluctuating Asymmetry Measured?

Left-right asymmetries can be measured using two groups of characters: meristic (numerable) characters and plastic or metric (measurable) characters.

For meristic or numerable characters, asymmetry in each organism is determined as the difference in the number of a specific character on the left and right sides. For example, Oxnevad et al (2002) counted three meristic characters in their study of the perch population: the number of gill rakers on the lower first branchial arch, the number of gill rakers on the upper first branchial arch, and the number of pectoral fin rays.

For plastic or metric characters, measuring the left and right sides of a specific character and determining the differences in measurements between the two sides determine fluctuating asymmetry. Pelabon and Van Breukelen (1998) for example, measured asymmetry in antler size in roe deer.

Preliminary Data

Our own work with fluctuating asymmetry involves counting the upper and lower gill rakers as well as the pectoral and pelvic fin rays of the Nile tilapia (*Oreochromis niloticus*) from two lakes in the Philippines. Gill rakers aid in the feeding of fishes and they differ in shape and number among different fishes. For example, fishes that eat large prey such as other fishes have short, widely spaced gill rakers while fishes that eat smaller prey have longer, thinner and more numerous gill rakers. Gill rakers are therefore good characters to use as indicators of changes in diet and environmental stress. However, pelvic fin and pectoral fin rays did not show much fluctuating asymmetry and therefore appear not to be good indicators of environmental stress for the Nile tilapia.

Our preliminary data using the four meristic characters mentioned (upper and lower gill rakers, pectoral and pelvic fin rays) of Nile tilapia from two lakes in the Philippines (Laguna and Taal lakes), indicate an FA index of .43 and .4233 respectively. These are taken from the meristic character counts of 75 fishes each from the two lakes. Based on the five-grade scale for developmental stability in fishes recommended by Zakharov et al (2001b), these values fall within the Grade IV level. This means that both lakes already affect the developmental stability of the Nile tilapia. This index is especially significant since this fish is known to be resistant to heavy metal pollution (Aralar and Aralar, 1994).

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