Chapter 3

Relationship Between Community Structure and Species Succession

The function of an ecosystem is to keep organisms in harmony with their environment. In an ecosystem, the biological community occupies the ecological niche under a unified system of energy distribution. External energy (such as solar energy) and the internal energy of the earth drive the continuous circulation of the earth's material in the ecosystem, which includes the materials cycle in the environment, nutrient transfer among organisms, and material exchange between organisms and the environment. This cycle also includes conversions among material forms, such as the synthesis and decomposition of living matter. The materials cycle in the ecosystem is closely related to the composition of the biological community, and species composition and abundance in the biological community are in a stable and balanced equilibrium in an environment without mutation. Because the resources of the environment space are limited, only a certain number of organisms can be carried in the system. When the carrying biomass is close to saturation, if the number (density) of one species increases, the growth of other species in the system will be affected, causing a change in community structure until a new balance is achieved. Biological communities are composed of numerous species, which inevitably leads to competition, predation, abiotic stress, and mutually beneficial relationships among species (Bruno *et al.*, 2003). All of the species in a given biome are interdependent on other species. There are several common relationships.

One common relationship is the food chain. The survival of the predator depends on the prey, and the survival and abundance of the prey are controlled by the predator. These opposing forces remain relatively stable. The proportion of two species inhabiting the same space also remains relatively stable.

A second common relationship is a competition. Species often compete for the same resources. For example, plants compete for light, space, water, and soil nutrients, while animals compete for food and habitat. Over evolutionary time, competition has promoted the ecological differentiation of species. As a result, when competition relaxes, the community structures of species are stable. For example, fish are both sedentary and migratory in rivers; some fish species thrive in the upper water layers and some prefer to inhabit the lower layers; and fish can be herbivorous

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or predatory. Different types of organisms in the system are closely related, but each has its place.

A third common relationship is a mutualism. Species may be interdependent in a variety of ways, including the symbiotic relationship between bacteria and algae in lichens, as well as between microbes and their hosts in the gastrointestinal tract of animals. The disruption of this balance may lead to the reorganization of community structure, the permanent loss of a biological resource, or a change in ecosystem function. A mutually beneficial relationship is not just an attribute between two partners. Macroscopically, species relationships in stable communities are in a mutually beneficial state. There is a lack of studies on the interspecific relationships of a wide range of communities (Bronstein, 1994). Competition and predation are not the only functional forms among community species. All organisms have competitive and mutually beneficial relationships, and the balance between competition and mutual benefit is typically the main characteristic of an ecosystem. In both aquatic and terrestrial ecosystems, mutually beneficial relationships among species have been well studied. Mutually beneficial relationships are universal in biological communities and may involve specific taxa, combinations of taxa, or the relationship between the part and the whole systems (Bruno *et al.*, 2003).

In addition to the diversity index and the species abundance ranking method, indices of species composition, the average distance among species, and weight have also been used for community evaluation (Rochet and Trenkel, 2003). The stability of a community includes the balanced relationships of the spatial niche, in which the "niche" reflects the "quantity" of relationships a species possesses, and "quantity" relates to the amount of space occupied. The relationships among organisms may also be quantified in terms of energy allocation and material transport in the food chain, where biomass, or niche values, may be an important indicator of community stability.

The stability of an ecosystem is related to the composition of environmental resources and species. From the perspective of species composition, earlier studies suggested that simple ecosystems are less stable than complex ones, but later studies have come to the opposite conclusion (Pimm, 1984; Connell, 1978; Mcnaughton, 1978). The weak correlation between species diversity and functional diversity in communities is also reflected in river ecosystems. Rivers that are rich in species diversity may not have high functional diversity; overlapping relationships among species niches in communities, multiple complementarities in the construction of species niches, and community complexity may also increase the ecological buffer and guarantee the capacity of community functions, which may be a mechanism that safeguards the ecological functions of communities. Communities have a basic species composition, which is very important for the establishment of a fish community framework in an aquatic ecosystem.

In ecosystems, the degree of diversity is influenced by diffusion patterns and potential biological interactions. Biological community characteristics are characterized by higher taxa because higher taxa have greater biomass abundance than other taxa. In a given system, changes in diversity are determined by periodic changes in biomass allocation among community species (Enquist B J *et al.*, 2002). Species distributions in a community are characterized by the dominant species and the rare species. That is, most species occupy a small area, while only a few species occupy a large ecological position. Species survival decreases with the increase in geographic range; however, the relationships between range size and rates of speciation or population size increase are not significant (Castiglione *et al.*, 2017). Community structure is affected by regional environmental characteristics, and it is difficult to capture all of the information about the relationships among species in the ecosystem in general models, as these are restricted by a lack of data sources in the research system (Bowman, 1986). In the food chain, community species fall in a series from top to bottom. In studies of communities, it is important to clarify the species that are first to be impacted by environmental stress, as well as the environmental stress process and its effects on the community at large. In order to investigate these ecological questions, it is important to carefully choose the research object, and it is worth exploring whether the answer can be found by clarifying the niche relationships among community species.

Information on the niches of community species can be obtained from fossil specimen data (Elith *et al.*, 2006), which may include information about specific species in space and time based on specimen characteristics (Nic *et al.*, 2018). Fossils can also provide information about specific historical periods, and researchers can use fossils to study the relationship between the biome and the environment on a geological scale (Stigall, 2012). Niche data and regional species distributions reveal the interactions among species and with the environment. In addition, character changes reflect the differentiation and adaptability of species within the environment; this helps to clarify the spatial processes of ecology and the evolution of biological communities, as well as species range distributions in different periods. The impact of environmental processes on species distributions can also be inferred from fossil numbers (Walls and Stigall, 2011). Similarly, species data in the literature can be used to study succession in biological communities, restore the structural characteristics of biological communities at different times, and study community construction beyond the regional scope. Species data improve our understanding of community evolution and may help in ecosystem reconstruction (Gravel *et al.*, 2006). During ecosystem reconstruction, it is necessary to consider the fact that diverse species cannot occupy a large niche, and that widespread species have a "wide" niche, whereas individual species have a "narrow" niche; the niche width of individual large species is also "wide." Under environmental stress, the miniaturization of some species indicates that the spatial niche of the species also becomes smaller. Species composition in the community will change accordingly, and ecosystem functions will be rearranged. Predictive tools and methods are needed to characterize the relationships among community species.

This chapter presents the relationships among community species from the perspective of species succession. We selected 104 species found in China, representing 61 genera, for the establishment of a simulated community, and the model was used to study the loss of one species and changes in interspecific relationships. Modeling studies also highlighted the fish in the Pearl River system, as far as possible, to choose the morphological taxonomic species of the "genus." Specialized species were also included in the model analysis, such as *Schizothorax meridionalis* (Tsao, 1964) and *Sinocyclocheilus* spp. (Fang, 1936). These species, along with other special species, are closer to the real-world river fish community. Through this study, we can understand the relationship between “missing” species and other species. In addition, we can deduce changes in community species relationships and the mechanisms of niche succession. Using the 104 fish species described in the previous section, a species-by-species disappearance simulation was conducted to analyze the response of some fish species in the community to the disappearance of other species. The principle is that if the simulated species disappears and the niche occupation of a given fish decreases, these species are “mutually beneficial.” If the simulated species disappears and the niche occupation of a given fish species remains unchanged, these species are “non-competitive.” If the simulated species disappears and the niche occupancy of a certain fish increases, the disappeared species is judged as “competitive” with the species with the corresponding niche increase.

Cypriniforms are the main freshwater fish in China. Of the 89 species selected, 84 were species in Cyprinidae. We also included six species of the Perciformes, representing six families; seven species of the Siluriformes in the same family; and one species each from the Osmeriformes and Tetraodntiformes. In general, the simulation analysis showed that fish that were closely related taxonomically had different responses to the loss of the same fish and did not exhibit clustering patterns consistent with taxonomic classification. This result might be due to differences in various competitive or mutually beneficial attributes, with the result that the degree of influence on niche change rate was different.

In the analysis of interspecific relationships within simulated communities, irrespective of the specific fish removed, the niche of some fish increased obviously. The initial niche of these fish in the simulated community was small or missing. Thus, niche expansion was obvious. In the simulated community of 104 species of fish, there were two species of fish that were competitive with all other fish: *Cyprinus chilia* (Wu, 1963) and *Onychostoma ovalis rhomboides* (Tang, 1942). These two species of fish have small distributions and populations in the real-world Pearl River system. Irrespective of the specific fish that lost its niche, the niche of some fish decreased. The initial basal niche of these fish in the simulated community was small or missing, and the niche reductions were obvious. In the simulated community of 104 species of fish, only *Procypris merus* (Lin, 1933), which is distributed in the southwest river and has a small population, was mutually beneficial to all other fish. Species with moderate niche change may be more favorable for community stability, suggesting that more consideration should be given to the niches of “stable” species in artificial ecosystem construction. The niche relationships within fish communities may be closely related to the energy allocation in the food chain. By analyzing succession in a simulated community, we can increase our understanding of species relationships and provide a means for the pre-evaluation of species relationships when reconstructing fish communities.

3.1 Simulations of Species Removal

Schoener (1974) stated that the niche of a species in a community is related to the distribution of resources and that to study the niche, the establishment of a complete theoretical system, including models at the individual and group levels, is required. In addition, to analyze species relationships in the community, it is necessary to understand the relationships between dimension and niche, as well as interspecific niche boundaries and niche shapes, the number and abundances of the species in a biome, the number of interactions among species (mainly feeding and competition relationships), and the intensity of these interactions expressed in terms of the proportion of species pairs that interact directly. The interaction force varies with the number of species, and the intensity of the interaction usually decreases significantly as the number of species increases (Rejmanek and Stary, 1979). The changes in an interspecific niche can be understood by simulating the loss of species in the community. There were 104 species of fish in the simulated community, which represented five orders and 12 families.

3.1.1 *Osmeriformes Lcucosoma chinensis (Osbeck, 1765)*

The niche variation of *Lcucosoma chinensis* (Osbeck, 1765) ranged from 0% to 98% in the absence of different species (see figure 3.1). Among the 103 species of fish, 58 species were mutually beneficial to *Lcucosoma chinensis*. There were 34 species that had more than a 10% effect on the niche of *Lcucosoma chinensis*. Of these, in which the largest effect was 98% by *Hypophthalmichthys molitrix*. There were 45 species of fish in competitive relationships with *Lcucosoma chinensis*. There were 30 species that affected the niche of *Lcucosoma chinensis* by more than 10%, with which the biggest effect was 23%. An additional 39 species had less than a 10% effect on the rate of the niche variation of *Lcucosoma chinensis*.

3.1.2 *Cypriniformes*

3.1.2.1 Cobitidae

3.1.2.1.1 Micronemacheilus pulcher (Nichols and Pope, 1927)

The niche variation of *Micronemacheilus pulcher* (Nichols and Pope, 1927) ranged from 0% to 124% in the absence of different species (see figure 3.2). Among the 103 species of fish, 41 species were mutually beneficial to *Micronemacheilus pulcher*. There were 9 species that had more than a 10% effect on the niche of *Micronemacheilus pulcher*. Of these, in which the largest effect was 98% by *hypophthalmichthys molitrix*. There are 62 species of fish in competitive relationships with *Micronemacheilus pulcher*. There were 58 species that affected the niche of *Micronemacheilus pulcher* by more than 10%, and 124% of those fishes. An additional 36 species had less than a 10% effect on the rate of niche variation of *Micronemacheilus pulcher*.

3.1.2.1.2 Sinibotia pulchra (Wu, 1939)

The niche variation of *Sinibotia pulchra* (Wu, 1939) ranged from 0% to 230% in the absence of different species (see figure 3.3). Among the 103 species of fish, 45 species were mutually beneficial to *Sinibotia pulchra*. There were 3 species that had more than a 10% effect on the niche of *Sinibotia pulchra*. Of these, in which

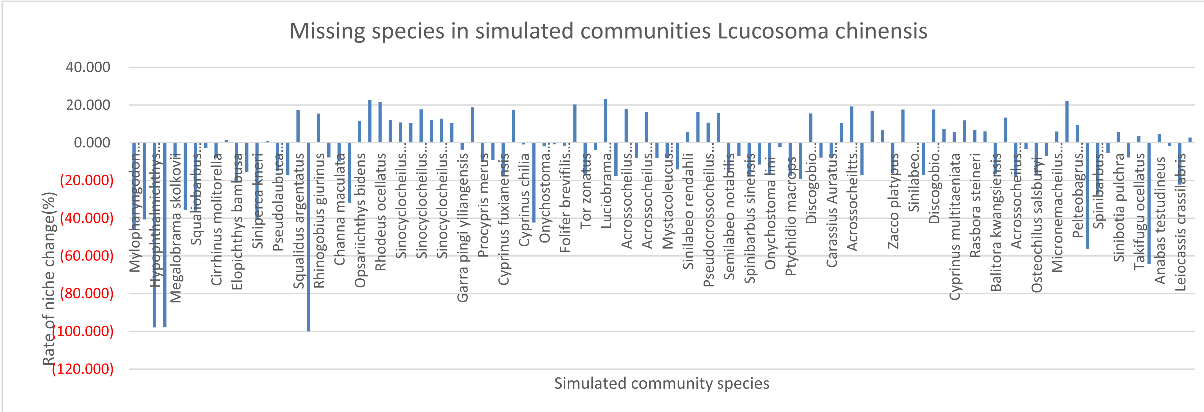

FIG. 3.1 – The responses of the niches of *Lcucosoma chinensis* to various missing fish in the simulated community.

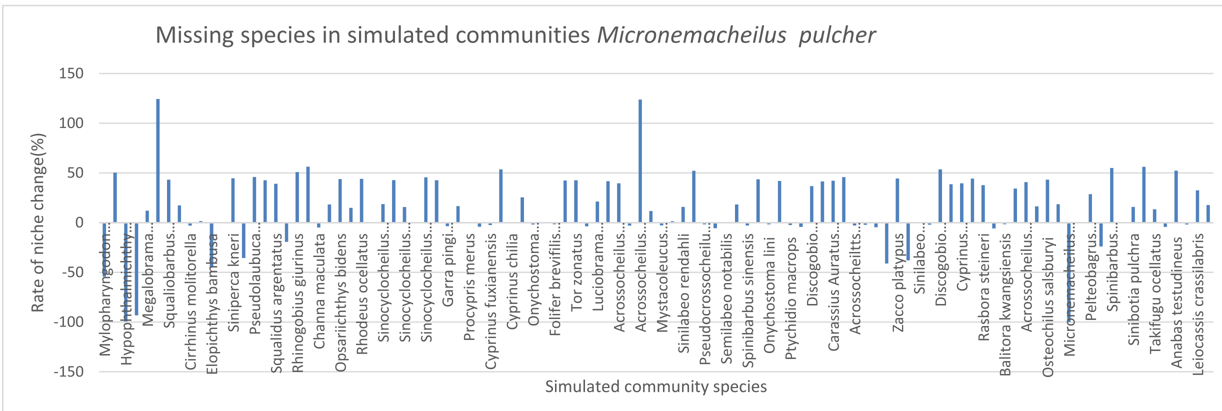

FIG. 3.2 – The responses of the niches of *Micronemacheilus pulcher* to various missing fish in the simulated community.

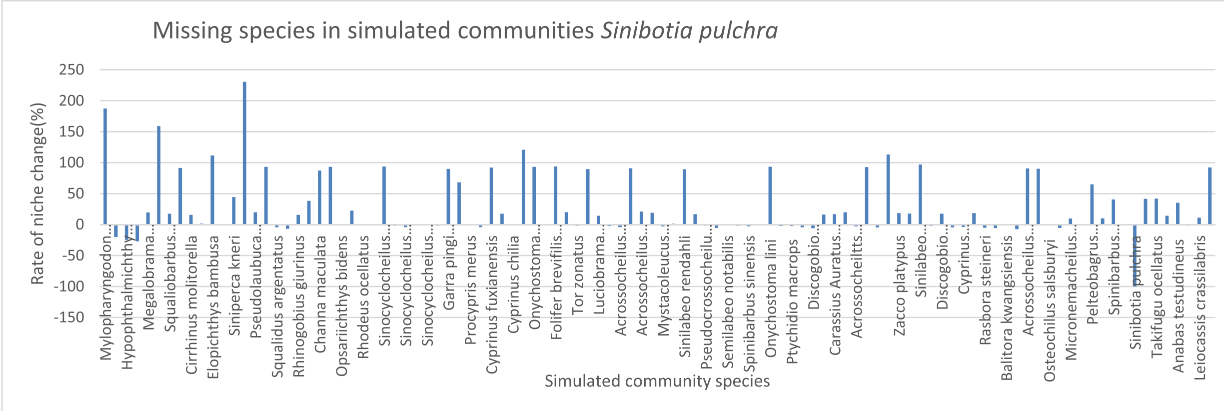

FIG. 3.3 – The responses of the niches of *Sinibotia pulchra* to various missing fish in the simulated community.

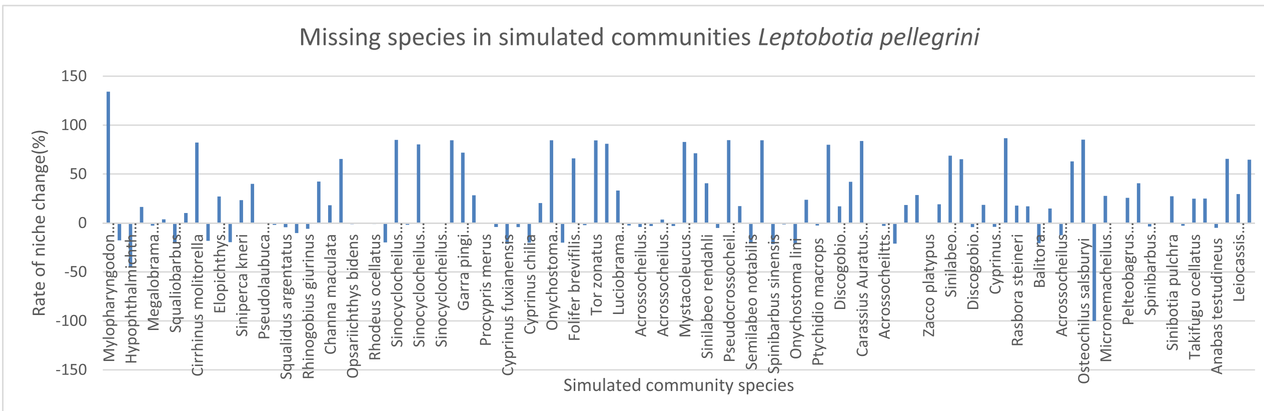

FIG. 3.4 – The responses of the niches of *Leptobotia pellegrini* to various missing fish in the simulated community.

the largest effect was 27% by *Hypophthalmichthys nobilis*. There were 58 species of fish in competitive relationships with *Sinibotia pulchra*. There were 54 species that affected the niche of *Sinibotia pulchra* by more than 10%, in which the biggest effect was 230% by *Misgurnus anguillicaudatus*. An additional 46 species had less than a 10% effect on the rate of the niche variation of *Sinibotia pulchra*.

3.1.2.1.3 Leptobotia pellegrini (Fang, 1963)

The niche variation of *Leptobotia pellegrini* (Fang, 1963) ranged from 0% to 134% in the absence of different species (see figure 3.4). Among the 103 species of fish, 46 species were mutually beneficial to *Leptobotia pellegrini*. There were 16 species that had more than a 10% effect on the niche of *Leptobotia pellegrini*. Of these, in which the largest effect was 27% by *Hypophthalmichthys molitrix*. There were 57 species of fish in competitive relationships with *Leptobotia pellegrini*. There were 53 species that affected the niche of *Leptobotia pellegrini* by more than 10%, with which the biggest effect was 134% by *Hypophthalmichthys molitrix*. An additional 34 species had less than a 10% effect on the rate of the niche variation of *Leptobotia pellegrini*.

3.1.2.1.4 Misgurnus anguillicaudatus (Cantor, 1842)

The niche variation of *Misgurnus anguillicaudatus* (Cantor, 1842) ranged from 0% to 63% in the absence of different species (see figure 3.5). Among the 103 species of fish, 58 species were mutually beneficial to the *Misgurnus anguillicaudatus*. There were 34 species that had more than a 10% effect on the niche of *Misgurnus anguillicaudatus*. Of these, in which the largest effect was 63% by *Hypophthalmichthys molitrix*. There were 19 species of fish in a competitive relationship with *Misgurnus anguillicaudatus*. There were 15 species that affected the niche of *Misgurnus anguillicaudatus* by more than 10%, and 51% of those were affected by *Lateolabrax japonicus*. An additional 73 species had less than a 10% effect on the rate of the niche variation of *Misgurnus anguillicaudatus*.

3.1.2.2 Cyprininae

3.1.2.2.1 Opsariichthys bidens (Günther, 1873)

The niche variation of *Opsariichthys bidens* (Günther, 1873) ranged from 0% to 63% in the absence of different species (see figure 3.6). Among the 103 species of fish, 91 species were mutually beneficial to *Opsariichthys bidens*. There were 87 species that had more than a 10% effect on the niche of *Opsariichthys bidens*. Of these, in which the largest effect was 87% by *Hemibagrus macropterus*. There were 12 species of fish in competitive relationships with *Opsariichthys bidens*. There were 2 species that affected the niche of *Opsariichthys bidens* by more than 10%, with which the biggest effect was 23% by *Megalobrama skolkovii*. An additional 39 species had less than a 10% effect on the rate of the niche variation of *Opsariichthys bidens*.

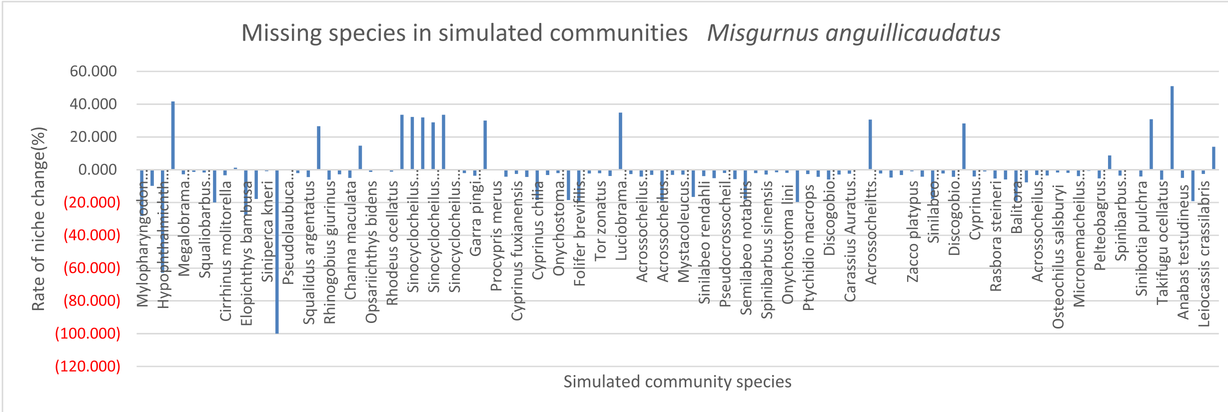

FIG. 3.5 – The responses of the niches of *Misgurnus anguillicaudatus* to various missing fish in the simulated community.

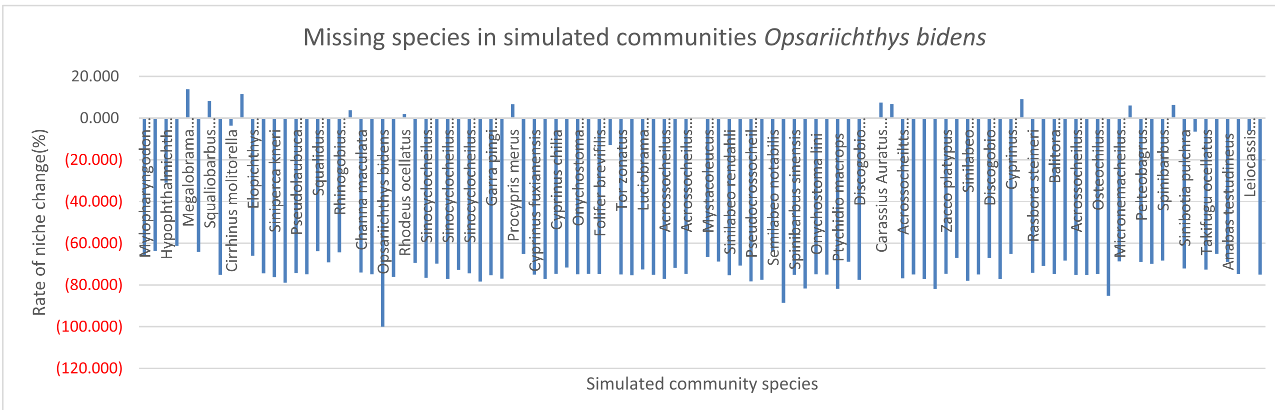

FIG. 3.6 – The responses of the niches of *Opsariichthys bidens* to various missing fish in the simulated community.

3.1.2.2.2 Rasbora steineri (Nichols and Pope, 1927)

The niche variation of *Rasbora steineri* (Nichols and Pope, 1927) ranged from 0% to 51% in the absence of different species (see figure 3.7). Among the 103 species of fish, 95 species were mutually beneficial to *Rasbora steineri*. There were 52 species that had more than a 10% effect on the niche of *Rasbora steineri*. Of these, in which the largest effect was 51% by *Semilabeo notabilis*. There were 8 species of fish in competitive relationships with *Rasbora steineri*. There were 2 species that affected the niche of *Rasbora steineri* by more than 10%, with which the biggest effect was 35% by *Hypophthalmichthys molitrix*. An additional 47 species had less than a 10% effect on the rate of the niche variation of *Rasbora steineri*.

3.1.2.2.3 Zacco platypus (Temminck and Schlegel, 1846)

The niche variation of *Zacco platypus* (Temminck and Schlegel, 1846) ranged from 0% to 116% in the absence of different species (see figure 3.8). Among the 103 species of fish, 47 species were mutually beneficial to *Zacco platypus*. There were 31 species that had more than a 10% effect on the niche of *Zacco platypus*. Of these, in which the largest effect was 81% by *Hypophthalmichthys molitrix*. There were 59 species of fish in competitive relationships with *Zacco platypus*. There were 46 species that affected the niche of *Zacco platypus* by more than 10%, in which the biggest effect was 116% by *Hypophthalmichthys molitrix*. An additional 47 species had less than a 10% effect on the rate of the niche variation of *Zacco platypus*.

3.1.2.2.4 Mylopharyngodon piceus (Richardson, 1846)

The niche variation of *Mylopharyngodon piceus* (Richardson, 1846) ranged from 0% to 629% in the absence of different species (see figure 3.9). Among the 103 species of fish, 91 species were mutually beneficial to *Mylopharyngodon piceus*. There were 3 species that had more than a 10% effect on the niche of *Mylopharyngodon piceus*. Of these, in which the largest effect was 12% by *Garra pingi pingi*. There were 12 species of fish in competitive relationships with *Mylopharyngodon piceus*. There were 3 species that affected the niche of *Mylopharyngodon piceus* by more than 10%, with which the biggest effect was 629% by *Hypophthalmichthys molitrix*. An additional 98 species had less than a 10% effect on the rate of the niche variation of *Mylopharyngodon piceus*.

3.1.2.2.5 Luciobrama macrocephalus (Lacepède, 1803)

The niche variation of *Luciobrama macrocephalus* (Lacepède, 1803) ranged from 12% to 1974% in the absence of different species (see figure 3.10). Among the 103 species of fish, 17 species were mutually beneficial to *Luciobrama macrocephalus*. All species had more than a 10% effect on the niche of *Luciobrama macrocephalus*. Of these, in which the largest effect was 55% by *Acrossocheilus iridescens iridescens*. There were 86 species of fish in competitive relationships with *Luciobrama macrocephalus*. All species affected the niche of *Luciobrama macrocephalus* by more than 10%, with which the biggest effect was 1974% by *Pelteobagrus vachellii*.

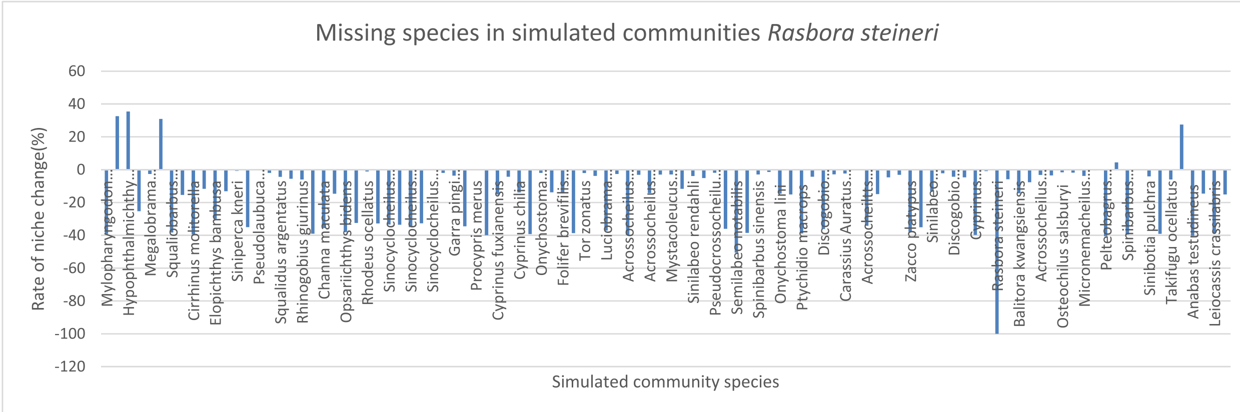

FIG. 3.7 – The responses of the niches of *Rasbora steineri* to various missing fish in the simulated community.

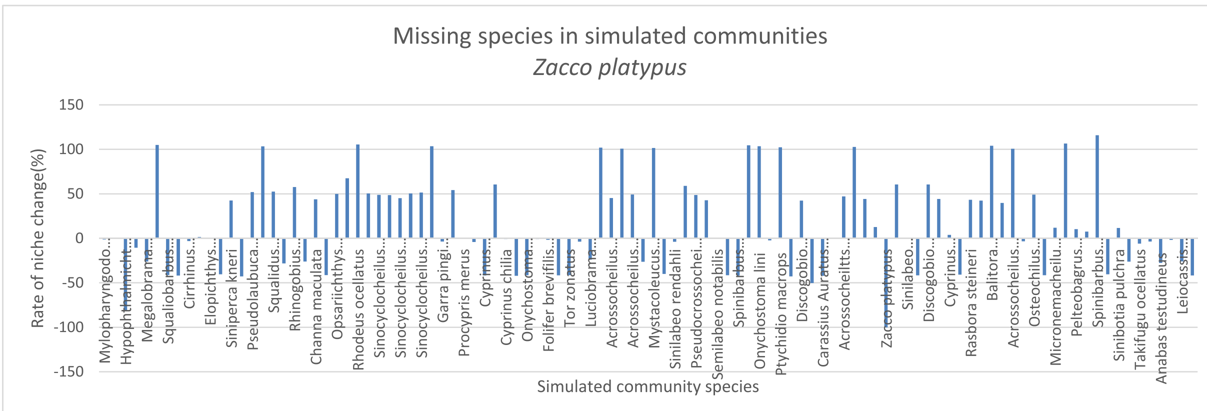

FIG. 3.8 – The responses of the niches of *Zacco platypus* to various missing fish in the simulated community.

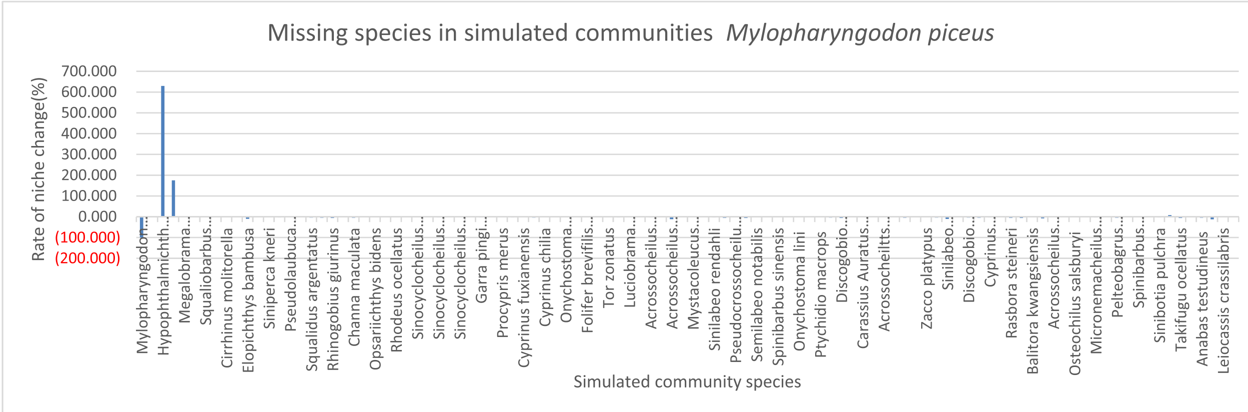

FIG. 3.9 – The responses of the niches of *Mylopharyngodon piceus* to various missing fish in the simulated community.

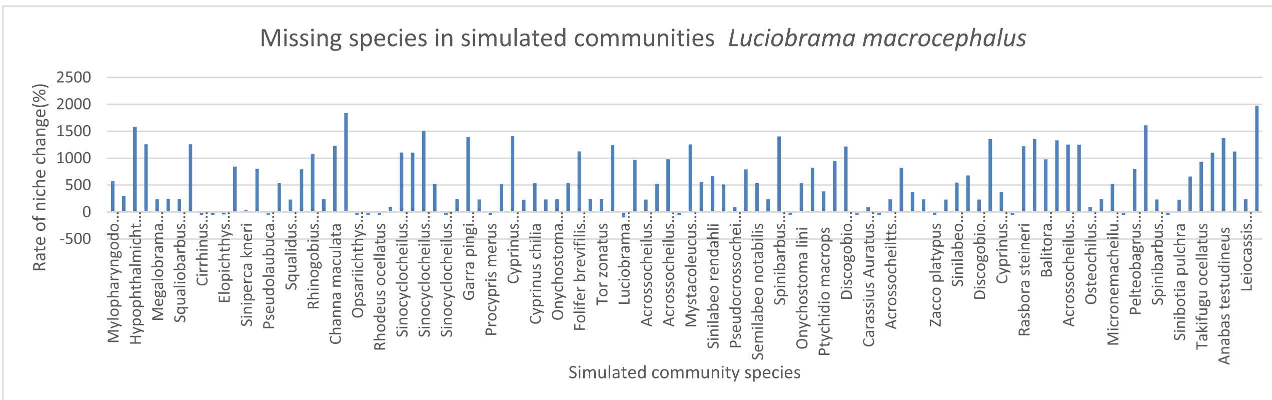

FIG. 3.10 – The responses of the niches of *Luciobrama macrocephalus* to various missing fish in the simulated community.

3.1.2.2.6 Ctenopharyngodon idella (Valenciennes, 1844)

The niche variation of *Ctenopharyngodon idella* (Valenciennes, 1844) ranged from 0% to 230% in the absence of different species (see figure 3.11). Among the 103 species of fish, 45 species were mutually beneficial to *Ctenopharyngodon idella*. There were 3 species that had more than a 10% effect on the niche of *Ctenopharyngodon idella*. Of these, in which the largest effect was 27% by *Hypophthalmichthys nobilis*. There were 58 species of fish in competitive relationships with *Ctenopharyngodon idella*. There were 54 species that affected the niche of *Ctenopharyngodon idella* by more than 10%, with which the biggest effect was 230% by *Misgurnus anguillicaudatus*. An additional 46 species had less than a 10% effect on the rate of the niche variation of *Ctenopharyngodon idella*.

