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# TABLE OF CONTENT

Archive

## Volume 7 (5); September 25, 2017

**Review**

### A Review on Challenges and Opportunities of Water Hyacinth.

Awoke Mengesha T.

*J. Life Sci. Biomed.,* 7(5): 51-61, 2017;
pii:S225199391700009-7

**Abstract**

This paper reviews the major existing challenges and their possible mitigation of water hyacinth. Water hyacinth (*Eichhornia crassipes*) is a cosmopolitan invasive aquatic plant which can tolerate a wide range of environmental conditions such as temperature, humidity, illumination, pH, salinity, wind, current and drought. The plant is morphologically plastic with a rapid mode of vegetative propagation that makes it well adapted to a long distance of dispersal and colonization under diverse ecological conditions. Origin of water hyacinth on the African continent was first reported in Egypt between 1879 and 1893; in South Africa in 1908, Zimbabwe in 1937, Zaire and Sudan in 1957, Senegal in 1964, Ethiopia in 1965, Nigeria in 1983 and Uganda in 1987. Water hyacinth has a multitude of direct and indirect effects. The main problems arising from the growth of Water Hyacinth in thick mats are: an enormous water loss through evapotranspiration, that alters the water balance of entire regions; the impediment to water flow, that increases sedimentation, causing flooding and soil erosion; the obstruction of navigation; hampering fishing and dramatically reducing the catch and the source of food and income for local populations; a drastic change in the physical and chemical properties of water and in the environment in the water bodies invaded, with detrimental effects on plants and animals; the reduction of the activity of electrical power stations, jeopardizing the power supply of the country and a serious threaten to agricultural production, following the blockage of irrigation canals and drainage systems. Although water hyacinth is seen in many countries including Ethiopia as a weed and is responsible for many of the problems outlined earlier in this fact sheet, many individuals, groups and institutions have been able to turn the problem around and find useful applications for the plant. Water hyacinth has received much attention in recent years due to its potential benefits as animal fodder, aqua feed, water purification, fertilizer, biogas production. There are several popular control mechanisms for preventing the spread of, or eradication of water hyacinth. The three main mechanisms used such as biological, chemical and physical control.

**Keywords:** Aquatic weed, Challenges, Ecology, Management, Water hyacinth

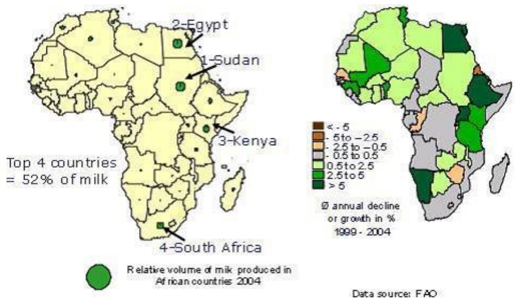
[Full text-PDF] [XML]

**Review**

### An Overview of Application of Animal Biotechnology in Africa: A Promising Approach for Life and Genetic Improvement of Farm Animals.

Asmare Belachew S.

*J. Life Sci. Biomed.,* 7(5): 62-68, 2017;
pii:S225199391700010-7




**Abstract**

Biotechnology is defined as 'any technological application that uses biological systems, living organisms or derivatives thereof, to make or modify products and processes for specific use'. There is no doubt that technology had a major impact on rates of genetic improvement in dairy cattle and is just as important to the structure of animal breeding programs. The new techniques for understanding and modifying the genetics of living organisms have led to rapid adoption and large investments in biotechnology research and development. Most of this development is taking place in North America, Western Europe and East Asia, with the United States far ahead of the others. However, a diverse range of developing countries, from the technologically advanced like Brazil, China, India, Malaysia and South Africa to the technologically less advanced like Egypt, the Philippines and Vietnam are also investing a significant part of their total research and development resources on agro-biotechnology. But the least developed countries are lagging far behind, with the very modest investments that have been made in countries like Kenya, Tanzania and Uganda originating mostly from a few donor agencies. The techniques that are currently available to reach this end can be divided into two different groups. The first group includes all technologies that interfere with reproduction efficiency. The outcome of these technologies is an increased breeding accuracy, selection intensity and, in some cases, a shortened generation interval. The second group of applications is based on the molecular determination of genetic variability and the identification of genetically valuable traits and characteristics. Although; there is growing trend for genetic improvement and production of livestock especially in the dairy sector, African countries are the least investors in research and development of animal biotechnology. Artificial insemination is the first generation animal biotechnology introduced in cattle in the fifties and other reproductive animal biotechnologies are lagging behind to be practiced in the developing world. The growing dairy production observed from north, east and South African countries can be enhanced by capacity building, research and application of animal biotechnology options beyond artificial insemination.

**Keywords:** Artificial Insemination, Breeding, Dairy, Molecular, Reproductive

[Full text-PDF] [XML]

Research Paper

## Effect of Dietary Scutellaria baicalensis Root Water Extract against Piscicola geometra Infection of Cobia.

Nurhanida Rizky P, Cheng T-Ch, Nursyam H.
*J. Life Sci. Biomed.,* 7(5): 69-75, 2017;
pii:S225199391700011-7

Figure 1. Heavy infestation of *P. geometra* caused moderate lesion and hemorrhage on cobia skin

**Abstract**
*Piscicola geometra* is an ectoparasite and the causative agent of infection in fish. Heavy infestation of *P. geometra* significantly causing mortality and serious economic losses to cobia industry. However, no single drug available today has used for the treatment or prevention of *P. geometra* infestation in fish. Water extracts of *Scutellaria baicalensis* root were evaluated for their effect on cobia infected by *P. geometra*. Fish were divided into two groups (group A for healthy fish and group B for infected fish) before being fed for 30 days with 0% as control, 0.5%, 1%, and 2% of *S. baicalensis*. Cobia growth performance, mortality, and total number of parasite infestation on fish were investigated. Result showed that infestation of *P. geometra* significantly reducing the growth performance and survival rate of cobia. Cobia fed with 1% *S. baicalensis* showed highly significant differences ($P < 0.05$) in growth performance (group A and B) and the number of parasite infestation (group B) compared to their respective controls. However, the growth performance of cobia fed with supplemented extract showed no significant differences in group A at the lowest concentration (0.5%) and the highest concentration (2%). Meanwhile group B showed significant different in growth performance among the treatment group ($P < 0.05$). This study demonstrated that *S. baicalensis* root water extract administered as a dietary supplementation is one of the most practical methods to prevent *P. geometra* infestation in cobia culture.

**Keywords:** Oral administration, *Piscicola geometra, Scutellaria baicalensis,* Growth performance, Cobia, Parasite infestation

[Full text-PDF] [XML]

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# A Review on Challenges and Opportunities of Water Hyacinth

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## ABSTRACT

**This paper reviews the major existing challenges and their possible mitigation of water hyacinth. Water hyacinth (*Eichhornia crassipes*) is a cosmopolitan invasive aquatic plant which can tolerate a wide range of environmental conditions such as temperature, humidity, illumination, pH, salinity, wind, current and drought. The plant is morphologically plastic with a rapid mode of vegetative propagation that makes it well adapted to a long distance of dispersal and colonization under diverse ecological conditions. Origin of water hyacinth on the African continent was first reported in Egypt between 1879 and 1893; in South Africa in 1908, Zimbabwe in 1937, Zaire and Sudan in 1957, Senegal in 1964, Ethiopia in 1965, Nigeria in 1983 and Uganda in 1987. Water hyacinth has a multitude of direct and indirect effects. The main problems arising from the growth of Water Hyacinth in thick mats are: an enormous water loss through evapotranspiration, that alters the water balance of entire regions; the impediment to water flow, that increases sedimentation, causing flooding and soil erosion; the obstruction of navigation; hampering fishing and dramatically reducing the catch and the source of food and income for local populations; a drastic change in the physical and chemical properties of water and in the environment in the water bodies invaded, with detrimental effects on plants and animals; the reduction of the activity of electrical power stations, jeopardizing the power supply of the country and a serious threaten to agricultural production, following the blockage of irrigation canals and drainage systems. Although water hyacinth is seen in many countries including Ethiopia as a weed and is responsible for many of the problems outlined earlier in this fact sheet, many individuals, groups and institutions have been able to turn the problem around and find useful applications for the plant. Water hyacinth has received much attention in recent years due to its potential benefits as animal fodder, aqua feed, water purification, fertilizer, biogas production. There are several popular control mechanisms for preventing the spread of, or eradication of water hyacinth. The three main mechanisms used such as biological, chemical and physical control.**

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**Keywords**
**Aquatic weed, Challenges, Ecology, Management, Water hyacinth**

## INTRODUCTION

Water Hyacinth belongs to Kingdom-Plantae, Order-Commelinids, Family-Pontederiaceae, Genus- Eichhoria and Species-crassipes. Water hyacinth (Eichhornia crassipes) is a cosmopolitan invasive aquatic plant which can tolerate a wide range of environmental conditions such as temperature, humidity, illumination, pH, salinity, wind, current and drought. The plant is morphologically plastic with a rapid mode of vegetative propagation that makes it well adapted to a long distance of dispersal and colonization under diverse ecological conditions. It is one of the most prolific aquatic plant which spreads at an alarming rate. It has spikes of light blue flowers and green color roundish leaves with inflated bladder like petioles. Water hyacinth (*Eichhornia crassipes*), native to South America, but now an environmental and social menace throughout the old world tropics, affects the environment and humans in diverse ways. Most of these are detrimental, although some are beneficial or potentially useful. Many of these effects are due to its potential to grow rapidly and produce enormous amounts of biomass, thereby covering extensive areas of naturally open water [1]. The extremely rapid rate of proliferation of Eichhornia crassipes results reduced penetration of dissolved oxygen in water body, change in water chemistry, disruption of aquatic flora and increased rate of water loss due to evapotranspiration. Eichhornia crassipes is very popular recently as animal feed, aqua feed, water purification, fertilizer, biogas production, even food for human and other products [2, 3]. Therefore, it is considered as a serious threat to biodiversity and recently massive attention has been given to its harvesting for use as alternative plant protein source for livestock.

