Bol. Zool. e Biol. Mar., N.S., n.º 30, pp. 195-216, São Paulo, 1973

BEHAVIORAL ASPECTS OF *ARCTURELLA SAWAYAE* MOREIRA, 1973 (CRUSTACEA, ISOPODA, VALVIFERA)*

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ASPECTOS DO COMPORTAMENTO DE *ARCTURELLA SAWAYAE* MOREIRA, (CRUSTÁCEA, ISOPODA, VALVIFERA)

RESUMO

Vários aspectos do comportamento do isópode *Arcturella sawayae* Moreira, 1973, são descritos e discutidos. O comportamento difere em fêmeas grávidas, quando carregando jovens nas antenas e quando já desprovidas de filhotes. O fato das fêmeas carregarem jovens nas antenas durante um certo período nada representa para a espécie em termos de maior dispersão ou sobrevivência. Os animais locomovem-se nadando ou rastejando ("crawling"). Foi observado que os jovens nadam notadamente quando compelidos. Apresentam, como todos os astacilídeos de um modo geral, morfologia e adaptações estruturais que os tornam animais excelentemente bem adaptados a viverem agarrados a formações salientes. Limpam-se constantemente, removendo os detritos que se acumulam sobre o corpo, ao mesmo tempo que a limpeza, pelas suas características, torna-se um ato auxiliar ou complementar de obtenção de alimento. A atitude de alerta é medida de precaução ou auto-defesa. Receptores de vibrações, turbulências e deslocamentos parecem ser mais importantes do que a visão para a auto-defesa.

SUMMARY

Several behavioral aspects of *Arcturella sawayae* Moreira, 1973, were described in detail in both reproductive females and juveniles. Gravid females, females carrying young on their second antennae and spent females not bearing young differ in behavior. The fact that the young are carried by females seems to be of no value for the species regarding its better survival and dispersion. Crawling and swimming were described and commented. Astacillids show many morphological and structural features which caracterize animals well adapted for climbing on projecting substrata. It was found that cleaning behavior is important in the elimination of adhered detritus from the surface of the body and the appendages, representing an additional auxiliary or complementary mode of feeding. Alert behavior is performed as a self-preservation measure. Receptors of vibrations, turbulence and wave displacement seem to be more important than vision for the onset of the alert behavior.

* Publ. n.º 343 do Inst. Oceanogr. U.S.P

Número especial em homenagem ao Prof. Dr. Paulo Sawaya, no ano jubilar de seu magistério.

INTRODUCTION

A number of papers have been devoted in recent years to the study of the biology and ecology of species of marine Isopoda (Bocquet, 1953; Kinne, 1954; Naylor, 1955; Wolff, 1962; Hessler, 1967, 1971; Moreira, 1966, 1971, 1973). However, ethological aspects have not been treated very extensively in the literature. Usually, in the available accounts the ethological informations are occasional or very brief.

Few ethological informations exist on the representatives of the family Astacillidae, which comprises isopods bearing interesting peculiar characteristics. In southern Brazil these isopods are usually found on seaweeds, bryozoans and gorgonids (Moreira, in press, and unpublished data). One of the most striking feature of juveniles astacilids is that as soon as they leave the brood-pouch, they cling on to the long second antennae of the females (Benedict, 1898; Ohlin, 1901; Richardson, 1905), "which thereby acquire a peculiar velvety appearence" (Sars, 1899).

The present paper aims to report on different behavioral aspects of the astacillid isopod *Arcturella sawayae* Moreira, 1973, concerning especifically to gravid and post-gravid females and juveniles in the first two post-marsupial stages.

MATERIAL AND METHODS

Ovigerous females were collected in the Ubatuba area, north littoral of São Paulo State, at 1 meter depth, from amongst the brown seaweed *Sargassum cymosum* C. Agarth. Further material (3 ovigerous females 8.0, 8.2 and 8.2 mm long) was gathered on *Galaxaura* sp., at 2 meters depth, off Praia do Segredo, Instituto de Biologia Marinha, USP (IBMar). These three female specimens were carefully observed in the IBMar flowing sea-water aquaria, in order to complete the observations (behavior of gravid females) of the Ubatuba specimens.