3.1.2.2.7 Ochetobius elongatus (Kner, 1867)

The niche variation of *Ochetobius elongatus* (Kner, 1867) ranged from 0% to 395% in the absence of different species (see figure 3.12). Among the 103 species of fish, 11 species were mutually beneficial to *Ochetobius elongatus*. No species had more than a 10% effect on the niche of *Ochetobius elongatus*. Of these, in which the largest effect was 3% by *Luciocyprinus langsoni*. There were 92 species of fish in competitive relationships with *Ochetobius elongatus*. There were 87 species that affected the niche of *Ochetobius elongatus* by more than 10%, with which the biggest effect was 395% by *Hypophthalmichthys nobilis*. An additional 16 species had less than a 10% effect on the rate of the niche variation of *Ochetobius elongatus*.

3.1.2.2.8 Elopichthys bambusa (Richardson, 1845)

The niche variation of *Elopichthys bambusa* (Richardson, 1845) ranged from 0% to 213% in the absence of different species (see figure 3.13). Among the 103 species of fish, 95 species were mutually beneficial to *Elopichthys bambusa*. There were 7 species that had more than a 10% effect on the niche of *Elopichthys bambusa*. Of these, in which the largest effect was 25% by *Mylopharyngodon piceus*. There were 8 species of fish in competitive relationships with *Elopichthys bambusa*. Only one species affected the niche of *Elopichthys bambusa* by more than 10%, with which the biggest effect was 213% by *Hypophthalmichthys molitrix*. An additional 90 species had less than a 10% effect on the rate of the niche variation of *Elopichthys bambusa*.

3.1.2.2.9 Squaliobarbus curriculus (Richardson, 1846)

The niche variation of *Squaliobarbus curriculus* (Richardson, 1846) ranged from 0% to 98% in the absence of different species (see figure 3.14). Among the 103 species of fish, 13 species were mutually beneficial to *Squaliobarbus curriculus*. There were 8 species that had more than a 10% effect on the niche of *Squaliobarbus curriculus*. Of these, in which the largest effect was 45% by *Elopichthys bambusa*. There were 30 species of fish in competitive relationships with *Squaliobarbus curriculus*. There were 20 species that affected the niche of *Squaliobarbus curriculus* by more than 10%, with which the biggest effect being 199% by *Micronemacheilus pulcher*. An additional 60 species had less than a 10% effect on the rate of the niche variation of *Squaliobarbus curriculus*.

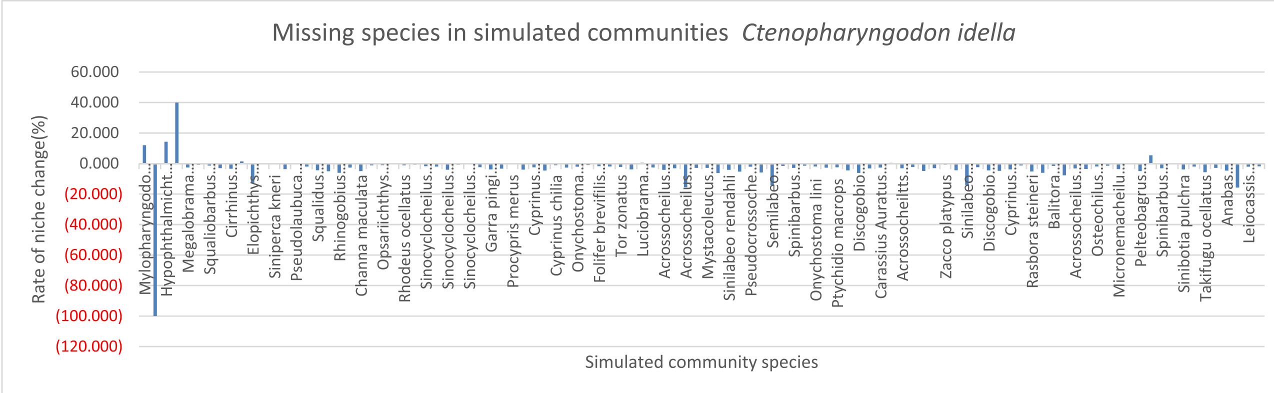

FIG. 3.11 – The responses of the niches of *Ctenopharyngodon idella* to various missing fish in the simulated community.

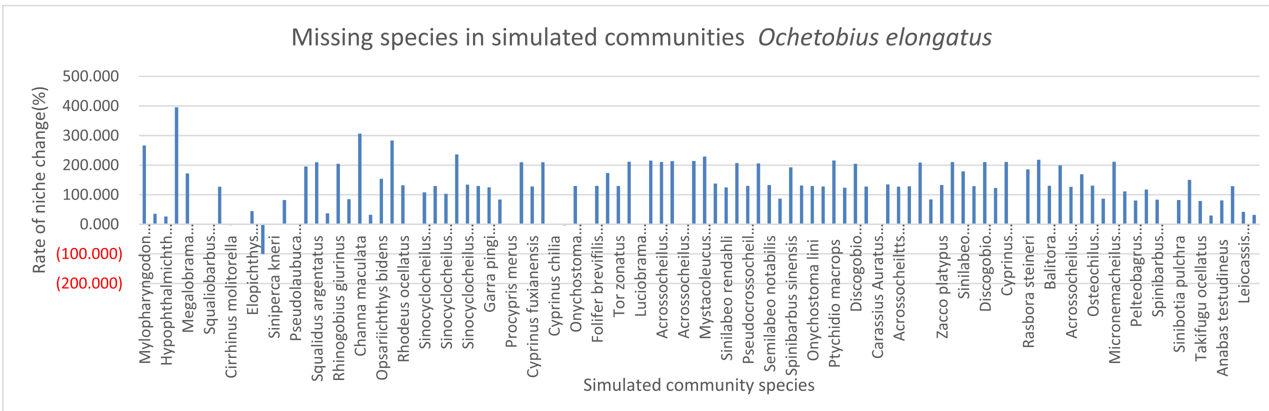

FIG. 3.12 – The responses of the niches of *Ochetobius elongatus* to various missing fish in the simulated community.

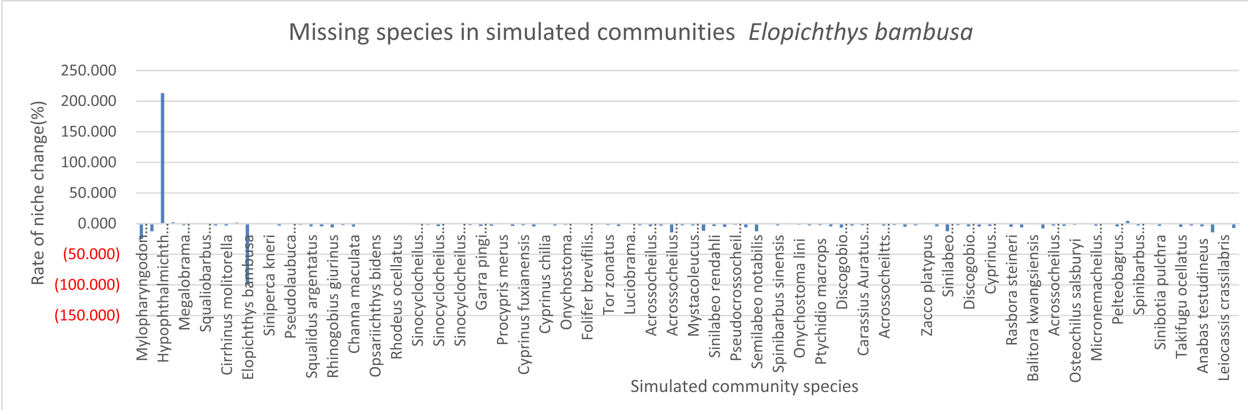

Fig. 3.13 – The responses of the niches of *Elopichthys bambusa* to various missing fish in the simulated community.

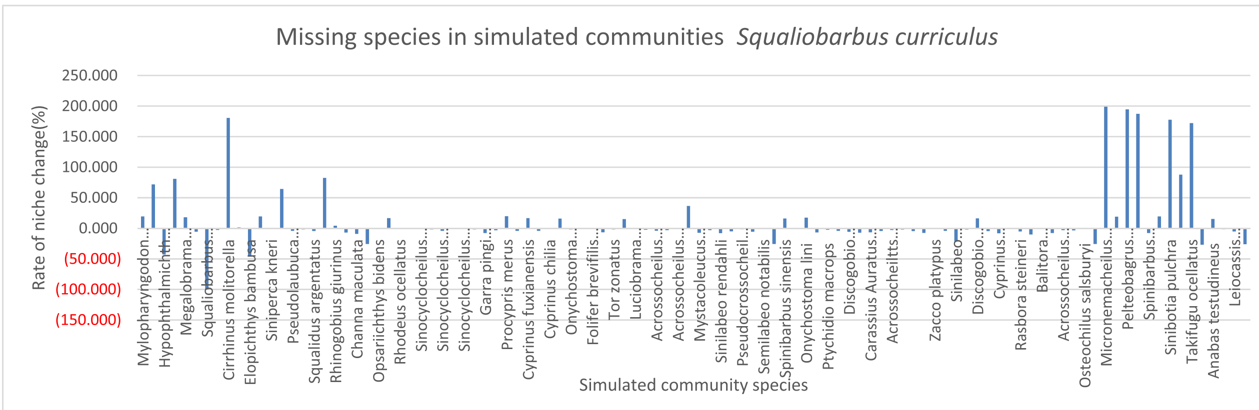

Fig. 3.14 – The responses of the niches of *Squaliobarbus curriculus* to various missing fish in the simulated community.

3.1.2.2.10 Ancherythroculter lini (Luo, 1994)

The niche variation of *Ancherythroculter lini* (Luo, 1994) ranged from 0% to 211% in the absence of different species (see figure 3.15). Among the 103 species of fish, 69 species were mutually beneficial to *Ancherythroculter lini*. There were 19 species that had more than a 10% effect on the niche of *Ancherythroculter lini*. Of these, in which the largest effect was 52% by *Hypophthalmichthys molitrix*. There were 34 species of fish in competitive relationships with *Ancherythroculter lini*. All of those species affected the niche of *Ancherythroculter lini* by more than 10%, with which the biggest effect was 211% by *Luciobrama macrocephalus*. An additional 50 species had less than a 10% effect on the rate of the niche variation of *Ancherythroculter lini*.

3.1.2.2.11 Pseudolaubuca sinensis (Bleeker, 1865)

The niche variation of *Pseudolaubuca sinensis* (Bleeker, 1865) ranged from 0% to 158% in the absence of different species see (figure 3.16). Among the 103 species of fish, 41 species were mutually beneficial to *Pseudolaubuca sinensis*. There were 4 species that had more than a 10% effect on the niche of *Pseudolaubuca sinensis*. Of these, in which the largest effect was 38% by *Hypophthalmichthys molitrix*. There were 62 species of fish in competitive relationships with *Pseudolaubuca sinensis*. There were 58 species that affected the niche of *Pseudolaubuca sinensis* by more than 10%, with which the biggest effect was 158% by *Hypophthalmichthys nobilis*. An additional 46 species had less than a 10% effect on the rate of the niche variation of *Pseudolaubuca sinensis*.

3.1.2.2.12 Parabramis pekinensis (Basilewsky, 1855)

The niche variation of *Parabramis pekinensis* (Basilewsky, 1855) ranged from 0% to 160% in the absence of different species (see figure 3.17). Among the 103 species of fish, 3 species were mutually beneficial to *Parabramis pekinensis*. There were 2 species that had more than a 10% effect on the niche of *Parabramis pekinensis*. Of these, in which the largest effect was 73% by *Hypophthalmichthys molitrix*. There were 99 species of fish in competitive relationships with *Parabramis pekinensis*. There were 98 species that affected the niche of *Parabramis pekinensis* by more than 10%, with which the biggest effect was 160% by *Leptobotia pellegrini*. An additional 2 species had less than a 10% effect on the rate of the niche variation of *Parabramis pekinensis*.

3.1.2.2.13 Hemiculter leucisculus (Basilewsky, 1855)

The niche variation of *Hemiculter leucisculus* (Basilewsky, 1855) ranged from 0% to 273% in the absence of different species (see figure 3.18). Among the 103 species of fish, 45 species were mutually beneficial to *Hemiculter leucisculus*. There were 3 species that had more than a 10% effect on the niche of *Hemiculter leucisculus*. Of these, in which the largest effect was 49% by *Hypophthalmichthys molitrix*. There were 37 species of fish in competitive relationships with *Hemiculter leucisculus*. There were 32 species that affected the niche of *Hemiculter leucisculus* by more than 10%, with which the biggest effect was 273% by *Carassius auratus auratus*. An additional 64 species had less than a 10% effect on the rate of the niche variation of *Hemiculter leucisculus*.

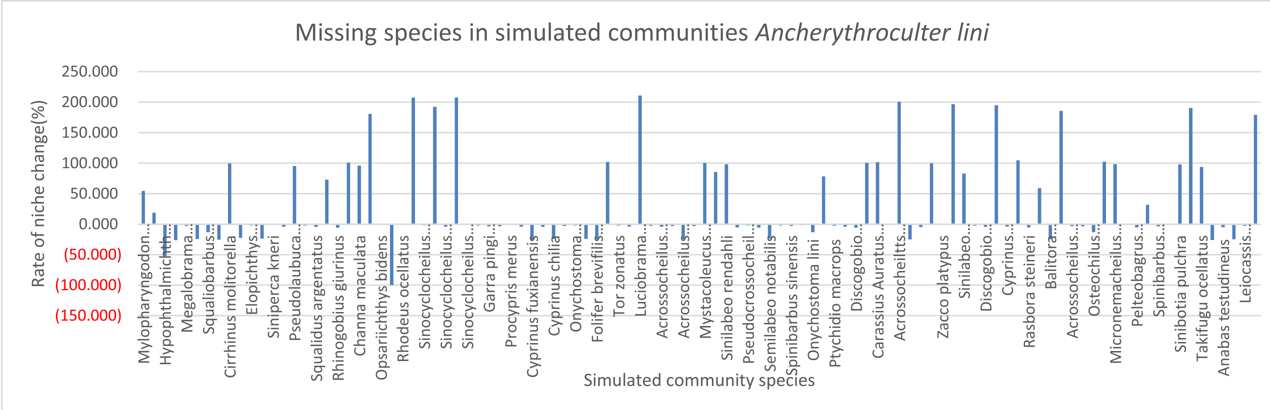

FIG. 3.15 – The responses of the niches of *Ancherythroculter lini* to various missing fish in the simulated community.

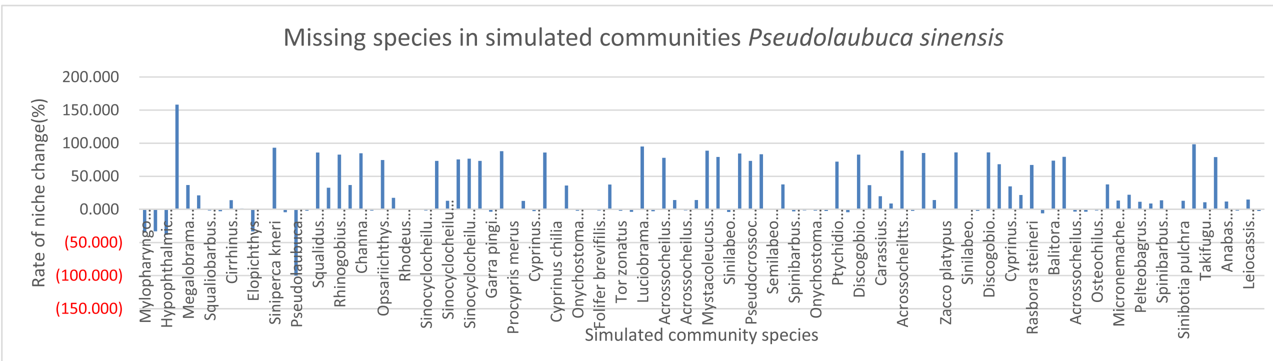

FIG. 3.16 – The responses of the niches of *Pseudolaubuca sinensis* to various missing fish in the simulated community.

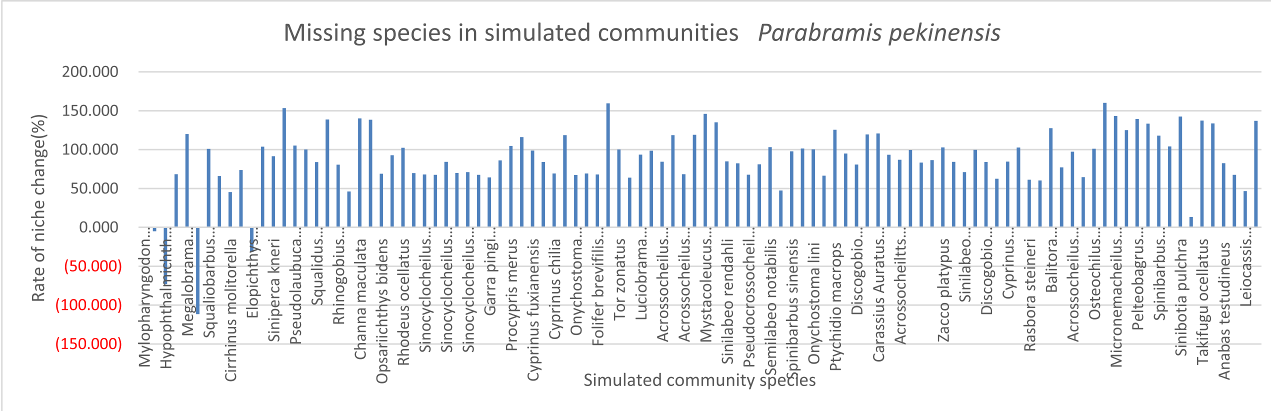

FIG. 3.17 – The responses of the niches of *Parabramis pekinensis* to various missing fish in the simulated community.

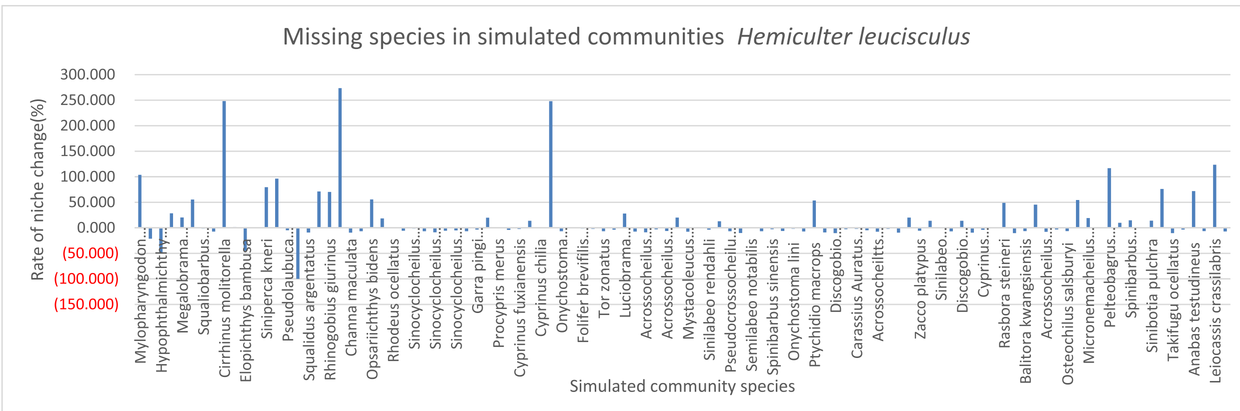

FIG. 3.18 – The responses of the niches of *Hemiculter leucisculus* to various missing fish in the simulated community.

3.1.2.2.14 Rasborinus lineatus (Pellegrin, 1907)

The niche variation of *Rasborinus lineatus* (Pellegrin, 1907) ranged from 0% to 193% in the absence of different species (see figure 3.19). Among the 103 species of fish, 30 species were mutually beneficial to *Rasborinus lineatus*. There were 12 species that had more than a 10% effect on the niche of *Rasborinus lineatus*. Of these, in which the largest effect was 52% by *Hypophthalmichthys nobilis*. There were 73 species of fish in competitive relationships with *Rasborinus lineatus*. There were 67 species that affected the niche of *Rasborinus lineatus* by more than 10%, with which the biggest effect was 193% by *Hypophthalmichthys nobilis*. An additional 46 species had less than a 10% effect on the rate of the niche variation of *Rasborinus lineatus*.

3.1.2.2.15 Megalobrama skolkovii (Dybowski, 1872)

The niche variation of *Megalobrama skolkovii* (Dybowski, 1872) ranged from 0% to 145% in the absence of different species (see figure 3.20). Among the 103 species of fish, 93 species were mutually beneficial to *Megalobrama skolkovii*. There were 74 species that had more than a 10% effect on the niche of *Megalobrama skolkovii*. Of these, in which the largest effect was 43% by *Hypophthalmichthys molitrix*. There were 10 species of fish in competitive relationships with *Megalobrama skolkovii*. There were 6 species that affected the niche of *Lcucosoma chinensis* by more than 10%, with which the biggest effect was 145% by *Anabas testudineus*. An additional 23 species had less than a 10% effect on the rate of the niche variation of *Megalobrama skolkovii*.

3.1.2.2.16 Xenocypris argentea (Günther, 1868)

The niche variation of *Xenocypris argentea* (Günther, 1868) ranged from 0% to 1704% in the absence of different species (see figure 3.21). Among the 103 species of fish, 24 species were mutually beneficial to *Xenocypris argentea*. Only one species had more than a 10% effect on the niche of *Lcucosoma chinensis* with an effect was 17% by *Mylopharyngodon piceus*. There were 79 species of fish in competitive relationships with *Xenocypris argentea*. There were 72 species that affected the niche of *Lcucosoma chinensis* by more than 10%, with which the biggest effect was 1704% by *Ctenopharyngodon idella*. An additional 39 species had less than a 10% effect on the rate of the niche variation of *Xenocypris argentea*.

3.1.2.2.17 Hypophthalmichthys molitrix (Valenciennes, 1844)

The niche variation of *Hypophthalmichthys molitrix* (Valenciennes, 1844) ranged from 0% to 10% in the absence of different species (see figure 3.22). Among the 103 species of fish, 93 species were mutually beneficial to *Hypophthalmichthys molitrix*. There were 10 species of fish in competitive relationships with *Hypophthalmichthys molitrix*. No species that affected the niche of No species by more than 10%, in which the biggest effect was 2% by *Sinilabeo discognathoides*. All of the species had less than a 10% effect on the rate of the niche variation of *Hypophthalmichthys molitrix*.

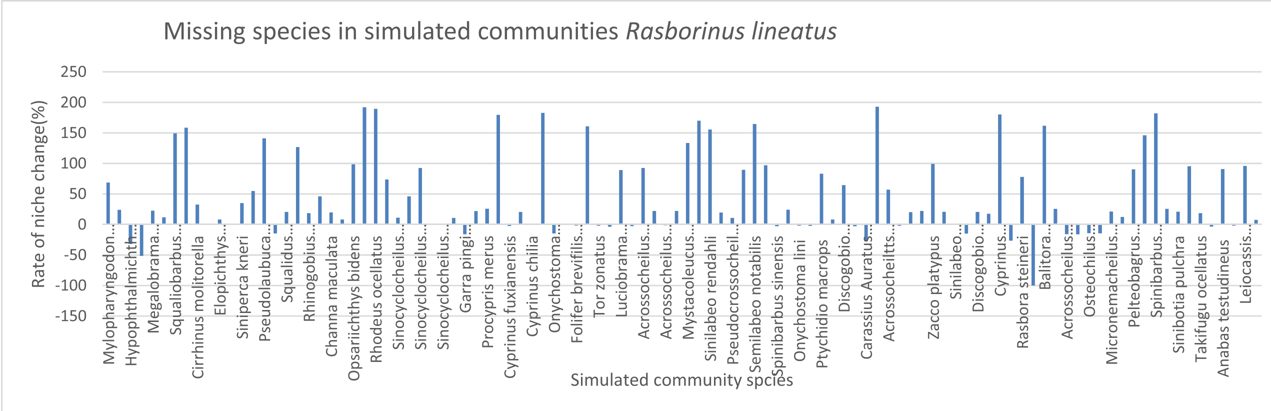

FIG. 3.19 – The responses of the niches of *Rasborinus lineatus* to various missing fish in the simulated community.

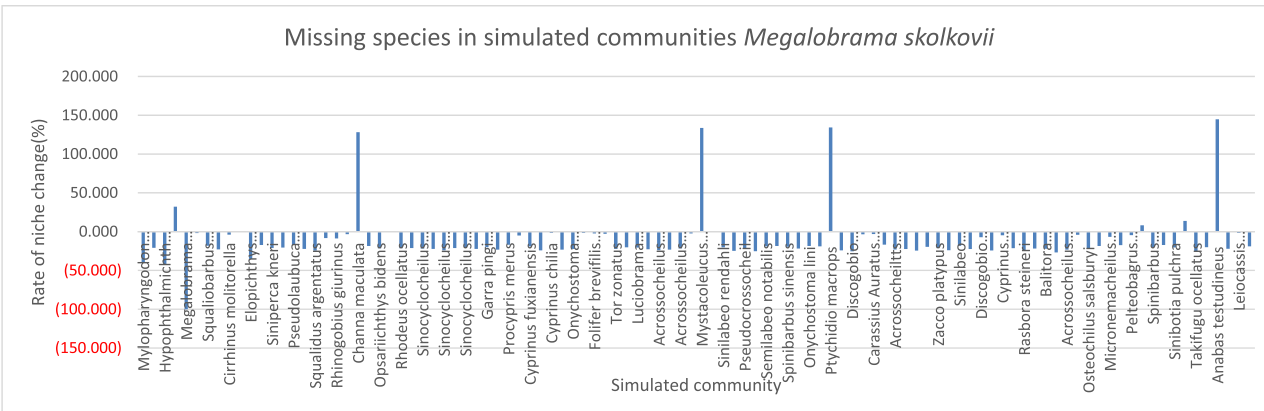

FIG. 3.20 – The responses of the niches of *Megalobrama skolkovii* to various missing fish in the simulated community.

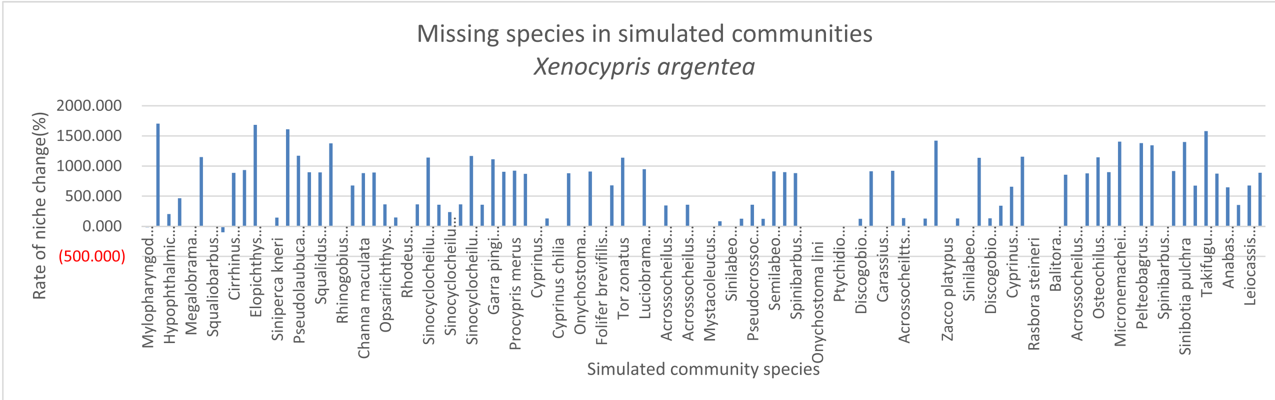

Fig. 3.21 – The responses of the niches of *Xenocypris argentea* to various missing fish in the simulated community.

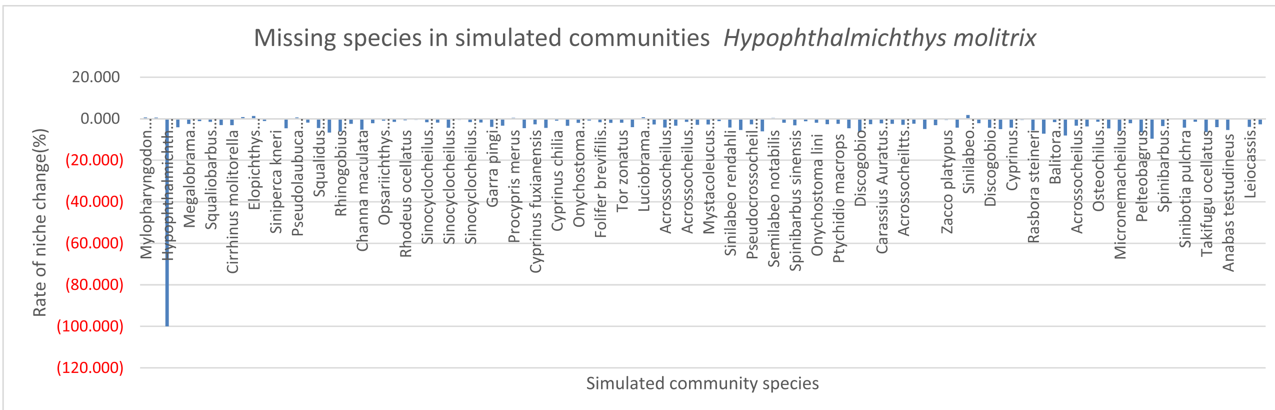

Fig. 3.22 – The responses of the niches of *Hypophthalmichthys molitrix* to various missing fish in the simulated community.

3.1.2.2.18 Hypophthalmichthys nobilis (Richardson, 1845)

The niche variation of *Hypophthalmichthys nobilis* (Richardson, 1845) ranged from 0% to 98% in the absence of different species (see figure 3.23). Among the 103 species of fish, 85 species were mutually beneficial to *Hypophthalmichthys nobilis*. There were 2 species that had more than a 10% effect on the niche of *Hypophthalmichthys nobilis*. Of these, in which the largest effect was 98% by *Hypophthalmichthys molitrix*. There were 18 species of fish in competitive relationships with *Hypophthalmichthys nobilis*. No species affected the niche of *Hypophthalmichthys nobilis* by more than 10%, with which the biggest effect was 2% by *Sinilabeo discognathoides*. An additional 46 species had less than a 10% effect on the rate of the niche variation of *Hypophthalmichthys nobilis*.

3.1.2.2.19 Pseudogyrinocheilus prochilus (Sauvage and Dabry, 1874)

The niche variation of *Pseudogyrinocheilus prochilus* (Sauvage and Dabry, 1874) ranged from 0% to 2319% in the absence of different species (see figure 3.24). Among the 103 species of fish, 36 species were mutually beneficial to *Pseudogyrinocheilus prochilus*. There were 10 species that had more than a 10% effect on the niche of *Pseudogyrinocheilus prochilus*. Of these, in which the largest effect was 20% by *Tachysurus argentivittatus*. There were 67 species of fish in competitive relationships with *Pseudogyrinocheilus prochilus*. There were 46 species that affected the niche of *Pseudogyrinocheilus prochilus* by more than 10%, with which the biggest effect being 2319% by *Pseudolaubuca sinensis*. An additional 47 species had less than a 10% effect on the rate of the niche variation of *Pseudogyrinocheilus prochilus*.

3.1.2.2.20 Squalidus argentatus (Sauvage and Dabry de Thiersant, 1874)

The niche variation of *Squalidus argentatus* (Sauvage and Dabry de Thiersant, 1874) ranged from 0% to 76% in the absence of different species (see figure 3.25). Among the 103 species of fish, 68 species were mutually beneficial to *Squalidus argentatus*. There were 32 species that had more than a 10% effect on the niche of *Squalidus argentatus*. Of these, in which the largest effect was 76% by *Hypophthalmichthys molitrix*. There were 35 species of fish in competitive relationships with *Squalidus argentatus*. There were 11 species that affected the niche of *Squalidus argentatus* by more than 10%, in which the biggest effect was 22% by *Hypophthalmichthys molitrix*. An additional 60 species had less than a 10% effect on the rate of the niche variation of *Squalidus argentatus*.

3.1.2.2.21 Rhodeus ocellatus (Kner, 1867)

The niche variation of *Rhodeus ocellatus* (Kner, 1867) ranged from 0% to 111% in the absence of different species (see figure 3.26). Among the 103 species of fish, 88 species were mutually beneficial to *Rhodeus ocellatus*. There were 71 species that had more than a 10% effect on the niche of *Rhodeus ocellatus*. Of these, in which 50 species affected *Rhodeus ocellatus* nearly 100%. There were 15 species of fish in competitive relationships with *Rhodeus ocellatus*. There were 9 species that affected the niche of *Rhodeus ocellatus* by more than 10%, with which the biggest effect was

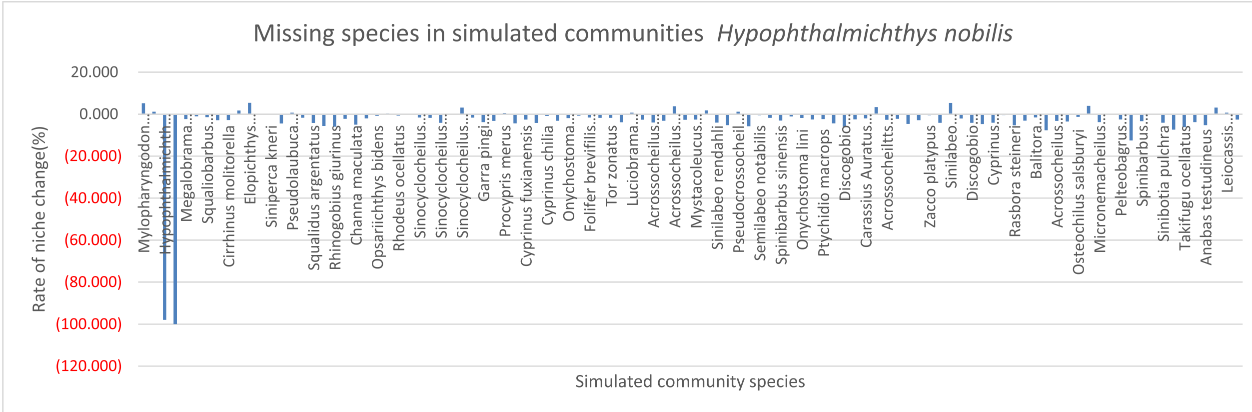

FIG. 3.23 – The responses of the niches of *Hypophthalmichthys nobilis* to various missing fish in the simulated community.

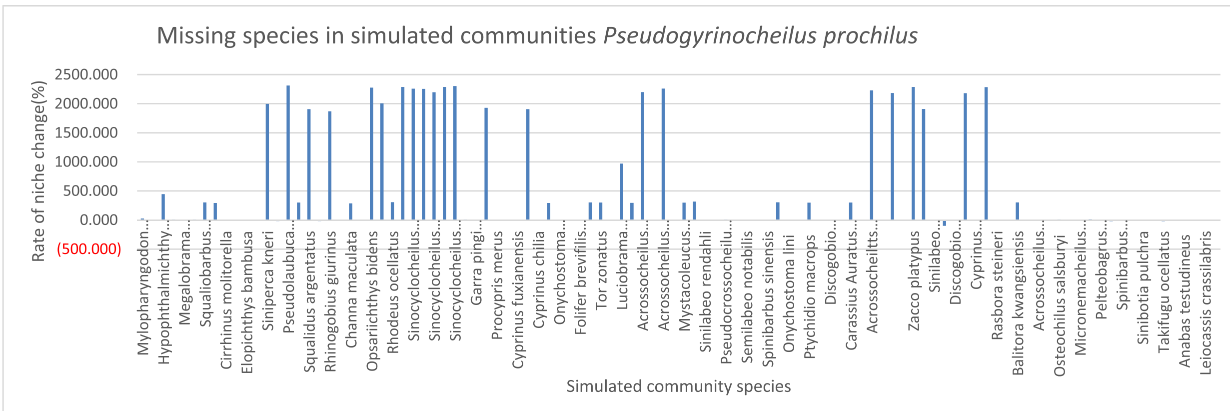

FIG. 3.24 – The responses of the niches of *Pseudogyrinocheilus prochilus* to various missing fish in the simulated community.