### Origin and distribution of water hyacinth

Water hyacinth (*Eichhornia crassipes*) species is common and widely distributed all over the world. Water hyacinth are a free-floating perennial aquatic plant native to tropical and sub-tropical South America; with bright green, waxy leaves and attractive, violet flowers that have yellow stripes on the banner petals. It is widely reported that water hyacinth is indigenous to Brazil having first been described from wild plants collected from Francisco River in 1824. By the early 1990s it had spread to virtually every country in the continent [4]. It is believed that the water hyacinth was introduced first into the United States at the World's Industrial and Cotton Centennial Exposition of 1884-1885 in Louisiana. Similarly Water Hyacinth (*Eichhornia crassipes* (Martius) Solms-Laubach), which is native to the Amazon basin, Brazil [5, 6] became widespread throughout the world, also due to its attractive appearance. It is commercially available as an ornamental for ponds. Its spread started with its deliberate introduction into North America from Brazil, in the late nineteenth century, as an ornamental in ponds and subsequently escaped cultivation [5][6].At present it occurs as a weed throughout tropical and subtropical regions of the world, including North and South America, Africa, Asia, Australia and New Zealand.

Water hyacinth has invaded freshwater systems in over 50 countries on five continents; it is especially pervasive throughout Southeast Asia, the southeastern United States, central and western Africa, and Central America [7-10]. On the African continent, water hyacinth was first reported in Egypt between 1879 and 1893; in South Africa in 1908; Zimbabwe (1937); Zaire and Sudan (1957); Senegal (1964); Ethiopia (1965); Nigeria (1983) and Uganda (1987). Penfound and Earle [4] reported that Water hyacinth spread through fragmentation of established plants and may re-sprout from rhizomes or germinate from seeds. Dispersal also occurs by water-borne seeds and by seeds that stick to the fit of birds. Migratory birds may be important in long distance dispersal [11]. The major means of dispersal, and the most difficult to control, is active transport by people who, ignorant of its impacts, seek to propagate it in other ponds and lakes. Humans also contribute to its spread in some areas by using the plant as a packing material and as cushions in boats [11].

Although exotic aquatic weeds have been reported to be present in Africa since the end of the nineteenth century [12] they started infesting massively African freshwater bodies during the early 1950s [13] and rapidly spread in many countries. The growth of these weeds is extremely fast and this allows them to develop huge infestations in areas where they had not been reported only a few years earlier. This plants invaded lakes, ponds, rivers, canals and agricultural fields, becoming noxious weeds. The damage to the environment and the economy is enormous, having a disrupting impact on agriculture, fisheries, production of electricity, transportation, health, means of sustenance, living conditions and social structure. Water Hyacinth, Water Lettuce and Water Fern pose the most serious problems.

Botanists and gardeners carry plants with them in their travels, and experts suspect that this is how the water hyacinth came to East Africa in the 1980s. Due to its attractive flowers; it was probably brought over as an ornamental for garden ponds [14]. The consensus is that Water Hyacinth entered Lake Victoria from Rwanda via the river Kagera [15]. The exact time and place of introduction has been debated, but the plant is native to South America, and therefore reached Lake Victoria due to human activity. It has spread prolifically, due to lack of natural enemies, an abundance of space, agreeable temperature conditions, and abundant nutrients [16]. It increased rapidly between 1992 -1998, was greatly reduced by 2001, and has since resurged to a lesser degree. Management techniques include (hyacinth-eating) insect controls and manual beach cleanup efforts [17].

Water hyacinth, *Eichhornia crassipes*, was first reported in Ethiopia in 1965 in Koka Lake and the Awash River. The Koka Lake (also known as Lake Gelila) is a reservoir in south-central part of Ethiopia created by the construction of the Koka Dam across the Awash River [18]. Since the first invasion, in the above reservoir, the weed has also been found in Lake Ellen and other rivers but never in the upper catchment of the Blue Nile until most recently. Sadly, in September 2011, it was officially recognized that one of the top ten ecologically dangerous and worst invasive weed, water hyacinth (Eichhornia crassipes), infested Lake Tana [19]. Except speculation, the exact source of water hyacinth infestation of Lake Tana is not known. The first infestations were found near the mouth of the Megech River on the northern shores of the lake. This noxious weed is now abundant along 40 km of the northern and north-eastern shoreline of the Lake, posing a significant threat to livelihoods, biodiversity, tourism and the general ecological health of the Lake Tana ecosystem. The infestation is greater in the northern tip of the Lake at Demebia district and is minimized towards the eastern tip of Libo-Kemkem district. A survey by a team of experts from the BoEPLAU conducted in September 2012 puts the infestation level at 20,000 hectares compared to 4,000 hectares in 2011. The 2014 survey estimate of water 11 hyacinth coverage was nearly 50 000 ha shore area of the lake, greater than doubled the 2012 coverage. Anteneh [20] Survey report revealed that water Hyacinth in Lake Tana the most devastating area coverage by the weed was observed at Megech River mouth extended both east and north direction with estimated ca. 34 500 ha (3162 ha thick, 2591 ha intermediate and 28687 ha scattered) and widely distribution of daughter plants observed that moved forward by the assistance of the wave.

## DISCUSSION

### Morphology and biology of water hyacinth

Water hyacinth is a perennial herbaceous plant is a floating freshwater hydrophyte. It belongs to the Family Pontederiaceae and all the species in the Genus Eichhornia are aquatic. Water hyacinth (Eichhornia crassipes) tends to form mats on the water surface. Sometimes water hyacinth can be found growing in muddy soils near the edge of an aquatic system. The leaves are arranged in a rosette. The plant is morphologically very plastic with a rapid mode of vegetative propagation which makes it well adapted to long distance dispersal and successful colonization of diverse ecological niches. It is one of the most prolific aquatic plants which spread at an alarming rate having spikes of large blue flowers and roundish leaves with inflated bladder - like petioles. The leaf stem usually is somewhat to completely swollen and filled with spongy tissue and thus acts as afloat. The blade of the leaf is oval to round and usually much smaller than the leaf stem. The common water hyacinth (Eichhornia crassipes) is vigorous growers known to double their population in two weeks. Water hyacinth grows rapidly. Growth of more than one tone of dry matter per day per hectare is not uncommon. One plant may be able to produce enough growth to cover 600 square meters in one year. Infestation breaks up in to “rafts” that drift wherever the winds and currents take them, rapidly infesting entire river systems [11].

Water Hyacinth shows considerable variation in both leaf and flower form and colour, also depending on the age of the plant. The flowers are bluish purple, large and self-fertile. The seeds are produced in large numbers and are contained in capsules, each capsule containing up to 300 seeds [21]. The seeds can remain viable for 5-20 years [22].The plant can also reproduce vegetatively through the production of horizontal stolns.

### Negative consequences of water hyacinth

Water hyacinth has a multitude of direct and indirect effects on almost all aspects of human life once a water body on which man so much depends is invaded and covered by the weed mats [23]: fisheries; water supply; hydroelectric power generation; human health; agriculture; transport; biodiversity; evapotranspiration and increased cost of water treatment are some of the adverse effects. There are already negative environmental and economic impacts caused by water hyacinth on Lake Tana and these include impairing and blocking of fishing grounds and fish breeding areas, reduced fish catches and fish quality, reduced tourism potential, reduced recession agricultural production and blockage of irrigation canals, loss of pasture lands and blocking of fishers movements could also be mentioned. Health impacts include increase in vector-borne diseases such as malaria, bilharzias and health related hazards from leeches and reptiles. Environmental impacts include deterioration in water quality, water loss through evapo-transpiration and a decline of aquatic biodiversity. Water hyacinth can cause a variety of problems when its rapid mat-like proliferation covers areas of fresh water. Some of the common problems are listed below:

**Fish production**. Once the water body is covered by the water hyacinth fishing activities will be curtailed as landing sites would be inaccessible. Furthermore breeding sites will be reduced and fishermen take longer to reach fishing grounds. According Kateregga and Sterner [24] report stated that water hyacinth mats invaded fishing grounds and blocked waterways. For the individual fisherman, the hyacinth mats reduced their catch by covering fishing grounds, delaying access to markets due to loss of output, increasing fishing costs due to the time and effort spent clearing waterways, forcing translocation, and causing loss of nets. Mailu’s [25] report cited the declines of fish production by 14 percent, 37 percent, and 59 percent in the catches of Oriochromus (a large genus of tilapia), Clarias (a genus of catfish), and Mormyrus (a genus of bottom-feeding breams), respectively, in the Kenyan section of the Lake Victoria. According to Twongo [11] noted that the weed mats sealed off breeding, nursery, feeding, and fishing grounds for various inshore fish species, like tilapia and young Nile perch. The mats also had detrimental effects by blocking light, severely reducing oxygen levels, and allowing poisonous gases, such as ammonia and hydrogen sulfide, to accumulate.

Kateregga and Sterner [24] stated that the effect of the water hyacinth on the catch ability of fish in the Kenya, Tanzania, and Uganda fisheries of Lake Victoria by incorporating the water hyacinth biomass as a negative factor in the catch ability coefficient. The results indicate that the catch ability of fish in the Lake Victoria fisheries was reduced by a factor of 2–45 percent during the period when the lake was highly infested by the water hyacinth. The relationship between water hyacinth infestation and fish production is inversely. Kateregga and Sterner [24] confirmed that the larger reduction in the catch ability of fish in Kenya's section was explained by the high abundance of water hyacinth mats in this area, compared, to Tanzania and Uganda.

**Weed problem**. The fast growth of Water Hyacinth allowed the plant to build huge populations in its ranges of introduction, developing dense mats on the surface of the water and becoming a major weed problem. It is considered the worst aquatic weed in the world. The rapid increase and spread of the plant into new areas is due particularly to its vegetative reproduction, a single plant being able to develop very rapidly a significant infestation. Moving easily with water currents, winds or other accidental means, such as fishing nets and boats, the plant invaded rivers, canals, ponds, lakes, dams and other freshwater bodies. Water hyacinth acts as a weed in paddy rice by interfering with germination and establishment [1].The main problems arising from the growth of Water Hyacinth in thick mats are (a) an enormous water loss through evapotranspiration, that alters the water balance of entire regions; (b) the impediment to water flow, that increases sedimentation, causing flooding and soil erosion; (c) the obstruction of navigation; (d) hampering fishing and dramatically reducing the catch and the source of food and income for local populations; (e) a drastic change in the physical and chemical properties of water and in the environment in the water bodies invaded, with detrimental effects on plants and animals; (f) the reduction of the activity of electrical power stations, jeopardizing the power supply of the country; and (g) a serious threaten to agricultural production, following the blockage of irrigation canals and drainage systems. The economy of the countries concerned was therefore seriously affected in many aspects. This weed represents an environmental problem as well and indirectly a public health problem, since it may create a microhabitat suitable for the breeding of many vectors of human diseases and for hosting poisonous snakes.

