Chapter 1
Introduction

Dieses Werk ist copyrightgeschützt und darf in keiner Form vervielfältigt werden noch an Dritte weitergegeben werden.
Es gilt nur für den persönlichen Gebrauch.

1.1. Preface

New developments and trends have enabled large scale production of tilapia. Since the 1980s and 90s international trade with tilapia products is increasing (Fitzsimmons, 2000). Today tilapia are, behind carps, the most produced species in global aquaculture. Within the last ten years the production of Nile tilapia (*Oreochromis niloticus*) has increased nearly tenfold (FAO, 2014). The benefits of tilapia can be found in a fast growth potential, high tolerance against diseases and early maturity. Their production is suitable in various systems e.g. earthen ponds or modern recirculation units. Females of this species are maternal mouthbrooder and incubate the eggs in their mouth. Due to the early maturation, in mixed sex populations an unwanted reproduction takes place and a new generation comes up. This upcoming generation competes against the basic stock which results in stunting and in an inhomogeneous output. Hence a negative result with regard to profitable production conditions (e.g. marketable size) is obvious. For an efficient large scale production all-male populations are required. Kept under similar conditions males came out with a higher and faster growth than females (Phelps and Popma, 2000; Drummond et al., 2009). To ensure an efficient large scale production and the increasing demand for all-male stocks, intensive breeding under controlled management is required (Elsbaay, 2013). It is found that environmental factors (e.g. water temperature or light) are influencing Nile tilapia reproduction (e.g. El-Naggar et al., 2000; de Lapeyre, 2007; El-Sayed and Kawanna, 2007). Using environmental factors to induce a sex reversal of fry, or to improve production conditions and fertility within Nile tilapia, can be beneficial in more than one way. Besides a higher outcome, this ensures an environmentally friendly, but even though economical production of the future fish tilapia.

Dieses Werk ist copyrightgeschützt und darf in keiner Form vervielfältigt werden noch an Dritte weitergegeben werden.
Es gilt nur für den persönlichen Gebrauch.

1.2. Factors influencing sex determination

It is of importance to understand the process of sex determination in tilapia in order to improve reproduction and production process within this species. Within *O. niloticus*, comparable to humans, sex determination in females follows a homogametic system (XX-chromosomes) whereas males are heterogametic (XY-chromosomes) (Scott et al., 1989; Desprez et al., 2003; Cnaani et al., 2008). Besides this *Oreochromis aureus* and *Oreochromis horneum* show a homogametic male system (ZZ/WZ) (Desprez et al., 2003; Cnaani et al., 2008). With the use of an andro-or gynogenesis, the possibility to obtain information about the sex determining mechanism in fish is given (Komen and Thorgaard, 2007). For example in species with a homogametic female system, as in Nile tilapia, the progeny of a gynogenesis are expected to be all-female. In contrast because males have XY-chromosomes, androgenetic progeny is either XX-female or YY-male, assuming that YY-males are viable (Komen and Thorgaard, 2007). Until today the complete mechanism in sex determination is not clearly understood. Earlier studies described the presence of autosomal recessive genes influencing the sex determination process in tilapia (Mair et al., 1991; Mair et al., 1997). The authors found males within a group of fully inbred mitotic gynogentic females. Besides autosomal or genetic factors environmental effects such as temperature influence sex in Nile tilapia (Mair et al., 1997, Abucay et al., 1999; Baroiller et al., 2009). Next to major and minor genetic factors temperature plays an important role in influencing sex within this species (figure 1).

Dieses Werk ist copyrightgeschützt und darf in keiner Form vervielfältigt werden noch an Dritte weitergegeben werden.
Es gilt nur für den persönlichen Gebrauch.

