Bull. Inst. Zool., Academia Sinica **23**(1): 75-79 (1984)

HYDROGEN-ION CONCENTRATION IN THE GUT OF *SARCOPHAGA RUFICORNIS* (FABR.) (DIPTERA: SARCOPHAGIDAE)

KAVITA CHAUDHRY

Zoology Department, University of Gorakhpur, Gorakhpur-273001, INDIA

(Received August 8, 1983)

Kavita Chaudhry (1984) Hydrogen-ion concentration in the gut of *Sarcophaga ruficornis* (Fabr.) (Diptera: Sarcophagidae). *Bull. Inst. Zool., Academia Sinica* **23**(1): 75-79. In *Sarcophaga ruficornis* (Fabr.), the foregut is slightly acidic ($6.0<pH<6.8$). This acidity increases through the first part of the midgut ($5.2<pH<6.0$) till it reaches a high peak ($3.6<pH<4.6$) in its middle. In the remaining posterior part of the midgut and the hindgut the pH remains near neutral ($6.8<pH<7.0$). The entire gut can, therefore, be differentiated into four pH zones, each maintaining a fairly constant level of pH in it. A powerful buffering mechanism thus seems to be existed in the alimentary canal of this insect.

The digestion of various nutrients within the gut of insects is likely to be limited to different degree by the hydrogen-ion concentration in its lumen. Though several workers, Swingle (1931), Waterhouse (1949), Grayson (1952), Wigglesworth (1953), Saxena (1954, 1955), Krishna (1955), Mall *et al.* (1968) and Balyan (1975) have studied the hydrogen-ion concentration in the gut of various groups of insects, but there is a great diversity in their observations as well as in their interpretations. However, no information is available about the Sarcophagid flies. The present work on *Sarcophaga ruficornis* was, therefore, undertaken with a view to elucidate some of the vexed problems of the pH of insect gut and for a better understanding of the nutritional physiology of this fly.

MATERIALS AND METHODS

The well developed pupae were drawn from the stock culture of *Sarcophaga ruficornis* (Fabr.) maintained in the laboratory. They were kept in a glass jar closed by a piece of cheese cloth. As soon as the emergence occurred the male and female individuals were isolated into separate jars to prevent mating. After six days feeding they were deprived of all food and subjected to a 24 h period of starvation. This was necessary to clear their alimentary canal and give them hunger stimulus so that in the experiments they could feed easily on the indicator mixed diet.

The hydrogen-ion concentration of the alimentary canal was determined by the "range indicator method" as suggested by Waterhouse (1940) and later followed by Saxena (1955), Krishna (1955), Awasthi (1968) and Singh (1975). The indicators of varying pH values chosen to determine the hydrogen-ion concentration of the different regions of the gut were: (i) bromophenol blue, (ii) bromocresol green, (iii) bromocresol purple, (iv) chlorophenol red, (v) bromothymol blue and (vi) phenol red. The 24-hour starved 7-day old adult flies were allowed to feed, one at a time, inside a glass tube for 5 minutes on a 3% sucrose solution containing 0.01% concentra-

tion of the indicators. Concentrations of phenol red and bromothymol blue were increased to 0.05% and 0.1% respectively, since 0.01% dilution did not show any distinct colour in the gut. At the end of 5 minutes, each fed fly was removed from the feeding tube, cleaned thoroughly and dissected on a clean slide in minute quantity of double distilled water under a stereo-microscope, at a specified time interval, so as to expose its alimentary canal. Position of the coloured food and any change in its colour from the original in the different parts of the gut were immediately noted. Thus, by these changes of colour of the appropriate chosen indicators, a narrow range of pH of the various parts of the gut could be determined. The experiment was replicated ten times with each indicator in both the sexes separately.

The "indicator paper technique" suggested by Srivastava (1957), Pant *et al.* (1959) and Srivastava and Srivastava (1956) was avoided due to certain demerits as discussed by Awasthi (1968). Nevertheless, it had to be resorted to only in the study of pH under starvation since there was no question of feeding the insect with the indicators.

