EYESTALK ABLATION IN CRUSTACEAN PRODUCTION: A BRIEF REVIEW OF THE ADVANTAGES, DISADVANTAGES, AND PUBLIC OPINIONS

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ABSTRACT
Global demand for crustaceans such as shrimp and prawns has prompted efforts to expand output, resulting in the implementation of diverse solutions. It has become a priority to manipulate the reproductive and maturation activities of crustaceans, particularly through eyestalk ablation. Crustacean eyestalks play some important role in overall performance specifically through the neuroendocrine organs. While this approach has shown potential in regulating ovarian growth and maturity, it is fraught with drawbacks and obstacles. Stress on crustaceans, changes in physiological processes, and mortality, particularly in bilateral ablation, are major challenges in providing eyestalk ablation. Despite its benefits, it raises concerns regarding challenges such as incomplete ovary development, decreased fecundity, and deleterious effects on male reproductive health. The physiological alterations caused by eyestalk ablation necessitate a rethink of its ethical implications. When evaluating animal welfare and production, alternatives to eyestalk ablation revealed non-ablation procedures that produce equivalent results. Evaluating these approaches highlights the importance of prioritizing crustacean well-being while maintaining increased productivity. Given the obvious disadvantages and alternatives both from research and public opinions, a modification or complete transition from eyestalk ablation toward more ethical and similarly successful techniques of crustacean production is advised for sustainable aquaculture practices.

Keywords: Animal welfare; Aquaculture practices; Crustaceans; Eyestalk ablation; Reproductive manipulation

INTRODUCTION
Crustaceans such as shrimps and prawns are prominent global delicacies that have continually gained recognition hence the demand continues to outweigh the supply (Dunaway & Macabuac, 2022; Irabor *et al*., 2022). To meet this growing demand, most farmers have to increase production levels, and with this also come numerous strategies. Consequently, the need to influence and condition the reproductive and maturation activities of these crustaceans has been considered of priority. Understanding the impacts of the eyestalks of crustaceans and their function in the general performance gives rise to the relevance attached to them in the production of crustaceans. The productivity of crustaceans has been manipulated through the adjustment of numerous metabolic processes involving the neuroendocrine organs and this is the principle behind the eyestalk ablation in crustaceans (Chen *et al.,* 2020).
The organs known as the X-organic sinus gland complex found in the eyestalks of crustaceans combine and expel lots of neuropeptides that regulate reproductive, physiological, and metabolic activities. Hence, the absence of this gland resulting from the severance of the eyestalks therefore negatively affects crustaceans (Zupo & Hopkins, 2022). Although, numerous positive reports have been recorded on the use of eyestalk ablation to influence ovary development and maturity, however, some disadvantages have also been observed which calls for a serious re-evaluation of the effects, causes, and challenges of this activity for a better-informed decision on whether to encourage, modify or discontinue its application in the production of crustaceans.

CHALLENGES IN ADMINISTERING EYESTALK ABLATION
Eyestalk ablation requires a lot of processes and considerations which are technically oriented depending on the type of ablation to be carried out. It can either be unilateral or bilateral depending on the number of the eyestalk being surgically removed. The ablation of the eyestalk is carried out through enucleation (squeezing one eyestalk between the thumb and index finger), cauterizing (through the use of a heated pair of forceps at the point of attachment of the eyestalk), or ligation (tying a piece of thread or string around the eyestalk and clenching the thread to restrict the flow of blood, shortly the eyestalk falls away after some of the days) are all methods for removing eyestalks. Other less intrusive strategies, such as restricting the daylight exposure period of the breeding crustacean have also been used (Dennenmoser *et al.,* 2020; Birch *et al.,* 2021; Laphyai *et al.*, 2021; Moreno-Reyes *et al.,* 2021; Rotem-Dai *et al.,* 2021).The achievement of these processes is very much feasible in unilateral eyestalk ablation compared to bilateral eyestalk ablation where both eyestalks are involved. Nevertheless, the stress level on the crustacean being ablated remains one of the major

problems encountered (Diggles, 2019). The stress resulting from the ablation process is inflicted on the crustacean from the handling down to the surgical removal of the eyestalk with no proper means of stress reducer. There are always cases of mass mortality recorded especially with bilateral eyestalk ablation as observed by (Martelli *et al.,* 2019). However, in most recent studies, the use of sterile surgical blades for the ablation processes has helped significantly in reducing stress (Patowary, 2023).

