Growth performance and prediction of carcass production of captive javan porcupine (*Hystrix javanica*)

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Abstract. Porcupines are unique mammals, their upper body is covered with hard hair resembling sharp cylindrical spines and belongs to the order Rodentia. It has long been used as a source of animal protein. Javan porcupine (*Hystrix javanica*) is an endemic animal on Java and its population is estimated to continue, due to habitat destruction, poaching, and its use without a conservation. Observations on the growth of young javan porcupines were carried out for 12 months in Small Mammal Captivity, Research Center Biology - Indonesian Institute of Sciences. This study aims to determine the growth performance of young porcupines in captivity based on number of births, namely singles, twins, and triplets. The young will be with their mother for 3 months, they will be placed in individual cages. Weighing porcupines is done once a week. The results suggest that porcupines continue grow until they are 12 months old and probably continued. The average weight gain of single born was 30.31 g/day; birth of twins 29.65 g/day, 29.72 g/day; and birth of triplets were 29.57 g/day, 28.14 g/day, and 29.79 g/day. Prediction of 12-month-old porcupine carcass production for single, twins, and triplets, respectively, was 6740.86 g; 6593.15 g; and 6470.50 g.

1 Introduction

The porcupine is the prickliest of rodents, with needle-like quills on its sides, back, and tail. The Javan porcupine (*Hystix javanica*) is one of the 11 species of Old World Porcupines (Family: Hystricidae). This animal is active at night, while throughout the day it stays in its nest inside the ground Nowak [1], the mating system is monogamous, and a pair becomes long-life partners and breeds several times a year [2]. In its natural habitat, porcupines like to eat tubers, rhizomes, forest fruits, leaves, young stems, roots, buds, internal stems, roots, bark, and bamboo shoots [3, 4].

The Javan porcupine is endemic to Indonesia, its distribution covering Java, Madura, Bali, Lombok, Sumbawa, and Flores Tanah Djampa, Rintja, and Sulawesi [5, 6]. These terrestrial animals can be found mainly in lowland areas, secondary forests, and degraded lands. Porcupines are omnivores that eat leaves, fruit and insects.

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Porcupines have a role as a seed dispersal agent [7]. Hystrix is a polyestrus and the gestation period for Hystrix is about 100 to 112 days [8]. A Hystrix usually has 2 to 4 youngs per birth. Female porcupine can give birth twice a year [9, 10]. According to Van Aarde [8], in their habitat the female porcupine gives birth to one to three young per birth, 58.8% single births, 32.1% twins, and 9.1% triplets. Although young porcupines begin to eat solid food after 2 weeks of birth, the mother porcupine still has to nurse it for 13 to 19 weeks postpartum [8]. Young porcupines will live in colonies until they reach two years of age. Before they reach the age of 2 years, they will live with their mother in the nest [9].

H. Javanica has protected status based on Minister of Environment and Forestry Regulation Number: P.92/MENLHK/SETJEN/KUM.1/8/2018, and It is currently classified as Least Concern by the IUCN Red List [11]. Although *H. javanica* has protected status, in reality, illegal hunting of porcupines continues to increase. People in several regions in Indonesia believe that porcupine meat and other parts of the body contain medicinal properties. Porcupines are being illegally hunted and exploited throughout their range in Indonesia facilitated by poor enforcement and legislative weakness. Porcupines are in decline due to habitat loss, retaliatory killings and uncontrolled poaching [12]. Their meat is consumed as an alternative and important source of protein in parts of their range and their quills are used for decorative purposes. Food and medicine derived from wildlife have important nutritional values especially in times of crisis, although the wildlife food often regarded as supplementary to local peoples' diet [13]. Mardiastuti, *et al.* [14] reported that the Javan porcupine (*H. javanica*) and the Malayan porcupine (*H. brachyura*) are used by local people in Indonesia as traditional medicine.

Based on the facts above, conservation and protection efforts for the Javan porcupine should be carried out before this animal is declared extinct. One of the efforts to save it is through captivity, namely the maintenance of wildlife outside their habitat (ex situ conservation). The use of protected wildlife should be followed by breeding efforts through captivity, so that harvesting can be carried out starting from the second generation (F2) which legally can be used commercially. Harvesting is no longer done by taking directly from nature. The purpose of this study was to observe the growth of young Javan porcupine born in captivity in the number of singles, twins, and triplets, and predicting the production of porcupines carcass at the age of 52 weeks.

