Korean J. Zool. 35:231-239, 1992

The Growth Analysis of the Crayfish (*Cambaroides similis* Koelbel) (Crustacea) 2. Relative Growth

Kun Seung Yeun, *Yong Tai Noh, and **Byong Kyun Jung

*Bas. Sci. Res. inst., Sungshin Women's Univ., Seoul 136-742; *Dept. of Biology, Kon-kuk Univ., Seoul 133-701; **Sok-Nam Prim., School, Chung Up, 582-890, Korea*

For the analysis of the relative growth of six body parts, such as carapace width, abdominal length, abdominal width, cheliped length, second pereiopod length and third pereiopod length, to the carapace length of crayfish (*Cambaroides similis* Koelbel), the equation $Y = bX^a$ were applied. The results were as follows: 1. In the relative growth of each body part to the carapace length, abdominal width and abdomial length in both sexes showed as positive allometry, the third pereiopod length in both sexes as isometry and the rest showed as negative. The least coefficient of the relative growth was found in cheliped length in female (0.9300). 2. The growth gradient of each body part to the carapace length in each sex revealed decreasing pattern in abdominal length and third pereiopod length in both sexes and the abdominal width in male with the growth centers on the initial growth period, and the rest showed increasing pattern with the growth centers on the 6th growth period except the abdominal width in female on the 3rd growth period.

KEY WORDS: Relative growth, Allometry, Isometry, Growth gradient.

While the growth quantity of the absolute growth is a function of time, the relative growth which is called synonymically by allometric, disharmonic or heterogonic growth, that all the body parts grow not equally to a standard body region can apply the exponential equation $Y = bX^a$ introduced by Huxley and Teissier (1936, 1937), and was followed Tonapi and Rao (1961, 1966), Matsuda (1963, 1967), Park and Lee (1971), Mukerji (1972), William (1972), Park (1976, 1977), Park and Son (1984) and Noh and Yeun (1986).

In this study, the crayfish (*Cambaroides similis* Koelbel) were surveyed on the seven body parts, carapace length, carapace width, abdominal length, abdominal width, cheliped length second pereiopod length and third pereiopod length, and were analyzed the relative growth appling the formulae.

Materials and Methods

Statistical calculation of relative growth

For the analysis of the relative growth, the formula orginated by Huxley and Teissier (1936 and 1937) $Y = bX^a$ was applied. In this exponential equation, X stands for the value of the standard aspect (carapace length) and Y is that of the dependent variable, allomatically growing part. That of b as the theoretical value of Y when the standard X is unique is called the initial growth index, because its value affects the initial size of an aspect. And as the equilibrium constant, the value of a is synonymically called the growth ratio (slope), the coefficient of relative growth, regression coefficient and growth coefficient. The parameters of a and b can be calculated by the usual least square method. By adopting of the logarithm at both sides of the original exponential equation, the logarithic form, $\log Y = \log b + a \log X$,

appears a simple linear relationship. The values of X and Y of the relative growth formula are also a function of time t in each growth period. Therefore the differential equation of the original formula is expressed as $1/Y \times dy/dt = a \times 1/X \times dx/dt$. This equation stated that X and Y mean the growth rate and can derive the function $a = 1/Y \times dy/dt/1/X \times dx/dt$, in which a means the ratio of the specific growth rate of Y to that of X.

When $a > 1$, we have positive allometry; when $a = 1$, isometry; when $a < 1$, negative allometry; when $a = 0$, ceasing of growth; when $a < 0$, actual negative growth. In case of positive allometry, the growth rate of the part is larger than that of the standard or whole and the isometry is the special case when the growth rate of the part is identical with that of the standard or whole.

Growth gradient

The growth gradient is the ratio of the specific growth rate of the two partial body parts at given growth period, and is expresed by the derivative $1/Yi \times dyi/dt/1/Xi \times dxi/dt$ (i = initial growth period to the last), which presents the potential degree of Yi to Xi. The growth period having the maximum potential of the growth gradient is called the growth center.

Results

For the study of certifying the growth state of *Cambaroides similis*, three hundred and fifty six crayfishes (190 male, 166 female) from the ones just after hatching to fully grown-up imagines were measured to the seven body parts, according to seven growing period in both sexes respectively. The mean of the measurement in each period of all the aspects were showed in Table 1. For the analysis of the relative growth to the carapace length of each body part in both sexes, the relative growth formula $Y = bX^a$ were applied (Table 2).