RESULTS

The results obtained are given in the Table 1. They show that the hydrogen-ion concentration of all the three regions of the gut of these flies differ from each other, however, no sexual difference was observed. The foregut is moderately acidic (pH range 6.0–6.8). The hindgut is almost neutral (pH range 6.8–7.0). The midgut, has been demarcated into five regions by Chaudhury (1972), differs from that of the foregut and hindgut in having three zones of different hydrogenion concentration. The anterior part of the midgut, comprising the thoracic ventriculus, abdominal ventriculus, and the anterior proximal loop is

TABLE 1.
The pH in different regions of the digestive tract of *S. ruficornis*

Name of indicators	Foregut		Midgut						Hindgut		
	Oesophagus	Crop	Thoracic Ventriculus	Abdominal Ventriculus	Anterior Portion of Proximal Loop	Posterior Portion of Proximal Loop	Helicoid region	Post-helicoid region	Anterior Intestine	First part of Rectum	Rectal pouch
Bromophenol Blue	>4.6	>4.6	>4.6	>4.6	>4.6	>2.8 <4.6	>4.6	>4.6	>4.6	>4.6	>4.6
Bromocresol Green	>5.2	>5.2	>5.2	>5.2	>5.2	>3.6 <5.2	>5.2	>5.2	>5.2	>5.2	>5.2
Bromocresol Purple	>5.2 <6.8	>5.2 <6.8	>5.2 <6.8	>5.2 <6.8	>5.2 <6.8	<5.2	>6.8	>6.8	>5.2 <6.8	>5.2 <6.8	>5.2 <6.8
Chlorophenol Red	>4.6 <7.0	>4.6 <7.0	>4.6 <7.0	>4.6 <7.0	>4.6 <7.0	<4.6	>4.6 <7.0	>4.6 <7.0	>4.6 <7.0	>4.6 <7.0	>4.6 <7.0
Bromothymol Blue	>6.0 <7.6	>6.0 <7.6	<6.0	<6.0	<6.0	<6.0	>6.0 <7.6	>6.0 <7.6	>6.0 <7.6	>6.0 <7.6	>6.0 <7.6
Phenol Red	<6.8	<6.8	<6.8	<6.8	<6.8	<6.8	>6.8 <8.4	>6.8 <8.4	>6.8 <8.4	>6.8 <8.4	>6.8 <8.4
Range of pH	>6.0 <6.8	>6.0 <6.8	>5.2 <6.0	>5.2 <6.0	>5.2 <6.0	>3.6 <4.6	>6.8 <7.0	>6.8 <7.0	>6.8 >7.0	>6.8 <7.0	>6.8 <7.0
	ZONE I		ZONE II			ZONE III	ZONE IV				

fairly acidic (pH range 5.2–6.0). The middle portion of the midgut consisting of the posterior part of the proximal loop only, is the most highly acidic region of the gut (pH range 3.6–4.6). Whereas, the pH condition of the remaining two posterior parts of the midgut, the helicoid and post-helicoid regions, is exactly similar to that of the hindgut (6.8–7.0), and manifests a tendency towards neutrality.

In order to ascertain whether starvation has any effect on the pH of the alimentary canal, similar experiments on normally fed flies as well as those starved for 48 h flies were carried out. The results showed that the hydrogen-ion concentration of the gut of these two sets of flies was more or less the same.

DISCUSSION

Great diversity in the hydrogen-ion concentration in insect gut has been recorded by various workers. According to Waterhouse (1949), in most insects the hydrogen-ion concentration in the different parts of the midgut varies only slightly from neutrality. Balyan (1975) and Shukla and Upadhyay (1979) also found that the gut was neither strongly acidic nor strongly alkaline in the insects they studied. Staudenmayer (1940) however, recorded acidic as well as alkaline midgut juices. Whereas, Grayson (1952) reported strongly alkaline gut in some insects. On the contrary, Waterhouse (1940) in blowflies and MacGregor (1931) in mosquitoes have observed strongly acidic gut. Almost similar observations were made by Saxena and Bhatnagar (1961). Swingle (1931) concluded that in the majority of insects he studied, the alimentary canal was only slightly acidic. Mall *et al.* (1968) also found a similar condition in *Cletus signatus*. In the present investigation it has been observed that the pH in the different parts of the gut of *Sarcophaga ruficornis* ranges from highly acidic to weakly acidic, and almost nearing neutral condition (pH range 3.6–7.0). Differences in the hydrogen-ion concentration in the different regions of the insect gut, as well as in the different parts of the same region have been recorded. Krishna (1955), Awasthi (1968) and Shukla and Upadhyay (1979) have found almost the same range of pH in the foregut and midgut. Mall *et al.* (1968) in *C. signatus* did not find much difference in the different regions of the gut. On the contrary, Goodchild (1952) in a West African bug and Saxena (1954, 1955) in *Leptocorisa* and *Dysdercus* have shown that differences in hydrogen-ion concentration in the various regions of the gut and in the different parts of the midgut. They have recored weakly acidic reaction in the first two ventriculi, while in the third and fourth ventriculi were strongly acidic and weakly alkaline, in the hindgut. Grayson (1952) in grasshopper and Wigglesworth (1953) in *Lucilia* have also reported similar differences in the midgut.