The females collected at Ubatuba were brought back alive to the laboratory in São Paulo, and kept in an aquarium with sea-water taken from the collecting site. The aquarium was placed in a room receiving natural ilumination from a window, but it did not receive direct sunlight. Inside the aquarium *Sargassum cymosum* was placed together with a large stone covered by *Ulva fasciata* Delile, *Hypnea* sp. and *Derbesia* sp. Both particulate organic matter (detritus) and debris, were also added as a possible source of food. Some days after the instalation of the aquarium, specimens of *Tisbe* sp. (Crustacea: Copepoda) and protozoans, were firstly noticed.

The water was continuosly aerated by a small electric pump, and the circulation of the water set up by aeration maintained organic matter constantly suspended. The amount of evaporated water was always replaced by equal amount of distilled water. The pH reading of the water was through a Beckman pH meter mod. H2. The water temperature was recorded daily. The salinity was measured through the Knudsen method, and the oxygen content by the Winkler method.

For the closer examination of the animals a low power dissecting microscope was used. Some animals, together with small fragments of seaweed and detritus, were placed in small Petri dishes hinged to a piece of cork, inside lhe aquarium. In this way, the behavior of a single animal and part of the feeding process were directly observed, without injuries or disturbances. A total of 9 females and 149 juveniles were observed alive and used in the different laboratory experiments.

During the period of observation the temperature varied from 25 4 to 21.7°C. The average temperature was 22.8°C. The daily variation was small, seldom exceeding 1°C. The salinity of the water as well as the temperature and oxygen content varied very little, being maintaned close to that of sea (salinity, 34.18‰; temperature, 25.0°C; oxygen content, 4.45 ml/l). The average value during the experiment was 34.14‰. The maximum recorded salinity was 34.54, the minimum 33.99‰. These extreme values refer to measures taken prior and after the replacement of the evaporated water by distilled water. The variation in the oxygen content (average 4.30 ml/l) was negligible. The recorded pH averaged 7.05.

1. *Behavior of reproductive females*

At the time of the capture the females were already in advanced breeding stage, bearing embryos in the marsupium. Owing to the good aquaria conditions given to them, the behavior of all gravid, afterwards spent females, could be carefully followed from capture to death.

Behavior of gravid females

The normal characteristic posture of the late gravid females (Fig. 1), seems to agree with that exibited by members of the family Astacillidae: the last three pairs of pereopods firmly griped to the seaweed, anterior half of the body erect, first pairs of pereopods somewhat outstretched, antennae 2 extending forward almost paralel one to another, with the distal end bent slightly down.

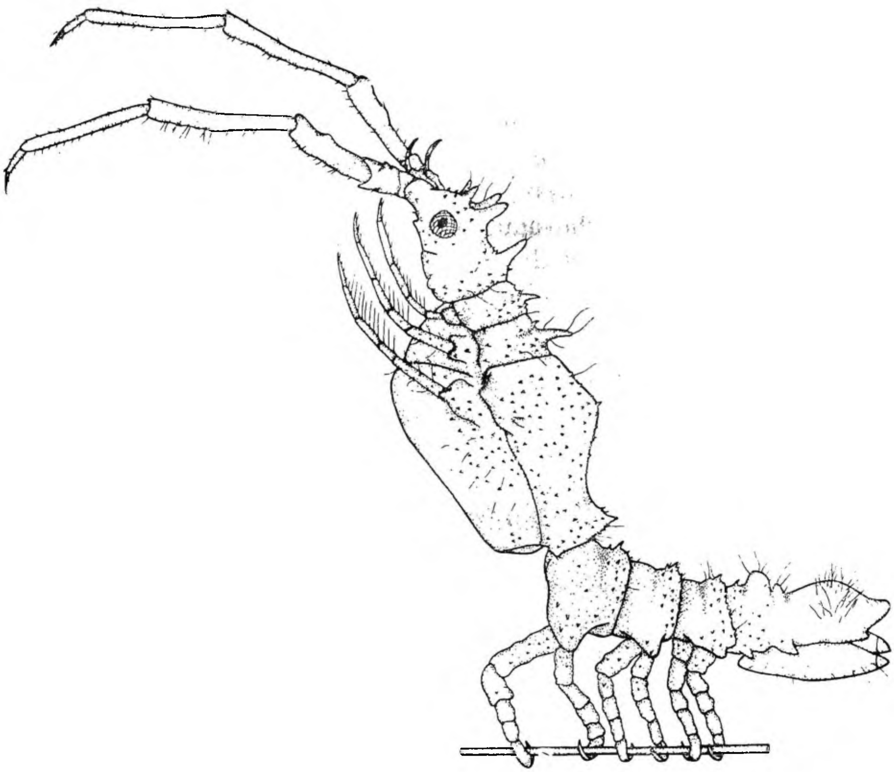

Fig. 1 — *Arcturella sawayae* Moreira, 1973, 8.0 mm in length. Characteristic posture exhibited by late gravid females.