Carapace width in male

The growth gradient of the carapace width in male is increased from 0.5001 of the initial growth period nymph to 1.1495 of the adult. The growth center is in the fully grown adult. The coefficient of the relative growth (a) and the initial growth index (b) are 0.9471 and 5.9560 respectively, that means the relative growth formula is expressed by the equation $Y = 5.9560X^{0.9471}$. The specific growth rate of the carapace width in male is found to be a negative allometry as 94.71 percent to that of the carapace length in male.

Abdominal length in male

The growth gradient of the abdominal length in male is decreased from 1.5193 of the initial growth perioed nymph to 0.8275 of the adult. The growth center is in the initial growth period nymph. The coefficient of the relative growth (a) and the initial growth index (b) are 1.0219 and 9.9015 respectively, that means the relative growth formula is expressed by the equation $Y = 9.9015X^{1.0219}$. The specific growth rate of the abdominal length in male is found to be a slight positive allometry as 102.19 percent to that of the carapace length in male.

Abdominal width in male

The growth gradient of the abdominal width in male is decreased steeply from 1.8218 of the initial growth period nymph to the second growth nymph and almost horizontally to the final adult (0.9812) thereafter. The growth center is in the initial growth period nymph. The coefficient of the relative growth (a) and the initial growth index (b) are 1.1418 and 2.9648 respectively, that means the relative growth formula is expressed by the equation $Y = 2.9648X^{1.1418}$. The specific growth rate of the abdominal width in male is found to be a psitive allometry as 114.18 percent to that of the carapace length in male.

Cheliped length in male

The growth gradient of the cheliped length in male is increased from 0.5900 of the initial growth period nymph to 1.1595 of the adult. The growth center is in the fully grown adult. The coefficient of the relative growth (a) and the initial growth index (b) are 0.9935 and 1.3763 respectively, that means the relative growth formula is expressed by the equation $Y = 1.3762X^{0.9935}$. The specific growth rate of the cheliped length in male is found to be a very slight negative allomery as 99.35 percent to that of the carapace length in

Table 1. The lengths of seven body parts for each growth period in mm (Mean ± SD).

	P	CL	CW	AL
Male	0	3.5290 ± 0.2289	2.3920 ± 0.2555	3.8000 ± 0.2596
	1	4.4840 ± 0.3490	2.1587 ± 0.2326	4.0407 ± 0.4924
	2	9.1822 ± 0.8344	4.3311 ± 0.3385	9.9433 ± 0.8250
	3	14.4054 ± 1.2422	7.0017 ± 1.0592	16.6552 ± 1.9118
	4	19.2477 ± 2.7513	9.9877 ± 1.9636	21.1045 ± 1.7904
	5	23.9800 ± 0.9341	12.5257 ± 0.4447	24.4800 ± 1.0543
	6	29.0367 ± 1.6128	15.4100 ± 1.2679	29.1267 ± 2.6454
Female	0	3.5290 ± 0.2289	2.3920 ± 0.2555	3.8080 ± 0.2596
	1	4.4840 ± 0.3490	2.1587 ± 0.2326	4.0407 ± 0.4924
	2	9.1200 ± 0.7075	4.4545 ± 0.4208	10.4373 ± 1.1291
	3	14.2650 ± 1.3015	7.1682 ± 0.9121	16.2132 ± 1.9854
	4	19.0767 ± 3.0602	9.6538 ± 2.1979	21.1630 ± 4.5604
	5	23.8000 ± 0.8548	12.6600 ± 0.7933	25.7790 ± 1.3984
	6	29.0222 ± 1.9767	15.7867 ± 1.4938	30.5778 ± 1.9358