Water Hyacinth is the principal aquatic weed in Africa. It is a weed problem in many countries, especially in Egypt and East, West and South Africa. This plant appeared in Lake Kyoga in Uganda in the early 1980s and it also occurs in Lake Kwania and down the Kyoga Nile. In 1988 it was observed in Lake Naivasha in Kenya. However, the most disturbing development in the region during the 1990s was in Lake Victoria. In 1990 dense mats of this weed were found interfering with fishing on the Tanzanian shore and during the same year mats were recorded on the Ugandan shore and around the Sese Islands. In Zimbabwe the plant attained the status of noxious weed in the 1980s. It was first recorded in Lake Kariba in 1994 and by 1996 it infested over 200 ha. In the early 1990s Water Hyacinth was also found in the Pangani River in Tanzania and the lower reaches of the Kagera River in Rwanda. In Ethiopia around in September 2011, it was officially recognized that one of the top ten ecologically dangerous and worst invasive weed, water hyacinth (Eichhornia crassipes), infested Lake Tana [19]. This plants invaded lakes, ponds, rivers, canals and agricultural fields, becoming noxious weeds.

**Ecological impact**. That is just one of its ecological impacts. Water hyacinth also reduces biological diversity, impacts native submersed plants, alters immersed plant communities by pushing away and crushing them, and also alter animal communities by blocking access to the water and/or eliminating plants the animals depend on for shelter and nesting. In Lake Victoria, African fishermen have noted that, in areas where there is much water hyacinth infestation, the water is still and warm and the fish disappear [26]. They also complain that crocodiles and snakes have become more prevalent.

The physical problems brought about by water hyacinth are now common knowledge. Water hyacinth mats clog waterways, making boating, fishing and almost all other water activities impossible. Many large hydropower schemes are suffering from the effects of water hyacinth.

According to Makhanu [27] revealed that Water supply will be affected as intake works would be clogged and the irrigation canals will be clogged or their hydraulic efficiency drastically reduced. Transport by ships or boats will be hindered. Also, evapotranspiration is increased as loss of biodiversity in the water body covered by the water hyacinth. The cost of purifying water tainted by water hyacinth will be increased tremendously. Hydroelectric power production will be affected since turbines would be clogged resulting into expensive repair, overhaul and maintenance. Human health will be affected in many ways: shoreline mats are habitats for certain snails (schisostomia vectors) and mosquitoes which spread malaria. Agriculture will be adversely affected [27].

**Hindrance to water transport**. Access to harbors and docking areas can be seriously hindered by mats of water hyacinth. Canals and freshwater rivers can become impassable as they clog up with densely intertwined carpets of the weed. It is also becoming a serious hazard to lake transport on Lake Victoria as large floating islands of water hyacinth form, while many of the inland waterways of south East Asia have been all but abandoned. Water hyacinth mats are difficult or impossible to penetrate with boats, and even small mats regularly foul boat propellers. This can have a severe effect on transport, especially where water transport is the norm [1].

**Blockage of irrigation, hydropower and water supply systems**. Many large hydropower schemes are suffering from the effects of water hyacinth. The Owen Falls hydropower scheme at Jinja on Lake Victoria is a victim of the weeds rapid reproduction rates and an increasing amount of time and money has to be invested in clearing the weed to prevent it entering the turbine and causing damage and power interruptions. Water hyacinth is now a major problem in some of the world's major dams - the Kariba dam which straddles the Zambia-Zimbabwe border on the Zambezi River and feeds Harare has pronounced infestations of the weed. Cock [1] revealed that Water hyacinth replaces existing aquatic plants, and develops floating mats of interlocked water hyacinth plants, which are colonized by several semi-aquatic plant species. As succession continues, floating mats dominated by large grasses may drift away or be grounded. This process can lead to rapid and profound changes in wetland ecology, e.g. shallow areas of water will be converted to swamps. In slow-moving water bodies, water hyacinth mats physically slow the flow of water, causing suspended particles to be precipitated, leading to silting. The reduced water flow can also cause flooding and adversely affect irrigation schemes. Water hyacinth acts as a weed in paddy rice by interfering with germination and establishment.

**Reduction of biodiversity**. Where water hyacinth is prolific, other aquatic plants have difficulty in surviving. This causes an imbalance in the aquatic micro-ecosystem and often means that a range of fauna that relies on a diversity of plant life for its existence will become extinct. Diversity of fish stocks is often affected with some benefiting and others suffering from the proliferation of water hyacinth. People often complain of localized water quality deterioration. This is of considerable concern where people come to collect water and to wash. Cock [1] stated that Water hyacinth has direct effects upon water chemistry. It can absorb large amounts of nitrogen and phosphorus, other nutrients and elements. It is this ability to pick up heavy metals which has led to the suggestion that water hyacinth could be used to help clean industrial effluent in water. By absorbing and using nutrients, water hyacinth deprives phytoplankton of them. This leads to reduced phytoplankton, zooplankton and fish stocks. Conversely, as the large amounts of organic material produced from senescent water hyacinth decompose, this leads to oxygen deficiency and anaerobic conditions under the floating water hyacinth mats. These anaerobic conditions have been the direct cause of fish death, and changes in the fish community by eliminating most species at the expense of air breathing species.

**Increased evapotranspiration.** Various studies have been carried out to certain the relationship between aquatic plants and the rate of evapotranspiration compared with evaporation from an open-surfaced water body. Saelthun [28] suggests that the rate of water loss due to evapotranspiration can be as much as 1.8 times that of evaporation from the same surface but free of plants. This has great implications where water is already scarce. It is estimated that the flow of water in the Nile could be reduced by up to one tenth due to increased losses in Lake Victoria from water hyacinth. Water hyacinth is reported to cause substantially increased loss of water by evapo-transpiration compared to open water, although this has recently been challenged. Displacement of water by water hyacinth can mean that the effective capacity of water reservoirs is reduced by up to 400 $m^3$ of water per hectare, causing water levels in reservoirs to fall more rapidly in dry periods. Water displacement, siltation of reservoirs and physical fouling of water intakes can have a major impact on hydroelectric schemes [1].

**Problems related to fishing.** Water hyacinth can present many problems for the fisherman. Access to sites becomes difficult when weed infestation is present, loss of fishing equipment often results when nets or lines become tangled in the root systems of the weed and the result of these problems is more often than not a reduction in catch and subsequent loss of livelihood. Infestations make access to fishing grounds increasingly time consuming or impossible, while physical interference with nets makes fishing more difficult or impractical. Some fishing communities in West Africa have been abandoned as a direct result of the arrival of water hyacinth [1]. In areas where fishermen eke a meager living from their trade, this can present serious socio-economic problems. Edward [30] stated water hyacinth infestation in Lake Tana is a threat to the fishing industry that supports the livelihood of an estimated 20,000 riparian communities and who are dependent on this natural resource. A reduction in water levels during the dry season (October to May but peak between July and September) caused large amounts of the water hyacinth to die and decomposition of the water hyacinth caused massive algal blooms which affected the taste of the fish with the result that fisher folk were unable to sell their catch. The impacts of this weed are similar to those on Lake Victoria. Fishermen on Lake Victoria have also noted that, in areas where there is much water hyacinth infestation, the water is 'still and warm and the fish disappear. They also complain that crocodiles and snakes. Conversely, as the large amounts of organic material produced from senescent water hyacinth decompose, this leads to oxygen deficiency and anaerobic conditions under the floating water hyacinth mats. These anaerobic conditions have been the direct cause of fish death, and changes in the fish community by eliminating most species at the expense of air breathing species. Stationary mats of water hyacinth also shade out bottom growing vegetation, thereby depriving some species of fish, of food and spawning grounds. The potential impact on fish diversity is enormous.

**Micro-habitat for a variety of disease vectors.** The diseases associated with the presence of aquatic weeds in tropical developing countries are among those that cause the major public health problems: malaria, schistosomiasis and lymphatic filariasis. Some species of mosquito larvae thrive on the environment created by the presence of aquatic weeds, while the link between schistosomiasis (bilharzia) and aquatic weed presence is well known. Although the statistical link is not well defined between the presence of aquatic weeds and malaria and schistosomiasis, it can be shown that the brughian type of filariasis (which is responsible for a minor share of lymphatic filariasis in South Asia) is entirely linked to the presence of aquatic weeds. Cock [1] reported that water hyacinth encourage the vectors of several human diseases, including the intermediate snail hosts of bilharzia (schistosomiasis) and most mosquito vectors, including those responsible for the transmission of malaria, encephalitis and filariasis. In parts of Africa, water hyacinth mats are reported to provide cover for lurking crocodiles and snakes.

**Positive consequence of water hyacinth**

Although water hyacinth is seen in many countries including Ethiopia as a weed and is responsible for many of the problems outlined earlier in this fact sheet, many individuals, groups and institutions have been able to turn the problem around and find useful applications for the plant. A water hyacinth composition have more than 95% water, has a fibrous tissue and a high energy and protein content, and can be used for a variety of useful applications. Water hyacinth harvests have been put into valuable uses in several countries. Methods of converting the plant material into valuable products have emerged. Apart from its ornamental value, the plant has been found useful as a source of animal feed [30] as a source of fertilizers for use in agriculture [31, 32], a source of bio- mass energy, a source of raw materials for building, handcraft making, paper and boards. In addition the plant has been found to be useful as a filter worth of solving man created problems of pollution in water bodies. However all the potential uses of the water hyacinth do not promote utilization of the weed to the level that qualifies it as a viable control option [33].

**Animal fodder.** Studies have shown that the nutrients in water hyacinth are available to ruminants. In Southeast Asia some no ruminant animals are fed rations containing water hyacinth. In China pig farmers boil chopped water hyacinth with vegetable waste, rice bran, copra cake and salt to make a suitable feed. In Malaysia fresh water hyacinth is cooked with rice bran and fishmeal and mixed with copra meal as feed for pigs, ducks and pond fish. Similar practices are much used in Indonesia, the Philippines and Thailand [35]. The high water and mineral content mean that it is not suited to all animals. In Bangladesh, huge amount of Eichhornia crassipes are produced due to large number of rivers, ponds, lakes and other water reservoirs. In many coastal areas of the country, Eichhornia crassipes is commonly used as forage for cattle either as basal feed resource or supplement to a diet consists of sugarcane, molasses and cereal straws.

The use of water hyacinth for animal feed in developing countries could help solve some of the nutritional problems that exist in these countries. Animal feed is often in short supply and although humans cannot eat water hyacinth directly, they can feed it to cattle and other animals which can convert the nutrient into useful food products for human consumption.