The females bearing embryos remain very still in this attitude most of their time. They are slightly more active at night than at daytime, moving per night only few centimeters at the maximum. During many nights they do not even leave the place from where they quietly spent the day. Usually they are found fastened to prominent places. Progression is by crawling. This motion is performed slowly and is similar to that of the young, which will be described in detail further on. In any one moment gravid females were observed leaving and swimming out from a place. Feeding and cleaning movements have been observed only once. Both these movements seem to be performed very seldom by gravid females.

Behavior of spent females, with young clinging on to the antennae 2

All late gravid females kept under observation were breeding about the same time. Table 1 shows for each female the length, partial length of the breeding period, and life span after breeding.

TABLE 1

Number and length of females of *Arcturella sawayae* Moreira, 1973, observed alive in aquaria conditions, and details of the reproductive period

Specimens N.º	Length of females (mm)	Partial length of breeding period (N.º of days)	Life span after breeding (N.º of days)
1	7.9	13	35
2	8.0	15	32
3	8.0	19	36
4	8.1	14	36
5	8.2	16	28
6	8.3	21	35

The spent females, similar to the gravid, still continue to walk mostly at night, but now slightly longer distances. Most of the day time they remain motionless in a place. They are hardly distinguishable from the seaweed *Sargassum*. The notable cryptic coloration pattern they exibit makes them more inconspicuous and their ready localization is difficult. Females displaying feeding movements were not observed except once when a female was seen eating a very small filament of the green alga *Derbesia* sp.

Many young climb immediately to the second antennae of the female as soon as they leave the female brood-pouch. This fact seems to influence the behavior of the spent females greatly. Curiously, the typical erect posture is now not so often observed. At this time the spent females usually assume two very characteristic postures:

1. Body straight, paralel to the seaweed margin, and

2. Body bentdown, hanging freely in the water from the seaweed margin.

In both these postures, the antennae are maintained always laterally stretched, so that they can hold the young, while the first pereopods are kept tightly juxtaposed to the mouth appendages. The antennae were often noted in close contact with the surface of the seaweed, as if resting on it. Most of their time the spent females remained motionless in both above described posture. From time to time, however, they perform some characteristics movements, as described below.

In the most typical of these movements the females lift the fore half of the body, then bend it completely down until the antennae come in contact with the seaweed. In this posture they remain immobile a few seconds, then returning to the original posture. The other post-gravid movement may be considered as a variant of the described one. The females repeat very rapidly the bending down of the body movements for 3 or 4 times consecutively, and do not remain still after each forward bending of the body.

There is not a regular sequence in the execution of both kinds of movements, i.e., after performing one, the other must not necessarily follow it. A preference for any of these two movements was also not observed. Since they may be executed freely in the water, the antennae bearing the young do not always touch the seaweeds.

The young are sparingly dispersed while the females move forwards little by little. Many of the young gripped on to the antennae leave them, either clinging quickly and firmly onto the neighboring seaweed, or swimming very fastly to cling on nearby to any suitable substrate. Only a few times young leaving the antennae were noticed while the females were performing the body bending movements. The present observations have shown that most of the young leave the antennae while these were resting on the seaweeds.

Experiment n.º 1. This simple experiment was conducted specially to investigate a possible relationship between the body movements executed by the females and the presence of young on their antennae.

From two females all young gripped on to the antennae were forced to leave, and to cling on to the nearest seaweed leaves. It was observed that the females, without young on their antennae, very seldom display bending movements.

Behavior of spent females, after the young leave the antennae 2

All young clinging onto the second antennae leave them after an average of 9 days (Table 2). Again, a drastic change in the behavior of the spent females was observed. From this moment on the characteristic posture displayed by the females is to keep the body straight, resting on the seaweeds. All the body bending movements have ceased, and the females remain motionless in place, hidden amongst the seaweeds. Only very seldom the females were seen to have moved slightly. All present observations suggest that there is a sharp restriction, and certainly a cessation for most of the females, in the consumption of food, both prior, as well as, after breeding.

