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## Adaptive radiation in fishes pdf

Lake Tanganyika is the oldest Ancient Lakes in East Africa. This lake contains about 250 species of cichlid fish, which are quite diverse in terms of morphology, behavior and ecology. The diversity of cichlids of Lake Tanganyika has evolved through explosive derivation, and adaptive radiation is considered a textbook example of the rapid differentiation of a single ancestor in a number of different species, characteristics used to take advantage of their environments and resources. It is important to integrate evidence from various research lines to explain the rapid derivation of cichlid species of Lake Tanganyika and the processes and mechanisms underlying its adaptive radiation. Great efforts have been made to solve the mystery of how so many species of ray dew evolved in such a short period of time, it is, and certainly will be taken. In this review, it summarizes morphological studies on the adaptive radiation of the cichlids of Lake Tanganyika and emphasizes its importance in understanding the adaptive radiation process.

### 1. Introduction Cichlid fish (Cichlidae) with about 3000 species distributed from Central and South America to Africa to Madagascar and South India represent the richest species of vertebrates, accounting for about 10% of today's teleost variety [1, 2]. Over the distribution intervals, cichlids have repeatedly shown their capacity to create adaptive radiation, which constitutes an extraordinary variation of niche partitioning ([3]–[3])—body shapes, color patterns and behaviors, and an enormous diversity of trophic and ecological specialties [4–6], which attracts a large number of evolutionary biologists and considers them one of the main models of biology evolutionary evolutionary (e.g.), [7–9], but the largest variety of raw fish is found in the Great Lakes of East Africa [2]. Although most endemic cichlid species are known from East African lakes, the largest lakes tanganyika, Malawi and Victoria contain a particularly rich fauna of cichlid fish with an estimated 250-800 species in each lake [1, 2]. Therefore, by appearing to be associated with the number of species lake size, appear to be in line with the expectation that the diversity of the species increases with habitat heterogeneity and distances and the opportunity for isolation with allopatric diversification [9]. Due to high degrees of endemism (95-99%), these cichlid rays most likely appeared through intralacustrine derivation [1, 7, 10]. With an age estimate of 9-12 Myr [11], Lake Tanganyika is by far the oldest of these lakes, and thus embodies the most diverse collection of species morphologically, behaviorally, ecologically and genetically [1, 2, 12-15], although the number of species is smallest. Currently 200 current species [10] are known for several more pending scientific explanations, the total number of cichlid species of Lake Tanganyika Estimated at 250 [1]. These 200 species were divided into 12 [16] tribes, largely supported by molecular data, or alternatively 16 [17] tribes [10]. The specific, varied morphology of these fish seems to be the result of adaptations in their niche [18], and thus, these fish are considered an ideal model system for adaptive radiation studies [4, 8, 9]. Schluter [19] identified adaptive radiation as a differentiation of a single ancestor to a sequence of species that lived in various environments and differed in the characteristics used to exploit these environments, and used four characteristics as criteria for detecting adaptive radiation: (1) common ancestors, (2) pheipic-environment (empirical evidence of correlation between different pheiments of species of their lineage and their different environments), (3) feature program (experimental or theoretical tests of performance or conformity of a trait in the relevant environment) and (4) rapid derivation. The first and fourth criteria are the subject of phylogenetic analyses of the type assembly. The second and third criteria are to find adaptive pheives that differ between species as a result of different natural selection. These adaptive pheasives may have caused reproductive isolation between species as by-products (for example, [20, 21]) or allowed two or more closely related species to form together in the same place and at the same time (source division, for example, [22, 23]). In Lake Tanganyika, cichlid species, herd species and species groups differ in many morphological features. Numerous morphological studies have been published on Lake Cichlid in Tanganyika in the past. In this brief review, we summarize the findings from these studies and highlight its importance for understanding the adaptive radiation process.2. A Quick Look at Large-Scale Phylogenetic Patterns and Species