	P	AW	Ch	Sp	Tp
Male	0	1.1500 ± 0.1025	4.8611 ± 0.4324	3.3160 ± 0.2945	3.7880 ± 0.3140
	1	1.6787 ± 0.1744	6.4043 ± 0.5384	4.0387 ± 0.4473	4.9080 ± 0.3804
	2	4.1133 ± 0.5905	11.7878 ± 4.3837	7.3511 ± 2.7882	10.2644 ± 0.9004
	3	6.5339 ± 0.7397	18.7017 ± 1.7065	12.7287 ± 1.4927	15.7251 ± 1.8526
	4	8.7081 ± 1.7233	25.1312 ± 5.7725	17.2871 ± 2.0377	21.0665 ± 3.2601
	5	10.8029 ± 0.6255	32.6026 ± 1.9626	21.5029 ± 1.4155	26.4057 ± 2.7503
	6	13.2133 ± 1.1401	41.8308 ± 4.3696	26.1400 ± 1.9116	31.2533 ± 1.7877
Female	0	1.1500 ± 0.0125	4.8611 ± 0.4324	3.3160 ± 0.2945	3.7880 ± 0.3140
	1	1.6787 ± 0.1744	6.4043 ± 0.5384	4.0387 ± 0.4473	4.9080 ± 0.3804
	2	4.0473 ± 0.3600	13.7055 ± 0.8509	8.1960 ± 0.4735	10.3120 ± 0.6271
	3	6.5788 ± 0.7986	18.5635 ± 3.6367	12.4241 ± 1.4351	15.5106 ± 1.8182
	4	9.2367 ± 1.2440	23.3685 ± 4.0039	17.0584 ± 1.9804	20.6975 ± 3.7010
	5	12.4467 ± 0.8770	29.2193 ± 2.1461	21.2333 ± 1.0913	25.9093 ± 1.4632
	6	16.2133 ± 1.4790	37.0156 ± 3.7600	25.4889 ± 2.0828	31.2000 ± 2.7936

SD: Standard deviation, P: Growth period (0~6), CL: Carapace length, CW: Carapace width, AL: Abdominal length, AW: Abdominal width, Ch: Cheliped length, Sp: Second pereiopod length, Tp: Third pereiopod length.

male.

Second pereiopod length in male

The growth gradient of the second periopod length in male is increased smoothly from 0.8538 of the initial growth period nymph to the first growth nymph and almost horizontally to the final growth adult (1.0580) thereafter. The growth center is in the adult. The coefficient of the relative growth (*a*) and the initial growth index (*b*) are 0.9921 and 9.0469 respectively, that means the relative growth formula is expressed by the equation $Y = 9.0469X^{0.9921}$. The specific growth rate of the second pereiopod length in male is found to be a slight negative allometry as 99.21 percent to that of the carapace length in male.

Third pereiopod length in male

The growth gradient of the third pereiopod length in male is decreased almost horizontally from 1.0987 of the initial growth period nymph to the final growth adult (0.9679). The growth center is in the initial growth period nymph. The coefficient of the relative growth (*a*) and the initial growth index (*b*) are 1.0017 and 1.0877 respectively, that means the relative growth formula is

Table 2. The growth gradient, the coefficient of relative growth (*a*) and the initial growth period index (*b*) of each body part to carapace length for both sexes.

	P	CW	AL	AW	Ch	Sp	Tp
Male	0	0.5001	1.5193	1.8218	0.5900	0.8538	1.0987
	1	0.8132	1.0898	1.2161	0.8849	0.9678	1.0220
	2	0.9750	0.9745	1.0939	1.0233	1.0118	0.9967
	3	1.0613	0.9141	1.0412	1.0934	1.0341	0.9837
	4	1.1088	0.8753	1.0118	1.1304	1.0466	0.9760
	5	1.1352	0.8479	0.9935	1.1498	1.0539	0.9711
	6	1.1495	0.8275	0.9812	1.1595	1.0580	0.9679
	a	0.9741	1.0219	1.1418	0.9935	0.9921	1.0017
	b	5.9560	9.9015	2.9648	1.3763	9.0469	1.0877
Female	0	0.4594	1.4923	1.1234	0.7754	0.9345	1.0668
	1	0.7951	1.1109	1.2127	0.8776	0.9698	1.0104
	2	0.9685	1.0104	1.2397	0.9150	0.9816	0.9904
	3	1.0725	0.9615	1.2447	0.9340	0.9874	0.9803
	4	1.1232	0.9326	1.2407	0.9455	0.9907	0.9703
	5	1.2498	0.9138	1.2328	0.9531	0.9929	0.9707
	6	2.2643	0.9022	1.2234	0.9587	0.9944	0.9685
	a	0.9531	1.0407	1.2259	0.9300	0.9775	0.9975
	b	5.9429	9.6716	2.5692	1.5780	9.4689	1.0972

Abbreviations are the same as in Table 1.

expressed by the equation $Y = 1.0877X^{1.0017}$. The specific growth rate of the third pereiopod length in male is found to be a almost isometry as 100.17 pecent to that of the carapace length in male.