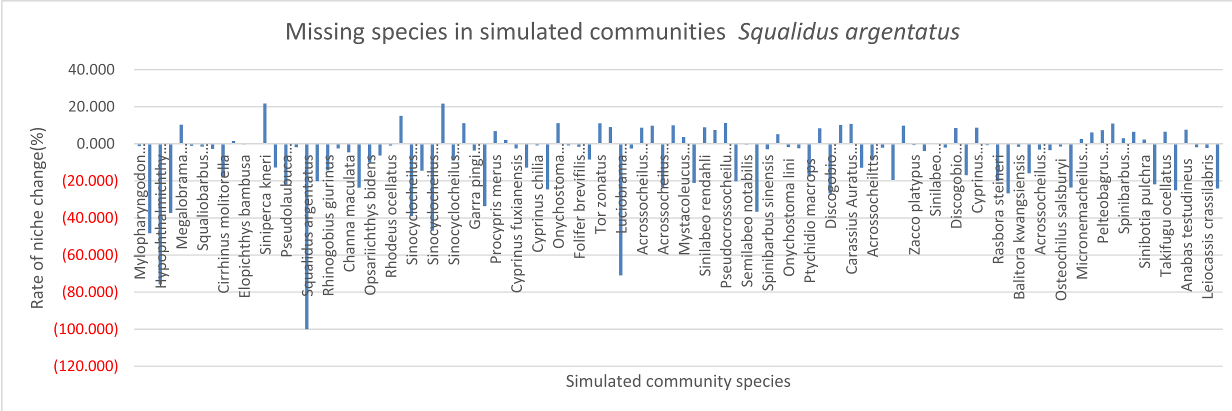

FIG. 3.25 – The responses of the niches of *Squalidus argentatus* to various missing fish in the simulated community.

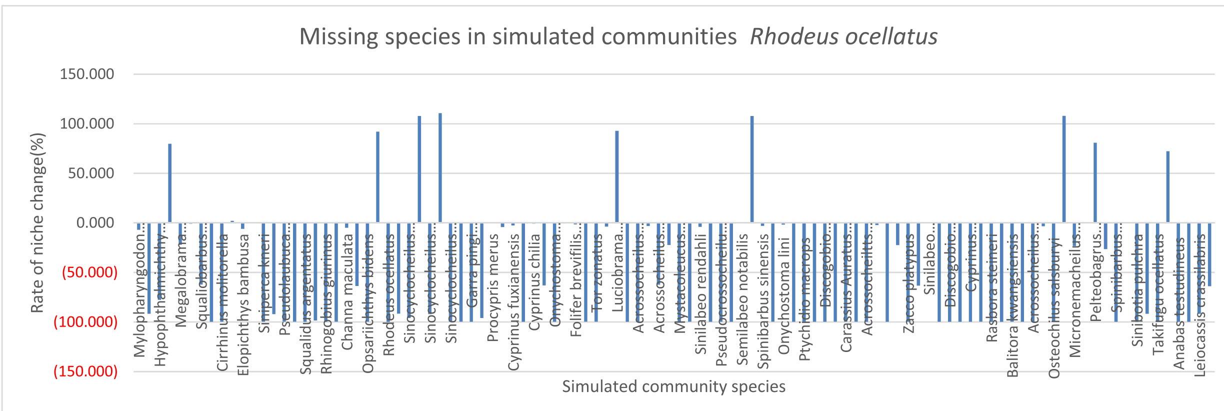

FIG. 3.26 – The responses of the niches of *Rhodeus ocellatus* to various missing fish in the simulated community.

111% by *Sinocyclocheilus anophthalmus*. An additional 23 species had less than a 10% effect on the rate of the niche variation of *Rhodeus ocellatus*.

3.1.2.2.22 Acheilognathus tonkinensis (Vaillant, 1892)

The niche variation of *Acheilognathus tonkinensis* (Vaillant, 1892) ranged from 0% to 842% in the absence of different species (see figure 3.27). Among the 103 species of fish, 33 species were mutually beneficial to *Acheilognathus tonkinensis*. There were 30 species that had more than a 10% effect on the niche of *Acheilognathus tonkinensis*. Of these, in which the largest effect was 87% by *Misgurnus anguillicaudatus*. There were 70 species of fish in competitive relationships with *Acheilognathus tonkinensis*. There were 67 species that affected the niche of *Acheilognathus tonkinensis* by more than 10%, with which the biggest effect was 842% by *Elopichthys bambusa*. An additional 6 species had less than a 10% effect on the rate of the niche variation of *Acheilognathus tonkinensis*.

3.1.2.2.23 Puntius semifasciolatus (Günther, 1968)

The niche variation of *Puntius semifasciolatus* (Günther, 1968) ranged from 0% to 77% in the absence of different species (see figure 3.28). Among the 103 species of fish, 20 species were mutually beneficial to *Puntius semifasciolatus*. There were 19 species that had more than a 10% effect on the niche of *Puntius semifasciolatus*. Of these, in which the largest effect was 77% by *Hypophthalmichthys nobilis*. There were 81 species of fish in competitive relationships with*Puntius semifasciolatus*. There were 7 species that affected the niche of *Puntius semifasciolatus* by more than 10%, with which the biggest effect was 11% by *Spinibarbus hollandi*. An additional 77 species had less than a 10% effect on the rate of the niche variation of *Puntius semifasciolatus*.

3.1.2.2.24 Spinibarbus hollandi (Oshima, 1919)

The niche variation of *Spinibarbus hollandi* (Oshima, 1919) ranged from 0% to 154% in the absence of different species (see figure 3.29). Among the 103 species of fish, 45 species were mutually beneficial to *Spinibarbus hollandi*. There were 22 species that had more than a 10% effect on the niche of *Spinibarbus hollandi*. Of these, in which the largest effect was 67% by *Hypophthalmichthys molitrix*. There were 58 species of fish in competitive relationships with *Spinibarbus hollandi*. There were 52 species that affected the niche of *Spinibarbus hollandi* by more than 10%, with which the biggest effect was 154% by *Hypophthalmichthys nobilis*. An additional 29 species had less than a 10% effect on the rate of the niche variation of *Spinibarbus hollandi*.

3.1.2.2.25 Spinibarbus sinensis (Bleeker, 1871)

The niche variation of *Spinibarbus sinensis* (Bleeker, 1871) ranged from 0% to 42% in the absence of different species (see figure 3.30). Among the 103 species of fish, 94 species were mutually beneficial to *Spinibarbus sinensis*. There were 64 species that had more than a 10% effect on the niche of *Spinibarbus sinensis*. Of these, in which the largest effect was 42% by *Puntius semifasciolatus*. There were 9 species of fish in competitive relationships with *Spinibarbus sinensis*. There were 5 species that affected the niche of *Spinibarbus sinensis* by more than 10%, with which the biggest

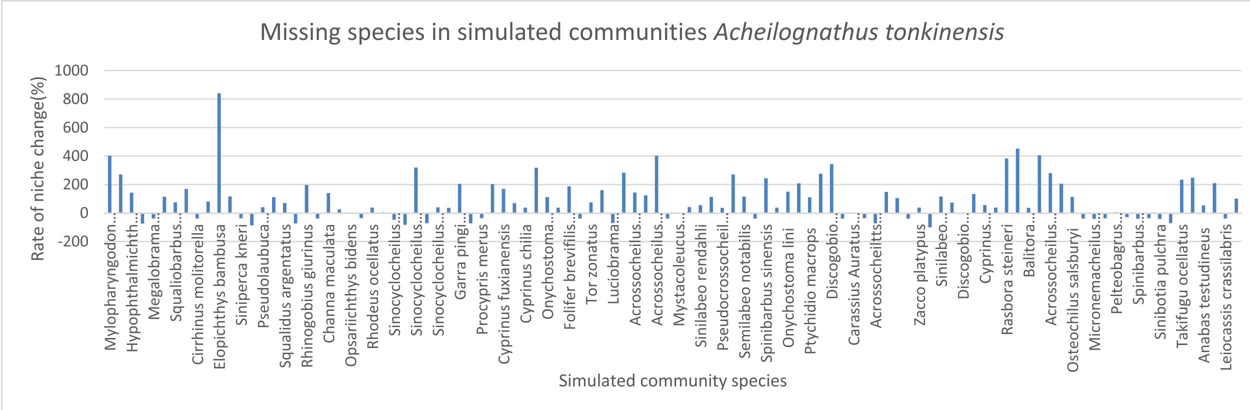

Fig. 3.27 – The responses of the niches of *Acheilognathus tonkinensis* to various missing fish in the simulated community.

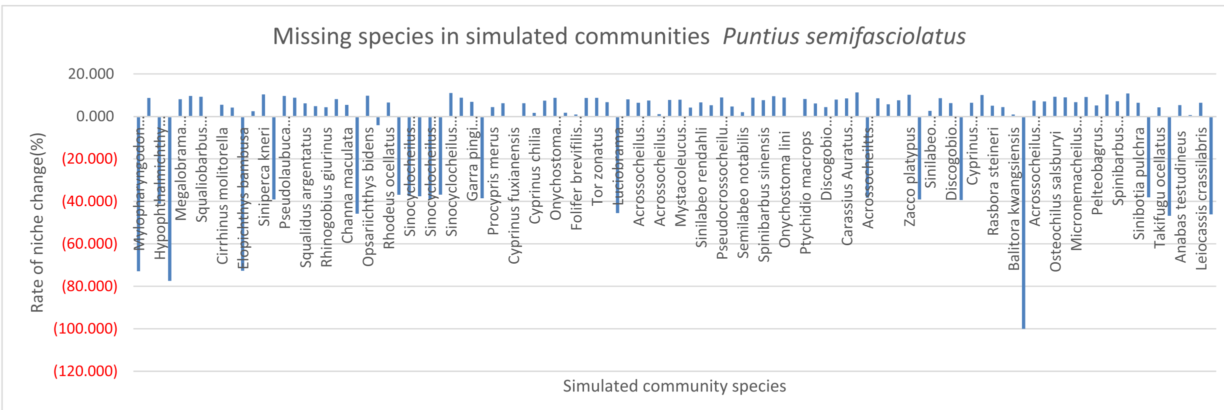

Fig. 3.28 – The responses of the niches of *Puntius semifasciolatus* to various missing fish in the simulated community.

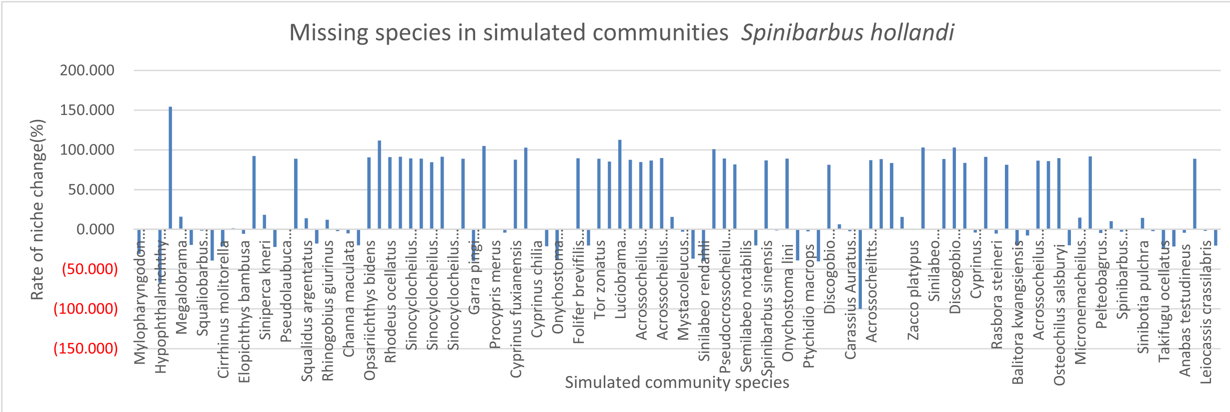

Fig. 3.29 – The responses of the niches of *Spinibarbus hollandi* to various missing fish in the simulated community.

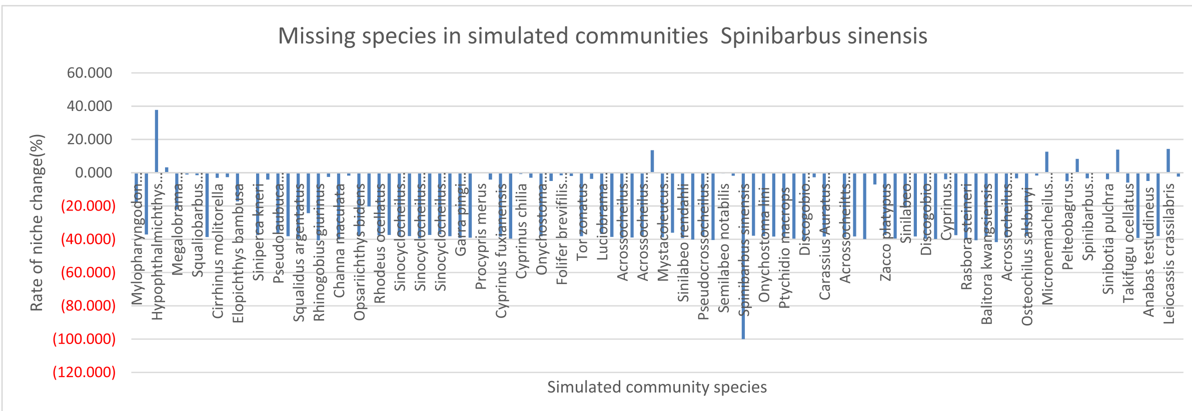

Fig. 3.30 – The responses of the niches of *Spinibarbus sinensis* to various missing fish in the simulated community.

effect was 38% by *Hypophthalmichthys molitrix*. An additional 34 species had less than a 10% effect on the rate of the niche variation of *Spinibarbus sinensis*.

3.1.2.2.26 Spinibarbus denticulatus denticulatus (Oshima, 1926)

The niche variation of *Spinibarbus denticulatus denticulatus* (Oshima, 1926) ranged from 0% to 66% in the absence of different species (see figure 3.31). Among the 103 species of fish, 88 species were mutually beneficial to *pinibarbus denticulatus denticulatus*. There were 57 species that had more than a 10% effect on the niche of *pinibarbus denticulatus denticulatus*. Of these, in which the largest effect was 66% by *Discogobiolongibarbatus*. There were 15 species of fish in competitive relationships with *pinibarbus denticulatus denticulatus*. There were 30 species that affected the niche of *pinibarbus denticulatus denticulatus* by more than 10%, with which the biggest effect was 17% by *Hypophthalmichthys nobilis*. An additional 45 species had less than a 10% effect on the rate of the niche variation of *pinibarbus denticulatus denticulatus*.

3.1.2.2.27 Sinocyclocheilus macrolepis (Wang, 1989)

The niche variation of *Sinocyclocheilus macrolepis* (Wang, 1989) ranged from 0% to 5117% in the absence of different species (see figure 3.32). Among the 103 species of fish, 2 species were mutually beneficial to *Sinocyclocheilus macrolepis*. There were 2 species that had more than a 10% effect on the niche of *Sinocyclocheilus macrolepis*. Of these, in which the largest effect was 93% by *Acrossocheilus iridescens iridescens*. There were 101 species of fish in competitive relationships with *Sinocyclocheilus macrolepis*. There were 97 species that affected the niche of *Sinocyclocheilus macrolepis* by more than 10%, with which the biggest effect was 5117% by *Cyprinus multitaeniata*. An additional 4 species had less than a 10% effect on the rate of the niche variation of *Sinocyclocheilus macrolepis*.

3.1.2.2.28 Sinocyclocheilus grahami tingi (Fang, 1936)

The niche variation of *Sinocyclocheilus grahami tingi* (Fang, 1936) ranged from 0% to 63% in the absence of different species (see figure 3.33). Among the 103 species of fish, 29 species were mutually beneficial to *Sinocyclocheilus grahami tingi*. There were 12 species that had more than a 10% effect on the niche of *Sinocyclocheilus grahami tingi*. Of these, in which the largest effect was 63% by *Luciobrama macrocephalus*. There were 74 species of fish in competitive relationships with *Sinocyclocheilus grahami tingi*. There were 4 species that affected the niche of *Sinocyclocheilus grahami tingi* by more than 10%, with which the biggest effect was 13% by *Tachysurus argentivittatus*. An additional 91 species had less than a 10% effect on the rate of the niche variation of *Sinocyclocheilus grahami tingi*.

3.1.2.2.29 Sinocyclocheilus yangzongensis (Tsu and Chen, 1982)

The niche variation of *Sinocyclocheilus yangzongensis* (Tsu and Chen, 1982) ranged from 0% to 13 293% in the absence of different species (see figure 3.34). Among the 103 species of fish, 29 species were mutually beneficial to *Sinocyclocheilus yangzongensis*. Only one species had more than a 10% effect on the niche of *Sinocyclocheilus yangzongensis*. Of which the largest effect was 40% by *Ptychidio macrops*.

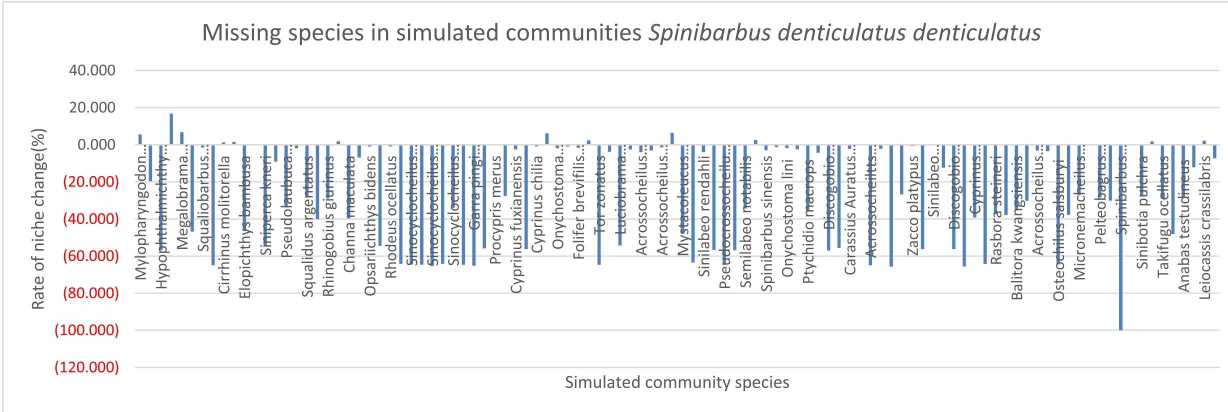

Fig. 3.31 – The responses of the niches of *Sinibarbus denticulatus denticulatus* to various missing fish in the simulated community.

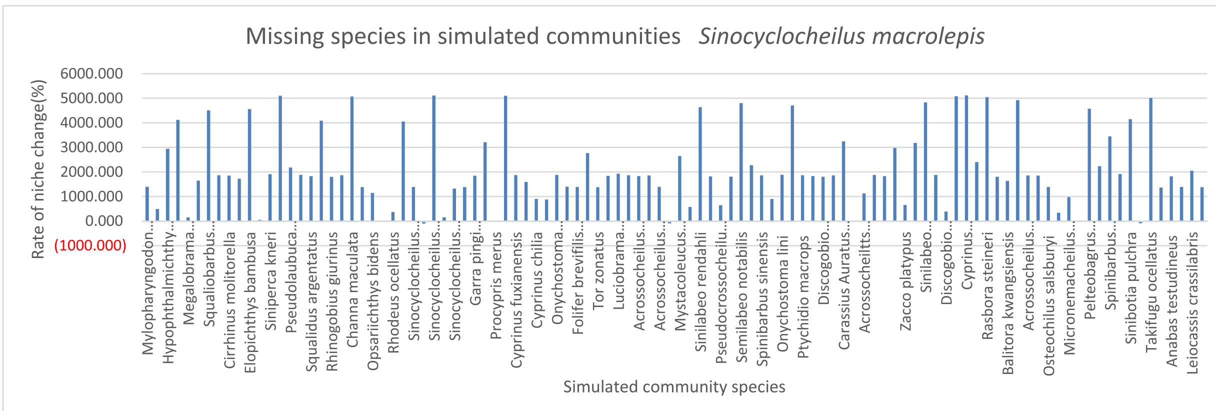

Fig. 3.32 – The responses of the niches of *Sinocyclocheilus macrolepis* to various missing fish in the simulated community.

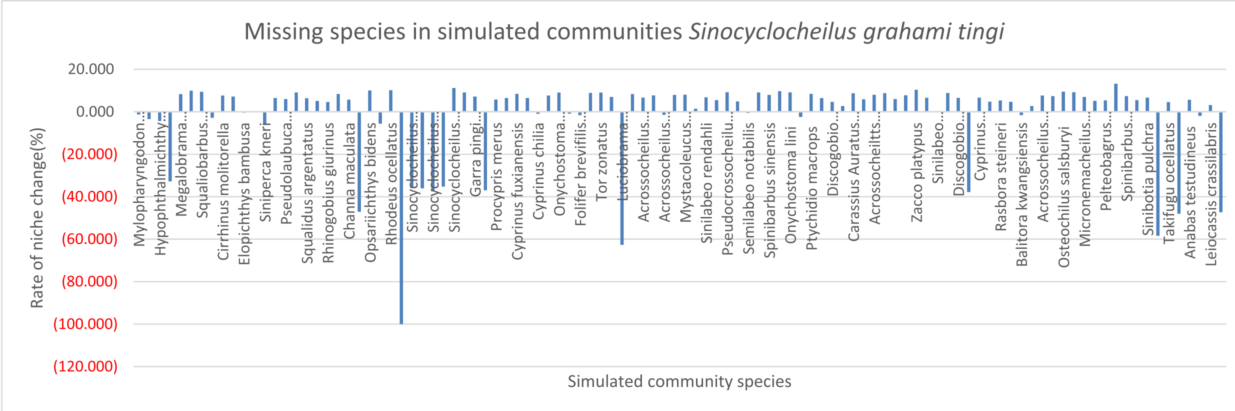

FIG. 3.33 – The responses of the niches of *Sinocyclocheilus grahami tingi* to various missing fish in the simulated community.

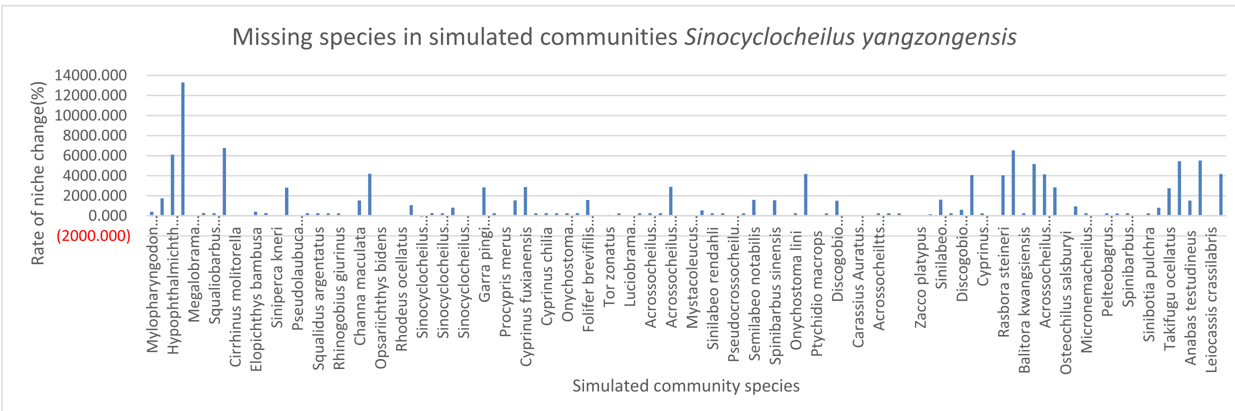

FIG. 3.34 – The responses of the niches of *Sinocyclocheilus yangzongensis* to various missing fish in the simulated community.

There were 74 species of fish in competitive relationships with *Sinocyclocheilus yangzongensis*. All of the species affected the niche of *Lcucosoma chinensis* by more than 10%, in which the biggest effect was 13 293% by *Hypophthalmichthys nobilis*. An additional 28 species had less than a 10% effect on the rate of the niche variation of *Sinocyclocheilus yangzongensis*.

3.1.2.2.30 Sinocyclocheilus anophthalmus (Chen and Chu, 1988)
The niche variation of *Sinocyclocheilus anophthalmus* (Chen and Chu, 1988) ranged from 0% to 2020% in the absence of different species (see figure 3.35). Among the 103 species of fish, 72 species were mutually beneficial to *Sinocyclocheilus anophthalmus*. There were 34 species that had more than a 10% effect on the niche of *Sinocyclocheilus anophthalmus*. Of these, in which the largest effect was 71% by *Xenocypris argentea*. There were 31 species of fish in competitive relationships with *Lcucosoma chinensis*. There were 15 species that affected the niche of *Sinocyclocheilus anophthalmus* by more than 10%, with which the biggest effect was 2020% by *Hypophthalmichthys nobilis*. An additional 54 species had less than a 10% effect on the rate of the niche variation of *Sinocyclocheilus anophthalmus*.

3.1.2.2.31 Sinocyclocheilus microphthalmus (Li, 1989)
The niche variation of *Sinocyclocheilus microphthalmus* (Li, 1989) ranged from 0% to 75% in the absence of different species (see figure 3.36). Among the 103 species of fish, 89 species were mutually beneficial to *Sinocyclocheilus microphthalmus*. There were 72 species that had more than a 10% effect on the niche of *Sinocyclocheilus microphthalmus*. Of these, in which the largest effect was 70% by *Lateolabrax japonicus*. There were 14 species of fish in competitive relationships with *Lcucosoma chinensis*. No species that affected the niche of *Sinocyclocheilus microphthalmus* by more than 10%, with which the biggest effect was 6% by *Hemibagrus guttatus*. An additional 31 species had less than a 10% effect on the rate of the niche variation of *Sinocyclocheilus microphthalmus*.

3.1.2.2.32 Sinocyclocheilus macrocephalus (Li, 1985)
The niche variation of *Sinocyclocheilus macrocephalus* (Li, 1985) ranged from 0% to 245% in the absence of different species (see figure 3.37). Among the 103 species of fish, 9 species were mutually beneficial to *Sinocyclocheilus macrocephalus*. There were 4 species that had more than a 10% effect on the niche of *Sinocyclocheilus macrocephalus*. Of these, in which the largest effect was 34% by *Ancherythroculter lini*. There were 94 species of fish in competitive relationships with *Sinocyclocheilus macrocephalus*. There were 79 species that affected the niche of *Lcucosoma chinensis* by more than 10%, with which the biggest effect was 23% by *Tachysurus argentivittatus*. An additional 39 species had less than a 10% effect on the rate of the niche variation of *Sinocyclocheilus macrocephalus*.

3.1.2.2.33 Mystacoleucus marginatus (Valenciennes, 1842)
The niche variation of *Mystacoleucus marginatus* (Valenciennes, 1842) ranged from 0% to 172% in the absence of different species (see figure 3.38). Among the 103

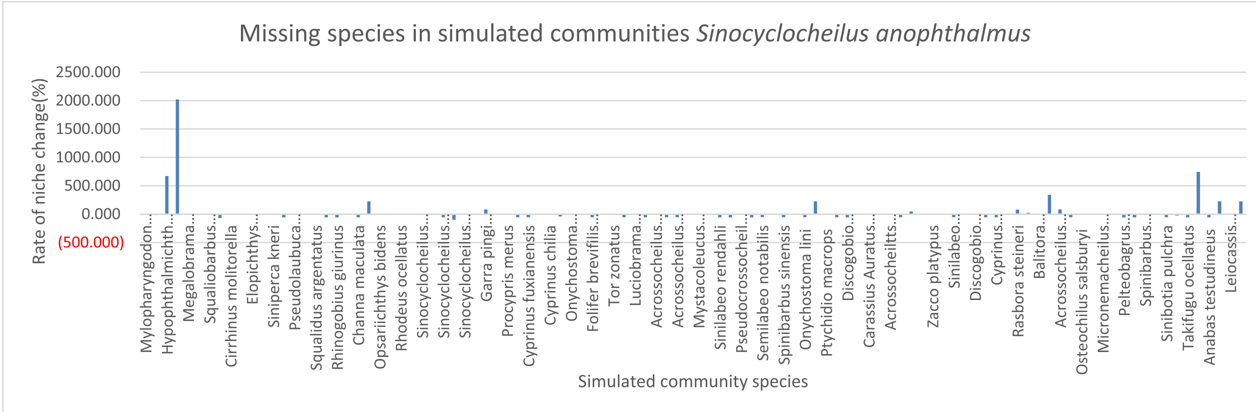

FIG. 3.35 – The responses of the niches of *Sinocyclocheilus anophthalmus* to various missing fish in the simulated community.

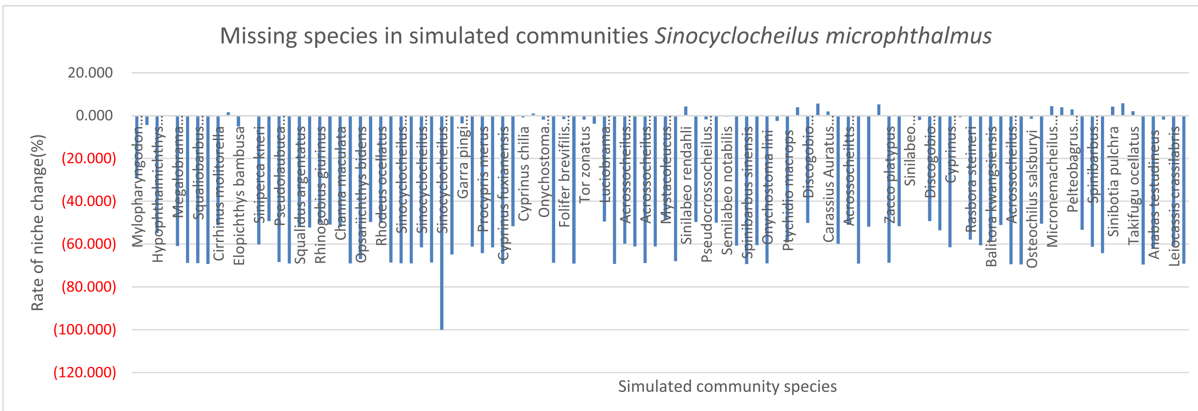

FIG. 3.36 – The responses of the niches of *Sinocyclocheilus microphthalmus* to various missing fish in the simulated community.

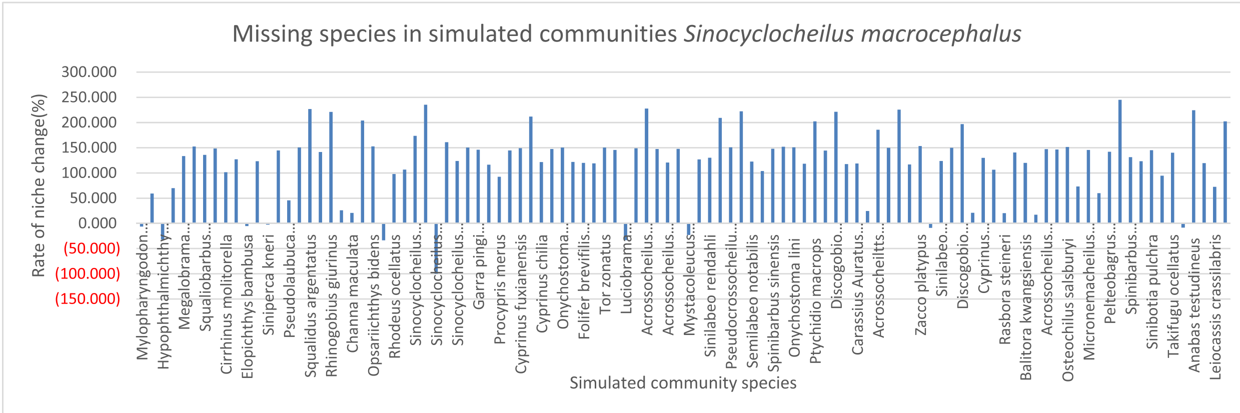

FIG. 3.37 – The responses of the niches of *Sinocyclocheilus macrocephalus* to various missing fish in the simulated community.

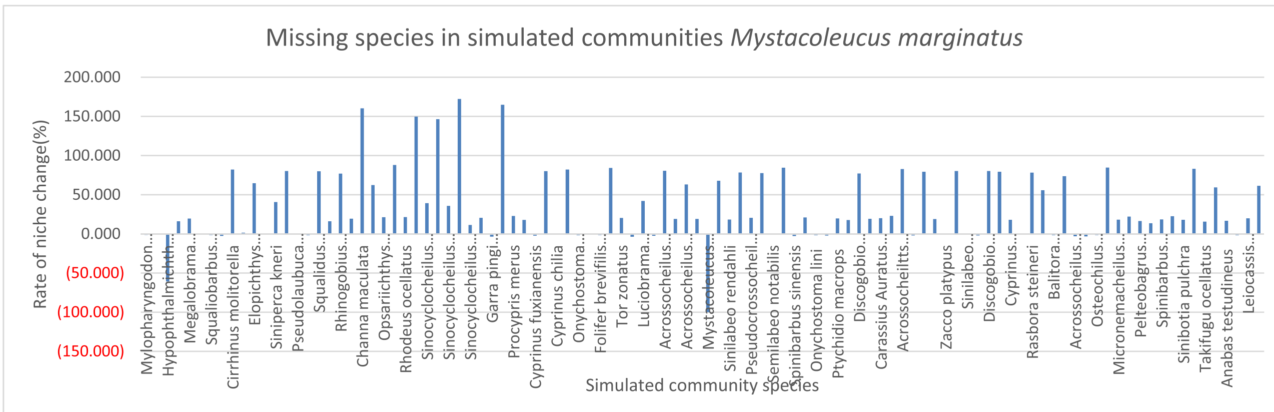

FIG. 3.38 – The responses of the niches of *Mystacoleucus marginatus* to various missing fish in the simulated community.

species of fish, 29 species were mutually beneficial to *Mystacoleucus marginatus*. Only one species had more than a 10% effect on the niche of *Mystacoleucus marginatus*. Of which was 61% by *Hypophthalmichthys molitrix*. There were 74 species of fish in competitive relationships with *Mystacoleucus marginatus*. There were 71 species that affected the niche of *Mystacoleucus marginatus* by more than 10%, with which the biggest effect was 172% by *Sinocyclocheilus anophthalmus*. An additional 31 species had less than a 10% effect on the rate of the niche variation of *Mystacoleucus marginatus*.

3.1.2.2.34 Luciocyprinus langsoni (Vaillant, 1904)

The niche variation of *Luciocyprinus langsoni* (Vaillant, 1904) ranged from 0% to 230% in the absence of different species (see figure 3.39). Among the 103 species of fish, 95 species were mutually beneficial to *Luciocyprinus langsoni*. There were 83 species that had more than a 10% effect on the niche of *Luciocyprinus langsoni*. Of these, in which the largest effect was 75% by *Elopichthys bambusa*. There were 8 species of fish in competitive relationships with *Luciocyprinus langsoni*. No species affected the niche of *Luciocyprinus langsoni* by more than 10%, with which the biggest effect was 5% by *Megalobrama skolkovii*. An additional 18 species had less than a 10% effect on the rate of the niche variation of *Luciocyprinus langsoni*.

3.1.2.2.35 Acrossocheiltts hemispinus hemispinus (Nichols, 1931)

The niche variation of *Acrossocheiltts hemispinus hemispinus* (Nichols, 1931) ranged from 0% to 221% in the absence of different species (see figure 3.40). Among the 103 species of fish, 49 species were mutually beneficial to *Acrossocheiltts hemispinus hemispinus*. There were 5 species that had more than a 10% effect on the niche of *Acrossocheiltts hemispinus hemispinus*. Of these, in which the largest effect was 40% by *Sinocyclocheilus macrocephalus*. There were 54 species of fish in competitive relationships with *Acrossocheiltts hemispinus hemispinus*. There were 28 species that affected the niche of *Acrossocheiltts hemispinus hemispinus* by more than 10%, in which the biggest effect was 221% by *Hypophthalmichthys nobilis*. An additional 70 species had less than a 10% effect on the rate of the niche variation of *Acrossocheiltts hemispinus hemispinus*.