Age-Tanganyika Cichlids Lake's first molecular phylogeny was published by Nishida in 1991 [32]. This allozyme-based phylogeny untied the relationships of 20 species representing all Tanganyika cichlid tribes and claimed that Lake Tanganyika Cichlids was polyfyletic. Later, many molecular phylogenetic studies, so much so that lakes malawi and Victoria have published highly precise knowledge of phylogenetic relationships within the herd of lake Tanganyika cichlid species and phylogenetic relationships in African lacustrine and riverine cichlid faunas (Figure 1) (reviewed by Figure 1), as opposed to the case of very young cichlid species. Besides Tylochromis polylepis and Oreochromis tanganyicae, Lake Tanganyika cichlids evolved from a common ancestor after the formation of lake 9-12 Ma [24, 27, 33]. These fish are thought to be spreading rapidly within the lake, which meets the first and fourth criteria of adaptive radiation offered by Schluter [19] (widespread and rapid derivation). Tylochromis polylepis and O. tanganyicae recently colonized the lake, dividing it into an already mature adaptive radiation [25, 31]. Other than these species, the herd of Tanganyika cichlid species consists of at least six main lineages [27]. Two of these genealogies are morphologically diverse species [34]. The substrate-incubation tribe consists of about 80 species endemic to the lake, as well as eight species that colonized the Congo River [35] and a species [36] that colonized the Malagarazi River after its intralacustrine radiation [37, 38]. Mouth-incubation c-lineage (sensu [24]) contains about 100 endemic species assigned to six [16] or ten [17] tribes (species numbers, phylogenetic relationships and biological characteristics of tribes are reviewed in [10]). While the monophyly of each tribe is well supported, phylogenetic relations between tribes are still largely unresolved, showing rapid diversification and adaptation of certain ecological niche at the onset of Lake Tanganyika radiation. Tropheni, one of the endemic mouth incubation tribes, has been shown to nest in haplochromines, but also originated in the remaining Great Lakes of East Africa and the most species rich lineage but primary Tanganyika radiation course[ 29, 30], which includes sediments of species the majority of the northern, eastern and south African riverine cichlid species. Lamprologini and simultaneous radiation from C-lineage were probably triggered by the onset of deepwater conditions in Lake Tanganyika about 6-6 Ma (radiation of the primary lacor) [27, 30, 38]. Alternative hypotheses [39, 40] suggest two to five times older age for Lake Tanganyika radiation, which will be significantly before the establishment of a real lacustrine habitat [11, 41, 42], and imply that the onset of radiation occurs in a river environment, a habitat is generally considered suitable for harboring a radiation [43]. The biological properties of the wee species of Lake Tananyika strongly advocate that there is Lake Tanganyika radiation, which occurred in a single deepwater lake, with a clear source division between most tribes and the relative age of East African cichlid species [10, 30]. Lake Tanganyika cichlids is usually well solved unlike the molecular phylogenies of lakes Malawi and Victoria, most species, breeds, and tribes are dissolved monophily, stating that this lineage is largely complete. Therefore, although the placement of some taxonomas is inconsistent with taxonomy, it is assumed that these molecular phylogens (usually based on mitochondrial genes) bring closely closer to real species trees [44-46]. The latest evidence from complementary analyses of nuclear DNA suggests that although well solved, mitochondrial phylogens it reflects real phylogenetic relationships but can be seriously misleading due to ancient incomplete lineage ranking, ancient (and recent) introverity and even hybrid derivation [26, 38, 47-53]. However, mitochondrial phylogenies have been used as proxies of species trees in comparative approaches to study the interaction and evolution of biological properties in a phylogenetic context (for example, [54–57]), thus revealing an error in potentially extracted evolutionary patterns.3. Adaptive Morphology The evolutionary success of the species is linked to the interaction of external environmental factors and specific characteristics of species. Some of these intrinsic features can be selected naturally (for example, trophic morphology, body size, body shape and visual pigments), others are predominantly sexually selected (e.g., body color, smell and courting sounds), the distinctions between natural and sexually selected traits may not be so obvious ([58]). Many authors have studied the morphological properties of Lake Tanganyika cichlids in terms of adaptation. These studies are divided into four main