Carapace width in female

The growth gradient of the carapace width in female is increased gradually from 0.4594 of the initial growth period nymph to 2.2643 of adult. The growth center is in the adult. The coefficient of the relative growth (*a*) and the initial growth index (*b*) are 0.9531 and 5.9429 respectively, that means the relative growth formula is expressed by the equation $Y = 5.9429X^{0.9531}$. The specific growth rate of the carapace width in female is found to be a negative allometry as 95.31 pecent to that of the carapace length in female.

Abdominal length in female

The growth gradient of the abdominal length in female is decreased from 1.4923 of the initial growth perioed nymph to the second growth period nymph and very smoothly to the adult (0.9022) thereafter. The growth center is in the initial growth period nymph. The coefficient of the relative growth (*a*) and the initial growth index (*b*) are 1.0407 and 9.6716 respectively, that means the relative growth formula is expressed by the equation $Y = 9.6716X^{1.0407}$. The specific growth rate of the abdominal length in female is found to be a positive allometry as 104.07 percent to that of the carapace length in female.

Abdominal width in female

The growth gradient of the abdominal width in female is increased smoothly from 1.1234 of the initial growth period nymph to the fourth growth period nymph and decreased almost horizontally to the adult (1.2234) thereafter. The growth center is in the fourth growth period nymph. The coefficient of the relative growth (*a*) and the initial growth index (*b*) are 1.2259 and 2.5692 respectively, that means the relative growth formula is expressed by the equation $Y = 2.5692X^{1.2259}$. The specific growth rate of the abdominal width in female is found to be the higest positive allometry

as 122.59 percent to that of the carapace length in female.

Cheliped length in female

The growth gradient of the cheliped length in female is increased very smoothly from 0.7754 of the initial growth period nymph to 0.9587 of the adult. The growth center is in the adult. The coefficient of the relative growth (*a*) and the initial growth index (*b*) are 0.9300 and 1.5780 respectively, that means the relative growth formula is expressed by the equation $Y = 1.5780X^{0.9300}$. The specific growth rate of the cheliped length in female is found to be the lowest negative allometry as 93.00 percent to that of the carapace length in female.

Second pereiopod length in female

The growth gradient of the second pereiopod length in female is increased very slightly from 0.9345 of the initial growth period nymph to 0.9944 of the adult and the growth center is in the adult. The coefficient of the relative growth (*a*) and the initial growth index (*b*) are 0.9775 and 9.4689 respectively, that means the relative growth formula is expressed by the equation $Y = 9.4689X^{0.9775}$. The specific growth rate of the second pereiopod length in female is found to be a negative allometry as 97.75 percent to that of the carapace length in female.

Third pereiopod length in female

The growth gradient of the third pereiopod length in female is decreased nearly horizontally from 1.0668 of the initial growth period nymph to 0.9685 of the adult and the growth center is in initial growth period nymph. The coefficient of the relative growth (*a*) and the initial growth index (*b*) are 0.9975 and 1.0972 respectively, that means the relative growth formula is expressed by the equation $Y = 1.0972X^{0.9975}$. The specific growth rate of the third pereiopod length in female is found to be the most slight negative allometry as 99.75 percent to that of the carapace length in female.

Discussion

In the relative growth of each body part to the carapace length in male, the abdomonal width and the abdominal length were showed as the positive allometry, the third pereiopod length as the isometry and the cheliped length, the second pereiopod length and the carapace width as the negative allometry (Fig. 1). That is, the coefficient of relative growth of the abdominal width to the carapace length is the largest as $a = 1.1418$, and those of relative growth are followed in the order as the abdominal length (1.0219), the third pereiopod length (1.0017), the cheliped length (0.9935), the second pereiopod length (0.9921) and the carapace width (0.9471). The relative growth of each body part to the catapace length in female, the abdominal width and the abdominal length are pointed out as the positive allometry,