The maximum and minimum life spans after breeding were, respectively, 36 and 28 days (Table 1). The females length of life after breeding averaged 33 days.

2. *Behavior of juveniles*

The behavior reported from now on refers to free-living young in the first and second post-marsupial stages of development. The main characteristic of these two stages is the absence of the last pair of pereopods, a feature common to all newly born isopods.

2.1 *General behavior*

The young used for the present observations were released from the brood-pouch at night. They were small (Table 2) and completely transparent. Immediately after birth, most of them cling onto the nearest seaweeds, while a smaller number are able to cling onto the female's body, reaching the second antennae afterwards (Table 2).

TABLE 2

Length of females, and number and length of juveniles of *Arcturella sawayae* Moreira, 1973, observed alive in aquaria conditions, and details of the relationship juveniles/adult females

Specimens N.º	Length of females (mm)	N.º/young liberated	Average length of young (mm)	N.º/young gripped onto antennae 2	N.º of days young remain onto antennae 2
1	7.9	21	1.6	6	10
2	8.0	25	1.5	8	9
3	8.0	24	1.5	8	9
4	8.1	26	1.7	9	10
5	8.2	26	1.4	10	9
6	8.3	27	1.5	10	7

The females maintain the antennae laterally distended in order to hold the young. The young were distributed irregularly on the antennae, gripping it firmly by the two posterior pairs of pereopods. Either the right or the left antennae usually carry a slightly higher number of young than the other. On the antennae the young assume different positions, sometimes the normal one, sometimes with head upside down, remaining so for long periods of time.

The characteristic posture is similiar to the posture of the females before breeding. All the young not carried by the females move little by little mostly at night, but short distances (scarcely a few centimeters). At daytime they usually remain in one place. Very seldom they are quiet. They are always moving either the oral appendages or the antennae 2.

Younger animals eat continuously. Obtaining of food is their major problem. Most of the motions performed at this time are directly or indirectly associated with the gathering of food.

2.2 *Motion*

Two kinds of motions are displayed by the young animals: crawling and swimming. Both are described in detail below.

Crawling

This type of locomotion is associated with the progression of the animal to find food. Gravid females also exhibit this motion to move from one place to another. However, as already pointed out, crawling in this case is not related with the gathering of food.

To progress the animal extends both the antennae 2 and the anterior portion of the body forwards; the seaweed filament or the margin of the alga is then held firmly between the antennae, while their tips, bending inwards, press the seaweed strongly; following this movement promptly, the last pair of pereopods is moved forward close to the nearest anterior pereopod, followed immediately by a forward movement of this pair; afterwards the antennae are released from pressing the alga and the animal assumes the original posture.

The animals progress repeating these movements 2 or 3 times consecutively. They then stop, starting promptly to look for food (Moreira, in press). If food is available, they remain in that place eating until the food finishes, only afterwards crawling again, and so on. Many times the animals remain still a few seconds in their characteristic posture, before starting the food gathering movements.

Swimming

It was observed that swimming is not directly related to the obtaining of food. This way of progression was seen a few times only. It seems that it is employed by the young occasionally. As was pointed out before, gravid or post-gravid females were not observed to make use of this type of locomotion. It was observed that young animals employ the swimming motion usually when in unpleasant surroundings or when in danger.

When facing these situations, the young leave their place abruptly, swimming vigorously and rapidly for a short distance. To swim the young, dorsal side upwards, extend the antennae 2 both together forwards, first pereopods tightly juxtaposed to the oral appendages, uropods widely open releasing the pleopods which flap vigorously. It was observed that the first two pairs of pleopods are the only appendages used in the propelling of the animal.

Experiment n.º2. A series of simple experiments were conducted to assess the ability of the young to move on, as well as, to leave a bottom devoid of fragments or projections suitable for to grip on.

The experiments have been conducted on three different types of substrata:

1. on a smooth glass bottom,

2. on a layer of soft mud, and

3. on a layer of very fine sand, covering the bottom of a Petri dish.

All experiments gave similar results, i.e., the animals feel uncon-fortable and helpless when facing such types of substrata, trying rapidly to leave them. The worst kind of bottom was represented by soft mud, where the young got entangled very soon, with body, pereopods and pleopods covered by agregated particles of mud. They soon die, after frustrating trials to find out a projection to cling on.