2 Materials and methods

This experiment was conducted in the Small Mammal Captivity of The Research Center for Biology, Indonesian Institute of Sciences (LIPI), Cibinong, Bogor Regency. The material used was 6 young Javan porcupines which were born from 3 females, consisting of a single, twins, and triplets. From birth to 12 weeks of age, the young porcupines are still with their mothers in the cage. Starting at 13 weeks of age, they were separated from their mothers and placed in three individual cages, each measuring length x width x height (2.25 m x 2.00 m x 2.75 m) with two layers of wire walls and a concrete floor. Single young in cage A, twins in cage B, and triplets in cage C. The feed given is tubers, vegetables, fruit, koi fish pellets as a source of protein and minerals. Feeding was carried out 2 times a day, namely at 08.30 a.m. and 04.30 p.m. The amount of feed given is about 15% of the body weight of each porcupine. Drinking water is available ad libitum. No calculation of consumption and feed conversion was carried out during the study.

The method of measuring phenotypic variables is the body live weight of the young porcupines through weighing at birth and then the young is weighed every week until the 52nd week or 1 year old. Weighing of young was carried out in the morning at 08.00 a.m before the feed was served. Weighing youngs aged 0-12 weeks using a digital scale with a capacity of 5 kg with an accuracy of 1 gram, and weighing porcupines aged 13-52 weeks

using a digital scale with a capacity of 25 kg with a scale of 0.1 kg. Daily weight gain was obtained from the different between final weights with initial weight which divided with total days of experiment (gram/porcupine/day) [15]. Meanwhile, the prediction of porcupine carcass weight at the age of 52 weeks was based on the percentage of carcass weight from previous studies, which was 59.68% Farida *et al*. [16] multiplied by the final body weight. Carcass is the body part of livestock without head, legs, skin, digestive organs, blood and kidneys. Therefore, the components called carcass are meat (muscle), bone and fat [17].

The data obtained from the research results were analyzed descriptively by describing the data in the form of tables or curves into a sentence as well as concluding the research results obtained [18].

3 Results and discussion

The average temperature around the captivity during the study was 25.52ºC (morning), 30.78ºC (noon) and 30.11ºC (afternoon). Average air humidity in the morning, afternoon and evening, respectively 81.83%; 64.26 % and 70.15%. According to Bartos [2] the ideal temperature for tropical porcupines is 70-85ºF or 21-29.4ºC. The factors of low temperature and high humidity in the morning and high temperature and low humidity during the day will affect the condition and productivity of the porcupine.

From Table 1, it can be seen that the birth weight of young Sunda porcupine ranged from 206 - 280 g, the litter size did not have much effect on birth weight. Reported by Roth [19] and Van Aarde [8], individual mass at birth equaling ca. 2.1% of mean adult female mass. Male and female neonates do not differ in body mass [8] and sex ratio at parturition does not differ from 1:1 [20]. Females average ca. 1 litter per year with a mean litter interval of 385 days. Litter size ranges from 1 to 3, with 58.8% of litters being singletons, 32.1% twins, and the remainder triplets [8].

The porcupine's body weight continued to increase until the age of 52 weeks although there was a slight fluctuation in body weight gain. Early weaning performed at the age of 12 weeks (84 days) did not affect the increase in body weight of single, twins, or triplets, while according to Van Aarde [8] mean length of lactation in 9 females porcupines was 101 days. Next Van Aarde [21] reported Postnatal growth rates do not differ between males and females and are nearly linear for the first 20 weeks of life, reaching an asymptotic point (and presumably full adult size) at ca. 52 weeks and an average mass of 11.7 kg. Table 1 shows the average final weight of single, twins , and triplets ranging from 10.84 – 11.30 kg. Reported by Barthelmess [22], the Cape porcupine (*Hystrix africaeaustralis*) or South African porcupine approached the age of 20 weeks and was close to linear until it reached the asymptotic point (adult age) reaching approximately 52 weeks.

The birth weight of single, twins, and triplets varied between 206 – 280 grams (Table 1). In singletons and twins, the birth weight of the young female was greater than that of the young male, on the contrary in the triplets, the birth weight of the young male was greater than that of the young female. At week 12, the young is separated or weaned from its mother. Reported by Bartos [2] young porcupine should remain with their mother in the cage for 24 - 52 weeks. Early weaning is intended so that the porcupine mother can mate and get pregnant again. In addition, based on observations in captivity, since the age of 8 weeks, the youngs have started to learn to eat solid food that is usually given to their mother and the youngs already appear strong and healthy. Early weaning did not affect the growth of young porcupines, because their body weightshould continued to increase (Table 1). Nowak [1] reported that young porcupines have the fastest growth period, which is around the age of 4-5 months, then will go up and down, and will reach adult body weight at the age of 1-2 years.