groups: trophic morphology, body shape, body size and nervous system studies.3.1. Trophic Morphology Cichlid fish exhibit a functionally separated jaw set, mouth jaws and faringeal jaws (Figure 2). It is considered an important innovation that represents an important factor for the emergence of a unique variety, especially among faringeal jaw vertebrates [59-61]. The faringeal jaw apparatus of cichlid fish is functionally integrated and highly specialized and is considered to represent a large adaptive complex [59]. Faringeal jaws separated from the mouth jaws are used for effective crushing and processing of foodst way. Thus, mouth jaws get rid of their double task of collecting and preparing food. Thanks to the division of these functions, it is possible to develop numerous specializations of food collection and procession mechanisms, and small changes in oral and phingeal jaw structure allow new food sources to be used in several generations, so that unused ecological niche can be quickly occupied [62, 63]. Thus, it seems that calid fish are particularly important for the tendency to adapt new ecological niche with special faringeal jaw buzz, but other trophic morphological properties have probably also played important roles for rapid diversification. Most likely, rapid differentiation in trophic specialties results in effective resource division, thereby driving the evolution of complex cichlid communities through ecological separation (e.g. [64, 65]). (a) (b) (a) (b) In several studies on Lake Tanganyika cichlids, it has been defined that trophic morphology is related to food habits (mouth jaws and teeth [65-69], pharyne] jaws [59, 69, 70], preorbital region [15, 71], and bowel [72, 73]). Lake Tanganyika cichlids are an important diversification force. In the types of algae feeding, for example, the shape of the jaw teeth differs according to the sources they use. Thus, species of the genus Petrochromis have high density tricuspid teeth, and these teeth have a similar structure for scanning single-celled algae from algae, whereas Tropheus and some other species of breeds have large bikupid teeth in the front row, which allows nip and tearing of threaded algae from rocks [66]. It has been shown that in cichlid fish with tooth shape in both oral and faringeal jaws, a single individual responds quickly to selection and change even during his lifetime [74, 75]. Recently, significant progress has been made regarding the developmental pathways and genetic basis that lead to different tooth shapes and numbers [76-78]. Further studies on this subject will certainly be important to fully understand how intraspecific differences between tooth shape and numbers sometimes arise as a rapid response to environmental/trophic constraints in species-rich adaptive radiations, where species often take up a fairly narrow ecological niche. Besides the number and shape of teeth, faringeal jaw and oral jaw shape (or preorbital region in general) are known to be well associated with strong diet, and natural selection has been shown to respond quickly when new habitats colonize or come to optimize nutritional performance throughout the ontogen. Fish fish have therefore been shown to have longer mouth jaws than insectical and herbivorous fish [15], in the same way that thin and elongational faringeal jaws were found to be highly associated with piscivory [79, 80]. However, recent evidence on lake Tanganyika cichlid Lepidiolamprologus elongatus suggests that the mature piscivorous morphotype is refined by relative expansion of the lower faringeal jaw caudal part, interpreted as a prerequisite for the installation of well-developed muscles and the construction of a powerful arm system that allows the processing of large game fish and reliance on special piscivory [70]. Intestinal length usually varies in the order of herbivores &lt; &lt; invertivores &lt; piscivores, and therefore the diet has been shown to be a good determinant of both Lake Tanganyika cichlid fish and intestinal length, a more important mechanism for driving the trophic shift in adaptive radiations that show gut length plasticity in response to diet [73]. Correlations between trophic morphology and diet quality were recognized even when calculated as filogen and intestinal length [73] in the form of oral jaw teeth[ 73]. Different natural selection on trophic morphologies leading to rapid morphological change has not been of great importance for the emergence of Lake Tanganyika's astonishing diversity of cichlids, the choice seemingly prevents stability further changes in structures related to trophic specialties if the species has already adapted well to a particular niche within a multi-species community [82]. On the other hand, the choice of balancing on trophic properties may have taken action to maintain intra-population