On the other substrata (smooth glass bottom and fine sand), the animals lay with the ventral surface upwards. In their trials to leave these bottoms, they perform a series of distinct movements, as follows:

a. non-synchronic whirling movements with both the antennae 2 and two posterior pairs of pereopods;

b. vigorous arching of the body, many times repeatedly, with head and tip of pleotelson pressing strongly on the substratum;

c. short strech rapid swimming, close to the surface of the bottom, with dorsum upside down, body straight and antennae 2 distended forwards and paralel one to another.

All these movements are performed caotically, as desperate trials to find out a suitable projection where they can grip onto. If they do not find one, they swim shortly as just described (item *c*), beginning movements *a* and *b* again, and so on. However, as soon as, a piece of *Sargassum* or some protruding substratum is offered, the animals promptly cling on, quickly returning to the normal posture. In any one moment the participation of the first pereopods was observed in those described attempts to find a prominence for to grab on.

2.3 *Cleaning behavior*

Cleaning is a constante process in the young animals, and one of the most typical movement performed by them. As the animals are constantly cleaning themselves, there is not a definitive or special period they use to do so.

In the course of the observations it became apparent that cleaning is directly associated with the feeding process, representing a secondary or complementary process of collecting food.

Two appendages are employed in the cleaning process: the first pair of pereopods and the antennae 2. The former are by far the most important appendages. The first pair of pereopods are used for cleaning the antennae 1, antennae 2, cephalon, eyes and pereopods II-IV In order to be cleaned the antennae 2 are bent downward so that they can be brushed by the pereopods I while drawn upward. The other mentioned appendages and body regions are brushed quickly by the pereopods I, which lift up to reach each considered part, removing the adhering detritus.

The antennae 2 are responsible for cleaning the dorsum, posterior portion of the body and last pereopods. For performing the cleaning movements, both antennae are drawn back independently or together, their tips scraping the same place several times; afterwards they are turned forward so that they can be brushed by rapid movements of the first pair of pereopods. After each cleaning movement executed by the antennae, the same are immediately brushed clean by the pereopods I.

In both cases (the first pair of pereopods working alone, or the second antennae working associated with them), the cleaning movements are repeated 2 or 3 times in rapid succession. No fixed sequence nor any regular alternation between both processes of cleaning was observed.

2.5 *Alert behavior*

Self-preservation measures were displayed by young animals in form of an alert reaction. The most striking feature of this reaction is that at the first sign of disturbance the individuals promptly stop feeding and stand motioless, in a sharp contrast with their normal great activity. The animals very quickly assume an erect posture, the first pereopods tightly juxtaposed to the mouth appendages, the antennae 2 slightly curved and extended forward almost paralel one to the other.

This alert posture does not last a long time (a few seconds only). However, watching the animals for long periods, it was observed that they display it frequently. Awareness and vibration movements seem to be essential for their self-preservation. The animals are very sensitive. Sudden or unusual movements, or unexpected vibrations, all are cues for the alert reaction. For instance, the seaweed being dislodged abruptly, a stronger or an unexpected water current whirling the organic masses or moving the alga, a strike on the table some 3-4 meters away from where the aquarium rests, disturbances such as turbulence and the harassment of the animals etc., to all these and to vibrations the animals react quickly. If the disturbance persists or if it is too strong, they make off at top speed, swimming rapidly to another site.

It appears that at this stage of development, vision seems to be unimportant in the awareness of the source of disturbance. The behavior of the animals when performing deposit feeding (Moreira, in press), also seems to point out the not full use of the vision. There was no evidence to prove the contrary.

Experiment n.º 3. Simple experiments were carried out in order to investigate the contribution of the vision to the alert behavior. The criterion used to judge the effectiveness of the vision was the reaction of the animals to the approach of a potential disturbing element or predator.

Young *Arcturella sawayae* together with living specimens of *Tisbe* sp. were carefully observed. It was seen that the specimens of *Tisbe* sp. can approach just close to the animals, without their display of any reaction. However, as soon as one specimen unexpectly contacts their body, they promptly react adopting the alert posture. Similarly the approach of any large object, as a pippete or a stripe of paper, of any color and size, was unable to provoque a reaction unless a body contact occurs.

