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Capacity of Autotomy and Postautotomy Movement of Original and Regenerated Tail of Lizards (*Mabouya multifasciata* Kuhl)

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Abstract. Lizards have the ability to shed their tails as a defence mechanism, known as autotomy. The tails will regenerate after automomy. Anatomical difference between original and regenerated tail could have resulted in the difference of capacity of autotomy and postautotomy tail movement. The aims of the research were to study the capacity of autotomy and postautotomy movement of original and regenerated tail of lizard. Comparation of the capacity of autotomy and postautotomic movement between original and the regenerated tail was studied using three groups of lizard, namely group of lizard with original tail (10 lizards), eight weeks regenerated tail group (10 lizards), and twelve weeks regenerate tail group(10 lizards). All groups received same treatment. The lizards were hold on the proximal part of tail with tweezers until autotomy has taken place, and the duration to autotomy and postautotmy movement were recorded. The result of the study revealed that the capacity of autotomy and the postautotomy movement were lower in regenerated tail compare to those of the original one.

Keywords: capacity of autotomy, postautotomy movement, original tail, regenerated tail, lizard

INTRODUCTION

No organisms are completely free from predation (Campbell, 2000). Every organism has a certain way of avoiding its enemies (Curtis, 1983). The ways that are often used to avoid predators include: camouflage, hiding, running away, and autotomy (Halliday, 1994). Autotomy is the ability to shed of the appendages as a way to escape from predator (Bellairs & Bryant, 1985).

Some Lacertilians have the ability to autotomize its tail, which is the break off of the tail at certain places along the tail (Bellairs & Bryant, 1985). Tail autotomy occurs when an animal is chased or captured by its tail (Winchester, 1965). The broken tail will wiggle for a while, attracting predator, while the animal runaway (Bustard, 1968).

In lizards (*Mabouya multifasciata* Kuhl), after autotomy, regeneration occurs and a new tail grows in a shape and size resemble to the original one (White, 1925). The difference between the original and the regenerated tail lies in the structure of the vertebrae, nerves, muscles, and skin (Balinsky, 1976). The regenerated tail is not supported by a series of vertebrae but a non-segmental cartilaginous tube instead. In a mature regenerated tail, the cartilaginous tube might become bone (Soesilo, 1982).

The structural differences between original and regenerated tail allow for alteration in the physiology of autotomy and postautotomy tail movements. Most of the researches on autotomy and regeneration have focused more on the regeneration process and the role of the nervous system in the regeneration. Until now, there has been very little research on the capacity of autotomy and postautotomy movement of regenerated tail.

The laxness of the morphological approach of biological research is a negative trend in the field of biology. Many modern biologists are unaware of the contribution that anatomy can make to our understanding of animal life (Bellairs & Bryant 1985).

Although the capacity of autotomy is of considerable importance related to lizard survival, it is surprising that in some groups of lizards the ability is lost, diminished, or completely absent, such as in the Agamide group, some geckos, and chameleons. Arnold (1984) states the importance of studying aspects of capanty of autotomy in various lizard taxons to determine the ecological and evolutionary aspects of the emergence and loss of this autotomy ability.

This study aims to examine how far the capacity of autotomy of the regenerated tail is compared to the original one, as well as how long the postautotomy movement takes place. This research is needed to determine the survival value of the capacity of autotomy of original and regenerated tail.

MATERIALS AND METHODS

Thirty mature adult male lizards with original tail were caught from paddy fields in Sleman, Yogyakarta, Indonesia. The equipment used in this study were: a set of fishing rod modified to catch lizard, a cage equipped with a water container, tweezers, a digital stopwatch, and stationery kit.

Before treatment, the lizards were acclimated in the laboratory cage for one week. Autotomy was performed twenty lizards by pinching the tail using tweezers at a distance of five cm from the base of the tail, then lift it with the lizard's head facing downwards. In general, within 5-10 seconds the lizard will shed its tail. Then the lizards are kept in cages and fed once every two days, with water supply were renewed every other day. The lizards were then treated as follows: the first 10 lizards were kept for 8 weeks allowing them to had 8 weeks old of regenerated tail, the next 10 lizards were kept for 12 weeks. To compare the capacity of autotomy and postautotomy tail movement between lizards with original and regenerated tail, 3 groups of lizards were used, namely the original tail lizard group (10 lizards), the group of lizards with 8 weeks old regenerated tail (10 lizards), and the lizard group which had 12 weeks old regenerated tail (10 lizards).

The three groups of lizards were then analyzed for

capacity of autotomy by holding the tail with tweezers and the duration time needed for autotomy to be took place were recorded. The duration of time for postautotomy movement were recorded, starting from the tail shed off until it ceased.

The quantitative data consist of the length of time required for the autotomy to occur (in seconds) and the length of time of the shed tail move (in seconds). The study used a completely randomized design at a 95% confidence level by performing autotomy on 3 groups of lizards, each with 10 duplications. One way analysis of variance (ANOVA) was performed on duration length of capacity of autotomy and postautotomy tail movement. Tukey-Test would be performed following significancy of variance test. SPSS 10 for Windows program were used to proceed the data.

RESULTS AND DISCUSSION

ANOVA and Tukey's test on capacity of autotomy are shown in table 1 and table 2, whereas the test on the length of the postautotomy tail movement are shown in table 3 and table 4.