Table 1. Body weight development of young porcupines born single, twins, and triplets

Week	Body weight					
	Single	Twins		Triplets		
	♀ (g)	♂ (g)	♀ (g)	♂ (g)	♀ (g)	♀ (g)
0 (birth)	261	206	280	254	212	210
1	388	325	430	292	323	279
2	408	472	647	470	460	370
3	454	602	793	587	595	529
4	774	750	954	676	702	646
5	903	879	1068	829	860	821
6	1126	1016	1183	1052	1105	914
7	1338	1205	1335	1176	1273	1133
8	1497	1285	1435	1380	1352	1376
9	1589	1439	1560	1455	1468	1384
10	1705	1622	1719	1653	1552	1500
11	2004	2102	2142	1826	1707	1625
12	2339	2235	2330	1904	1915	1907
13	2980	3140	3355	2112	2204	2211
14	3467	3213	3620	2305	2401	2399
15	3602	3340	3710	2462	2510	2521
16	3877	3510	3830	2611	2778	2764
17	4005	3550	3925	3026	3123	3017
18	4158	4110	4035	3312	3502	3398
19	4230	4220	4150	3616	3836	3792
20	4369	4340	4260	4037	4200	4102
21	4412	4355	4335	4508	4756	4613
22	4568	4410	4400	4765	5007	4822
23	4673	4600	4550	4839	5110	4938
24	4788	4635	4640	4910	5204	5108

25	4876	4710	4714	5132	5386	5307
26	5075	4730	4810	5348	5501	5435
27	5287	5170	5275	5698	5799	5797
28	5690	5610	5740	6005	6189	6101
29	6003	6025	6205	6414	6215	6416
30	6668	6615	6700	6799	6304	6811
31	7100	6985	7105	7100	6412	7069
32	7513	7490	7595	7255	6578	7236
33	7941	7901	8010	7430	6866	7504
34	8337	8433	8500	7646	7005	7709
35	8790	8965	9087	7854	7268	7942
36	9025	9307	9305	8038	7455	8094
37	9398	9411	9491	8224	7680	8235
38	9506	9521	9584	8467	7897	8444
39	9868	9651	10011	8659	8075	8652
40	10036	9725	10206	8891	8269	8847
41	10201	9775	10288	9065	8497	9006
42	10365	9795	10316	9287	8723	9244
43	10453	9823	10504	9465	8986	9406
44	10521	9902	10527	9577	9018	9539
45	10626	9936	10554	9605	9112	9657
46	10707	9949	10608	9799	9268	9706
47	10789	9973	10615	9895	9413	9968
48	10828	10022	10691	10112	9689	10254
49	10879	10042	10674	10487	9790	10586
50	10901	10056	10744	10698	9824	10820
51	10989	10610	10889	10895	9951	10915
52	11295	10997	11098	11018	10455	11053
Average of final body weight	11295	11047.5		10842		