There has always been an issue with the loss of haemolymph and high heartbeat rate which is incurred from a series of handling during ablation processes and this has also caused mass mortality in eyestalk ablated prawn (Albalat *et al.,* 2022). In situations where both eyestalks are ablated, there is always a time frame given between the first surgically removed eyestalk and the second. This has helped to reduce the mortality level to zero when combined with a level of cooled seawater to control the heartbeat (Domnik *et al.,* 2016). The criteria for growth and molting measurement of lobsters is one of the challenges encountered in the inducement of maturation and spawning using eyestalk ablation because it is difficult to get the actual weight of the lobsters. The intake and high absorption of water caused by eyestalk ablation leads to excessive weight and this distorts the evaluation of the growth. Consequently, the weight of lobsters is better evaluated in its dry state.

The molting process in most crustaceans is highly affected by the ablation of the eyestalk and this is further influenced by the number of ablation carried out as well as the type; bilateral eyestalk ablation is regarded to have a much more significant level of manipulation on the molting process (Pamuru *et al.* 2016; Kamaruding *et al.,* 2018).

Eyestalk-ablated crustaceans have been observed to display a high level of pigment loss; this is mostly noticed after the molting process. Green *et al.* (2019) and McLean (2021) confirmed the dark blue-coloured crustacean with an exoskeleton dorsally ringed in blue colour changed after ablation to crimson red pigmentation tending towards the end of the body. He also observed the colour changes on the pleopod to greyish-white. Depletion in the enzymes needed for the digestion process caused by the ablation of eyestalk results in alteration in the synthesizing of enzymes. This is one of the main challenges encountered during and after the ablation process (Webster *et al.,* 2015).

Figure 1: Eyestalk ablation process in a crustacean (Whiteleg shrimp). Source: Kannan *et al*., (2015)

ADVANTAGES OF EYESTALK ABLATION IN CRUSTACEANS

Eyestalk ablation in crustaceans has been said to have numerous advantages making it widely adopted in aquaculture and biomedical. It has been used as a hormonal control measure in the life cycle of molts. One of the primary advantages of eyestalk ablation in crustaceans is its impact on the hormonal control of the molt cycle. The neurosecretory cells in the brain of crustaceans produce ecdysteroids, which regulate molting and growth (Patowary, 2023). The eyestalk contains the Y-organ, a structure that synthesizes and releases ecdysteroids. Ablation of the eyestalk disrupts the release of ecdysteroids, thereby affecting the molting process (Hosamani *et al.,* 2017).

This effect can be beneficial in aquaculture, as it allows for the controlled manipulation of the molting process. By ablating the eyestalk, farmers can induce a premature molt in crustaceans, allowing them to harvest larger and more valuable specimens. Additionally, this technique can be used to synchronize molting among a group of crustaceans, making it easier to manage and maintain a healthy population (Lemos & Weissman, 2021).

Eyestalk ablation in crustaceans is also known to have the potential to positively impact growth and development. By disrupting the release of ecdysteroids, eyestalk ablation can slow down the growth of crustaceans. This can be beneficial in aquaculture, as it allows farmers to control the size of the harvested crustaceans, ensuring a consistent and high-quality product. Moreover, it can also lead to an increase in the overall lifespan of crustaceans. Through slow growth and development, eyestalk ablation can potentially extend the lifespan of these crustaceans, making them more valuable in the aquaculture industry (Alfaro-Montoya *et al.,* 2019).