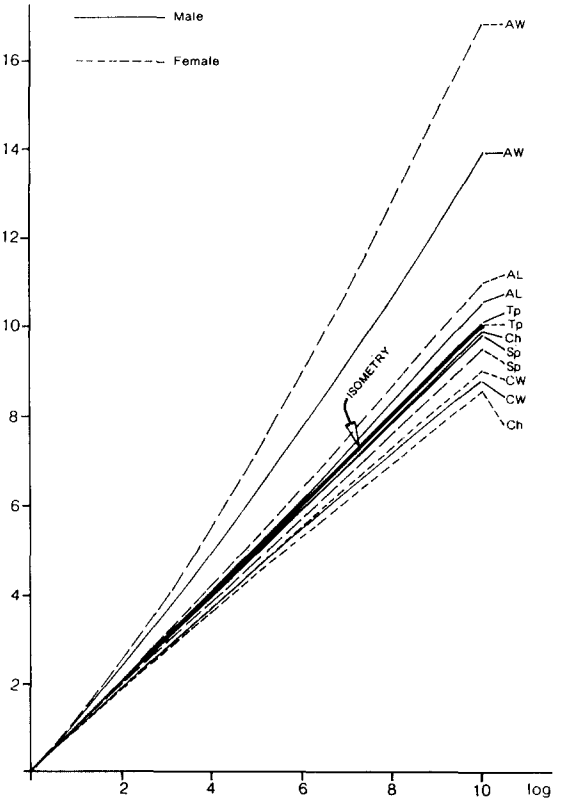

Fig. 1. The relative growths of each body past to the carapace length in both sexes (Abbreviations are the same as in Table 1).

the third pereiopod length as isometry and the second pereiopod length, the carapace width and the cheliped length are the negative allometry. That is, the coefficient of relative growth of the abdominal width is the largest as $a = 1.2259$, and those of the abdominal length (1.0407), the third pereiopod length (0.9975), the second pereiopod length (0.9775), the carapace width (0.9531) and the cheliped length (0.9300) are followed in that order. In previous papers of growth of insects, the authors, Park and Lee (1971), Park (1977), are pointed out that the coefficients of relative growth varied in several aspects to the reference part. It seemed the difference among the coefficients of relative growth of several aspects to the habitat and the ecological niche of each species. The initial growth index of the abdominal length was the largest in both sexes as $b = 9.9015$ of male and $b = 9.6716$ of female, and are followed by the second pereiopod length (9.0469 of male, 9.4689 of female), the carapacr width (5.9560 of male, 5.9429 of female), the abdominal width (2.9648 of male, 2.5692 of female), the cheliped length (1.3763 of male, 1.5780 of female), and the third pereiopod length (1.0877 of male, 1.0972 of female) in that order (Table 2). In the studies of the growth analysis of insects, authors described the relation between the coefficient of relative growth (*a*) and the initial growth index (*b*) that changed vice versa (Park and Lee, 1971) or changed dependently or independently with each other by the aspects (Matsuda, 1967; Park, 1977). In this study, the initial growth index changes independently.

The growth gradients of the relative growth in both sexes, the abdominal length of both sexes and the abdominal width of male showed the concave shaped decrease, and those of the third pereiopod length of both sexes decreased almost horizontally. That is, the growth centers of the former are in the initial growth period and those of the latter are in the final growth period. That of the abdominal width in female only increased from the initial growth period to the third growth period and decreased thereafter, so the growth center was in the third growth period (Figs. 2-3).

Cheliped length in male

The growth gradient of the cheliped length in male is increased from 0.5900 of the initial growth period nymph to 1.1595 of the adult. The growth center is in the fully grown adult. The coefficient of the relative growth (*a*) and the initial growth index (*b*) are 0.9935 and 1.3763 respectively, that means the relative growth formula is expressed by the equation $Y = 1.3762X^{0.9935}$. The specific growth rate of the cheliped length in male is found to be a very slight negative allomery as 99.35 percent to that of the carapace length in male.