DISCUSSION

The study of the behavior of both adult females and juveniles of *Arcturella sawayae* Moreira, 1973, have shown many interesting aspects not fully observed and described before in marine isopods.

The behavior of mature females differs from that of the juveniles, and it also differs in each of their reproductive stages, e.g., when bearing young in the marsupium, with young clinged to the second antennae, and finely when is a spent condition, without young on the antennae. In this last stage the females spend most of their time hidden motionless until death. All their movement and activities are drastically reduced.

The series of movements performed by gravid females is extremely interesting while the young were gripped onto their second antennae. It seems that both the posture taken and the movements executed by the females at this time are directly related with the presence of the young on the antennae. Experiment n.º 1 seems to indicate that, when the females loose the young they stop displaying these movements. The body bending movements appear to be performed mainly to induce the young to leave the antennae. This usually occurs while the antennae are resting on the seaweed.

However, it seems that similar body movements are performed also by individuals other than females carrying young on the antennae, as can be inferred from Goodsir's (1841, apud Harger, 1880) statement, which observed live specimens of *Astacilla* "waving its body backwards and forwards" Unfortunately, Goodsir did not mention the developmental stages of the animals he watched, nor the sex or if young were on their antennae. Juveniles of *Arcturella sawayae* were not observed displaying such body bending movements.

Juveniles emerging from the marsupium cling promptly either onto the female antennae 2 or to the surrounding algae. Those gripped on to the antennae are gradually, sparingly distributed during the female's displacement. However, it is doubtfull if the presence of young on the antennae, as well as, their gradual dispersion, has some value for a better survival of them, or some protection significance.

First, no marked difference was observed in the dispersion of animals clinging to the antennae and in those clinging to the seaweeds, nor any difference in the behavior of those forced to leave the antennae. Second, the motion rate of the females is very slow, since they were found at the time of death not too far from the birth site. Third, the average time spent by the young on the female antennae is very short (Table 2). Fourth, not all young leaving the marsupium climb onto the female antennae, since most of the brood cling to the nearest surrounding algae. Fifth, the movement of to grip on to the antennae of the females results from the highly developed "clinging instinct" exibited by the animals. As soon as they come out from the brood-pouch they promptly grip onto any substrate available at the moment. Some climb directly onto the seaweeds, while others onto the females body, reaching the antennae afterwards, which are, as the seaweeds, a suitable place for to climb on.

It is usual amongst marine isopods that most of the males and females die soon after copulation (males) or after breeding (females) (Kjennerud, 1952; Naylor, 1955; McCrimmon and Bray, 1962; Naylor and Quénisset, 1964; Narver, 1968; White, 1970; Sjöberg, 1970; Jones and Naylor, 1971). It was seen that the females of *Arcturella sawayae* also die after reproduction, some days after the last juvenile has left the brood-pouch (Table 2). It seems also common among marine isopods that males die before the females (Muus, 1967; Jazdzewsky, 1969; Sjöberg, 1970). This probably occurs in *Arcturella sawayae* and may be one of the reasons for the absence of the males from the samples collected at São Sebastião and at Ubatuba.

The females' survival time after the last young left the marsupium varies amongst the species of isopods. In *Arcturella sawayae* the females life span after breeding varies from between 28 and 36 days, the average time being 33 days (Table 1). In other species of isopods, however, this time is much shorter (only a few days), as for instance, in *Glyptonotus antarcticus* (White, 1970).

Individual isopods usually employ one or more kinds of movements to progress (Tait, 1926; Green, 1957; Dearborn, 1967; Glynn, 1968; Bastida and Torti, 1969-1970; Jones, 1971; Moreira, 1971), but crawling and swimming are by far the most extensively used. It was observed that *Arcturella sawayae* uses these two kinds of locomotion. They are employed according to their requirements. It was observed that young *Arcturella sawayae* commonly display the swimming motion when they are impelled to, i.e., usually in abnormal situations. A few times young animals were seen spontaneously swimming out from one place in order to reach another.

Crawling is the common way of motion used by juveniles to progress. Observed reproductive females also move on only by crawling, just as the young. Thus, the present observations point out that crawling is the regular way of progression of both young and adult animals. The functional appendages in this type of locomotion are the antennae 2 and the last three pairs of pereopods.