The behavioral changes in crustaceans brought about by eyestalk ablation can be advantageous in certain situations, such as ablating the eyestalk can cause a decrease in aggression and cannibalism among grouped crustaceans. This can be beneficial in aquaculture settings, as it promotes a more peaceful and stable environment for the crustaceans. Additionally, eyestalk ablation can also lead to a decrease in activity levels in crustaceans, making them more docile and easier to handle. This can be particularly helpful in biomedical research, where handling and manipulating crustaceans is a crucial aspect of the experimental process (Diggles, 2019; Passantino *et al.,* 2021).

DISADVANTAGES OF EYESTALK ABLATION

The concept of eyestalk ablation was earlier used to stimulate ovary development and maturation in crustaceans that do not naturally mature and spawn in time under captivity (Maschio *et al.,* 2022). However, the repeated use of this process has been observed to have some side effects irrespective of the positive results achieved. Naturally, penaeid shrimps under captivity possess well-developed ovary which brings about their spawning, but such is damaged as a result of eyestalk ablation. The same effect was reported in other species that have the same quality to naturally develop matured ovaries and spawn in a culture system (Alfaro-Montoya *et al* 2019). Eyestalk ablation is known to affect such species by reducing drastically the interbreeding time thereby regulating the amount of egg produced within a space of time. Also, a high depletion in the fecundity level with repeated use of the eyestalk ablation to induce maturation and spawning in *P. monodon* (Laining *et al.,* 2016; Prasetyo *et al.,* 2017).

The frequent stimulation of the process of ovary development and spawning results in excessive stress on the reproductive organs and processes in turn causing incomplete ovary development and poor yolk formation since ample time is not given for recouping. In most cases also, eyestalk ablation has been attributed to poor feeding rate in crustacean species; this has further served as part of the hindrance to faster and well-developed yolk due to poor dietary intake (Magaña-Gallegos *et al.,* 2018).

The time at which the eyestalk ablation is carried out influences to a great extent the yolk production level. Albalat *et al.* (2022) reported that in addition to the poor feed consumption rate, the general physiological makeup of crustaceans such as *Peneaus vannamei* was altered by the eyestalk ablation process. The survival rate of the larvae from eyestalk ablation stimulated spawning has been observed to be significantly low compared to their naturally developed and spawned counterparts (Kannan *et al.,* 2015). Nevertheless, the number of production per time was observed to have increased by two to four weeks consequent to the administered eyestalk ablation in prawn and shrimp (Magaña-Gallegos *et al.,* 2018).

Eyestalk ablation method of improving production in crustaceans although have recorded some positive impacts, also encourages increased production of low-quality hatchlings and stock mortality. Wang *et al.* (2020) suggested that the impact of eyestalk ablation on the breaking down of glucose and ecdysis could be a major sign of its relevance on nutrient breakdown. Also, the alterations in maternal roles contribute to the unfavorable conditions faced by embryos and early larvae thereby truncating their survival since the much-needed nutrients rely on maternally ingested nutrients. The nature and number of the eyes influence greatly the characteristics of the maternal anatomical and physiological structure of crustaceans (Ramos, 2017).

Most male crustaceans suffer from the negative effects of eyestalk ablation such as potency-related issues(an unnatural trigger in the sperm duct due to the presence of large volume of spermatophores and frequent spermatozoa production), resulting from the unsteady changes encountered from eyestalk ablation (Jiang *et al.,* 2019). Deoxyribonucleic acid (DNA) depletion in such sperm ducts is inevitable as the large volume encourages quite several empty spermatogenic lobules in the testicular area of the male crustacean. Also, the excessive volume of the spermatophores increases the weight of the sperm duct thereby dragging the weight of the testes downwards within the period maturation and spawning is induced as observed in *C. quadricarinatus* and prawn *Parapenaeopsis hardwickii* (Harlıoğlu *et al.,* 2018; Arath & Ayanath, 2019). Eyestalk ablation has been observed to also result in hypertrophy of the androgenic gland (AG) due to the increased performance of the polypeptide profile of the AG, consequently causing restlessness and improved RNA breakdown. An unnatural display of some polypeptides in the form of female-related hormones was observed in *C. quadricarinatus* males subjected to eyestalk ablation (Vázquez-Islas *et al.,* 2015; Harris, 2017). Aside the notable disadvantages, the eyestalk ablation lead to some significant physiological and morphological changes which in most cases affect the general performance of crustaceans.