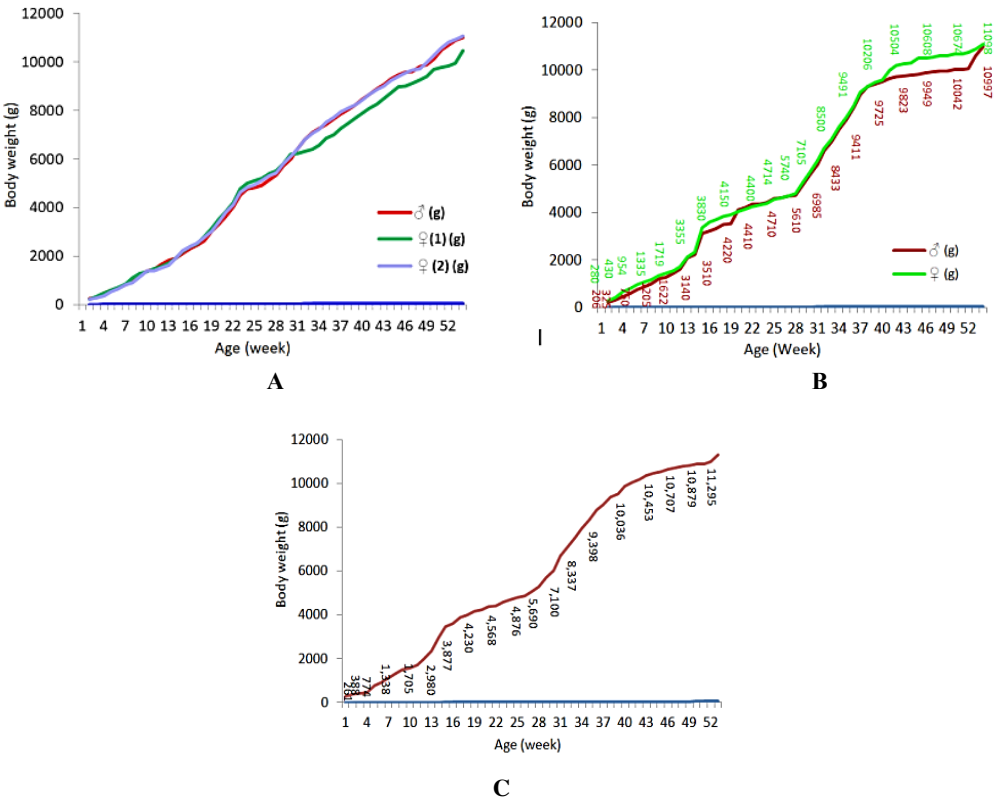

Fig 1. Body weight of development of sunda porcupine of litters being singletons (A), twins (B), and triplets (C)

In zootechnical studies, there are two main aspects in the growth process. The first aspect is the initial growth as an increase in body size (weight and length) per unit time, most of which have been achieved in the embryonic stage, including in the process. The second aspect is growth as a morphogenetic process, namely the increase in different body parts with changes in the size and shape of body components caused by differences in the intensity of growth of various organs and tissues. This differential growth can be called development. The part-to-whole relationship is considered stepwise, as carcass is related to live weight, major components are related to carcass weight, and individual bone, muscle, and fat depots are related to their respective total tissue weights. If animal height or weight are measured from conception to senescence, the data usually follow a flattened "S" shape called the sigmoid curve. The sigmoidal growth curve is formed because age does not cause an increase in body weight, but provides an opportunity for animals to grow, reach maturity and interact with the environment [23]. Growth initially took place very quickly (acceleration) then decreased and tended to be constant. But the growth curves of meat animals raised under commercial conditions may appear as relatively flat slopes (the middle segment of the flat "S", and the sigmoid shape may only become apparent if the data include very young animals or animal beyond a typical market weight. In other words, growth velocity is approximately constant during the commercial growing period.

From Figure 1, it can be seen that the three curves A dan B form like the letter S, while the C curve looks straighter because the body weight development of the three young porcupines from birth to 52 weeks of age is not much different. As reported by Von

Bertalanffy [24], curves of animal mass growth over time are shaped in S, which is also known as sigmoid or sigmoidal curves, while according to Silva *et al*. [25] and Rodrigues, *et al*. 26] that the body growth of most animal species can be described by a sigmoid curve and, therefore, fit by nonlinear models which are widely used for a large number of regression applications. Animal development is related to metabolic rate, which directly influences mass, shape, size, and other body traits [24]. The difference in the shape of the C curve is thought to be due to the number of triplets births, so that during lactation there is competition for mother's milk and after weaning there is competition for feed. This is in accordance with Smith and Mangkoewidjojo [27], stated that adult body weight was influenced by litter size, birth weight (initial weight), mother's milk production and feeding. Cahpman [28] defined maternal effect as the influence, contribution or impact on the phenotype of an individual caused directly by the phenotype of the parent. Body weight can be influenced directly by genetic and maternal effects as well as environmental factors [29, 30, 31]. Maternal effects on offspring phenotype can be caused by genetic or environmental differences between parents, or they can also be caused by genetic and environmental interactions. Body weight gain can be used as a variable to determine the growth of porcupines. Body weight gain is the difference between body weight (harvest) and initial body weight at a certain time. The average weight gain of porcupines for single, twins, and triplets are presented in Table 2.