polymorphism in Lake Cichlids, Tanganyika [83, 84]. For example, the scale-eating Perissodus microlepis has morphological dimorphism to the right and left in the direction of mouth opening [85]. This oral deviation has been shown hereditarily [86, 87], although environmental factors can affect the formation of this mouth laterality through development [88]. Various population models have shown that this lateral dimorphism is protected by a negative frequency-related selection caused by interactions between predatory and predatory species (e.g. [89, 90]). An empirical study found that dysasotative medism between right-mouthed individuals and left-mouthed individuals stabilizes this intra-population dimorphism more strongly than only negative frequency-related selection moves [91]. Significant progress has been made in understanding the genetic basis of differences in jaw morphology of cichlids in recent years [92-94]. However, studies on genetic determination of jaw morphologies, genetic basis of other diet-related traits (for example, faringeal bone and intestine) and the fullness of foodstuffs in the nutrition, processing and digestion of certain tythnic morphologies are necessary to learn more about the mechanisms underlying the rapid generation of numerous trophic types as adaptation to certain sources in Lake Tanganyika cichlids. Trophic specialization of faringeal jaws can also lead to reproductive isolation among species through the choice of pairs. Cichlid fish produce sound during the male courting show [95, 96], and this sound appears to be produced by stridulation of faringeal jaws [97]. The sounds of courting have been shown to be different between the closely related species of Lake Malawi cichlids [96, 98]. Therefore, if females use male courting sound as a tip for mate selection, special differences in sound can probably lead to various mating and therefore reproductive isolation [95, 97]. Lake Tanganyika cichlids are highly diverse in faringeal jaw morphology, and thus, the choice of mate in currency sounds may represent an additional mode of diversification or prevent heterospecific pairings between already closely related species, a hypothesis that calls for more detailed research.3.2. Body Shape In Lake cichlids caused bytan, the effect of phyloges on the evolution of body shape is small, and body shape evolution is seen to be strongly influenced by eating habits [18]. Piscivorous fish, for example, usually tend to have a much larger head and a thin body of twisted fish [18]. Therefore, body shape trophic morphology is not imless [99]. Body shapes It is often associated with swimming modes in fish (for example, [100–102]), suggesting that different body shapes of Lake Tanganyika are also associated with other ecological factors, such as the effectiveness of escaping predators. In some types of medis incubation of the mouth, the size and shape of the head differ between the sexes. This sexual dimorphism in head size and shape appears to be associated with a larger bukcal cavity in women [103, 104], suggesting that the evolution of body shape is partly associated with reproductive ecology. In the tropheus moorii species complex, differences were observed in the orientation of the oral and head profile, although there were no obvious differences in nutritional preferences, mating and reproductive behaviors [104, 105], which shows that the observed body shape difference may have been caused by random genetic drift. Genetic drift can develop phenalypies without adaptation and perhaps lead populations through adaptive valleys to the domain of new adaptive peaks (drifting overturns, [19]). Nevertheless, lake Tanganyika cichlid species have to establish themselves within a dense community of many species. As a result, intraspecific morphological variation is typically quite low in the natural environment due to specific competition and narrow ecological niche, limiting the morphosuzza occupied by a single species. If environmental conditions change, the pheasopy can quickly adapt to the new environment. This phenomenon was recently demonstrated by comparing the morphologies of individuals in the four wild populations of the Tropheus moorii species with F1 offspring raised to the pond [106]. The extent of the morphological change between wild and pool-bred F1 fish was 2.4 times larger than bidirectional population differences, and all four populations showed the same overall trend in morphological change. Lake Tanganyika cichlids, the variety of body shapes can at least be partially associated with fish adaptive radiation through weld partitioning, various myelics, low hybrid fitness, and/or other mechanisms. However, nothing is known about the genetic basis of body shapes and also lacks detailed studies on the efficiency of certain body shapes in