Second pereiopod length in male

The growth gradient of the second periopod length in male is increased smoothly from 0.8538 of the initial growth period nymph to the first growth nymph and almost horizontally to the final growth adult (1.0580) thereafter. The growth center is in the adult. The coefficient of the relative growth (*a*) and the initial growth index (*b*) are 0.9921 and 9.0469 respectively, that means the relative growth formula is expressed by the equation $Y = 9.0469X^{0.9921}$. The specific growth rate of the second pereiopod length in male is found

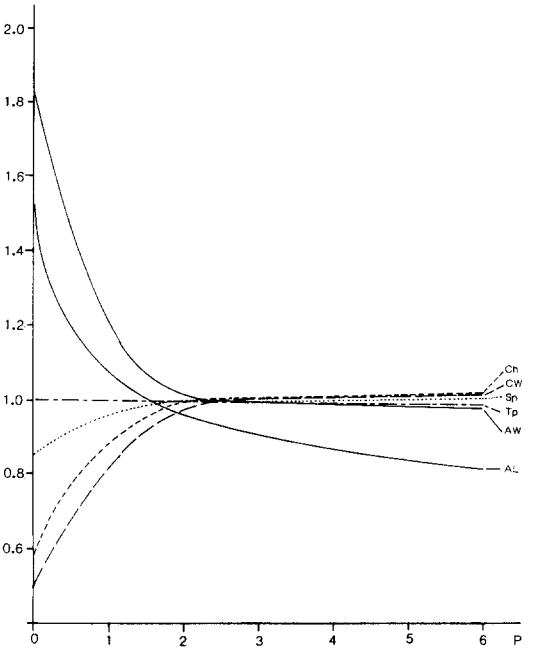

Fig. 2. The growth gradients of each body past to the carapace length in male (Abbreviations are the same as in Table 1).

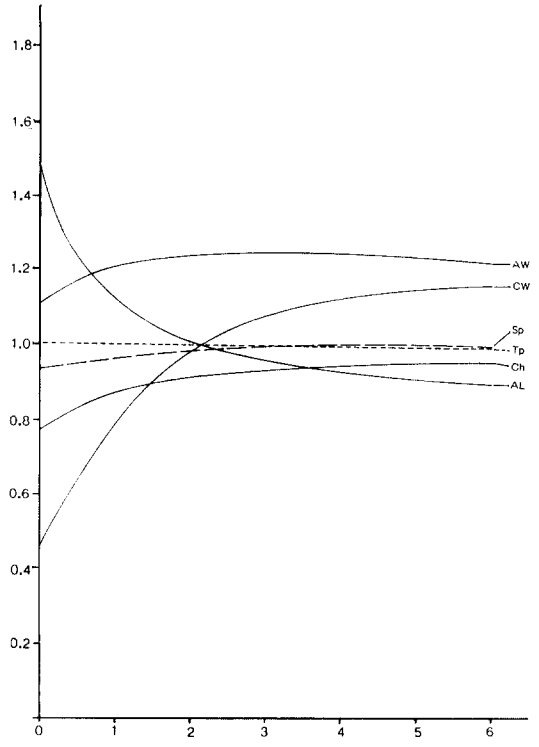

Fig. 3. The growth gradients of each body past to the carapace length in female (Abbreviations are the same as in Table 1).

to be a slight negative allometry as 99.21 percent to that of the carapace length in male.

Third pereiopod length in male

The growth gradient of the third pereiopod length in male is decreased almost horizontally from 1.0987 of the initial growth period nymph to the final growth adult (0.9679). The growth center is in the initial growth period nymph. The coefficient of the relative growth (*a*) and the initial growth index (*b*) are 1.0017 and 1.0877 respectively, that means the relative growth formula is expressed by the equation $Y = 1.0877X^{1.0017}$. The specific growth rate of the third pereiopod length in male is found to be a almost isometry as 100.17 pecent to that of the carapace length in male.

Carapace width in female

The growth gradient of the carapace width in female is increased gradually from 0.4594 of the initial growth period nymph to 2.2643 of adult. The growth center is in the adult. The coefficient of the relative growth (*a*) and the initial growth index (*b*) are 0.9531 and 5.9429 respectively, that means the relative growth formula is expressed by the equation $Y = 5.9429X^{0.9531}$. The specific growth rate of the carapace width in female is found to be a negative allometry as 95.31 pecent to that of the carapace length in female.