Water hyacinth (Eichhornia crassipes) an abundantly available aquatic plant of many country considered menace and the age old tradition believe that if this plan is fed to animal it will affect the health of the animals with severe diarrhea and suffer from salt imbalances. Many authors stated the utilization of Water Hyacinth (Eichhornia Crassipes) for livestock feed in different form. Many authors stated the utilization of Water Hyacinth (Eichhornia Crassipes) for livestock feed in different form. According to Villadolid and Bunag [35] have given a short but useful review of the uses of water hyacinth for animal, fish and human food. Sharma [36] has also discussed the uses of water hyacinth for livestock food. There is also reference is made to the harvesting of water hyacinth in Bangladesh, India, Indonesia and the Sudan to feed livestock.

**Basket work.** In the Philippines water hyacinth is dried and used to make baskets and matting for domestic use. The key to a good product is to ensure that the stalks are properly dried before being used. If the stalks still contain moisture then this can cause the product to rot quite quickly. In India, water hyacinth is also used to produce similar goods for the tourist industry. Traditional basket making and weaving skills are used.

**Biogas production.** The possibility of converting water hyacinth to biogas has been an area of major interest for many years. Conversion of other organic matter, usually animal or human waste, is a well-established small and medium scale technology in a number of developing countries, notably in China and India. The process is one of anaerobic digestion which takes place in a reactor or digester (an air tight container usually sited below ground) and the usable product is methane gas which can be used as a fuel for cooking, lighting or for powering an engine to provide shaft power. The residue from the digestion process provides a fertilizer rich in nutrients.

**Water purification.** Water hyacinth can be used to aid the process of water purification either for drinking water or for liquid effluent from sewage systems. A drinking water treatment water hyacinth has been used as part of the pretreatment purification step. Clean, healthy plants have been incorporated into water clarifiers and help with the removal of small flock that remain after initial coagulation and flock removal or settling [37]. Water hyacinth roots naturally absorb pollutants, including such toxic chemicals as lead, mercury, and strontium 90 (as well as some organic compounds). The result is a significant decrease in turbidity due to the removal of flock and also slight reduction in organic matter in the water. Water hyacinth is already being used to clean up waste water in small scale sewage treatment plants. Phyto remediation used for removing heavy metals and other pollutants is a newly developed environmental protection technique. In sewage systems, the root structures of water hyacinth (and other aquatic plants) provide a suitable environment for aerobic bacteria to function. Aerobic bacteria feed on nutrients and produce inorganic compounds which in turn provide food for the plants. The plants grow quickly and can be harvested to provide rich and valuable compost. Water hyacinth has also been used for the removal or reduction of nutrients, heavy metals, organic compounds and pathogens from water [30].

**Fertilizers.** Water hyacinth can be used on the land either as a green manure or as compost. As a green manure it can be either ploughed into the ground or used as mulch. The plant is ideal for composting. After removing the plant from the water it can be left to dry for a few days before being mixed with ash, soil and some animal manure. Microbial decomposition breaks down the fats, lipids, proteins, sugars and starches. The mixture can be left in piles to compost, the warmer climate of tropical countries accelerating the process and producing rich pathogen free compost which can be applied directly to the soil. The compost increases soil fertility and crop yield and generally improves the quality of the soil.

Compost can be made on a large or small scale and is well suited to labour intensive, low capital production. In developing countries where mineral fertilizer is expensive, it is an elegant solution to the problem of water hyacinth proliferation and also poor soil quality. In Sri Lanka water hyacinth is mixed with organic municipal waste, ash and soil, composted and sold to local farmers and market gardeners.

**Fish feed.** At the same time, the water hyacinth is believed to have promoted fish diversity, particularly smaller species and the young. Mechanisms for this include providing shelter from predators as well as reducing fishing pressure. It enhanced the abundance of lungfish and Haplochromines (riverine "haps") and depressed the number of tilapias and Synodontis, a member of the catfish genus [39]. The author confirmed that thus, structural changes in the species composition of Lake Victoria's fish stocks may have been induced by the water hyacinth infestation of the lake

The Chinese grass carp is a fast growing fish which eats aquatic plants. It grows at a tremendous rate and reaches sizes of up to 32 kg [34]. It is an edible fish with a tasty white meat. It will eat submerged or floating plants and also bank grasses. The fish can be used for weed control and will eat up to 18 - 40% of its own body weight in a single day [30].

Other fish such as the tilapia, silver carp and the silver dollar fish are all aquatic and can be used to control aquatic weeds. The manatee or sea cow has also been suggested as another herbivore which could be used for aquatic weed control.

Water hyacinth has also been used indirectly to feed fish. Dehydrated water hyacinth has been added to the diet of channel catfish fingerlings to increase their growth [30]. It has also been noted that decay of water hyacinth after chemical control releases nutrients which promote the growth of phytoplankton with subsequent increases in fish yield [30].

**Strategy for management of water Hyacinth**

There are several popular control mechanisms for preventing the spread of, or eradication of, water hyacinth. Water hyacinth control methods fall into three main categories: physical, chemical and biological [39]. Its use as a livestock feed is considered as an effective physical control method. The best method of controlling water hyacinth is to prevent it from being introduced in to a marine and fresh water system. This can be done by educating the public about the problems that occur from disposal of unwanted water garden or aquarium plants in to marine and fresh water systems or by not properly cleaning boats, trailers, other water sports equipment, bait buckets, or fishing equipment to remove all plant material before moving the equipment to another fresh water system or within the lake boundaries itself.

Biological control is the most widely favored long term control method, being relatively easy to use, and arguably providing the only economic and sustainable control. Below we will briefly discuss each of these methods.

**Mechanical control.** Mechanical removal requires mechanical harvesters, self-tipping dump trucks, personnel (site supervisors, mechanics, and laborers), and disposal site for the removed weed biomass, push-boats, floating barriers, fuel and lubricants as the minimum items for implementation. Costs of removal per hectare are dependent on size of the infested area, distance to disposal site, density of the weed, accessibility of the areas infested and potential for re-infestation. It is not suitable for large infestations and is generally regarded as a short-term solution. For example Westerdahl and Getsinger [40] confirmed that mechanical controls such as harvesting have been used for nearly 100 years in Florida, but are ineffective for large scale control, very expensive, and cannot keep pace with the rapid plant growth in large water systems. The total cost per hectare is 681.3 USD [41] but costs of 250 USD per hectare have been reported. Manual /mechanical methods: For small ponds or lakes infested with water hyacinth, harvesting and removal of plant material from the water can be attempted. Care must be taken to remove all plant material, including small fragments. Removal of water hyacinth can be integrated with the preparation of organic fertilizer, so that it can add value for the community by preparing compost, silage for cattle feed and fish feed around each spots of removal sites. Effectiveness of manual control can be limited by wind movements, expansive mats covering large expanse area, location of infestation, water depth. In Lake Tana water hyacinth control efforts were implemented in a spirited way but there were challenges related namely; health threats of bilharzias, leech bites, malaria and cold water environment. Lack of appropriate equipment and protective wear and lack of support in initial stages were among the challenges [29].

**Biological control.** Biological control is the most widely favored long term control method, being relatively easy to use, and arguably providing the only economic and sustainable control. Three insects and a fungus have been extensively studied and subsequently released to control water hyacinth. According to Grodowitz, M.J. [42].these three insects have been released for the biological control of water hyacinth. These include two weevil species (Neochetina spp.) and a moth (Sameodes albiguttalis). Unfortunately large scale reductions in water hyacinth populations did not occur. Instead insect predation reduced plant height, decreased the number of seeds produced, and decreased the seasonal growth of the plants. This, in turn, allowed better boat access into plant mats, reduced use of herbicides, and resulted in less plant problems. In Louisiana, the seasonal growth of water hyacinth was reduced from a high of over 400,000 hectares per year to lows of only about 80,000 hectares. However this method needs multidisciplinary study prior to introduce exotic species to water ecosystem that might cause for massive degradation of the resource. Grazing: most animals, except rabbits, do not readily eat the plant, possibly because its leaves are 95 percent water and have high tannin content. Rehabilitating some hotspot shores by wetland plants like papyrus is one of the remedy to overcome water hyacinth dominance. Papyrus serves as biological control. According to Anteneh [20] Survey repot in Lake Tana the infestation water hyacinth was highest in the areas which indigenous Macrophytes such as papyrus devastated area. However area where papyrus is dominant, water hyacinth coverage becomes limited, because of Papyrus out competes water hyacinth.

**Chemical control.** Water hyacinth can be controlled using glyph sate as a foliar spray and copper complexes used only as a foliar spray. But herbicide use is more highly regulated in aquatic systems than in terrestrial systems. Chemical control, through the use of certain herbicides such as 2, 4-D or glyphosate, seems to be an economically feasible option in some countries, but not in others with less economic development. Westerdahl and Getsinger [40] report excellent control of water hyacinth by the use of the aquatic herbicides 2, 4-D or diquat. Chemical control is the least favored due the unknown long-term effects on the environment and the communities with which it comes into contact. In addition, in many countries public opinion is strongly against the use of chemicals in water, which is used for drinking purposes. So that cannot be recommended at this moment. Even though Manual removal requires a large labor force, and Governments of the developing world do not always have the means to pay for this operation, this would seems the best means of controlling the water hyacinth in Lake Tana.

## CONCLUSION

Water hyacinth are negative environmental and economic impacts these include impairing and blocking of fishing grounds and fish breeding areas, reduced fish catches and fish quality, reduced tourism potential, reduced recession agricultural production and blockage of irrigation canals, loss of pasture lands and blocking of fishers movements could also be mentioned. Health impacts include increase in vector-borne diseases such as malaria, bilharzias and health related hazards from leeches and reptiles. Environmental impacts include deterioration in water quality, water loss through evapotranspiration and a decline of aquatic biodiversity. In conclusion, water hyacinth can be brought to make compost, mulching and to clean the sewage. It is a good way to change waste products into useful things. Apart from its ornamental value, the plant has been found useful as a source of animal feed as a source of fertilizers for use in agriculture, a source of bio- mass energy, a source of raw materials for building, handcraft making, paper and boards. In addition the plant has been found to be useful as a filter worth of solving man created problems of pollution in water bodies. More research is needed in order Water hyacinth has a multitude of negative consequences on economical, ecological and social. Current measurements were also made and they indicate that the wind is the main driving force of currents in the area. They also show that the circulation in the gulf is mainly horizontal rather than vertical. Water hyacinth could be an excellent source of proteins, vitamins, and minerals, and could be of particular value as a dietary supplement in countries where human diets are generally deficient in these nutrients. Water hyacinth control methods fall into three main categories: physical, chemical and biological. Its use as a livestock feed is considered as an effective physical control method.

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### Competing interests

The authors declare that they have no conflict of interest with respect to the research, authorship or publications of this article.