3.1.2.2.36 Acrossocheilus beijiangensis (Wu and Lin, 1982)

The niche variation of *Acrossocheilus beijiangensis* (Wu and Lin, 1982) ranged from 0% to 1564% in the absence of different species (see figure 3.41). Among the 103 species of fish, 40 species were mutually beneficial to *Acrossocheilus beijiangensis*. There were 26 species that had more than a 10% effect on the niche of *Acrossocheilus beijiangensis*. Of these, in which the largest effect was 98% by *Acrossocheilus beijiangensis*. There were 63 species of fish in competitive relationships with *Lcucosoma chinensis*. There were 30 species that affected the niche of *Acrossocheilus beijiangensis* by more than 10%, in which the biggest effect was 1564% by *Hypophthalmichthys nobilis*. An additional 47 species had less than a 10% effect on the rate of the niche variation of *Acrossocheilus beijiangensis*.

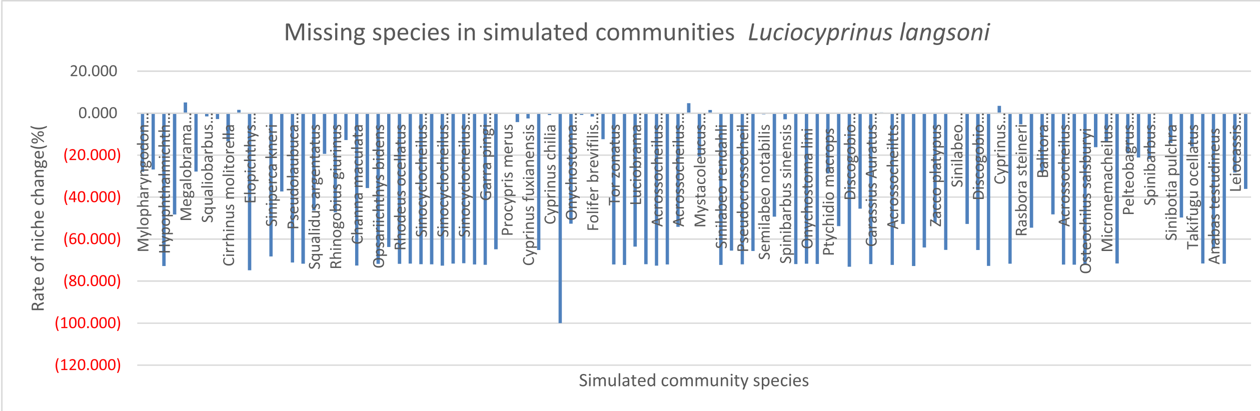

FIG. 3.39 – The responses of the niches of *Luciocyprinus langsoni* to various missing fish in the simulated community.

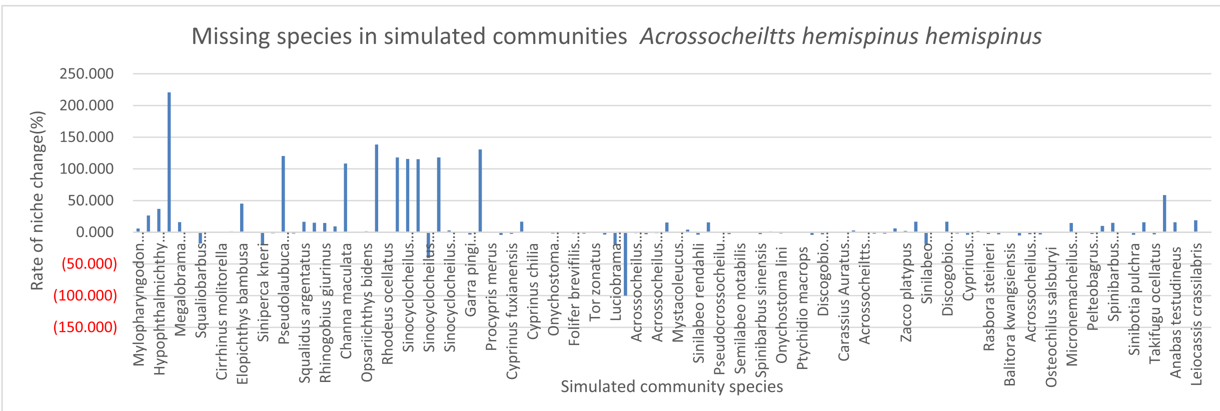

FIG. 3.40 – The responses of the niches of *Acrossocheiltts hemispinus hemispinus* to various missing fish in the simulated community.

3.1.2.2.37 Acrossocheilus paradoxus (Regan, 1908)

The niche variation of *Acrossocheilus paradoxus* (Regan, 1908) ranged from 0% to 69% in the absence of different species (see figure 3.42). Among the 103 species of fish, 67 species were mutually beneficial to *Acrossocheilus paradoxus*. There were 43 species that had more than a 10% effect on the niche of *Acrossocheilus paradoxus*. Of these, in which the largest effect was 63% by *Hemibagrus guttatus*. There were 36 species of fish in competitive relationships with *Acrossocheilus paradoxus*. There were 28 species that affected the niche of *Acrossocheilus paradoxus* by more than 10%, with which the biggest effect was 69% by *Ctenopharyngodon idella*. An additional 32 species had less than a 10% effect on the rate of the niche variation of *Acrossocheilus paradoxus*.

3.1.2.2.38 Acrossocheilus clivosius (Lin, 1935)

The niche variation of *Acrossocheilus clivosius* (Lin, 1935) ranged from 0% to 5774% in the absence of different species (see figure 3.43). Among the 103 species of fish, 15 species were mutually beneficial to *Acrossocheilus clivosius*. There were 2 species that had more than a 10% effect on the niche of *Acrossocheilus clivosius*. Of these, in which the largest effect was 57% by *Lcucosoma chinensis*. There were 88 species of fish in competitive relationships with *Acrossocheilus clivosius*. There were 76 species that affected the niche of *Acrossocheilus clivosius* by more than 10%, in which the biggest effect was 5774% by *Hypophthalmichthys molitrix*. An additional 25 species had less than a 10% effect on the rate of the niche variation of *Acrossocheilus clivosius*.

3.1.2.2.39 Acrossocheilus iridescens iridescens (Nichols and Pope, 1927)

The niche variation of *Acrossocheilus iridescens iridescens* (Nichols and Pope, 1927) ranged from 0% to 56% in the absence of different species (see figure 3.44). Among the 103 species of fish, 100 species were mutually beneficial to *Acrossocheilus iridescens iridescens*. There were 92 species that had more than a 10% effect on the niche of *Acrossocheilus iridescens iridescens*. Of these, in which the largest effect was 56% by *Takifugu ocellatus*. There were 3 species of fish in competitive relationships with *Acrossocheilus iridescens iridescens*. No species affected the niche of *Acrossocheilus iridescens iridescens* by more than 10%, with which the biggest effect was 2% by *Cyprinus carpio Linnaeus*. An additional 11 species had less than a 10% effect on the rate of the niche variation of *Acrossocheilus iridescens iridescens*.

3.1.2.2.40 Acrossocheilus fasciatus (Steindachner, 1892)

The niche variation of *Acrossocheilus fasciatus* (Steindachner, 1892) ranged from 0% to 96% in the absence of different species (see figure 3.45). Among the 103 species of fish, 81 species were mutually beneficial to *Acrossocheilus fasciatus*. All of those species had more than a 10% effect on the niche of *Acrossocheilus fasciatus*. Of these, in which the largest effect was 96% by *Carassius auratus auratus*. There were 22 species of fish in competitive relationships with *Acrossocheilus fasciatus*. There were 20 species that affected the niche of *Acrossocheilus fasciatus*

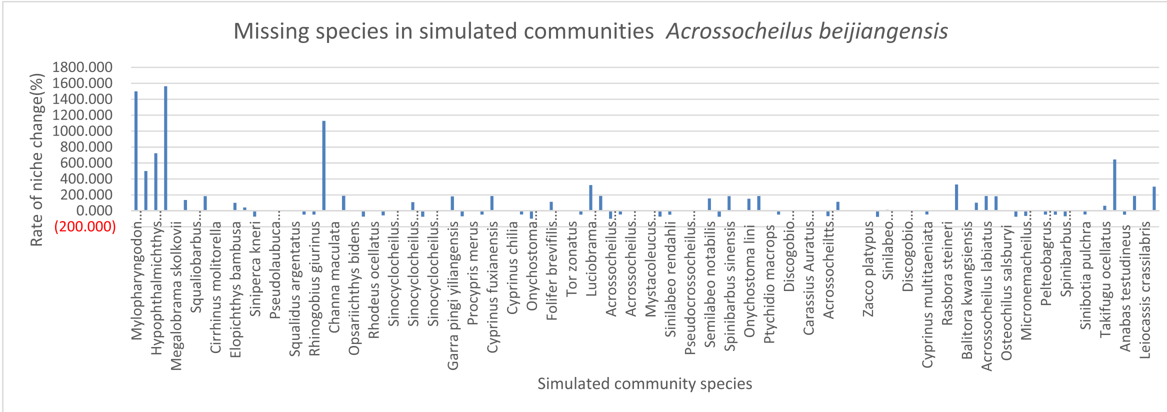

FIG. 3.41 – The responses of the niches of *Acrossocheilus beijiangensis* to various missing fish in the simulated community.

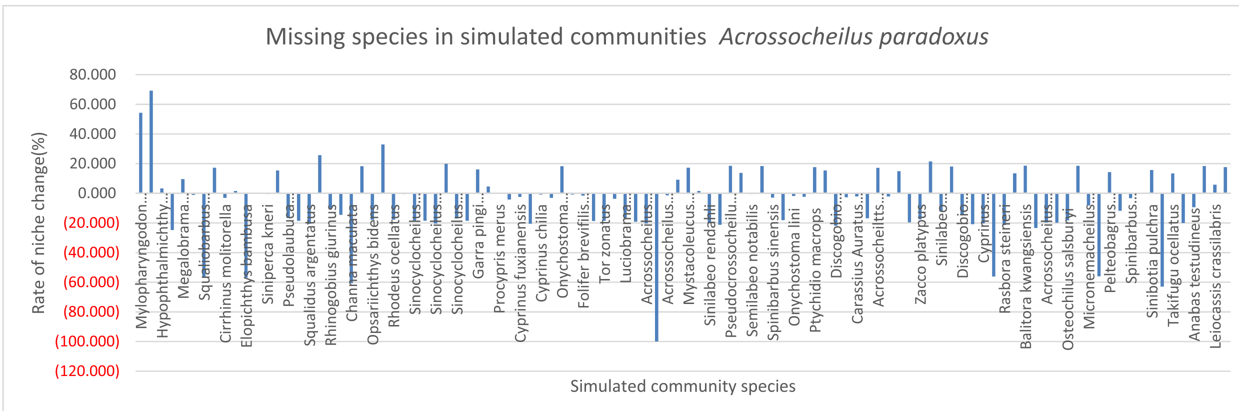

FIG. 3.42 – The responses of the niches of *Acrossocheilus paradoxus* to various missing fish in the simulated community.

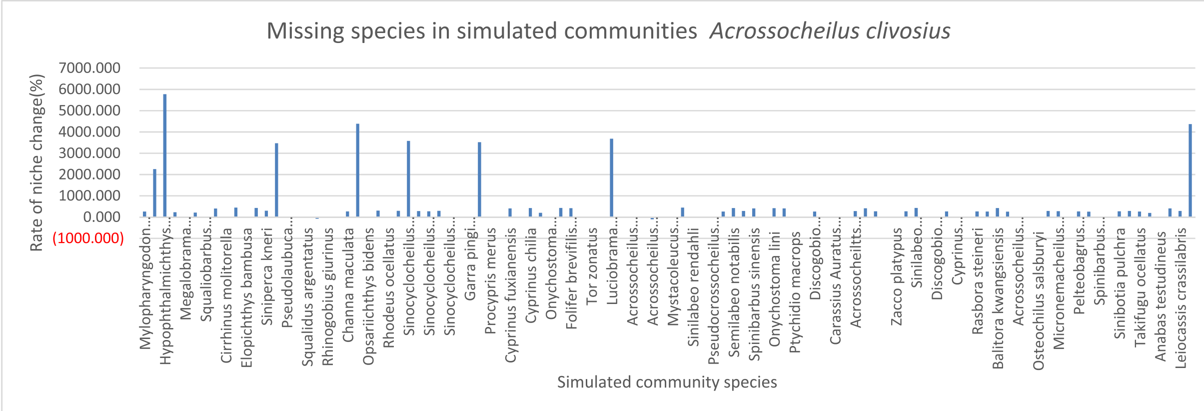

Fig. 3.43 – The responses of the niches of *Acrossocheilus clivosius* to various missing fish in the simulated community.

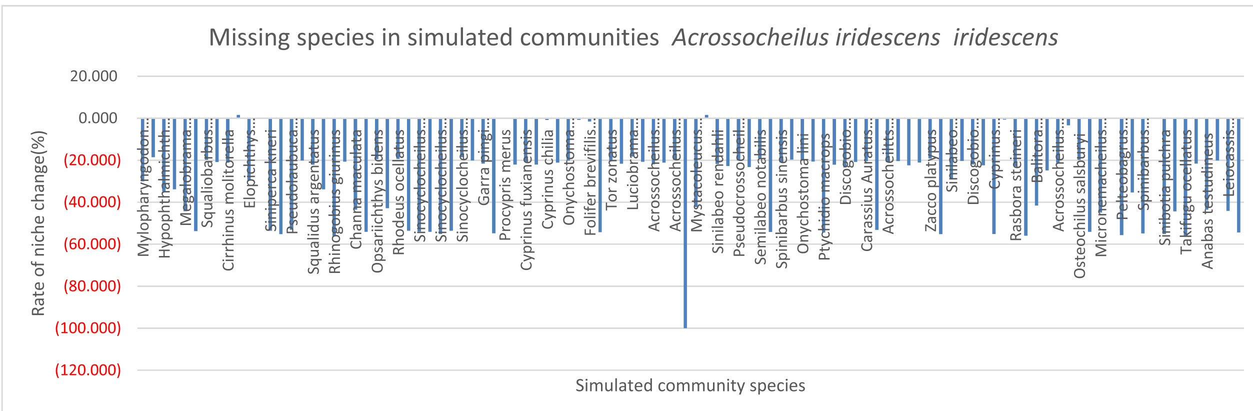

Fig. 3.44 – The responses of the niches of *Acrossocheilus iridescens indescens* to various missing fish in the simulated community.

by more than 10%, with which the biggest effect was 230% by *Lateolabrax japonicus*. An additional 3 species had less than a 10% effect on the rate of the niche variation of *Acrossocheilus fasciatus*.

3.1.2.2.41 Acrossocheiltts elongatus (Pellegrin and Chevey, 1934)

The niche variation of *Acrossocheiltts elongatus* (Pellegrin and Chevey, 1934) ranged from 0% to 579% in the absence of different species (see figure 3.46). Among the 103 species of fish, 54 species were mutually beneficial to *Acrossocheiltts elongatus*. There were 2 species that had more than a 10% effect on the niche of *Acrossocheiltts elongatus*. Of these, in which the largest effect was 63% by *Tachysurus argentivittatus*. There were 49 species of fish in competitive relationships with *Acrossocheiltts elongatus*. There were 27 species that affected the niche of *Acrossocheiltts elongatus* by more than 10%, in which the biggest effect was 579% by *Hypophthalmichthys molitrix*. An additional 74 species had less than a 10% effect on the rate of the niche variation of *Acrossocheiltts elongatus*.

3.1.2.2.42 Acrossocheilus labiatus (Regan, 1908)

The niche variation of *Acrossocheilus labiatus* (Regan, 1908) ranged from 0% to 284% in the absence of different species (see figure 3.47). Among the 103 species of fish, 40 species were mutually beneficial to *Acrossocheilus labiatus*. There were 22 species that had more than a 10% effect on the niche of *Acrossocheilus labiatus*. Of these, in which the largest effect was 49% by *Semilabeo notabilis*. There were 63 species of fish in competitive relationships with *Acrossocheilus labiatus*. There were 55 species that affected the niche of *Acrossocheilus labiatus* by more than 10%, with which the biggest effect was 284% by *Ctenopharyngodon idella*. An additional 26 species had less than a 10% effect on the rate of the niche variation of *Acrossocheilus labiatus*.

3.1.2.2.43 Onychostoma macrolepis (Bleeker, 1871)

The niche variation of *Onychostoma macrolepis* (Bleeker, 1871) ranged from 0% to 459% in the absence of different species (see figure 3.48). Among the 103 species of fish, 42 species were mutually beneficial to *Onychostoma macrolepis*. There were 24 species that had more than a 10% effect on the niche of *Onychostoma macrolepis*. Of these, in which the largest effect was 99% by *Lateolabrax japonicus*. There were 61 species of fish in competitive relationships with *Onychostoma macrolepis*. There were 52 species that affected the niche of *Onychostoma macrolepis* by more than 10%, with which the biggest effect was 459% by *Pelteobagrus fulvidraco*. An additional 27 species had less than a 10% effect on the rate of the niche variation of *Onychostoma macrolepis*.

3.1.2.2.44 Onychostoma sima (Sauvage and Dabry, 1874)

The niche variation of *Onychostoma sima* (Sauvage and Dabry, 1874) ranged from 0% to 970% in the absence of different species (see figure 3.49). Among the 103 species of fish, 92 species were mutually beneficial to *Onychostoma sima*. There were 14 species that had more than a 10% effect on the niche of *Onychostoma sima*. Of

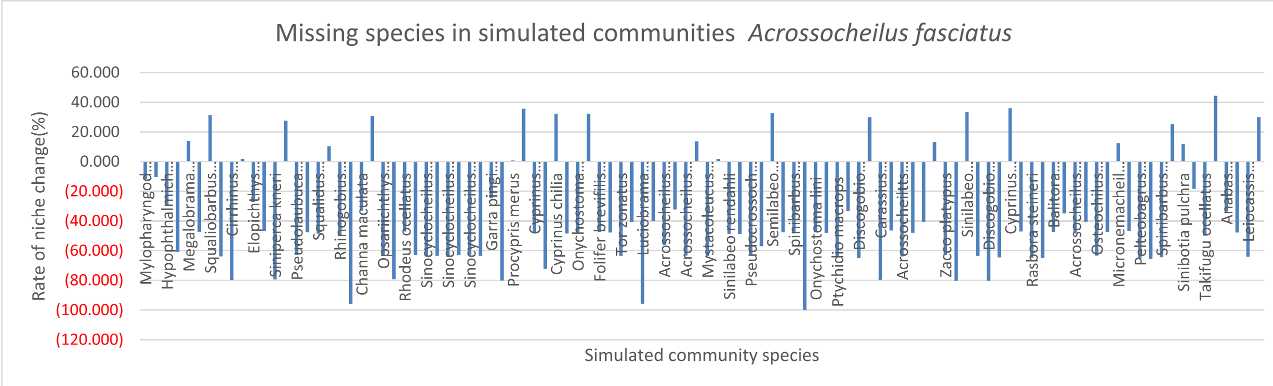

FIG. 3.45 – The responses of the niches of *Acrossocheilus fasciatus* to various missing fish in the simulated community.

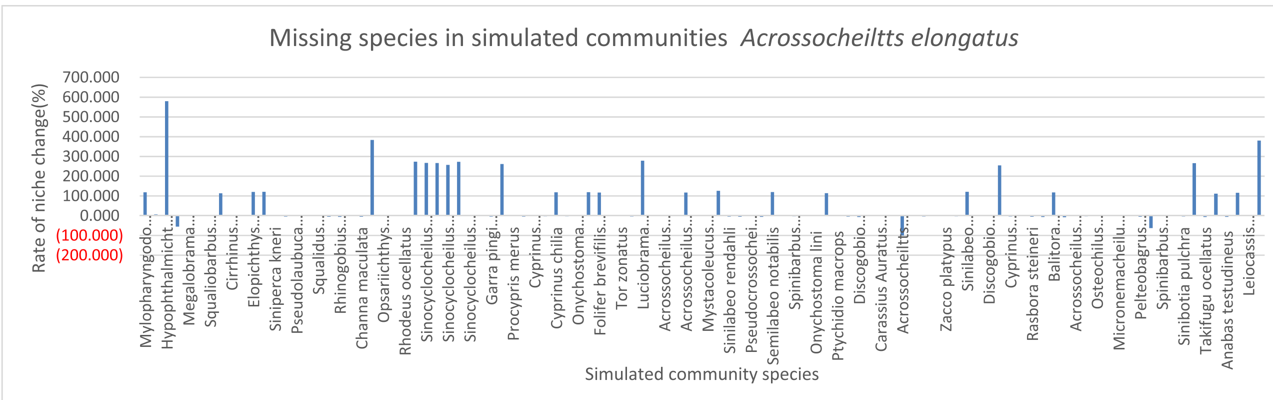

FIG. 3.46 – The responses of the niches of *Acrossocheiltts elongatus* to various missing fish in the simulated community.

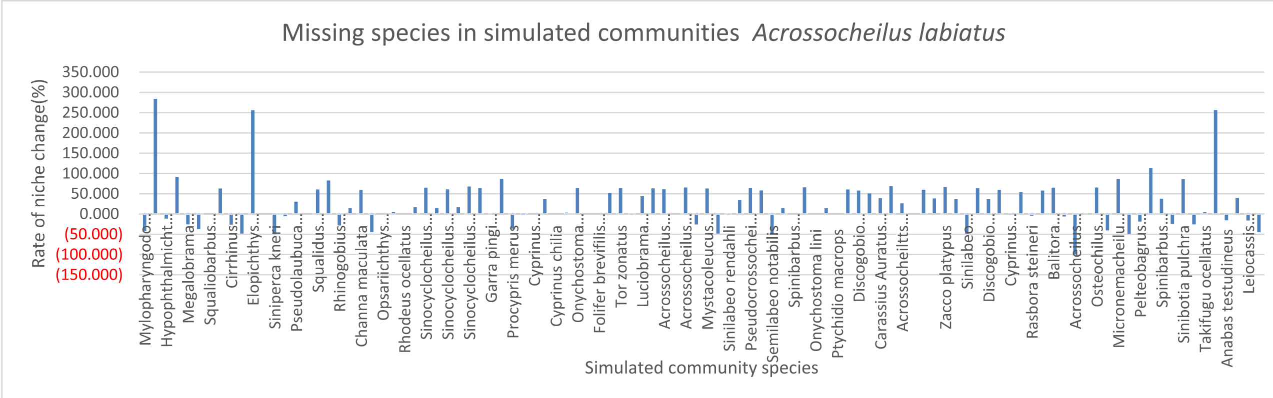

FIG. 3.47 – The responses of the niches of *Acrossocheilus labiatus* to various missing fish in the simulated community.

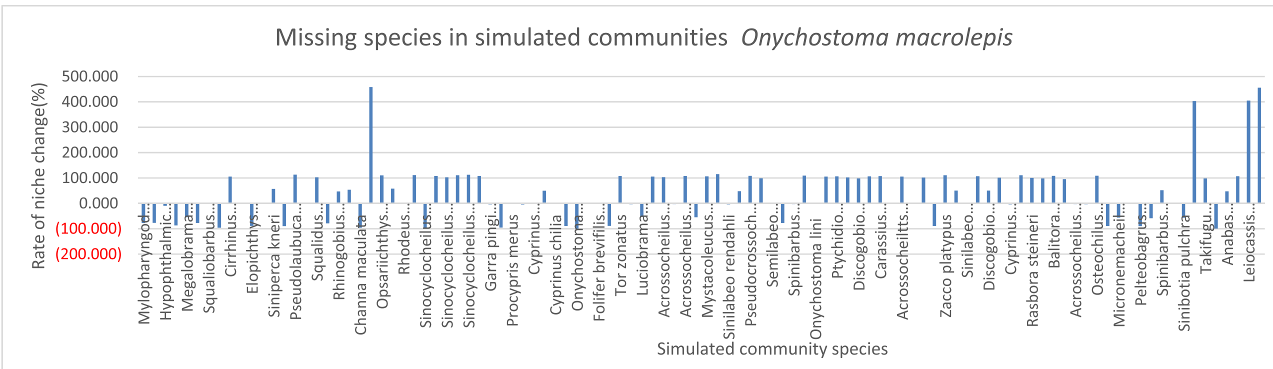

FIG. 3.48 – The responses of the niches of *Onychostoma macrolepis* to various missing fish in the simulated community.

these, in which the largest effect was 97% by *Luciobrama macrocephalus*. There were 11 species of fish in competitive relationships with *Onychostoma sima*. There were 2 species that affected the niche of *Onychostoma sima* by more than 10%, with which the biggest effect was 21% by *Sinilabeo discognathoides*. An additional 87 species had less than a 10% effect on the rate of the niche variation of *Onychostoma sima*.

3.1.2.2.45 Onychostoma lini (Wu, 1939)

The niche variation of *Onychostoma lini* (Wu, 1939) ranged from 0% to 1991% in the absence of different species (see figure 3.50). Among the 103 species of fish, 3 species were mutually beneficial to *Onychostoma lini*. There were 2 species that had more than a 10% effect on the niche of *Onychostoma lini*. Of these, in which the largest effect was 50% by *Leiocassis crassilabris*. There were 86 species of fish in competitive relationships with *Onychostoma lini*. There were 85 species that affected the niche of *Onychostoma lini* by more than 10%, in which the biggest effect was 1991% by *Hypophthalmichthys molitrix*. An additional 15 species had less than a 10% effect on the rate of the niche variation of *Onychostoma lini*.

3.1.2.2.46 Onychostoma barbatulum (Pellegrin, 1908)

The niche variation of *Onychostoma barbatulum* (Pellegrin, 1908) ranged from 0% to 2006% in the absence of different species (see figure 3.51). Among the 103 species of fish, 61 species were mutually beneficial to *Onychostoma barbatulum*. There were 34 species that had more than a 10% effect on the niche of *Onychostoma barbatulum*. Of these, in which the largest effect was 80% by *Sinilabeo rendahli*. There were 41 species of fish in competitive relationships with *Onychostoma barbatulum*. There were 30 species that affected the niche of *Onychostoma barbatulum* by more than 10%, in which the biggest effect was 2006% by *Hypophthalmichthys molitrix*. An additional 39 species had less than a 10% effect on the rate of the niche variation of *Onychostoma barbatulum*.

3.1.2.2.47 Onychostoma ovalis rhomboides (Tang, 1942)

The niche variation of *Onychostoma ovalis rhomboides* (Tang, 1942) ranged from 0% to 4618% in the absence of different species (see figure 3.52). Among the 103 species of fish, No species were mutually beneficial to *Onychostoma ovalis rhomboides*. All the species were competitive relationships with *Onychostoma ovalis rhomboides* by more than 200%, and 4618% with *Ctenopharyngodon idella*.

3.1.2.2.48 Folifer brevifilis brevifilis (Peters, 1881)

The niche variation of *Folifer brevifilis brevifilis* (Peters, 1881) ranged from 0% to 228% in the absence of different species (see figure 3.53). Among the 103 species of fish, 21 species were mutually beneficial to *Lcucosoma chinensis*. There were 7 species that had more than a 10% effect on the niche of *Lcucosoma chinensis*. Of these, in which the largest effect was 91% by *Hypophthalmichthys nobilis*. There were 82 species of fish in competitive relationships with *Lcucosoma chinensis*. There were 73 species that affected the niche of *Lcucosoma chinensis* by more than 10%, with which the biggest effect being 228% by *Hypophthalmichthys molitrix*. An additional

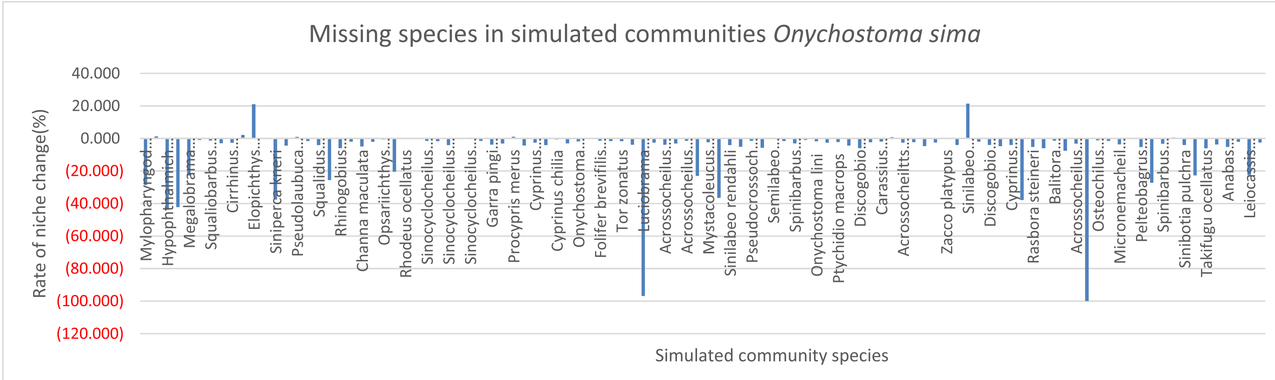

Fig. 3.49 – The responses of the niches of *Onychostoma sima* responses to various missing fish in the simulated community.

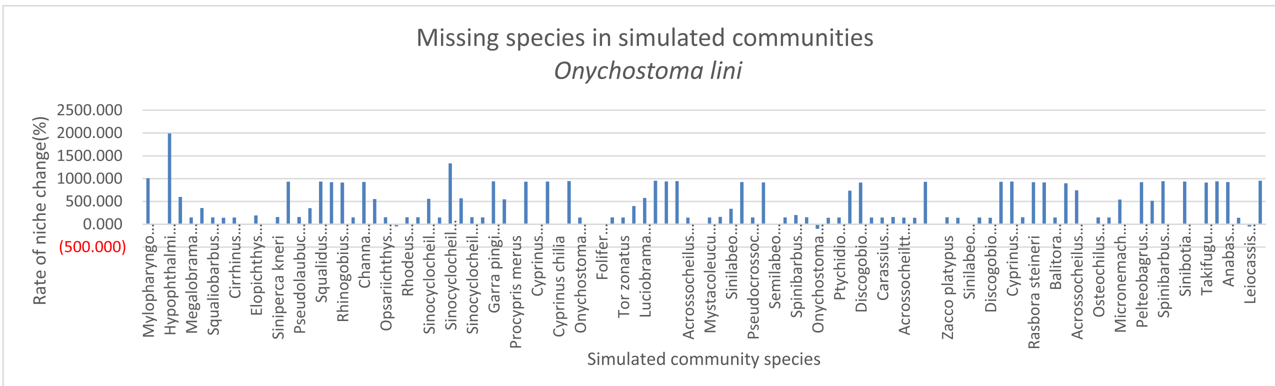

Fig. 3.50 – The responses of the niches of *Onychostoma lini* to various missing fish in the simulated community.

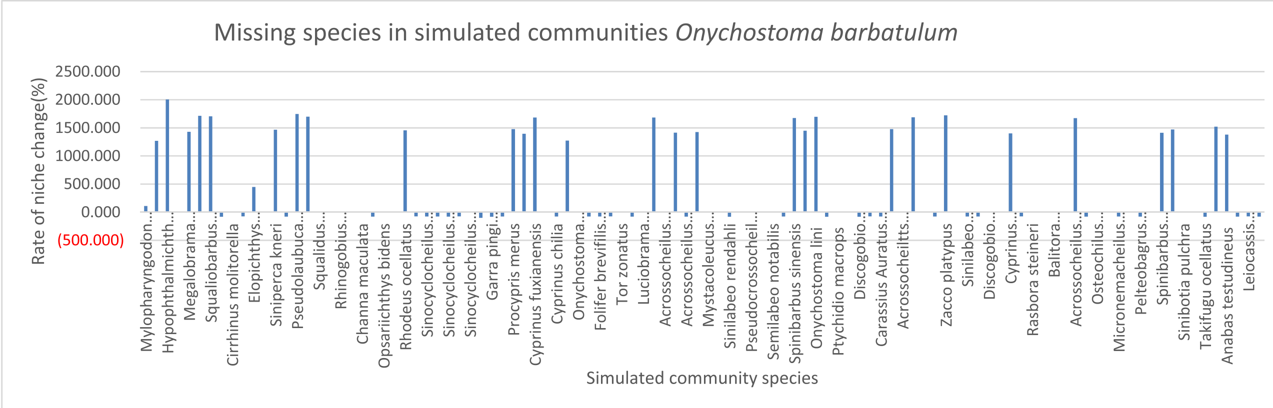

Fig. 3.51 – The responses of the niches of *Onychostoma barbatulum* to various missing fish in the simulated community.

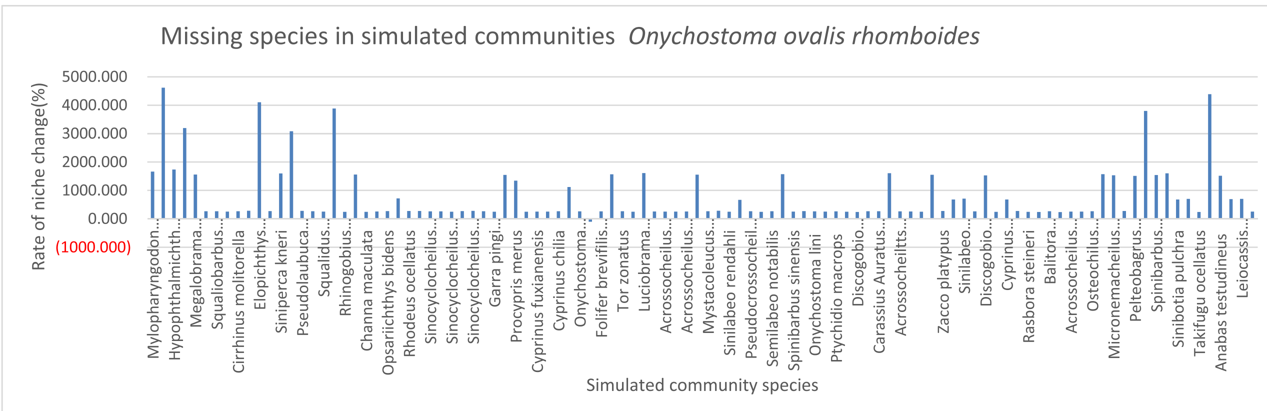

Fig. 3.52 – The responses of the niches of *Onychostoma ovalis rhomboides* to various missing fish in the simulated community.

23 species had less than a 10% effect on the rate of the niche variation of *Lcucosoma chinensis*.

3.1.2.2.49 Tor sinensis (Wu, 1977)

The niche variation of *Tor sinensis* (Wu, 1977) ranged from 0% to 65% in the absence of different species (see figure 3.54). Among the 103 species of fish, 63 species were mutually beneficial to *Tor sinensis*. There were 40 species that had more than a 10% effect on the niche of *Tor sinensis*. Of these, in which the largest effect was 65% by *Pelteobagrus vachellii*. There were 40 species of fish in competitive relationships with *Tor sinensis* by more than 10%, in which the biggest effect was 253% by *Hypophthalmichthys molitrix Tor sinensis* (Wu, 1977). An additional 62 species had less than a 10% effect on the rate of the niche variation of *Tor sinensis*.

3.1.2.2.50 Tor zonatus (Lin, 1935)

The niche variation of *Tor zonatus* (Lin, 1935) ranged from 0% to 3994% in the absence of different species (see figure 3.55). Among the 103 species of fish, 2 species were mutually beneficial to *Tor zonatus*. One of the species that had more than a 10% effect on the niche of *Tor zonatus*. In which the largest effect was 56% by *Tachysurus argentivittatus*. There were 101 species of fish in competitive relationships with *Tor zonatus*. There were 59 species that affected the niche of *Tor zonatus* by more than 10%, with which the biggest effect was 399% by *Hypophthalmichthys molitrix*. An additional 43 species had less than a 10% effect on the rate of the niche variation of *Tor zonatus*.