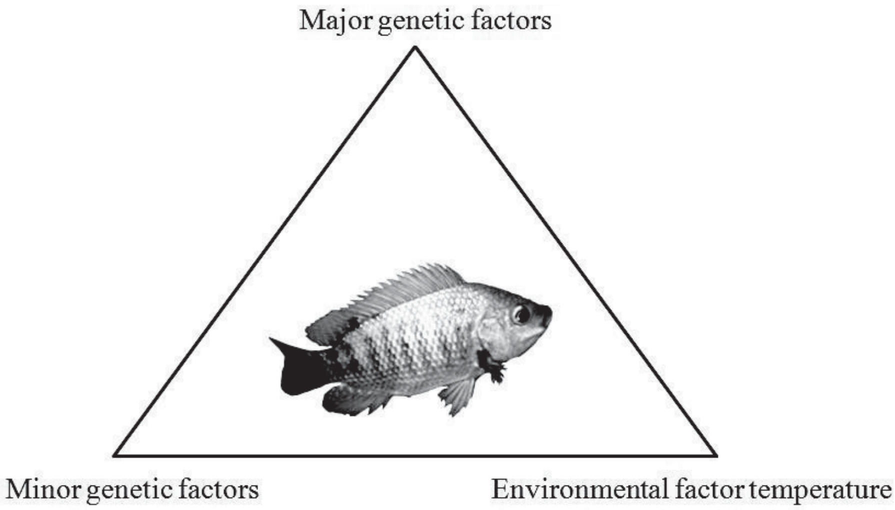

Figure 1 Factors influencing sex in Nile tilapia (modified figure from Baroiller et al., 2009)

On the one hand such effects or interactions make breeding more complicated but on the other hand it offers new methods and opportunities to influence the phenotypic sex in Nile tilapia.

1.3. Monosex populations in Nile tilapia

Within *O. niloticus* different methods provide the possibility to produce monosex populations e.g. for an efficient large scale production or homogenous groups for research.

As a simple method to produce all-male or all-female populations manual sexing of fish could be used. For this, number of openings and shape of the urogenital papillae is used. Within males the urogenital papilla has only one opening whereas females show two openings and one with a more olive or slit-like shape (Wessels, 2006).

Dieses Werk ist copyrightgeschützt und darf in keiner Form vervielfältigt werden noch an Dritte weitergegeben werden.
Es gilt nur für den persönlichen Gebrauch.

This method is rather time and labour intensive, because both sex have to be kept until they have reached a judgeable size and half of the fish will be disposed afterwards. This method can be used to sort parental generations e.g. separating males and females for selected breeding.

Hybridisation can be applied to produce monosex populations within tilapia. Therefore two species, *O. niloticus* (homogametic female (XX)) and *O. aureus* (homogametic male (ZZ)) are mated to produce all-male populations. Especially for developing countries both methods are not affordable. Manual sexing is wasting resources and within hybridisation both breeding lines have to be kept and mated every time new (Mair et al., 1997).

Usually all-male populations are generated using testosterone supplemented feed during the time of sex differentiation. The hormone is mixed with feedstuff and fed to fry to establish functional males. Commonly a dosage of 60 mg 17α-methyltestosterone (MT) per kg feedstuff is used to provide a successful treatment (Phelps and Popma, 2000). But this method is not only beneficial. An earlier study focused on residues of androgens in marketable fish and supposed a negative impact on the environment (Desprez et al., 2003). Furthermore, if the waste water is not disposed correctly MT can accumulate in sediment of fish ponds (Homklin et al., 2010). This can cause a risk for environment and humans if contaminated sediment or water is not handled with adequate care.

Using YY-males is another possibility to provide all-male stocks. Therefore YY-sires are mated with normal females. The production of YY-males beginning with a normal mating is described in detail at Mair et al. (1997). Müller-Belecke and Hörstgen-Schwark (2007) identified a YY-male out of mitotic gynogentic progenies. Nevertheless, to establish YY-males various steps are necessary and besides major investment, advanced knowledge is required. Thus, such males are costly and not affordable for many producers.

It was found that high temperatures (>34°C) during an early stage of sex differentiation can affect the phenotypic sex in Nile tilapia and results into a higher male ratio (Tessema et al., 2006, Baroiller et al., 2009).

Dieses Werk ist copyrightgeschützt und darf in keiner Form vervielfältigt werden noch an Dritte weitergegeben werden.
Es gilt nur für den persönlichen Gebrauch.