Abdominal length in female

The growth gradient of the abdominal length in female is decreased from 1.4923 of the initial growth perioed nymph to the second growth period nymph and very smoothly to the adult (0.9022) thereafter. The growth center is in the initial growth period nymph. The coefficient of the relative growth (*a*) and the initial growth index (*b*) are 1.0407 and 9.6716 respectively, that means the relative growth formula is expressed by the equation $Y = 9.6716X^{1.0407}$. The specific growth rate of the abdominal length in female is found to be a positive allometry as 104.07 percent to that of the carapace length in female.

Abdominal width in female

The growth gradient of the abdominal width in female is increased smoothly from 1.1234 of the initial growth period nymph to the fourth growth period nymph and decreased almost horizontally to the adult (1.2234) thereafter. The growth center is in the fourth growth period nymph. The coefficient of the relative growth (*a*) and the initial growth index (*b*) are 1.2259 and 2.5692 respectively, that means the relative growth formula is expressed by the equation $Y = 2.5692X^{1.2259}$. The specific growth rate of the abdominal width in female is found to be the higest positive allometry as 122.59 percent to that of the carapace length in female.

Cheliped length in female

The growth gradient of the cheliped length in female is increased very smoothly from 0.7754 of the initial growth period nymph to 0.9587 of the adult. The growth center is in the adult. The coefficient of the relative growth (*a*) and the initial growth index (*b*) are 0.9300 and 1.5780 respectively, that means the relative growth formula is expressed by the equation $Y = 1.5780X^{0.9300}$

The specific growth rate of the cheliped length in female is found to be the lowest negative allometry as 93.00 percent to that of the carapace length in female.

Second pereiopod length in female

The growth gradient of the second pereiopod length in female is increased very slightly from 0.9345 of the initial growth period nymph to 0.9944 of the adult and the growth center is in the adult. The coefficient of the relative growth (*a*) and the initial growth index (*b*) are 0.9775 and 9.4689 respectively, that means the relative growth formula is expressed by the equation $Y = 9.4689X^{0.9775}$. The specific growth rate of the second pereiopod length in female is found to be a negative allometry as 97.75 percent to that of the carapace length in female.

Third pereiopod length in female

The growth gradient of the third pereiopod length in female is decreased nearly horizontally from 1.0668 of the initial growth period nymph to 0.9685 of the adult and the growth center is in initial growth period nymph. The coefficient of the relative growth (*a*) and the initial growth index (*b*) are 0.9975 and 1.0972 respectively, that means the relative growth formula is expressed by the equation $Y = 1.0972X^{0.9975}$. The specific growth rate of the third pereiopod length in female is found to be the most slight negative allometry as 99.75 percent to that of the carapace length in female.

Discussion

In the relative growth of each body part to the carapace length in male, the abdomonal width and the abdominal length were showed as the positive allometry, the third pereiopod length as the isometry and the cheliped length, the second pereiopod length and the carapace width as the negative allometry (Fig. 1). That is, the coefficient of relative growth of the abdominal width to the carapace length is the largest as $a = 1.1418$, and those of relative growth are followed in the order as the abdominal length (1.0219), the third pereiopod length (1.0017), the cheliped length (0.9935), the second pereiopod length (0.9921) and the carapace width (0.9471). The relative growth of each body part to the catapace length in female, the abdominal width and the abdominal length are pointed out as the positive allometry, the third pereiopod length as isometry and the second pereiopod length, the carapace width and the cheliped length are the negative allometry. That is, the coefficient of relative growth of the abdominal width is the largest as $a = 1.2259$, and those of the abdominal length (1.0407), the third pereiopod length (0.9975), the second pereiopod length (0.9775), the carapace width (0.9531) and the cheliped length (0.9300) are followed in that order. In previous papers of growth of insects, the authors, Park and Lee (1971), Park (1977), are pointed out that the coefficients of relative growth varied in several aspects to the reference part. It seemed the difference among the coefficients of relative growth of several aspects to the habitat and the ecological niche of each species. The initial growth index of the abdominal length was the largest in both sexes as $b = 9.9015$ of male and $b = 9.6716$ of female, and are followed by the second pereiopod length (9.0469 of male, 9.4689 of female), the carapacr width (5.9560 of male, 5.9429 of female), the abdominal width (2.9648 of male, .2.5692 of female), the cheliped length (1.3763 of male, 1.5780 of female), and the third pereiopod length (1.0877 of male, 1.0972 of female) in that order (Table 2). In the studies of the growth analysis of insects, authors described the relation between the coefficient of relative growth (*a*) and the initial growth index (*b*) that changed vice versa (Park and Lee, 1971) or changed dependently or independently with each other by the aspects (Matsuda, 1967; Park, 1977). In this study, the initial growth index changes independently.

