The fertility of tetraploid hybrids and the sterility of their triploid offspring

Shaojun Liu[(1)], Yuandong Sun[(1)], Gongjiang Zhou[(1)], Xuanjie Zhang[(1)], Hao Feng[(1)], Xiaoxiao He[(1)], Hu Fang[(1)], Chen Luo[(1)], Guihua Zhu[(2)], Hui Yang[(2)], Yun Liu[(1)]

(1) College of Life Science, Hunan Normal University, Changsha 410081, Hunan, P. R. China
(2) Donghu Fish Farm, Xiangying 412000, Hunan, P. R. China

ABSTRACT: The testes of tetraploids consisted of many lobules in which the germ cells such as the spermatogonia, spermatids and the mature sperm were observed. In the cytoplasm of sertoil's cells that surrounded the spermatogonia, the granules that were probably related to the formation of some sex steroid hormones were found. The ovary of tetraploids consisted of many ova. The structure of the gonads in tetraploids were similar to those in diploids, indicating that the tetraploid hybrids possessed the normal testes and ovary, producing the normal diploid sperm and diploid eggs, respectively. The diploid sperm and diploid eggs were respectively larger than the haploid sperm and eggs in sizes. The diploid sperm and diploid eggs can normally fertilize to produce next tetraploid generation.

During breeding season three types of gonadal structure of triploid crucian carp, produced by crossing allotetraploids (♂) with Japanese crucian carp (Carassius auratus Cavieri T. et S) (♀), were found. The first type was the testis that consisted of many lobules in which there were numerous spermatides. Some degenerated spermatides were found and no mature spermatozoon was observed. The second type was the ovary-like gonad consisting of many nests of small undeveloped cells and a few small growing oocytes as well as degenerated oocytes. The third type was the fat tissue, in which case, only two strips of fat tissue were located on the gonadal positions, neither testis nor ovary being observed. Over more than ten years, no fertile triploid was found. Combined with the structure of the tissues located in the gonad positions, the triploid crucian carp was proved to be sterile. The triploid caurian carp was produced on a large scale in China.

1. INTRODUCTION

The F3-F11 hybrids of red crucian carp (Carassius auratus red var.) (♀)xcommon carp (Cyprinus carpio L.) (♂) were proved to be allotetraploids with 200 chromosomes, showing the tetraploidy can be inherited from one generation to another. The sterile triploids were produced on a large scale by crossing tetraploids with diploids. The tetraploid hybrids will probably form a new species with 200 chromosomes. So it is necessary to make clear the structure of the gonads in tetraploids. One of the important aims for the production of tetraploids is for the production of sterile triploids. The sterility of the triploids can resolve the problem of precocious sexual maturation. The sterile triploids do not disturb the natural fish resources when they are put in natural water. The sterility of the triploids is also related to a faster growth rate.

2. METHODS

The electron microscope, scanning electron microscope and light microscope were used to observe the gonads in tetraploids and triploids.

3. RESULTS

3.1. The structure of gonads in tetraploids

i. Similar to the testis of diploid common carp, the testis of tetraploids consisted of many lobules in which the germ cells such as the spermatogonia, spermatids and mature sperm were observed. In the cytoplasm of Sertoil's cells which surrounded the spermatogoia, the granules that were probably related to the formation of some sex steroid hormones were found.

ii. Similar to the ovary of diploids, the ovary of tetraploids consisted of many normal ova.

iii. However there existed differences in the sizes between the diploid gametes produced by tetraploids and haploids produced by diploids. The diameter of the head of diploid sperm was about 2.40 μm that was obviously larger than that of haploid sperm with about 1.90 μm, produced by common carp. The size of spermatogonia in tetraploids was also larger than that in diploid common carp. The size of the diploid eggs with the diameter of 0.17 cm was obviously larger than that of haploid eggs of red crucian carp with the diameter of 0.13 cm.

3.2. The structure of gonads in triploids

Three types of gonadal structure were found in the triploid crucian carp.

i. The testis of triploids consisted of many lobules in which there were numerous spermatides. Some degenerated spermatides were found and no mature spermatozoon was observed.

ii. The ovary-like gonad in triploids consisted of many nests of small undeveloped cells and a few small growing oocytes as well as some degenerated oocytes. No mature ova was observed.

iii. Only two strips of fat tissue were located on the gonadal positions, neither testis nor ovary being observed.

iv. Over more than ten years, no fertile triploid was found. Combined with the structure of the tissues located in the gonad positions, the triploid crucian carp was proved to be sterile.

4. CONCLUSION

1. The structure of gonads of tetraploids was similar to that of diploids. With the larger sizes, the diploid gametes produced by the tetraploids were normal, indicating that tetraploidy can be inherited from one generation to another. The tetraploids will probably form a new species with 200 chromosomes. The formation of the tetraploid population has significance in both the biological evolution and the application.
2. The 100% triploids can be produced by mating the tetraploids with the diploids.
3. The three types of structure found in the gonad places in triploid crucian carp indicated that they were sterile.
4. The sterility of the triploids was related to the maternal and paternal parents. The tetraploid's maternal parent is red crucian carp. The tetraploid's paternal parent is the common carp. The triploid's maternal parent is the Japanese crucian carp. So the triploid crucian carp is allotriploid. It is also triple fish.
5. In triploids, the homologue chromosomes cannot normally pair during meiosis. It is probably one of the reasons for the sterility.
6. The sterility of the triploids can resolve the problem of precocious sexual maturation.
7. The sterile triploids will not disturb the natural fish resources when they are put in natural water.

8. It is possible that the triploids grows faster because the energy used in the gonad development will probably transfer to the energy used in the muscle development.
9. The sterile triploids will be the ideal object used for transgenic fish because of the sterility.