CHAPTER 6

GENERAL DISCUSSION AND CONCLUSION

General objectives of this study were achieved on aspects of the ecology, life cycle and pathology of the ectoparasite, *L. clariae* collected from the gills of *C. gariepinus* from the Vaal River system. It was confirmed that parasites of fish depend on various factors for their survival and success, including season of the year and characteristics of water; however they are more affected by the physiological and biological features of their hosts, such as the ability of the fish to develop immunity towards a particular parasite and age of the host as suggested by Dogiel et al. (1961).

In Chapter 3 it was shown that some aspects of the ecology of *L. clariae* are influenced by the host to which it attaches. The size of *L.clariae* was determined by the host size, its attachment preference on the gill was influenced by the position of the gill in the gill chamber. The parasite abundance and prevalence however, were neither dependent on the size of the host nor influenced by the water quality.

This finding was surprising as it was expected that the host size would determine the parasite abundance as Lo et al. (1998) states that gill surface increases with fish size, which causes an increase in water flow over the gills. Also in their natural environment larger individuals have higher physical (ventilation volume) and chemical (mucus) stimuli, which increase their attractiveness to parasites as compared to small fish.

The non significant difference between the two study sites with different water qualities was also surprising as many studies (Avenant-Oldewage 2003; Galli et al. 2001; Marx & Avenant-Oldewage 1996; Khan & Thulin 1991) suggest that parasite abundance and prevalence are determined by the water quality in which the host fish lives. It was expected that abundance and prevalence would be higher in the Vaal Dam, than the Vaal River Barrage due to the better water quality of the dam believed to allow for proliferation of ectoparasites. This observation suggests that the water

quality can not be used solely as a determinant of the parasite survival, but should be used coupled with other factors, such as the immune status of the fish host which might also have influenced correlation of the size of the fish to the prevalence and abundance of the parasites. The size of the fish specimens collected in the current study ranged between 40.6 and 121cm, this suggest that these were old fish which might have been previously exposed to *L. clariae* infestation, hence have developed immunity against the parasite similar to that observed by Johnson & Albright (1992) who observed a decrease in percentage of copepods (*Lepeophtheirus salmonis*) recovered from coho salmon from 35% to 0% 15day post infection.

Host rejection was also suggested in Chapter 4, where the mean intensity of recovered parasites from infested experimental fish decreased significantly from the mean intensity of parasites used to infest the fish and very low infestation success was observed. This chapter also showed that parasite survival depends on both biotic and abiotic factors. Development of nauplius stages depended on photoperiod, faster development rate being observed during longer day light periods.

However, the results in Chapter 4 describing the life cycle of *L. clariae* differed from the previously studied life cycles of lernaeids, *L. chinensis* and *L. cyprinacea*. The number of nauplius stages of *L. clariae* is similar to nauplius stages recorded for *L. cyprinacea*, but differs from nauplius stages recorded for *L. chinensis.* Though it is suggested that each species be treated as a separate entity, it was expected that *L. clariae* will have the same life stages as *L. chinensis*, since they are both lamproglenids. This suggests that Kuang (1962) might have mistaken the late stages of some of the nauplius stages as different stages, since they look different. Hence, in the current study the number of moults was determined as to accurately record the number of nauplius stages.

The difference in the number of copepodite stages between *L. clariae* and the two lernaeids suggest that there might still be a missing stage in this described life cycle of *L. clariae*. Besides that it differs from the number of stages recorded for other lernaeids, development from one stage to the next is mainly marked by an addition of a body segment. In the current study the first copepodid differed from the second copepodid by two segments, instead of the expected one segment. However, considering the number of experiments done on this life cycle, it is also possible that there are only four copepodid stages in *L. clariae*.

The fact that experimental fish used in the current study were bred and reared in the laboratory rules the possibility of previous exposure to *L. clariae* infestation out, and thus leaves the issue of age/size being the possible cause of host rejection or inability to attach. Hence, it is suggested that further studies be done to determine the number of copepodid stages of *L. clariae*, preferably with small catfish, less than 30cm in length as these fish might cause less host rejection, than older ones and are easier to keep. This would be in accordance to the work by Grabda (1963) who used small size fish about 3-4cm in length as experimental fish.

The difference in the number of appendages observed on the cephalothorax of the copepodite stages, as compared to those observed in the copepodite stages of *Lernaea cyprinacea* suggests that a more advanced technique such as scanning electron microscopy should be applied to determine whether mandibles and maxillules are really obscured by the second maxilla or lost as suggested in chapter 5. Microdissection of the mouthparts and removal of the second maxilla and observation of this region with scanning electron microscopy can reveal whether these appendages are present. Furthermore, sectioning and reconstruction of this region is recommended as it will give an indication of the number of ganglia present in this region of the

parasite. According to Huys & Boxshall (1991) and Roberts & Janovy (2005) the body of a copepod comprises a cephalosome of six somites. The cephalosome consists of five cephalic somites and the first thoracic somite which bears the maxillipeds. According to Ruppert & Barnes (1994) the arthropod brain consists of three major regions: an anterior protocerebrum, a median deuterocerebrum and a posterior tritocerebrum (Fig.1).