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# An Overview of Application of Animal Biotechnology in Africa: A Promising Approach for Life and Genetic Improvement of Farm Animals

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## ABSTRACT

**Biotechnology is defined as 'any technological application that uses biological systems, living organisms or derivatives thereof, to make or modify products and processes for specific use'. There is no doubt that technology had a major impact on rates of genetic improvement in dairy cattle and is just as important to the structure of animal breeding programs. The new techniques for understanding and modifying the genetics of living organisms have led to rapid adoption and large investments in biotechnology research and development. Most of this development is taking place in North America, Western Europe and East Asia, with the United States far ahead of the others. However, a diverse range of developing countries, from the technologically advanced like Brazil, China, India, Malaysia and South Africa to the technologically less advanced like Egypt, the Philippines and Vietnam are also investing a significant part of their total research and development resources on agro-biotechnology. But the least developed countries are lagging far behind, with the very modest investments that have been made in countries like Kenya, Tanzania and Uganda originating mostly from a few donor agencies. The techniques that are currently available to reach this end can be divided into two different groups. The first group includes all technologies that interfere with reproduction efficiency. The outcome of these technologies is an increased breeding accuracy, selection intensity and, in some cases, a shortened generation interval. The second group of applications is based on the molecular determination of genetic variability and the identification of genetically valuable traits and characteristics. Although; there is growing trend for genetic improvement and production of livestock especially in the dairy sector, African countries are the least investors in research and development of animal biotechnology. Artificial insemination is the first generation animal biotechnology introduced in cattle in the fifties and other reproductive animal biotechnologies are lagging behind to be practiced in the developing world. The growing dairy production observed from north, east and South African countries can be enhanced by capacity building, research and application of animal biotechnology options beyond artificial insemination.**

**Review**

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## INTRODUCTION

According to Sasson [1], the word 'biotechnology' was coined by Karl Ereky, a Hungarian engineer, in 1919 to refer to methods and techniques that allow the production of substances from raw materials with the aid of living organisms. A standard definition of biotechnology has been reached in the Convention on Biological Diversity (1992): 'any technological application that uses biological systems, living organisms or derivatives thereof, to make or modify products and processes for specific use'. This definition was agreed by 168 member nations and also accepted by the Food and Agricultural Organization of the United Nations (FAO) and the World Health Organization (WHO). Similarly; biotechnology can be broadly defined as the application of biological knowledge to practical needs. These technologies fall generally into two categories, reproductive and molecular. Not all of this is new. Artificial insemination was introduced in cattle in the fifties. There is no doubt that technology had a major impact on rates of genetic improvement in dairy cattle and is just as important to the structure of animal breeding programs [2]. Moreover; Biotechnologies are therefore a collection of techniques or processes using living organisms or their units to develop added-value products and services [1] and thus adding market value to local livestock breeds is a recognized strategy in conservation of AnGR [3], but the genetic improvement of breeds' traits is also a concrete option for increasing their profitability. Besides; the application of biotechnology techniques can be for production of knowledge goods and services for the betterment of human beings [4].

Livestock systems occupy about 30% of the planet's ice-free terrestrial surface area and this sector is increasingly organized in long market chains employing approximately 1.3 billion people globally and directly supporting the livelihoods of 600 million smallholding farmers in the developing countries [5]. In support of this task; the use of advanced tools such as genetic modification will undoubtedly have a profound impact on agriculture in the 21st century. The new techniques for understanding and modifying the genetics of living organisms have led to rapid adoption and large investments in biotechnology research and development (R&D). Most of this development is taking place in North America, Western Europe and East Asia, with the United States far ahead of the others. However, a diverse range of developing countries, from the technologically advanced like Brazil, China, India, Malaysia and South Africa to the technologically less advanced like Egypt, the Philippines and Vietnam are also investing a significant part of their total R&D resources on agro-biotechnology. But the least developed countries are lagging far behind, with the very modest investments that have been made in countries like Kenya, Tanzania and Uganda originating mostly from a few donor agencies [6]. Thus, the general objective of this review is to assess techniques and applications of biotechnology in livestock with emphasis to dairy sector of Africa and to address the following specific objectives:

- To review the available tools , techniques and applications of animal biotechnology as genetic improvement of livestock in Africa
- To review the role of animal biotechnology in bringing genetic improvement of livestock especially the dairy sector of Africa

## DISCUSSION

### Overview of animal biotechnology tools and applications

Biotechnology is multidisciplinary in nature encompassing microbiology, chemistry, biochemistry, genetics, molecular biology, immunology, physiology and engineering. Biotechnology therefore has application in the fields of agriculture, medicine, food, industry, and environmental management [4] and the biotechnological application is used to improve the yield of crop and animal species and their product quality such as nutritional value and shelf life [7]. The common goal of all efforts undertaken in this field is genetic progress within a population, i.e. the improvement of the genetic resources and, ultimately, the phenotypic outcome [8].

According to Parawira and Khosa [4] report, biotechnology is the least developed in the sub-Saharan region outside South Africa and much of the biotechnology applied is mainly traditional biotechnology, particularly in agriculture and food. This is mainly because of lack of adequate public research capacity, that is, the portfolio of resources – human, physical and financial, available in the research system for performing and utilizing the research. These challenges, either directly or indirectly affects capacity building and retention of personnel. Nevertheless, Zimbabwe is employing various forms of biotechnological techniques in its agricultural, environmental, Industrial, medicine and food industry research. This trend in biotechnology research and development is important as the country recover, maintain and eventually expand resources needed for it to have a competitive position in regional and international markets and for sustainable development.

### Techniques and applications of animal biotechnology

All factors of genetic progress (the accuracy of choosing candidates for breeding, the additive genetic variation within the population, the selection intensity (i.e. the proportion of the population selected for further breeding), and the generation interval (the age of breeding) can be influenced, to a varying extent, by modern biotechnology [8].

The techniques that are currently available to reach this end can be divided into two different groups [8]. The first group includes all technologies that interfere with reproduction efficiency: artificial insemination, embryo transfer (ET), embryo sexing, multiple ovulations, and ova pick-up and cloning, amongst others. The outcome of these technologies is an increased breeding accuracy, selection intensity and, in some cases, a shortened generation interval.

The second group of applications is based on the molecular determination of genetic variability and the identification of genetically valuable traits and characteristics. This includes the identification and characterization of quantitative trait loci (QTL) and the use of molecular markers for improved selection procedures. Furthermore, according to Bhagavan and Virgin [6] all of the modern biotechnology techniques can be used, and are being used, in the breeding of crops and livestock including molecular diagnostics and serology to aid crop and livestock production and protection, tissue culture , marker aided selection (MAS), genetic modification/genetic engineering , vaccine technology, functional genomics and bioinformatics.

## Molecular animal biotechnology options

**MAS programmes as a molecular animal biotechnology option.** According to FAO [9] report, in a population, when the marker and gene are very close the physical characteristics of the animals will be statistically associated with the marker and will stay linked for generations of breeding. If this statistical relationship is detected, individuals can be selected when the desired form of the molecular marker is present, since its presence would be an indication of the desired trait under study. This is known as "Marker Assisted Selection". According to Coutinho [10] it was only after the discovery of the DNA structure by Watson and Crick in 1953 and of recombinant DNA technology in the 1970s that modern biotechnology has been designated for using of genetic information obtained directly from DNA. Moreover ; since the 1970s, the identification and genotyping of large numbers of genetic markers, the use of this technology to identify genomic regions that control variation in quantitative traits and to show how the resulting quantitative trait loci (QTL) could be used to enhance selection, have raised high expectations for the application of marker-assisted selection (MAS) in livestock.

The first reported map in livestock was for the chicken in 1992, which was quickly followed by publication of maps for cattle, pigs and sheep. Since then, the search for useful markers has continued and further species have been targeted, including the goat, horse, rabbit and turkey (see http://www.thearkdb.org) [11]. MAS can, in theory, be applied to any agriculturally important species, and active research programmes have been devoted to building molecular marker maps and to detecting QTLs for potential use in MAS programmes in a range of plant and animal species [11] in that biotechnology provides the production of goods and services by using of living organisms or their parts. For thousands of years, several human activities, such as fermented foods production (bread, wine, yogurt, beer, etc.) are examples of the use of biotechnology [10].

**Biotechnology approaches used to identify genes.** Five biotechnology approaches used to identify genes of interest: QTL mapping, candidate genes approach, DNA and mRNA sequencing, including gene expression, genome scan approach, fine mapping.

**Quantitative trait loci (QTL) mapping.** QTL mapping is based on the identification of chromosomal regions associated with the genetic variation of traits of economic interest. This identification is dependent both on the development of genetic maps saturated with polymorphic molecular markers and on a population structure that shows segregation for the trait of interest [10].

**Table 1.** QTL mapping for some economically important traits

| No. | QTL | Species of LS | Trait affected (Milk Production) | Source |
|---|---|---|---|---|
| 1 | BM143 | Cattle | Milk yield, protein yield, protein percentage, fat yield, fat percentage | [12] |
| 2 | Diacilglicerol O-Acetiltransferase (DGAT1) | Cattle | Milk composition and production | [13] |
| 3 | Myostatin | Cattle | Muscle development | |
| 5 | Calpastatin gene | Cattle | Tenderization of meat. | [14] |
| 6 | Myostatin F94L | Cattle | Double-muscling | [15] |
| 7 | Diacylglycerol Acyltransferase (DGAT) | Cattle | Muscle fat content | [16] |

QTL= quantitative trait loci; LS= Livestock

### Candidate genes approach

The candidate gene approach studies the relationship between the traits and known genes that may be associated with the physiological pathways underlying the trait [17]. In other words, this approach assumes that a gene involved in the physiology of the trait could harbor a mutation causing variation in the trait. The gene or part of gene, are sequenced in a number of different animals, and any variation found in the DNA sequences, is tested for association with variation in the phenotypic trait. This approach has had some success [18]. For example a mutation was discovered in the estrogen receptor locus (ESR) which results increased litter size in pig.

**Table 2.** Candidate genes for some economically important traits

| No | Candidate genes | Trait<br>Meat quality of farm animals | Species of LS | Source |
|---|---|---|---|---|
| 1 | Halothane and RN genes | Meat quality | Pigs | [19] |
| 2 | Myostatin gene | Double-muscling | Cattle | [20] |
| 3 | Calpain and calpastatin | Meat tenderness | Cattle | [21] |
| 5 | Extracellular fatty acid binding protein (EX-ABP) gene | Abdominal fat Traits | Chicken | [22] |
| 6 | Liver fatty acid-binding protein (L-FABP) gene | Abdominal fat weight and percentage of abdominal fat | Chicken | [23] |
| 7 | Calpastatin (CAST) gene | Raw firmness scores and average tenderness, juiciness, and chewiness | Pig | [24] |

LS= Livestock; CAST= Calpastatin gene; RN gene= Napole gene

### Reproductive animal biotechnology option

**Artificial insemination (AI) in cattle.** Genetic progress in cattle can be increased up to 50% through the application of AI, the first generation biotechnology, using either extended semen that has been preserved in liquid form (fresh, or cooled to 5ºC), or deep-frozen [25]. During the past 50 years, the development and application of cattle AI with preserved (either chilled or frozen) semen have been growing exponentially on a global scale [26]. The number of produced semen doses is >250 million worldwide [27] and this technique can enable a single bull to be used for fertilization simultaneously in several countries for up to 100 000 inseminations a year [8].