Crozier (1923) and Swingle (1931) found an increase of pH from the foregut to the midgut followed by a gradual decrease in the hindgut. While Mall *et al.* (1969) observed that the pH decreases very slightly in the third ventriculus and then again increases in the hindgut. A decrease of pH in the midgut has also been recorded in *Sarcophaga*, but here the differences are very well marked. In fact in *Sarcophaga*, four distinct zones of hydrogen-ion concentration in the gut are clearly indicated in both sexes (6.0–6.8; 5.2–6.0; 3.6–4.6; 6.8–7.0 respectively). Through three of these four zones acidity gradually builds up from the anterior part of the gut till it attains a peak (3.6–4.6) in the posterior portion of the proximal loop of the midgut. Beyond this, the pH increases and extremely poor acidic conditions prevail in the rest of the gut. The result is that the pH characteristics of the helicoid, posthelicoid, and the hindgut regions, which together constitute the fourth zone, shifts towards neutrality.

The problem of association of the hydrogen-ion concentration with the nature of diet of the insect is still very vexed. According to Srivastava and Srivastava (1956) there is enough evidence indicating that the hydrogen-ion concentration in the midgut is more or

less independent of the nature of food of the insect. Shukla and Upadhyay (1979) also subscribe to this view. Awasthi (1968) has even pointed out that although *Aulacophora foveicollis* and *Epillachna dodecastigma* feed on same cucurbitaceous plants, yet they have a difference of pH in gut regions. Contrary to it, Wigglesworth (1927) has pointed out that pH is not a physiological constant but varies according to the type of food eaten by the insect. Crozier (1923) and Kovoor (1967) opine that pH may be related to the diet and the functioning of the malpighian tubules and the digestive caeca. Mall *et al.* (1968) in *C. signodus*, comparing the pH values of food plants on which it feeds with found relationships between the two could not be ruled out. Mall *et al.* (1968) have also reported identical pH in the gut of starved and fed insects although Srivastava (1957) found that total starvation is likely to affect the pH of the gut. In *Sarcophaga*, the hydrogen-ion concentration of the 48 hours starved individuals was just the same as those of the fed ones. This suggests that the presence of ingested food and associated physiological processes to which it is subjected to within the gut, does not affect the pH of the various parts of the gut of those flies. Thus from the present investigations, the relationship between pH and food does occur in the insect gut.

Acknowledgements: I am very grateful to Prof. H. S. Chaudhry and Dr. S. S. Krishna for their supervision and guidance. Thanks are also due to the C. S. I. R., New Delhi for the award of a Junior Fellowship.

REFERENCES

AWASTHI, V. B. (1968) Studies on pH of the digestive tract of *Aulacophora foveiocllis* Lucas and *Epilachna dodecastigma* Wied. *Indian J. Ent.* **30**(1): 33-36.

BALYAN, B. S. (1975) Studies on the hydrogen-ion concentration and digestive enzymes in the mature larvae and adults of *Agrotis ypsilon* Rott. and *Heliothis armigera* Hubn. *Indian J. Ent.* **37**(2): 137-140.

CHAUDHARY, K. (1972) Morphology of the alimentary canal of *Sarcophaga ruficornis* (Fabricius) (Diptera: Sarcophagidae). *Zool. Beitr.* **18**(3): 361-369.

CROZIER, W. J. (1923) Hydrogen-ion concentration within alimentary tract of insects. *J. Gen. Physiol.* **6**(3): 289-293.

GOODCHILD, A. J. P. (1952) A study of the digestive system of the West African Cacao caspid bugs. (Hemiptera: Miridae). *Proc. Zool. Soc. Lond.* **122**: 543-572.

GRAYSON, J. M. (1952) Acidity-Alkalinity in the alimentary canal of twenty insect species. *Virginai J. Sci.* **2**: 49-59.