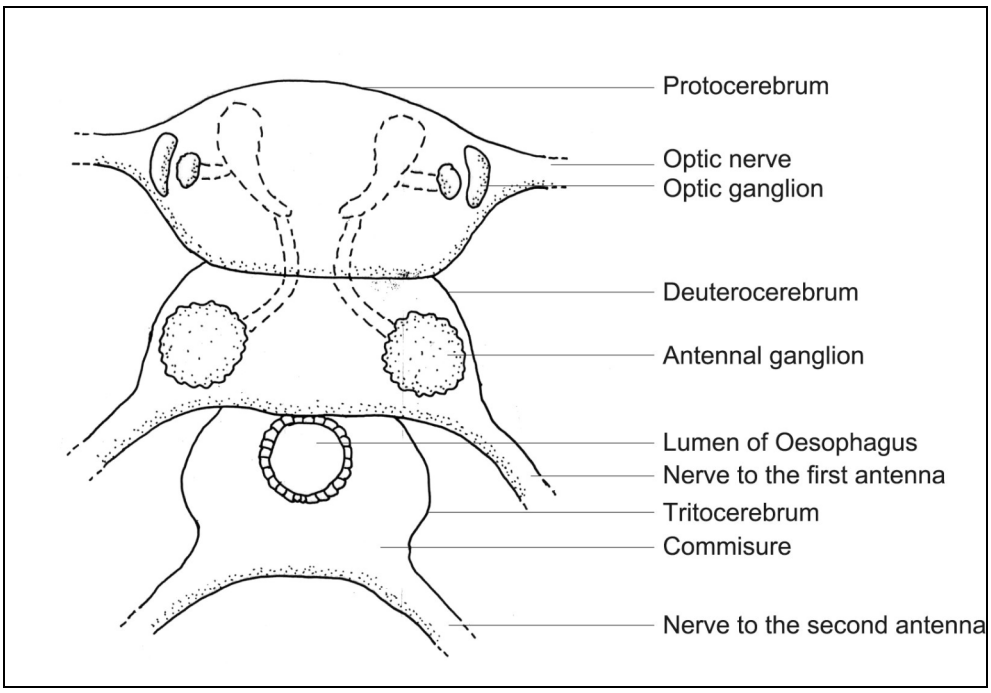

Fig. 1. A crustacean brain redrawn from Barnes & Ruppert (1994).

The optic and other centres of the protocerebrum function in intergrating photoreception and movement and probably for initiating complex behaviour. The deuterocerebrum receives the antennules nerves in crustaceans, and contains their association centres. The tritocerebrum gives rise to nerves that innervate the labium, the digestive tract and the second antennae in crustaceans. The commisure of the tritocerebrum is postoral. Most zoologists agree that the heads of all arthropods contain two or three preoral segments, and the antennae are segmental appendages.

The tritocerebrum is a segmental ganglion that has shifted anteriorly. Hence, sectioning and reconstruction of this region will give a clear indication of the number of ganglia present in this region of the parasite and their nerve bundles connection to appendages, thereby allowing location of mandibles and maxillules remnants.

Results in Chapter 5 on the pathology of this parasite showed that *L. clariae* causes three phases of host reaction associated with its adult stage; the gravid adult stage causes less pathology when compared to the earlier stages. Eventually it causes hyperplasia and hypertrophy leading to fusion of gill lamellae.

Although it is suggested that low infestations are not harmful to the fish, and high infestations may be detrimental, a recent observation by Molnar & Scekely (2004) suggest that low infestations of *Sinergasilus lieni* (Copepoda) can cause severe histological changes and they recorded that 8 and 27 specimens of this copepod cause similar extensive pathological changes on their host.

Pathological observations in the current study were only made through description of the mechanical damage caused by *L. clariae* on its host fish, but the physiological aspects of pathology were not studied, so it is suggested that in continuation the physiological response of the fish on this copepod infestation should be determined.

Chronic stress in fish may result in immunosupression, thus leading to increased susceptibility to secondary infections (Pickering & Pottinger 1989). The common method for measuring the stress response in fish involves measuring the concentration of corticosteroids in the blood plasma. Cortisol is most frequently measured as it is an active hormone in the neuroendocrine stress response. The increase of cortisol release is a physiological response to a stressor and it functions to re-establish homeostasis (Fevoldin et al. 1993). The cortisol level of naïve fish reared

in the laboratory will be measured, then these fish will be exposed to *L. clariae* infestation and the cortisol level be measured a week or two post infestation and over a long term.

It would also be worthwhile to determine whether the damage caused by *L. clariae* is reversible or permanent to its host fish as repeated infestations may occur in nature, so that a continuous low infestation over ten or more years may cause a large percentage of gill damage which will be comparable or worse than a single high intensity of infestation.

Although it has been previously stated without proof that *L. clariae* is a blood sucking parasite (Marx & Avenant-Oldewage 1996), the current study suggested that *L. clariae* feeds on host tissue. It is therefore recommended that analysis of the digestive tract content of this parasite be done through histochemistry to exactly determine the feeding preference of *L. clariae*. Studies to determine the laverage of muscles of mandibles and maxillipeds and their connection to the apodemes should also be done as it was suggested that mandibles and maxillipeds, together with their musculature are involved in the feeding mode of this parasite. It is therefore suggested that these studies would verify these suggestions.

Furthermore genetic studies are also recommended to determine the phylogenetic status of *Lamproglena*, as it shares most of its morphological structures with other copepod families, which makes its inclusion in the family Lernaeidae debatable. Genetics studies can aid in determining its affinities. All this information will add to the knowledge of the biology of lamproglenids and can also be applied in other copepod species.