Table 1. ANOVA of capacity of autotomy

Source of variation	Sum of squares	Degrees of freedom	Middle square	F	Sig.
Between groups	580,339	2	290,169	17,397	0,000
Within groups	350,257	21	16,679		
Total	930,596	23			

Table 2. Tukey's test of capacity of autotomy

Group	N	Grouping	
		1	2
Original tail	8	1,576	
8 weeks regenerated tail	8	1,846	
12 weeks regenerated tail	8		12,140

Table 3. ANOVA of postautotomy tail movement

Source of variation	Sum of squares	Free degrees of freedom	Middle square	F	Sig.
Betwen groups	474638,44	2	237319,22	121,88	0,000
Within groups	52572,05	27	1947,11		
Total	527210,49	29			

Tabel 4. Tukey's test of postautotomy tail movement

Group	N	Grouping	
		1	2
Original tail	8		333.15
8 weeks regenerated tail	8	65,08	
12 weeks regenerated tail	8	67,59	

Based on the ANOVA and Tukey's test in table 1, table 2, table 3, and table 4, the results from observations on the capacity of autotomy and postautotomy tail movement are presented in table 5.

Table 5. Mean of duration of autotomy time and duration of postautotomy tail movement

Groups	Mean of duration (seconds) + SD	
	autotomy	postautotomy tail movement
original tail	1,58 ± 0,71 a*	333,15 ± 59,06 a
8 weeks old regenerated tail	1,85 ± 1,20 a	65,08 ± 27,28 b
12 weeks old regenerated tail	12,14 ± 7,79 b	67,59 ± 40,12 b

* similar alphabet refer to no significant differences between them

Statistical analysis showed that there is a significant difference (P> 0.05) in the length of time required for tail autotomy to occur between the original tail group, the group of lizards with 8 weeks old regenerated tail, and the group of lizards with 12 weeks old regenerated tail. Subsequent test between groups using Tukey's test reveal that group of 12 weeks old regenerated tail is significantly differ from the original tail group and the 8 weeks old regenerated tail group. The time needed for autotomy in the group of 12 weeks regenerated tail was the longest, reaching 12.14 seconds. It means that in this group the capacity of autotomy is the lowest. This is probably due to the reinforcement in the cartilage tube of the tail regenerate, as the mature cartilaginous tube would be calcified, making it hard and difficult to break (Luthfi, 2002). Another possibility is that mature cartilaginous tube has no fracture plane as in the original caudal vertebrae. According to Soesilo (1982), autotomy of the lizard with original tail broke off at a fracture plane point of vertebrae. The absence of this fracture plane in the regenerated tail made it more difficult for the tail to break off, so the autotomy need longer time.

Autotomy is a form of defense for Lacertilian to escape predators. Loss of tails after autotomy makes lizards more prone to subsequent predation (Dial & Fitzpatrick, 1983) and reduces their social status (Fox & Rostker, 1982) thereby increasing the risk of death. Decreasing capacity of autotomy in lizards with 12 weeks old regenerated tail is likely to be detrimental in the self-defense mechanism if not compensated by changes in behavior. The longer autotomy time needed the easier for predators to catch their prey. Lin et. al. (2017), however, pointed out that there were no differences in term of survival rate between lizard with original tail and lizard with regenerated tail. The low

survival rate of lizard encounter predator was experienced by tailles lizard following autotomy. However, the risk of mortality returned to baseline after the tails were fully grown (Lin et. al., 2017). Even though Lin et al. (2017) report seems contadictory to our findings, it might be that Lin's report is a special case since the observation was did only for birds as predator. Survival rate for any other predator could reveal different result. The birds would perceive and catch lizard differently to that of land predators.

ANOVA statistical analysis for the length of postautotomy tail movement showed that there was a significant difference ($P < 0.005$) between the original tail group, the 8 weeks regenerated tail group and the 12 weeks regenerated tail group. Tukey's test indicated that the group of 8 weeks and 12 weeks regenerated tail are significantly different from the original tail group.

For original tail group, mean of the length of the postautotomy tail movement reached 333.15 seconds. For the group of 8 weeks and 12 weeks regenerated tail, there was a decrease so that the length of movement of the tail was 65.05 seconds and 67.59 seconds, respectively. This is probably due to the difference in the number of nerves innervating the autotomy segments in the lizard's tail. In regenerated tail, all muscle segments are only invaded by three pairs of spinal nerves originating from 3 pairs of spinal ganglion in the last three remaining segments of the original tail. Whereas in the original tail, one autotomy segment is innervated by three pairs of spinal nerves originating from 3 pairs of spinal ganglions from 3 segments anteriorly (Bellairs & Bryant, 1985).

Other than that, it was known from observation that original tail has more agile and stronger postautotomy movement than the regenerated one. Movement of shed tail after an autotomy is probably a reflex that occurs after the spinal cord breaks off (Bellairs & Bryant, 1985). The post autotomy tail movement attracts predators and offers predators an easier way to find food. This gives the lizard a better chance to escape. In an autotomy event, the tail movement that is not strong enough and less agile, does not attract predators, so in this case autotomy only serves to escape from the bite or grip of the prey. In Lacertilia with a less strong and less agile tail movement, the predator will immediately chase the prey and ignore the wriggling shed tail (Dial & Fitzpatrick, 1983).

CONCLUSION

The study showed that the capacity of autotomy and postautotomy tail movement were lower in lizard with mature regenerated tail compare to one with original tail.

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