Swimming is very seldomly performed. The only appendages employed in this type of progression are the pleopods. The animals open the valvular uropods widely and the pleopods protrude, flapping vigorously, propelling them forwards. Sars (1899) was able to observe and describe the swimming motion in *Astacilla longicornis* (Sowb.), reporting that it is effected by the two anterior pairs of pleopods. Swimming, performed also solely by the beating of the pleopods, is briefly mentioned in a few valviferan isopods, as for instance, in *Idotea neglecta* by Kjennerud (1952), in *Mesidotea entomon* by Green (1957), as well as, by Goodsir (1841, apud Harger, 1880) in some astacillids isopods of the genus *Astacilla*. However, excepting Sars, none of these authors especifically mention which pairs of pleopods are used effectively to push the animal forwards. The present obser-variations on young *Arcturella sawayae* corroborate Sars observations.

Goodsir (op. cit.) observing live specimens of *Astacilla,* stated that "swimming is the natural mode of progression" In relation to the last pairs of pereopods, he says that they are seldom used for progression. Due to the similarities of form and structure of the appendages in all the members of the family Astacillidae, their rep-esentatives certainly will be able to progress either by crawling or swimming, the walking motion being surely performed in a similar way as described in this paper. However, not considering the expected specific differences, the present observations strongly suggest that crawling is certainly the most used mode of progression in most of the astacillid species.

Astacillids are commonly found gripped onto a variety of animals or plants protruding from the bottom. *Astacilla longicornis* occurs mostly on the hydroids *Funiculina* sp. (Hult, 1941). This species is also frequently found among *Laminaria* and *Corallina,* on bryozoans, as well as, on spines of *Echinus esculentus* (= *Echinus spherus*), *Strongylocentrotus droebachiensis* (= *Echinus droebachiensis*) and *Dorocidaris papillata* (= *Cidaris papillata*) (Hult, op. cit., quoting several authors). *Antarcturus acanthurus* occurs on alcyonarians (Monod, 1926). *Astacilla affinis* was reported by Sars (1899) on deep-water hydroids and gorgonids, and on spines of *Asterechinus elegans* (= *Echinus elegans*). Both *Parastacilla truculenta* and *P. bakeri* were collected on seaweeds (Hale, 1924). *Arcturella sawayae* was gathered up to date on both *Sargassum cymosum* and *Galaxaura* sp. (present data).

It seems that astacillids are by no means particular about the type of substratum, once it affords a firm hold so they can cling onto it securely. They are well adapted to live a sedentary life on these kinds of substrata. It has been shown (Experiment n.° 2) that *Arcturella sawayae* behaves caotically on bottoms devoid of projecting structures suitable for to grip on. It is anatomically, and by extension all astacillids are, well adapted to cling rather than to swin or to crawl extensively. This is shown clearly by their most employed kind of progression and by the way it is performed, and chiefly by the morphology of the body and structure of the pereopods, differentiated into pereopods to grip onto and pereopods for filtering the water current.

Sporadically, young animals leave their place swimming fastly to another one, apparently without clear reasons. Reproductive females were observed not to display a similar behavior. Sars (1899) already reported that the animal "at times it is seen to leave go its hold, and to start off rather rapidly through the water, in order to affix itself on some other place"

Young, male and female astacillids may live together in large number on the same leaf or twig (Sars, 1899; Hult, 1941). Goodsir (1841, apud Harger, 1880), however, observed that "each individual will select a branch of coralline, will keep that branch exclusively to itself, and will defend it with the greatest vigor against all intruders" The present observations on juveniles and reproductive females of *Arcturella sawayae* did not corroborate that statement, neither Sars' (op. cit.) or Hult's (op. cit.) observations on *Astacilla longicornis*.

Due to their sedentary way of life, these animals frequently hold on the surface of the body and appendages, all sorts of plants and epizoans. Many of the examined specimens of *Arcturella sawayae* host minute filaments of the alga *Derbesia* sp., foramnifera tests, tiny coiled calcareous tubes of polychaetes etc. This fact of host plants and epizoans, allied to the pattern of coloration (cryptic coloration) they display according to the nature of the substratum, make their prompt recognition highly difficult. In the present examined specimens, only gravid females exhibit it.