**Embryo transfer.** Although not economically feasible for commercial use on small farms at present [28], the embryo transfer (ET) methodology is a suitable, more integrated approach for genetic distribution than AI, leading to improvement of genetic basis within 5 years [29] and embryo technology can greatly contribute to research and genetic improvement in local breeds [28]. Moreover, as for AI, allows movement of material worldwide and reduces the risk of transmitting specific diseases, provided the embryos are free from contamination [29].

There are two procedures presently available for the production of embryos from donor females [28]. One consists of super ovulation using a range of hormone implants and treatments, followed by AI and then flushing of the uterus to gather the embryos. The other, called *in vitro* fertilization (IVF) consists of recovery of eggs from the ovaries with the aid of the ultrasound-guided transvaginal oocyte pick-up (OPU) technique. When heifers reach puberty at 11-12 months of age, their oocytes may be retrieved weekly or even twice a week. These are matured and fertilized *in vitro* and kept until they are ready for implantation into foster females. In this way, high-value female calves can be used for breeding long before they reach their normal breeding age. IVF facilitates recovery of a large number of embryos from a single female at a reduced cost, thus making ET techniques economically feasible on a large scale.

**In vitro embryo production (IVP).** Methods for *in vitro* maturation (IVM), fertilization (IVF) and culture (IVC) are available for cattle, proved by the birth of innumerable calves' worldwide [30]. *In vitro* fertilization (IVF), the process of fertilizing and growing cattle embryos in the lab, is not a new technology. Briefly, eggs (or oocytes) are harvested from cows: 1) through the use of a transvaginal ultrasound-guided needle (mostly used in cows with high genetic value – more expensive method); or 2) straight from the ovaries of cows sent to the slaughterhouse (a much cheaper method). Once harvested, these oocytes are brought to the lab and placed in solutions that mimic the uterine environment. This allows sperm to fertilize the eggs and the formed embryos to grow until transferred to recipient cows, roughly one week after oocytes were harvested from the ovaries [31].

**Embryo splitting, bisection and reproductive cloning by nuclear transfer.** Cloning, as a multiplication technique, has been used in small ruminants since the late 1970´s. Splitting of cattle embryos can be used to increase the number of embryos available from selected females and to produce genetically identical animals for biomedical research. Both separation of blastomeres in 2-4 cell-embryos and embryo (morula or blastocyst) bisection have proven efficient to yield monocygotic twins after quick laparoscopic transfer to recipient cows.

Pregnancy rates achieved were similar to when transferring whole embryos and twinning reached 50% after pair transfer. The overall efficiency of cow embryo splitting (number of calves born per embryos bisected and transferred) can reach almost 60 % [32].

**Embryo sexing.** Technologies for rapid and reliable sexing of embryos allow the generation of the desired sex at specific points in a genetic improvement programme, markedly reducing the number of animals required and enabling increased breeding progress. A number of approaches to the sexing of semen have been attempted; however, the only method of semen sexing that has shown any promise has been the sorting of spermatozoa according to the DNA content by means of flow cytometry [33]. Embryo sexing has been attempted by a variety of methods, including cytogenetic analysis, assays for X-linked enzyme activity, analysis of differential development rates, detection of male-specific antigens, and the use of Y-chromosome specific DNA sequences [8].

## Factors for limited applications of biotechnology

As biotechnology industries are knowledge- and resource-intensive, two of the major drivers of its growth are effective and sustainable research and development and innovations [34].

### Dairy production: a potential sector for animal biotechnology to be applied on:

World milk production is derived from cows, buffaloes, goats, sheep and camels [35]. Moreover; As in Sub-Saharan Africa (SSA) in general, cow milk production is predominant in Eastern Africa, followed by goat milk, sheep milk and camel milk [36]. The milk production has doubled from 1996 to 2013 reaching 40 million MT and in volume terms the major growth has been in the countries in North Africa and in Kenya and South Africa. The other countries in Sub-Sahara Africa have all experienced high relatively growth but from an extremely low level, the milk production in Africa accounts only for 5% of the world milk production [35,37] and it is not foreseen to be able to cover the demand in the coming decades [37]. The largest milk-producing countries are Egypt, Kenya, South Africa and Sudan [35], the top five African milk producing countries in terms of milk volume being Sudan, Egypt, Kenya, South Africa and Algeria. Meanwhile, the first four countries alone produce 52% of total African milk [37].

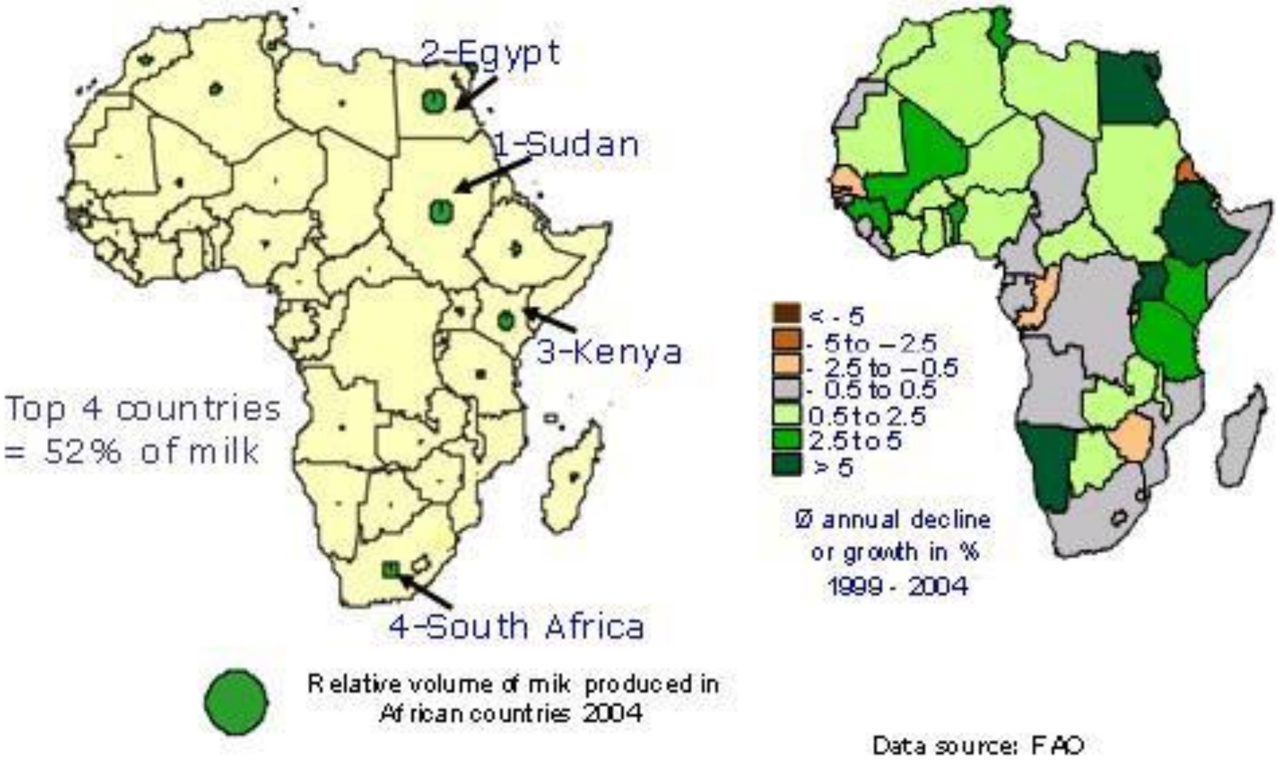


**Figure 1.** Milk production structure in Africa

Moreover, Eastern Africa is the leading first milk-producing region in Africa, representing 68% of the continent's milk output [38]. Ethiopia, Kenya and Tanzania are among the biggest dairy producers in Africa. The dairy sector is one of the fastest growing agricultural sub-sectors in Eastern African countries, which has generated significant economic returns and employment opportunities along dairy value chains. In Rwanda, according to the 2013 National Dairy Strategy (NDS), milk production has been rising rapidly, from 51.5 million (m) litres (l) in 2000 to 445 m l in 2012 and continued rapid growth is expected. This rapid rise in milk production has been attributed to a favorable policy and institutional environment and important investments by the Government and development partners [39].

**Table 3.** Dairy production in Eastern Africa in 2011

| Country | Milk (million t) 2011 | Milk (% of growth rate, 2000-11) | Butter (1000 t) | Cheese (1000 t) |
|---|---|---|---|---|
| **Ethiopia** | 4.4 | 14.2 | 17.6 | 5.8 |
| **Kenya** | 4.3 | 5.5 | 14.7 | 0.3 |
| **Rwanda** | 0.2 | 5.3 | 0.7 | n/a |
| **Tanzania** | 1.8 | 7.8 | 13.0 | 13.0 |
| **Uganda** | 1.2 | 8.0 | n/a | n/a |

Source: FAO STAT, 2014

## CONCLUSION AND RECOMMENDATIONS

AI is the first generation animal biotechnology in practice for the dairy sector starting in the fifties and other reproductive animal biotechnologies are lagging behind to be practiced in the developing world. Although, there is growing trend for genetic improvement and production of livestock especially in the dairy sector, developing countries including Africa are the least investors in research and development of animal biotechnology. The growing dairy production observed from north, east and South African countries can be enhanced by capacity building, research and application of animal biotechnology options beyond artificial insemination.

### Competing interests

The authors declare that they have no competing interests.