Table 2. Body weight gain and prediction of carcass production of young porcupine, 1 year old (52 months)

Item	Single	Twins		Triplets		
	♀	♂	♀	♂	♀	♀
Initial BW (g)	261	206	280	254	212	210
Final BW (g)	11,295	10,997	11,098	11,018	10,455	11,053
BW gain per week (g)	212.19	207.52	208.04	207.00	196.98	208.52
BW gain per day (g)	30.31	29.65	29.72	29.57	28.14	29.79
Estimated carcass weight (g) based on carcass percentage = 59.68%*)	6740.86	6563.01	6623.29	6575.54	6239.54	6596.43
Average carcass weight	6740.86	6593.15		6470.50		

Source : Farida *et al*. [16]

Table 3. Slaughter weight, weight, and carcass percentage of Javan porcupine compared to other animals*)

Item	Sex	Slaughter weight (kg)	Carcas weight (kg)	Carcas (%)
Sunda porcupine	Female	6.40	3.79	59.68
	Male	8.70	5.16	59.66
Java mouse-deer	Female	1.92	0.99	50.65
	Male	1.53	0.75	50.48
Rex rabbit	Female	3.02	1.54	51.19

	Male	2.71	1.41	51.95
Goat	Female	24.27	9.77	39.39
	Male	24.23	11.03	42.48
Sheep	Female	25.13	11.70	43.01
	Male	25.80	12.53	44.18
Cattle	Female	214.32	110.60	51.18
	Male	226.14	115.51	51.02

Source: Farida *et al*. [16]

From Table 2, it can be seen that the average daily body weight gain of porcupines were 30.31 g/head (single), 29.65 and 29.72 g/head (twins) and 29.57; 28.14; and 29.79 g/head (triplets). Growth is generally expressed by increasing body weight and body dimensions as a reflection of the adequacy of food intake for body metabolism [32]. Table 2 shows that the average daily weight gain for single young is higher than that of twins and triplets. This is presumably because single-born get enough mother's milk intake, while twins and triplets have to compete for various milks from their mothers in the early stages of their growth. Body weight can be influenced directly by genetic and maternal effects as well as environmental factors [29, 31]. The increase in body weight of young porcupines after being weaned from their mother will depend on the adequacy of feed and nutritional intake. The increase in body weight between male and female was not affected by birth weight, it was proven that young born with low body weights could achieve high daily body weight gain. This may be the effect of the response of the porcupine to environmental conditions such as differences in response to the feed intake. It was stated by Soeparno [33] that among individuals within a breed or between animal races there are differences in responses to the environment, including nutritional, physical, and microbiological. The difference in response causes a difference in the rate of growth. In addition, there are still similarities in the breed or type of porcupine used in this study, namely the Javan porcupine. As reported by Tillman, *et al*. [34], food is not the only factor influencing body composition, as breeding and sex are also strong determinants, especially when food is sufficient to support rapid growth. The same thing was also stated by Soeparno [33] also Everitt and Jury [35], that sex, hormones and castration and genotype also affect animal growth.

Increased use of the Javan porcupine for meat and medicinal purposes in some areas of Indonesia [35]. It has also increased illegal hunting and overexploitation of these animals Gomes [12]. In order to maintain the preservation of protected wild animals, through captive efforts (ex situ) namely breeding wild animals outside their habitat in a controlled manner, harvesting for commercial purposes can be carried out starting from the second generation (F2). Based on the results of research Alves *et al*. [13], that the percentage of porcupine carcasses was higher than that of deer, rex rabbits, goats, sheep, and cattle (Table 3). Prediction of carcass weight calculation of captive Javan porcupine at the age of 52 weeks, respectively 6740.86 g (single), 6563.01 g and 6623.29 g (twins), and 6575.54g; 6239.54 g; and 6596.43 g (triplets). From the prediction of carcass weight (Table 2), singletons produced higher carcass weights than twins and triplets, while the carcass weight produced by twins was not much different from triplets.

The high carcas percentage of the Javan porcupine indicates that this animal has the potential to be bred as a meat-producing animal and can support food diversification

programs, especially in Central Java and East Java, where most of the population has long consumed porcupines meat [35]. Porcupines are relatively undemanding to look after in captivity and acclimatise quickly to the captive environment. They become conditioned to people and are of a large enough size to make a memorable experience for captive visitors, as well as being quite engaging. They can also be used as education/outreach animals, easy to be tame, particularly if they have been hand-reared.

4 Conclusion

The growth curves of porcupines born single, twins, and triplets continued to increase until the observation limit of 52 weeks. Number of births, birth weight, and gender had no effect on final body weight and daily weight gain. The carcass weight of the porcupine is quite high at the age of 52 weeks, so that the porcupine has the potential to be bred as a meat-producing animal to meet protein needs and support food diversification.

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