PHYSIOLOGICAL AND MORPHOLOGICAL CHANGES CAUSED BY EYESTALK ABLATION

Eyestalk ablation being an artificially induced process involves so many mechanisms that defers from the natural, especially with some physicochemical adjustments carried out in the culture medium to facilitate the process. These adjustments influence the parameters and also contribute to unhealthy occurrences since eyestalk ablation involves the expelling of a good number of hormones (hyperglycaemic, molt-inhibiting, mandibular organ inhibiting, and vitellogenesis-inhibiting) that are needed for the normal physiological function of crustaceans (Webster, 2015; Chung *et al.,* 2020 Sittikankaew *et al.,* 2020; Huang *et al.*, 2021). In the absence of these hormones, the physiological function is automatically altered thereby affecting the general wellbeing of the species. In some studies carried out on *Rhithropanopeus harrisii*, *Homarus americanus*, and *Alpheus heterochaelis* subjected to eyestalk ablation, a significant increase in the carapace of postlarva at an early zoeal stage was observed (Quinn, 2016; Gore, 2017; Mudiyanselage, 2022). Although, not a common occurrence since there are only few reports documented.

Ablation of the eyestalks of crustaceans brings about an alteration in their vision and feeding rate especially in cases of bilateral ablation, consequently preventing proper growth and development. (Ikhwanuddin *et al.*, 2016) revealed the effect of lack of vision on poor movement and growth of *Portunus pelagicus* larvae, however, no prey was encountered while swimming. The poor feed consumption rate significantly affects the larvae since adequate growth through the enlargement or resorption of both chelae and pleopods is expected at that stage. Contrary to this, the food consumption rate of eyestalk ablated crayfish, *Procambus clarkii,* increased significantly in the feeding rate displayed compared to its normal counterpart (Tiani *et al*., 2020). This was attributed to the morphological changes, hyper activeness, and increased energy required balancing up the metabolic and physiological functions.

The ablating time also contribute to the effects the eyestalk ablation has on the crustaceans since some of the notable physiological and morphological changes involve hindering of the enlargement of the pleopods and chelae of the larvae (San Antonio, 2021). As the larvae develop from one stage to another, the pleopods and chelae are reasonably enlarged as a result of the endocrine cells found in the eyestalk prompting the speedy development of zoeal. Meng, *et al.* (2020) in a study on the larvae of *P. trituberculatus* reported that wrong timing in eyestalk ablation negatively affected the crustaceans. In same vein, the best time to administer eyestalk ablation in *A. heterochaelis* and *H. americanus*, was reported to be before development of moult at the second larvae stage (Gross & Knowlton, 2002). It is however common with decapods crustaceans that in changing from one stage to another especially to postlarva, the eyestalk ablation must be carried out at the apex of the zoeal stage. The observed incomplete changes caused by poor control of the endocrine by the neurosecretory system are attributed to wrong timing.

Considerably, the pattern to which the growth occurs is by the enlargement and resorption of both the appendages as well as the body parts, therefore, involving a lot of energy distributed across a long period. The availability of required nutrients at the zoeal stage before transformation to the next stage, significant growth in the chelae and pleopods are influenced. Although, the chelae and pleopod may be docile at the zoeal stage; the energy burden is reduced without causing any side effects to the processes since swimming to locate feed and ward off predators is achieved using the dorsal fin (Huntingford, 2012).