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# Effect of Dietary *Scutellaria baicalensis* Root Water Extract against *Piscicola geometra* Infection of Cobia

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## ABSTRACT

***Piscicola geometra* is an ectoparasite and the causative agent of infection in fish. Heavy infestation of *P. geometra* significantly causing mortality and serious economic losses to cobia industry. However, no single drug available today has used for the treatment or prevention of *P. geometra* infestation in fish. Water extracts of *Scutellaria baicalensis* root were evaluated for their effect on cobia infected by *P. geometra*. Fish were divided into two groups (group A for healthy fish and group B for infected fish) before being fed for 30 days with 0% as control, 0.5%, 1%, and 2% of *S. baicalensis*. Cobia growth performance, mortality, and total number of parasite infestation on fish were investigated. Result showed that infestation of *P. geometra* significantly reducing the growth performance and survival rate of cobia. Cobia fed with 1% *S. baicalensis* showed highly significant differences (P<0.05) in growth performance (group A and B) and the number of parasite infestation (group B) compared to their respective controls. However, the growth performance of cobia fed with supplemented extract showed no significant differences in group A at the lowest concentration (0.5%) and the highest concentration (2%). Meanwhile group B showed significant different in growth performance among the treatment group (P<0.05). This study demonstrated that *S. baicalensis* root water extract administered as a dietary supplementation is one of the most practical methods to prevent *P. geometra* infestation in cobia culture.**

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## INTRODUCTION

Cobia (*Rachycentron canadum*), locally known as *badee* in Indonesia is one of the most promising candidate for marine culture industry in the world [1, 2]. The hardiness cobia is living in different environment and easy to adapt (distributed worldwide between in 50 and 1200 m depth, 16.8 to 32.2ºC of temperatures, and 5 to 44.5 of salinities [3, 4]), fast growth (up to 4 – 6 kg in a year with 90% of survival rate [5]), good conversion rate (1.6 to 1) [6], and high market value (excellent white meat flesh quality) [7]. Moreover, 100 g of cobia meat contains around 32 – 507 mg of docosahexanoic acid (DHA) and 280 – 485 mg of eicosapentanoic acid (EPA) which 24% higher than Atlantic salmon that contain 10 – 11.6 mg of DHA/100g and 76 – 83 mg of EPA/100 g [8, 9]. Cobia production is expanding rapidly in Taiwan, Vietnam, China, Philippines, Indonesia, Iran, and Reunion Island [4-6, 10].

However, intensification of aquaculture production has resulted in an increased incidence of disease outbreaks as the major constraints of the mariculture industry [4]. Although there has been no detailed review of the parasites disease of cobia, the wild cobia has been reported infect by parasite at gastrointestinal tract, gills, and skin [3, 11]. Parasites infestation causing mortality, growth retardation and serious economic losses to the cobia industry [12]. *Piscicola geometra* has found to infest the eye, gills, and skin of cobia culture in Taiwan and caused a lesion, erosion, and hemorrhage. Class of Hirudinea of the Rhynchobdellida is a blood sucker leech which utilizes a proboscis to penetrate the tissue of the host [13]. The wounding makes the growth of fish slower and changes their skin color become darker, also can cause the fall of the market value [4].

Antibiotics and the veterinary drug has been applied in aquaculture to treat fish disease [14, 15]. Although the fish disease is able to be healed, the incidence of water pollution, accumulation of chemical residues, drug resistant bacteria, and highly toxic substances has become a major problem in public health [16, 17]. Nowadays, humans have returned back to nature and started to use medicinal plants as a promising alternative method to control fish disease [18, 19]. The dried root of *S. baicalensis* has been listed in Traditional Chinese Medicine (TCM) [20]. A highly active compound such as alkaloids, flavonoids, phenolics, terpenoids, steroids, pigments, and essential oils contains in *S. baicalensis* root has provided a cheaper source to treat many diseases, reducing stress responses, enhancing immune responses and mitigate many side effects with greater accuracy [21-24]. The aim of this study is to evaluate the effects of dietary *S. baicalensis* root water extract on the growth performance and disease resistance of cobia against *Piscicola geometra* infestation.

## MATERIAL AND METHODS

### Ethical approval

The review board and ethics committee of Tungkang Marine Biotechnology Research Station Taiwan approved the study protocol and informed consent were taken from all the participants.

### Preparation of plant extract

The dried root of *S. baicalensis* was powdered mechanically using an electrical stainless grinder. The powdered (10 gram) were extracted with distilled water (150 ml) and boiled at 95ºC for 20 min. The extracts were divided into four 50 ml Falcon tube and centrifuged for 10 min at 4ºC, 1000 xg. The clear supernatant was stored at -20ºC of refrigerator for further uses. A standard commercial diet for cobia was used throughout and designed as the control diet. Different concentration of *S. baicalensis* root water extract was sprayed into the commercial feed slowly and mixing part by part (control, 0.5%, 1%, and 2%). The diets were dried under the sterile condition in a hot air oven at 60º for 24 h.

### Parasites and hosts

A total of 240 healthy cobia, with 23.3 ± 2.3 gram of body weight and 10 ± 2 cm of body length were obtained from Tungkang Marine Biotechnology Research Station, Taiwan and maintained in 200-l of tanks with air stone and water circulation. The fish were acclimatized under laboratory conditions for 7 days and fed with commercial diet for cobia. After acclimation, 120 of fish cohabited with the ones infected with *P. geometra.*

### Fish and experimental protocol

The experiments were carried out at Tungkang Marine Biotechnology Research Station, Taiwan. Experimental study was divided into two group treatment. After two weeks of post-infestation, healthy fish (without leech infestation) were randomly distributed in group treatment A and infected fish in group treatment B. Each group contains four treatment including control with three replicates. Each tank (200-l) was stocked with 10 fish. Fish were fed with experimental diet in twice a day at a rate of 5% body weight for 30 days. During the experimental period, the temperature was ranged from 26 to 28ºC and salinity from 33 to 35 ppt. Total number and mean body weight of fish in each tank were measured in seven days interval. The effects of treatments on the number of parasites were analyzed by comparing with those in control group after 30 days of post-experimental diet feeding.

### Fish growth performance calculation

Growth performance were assessed by net weight gain (WG), specific growth rate (SGR), feed conversion ratio (FCR), and survival growth rate (SGR) at seven days interval. Calculations were made using equation was describe

[25]. The amount of the fed was increasingly based on the fish body weight. Clinical history of lesion, behavior, and mortality of the fish was observed every day. The number of leech in each fish was randomly counted in the end of experiment.

$$\text{Survival growth rate (SGR)} \frac{\ln(Final\ weight\ (g)) - \ln(Initial\ weight\ (g))\ x\ 100}{total\ duration\ of\ the\ experiment\ (days)} \ldots\ldots \quad (1)$$

$$\text{Feed Conversion Ration (FCR)} = \frac{total\ amount\ of\ feed\ (g)}{weight\ gain\ (g)} \ldots\ldots\ldots\ldots \quad (2)$$

$$\text{Weight gain rate (\%)} = 100\ x\ \frac{Final\ body\ weight(g) - initial\ body\ weight(g)}{initial\ body\ weight\ (g)} .. \quad (3)$$

**Statistical analysis**

All data are presented as means ± standard deviation (SD). Statistical analysis was performed using SPSS 16.0 software by one-way ANOVA (analysis of variance) and accepted at the P<0.05 level. Significant differences between control and treatment groups were determined using post-hoc Duncan's test.

## RESULTS

Body weight (BW), weight gain (WG), survival growth rate (SGR), feed conversion ratio (FCR) and survival rate of cobia fed the experimental diet in both of group are shown in Tables 1 and 2. *Scutellaria baicalensis* supplemented to the fish feed were significantly enhancing the growth performance of cobia compared with control feed (P<0.05) in both of the groups. Table 1 showed that, healthy cobia fed with 1% concentration of plant extract were significantly higher than other groups treatment at the growth performance with 35.6 ± 1.2 of final body weight, 74.34 ± 5.8 of weight gain, 50.60 ± 4.1 of survival growth rate, and the FCR around 1.14 (P<0.05). According to the statistical analysis, there was no significant differences of the growth performance between the lowest concentration (0.5%) and the higher concentration (2%) in group A (P<0.05). However, no fish die in group A during the experiment.

In contrast with group A, heavy infestation of *P. geometra* caused moderate hemorrhage on skin (Figure 1) and significantly reduce the body weight of cobia after 30 days of infestation (Figure 2). Administration of 1% of *S. baicalensis* to the infected cobia slightly enhance the growth performance of fish (Figures 1 and 2) compared with control. However, there were no significant differences in weight gain of fish in group B among all treatments. There were no significant differences in survival growth rate and feed conversion ratio among fish fed with control and 0.5% or among fish fed with 1% and 2% concentration of extract (P<0.05). In addition, the survival rate in fish fed with 1% concentration of extract was significantly higher than fish fed with control, 0.5%, and 2% (P<0.05; Table 2).

Infestation of *P. geometra* in the groups treated with 1% and 2% concentration of *S. baicalensis* root were significantly reduced compared with control. There were no significant differences in parasite infestation in fish fed with commercial diet and 0.5% concentration of *S. baicalensis* root (P<0.05; Table 3).

**Table 1.** Weight gain, specific growth ratio, feed conversion ratio, and survival of the healthy and infected cobia fed diets containing the various concentrations of *S. baicalensis* root for 30 days.

| Treatment Group A | Final body weight (g) | Weight gain[1] (g) | SGR[2] (% BW $day^{-1}$) | FCR[3] (g dry feed/g gain) | Survival (%) |
|---|---|---|---|---|---|
| Control | 33.6 ± 1.1 $^{b}$ | 55.05 ± 5.4 $^{b}$ | 39.77 ± 3.8 $^{b}$ | 1.46 ± 0.08 $^{b}$ | 100 $^{a}$ |
| 0.50% | 33.77 ± 1.7 $^{ab}$ | 62.31 ± 87.2 $^{ab}$ | 44.49 ± 5.2 $^{ab}$ | 1.33 ± 0.08 $^{ab}$ | 100 $^{a}$ |
| 1% | 35.6 ± 1.2 $^{a}$ | 74.34 ± 5.8 $^{a}$ | 50.60 ± 4.1 $^{a}$ | 1.14 ± 0.06 $^{a}$ | 100 $^{a}$ |
| 2% | 34.7 ± 0.7 $^{ab}$ | 54.43 ± 4.5 $^{ab}$ | 40.77 ± 2.6 $^{ab}$ | 1.53 ± 0.08 $^{ab}$ | 100 $^{a}$ |
| **SEM** | 0.54 | 2.56 | 1.78 | 0.03 | 0 |
| **[4]*P*-value** | 0.037 | 0.02 | 0.045 | 0.011 | 0 |