3.1.2.2.51 Bangana decora (Peters, 1881)

The niche variation of *Bangana decora* (Peters, 1881) ranged from 0% to 98% in the absence of different species (see figure 3.56). Among the 103 species of fish, 87 species were mutually beneficial to *Bangana decora*. There were 71 species that had more than a 10% effect on the niche of *Bangana decora*. Of these, in which the largest effect was 98% by *Sinocyclocheilus macrocephalus*. There were 16 species of fish in competitive relationships with *Bangana decora*. There were 11 species that affected the niche of *Bangana decora* by more than 10%, with which the biggest effect was 37% by *Cyprinus carpio*. An additional 21 species had less than a 10% effect on the rate of the niche variation of *Bangana decora*.

3.1.2.2.52 Sinilabeo rendahli (Kimura, 1934)

The niche variation of *Sinilabeo rendahli* (Kimura, 1934) ranged from 0% to 3930% in the absence of different species (see figure 3.57). Among the 103 species of fish, 7 species were mutually beneficial to *Sinilabeo rendahli*. There were 2 species that had more than a 10% effect on the niche of *Sinilabeo rendahli*. The largest effect was 91% by *Hypophthalmichthys nobilis*. There were 96 species of fish in competitive relationships with *Sinilabeo rendahli*. There were 66 species that affected the niche of *Sinilabeo rendahli* by more than 10%, with which the biggest effect was 3930% by *Elopichthys bambusa*. An additional 35 species had less than a 10% effect on the rate of the niche variation of *Sinilabeo rendahli*.

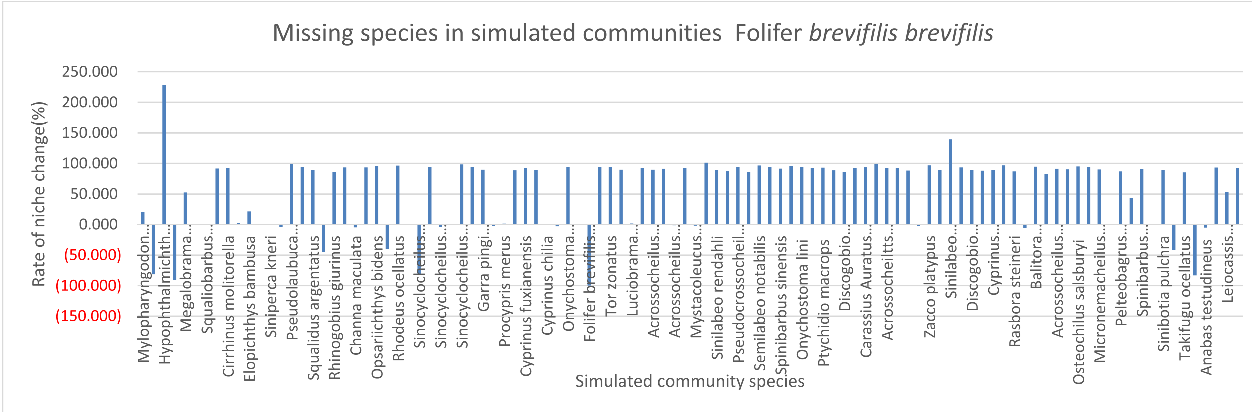

Fig. 3.53 – The responses of the niches of *Folifer brevifilis brevifilis* to various missing fish in the simulated community.

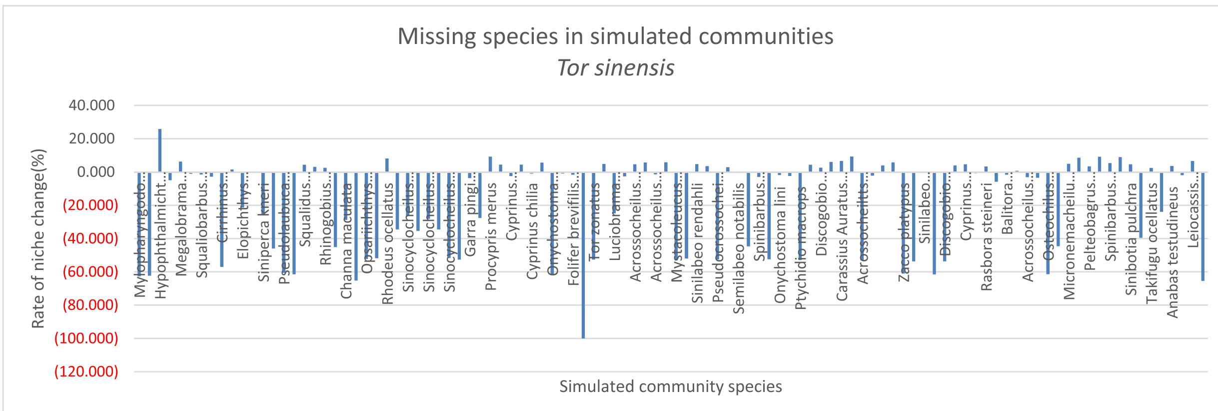

Fig. 3.54 – The responses of the niches of *Tor sinensis* to various missing fish in the simulated community.

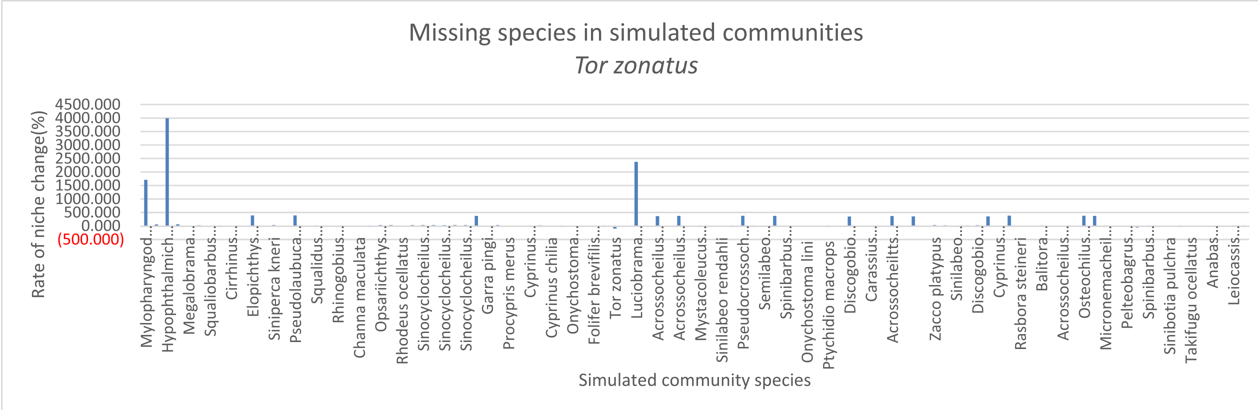

Fig. 3.55 – The responses of the niches of *Tor zonatus* to various missing fish in the simulated community.

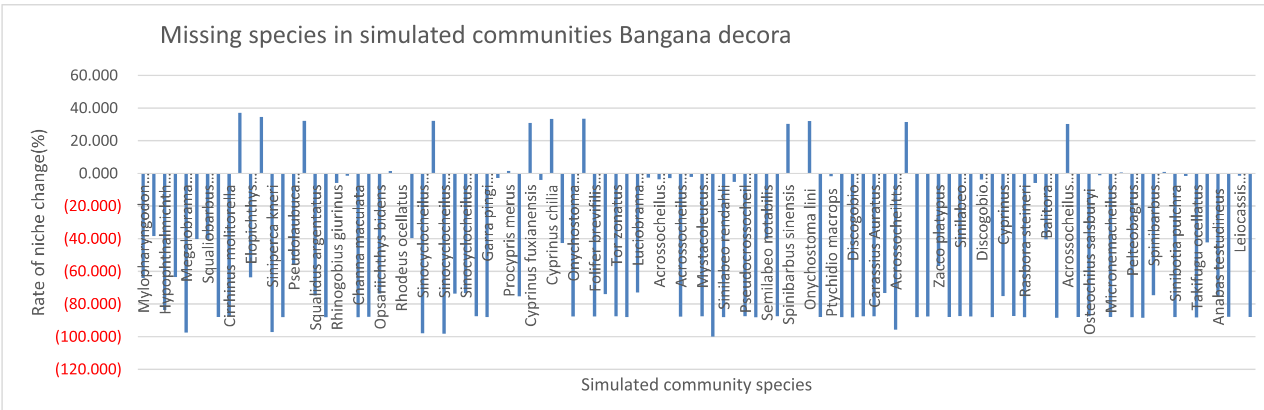

Fig. 3.56 – The responses of the niches of *Bangana decora* to various missing fish in the simulated community.

3.1.2.2.53 Parasinilabeo assimilis (Wu and Yao, 1982)
The niche variation of *Parasinilabeo assimilis* (Wu and Yao, 1982) ranged from 0% to 1049% in the absence of different species (see figure 3.58). Among the 103 species of fish, 65 species were mutually beneficial to *Parasinilabeo assimilis*. There were 34 species that had more than a 10% effect on the niche of *Parasinilabeo assimilis*. Of these, in which the largest effect was 34% by *Puntius semifasciolatus*. There were 38 species of fish in competitive relationships with *Parasinilabeo assimilis*. There were 19 species that affected the niche of *Parasinilabeo assimilis* by more than 10%, in which the biggest effect was 1049% by *Hypophthalmichthys molitrix*. An additional 50 species had less than a 10% effect on the rate of the niche variation of *Parasinilabeo assimilis*.

3.1.2.2.54 Sinilabeo discognathoides (Nichols and Pope, 1927)
The niche variation of *Sinilabeo discognathoides* (Nichols and Pope, 1927) ranged from 0% to 273% in the absence of different species (see figure 3.59). Among the 103 species of fish, 11 species were mutually beneficial to *Sinilabeo discognathoides*. No species had more than a 10% effect on the niche of *Sinilabeo discognathoides*. Of these, in which the largest effect was 4% by *Anabas testudineus*. There were 92 species of fish in competitive relationships with *Sinilabeo discognathoides*. There were 68 species that affected the niche of *Sinilabeo discognathoides* by more than 10%, with which the biggest effect was 273% by *Luciobrama macrocephalus*. An additional 35 species had less than a 10% effect on the rate of the niche variation of *Sinilabeo discognathoides*.

3.1.2.2.55 Sinilabeo discognathoides wui (Zheng and Chen, 1983)
The niche variation of *Sinilabeo discognathoides wui* (Zheng and Chen, 1983) ranged from 0% to 1097% in the absence of different species (see figure 3.60). Among the 103 species of fish, 32 species were mutually beneficial to *Sinilabeo discognathoides wui*. There were 13 species that had more than a 10% effect on the niche of *Sinilabeo discognathoides wui*. Of these, in which the largest effect was 88% by *Tachysurus argentivittatus*. There were 71 species of fish in competitive relationships with *Sinilabeo discognathoides wui*. There were 54 species that affected the niche of *Sinilabeo discognathoides wui* by more than 10%, in which the biggest effect was 1097% by *Bangana decora*. An additional 46 species had less than a 10% effect on the rate of the niche variation of *Sinilabeo discognathoides wui*.

3.1.2.2.56 Cirrhinus molitorella (Valenciennes, 1844)
The niche variation of *Cirrhinus molitorella* (Valenciennes, 1844) ranged from 0% to 369% in the absence of different species (see figure 3.61). Among the 103 species of fish, 70 species were mutually beneficial to *Cirrhinus molitorella*. There were 54 species that had more than a 10% effect on the niche of *Cirrhinus molitorella*. Of these, in which the largest effect was 79% by *Hypophthalmichthys nobilis*. There were 33 species of fish in competitive relationships with *Cirrhinus molitorella*. There were 19 species that affected the niche of *Cirrhinus molitorella* by more than 10%, with which the biggest effect being 369% by *Hypophthalmichthys molitrix*. An additional

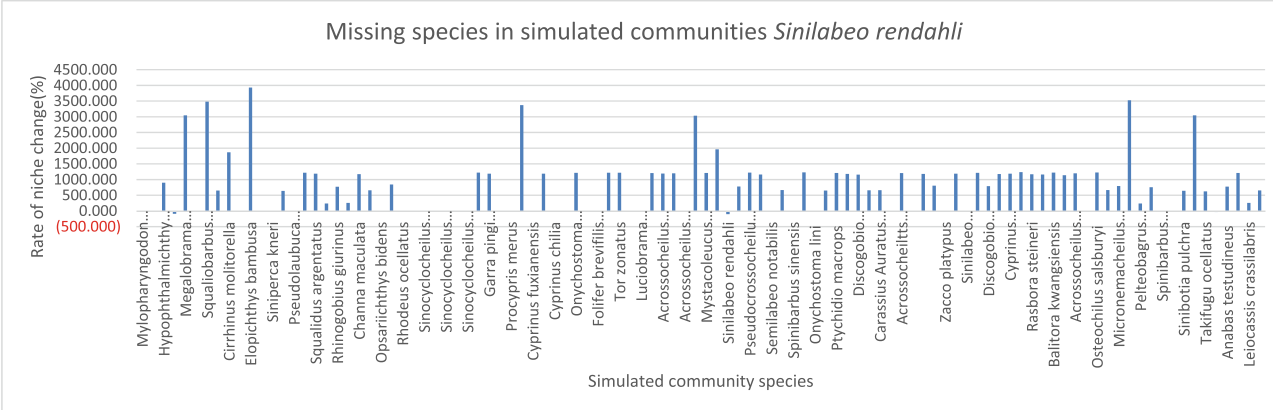

FIG. 3.57 – The responses of the niches of *Sinilabeo rendahli* to various missing fish in the simulated community.

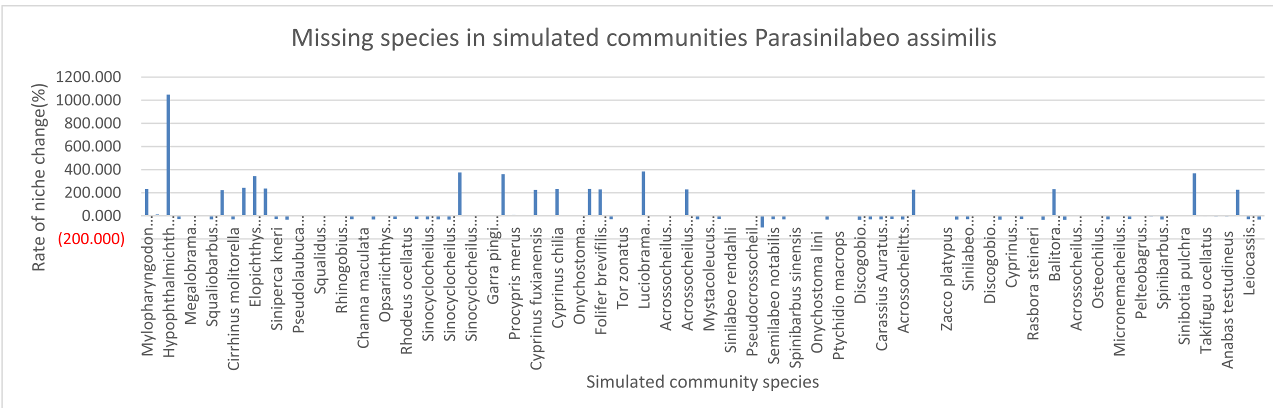

FIG. 3.58 – The responses of the niches of *Parasinilabeo assimilis* to various missing fish in the simulated community.

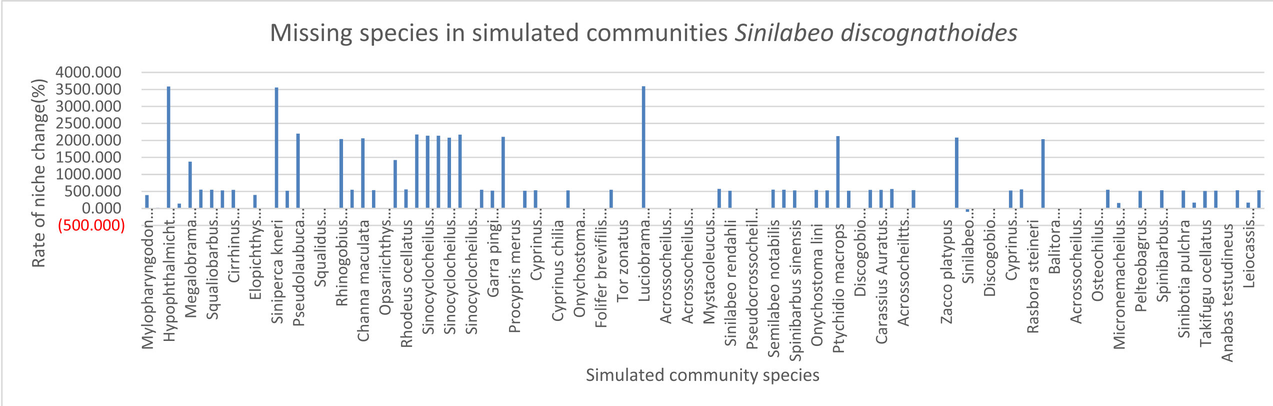

FIG. 3.59 – The responses of the niches of *Sinilabeo discognathoides* to various missing fish in the simulated community.

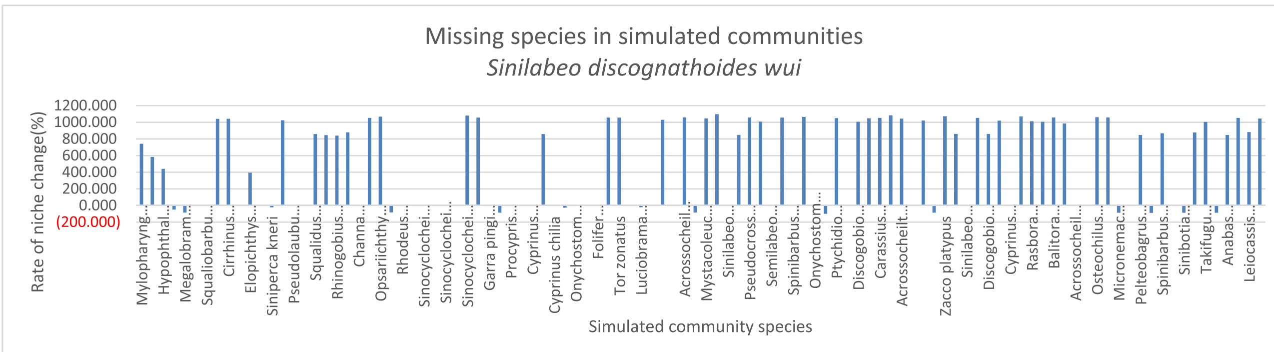

FIG. 3.60 – The responses of the niches of *Sinilabeo discognathoides wui* to various missing fish in the simulated community.

23 species had less than a 10% effect on the rate of the niche variation of *Cirrhinus molitorella*.

3.1.2.2.57 Rectoris posehensis (Lin, 1935)

The niche variation of *Rectoris posehensis* (Lin, 1935) ranged from 0% to 6097% in the absence of different species (see figure 3.62). Among the 103 species of fish, 33 species were mutually beneficial to *Rectoris posehensis*. There were 3 species that had more than a 10% effect on the niche of *Rectoris posehensis*. Of these, in which the largest effect was 49% by *Rectoris posehensis*. There were 70 species of fish in competitive relationships with *Rectoris posehensis*. There were 33 species that affected the niche of *Rectoris posehensis* by more than 10%, with which the biggest effect was 6097% by *Rectoris posehensis*. An additional 68 species had less than a 10% effect on the rate of the niche variation of *Rectoris posehensis*.

3.1.2.2.58 Semilabeo obscurus (Lin, 1981)

The niche variation of *Semilabeo obscurus* (Lin, 1981) ranged from 0% to 97% in the absence of different species (see figure 3.63). Among the 103 species of fish, 71 species were mutually beneficial to *Semilabeo obscurus*. There were 11 species that had more than a 10% effect on the niche of *Semilabeo obscurus*. Of these, in which the largest effect was 97% by *Sinilabeo rendahli*. There were 11 species of fish in competitive relationships with *Semilabeo obscurus*. There were 5 species that affected the niche of *Semilabeo obscurus* by more than 10%, with which the biggest effect was 95% by *Elopichthys bambusa*. An additional 27 species had less than a 10% effect on the rate of the niche variation of *Semilabeo obscurus*.

3.1.2.2.59 Semilabeo notabilis (Peters, 1881)

The niche variation of *Semilabeo notabilis* (Peters, 1881) ranged from 0% to 60% in the absence of different species (see figure 3.64). Among the 103 species of fish, 53 species were mutually beneficial to *Semilabeo notabilis*. There were 21 species that had more than a 10% effect on the niche of *Semilabeo notabilis*. Of these, in which the largest effect was 60% by *Elopichthys bambusa*. There were 50 species of fish in competitive relationships with *Semilabeo notabilis*. There were 3 species that affected the niche of *Semilabeo notabilis* by more than 10%, with which the biggest effect was 22% by *Ancherythroculter lini*. An additional 71 species had less than a 10% effect on the rate of the niche variation of *Semilabeo notabilis*.

3.1.2.2.60 Discocheilus wui (Chen en Lan, 1992)

The niche variation of *Discocheilus wui* (Chen en Lan, 1992) ranged from 0% to 1097% in the absence of different species (see figure 3.65). Among the 103 species of fish, 32 species were mutually beneficial to *Discocheilus wui*. There were 9 species that had more than a 10% effect on the niche of *Discocheilus wui*. Of these, in which the largest effect was 25% by *Ochetobius elongatus*. There were 92 species of fish in competitive relationships with *Discocheilus wui*. There were 65 species that affected the niche of *Discocheilus wui* by more than 10%, with which the biggest effect was

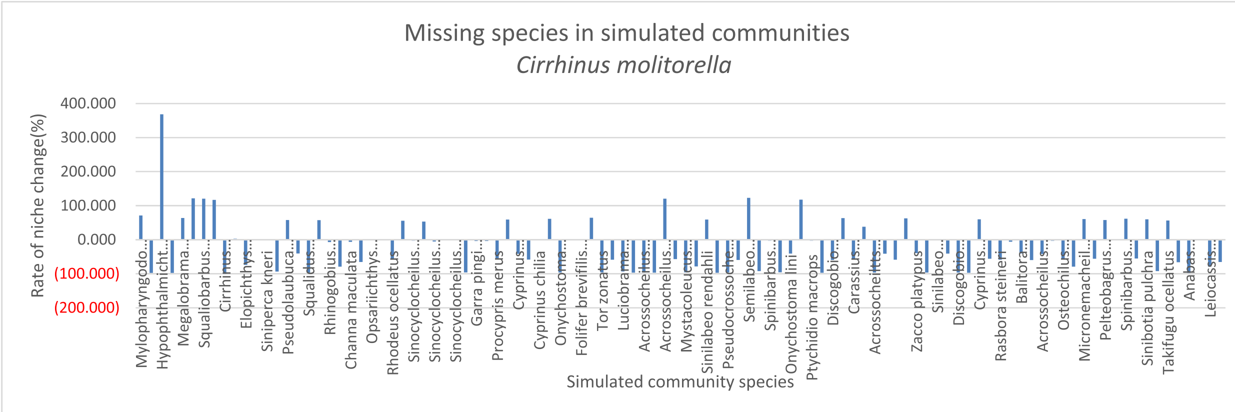

FIG. 3.61 – The responses of the niches of *Cirrhinus molitorella* to various missing fish in the simulated community.

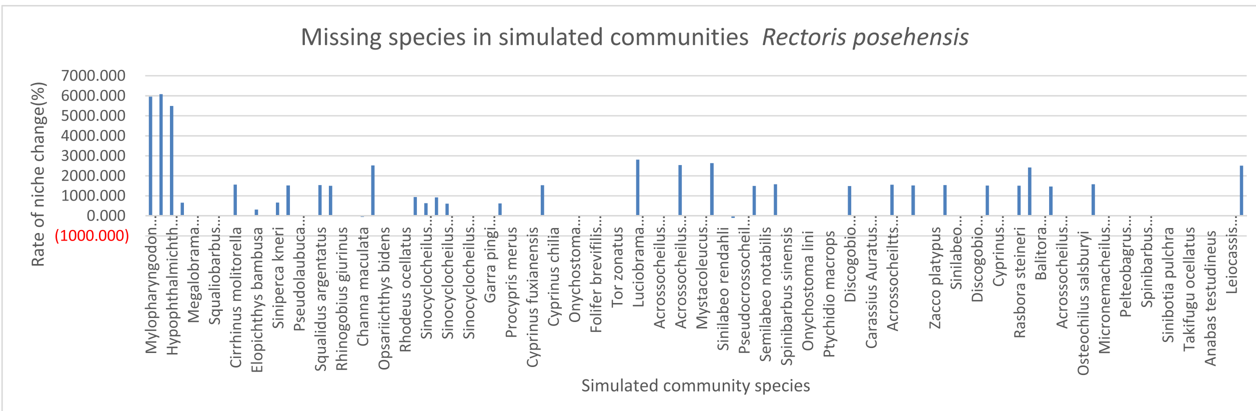

FIG. 3.62 – The responses of the niches of *Rectoris posehensis* to various missing fish in the simulated community.

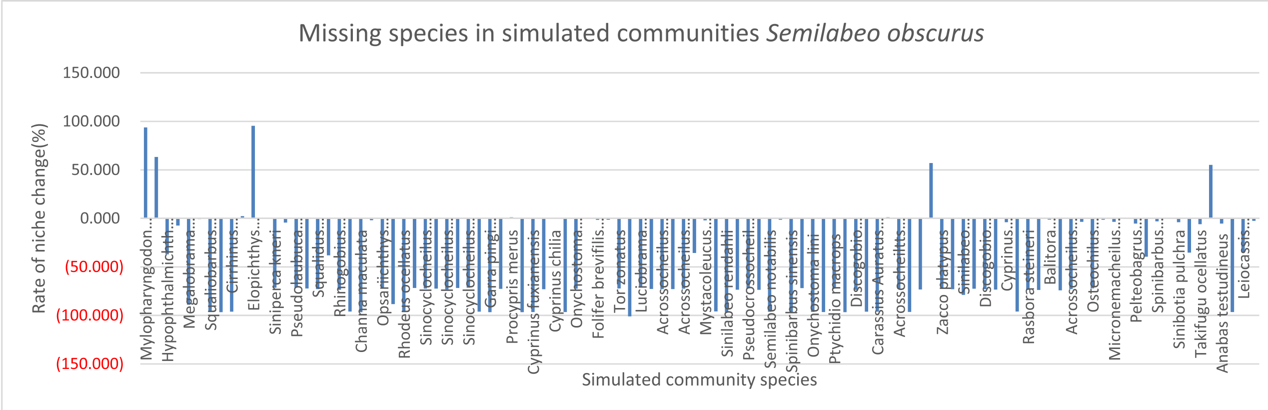

Fig. 3.63 – The responses of the niches of *Semilabeo obscurus* to various missing fish in the simulated community.

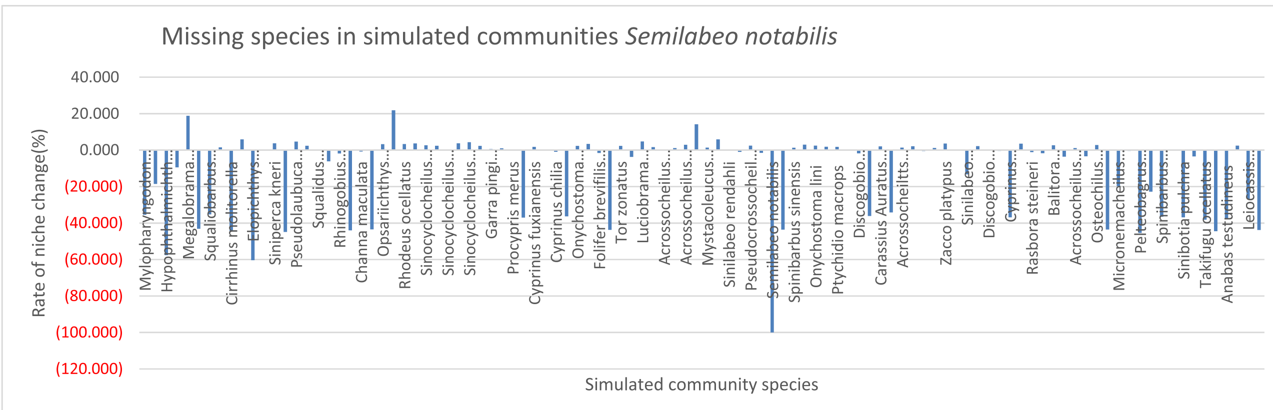

Fig. 3.64 – The responses of the niches of *Semilabeo notabilis* to various missing fish in the simulated community.

99% by *Leiocassis crassilabris*. An additional 46 species had less than a 10% effect on the rate of the niche variation of *Discocheilus wui*.

3.1.2.2.61 Osteochilus salsburyi (Nichols and Pope, 1927)

The niche variation of *Osteochilus salsburyi* (Nichols and Pope, 1927) ranged from 0% to 95% in the absence of different species (see figure 3.66). Among the 103 species of fish, 83 species were mutually beneficial to *Osteochilus salsburyi*. There were 50 species that had more than a 10% effect on the niche of *Osteochilus salsburyi*. Of these, in which the largest effect was 95% by *Elopichthys bambusa*. There were 20 species of fish in competitive relationships with *Osteochilus salsburyi*. There were 15 species that affected the niche of *Osteochilus salsburyi* by more than 10%, with which the biggest effect was 71% by *Luciocyprinus langsoni*. An additional 39 species had less than a 10% effect on the rate of the niche variation of *Osteochilus salsburyi*.

3.1.2.2.62 Pseudocrossocheilus bamaensis (Fang, 1981)

The niche variation of *Pseudocrossocheilus bamaensis* (Fang, 1981) ranged from 0% to 332% in the absence of different species (see figure 3.67). Among the 103 species of fish, 51 species were mutually beneficial to *Pseudocrossocheilus bamaensis*. There were 27 species that had more than a 10% effect on the niche of *Pseudocrossocheilus bamaensis*. Of these, in which the largest effect was 80% by *Hypophthalmichthys nobilis*. There were 52 species of fish in competitive relationships with *Pseudocrossocheilus bamaensis*. There were 46 species that affected the niche of *Pseudocrossocheilus bamaensis* by more than 10%, with which the biggest effect was 332% by *Bangana decora*. An additional 30 species had less than a 10% effect on the rate of the niche variation of *Pseudocrossocheilus bamaensis*.

3.1.2.2.63 Ptychidio macrops (Fang, 1981)

The niche variation of *Ptychidio macrops* (Fang, 1981) ranged from 0% to 243% in the absence of different species (see figure 3.68). Among the 103 species of fish, 42 species were mutually beneficial to *Ptychidio macrops*. There were 11 species that had more than a 10% effect on the niche of *Ptychidio macrops*. Of these, in which the largest effect was 40% by *Hypophthalmichthys nobilis*. There were 61 species of fish in competitive relationships with *Ptychidio macrops*. There were 51 species that affected the niche of *Ptychidio macrops* by more than 10%, with which the biggest effect was 243% by *Luciobrama macrocephalus*. An additional 41 species had less than a 10% effect on the rate of the niche variation of *Ptychidio macrops*.

3.1.2.2.64 Ptychidio jordani (Myers, 1930)

The niche variation of *Ptychidio jordani* (Myers, 1930) ranged from 0% to 86% in the absence of different species (see figure 3.69). Among the 103 species of fish, 31 species were mutually beneficial to *Ptychidio jordani*. There were 3 species that had more than a 10% effect on the niche of *Ptychidio jordani*. Of these, in which the

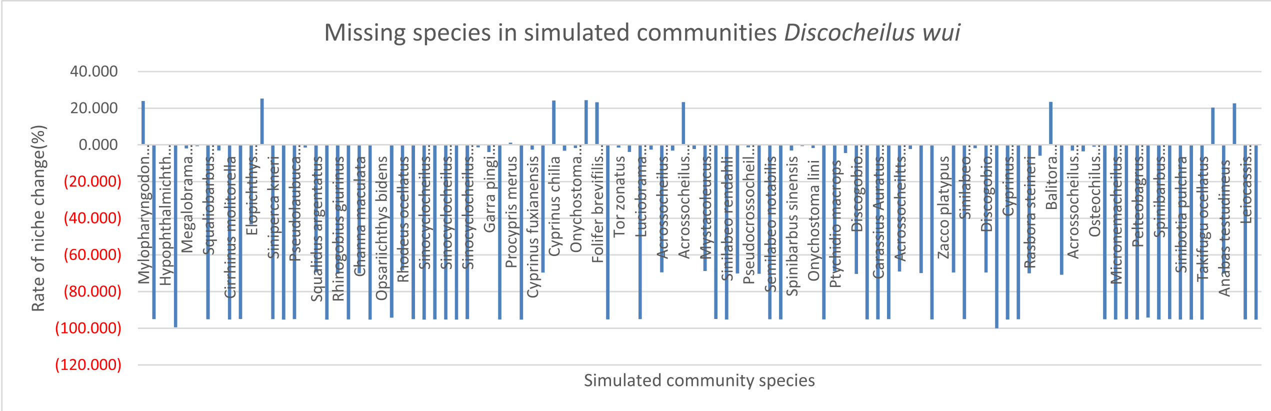

FIG. 3.65 – The responses of the niches of *Discocheilus wui* to various missing fish in the simulated community.

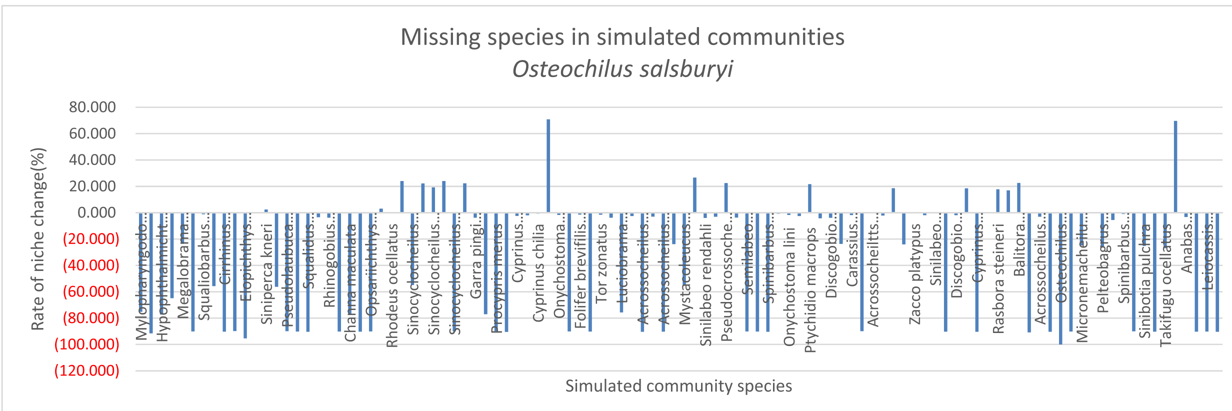

FIG. 3.66 – The responses of the niches of *Osteochilus salsburyi* to various missing fish in the simulated community.