The growth gradients of the relative growth in both sexes, the abdominal length of both sexes and the abdominal width of male showed the concave shaped decrease, and those of the third pereiopod length of both sexes decreased almost horizontally. That is, the growth centers of the former are in the initial growth period and those of the latter are in the final growth period. That of the abdominal width in female only increased from the initial growth period to the third growth

period and decreased thereafter, so the growth center was in the third growth period (Figs. 2-3).

References

Huxley, J. S., and G. Teissier, 1936. Terminology of Relative Growth. *Nature* **9:** 780-781.

Matsuda, R., 1963. A study of relative growth of leg and antennal segments in two species of *Orthotylus* (Het., Miridae). *Proc. R. Ent. Soc. Lon. (A)* **38:** 86-89.

Matsuda, R., 1967. Evolution of relative growth and its taxonomic significance in some animals. *Bull. Nat. Inst. Scis. India* **34:** 95-107.

Mukerji, M. K., 1972. A study of allometric growth in five species of Mirids (Miridae, Hem). *Can. Ent.* **104:** 1223-1228.

Noh, Y. T. and K. S. Yeun, 1986. Growth Analysis of the Potato lady Beetle, *Epilachna vigintioctopunctata* Fabricius (Coccinellidae). *J. Sic. Kon-Kuk Univ.* **11:** 93-107.

Park, S. O., 1976. A mathematical study on the growth pattern of the antennal segments in *Anoplocnemis dallasi* (Coridae, Het.), *Nature and Life* **6:** 37-50.

Park, S. O., 1977. Biostatistical studies on growth pattern and growth factor of the praying mantis, *Paratenodera angustipennis* (Mantidae). *J. Hyosung Women's Univ.* **19:** 229-321.

Park, S. O. and C. E. Lee, 1971. An analytical study on the growth of *Anoplocanemis dallasi* K. *Korean J. Zool.* **14:** 139-158.

Park, S. O. and M. H. Son, 1984. Growth Analysis of the Ash-Gray Leaf Bug, *Piesma maculata. Korean J. Entom.* **14:** 23-30.

Topani, G. T. and R. B. Rao, 1961. On the growth of antennae of *Gerris fluviorum* F. (Hem., Gerridae). *Curr. Sci.* **30:** 226-228.

Topani, G. T. and R. B. Rao, 1966. A study of growth in *Limnometra fluviorum* F. (Hemipetra-Heteropetra), *Proc. Second All-Ind. Cong. Zool.* **2:** 429-437.

William, C. B., 1972. A grophical method of demonstrating allometric growth with special reference to the antennae of Thysanoptera. *J. Ent.* **41:** 151-153.

(Accepted January 31, 1992)

가재(*Cambaroides similis* Koelbel)의 상대성장 분석

연규성 · *노용태 · **정병균(성신여자대학교 기초과학연구소,
*건국대학교 자연과학대학 생물학과, **석남국민학교)

전북 정주시 입원에서 채집한 가재(*Cambaroides similis* Koelbel)를 암수별(암컷 195개체, 수컷 170개체)로 열곱가지 체량 즉, 두흉갑각장, 두흉갑각폭, 복절장, 복절폭, 제일각장, 제이각장 및 제삼각장을 측정하여 두흉갑각장에 대한 상대성장(성장식 $Y = bX^a$)을 분석한 결과 다음과 같다. 1. 암수 각 두흉갑각장에 대한 상대성장은 복절장과 복절폭에서 암수 모두 우성장을 보였고 제삼각장에서는 모두 등성장을, 그리고 나머지 체량에서는 모두 열성장을 나타냈다. 2. 성장경도는 암수 복절장과 제삼각장 및 수컷의 복절폭에서 감소추세를 나타내어 성장중심은 성장초기에 (0)에 있었고, 나머지 체량에서는 증가추세를 보여 성장중심은 최종 성장기 (6)에 두었는데 암컷의 복절폭만은 제삼성장기 (3)까지 증가하다가 감소하므로써 성장 중심은 제삼성장기에 있었다.