nutrition and swimming, thus opening up a large area of research for the future.3.3. Body SizeThe size of the file is one of the simplest characters that varies between species. The evolution of body size is due to the balance between the choice that prefers large body size and the choice that prefers small body size (e.g. [107, 108]). While the choice of fecundity for women and sexual selection for men are widely considered to be greater evolutionary forces in favor of greater body size in most sexual animals, the balancing of choice in favor of small body size is often masked by the good state of large individuals and is therefore less pronounced [108]. Cichlid fish in Lake Tanganyika, body size The standard length ranges from 42 to 650 mm (the smallest species are shell-brooder Neolamprologus multifasciatus, and the largest species of substrate brooder Boulengerochromis microlepis [34]). In telmatochromis temporalis, the effect of environmental constraints on body size was examined. It consists of such dwarf and normal morphs, and these two morphines have been shown to evolve through different natural selection, where dwarf morphine is the result of the adaptation of small body size to using empty gastropod shells as shelters [109, 110]. Another shell-brooder that benefits from body size feature, Lamprologus callipterus, has been studied which shows the most extreme male biased sexual height dimorphism among animals (males &gt; heavier than females 12 times [111]). Males of this species collect empty gastropod shells to form their nests. This behavior is unique among Lake Cichlids in Tanganyika. Experimental and theoretical tests revealed that the large male size of this species was limited to the ability to carry empty shells [112] and intersexual selection [113], and experimental tests found that the size of the female was limited by the ability to lay eggs inside the shells [112]. Size-various miyeting animals have been reported in a wide range (e.g., planarians [114], snails [115], gammarus [116], insects [117-119], fish [120, 121], frogs [122], [123], lizards [124], mammals [125], and birds [126]) and species or morphs can cause reproductive insulation [127-129]. Lake Tanganyika cichlid fish may have contributed at least part of this species' explosive radiation through various mions of different natural selection on body size, and more, various other mechanisms such as low hybrid fitness and weld partitioning. Further study of internal and external factors affecting body size may give deep understandings of the mechanisms underlying adaptive radiation of these fish.3.4. Nervous System Some studies have explained the correlations between the nervous system and ecology. Huber and his colleagues [130] and Pollen and colleagues [131] have shown that the relative development of various brain structures is related to habitat, social behavior, resources and the environment. Thus, for example, telensefalone seems to take part in various tasks such as taking part in various tasks such as processing visual and sweetening stimuli, and learning, agonistic and courtship behaviors [130], larger and hypothalamus, seem to have nutritional integrative functions, aggression, reproduction, and vision [130], monogamous species were smaller than monogamous species. We recommend that these studies may act independently in different brain regions of selection or drift. Gonzalez-Voyer and colleagues [57] showed that this female brain size was associated with the type of incubation care and diet and male brain size just suggesting that with the type of diet, the larger burden on more complex dietary choice and incubation care can demand greater brain size. Sylvester and his colleagues [132] showed that an alternative SNP of IRX1B caused differences in the relational size of the telencephalon against talamus between potential rock-dwelling and sand-dwelling Lake Malawi cichlids. Although it is not at all clear how the increase in brain size will lead to functional differences (for example, increased cognitive abilities)[133], brain morphology may have played an important role in the adaptive radiation of Lake Tanganyika.3.5. Other Morphologies We have reviewed the morphological properties that can include adaptive radiation in a trophic

morphology, body shape, body size and nervous system, causal Lake Tanganyika cichlids. However, other morphological properties of these fish are also extremely diverse. The diversity of these other properties can be the result of adaptation to various environments, genetic drift, or phenotypic plasticity during development. Unfortunately, almost nothing is known about its function and the genetic basis of these traits. For example, infraorbitals (a series of bones surrounding the lower half of the eye) have been shown to vary significantly in shape