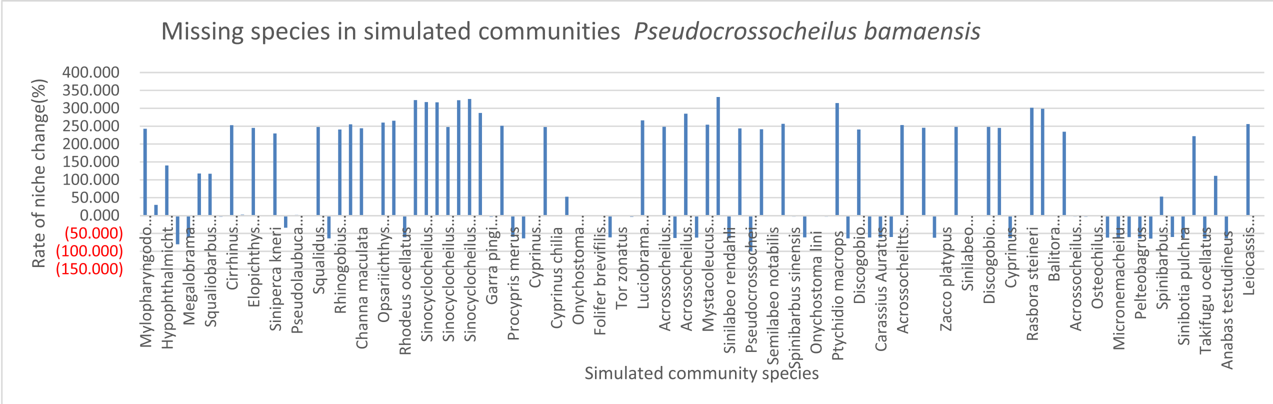

FIG. 3.67 – The responses of the niches of *Pseudocrossocheilus bamaensis* to various missing fish in the simulated community.

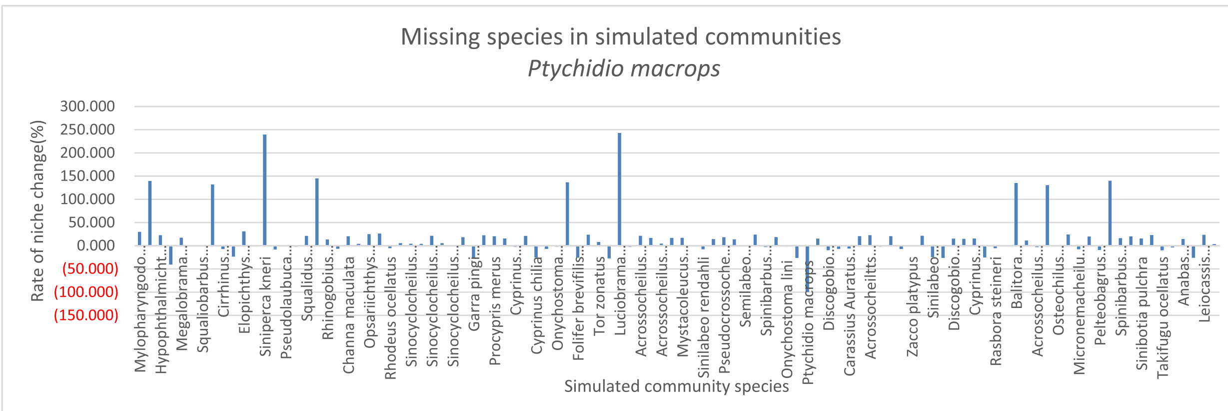

FIG. 3.68 – The responses of the niches of *Ptychidio macrops* to various missing fish in the simulated community.

largest effect was 36% by *Mylopharyngodon piceus*. There were 72 species of fish in competitive relationships with *Ptychidio jordani*. There were 67 species that affected the niche of *Ptychidio jordani* by more than 10%, with which the biggest effect was 86% by *Procypris merus*. An additional 33 species had less than a 10% effect on the rate of the niche variation of *Ptychidio jordani*.

3.1.2.2.65 Garra pingi yiliangensis (Wu and Chen, 1982)

The niche variation of *Garra pingi yiliangensis* (Wu and Chen, 1982) ranged from 0% to near 100% in the absence of different species (see figure 3.70). Among the 103 species of fish, 97 species were mutually beneficial to *Garra pingi yiliangensis*. There were 77 species that had more than a 10% effect on the niche of *Garra pingi yiliangensis*. Of these, in which the largest effect was nearly 100% by *Misgurnus anguillicaudatus*. There were 6 species of fish in competitive relationships with *Garra pingi yiliangensis*. No species affected the niche of *Garra pingi yiliangensis* by more than 10%, with which the biggest effect was 82% by *Cyprinus carpio*. An additional 61 species had less than a 10% effect on the rate of the niche variation of *Garra pingi yiliangensis*.

3.1.2.2.66 Garra pingi hainanensis (Chen and Zheng, 1983)

The niche variation of *Garra pingi hainanensis* (Chen and Zheng, 1983) ranged from 0% to 192% in the absence of different species (see figure 3.71). Among the 103 species of fish, 96 species were mutually beneficial to *Garra pingi hainanensis*. There were 88 species that had more than a 10% effect on the niche of *Garra pingi hainanensis*. Of these, in which the largest effect was 98% by *Anabas testudineus*. There were 7 species of fish in competitive relationships with *Garra pingi hainanensis*. There were 2 species that affected the niche of *Garra pingi hainanensis* by more than 10%, with which the biggest effect was 192% by *LMylopharyngodon piceus*. An additional 13 species had less than a 10% effect on the rate of the niche variation of *Garra pingi hainanensis*.

3.1.2.2.67 Garra pingi pingi (Tchang, 1929)

The niche variation of *Garra pingi pingi* (Tchang, 1929) ranged from 0% to 3207% in the absence of different species (see figure 3.72). Among the 103 species of fish, 57 species were mutually beneficial to *Garra pingi pingi*. There were 16 species that had more than a 10% effect on the niche of *Garra pingi pingi*. Of these, in which the largest effect was 76% by *Ctenopharyngodon idella*. There were 46 species of fish in competitive relationships with *Garra pingi pingi*. There were 32 species that affected the niche of *Garra pingi pingi* by more than 10%, in which the biggest effect was 3207% by *Hypophthalmichthys molitrix*. An additional 24 species had less than a 10% effect on the rate of the niche variation of *Garra pingi pingi*.

3.1.2.2.68 Garra orientalis (Nichols, 1925)

The niche variation of *Garra orientalis* (Nichols, 1925) ranged from 0% to 5216% in the absence of different species (see figure 3.73). Among the 103 species of fish, 14

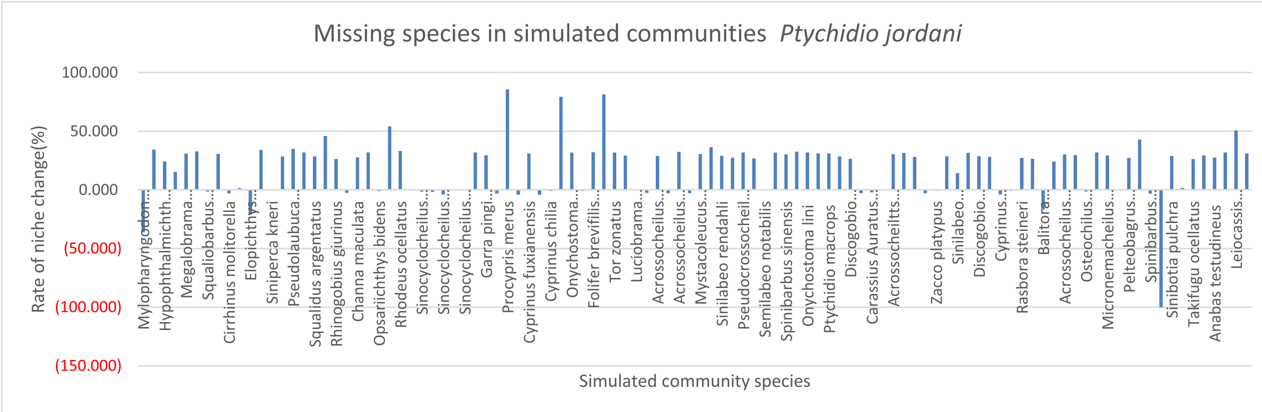

FIG. 3.69 – The responses of the niches of *Ptychidio jordani* to various missing fish in the simulated community.

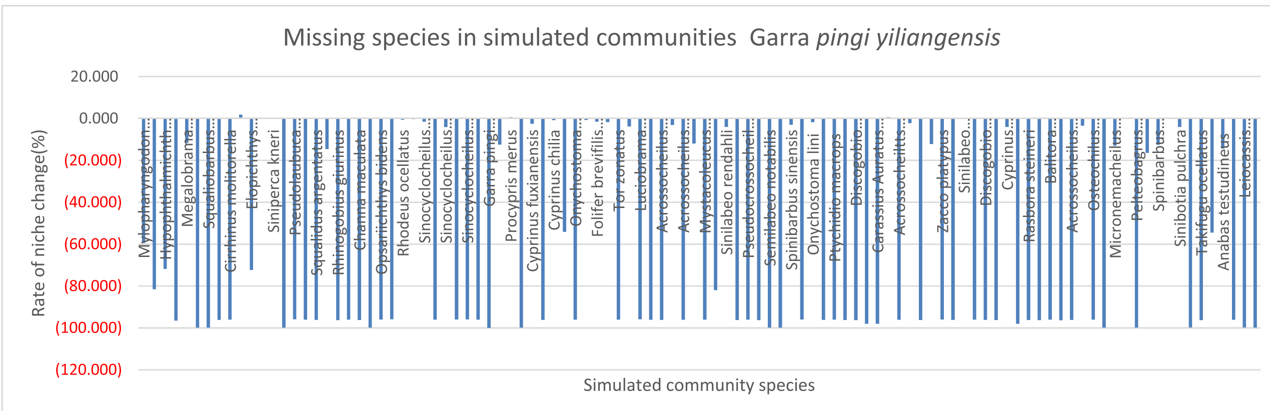

FIG. 3.70 – The responses of the niches of *Garra pingi yiliangensis* to various missing fish in the simulated community.

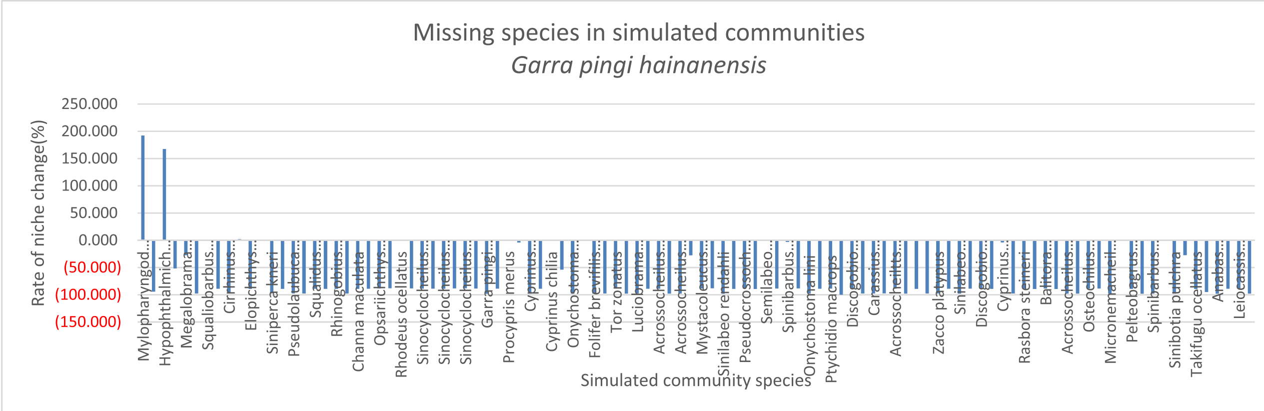

FIG. 3.71 – The responses of the niches of *Garra pingi hainanensis* to various missing fish in the simulated community.

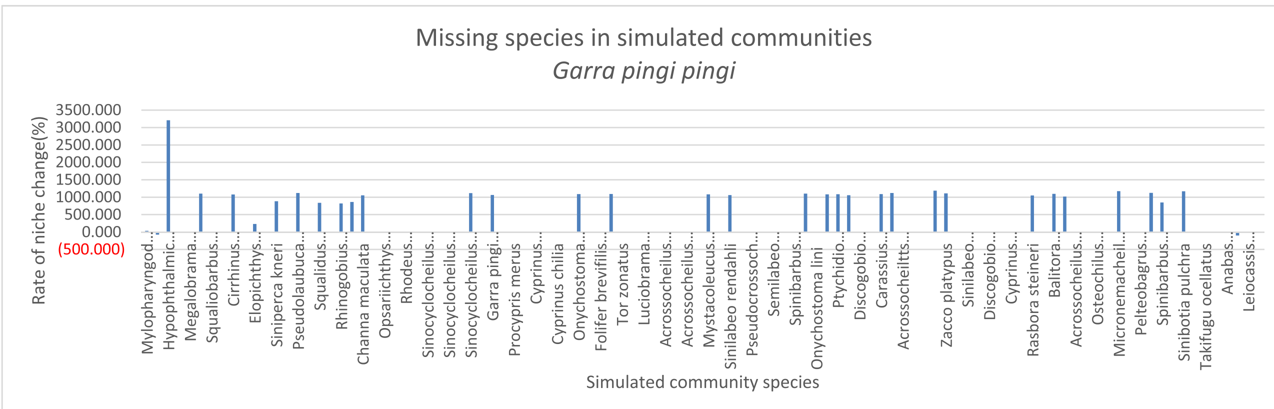

FIG. 3.72 – The responses of the niches of *Garra pingi pingi* to various missing fish in the simulated community.

species were mutually beneficial to *Garra orientalis*. All of the species had more than a 10% effect on the niche of *Garra orientalis*. Of these, in which the largest effect was 70% by *Anabas testudineus*. There were 89 species of fish in competitive relationships with *Garra orientalis*. There were 80 species that affected the niche of *Garra orientalis* by more than 10%, with which the biggest effect was 5216% by *Luciobrama macrocephalus*. An additional 46 species had less than a 10% effect on the rate of the niche variation of *Garra orientalis*.

3.1.2.2.69 Discogobio tetrabarbatus (Lin, 1931)

The niche variation of *Discogobio tetrabarbatus* (Lin, 1931) ranged from 0% to 213% in the absence of different species (see figure 3.74). Among the 103 species of fish, 76 species were mutually beneficial to *Discogobio tetrabarbatus*. There were 36 species that had more than a 10% effect on the niche of *Discogobio tetrabarbatus*. Of these, in which the largest effect was 98% by *Elopichthys bambusa*. There were 27 species of fish in competitive relationships with *Discogobio tetrabarbatus*. There were 17 species that affected the niche of *Discogobio tetrabarbatus* by more than 10%, with which the biggest effect was 213% by *Sinocyclocheilus yangzongensis*. An additional 50 species had less than a 10% effect on the rate of the niche variation of *Discogobio tetrabarbatus*.

3.1.2.2.70 Discogo biolongibarbatus (Wu, 1982)

The niche variation of *Discogo biolongibarbatus* (Wu, 1982) ranged from 0% to 99% in the absence of different species (see figure 3.75). Among the 103 species of fish, 58 species were mutually beneficial to *Discogo biolongibarbatus*. There were 45 species that had more than a 10% effect on the niche of *Discogo biolongibarbatus*. Of these, in which the largest effect was 99% by *Sinilabeo rendahlis*. There were 16 species of fish in competitive relationships with *Discogo biolongibarbatus*. There were 12 species that affected the niche of *Discogo biolongibarbatus* by more than 10%, with which the biggest effect was 36% by *Hypophthalmichthys molitrix*. An additional 45 species had less than a 10% effect on the rate of the niche variation of *Discogo biolongibarbatus*.

3.1.2.2.71 Discogobio brachyphysallidos (Huang, 1989)

The niche variation of *Discogobio brachyphysallidos* (Huang, 1989) ranged from 0% to 344% in the absence of different species (see figure 3.76). Among the 103 species of fish, 90 species were mutually beneficial to *Discogobio brachyphysallidos*. There were 66 species that had more than a 10% effect on the niche of *Discogobio brachyphysallidos*. Of these, in which the largest effect was 99% by *Misgurnus anguillicaudatus*. There were 13 species of fish in competitive relationships with *Discogobio brachyphysallidos*. There were 8 species that affected the niche of *Discogobio brachyphysallidos* by more than 10%, with which the biggest effect was 344% by *Ctenopharyngodon idella*. An additional 29 species had less than a 10% effect on the rate of the niche variation of *Discogobio brachyphysallidos*.

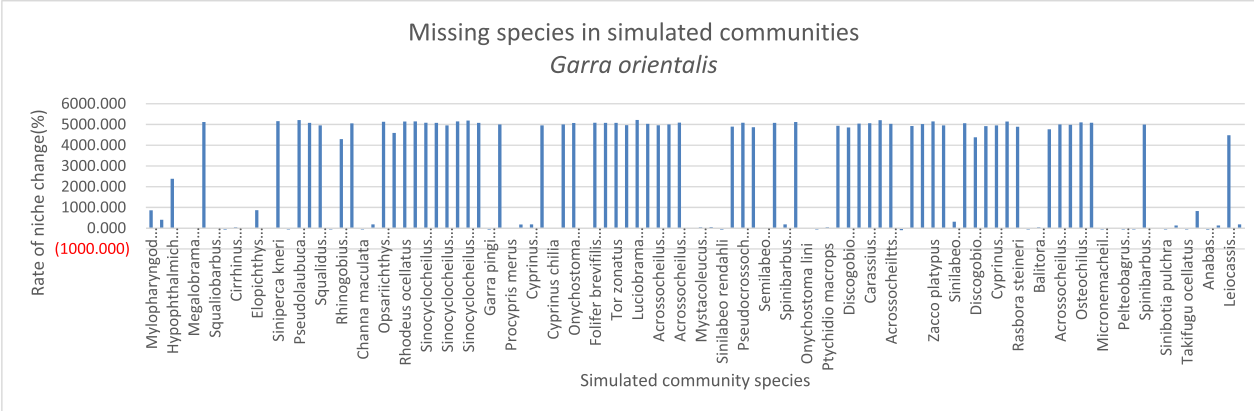

FIG. 3.73 – The responses of the niches of *Garra orientalis* to various missing fish in the simulated community.

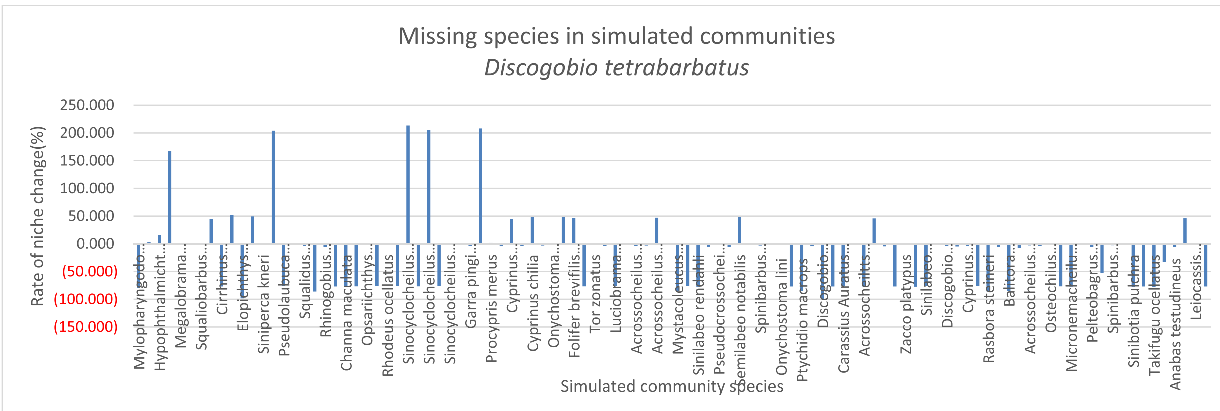

FIG. 3.74 – The responses of the niches of *Discogobio tetrabarbatus* to various missing fish in the simulated community.

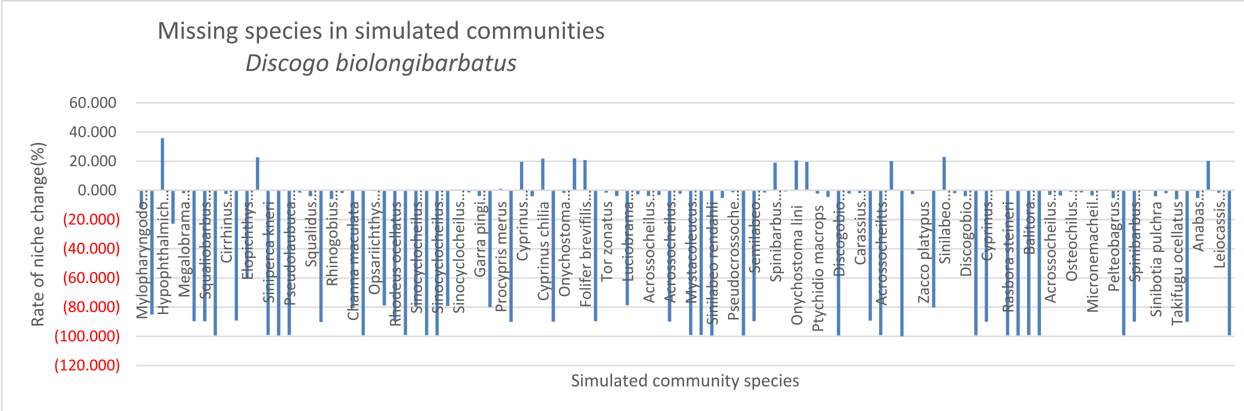

FIG. 3.75 – The responses of the niches of *Discogo biolongibarbatus* to various missing fish in the simulated community.

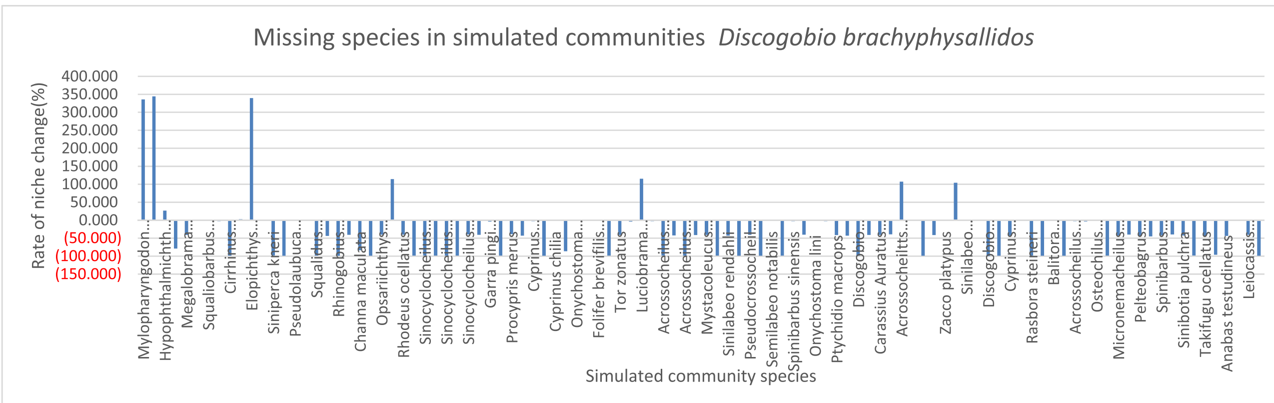

FIG. 3.76 – The responses of the niches of *Discogobio brachyphysallidos* to various missing fish in the simulated community.

3.1.2.2.72 Procypris merus (Lin, 1933)

The niche variation of *Procypris merus* (Lin, 1933) ranged from 0% to 1482% in the absence of different species (see figure 3.77). Among the 103 species of fish, 23 species were mutually beneficial to *Procypris merus*. There were 14 species that had more than a 10% effect on the niche of *Procypris merus*. Of these, in which the largest effect was 97% by *Schizothorax meridionalis*. There were 81 species of fish in competitive relationships with *Procypris merus*. There were 19 species that affected the niche of *Procypris merus* by more than 10%, in which the biggest effect was 1482% by *Onychostoma barbatulum*. An additional 46 species had less than a 10% effect on the rate of the niche variation of *Procypris merus*.

3.1.2.2.73 Cyprinus rabaudi (Tchang, 1930)

The niche variation of *Cyprinus rabaudi* (Tchang, 1930) ranged from 0% to 232% in the absence of different species (see figure 3.78). Among the 103 species of fish, 30 species were mutually beneficial to *Cyprinus rabaudi*. There were 3 species that had more than a 10% effect on the niche of *Cyprinus rabaudi*. Of these, in which the largest effect was 69% by *Hypophthalmichthys molitrix*. There were 73 species of fish in competitive relationships with *Cyprinus rabaudi*. There were 68 species that affected the niche of *Cyprinus rabaudi* by more than 10%, with which the biggest effect was 232% by *Hypophthalmichthys nobilis*. An additional 32 species had less than a 10% effect on the rate of the niche variation of *Cyprinus rabaudi*.

3.1.2.2.74 Cyprinus multitaeniatus (Pellegrin and Chevey, 1936)

The niche variation of *Cyprinus multitaeniatus* (Pellegrin and Chevey, 1936) ranged from 0% to 39% in the absence of different species (see figure 3.79). Among the 103 species of fish, 32 species were mutually beneficial to *Cyprinus carpio*. There were 25 species that had more than a 10% effect on the niche of *Cyprinus carpio*. Of these, in which the largest effect was 39% by *Takifugu ocellatus*. There were 71 species of fish in competitive relationships with *Cyprinus carpio*. There were 68 species that affected the niche of *Cyprinus carpio* by more than 10%, with which the biggest effect was 32% by *Ancherythroculter lini*. An additional 10 species had less than a 10% effect on the rate of the niche variation of *Cyprinus carpio*.

3.1.2.2.75 Cyprinus multitaeniata (Pellegrin and Chevey, 1936)

The niche variation of *Cyprinus multitaeniata* (Pellegrin and Chevey, 1936) ranged from 0% to 366% in the absence of different species (see figure 3.80). Among the 103 species of fish, 22 species were mutually beneficial to *Cyprinus multitaeniata*. Only *Hypophthalmichthys molitrix* had more than a 10% effect on the niche of *Cyprinus multitaeniata*, and the effect was 16%. There were 81 species of fish in competitive relationships with *Cyprinus multitaeniata*. There were 78 species that affected the niche of *Cyprinus multitaeniata* by more than 10%, with which the biggest effect was 366% by *Acheilognathus tonkinensis*. An additional 24 species had less than a 10% effect on the rate of the niche variation of *Cyprinus multitaeniata*.

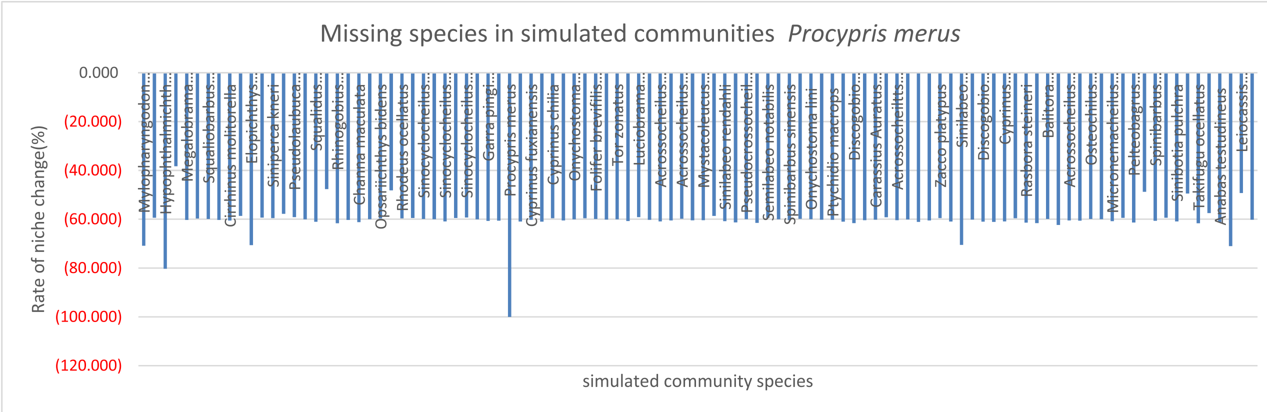

FIG. 3.77 – The responses of the niches of *Procypris merus* to various missing fish in the simulated community.

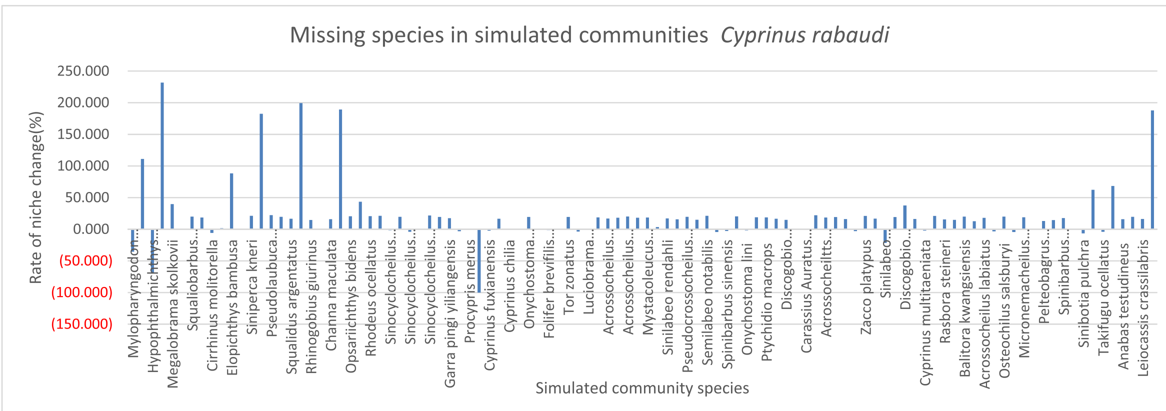

FIG. 3.78 – The responses of the niches of *Cyprinus rabaudi* to various missing fish in the simulated community.

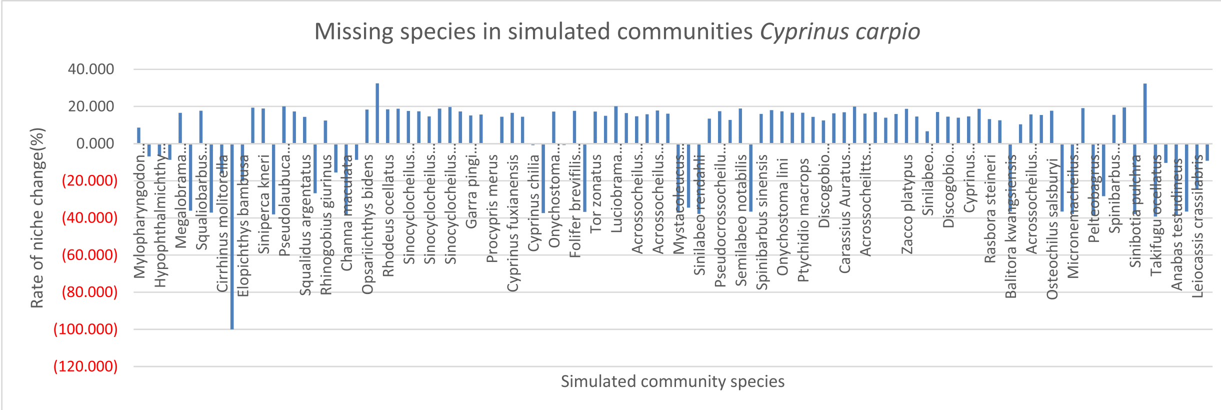

FIG. 3.79 – The responses of the niches of *Cyprinus carpio* to various missing fish in the simulated community.

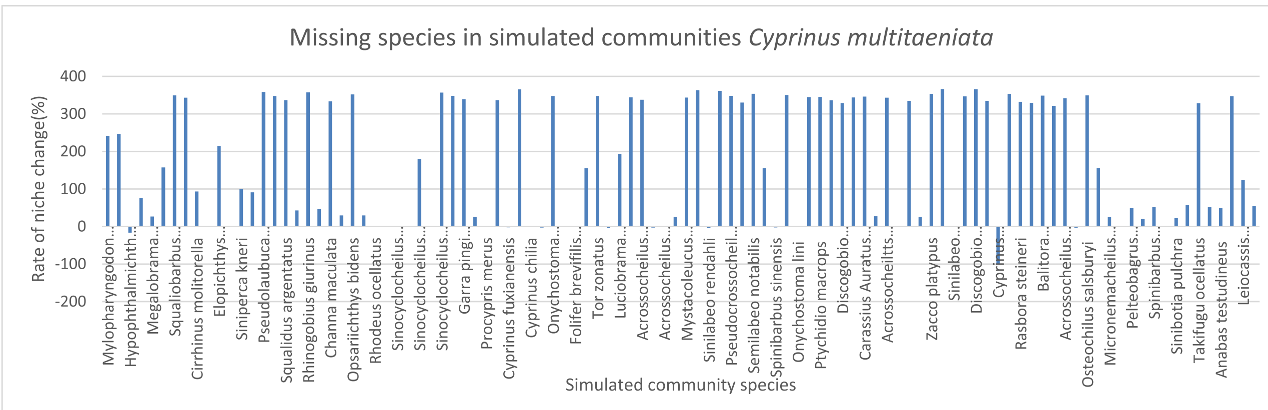

FIG. 3.80 – The responses of the niches of *Cyprinus multitaeniata* to various missing fish in the simulated community.

3.1.2.2.76 Cyprinus fuxianensis (Yang et al., 1982)
The niche variation of *Cyprinus fuxianensis* (Yang *et al.*, 1982) ranged from 0% to 2152% in the absence of different species (see figure 3.81). Among the 103 species of fish, only *Onychostoma sima* was mutually beneficial to *Cyprinus fuxianensis* with a 0.3% effect on the niche of *Cyprinus fuxianensis*. There were 102 species of fish in competitive relationships with *Cyprinus fuxianensis*. There were 87 species that affected the niche of *Cyprinus fuxianensis* by more than 10%, with which the biggest effect was 2152% by *Mylopharyngodon piceus*. An additional 15 species had less than a 10% effect on the rate of the niche variation of *Cyprinus fuxianensis*.

3.1.2.2.77 Cyprinus yilongensis (Yang et al., 1982)
The niche variation of *Cyprinus yilongensis* (Yang *et al.*, 1982) ranged from 0% to 742% in the absence of different species (see figure 3.82). Among the 103 species of fish, 69 species were mutually beneficial to *Cyprinus yilongensis*. There were 57 species that had more than a 10% effect on the niche of *Cyprinus yilongensis*. Of these, in which the largest effect was 97% by *Mylopharyngodon piceus*. There were 34 species of fish in competitive relationships with *Cyprinus yilongensis*. There were 31 species that affected the niche of *Cyprinus yilongensis* by more than 10%, with which the biggest effect was 742% by *Hypophthalmichthys molitrix*. An additional 5 species had less than a 10% effect on the rate of the niche variation of *Cyprinus yilongensis*.

3.1.2.2.78 Cyprinus chilia (Wu, 1963)
The niche variation of *Cyprinus chilia* (Wu, 1963) ranged from 0% to 4199% in the absence of different species (see figure 3.83). Among the 103 species of fish, no species were mutually beneficial to *Cyprinus chilia*. There were 100 species of fish in competitive relationships with *Cyprinus chilia* by more than 10%, in which the biggest effect was 4199% by *Leptobotia pellegrini*. An additional 3 species had less than a 10% effect on the rate of the niche variation of *Cyprinus chilia*.

3.1.2.2.79 Cyprinus pellegrini (Tchang, 1933)
The niche variation of *Cyprinus pellegrini* (Tchang, 1933) ranged from 0% to 937% in the absence of different species (see figure 3.84). Among the 103 species of fish, 86 species were mutually beneficial to *Cyprinus pellegrini*. There were 64 species that had more than a 10% effect on the niche of *Cyprinus pellegrini*. Of these, in which the largest effect was 90% by *Hypophthalmichthys nobilis*. There were 17 species of fish in competitive relationships with *Cyprinus pellegrini*. There were 5 species that affected the niche of *Cyprinus pellegrini* by more than 10%, with which the biggest effect was 937% by *Hypophthalmichthys molitrix*. An additional 46 species had less than a 10% effect on the rate of the niche variation of *Cyprinus pellegrini*.