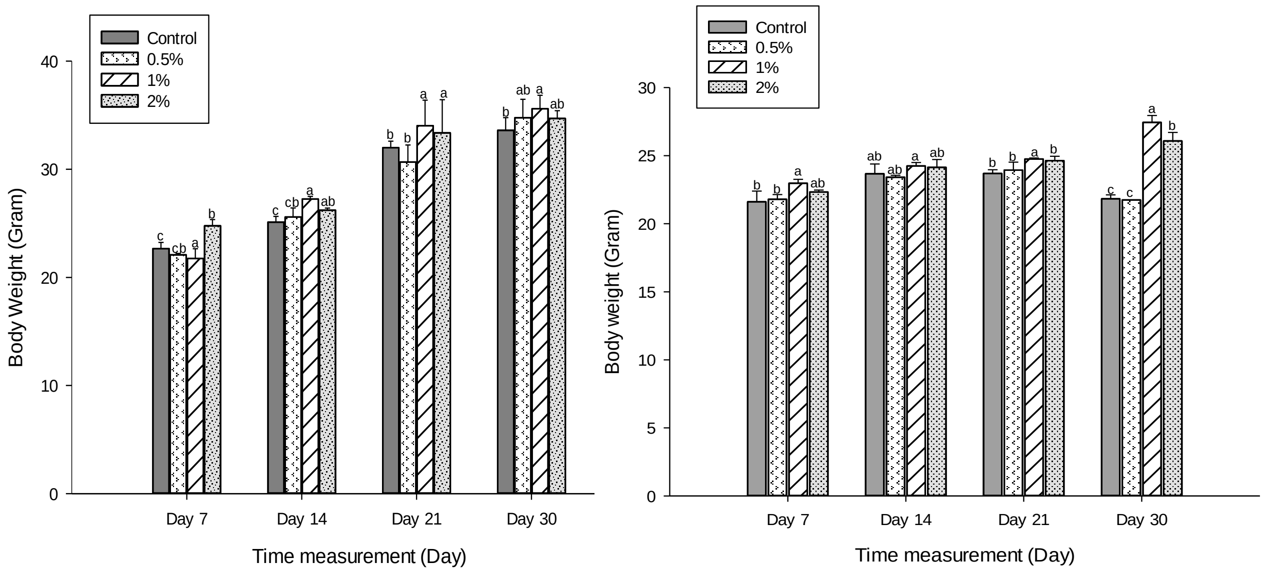
Values are means from triplicate groups of fish (mean ± standard deviations n=10), where the means in each row with different superscripts are significantly different (P<0.05). [1]Weight gain= 100 x (final body weight - initial body weight) / initial body weight. [2]Specific growth ratio = 100 x ln (final weight/initial weight)/ days of the experiment. [3]Feed conversion ratio= g dry feed consumed/g wet weight gain. [4]Values represent of five observations per treatment and their SEM.

**Table 2.** Weight gain, specific growth ratio, feed conversion ratio, and survival of infected cobia fed diets containing the various concentrations of *S. baicalensis* root for 30 days.

| Treatment Group B | Final body weight (g) | Weight gain[1] (g) | SGR[2] (% BW day$^{-1}$) | FCR[3] (g dry feed/g gain) | Survival (%) |
|---|---|---|---|---|---|
| Control | 21 ± 0.2$^{c}$ | 21.83 ± 0.1$^{a}$ | 3.97 ± 0.1$^{b}$ | 3.25 ± 1.2$^{b}$ | 70$^{b}$ |
| 0.5% | 21.42 ± 0$^{c}$ | 21.75 ± 1.1$^{a}$ | 1.54 ± 0.8$^{b}$ | 2.85 ± 1.1$^{b}$ | 80$^{ab}$ |
| 1% | 21 ± 0.5$^{a}$ | 27.44 ± 2.3$^{a}$ | 30.69 ± 1.6$^{ab}$ | 1.02 ± 0.1$^{a}$ | 90$^{a}$ |
| 2% | 22 ± 0.6$^{b}$ | 26.08 ± 5$^{a}$ | 18.56 ± 3.2$^{ab}$ | 1.78 ± 0.5$^{a}$ | 85$^{ab}$ |
| **SEM** | 0.15 | 1 | 0 | 1.46 | 3.3 |
| **[4]P - value** | 0.007 | 0.008 | 0.008 | 0.006 | 0.004 |

Values are means from triplicate groups of fish (mean ± standard deviations n=10), where the means in each row with different superscripts are significantly different (P<0.05). [1]Weight gain = 100 x (final body weight - initial body weight) / initial body weight. [2]Specific growth ratio= 100 x ln (final weight/initial weight)/ days of the experiment. [3]Feed conversion ratio= g dry feed consumed/g wet weight gain. [4]Values represent of five observations per treatment and their SEM.

**Figure 1**. Heavy infestation of *P. geometra* caused moderate lesion and hemorrhage on cobia skin




**Group A** **Group B**

**Figure 2.** Body weight of healthy cobia (group A) and cobia infected by *P. geometra* (group B) fed with various concentration of *S. baicalensis* root water extract for 30 days (values are mean ± S. E). Mean value with different superscript with in a column for a parameter are significantly different (P < 0.05).

**Table 3.** The effectiveness of administration of *S. baicalensis* root water extract of cobia to treat *P. geometra*

| Experimental group B | Number of parasites per fish for 30 days of feeding |
|---|---|
| Control | $56.70 \pm 7.8^{b}$ |
| 0.5% | $53.57 \pm 9.6^{b}$ |
| 1% | $35.45 \pm 13.5^{a}$ |
| 2% | $28.98 \pm 18.7^{a}$ |

Different superscripts are shows the significantly different (P < 0.05), intensity ± SD

## DISCUSSION

*Piscicola geometra* is a significant cause of disease in fish, livestock and serious economic losses to the aquaculture industry. Since the used of veterinary drugs has attracted criticism, there was an urgent need to find new drugs to treat and prevent fish disease [17]. The root of *Scutellaria baicalensis* has been listed in a traditional Chinese medicine to treat human disease [24]. Although *S. baicalensis* root has been common use for human therapy for millennia, there has been tested for controlling and against fish disease [26]. These results demonstrated essentially of dietary *S. baicalensis* root for normal physiological function and had activity against parasite infestation of cobia.

In this study, the effectiveness of *S. baicalensis* root on *Piscicola geometra* was evaluated using oral administration. This study showed that heavy infestation of *P. geometra* has inhibited the growth performance of cobia. However, cobia fed with *S. baicalensis* root water extract has increased the growth performance of healthy fish (group A) and slightly improve the specific growth rate of cobia in group B (parasite infected) compared to untreated control. Administration of *S. baicalensis* also reduced the number of living parasites of 1% concentration and significantly improved the survival rate of cobia infected by *P. geometra* ($P<0.05$). According to the Ramudu KR and Dash [27], active compounds of herbal plants supplemented on feed could induce the secretion of high protein synthesis of the digestive enzyme and stimulating the appetite and increasing food consumption and efficiencies.

The root of *S. baicalensis* produces more than 30 types of bioactive including 4'-deoxyflavones which promotes various activities such as anti-stress, growth promotion, immunostimulation, and antimicrobial activity [20]. Some study, administration of *S. baicalensis* root has significantly improved specific growth rate of olive flounder with 2% of concentration [28]. Moreover, oral administration of *S. baicalensis* root also can modulate the innate immune system of tilapia with an optimal feeding period of 3 weeks [29]. Some of the herbal extracts also have been reported to treat some parasitic disease in farm fish [26].

Water extracts of tropical seaweed *Asparagopsis taxiformis* showed the most potential for development as a natural treatment to manage the monogenean ectoparasite [30]. Dietary of garlic extract significantly reduced the infection of *Neobenedenia* sp in barramundi farmed [31]. Additionally, administrated of praziquantel resulted in over 80% reduction in worm intensity of chub mackerel culture [32]. However, freshwater bathing of praziquantel drastically increased the parasite intensity due to stress and loss of mucus during the bathing [32]. These results indicated that dietary *S. baicalensis* root could improve the growth performance and had anti-parasitic against *P. geometra* infestation with 1% of concentration.

## CONCLUSION

The present study provided evidence that dietary *S. baicalensis* root could significantly enhance the growth performance and protection against parasite infection for cobia. Further work is needed to establish the stimulatory dose and optimal time of feeding of *S. baicalensis* root.

### Authors' Contributions

Putri Nurhanida Rizky participated in the performed experiments, drafting the manuscript, analyze and interpretation the data. Cheng Ta-Chih participated in the design of study and financial support. Happy nursyam participated in the critically revised the manuscript for important intellectual contents. All authors of this research paper have directly participated in the planning, execution, or analysis of this study and have read and approved the final version submitted.

**Competing interests**

All authors declare that they have no competing interests that might have influenced the performance or presentation of the work described in this manuscript.

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**2.** Karen KS, Otto CM. 2007. Pregnancy in women with valvular heart disease. Heart. 2007 May; 93(5): 552–558. DOI, Link
**3.** Doll MA, Salazar-González RA, Bodduluri S, Hein DW. Arylamine N-acetyltransferase 2 genotype-dependent N-acetylation of isoniazid in cryopreserved human hepatocytes. Acta Pharm Sin B, 2017; 7(4):517-522. DOI, Link

**For In press manuscripts (maximum 2):**
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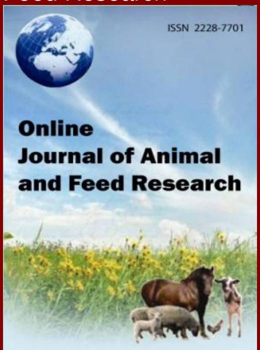


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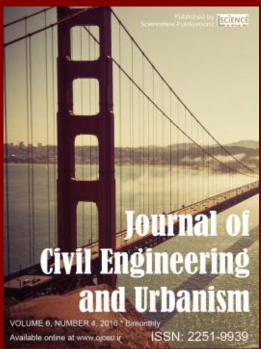


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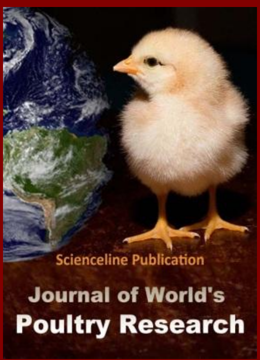


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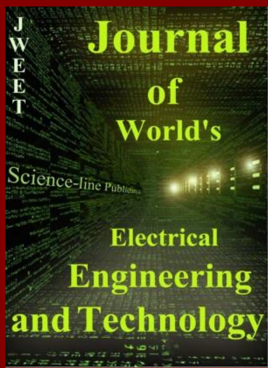


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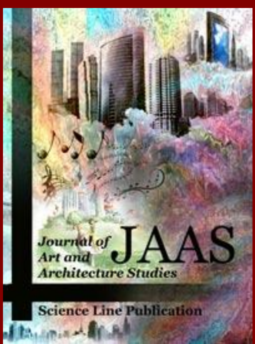


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