between Lake Tanganyika cichlids (Figure 3) [134]. However, while it is still unknown what causes the intermediate specific differences observed in this morphological structure, it is suggested that infraorbitals have the function of regulating the movement of jaws compared to other bones, and that the number and size of sensory pores in these bones may be associated with noise sensitivity [135]. (a) (b) (a) (b) Some morphological characters differ at various taxonomic levels and reflect the difference between the time of morphological dedring. For example, the shape of infraorbitals tends to differ between tribes, suggesting that its morphology differs during initial radiation. Body shape and shape of mouth jaw teeth, on the other hand, tend to differ at lower taxonomic levels, such as between breeds and species, the differentiation of these morphologies suggests reflecting later evolutionary events.4. Ontogenetic Changes in Morphology: A largely neglected topic on adaptation and natural selection at Lake Cichlids, Tanganika, often focuses on traits in adult organisms, but high mortality among young people, in addition to predation pressure, strong electoral pressure, competitive avoidance and resource division are probably important early in life (e.g. Therefore, individuals have to compete not only for resources against heterospecific individuals, but also against conspecific individuals. For species that make up a number of size-classes (many invertebrates, fish, amphibians and reptiles) based on body size differences, often the smallest size classes of a species pose a complex problem, with the largest [137]. Because resource utilization capabilities and the risk of predation are often associated with body size, many types undergo sometimes dramatic and dramatic changes in habitat use and/or food selection [138]. Therefore, among fish, ontogenetic changes in resource use are almost universal, and changes in food selection depending on size are documented in numerous species, typically with positive correlations between food size and body size (e.g. [139-145]). These ontogenetic changes in resource use can greatly complicate species interactions that will have significant consequences for community dynamics, especially in multi-community communities [138]. If small and large species coexist, the most important feature of this interaction is not how adults interact, but how larger species can hire in younger phases similar to the size ranges found in smaller species. Such interactions can create bottlenecks in recruitment to species [146], and therefore adaptive fine-tuning is especially important in children's stages, especially during periods when where/resources are limited in regions/periods. The Ontogenetic niche helps maximize fitness by reducing competition with conspecifics through resource separation [138], minimizing the risk of predation through habitat changes [147], and maximizing growth through dietary shifts [148]. These ontogenetic changes in resource use can be quite sudden and are often associated with periods of discerning growth in life history (e.g. [149, 150]). For many fish, the transition to piscivory is a very important ontogenetic niche exchange [151]. Typically, highly specialized piscivores are not particularly good zooplankton and benthic invertebrates, which prey on prey in early life [138, 151] and delayed shifts for piscivory are not in the diet, which can cause slow growth and increased mortality, especially competition for resources with specialized planktivorous species [138, 151, 152]. The transition to piscivory usually starts an increase in the rate of growth, translating into greater body size and greater survival-large individuals are often less vulnerable to predation and adapted to survive better periods of hunger-specific piscivores throughout life [151, 152]. Transition dates can vary significantly between types (for example, [151]). For example, species-specific differences in the allometry of trophic structures, incubation time and size during incubation were proposed to at least partially explain these intermediate differences in the timing of the transition to piscivory [151, 153]. Although there are a significant amount of studies on dietary changes related to ontogenetic changes of overall body shape in fish (e.g., [139-141, 144, 145]), studies directly related to genetic changes in diet and genetic changes in the growth habits of the thrifric device are few (e.g., [142]). Whereas lower isometric growth jaw Lake Tanganyika cichlid *Lamprologus ornatipinnis* has been reported [69], A species that feeds mainly on invertebrates and therefore does not experience a drastic change in eating habits during ontojen, Hellig and his colleagues [70],[70] has shown that an allometric change in ontogenetic lower faringeal jaw development of *Lepidolamprologus elongatus*, the top predator in the shallow rocky habitat of Lake Tanganyika, coincides with a nutritional shift to the special piscivory (Figure 4). This observation may show that different allometry is associated with strong expertise, but it should be tested whether this is a general phenomenon in trophic specialists, the extent to which the genetic basis for such morphological changes is, and the extent to which differential gene expression producing morphology differences contributes to the acetic diversity of cichlides in Lake Tanganyika. 