3.1.2.2.80 Cyprinus longzhouensis (Yang and Hwang, 1982)
The niche variation of *Cyprinus longzhouensis* (Yang and Hwang, 1982) ranged from 0% to 80% in the absence of different species (see figure 3.85). Among the 103 species of fish, 100 species were mutually beneficial to *Cyprinus longzhouensis*. There were 79 species that had more than a 10% effect on the niche of *Cyprinus*

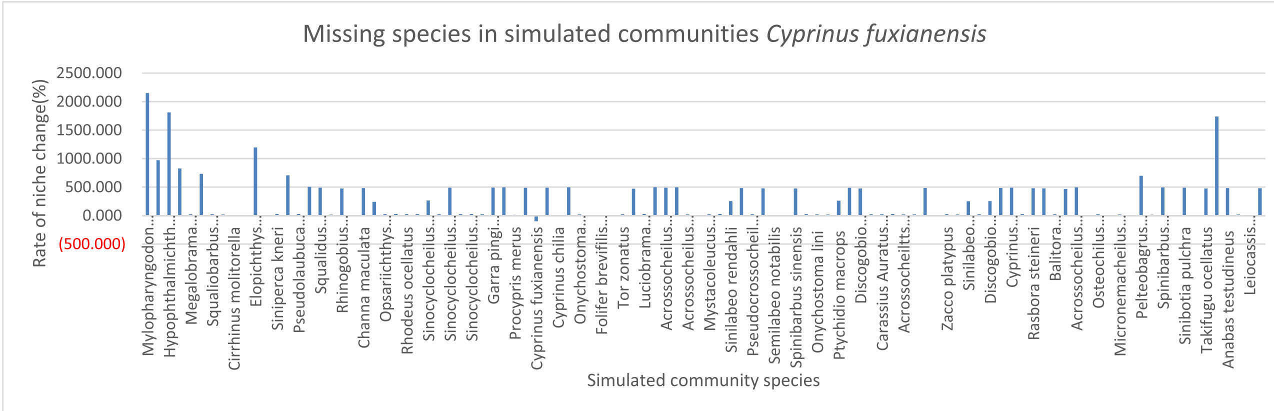

FIG. 3.81 – The responses of the niches of *Cyprinus fuxianensis* to various missing fish in the simulated community.

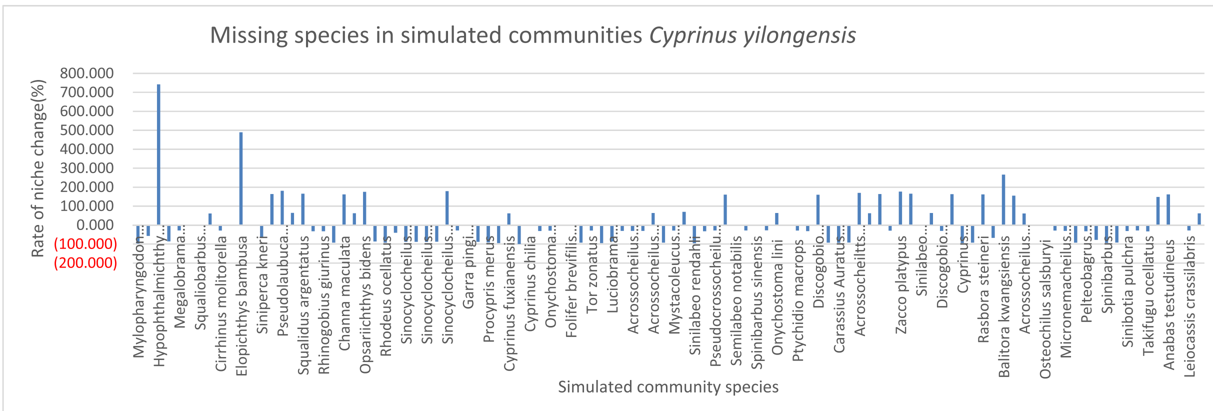

FIG. 3.82 – The responses of the niches of *Cyprinus yilongensis* to various missing fish in the simulated community.

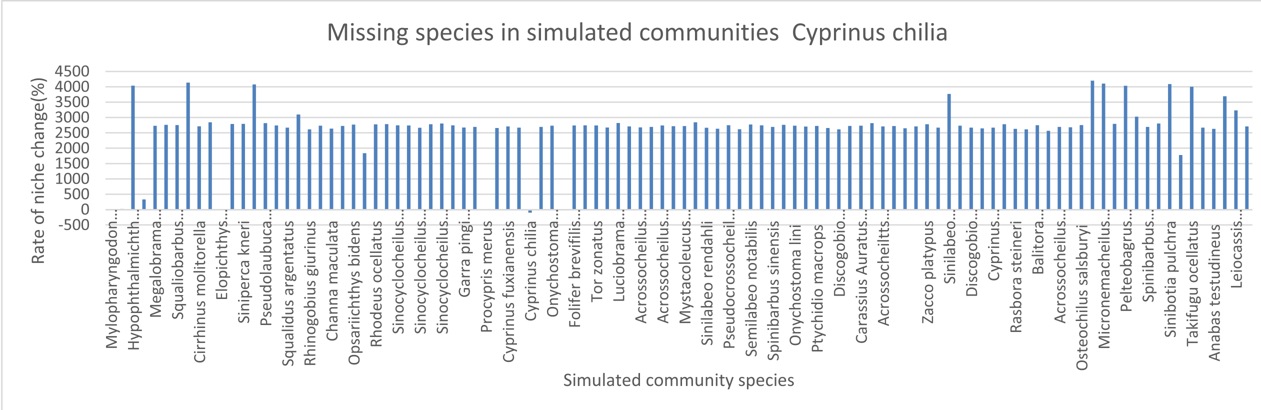

FIG. 3.83 – The responses of the niches of *Cyprinus chilia* to various missing fish in the simulated community.

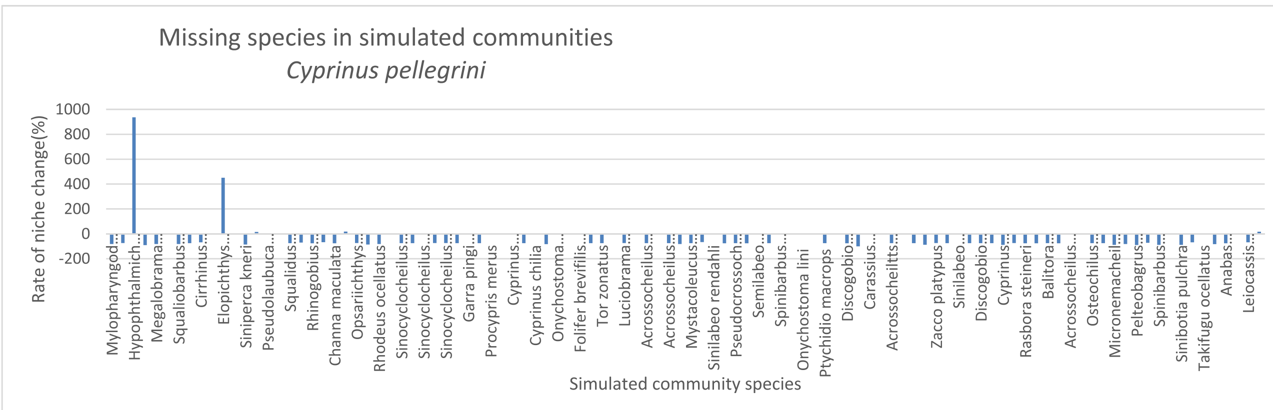

FIG. 3.84 – The responses of the niches of *Cyprinus pellegrini* to various missing fish in the simulated community.

longzhouensis. Of these, in which the largest effect was 80% by *Hypophthalmichthys molitrix*. There were 3 species of fish in competitive relationships with *Cyprinus longzhouensis*. No species that affected the niche of *Cyprinus longzhouensis* by more than 10%, with which the biggest effect was 1% by *Luciobrama macrocephalus*. An additional 24 species had less than a 10% effect on the rate of the niche variation of *Cyprinus longzhouensis*.

3.1.2.2.81 Carassius Auratus gibelio (Bloch, 1782)

The niche variation of *Carassius Auratus gibelio* (Bloch, 1782) ranged from 0% to 98% in the absence of different species (see figure 3.86). Among the 103 species of fish, 97 species were mutually beneficial to *Carassius Auratus gibelio*. There were 71 species that had more than a 10% effect on the niche of *Carassius Auratus gibelio*. Of these, in which the largest effect was 98% by *Hypophthalmichthys nobilis*. There were 6 species of fish in competitive relationships with *Carassius Auratus gibelio*. No species affected the niche of *Carassius Auratus gibelio* by more than 10%, with which the biggest effect was 2% by *Cyprinus carpio*. An additional 32 species had less than a 10% effect on the rate of the niche variation of *Carassius Auratus gibelio*.

3.1.2.2.82 Carassius auratus auratus (Linnaeus, 1758)

The niche variation of *Carassius auratus auratus* (Linnaeus, 1758) ranged from 0% to 300% in the absence of different species (see figure 3.87). Among the 103 species of fish, 57 species were mutually beneficial to *Carassius auratus auratus*. All of those species had more than a 10% effect on the niche of *Carassius auratus auratus*. Of these, in which the largest effect was 97% by *Misgurnus anguillicaudatus*. There were 46 species of fish in competitive relationships with *Carassius auratus auratus*. There were 44 species that affected the niche of *Carassius auratus auratus* by more than 10%, with which the biggest effect was 300% by *Ancherythroculter lini*. An additional 2 species had less than a 10% effect on the rate of the niche variation of *Carassius auratus auratus*.

3.1.2.2.83 Carassioides cantonensis (Heincke, 1892)

The niche variation of *Carassioides cantonensis* (Heincke, 1892) ranged from 0% to 2055% in the absence of different species (see figure 3.88). Among the 103 species of fish, 27 species were mutually beneficial to *Carassioides cantonensis*. There were 7 species that had near a 10% effect on the niche of *Carassioides cantonensis*. Of these, in which the largest effect was 10% by *Acrossocheiltts hemispinus hemispinus*. There were 76 species of fish in competitive relationships with *Carassioides cantonensis*. There were 61 species that affected the niche of *Carassioides cantonensis* by more than 10%, in which the biggest effect was 2055% by *Osteochilus salsburyi*. An additional 41 species had less than a 10% effect on the rate of the niche variation of *Carassioides cantonensis*.

3.1.2.2.84 Schizothorax meridionalis (Tsao, 1964)

The niche variation of *Schizothorax meridionalis* (Tsao, 1964) ranged from 0% to 2215% in the absence of different species (see figure 3.89). Among the 103 species of

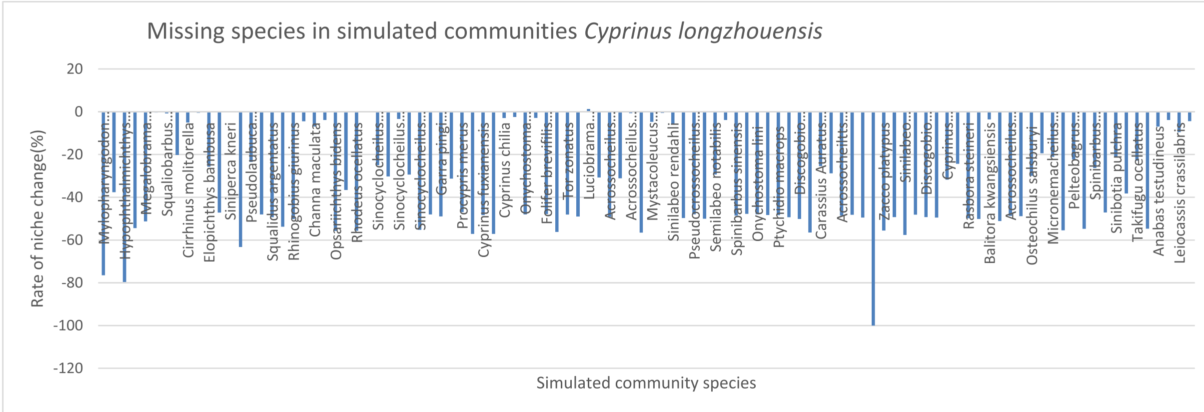

FIG. 3.85 – The responses of the niches of *Cyprinus longzhouensis* to various missing fish in the simulated community.

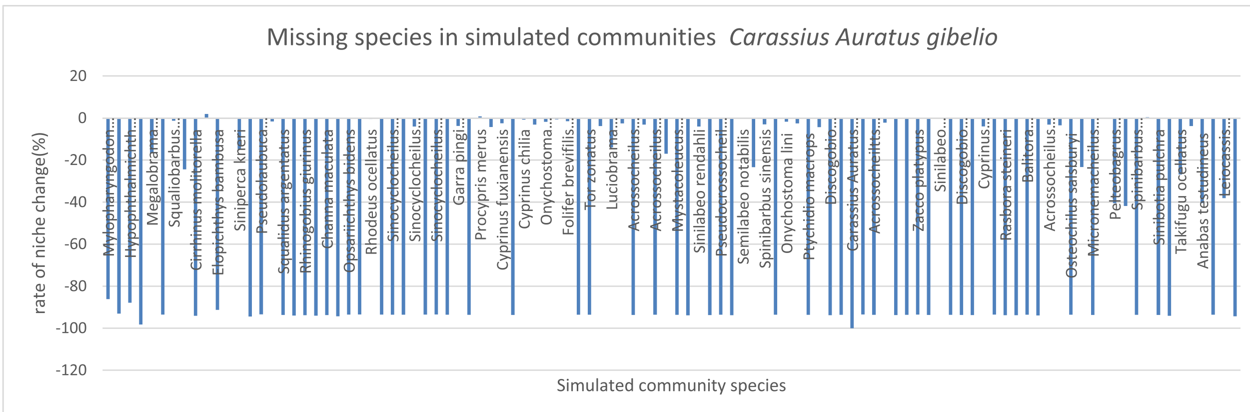

FIG. 3.86 – The responses of the niches of *Carassius Auratus gibelio* to various missing fish in the simulated community.

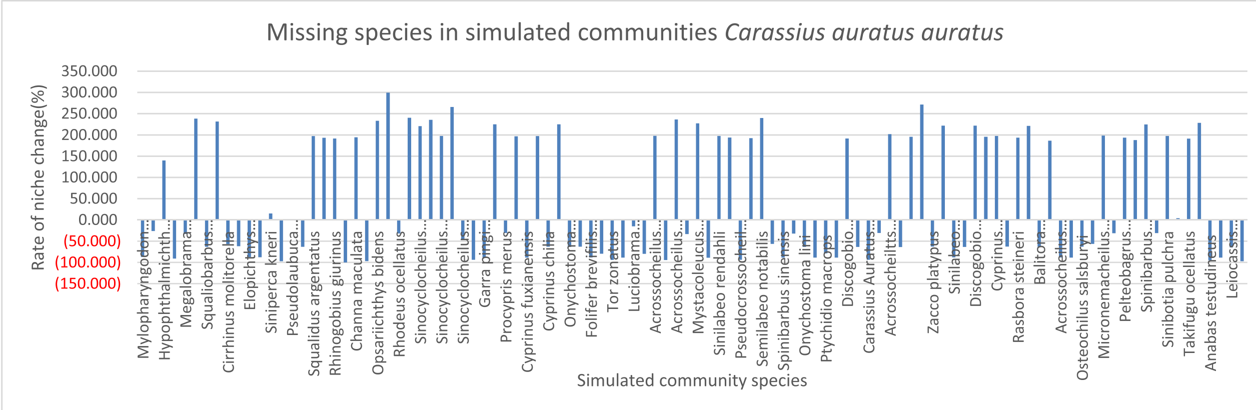

FIG. 3.87 – The responses of the niches of *Carassius auratus auratus* to various missing fish in the simulated community.

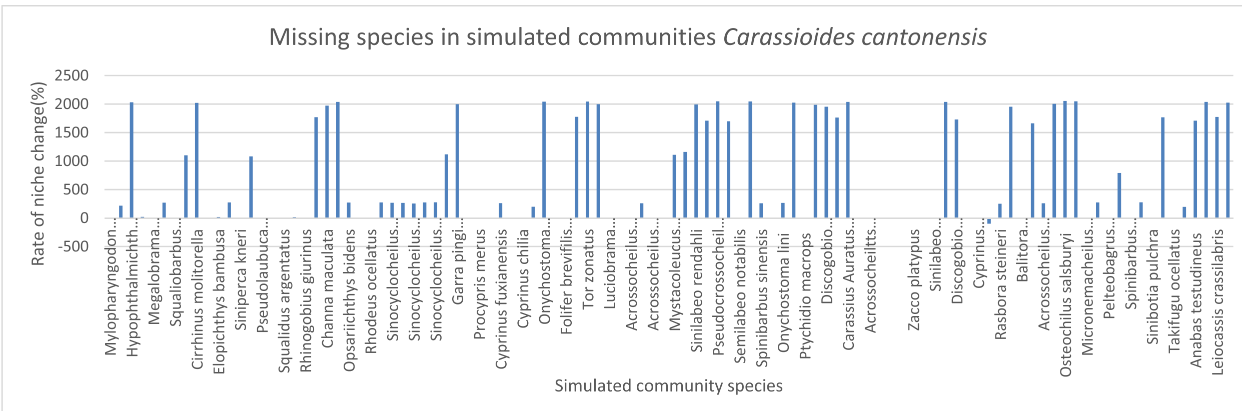

FIG. 3.88 – The responses of the niches of *Carassioides cantonensis* to various missing fish in the simulated community.

fish, 62 species were mutually beneficial to *Lcucosoma chinensis*. All those species had more than a 10% effect on the niche of *Lcucosoma chinensis*. Of these, in which the largest effect was 99% by *Mylopharyngodon piceus*. There were 41 species of fish in competitive relationships with *Lcucosoma chinensis*. There were 40 species that affected the niche of *Lcucosoma chinensis* by more than 10%, in which the biggest effect was 2215% by *Hypophthalmichthys nobilis*. An additional species had less than a 10% effect on the rate of the niche variation of *Lcucosoma chinensis*.

3.1.2.3 Balitora kwangsiensis (Fang, 1930)

The niche variation of *Balitora kwangsiensis* (Fang, 1930) ranged from 0% to 67% in the absence of different species (see figure 3.90). Among the 103 species of fish, 78 species were mutually beneficial to *Balitora kwangsiensis*. There were 49 species that had more than a 10% effect on the niche of *Balitora kwangsiensis*. Of these, in which the largest effect was 67% by *Ctenopharyngodon idella*. There were 25 species of fish in competitive relationships with *Balitora kwangsiensis*. All of those species affected the niche of *Balitora kwangsiensis* by less than 9%, and 9% by *Spinibarbus hollandi*. An additional 54 species had less than a 10% effect on the rate of the niche variation of *Balitora kwangsiensis*.

3.1.3 Siluriformes, Bagridae

3.1.3.1 Hemibagrus macropterus (Bleeker, 1870)

The niche variation of *Hemibagrus macropterus* (Bleeker, 1870) ranged from 0% to 105% in the absence of different species (see figure 3.91). Among the 103 species of fish, 64 species were mutually beneficial to *Hemibagrus macropterus*. There were 23 species that had more than a 10% effect on the niche of *Hemibagrus macropterus*. Of these, in which the largest effect was 20% by *Mylopharyngodon piceus*. There were 39 species of fish in competitive relationships with *Hemibagrus macropterus*. There were 30 species that affected the niche of *Hemibagrus macropterus* by more than 10%, with which the biggest effect was 105% by *Lateolabrax japonicus*. An additional 50 species had less than a 10% effect on the rate of the niche variation of *Hemibagrus macropterus*.

3.1.3.2 Hemibagrus guttatus (Lacepède, 1803)

The niche variation of *Hemibagrus guttatus* (Lacepède, 1803) ranged from 0% to 76% in the absence of different species (see figure 3.92). Among the 103 species of fish, 96 species were mutually beneficial to *Hemibagrus guttatus*. There were 9 species that had more than a 10% effect on the niche of *Hemibagrus guttatus*. Of these, in which the largest effect was 76% by *Hypophthalmichthys molitrix*. There were 7 species of fish in competitive relationships with *Hemibagrus guttatus*. All those species affected the niche of *Hemibagrus guttatus* by less than 10%, and *Hypophthalmichthys nobilis* was the biggest near 10% that affected *Hemibagrus*

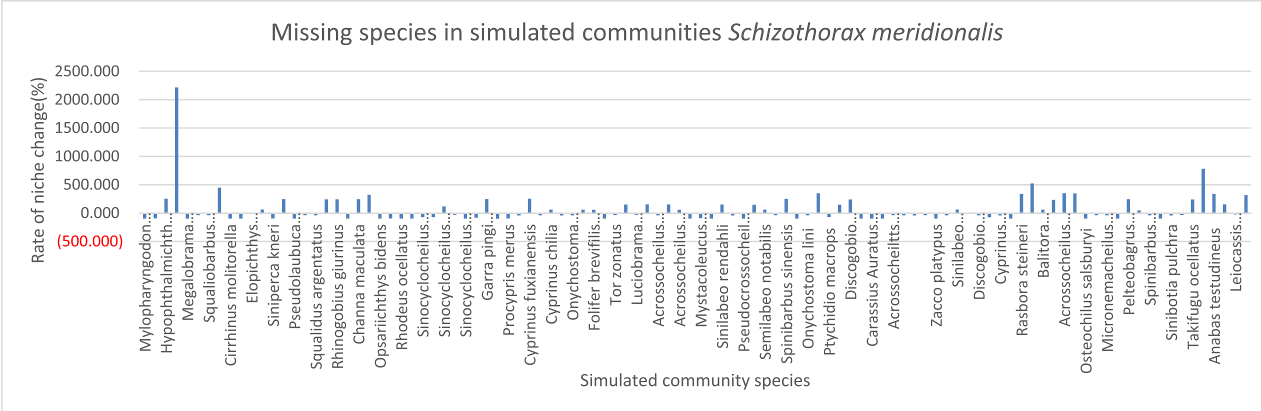

FIG. 3.89 – The responses of the niches of *Schizothorax meridionalis* to various missing fish in the simulated community.

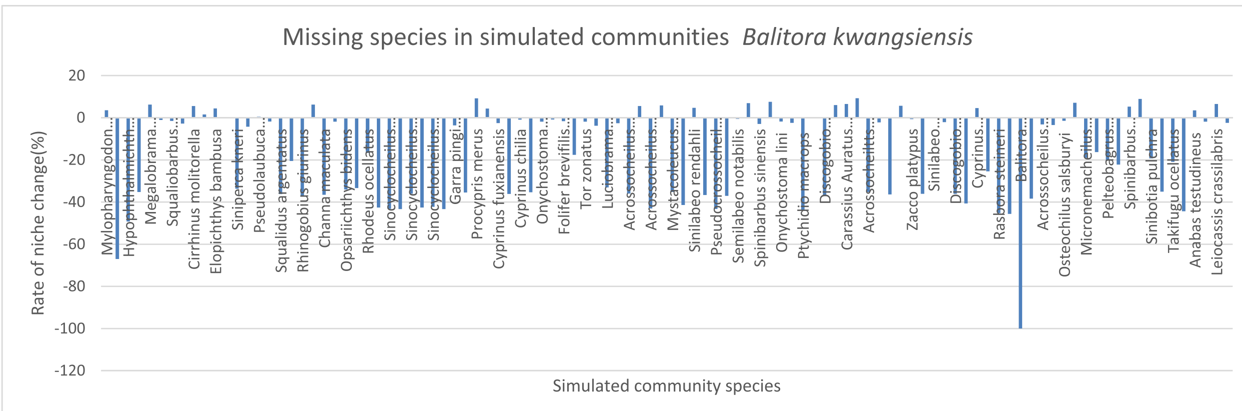

FIG. 3.90 – The responses of the niches of *Balitora kwangsiensis* to various missing fish in the simulated community.

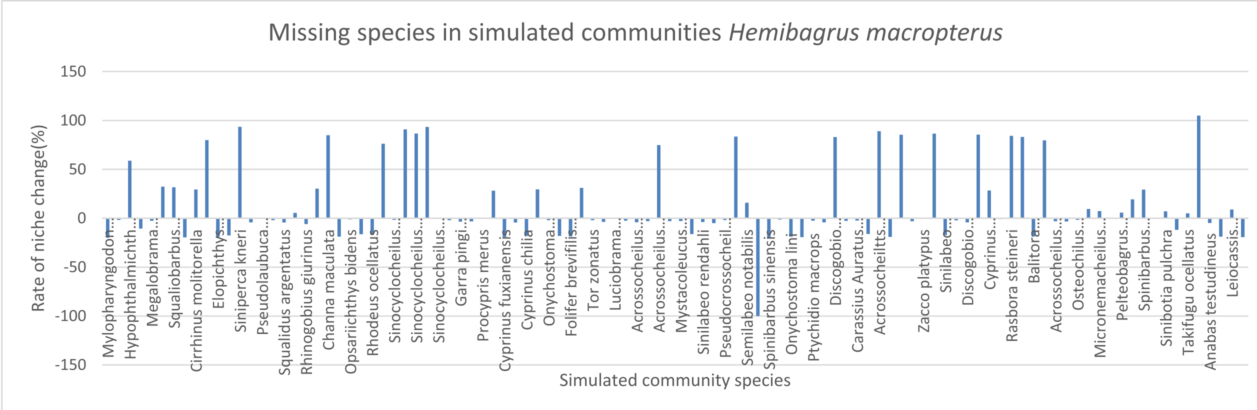

FIG. 3.91 – The responses of the niches of *Hemibagrus macropterus* to various missing fish in the simulated community.

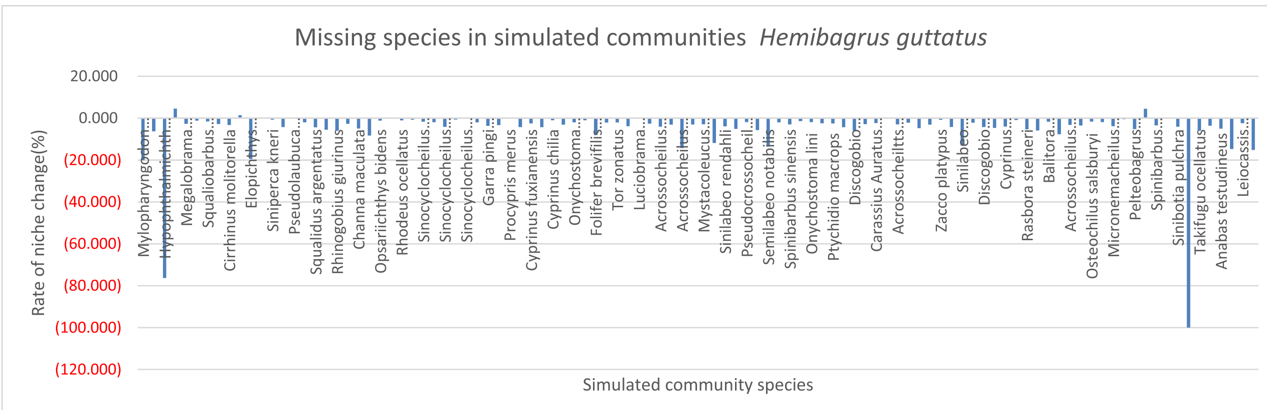

FIG. 3.92 – The responses of the niches of *Hemibagrus guttatus* to various missing fish in the simulated community.

guttatus. An additional 94 species had less than a 10% effect on the rate of the niche variation of *Hemibagrus guttatus*.

3.1.3.3 Tachysurus argentivittatus (Regan, 1905)

The niche variation of *Tachysurus argentivittatus* (Regan, 1905) ranged from 0% to 93% in the absence of different species (see figure 3.93). Among the 103 species of fish, 99 species were mutually beneficial to *Tachysurus argentivittatus*. There were 83 species that had more than a 10% effect on the niche of *Tachysurus argentivittatus*. Of these, in which the largest effect was 93% by *Hypophthalmichthys nobilis*. There were 4 species of fish in competitive relationships with *Tachysurus argentivittatus*. All those species that affected the niche of *Tachysurus argentivittatus* by less than 10%, and 2% of these were the biggest affected by *Cyprinus carpio*. An additional 20 species had less than a 10% effect on the rate of the niche variation of *Tachysurus argentivittatus*.

3.1.3.4 Leiocassis crassilabris (Günther, 1864)

The niche variation of *Leiocassis crassilabris* (Günther, 1864) ranged from 0% to 351% in the absence of different species (see figure 3.94). Among the 103 species of fish, 10 species were mutually beneficial to *Leiocassis crassilabris*. There were 2 species that had more than a 10% effect on the niche of *Leiocassis crassilabris*. Of these, in which the largest effect was 97% by *Hypophthalmichthys nobilis*. There were 93 species of fish in competitive relationships with *Leiocassis crassilabris*. There were 92 species that affected the niche of *Leiocassis crassilabris* by more than 10%, with which the biggest effect was 351% by *Acrossocheilus fasciatus*. An additional 9 species had less than a 10% effect on the rate of the niche variation of *Leiocassis crassilabris*.

3.1.3.5 Pelteobagrus vachellii (Richardson, 1846)

The niche variation of *Pelteobagrus vachellii* (Richardson, 1846) ranged from 0% to 44% in the absence of different species (see figure 3.95). Among the 103 species of fish, 96 species were mutually beneficial to *Pelteobagrus vachellii*. There were 14 species that had more than a 10% effect on the niche of *Pelteobagrus vachellii*. Of these, in which the largest effect was 33% by *Lateolabrax japonicus*. There were 7 species of fish in competitive relationships with *Pelteobagrus vachellii*. There were 4 species that affected the niche of *Pelteobagrus vachellii* by more than 10%, with which the biggest effect was 44% by *Hypophthalmichthys molitrix*. An additional 85 species had less than a 10% effect on the rate of the niche variation of *Pelteobagrus vachellii*.

3.1.3.6 Pelteobagrus intermedius (Nichols and Pope, 1927)

The niche variation of *Pelteobagrus intermedius* (Nichols and Pope, 1927) ranged from 0% to 103% in the absence of different species (see figure 3.96). Among the 103

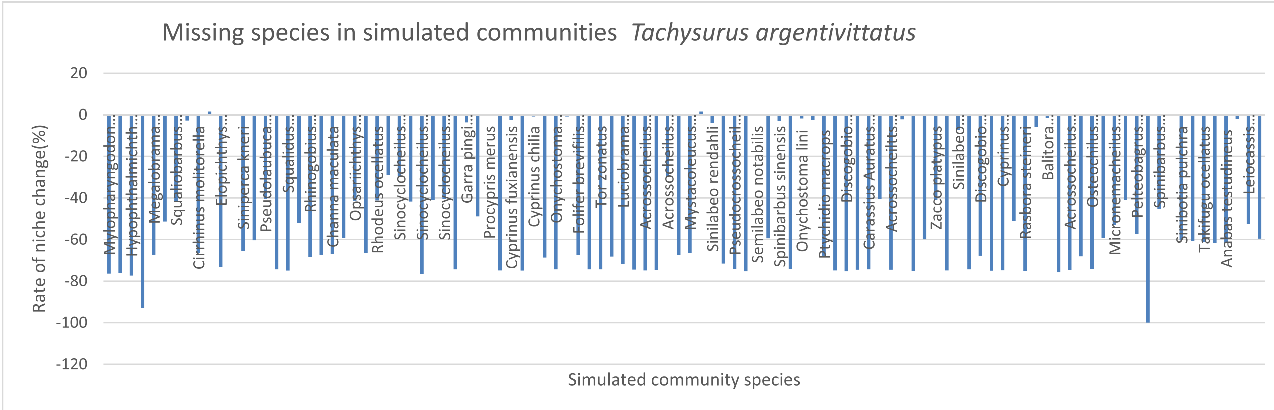

FIG. 3.93 – The responses of the niches of *Tachysurus argentivittatus* to various missing fish in the simulated community.

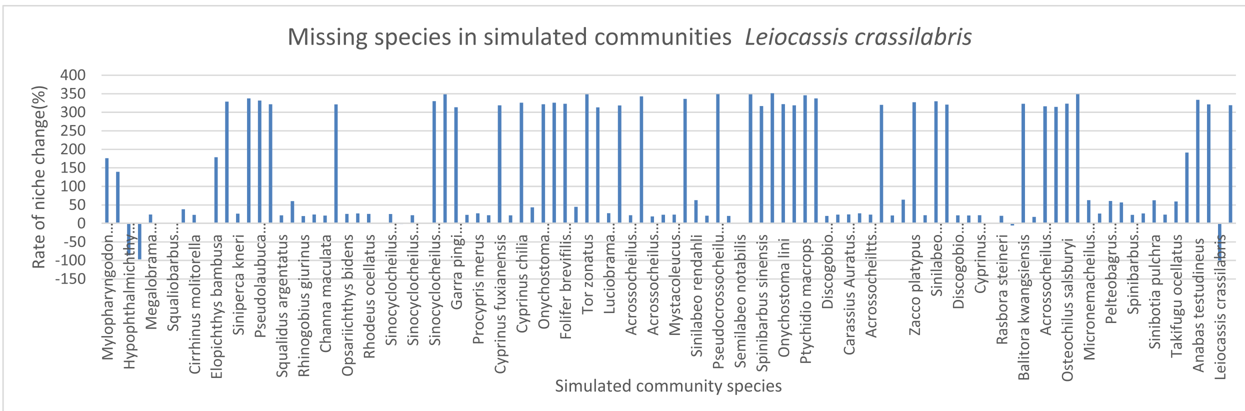

FIG. 3.94 – The responses of the niches of *Leiocassis crassilabris* to various missing fish in the simulated community.

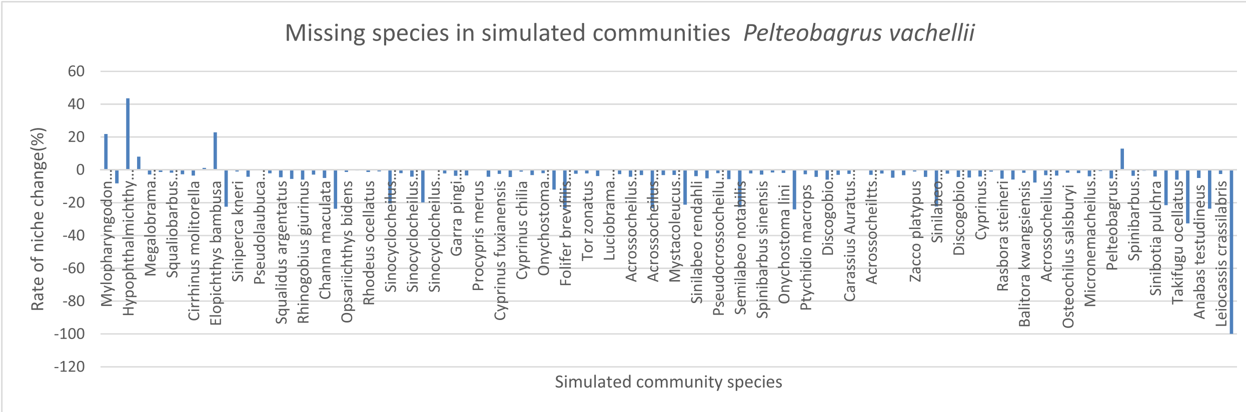

FIG. 3.95 – The responses of the niches of *Pelteobagrus vachellii* to various missing fish in the simulated community.