Some unsaturated fatty acids such as Omega 3 fatty acids (n-3 HUFA) are of high importance to crustaceans like larvae of *Scylla serrata* and *P. trituberculatus* (Yang *et al.*, 2023). The consumption of rotifers as a diet helps in the changing of zoeal from one stage to another, especially with the chelae and pleopod features. This is because of the docosahexaenoic acid and eicosapentaenoic acid contained in rotifers that can adequately replace Omega 3 fatty acids (n-3 HUFA) in their diet (Hamre *et al.,* 2013). Also, the salinity of the water contained in the culture medium affects the zoeal morphogenesis, by implication, the environment and feeding conditions play vital roles in the transformation processes. Inflammation of morphological features like chelae and pleopod is a resultant effect of significantly high amounts of omega-3 fatty acids in the culture medium. This excessive inflammation leads to increased mortality of larvae before they fully transform to the next stage (post molt) (Gore, 2017; Richardson *et al.*, 2019; Lemos & Weissman, 2021). Although the massive mortality could be considered as the adjustment of the neurosecretory system located in the eyestalk which is seen as part of the conditions in a culture medium, with the right energy level enforced by culturists, such an event can be averted (Mohamed-Omar, 2016).

PUBLIC OPINIONS AND ALTERNATIVES

The importance of eyestalk ablation to the growth and development of aquaculture has been seen as a good measure to boost productivity in crustaceans. Undermining its negative effects, however, it has helped in the achievement of the high productivity experienced especially in shrimp culture. The advantages attached to eyestalk ablation have hampered the need to examine another means ever since, however, recent findings pose a contrary opinion. Non-ablated species have been observed to show very reasonable levels of growth, development, and reproductive characteristics and command good market prices as their ablated counterpart (Arnold *et al.*, 2013). Culturists consider the entire process of eyestalk ablation a stress-free one even with the highly technical approach such as incision and pinching adopted but the public sees it as an act of wickedness and subjecting the animal to unhealthy conditions. Such conditions can lead to the outbreak of disease as the immune system is affected by the removal process. Animal welfare is now of top priority which makes this non-ablation approach a welcomed idea since it is stress-free and other physiological challenges encountered during the ablation process are avoided (Subasinghe *et al.,* 2023).

Some studies conducted to ascertain the effect of avoided ablation were able to get organic certification and possessed a comparable quality with ablated species. The finding also revealed non-ablated species to significantly meet commercial production at a reduced cost with optimum health status (Zacarias, 2020).

The need to explore an alternative means to enhance maturation and spawning in crustaceans that is less stressful is a necessity. However, whether or not the crustaceans feel pain during ablation remains an assumption as the small nature of their nervous system supports this. Many researches also revealed that the negative effects of eyestalk ablation are a hindrance to its usage (Amer *et al.,* 2015; Jiang *et al.,* 2018; Patowary, 2023). It is observed to deter the proper growth and development of the species, poor egg production, depleted survival rate, and massive mortality. It also affects the molting cycle of many crustaceans and increases the cost of production through excessive feeding.

CONCLUSIONS AND RECOMMENDATION

Eyestalk ablation being a means of enhancing maturation and spawning has a deteriorating effect on the well-being of these crustaceans such as the molting cycle, poor egg production, sight, as well as alteration in the feeding, survival, and growth rates. Though the method has been applauded for its reproductive capacity, with these numerous side effects, its further use without positive modification becomes an unhealthy method that need not be sustained.

A better approach can be applied to ensure the same result is achieved with the well-being of the animal put into consideration. With the findings of most research revealing the insignificant differences that exist between ablated and non-ablated in terms of performance and productivity, there is no need to subject the animal to such a cruel situation. With proper management practices, the natural growth processes of crustaceans unaltered remain a good alternative to the eyestalk ablation inducement method.

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