5. The results, along with Darwin's finches from the Galapagos Islands (e.g., [158]) and Hawaiian silver swords (e.g., [159]), represent well-established model systems for the study of adaptive radiation. Numerous morphological studies at Lake Cichlid, Tanganika, have greatly contributed to ever-increasing knowledge of evolutionary pathways and mechanisms that have created enormous diversity over a short period of time. Rapid changes, especially in morphological properties, ensure that cichlid fish quickly adapt to new resources. Thus, such adaptive pheasives would have played important roles during adaptive radiation. Lake Tanganyika cichlids are extremely diverse in their morphology, and many morphological properties seem to be related to adaptive radiation. However, information about adaptive pheasives is still poor. Obviously, further study is necessary to uncover these fish adaptive radiation mechanisms, but recent methodological advances seem promising to answer a wide range of evolutionary questions, especially in the field of geometric morphometrics, and even allow (adaptive) shape changes (review [160]) to address questions at the population level. In this review, we examined only morphological studies. However, the integration of evidence obtained only from various research areas will significantly advance our understanding of the evolutionary mechanisms underlying the adaptive radiation (s) of the cichlid fish (Lake Tanganyika). For example, in some Lake Malawi and Victoria cichlids (for example, [161-163]) destructive sexual selection of male coloring has been shown to lead to speculation, and scent cues are important for the choice of pairs in some Lake Malawi cichlids [164]. Therefore, the choice of women for male nikes color and odor signals (and still play) may have played important roles in at least part of the explosive radiation of the Lake Tanganyika cichlid species [58]. Indeed, more than 10% of Lake Tanganika's cichlid species (e.g. *Benthochromini* and some species of *Ectodini*, *Tropheini* and *Bathybatini*) exhibit obvious sexual disfigurement [34]. However, there is currently no clear evidence for sexual selection based on body coloring, which is of great importance for driving rapid diversification in Lake Tanganyika's swarm of cichlid species. However, body coloring can serve as a tip for species/mate recognition and prevent inter-specific or intermorph gene flow in the case of secondary contact, due to human-induced or lake-level fluctuations, *tropheus moorii* [165-167] may have been sampled with evidence for various mating of color between original allopatrically distributed color morphs. Thus, allopatrically developed mate selection tips serve as prezigothic isolation mechanisms that prevent hybridization cichlid types/morphs in case of secondary contact. Recent paleolimnological and geological studies have shed light on the dynamics of past water level fluctuations that acted as species pumps with recurrent fragmentations and secondary admics of populations in the Great Lakes of East Africa [169-171]. Ecological studies provide insights into the degree of intra-and intermediate-specific interactions (for example, [172-179]), and recent advances in sequenchning techniques allow for the production of large amounts of array data at relatively low costs, and taksona provides exciting new possibilities for investigating phylogenetic relationships between population genetic structure and the genetic basis and regulation of certain characteristics. At the moment, we are still a long way from fully understanding what drives and still drives the herds of east African cichlid species, but recent advances in various research areas carry a promising future for researchers. NoticesThis study was supported in part by T. Takahashi and the Global COE Program (A06) Kyoto University.Copyright © 2011 Tetsumi Takahashi and Stephan Koblmüller by Hibe-in-Aid for Young Scientists (no. 20770065). This is an open access article distributed under the Creative Commons Attribution License, which allows unlimited use, distribution and reproduction in any environment, provided that the original work is properly specified. Attribution.

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