Cryptic coloration has been already reported for many species of both predaceous animals and their prey (Hesse *et al.,* 1951; Moore, 1958; Nicol, 1967; Vernberg and Vernberg, 1970), including species of isopods (Hale, 1924; Sawaya, 1939; Kjennerud, 1952; Armitage, 1960; Lee, 1966; MacGinitie and MacGinitie, 1968; Ricketts and Calvin, 1968; Jazdzewsky, 1969; Bastida and Torti, 1969-1970). Considering the color pattern exhibited by *Arcturella sawayae* reproductive females, and considering both their general and feeding behavior, it may be surely stated that the color pattern they displayed has a significance of cryptic protective coloration. Similar protective coloration has been already found in the isopods *Serolis polaris* and *Serolis laevis* (Moreira, 1971).

One of the most frequent movements performed by the animals is that of cleaning. The surface of the body and appendages are cleaned by both the second antennae and first pair of pereopods. Each one of these appendages cleans specific regions of the body.

It appears that the cleaning process is executed primarily for the elimination of all the material adhering to the body, the excessive accumulation of which could be harmfull to the animals. As they are of restricted locomotion, this habit causes a fast accumulation of sediment. The significance of passing material accumulated on the body through the mouth parts seems to be especially important for the animal in order to eliminate it readily. At same time it clearly represents an auxiliary or complementary mode of feeding developed by the animals, once the edible part of the material cleaned from the body is worked up by the oral appendages and ingested.

Alert behavior is directly related with self-preservation. The primary reaction of the animals to a disturbing agent is to stop feeding and to remain motionless in the alert posture. In case of the disturbing agent's increase in force they react promptly swimming out from a gripping place at top speed.

It was determined that the juveniles react quickly as soon as the disturbing element (for instance, a copepod), contacts their body (Experiment n.° 3). It was observed that they do not react to the simple approach of larger elements, which seems an indication that the eyes are unimportant to the onset of the alert posture. However, it was determined that the animals react very quickly to vibrations and turbulence.

Newly born animals have compound eyes. They are small, laterally placed and formed by a few distinct ommatidia. Species with well-developed compound eyes have a limited visual acuity but highly developed movement perceptibility (Waterman, 1961). The performed experiments (Experiment n.º 3) have shown that visual acuity and perceptibility of movements seem to be not fully developed at these stages of growth, perhaps due to the yet incomplete formation of the ommatidia.

All observations, however, suggest that the perception of vibrations, turbulence and displacement waves are more important to the young animals than vision. Mechanoreceptors are probably involved, being capable of detecting mechanical cues. The animals may have receptors which are very sensitive to vibrations, as well as, sensory setae capable of detecting turbulence and water currents.

CONCLUSIONS

1. Gravid and post-gravid females differ in behavior, especially in relation to locomotion, posture and movements.

2. Many newly born young grip onto the female antennae 2 (which has no value to the species regarding better dispersion, protection etc.) due to a highly developed "clinging instinct"

3. It appears that the body bending movements performed by spent females is executed in order to dislodge the young from their antennae.

4. Females die after reproduction, i.e., after the last young has left the antennae 2.

5. The common way of progression employed by adults and juveniles is crawling. Swimming is employed by juveniles when impelled to.

6. Crawling is performed by the second antennae and last three pairs of pereopods. Swimming is performed by the first two pairs of pleopods.

7 It seems that the astacillids are not particular about the type of substratum, once it can afford a firm hold for gripping onto.

8. Due to their morphology, structure of appendages and behavior, astacillids are well adapted animals to cling on, rather than to swimming or to crawling extensively.

9. Older astacillids present cryptic protective coloration, younger specimens are colorless.

10. The cleaning process is performed primarily for the elimination of adhered detritus from the body surface. It represents also an auxiliary or complementary mode of feeding.

11. Alert behavior is highly developed in younger animals, which are very sensitive to vibrations and turbulence. It represents a self-preservation measure. The eyes seem to be unimportant to the onset of the alert posture.

12 It appears that receptors of turbulence, vibration and displacement waves are more important to the juveniles than vision for self-preservation.

ACKNOWLEDGEMENT

I would like to thank Professor Dr. Paulo Sawaya, Director, Instituto de Biologia Marinha, USP, for place at my disposal all the facilities of the Instituto de Biologia Marinha, São Sebastião, SP For the correction of the English text I am much obliged to Prof. Dr. Tagea K. S. Björnberg, from the Department of Zoology, USP

I am privileged on this occasion to make the present contribution in honor of Professor Dr. Paulo Sawaya, to whom I personally owe for much attention and help.

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