KOVOOR, J. (1967) The intestinal pH of higher termites: *Microcerotermes edentatus* Was, Amitermitinae). *Insects Sociaux* **14**(2): 157-160.

KRISHNA, S. S. (1955) Physiology of digestion in *Trogoderma* larva. *J. Zool. Soc. India* **7**(2): 170-176.

MACGREGOR, M. E. (1931) The nutrition of adult mosquitoes. Preliminary contributions. *Trans. R. Soc. Trop. Med. Hyg.* **24**: 465-472.

MALL, S. B. and A. N. CHATTORAJ (1968) Hydrogen-ion concentration and digestive enzymes in *Cletus signatus* Walker (Heteroptera: Coreidae). *Indian J. Ent.* **30**(2): 154-162.

PANT, N. C., SRIVASTAVA, P. D. and GHAI, S. (1959) Physiology of digestion in the larvae of *Chilo zonellus* Swinhoe. *Indian J. Ent.* **21**: 238-245.

SAXENA, K. N. (1954) Physiology of the alimentary canal of *Leptocorisa varicornis* Fabr. (Hemiptera: Coreidae). *J. Zool. Soc. India* **6**: 111-112.

SAXENA, K. N. (1955) Studies on the passage of food, hydrogen-ion concentration and enzymes in the gut and salivary glands of *Dysdercus koenigii* Fabr. (Pyrrhocoridae: Heteroptera). *J. Zool. Soc. India* **7**: 145-154.

SAXENA, K. N. and BHATNAGAR, P. L. (1961) Nature and characteristic of Invertase in relation to sucrose in the gut of *Oxycarenus hyalinipennis* (Costa) (Heteroptera: Lygaeidae). *J. Insect Physiol.* **7**: 109-126.

SHUKLA, G. S. and UPADHYAY, V. B. (1979) Studies on the hydrogen-ion concentration of the alimentary canal of *Catharsius molossus* (Lϕ.) (Coleoptera: Scarabaeidae). *Comp. Physiol. Ecol.* **4**(2): 84-85.

SINGH, D. R. (1975) Hydrogen-ion concentration (pH) in certain Lepidopterans (Lepidoptera). *Dtsch. Ent. Z.* **23**(1-3): 187-199.

SRIVASTAVA, P.D. (1957) Studies on the choice of food plant and certain aspects of digestive physiology of the larvae and adults of *Athalia lugIns proxima* (Klug) and *Epilachna vigintioctopunctata* (F.). *Bull. Ent. Res.* **48**: 289-297.

SRIVASTAVA, U.S. and SRIVASTAVA, P.D. (1956) On the hydrogen-ion concentration in the alimentary canal of certain orthopteroid insects. *Beitr. Entomol.* **6**(5/6): 493-498.

STAUDENMAYER, T. (1940) Die Wassert offionenkozentrationder insecten. *Anz. Schadlingsh.* **16**: 114-119 and 125-132.

SWINGLE, M.C. (1931) Hydrogen-ion concentration within the digestive tract of certain insects. *Ann. Ent. Soc. Am.* **24**: 489-495.

WATERHOUSE, D.F. (1940) Studies on the physiology and toxicology of blowflies, Part V. The hydrogen-ion concentration in the alimentary canal. *Counc. Sci. Ind. Res. Australia Pamphlet* **102**: 7-27.

WATERHOUSE, D.F. (1949) The hydrogen-ion concentration in the alimentary canal of larva and adult of Lepidoptera. *Aust. J. Sci. Res.* **2**(B): 428-437.

WIGGLESWORTH, V.B. (1927) Digestion in the cockroach. I. The hydrogen-ion concentration in the alimentary canal. *Biochem. J.* **21**: 79-96.

WIGGLESWORTH, V.B. (1953) The principles of insect physiology. Methuen and Co. Ltd. London.

一種肉蠅腸內之氫離子濃度

KAVITA CHAUDHRY

Sarcodhaga rucificornis 之前腸稍帶酸性 (6.0<pH<6.8)。此酸性在中腸前部繼續增加 (5.2<pH<6.0)，至中腸中部達到最高 (3.6<pH<4.6)。中腸後部和後腸之 pH 值近乎中性 (6.8<pH<7.0)。因此，依 pH 值，此種肉蠅之腸可分爲 4 區，而每一區都保持穩定之 pH 值。是以推知似乎一種强而有力之緩衝機轉存在於此種昆蟲的消化道。