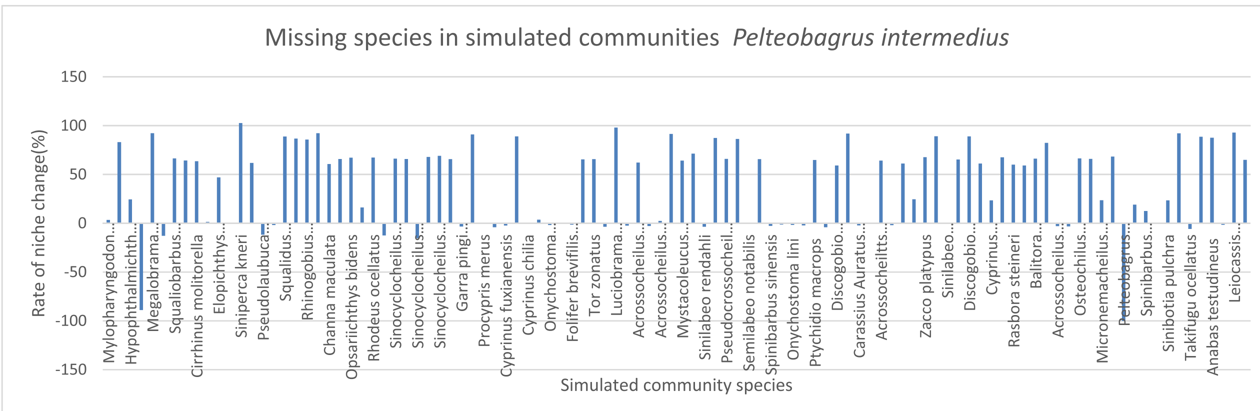

FIG. 3.96 – The responses of the niches of *Pelteobagrus intermedius* to various missing fish in the simulated community.

species of fish, 31 species were mutually beneficial to *Pelteobagrus intermedius*. There were 5 species that had more than a 10% effect on the niche of *Pelteobagrus intermedius*. Of these, in which the largest effect was 89% by *Hypophthalmichthys nobilis*. There were 72 species of fish in competitive relationships with *Pelteobagrus intermedius*. There were 65 species that affected the niche of *Pelteobagrus intermedius* by more than 10%, with which the biggest effect was 103% by *Siniperca kneri*. An additional 33 species had less than a 10% effect on the rate of the niche variation of *Pelteobagrus intermedius*.

3.1.3.7 Pelteobagrus fulvidraco (Richardson, 1846)

The niche variation of *Pelteobagrus fulvidraco* (Richardson, 1846) ranged from 0% to 35% in the absence of different species (see figure 3.97). Among the 103 species of fish, 95 species were mutually beneficial to *Pelteobagrus fulvidraco*. There were 15 species that had more than a 10% effect on the niche of *Pelteobagrus fulvidraco*. Of these, in which the largest effect was 35% by *Mylopharyngodon piceus*. There were 8 species of fish in competitive relationships with *Pelteobagrus fulvidraco*. There were 4 species that affected the niche of *Pelteobagrus fulvidraco* by more than 10%, with which the biggest effect was 22% by *Hypophthalmichthys nobilis*. An additional 80 species had less than a 10% effect on the rate of the niche variation of *Pelteobagrus fulvidraco*.

3.1.4 Perciformes

3.1.4.1 Lateolabrax japonicus (Cuvier, 1828)

The niche variation of *Lateolabrax japonicus* (Cuvier, 1828) ranged from 0% to 29% in the absence of different species (see figure 3.98). Among the 103 species of fish, 94 species were mutually beneficial to *Lateolabrax japonicus*. There were 8 species that had more than a 10% effect on the niche of *Lateolabrax japonicus*. Of these, in which the largest effect was 17% by *Pelteobagrus vachelli*. There were 9 species of fish in competitive relationships with *Lateolabrax japonicus*. There were 3 species that affected the niche of *Lateolabrax japonicus* by more than 10%, with which the biggest effect was 29% by *Hypophthalmichthys nobilis*. An additional 92 species had less than a 10% effect on the rate of the niche variation of *Lateolabrax japonicus*.

3.1.4.2 Anabas testudineus (Bloch, 1792)

The niche variation of *Anabas testudineus* (Bloch, 1792) ranged from 0% to 62% in the absence of different species (see figure 3.99). Among the 103 species of fish, 73 species were mutually beneficial to *Anabas testudineus*. There were 24 species that had more than a 10% effect on the niche of *Anabas testudineus*. Of these, in which the largest effect was 51% by *Hypophthalmichthys molitrix*. There were 30 species of fish in competitive relationships with *Anabas testudineus*. There were 25 species that affected the niche of *Anabas testudineus* by more than 10%, with which the biggest

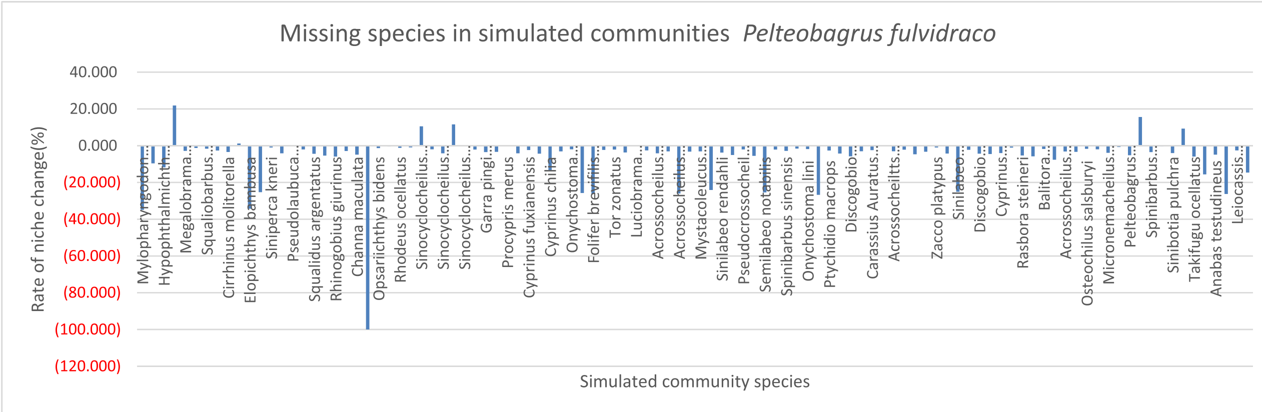

FIG. 3.97 – The responses of the niches of *Pelteobagrus fulvidraco* to various missing fish in the simulated community.

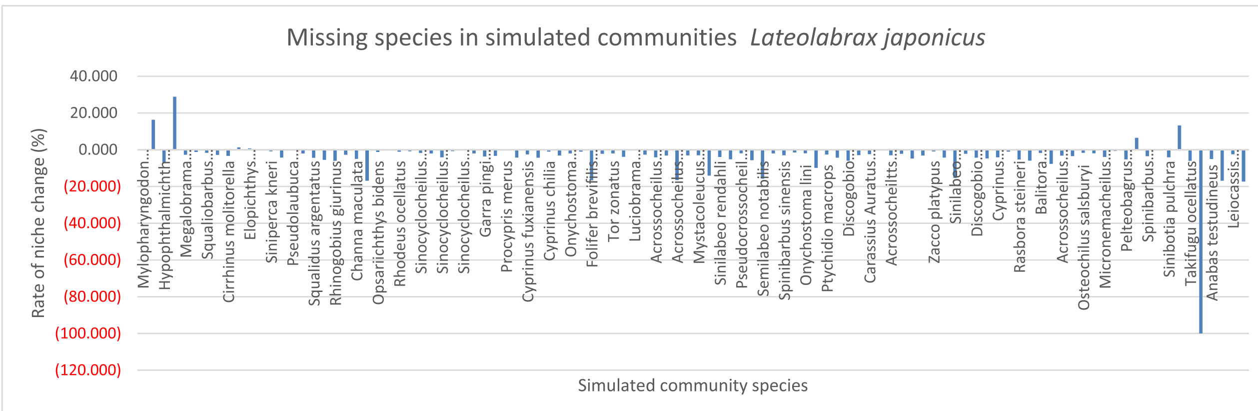

FIG. 3.98 – The responses of the niches of *Lateolabrax japonicus* to various missing fish in the simulated community.

effect was 62% by *Leiocassis crassilabris*. An additional 54 species had less than a 10% effect on the rate of the niche variation of *Anabas testudineus*.

3.1.4.3 Bostrichthys sinensis (Lacépède, 1801)

The niche variation of *Bostrichthys sinensis* (Lacépède, 1801) ranged from 0% to 186% in the absence of different species (see figure 3.100). Among the 103 species of fish, 76 species were mutually beneficial to *Bostrichthys sinensis*. There were 3 species that had more than a 10% effect on the niche of *Bostrichthys sinensis*. Of these, in which the largest effect was 90% by *Acrossocheilus clivosius*. There were 27 species of fish in competitive relationships with *Bostrichthys sinensis*. There were 17 species that affected the niche of *Bostrichthys sinensis* by more than 10%, with which the biggest effect was 186% by *Elopichthys bambusa*. An additional 23 species had less than a 10% effect on the rate of the niche variation of *Bostrichthys sinensis*.

3.1.4.4 Siniperca kneri (Garman, 1912)

The niche variation of *Siniperca kneri* (Garman, 1912) ranged from 0% to 109% in the absence of different species (see figure 3.101). Among the 103 species of fish, 65 species were mutually beneficial to *Siniperca kneri*. There were 19 species that had more than a 10% effect on the niche of *Siniperca kneri*. Of these, in which the largest effect was 35% by *Hypophthalmichthys molitrix*. There were 38 species of fish in competitive relationships with *Siniperca kneri*. There were 33 species that affected the niche of *Siniperca kneri* by more than 10%, in which the biggest effect was 109% by *Hypophthalmichthys nobilis*. An additional 51 species had less than a 10% effect on the rate of the niche variation of *Siniperca kneri*.

3.1.4.5 Channa maculata (Lacépède, 1801)

The niche variation of *Channa maculata* (Lacépède, 1801) ranged from 0% to 68% in the absence of different species (see figure 3.102). Among the 103 species of fish, 77 species were mutually beneficial to *Channa maculata*. There were 17 species that had more than a 10% effect on the niche of *Channa maculata*. Of these, in which the largest effect was 68% by *Hypophthalmichthys molitrix*. There were 26 species of fish in competitive relationships with *Channa maculata*. There were 23 species that affected the niche of *Channa maculata* by more than 10%, with which the biggest effect was 68% by *Sinocyclocheilus grahami tingi*. An additional 60 species had less than a 10% effect on the rate of the niche variation of *Channa maculata*.

3.1.4.6 Rhinogobius giurinus (Rutter, 1897)

The niche variation of *Rhinogobius giurinus* (Rutter, 1897) ranged from 0% to 178% in the absence of different species (see figure 3.103). Among the 103 species of fish, 25 species were mutually beneficial to *Rhinogobius giurinus*. There were 3 species that had more than a 10% effect on the niche of *Rhinogobius giurinus*. Of these, in which the largest effect was 17% by *Mylopharyngodon piceus*. There were 78 species

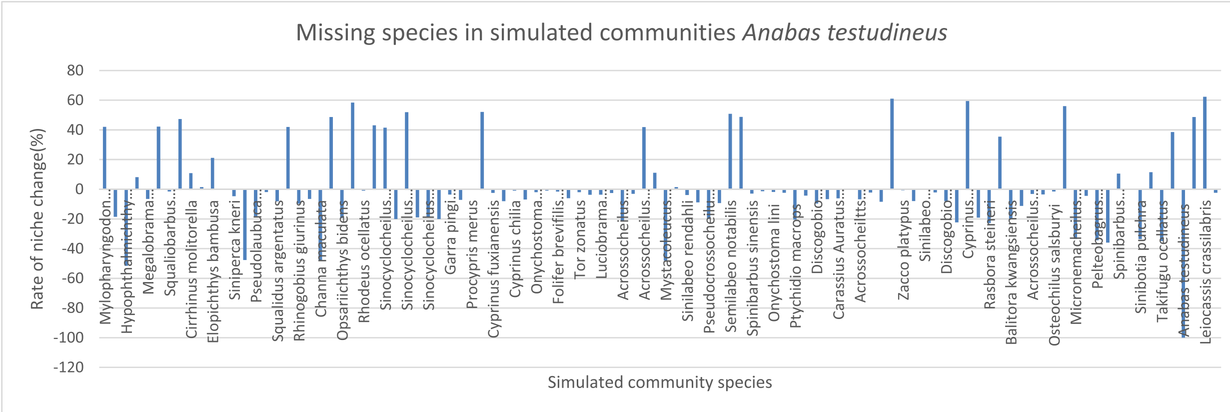

Fig. 3.99 – The responses of the niches of *Anabas testudineus* to various missing fish in the simulated community.

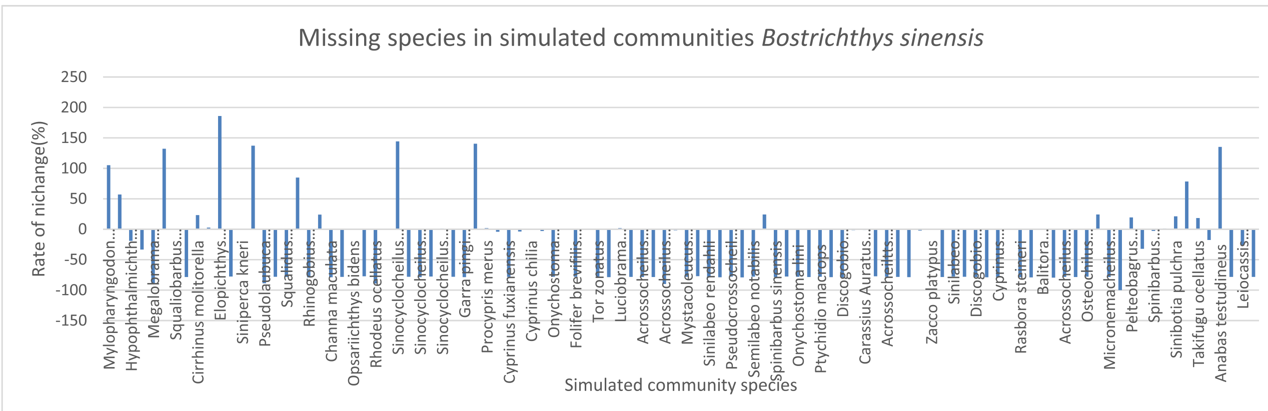

Fig. 3.100 – The responses of the niches of *Bostrichthys sinensis* to various missing fish in the simulated community.

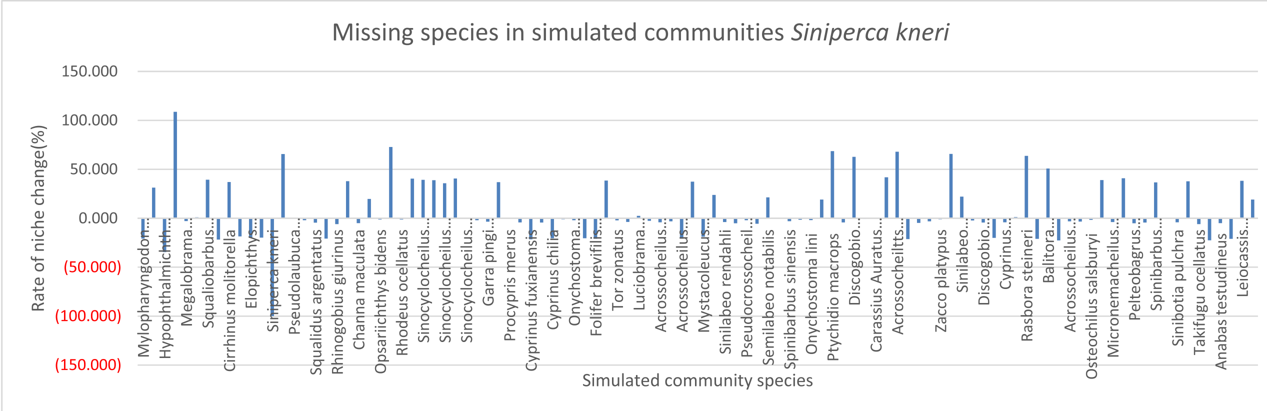

Fig. 3.101 – The responses of the niches of *Siniperca kneri* to various missing fish in the simulated community.

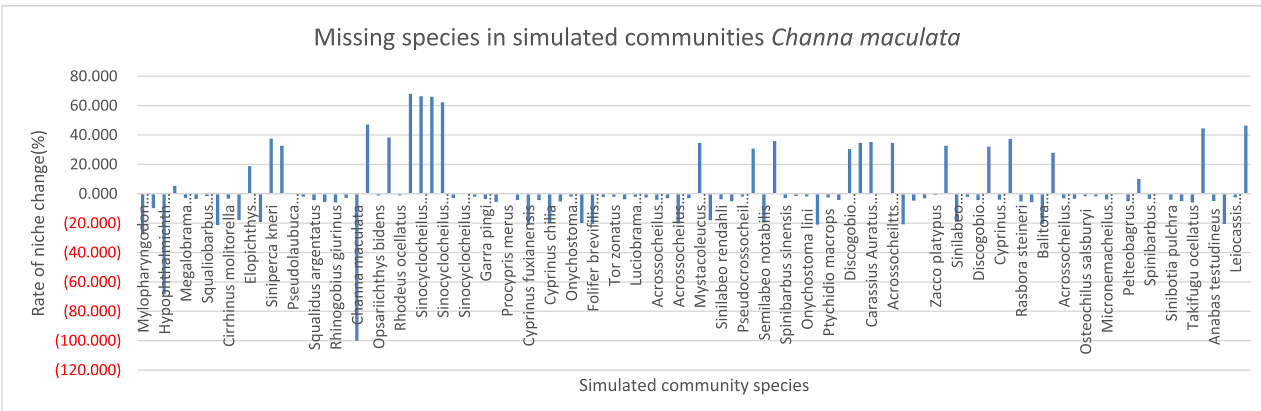

Fig. 3.102 – The responses of the niches of *Channa maculata* to various missing fish in the simulated community.

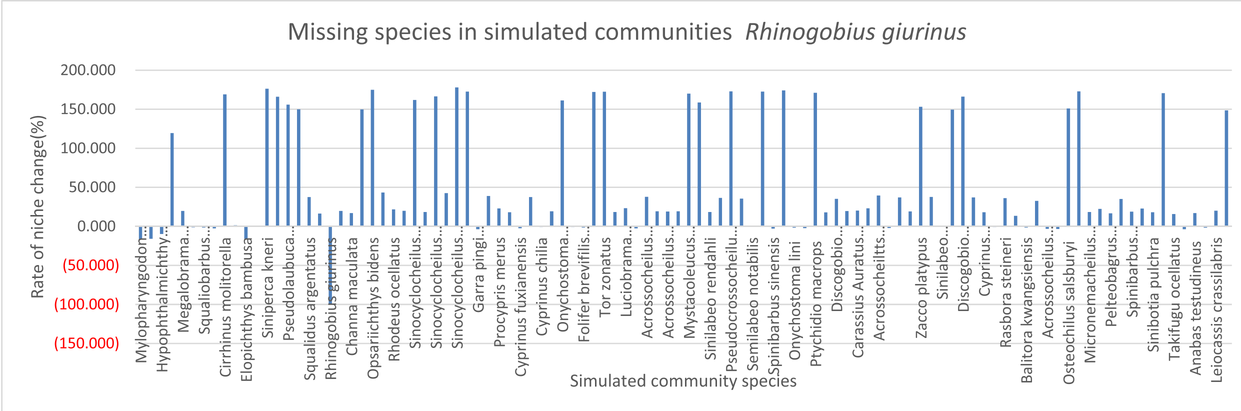

FIG. 3.103 – The responses of the niches of *Rhinogobius giurinus* to various missing fish in the simulated community.

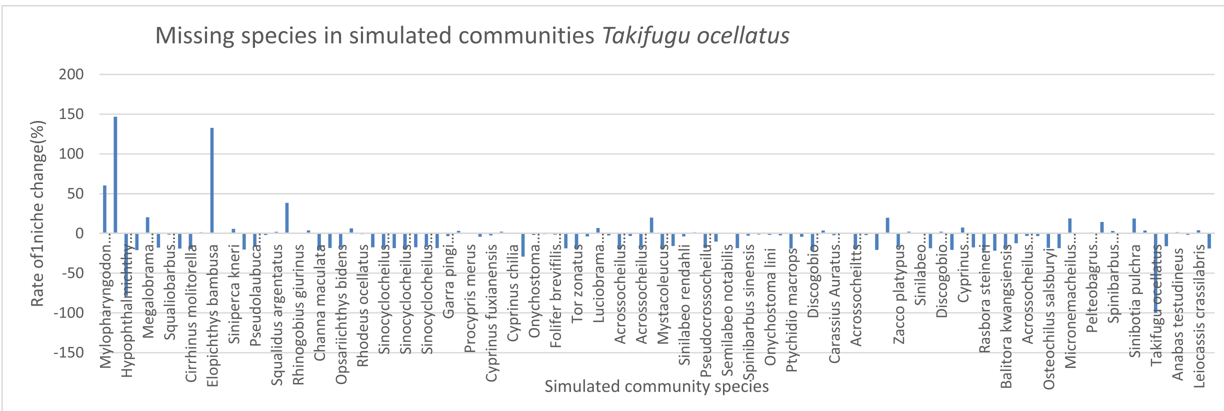

FIG. 3.104 – The responses of the niches of *Takifugu ocellatus* to various missing fish in the simulated community.

of fish in competitive relationships with *Rhinogobius giurinus*. There were 76 species that affected the niche of *Rhinogobius giurinus* by more than 10%, with which the biggest effect was 178% by *Sinocyclocheilus microphthalmus*. An additional 24 species had less than a 10% effect on the rate of the niche variation of *Rhinogobius giurinus*.

3.1.5 Tetraodontiformes

3.1.5.1 Takifugu ocellatus (Linnaeus, 1758)

The niche variation of *Takifugu ocellatus* (Linnaeus, 1758) ranged from 0% to 147% in the absence of different species (see figure 3.104). Among the 103 species of fish, 71 species were mutually beneficial to *Takifugu ocellatus*. There were 43 species that had more than a 10% effect on the niche of *Takifugu ocellatus*. Of these, in which the largest effect was 78% by *Hypophthalmichthys molitrix*. There were 60 species of fish in competitive relationships with *Takifugu ocellatus*. There were 10 species that affected the niche of *Takifugu ocellatus* by more than 10%, with which the biggest effect was 147% by *Ctenopharyngodon idella*. An additional 46 species had less than a 10% effect on the rate of the niche variation of *Takifugu ocellatus*.

3.2 Simulated Community

3.2.1 Niche Composition

The simulated community was composed of 104 species of fish that were distributed at 100% niche accumulation. The maximum niche was 10.647% for *Hypophthalmichthys molitrix*, while the minimum niche was 0.007% for *Sinocyclocheilus yangzongensis*. Across all fish, the numeric value of the middle bit of an ordered sort was 0.9615%. In total, 41 species were above the median, occupying 73.807% of the total niche, while 22 species occupied less than 10% of the median, accounting for 1.102% of the niche (see table 3.1).

Of the fish species occupying 74% of the niche, 33 (occupying 58% of the niche) are common species in the main stem and tributaries of the Pearl River, with the exception of *Luciocyprinus langsoni*, *Elopichthys bambusa*, *Sinocyclocheilus microphthalmus*, *Balitora kwangsiensis*, *Tor sinensis*, *Garra pingi yiliangensis*, *Cyprinus longzhouensis*, *Sinocyclocheilus grahami tingi*, and *Procypris merus*. Most of the remaining fish, accounting for 13.9% of the niche, were also common species, such as *Siniperca kneri*, *Ptychidio jordani*, *Ptychidio macrops*, *Rhodeus ocellatus*, *Onychostoma sima*, *Squaliobarbus curriculus*, *Osteochilus salsburyi*, *Pelteobagrus vachellii*, *Sinibotia pulchra*, *Rhinogobius giurinus*, *Ancherythroculter lini*, *Takifugu ocellatus*, *Hemiculter leucisculus*, *Pelteobagrus fulvidraco*, *Leiocassis crassilabris*, *Pelteobagrus intermedius*, *Carassius auratus auratus*, *Bostrichthys sinensis*, *Cirrhinus molitorella*, *Xenocypris argentea*, *Garra pingi pingi*, *Parasinilabeo*

TAB. 3.1 – The niches of the 104 fish species in the simulated community.

Niche greater than median		Niche less than the median			
		Niche less than median/greater than 10% of the median		Niche less than 10% of the median	
Fish	Niche (%)	Fish	Niche (%)	Fish	Niche (%)
Hypophthalmichthys molitrix	10.647	*Siniperca kneri*	0.954	*Schizothorax meridionalis*	0.093
Hypophthalmichthys nobilis	3.551	*Ptychidio jordani*	0.932	*Xenocypris argentea*	0.083
Opsariichthys bidens	2.664	*Ptychidio macrops*	0.912	*Garra pingi pingi*	0.080
Tachysurus argentivittatus	2.530	*Rhodeus ocellatus*	0.911	*Parasinilabeo assimilisParasinilabeo assimilis*	0.080
Luciocyprinus langsoni	2.381	*Onychostoma sima*	0.877	*Acrossocheilus beijiangensis*	0.078
Puntius semifasciolatus	2.232	*Squaliobarbus curriculus*	0.874	*Onychostoma barbatulum*	0.070
Sinocyclocheilus microphthalmus	2.178	*Cyprinus rabaudi*	0.858	*Carassioides cantonensis*	0.068
Balitora kwangsiensis	2.077	*Osteochilus salsburyi*	0.841	*Sinocyclocheilus anophthalmus*	0.065
Tor sinensis	2.061	*Pelteobagrus vachellii*	0.840	*Luciobrama macrocephalus*	0.062
Spinibarbus denticulatus denticulatus	1.943	*Mystacoleucus marginatus*	0.821	*Pseudogyrinocheilus prochilus*	0.062
Garra pingi yiliangensis	1.926	*Discogobiolongibarbatus*	0.821	*Tor zonatus*	0.053
Lcucosoma chinensis	1.844	*Sinibotia pulchra*	0.818	*Onychostoma lini*	0.045
Mylopharyngodon piceus	1.790	*Rhinogobius giurinus*	0.809	*Sinilabeo rendahli*	0.045
Acrossocheilus iridescens iridescens	1.773	*Ancherythroculter lini*	0.800	*Cyprinus fuxianensis*	0.038
Cyprinus longzhouensis	1.726	*Takifugu ocellatus*	0.789	*Sinocyclocheilus macrolepis*	0.037
Sinocyclocheilus grahami tingi	1.662	*Hemiculter leucisculus*	0.786	*Garra orientalis*	0.031
Procypris merus	1.656	*Pelteobagrus fulvidraco*	0.746	*Sinilabeo discognathoides*	0.024
Parabramis pekinensis	1.560	*Discocheilus wui*	0.741	*Acrossocheilus clivosius*	0.022
Elopichthys bambusa	1.513	*Rasborinus lineatus*	0.716	*Onychostoma ovalis rhomboides*	0.021

TAB. 3.1 – (continued).

Niche greater than median		Niche less than the median			
		Niche less than median/greater than 10% of the median		Niche less than 10% of the median	
Fish	Niche (%)	Fish	Niche (%)	Fish	Niche (%)
Acrossocheilus paradoxus	1.500	*Garra pingi hainanensis*	0.714	*Rectoris posehensis*	0.019
Cyprinus carpio	1.444	*Leiocassis crassilabris*	0.681	*Cyprinus chilia*	0.019
Rasbora steineri	1.439	*Pelteobagrus intermedius*	0.655	*Sinocyclocheilus yangzongensis*	0.007
Hemibagrus guttatus	1.430	*Cyprinus multitaeniata*	0.619		
Squalidus argentatus	1.406	*Carassius auratus auratus*	0.594		
Ctenopharyngodon idella	1.346	*Sinocyclocheilus macrocephalus*	0.589		
Anabas testudineus	1.282	*Semilabeo obscurus*	0.545		
Carassius Auratus gibelio	1.245	*Bangana decora*	0.544		
Micronemacheilus pulcher	1.244	*Discogobio brachyphysallidos*	0.460		
Lateolabrax japonicus	1.225	*Folifer brevifilis brevifilis*	0.445		
Zacco platypus	1.149	*Ochetobius elongatus*	0.415		
Acrossocheilus fasciatus	1.120	*Discogobio tetrabarbatus*	0.379		
Spinibarbus sinensis	1.098	*Acrossocheilus labiatus*	0.373		
Hemibagrus macropterus	1.075	*Bostrichthys sinensis*	0.354		
Misgurnus anguillicaudatus	1.060	*Onychostoma macrolepis*	0.338		
Semilabeo notabilis	1.053	*Cirrhinus molitorella*	0.327		
Megalobrama skolkovii	1.045	*Pseudocrossocheilus bamaensis*	0.302		
Pseudolaubuca sinensis	1.045	*Acheilognathus tonkinensis*	0.242		
Acrossocheiltts hemispinus hemispinus	0.977	*Cyprinus pellegrini*	0.209		

Tab. 3.1 – (continued).

Channa maculata	0.975	*Cyprinus yilongensis*	0.197		
Spinibarbus hollandi	0.969	*Acrossocheiltts elongatus*	0.155		
Leptobotia pellegrini	0.965	*Sinilabeo discognathoides wui*	0.106		
Niche subtotal%	73.807		25.090		1.1025

assimilis, and *Sinilabeo rendahli*. The linear river has a large geographical span, and the environmental difference among regions is great. We are puzzled by the fish species that were identified as the objects of the community study model, what ecological problems the results of the study represent, and the "boundary" problem of the model.

In total, 55 species are recorded as the main fishing targets (dominant species) in the Pearl River (Pearl River Fishery Resources Survey Commission, 1985). The total niche value of these fish was about 72%, and they also accounted for more than two-thirds of the ecological niche. Thus, to some extent, the model reflects the overall niche information for the dominant and non-dominant species in the community. Of the 104 species of fish in the simulated community, the main species of fish in the Pearl River were taken as the research object. The research results obtained from our model can be "mutually verified" with the fragmented data from historical records.

3.2.2 Niche Change

There are 104 species of fish in the community. In each analysis, one fish was removed, and the model analysis maintained 103 fish species. A total of 104 "communities" were analyzed, with one fish species missing from each "community." The median value of the average change rate in the niche of a given species during this cycle was 198%, and species with higher than median values accounted for 17.3%. The loss of these species caused a great change in community structure. Thus, in a sense, the niche of these types of fish in the simulated community was irreplaceable; that is, it was difficult for other fish to fill the niche of these particular species. Species below the median accounted for 83% of all species. Species with niches affected less than 50% by fish removal accounted for 61% of all species (see figure 3.105).

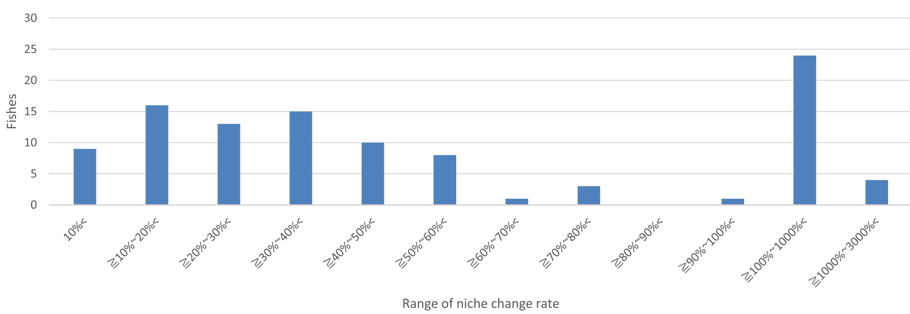

FIG. 3.105 – Distributions of species in the simulated community that affect niche change rate.

3.2.2.1 Niche Increase

A total of 26 fish species (see table 3.2) were included in the "primary community" of the 104 fish species, with each fish removed increasing the niche by more than 10%. Species 1–9 were mainly upriver species, which naturally became the "central community" of the upriver region in the model analysis. The species sensitive to niche increase (*i.e.*, an occurrence rate >5%) were *Leiocassis crassilabris* and *Cyprinus multitaeniata*. Species 10–26 were mainly distributed in the middle and lower river reaches and naturally became the "central community" of the middle and lower reaches in the model analysis. These niche-sensitive species included *Mylopharyngodon piceus*, *Ctenopharyngodon idella*, *Hypophthalmichthys nobilis*, *Squalidus argentatus*, *Hypophthalmichthys molitrix*, and *Rhinogobius giurinus* (table 3.1). The largest niche increase was in *Rhodeus ocellatus*, which increased by 51% due to *Ancherythroculter lini* removal; the next largest increase was in *Mylopharyngodon piceus*, which increased by 43% due to *Xenocypris argentea* removal.

TAB. 3.2 – Species with more than 10% niche increase.

No	Fish	Frequency of occurrence	Occurrence rate (%)
1	*Leiocassis crassilabris*	32	16.2
2	*Cyprinus multitaeniata*	30	15.2
3	*Sinocyclocheilus macrolepis*	8	4.0
4	*Sinocyclocheilus macrocephalus*	2	1.0
5	*Sinilabeo rendahli*	2	1.0
6	*Carassioides cantonensis*	2	1.0
7	*Onychostoma barbatulum*	1	0.5
8	*Rasborinus lineatus*	1	0.5
9	*Zacco platypus*	1	0.5
10	*Mylopharyngodon piceus*	24	12.1
11	*Ctenopharyngodon idella*	15	7.6
12	*Hypophthalmichthys nobilis*	14	7.1
13	*Squalidus argentatus*	12	6.1
14	*Hypophthalmichthys molitrix*	10	5.1
15	*Rhinogobius giurinus*	10	5.1
16	*Ochetobius elongatus*	9	4.5
17	*Carassius auratus auratus*	6	3.0
18	*Garra orientalis*	5	2.5
19	*Squaliobarbus curriculus*	4	2.0
20	*Xenocypris argentea*	2	1.0
21	*Elopichthys bambusa*	2	1.0
22	*Rhodeus ocellatus*	2	1.0
23	*Ptychidio jordani*	1	0.5
24	*Spinibarbus hollandi*	1	0.5
25	*Ptychidio macrops*	1	0.5
26	*Hemiculter leucisculus*	1	0.5
	Total	198	100

3.2.2.2 Niche Reduction

A total of 24 fish species were included in the "primary community" of the 104 fish species, with each fish removed reducing the niche by more than 10%. Among them, species 1–6 were mainly upstream species and naturally became the "central community" in the model analysis. The species sensitive to niche reduction (*i.e.*, with an occurrence rate is >5%) were *Garra pingi yiliangensis*, *Luciocyprinus langsoni*, *Elopichthys bambusa*, and *Sinocyclocheilus microphthalmus*. Species 7–24 were mainly distributed in the middle and lower reaches of the river and naturally became the "central community" in the middle and lower reaches of the river. These species included *Opsariichthys bidens*, *Tachysurus argentivittatus*, and *Carassius auratus auratus*. The largest decrease was in *Ancherythroculter lini*, which was an 87% decrease in response to the loss of *Squaliobarbus curriculus*. The next largest decrease (81%) was in *Siniperca kneri* due to *Carassius auratus auratus* loss (see table 3.3).

Tab. 3.3 – Species with greater than 10% niche reductions.

No	Fish	Frequency of occurrence	Occurrence rate (%)
1	*Garra pingi yiliangensis*	23	13.0
2	*Luciocyprinus langsoni*	14	7.9
3	*Sinocyclocheilus microphthalmus*	10	5.6
4	*Procypris merus*	6	3.4
5	*Cyprinus longzhouensis*	4	2.3
6	*Discocheilus wui*	1	0.6
7	*Opsariichthys bidens*	42	23.7
8	*Tachysurus argentivittatus*	21	11.9
9	*Carassius auratus auratus*	16	9.0
10	*Ochetobius elongatus*	8	4.5
11	*Ancherythroculter lini*	7	4.0
12	*Hypophthalmichthys molitrix*	4	2.3
13	*Osteochilus salsburyi*	3	1.7
14	*Hypophthalmichthys nobilis*	3	1.7
15	*Pseudolaubuca sinensis*	3	1.7
16	*Siniperca kneri Garman*	2	1.1
17	*Ctenopharyngodon idella*	2	1.1
18	*Cyprinus carpio*	2	1.1
19	*Rhinogobius giurinus*	1	0.6
20	*Xenocypris argentea*	1	0.6
21	*Channa maculata*	1	0.6
22	*Pelteobagrus fulvidraco*	1	0.6
23	*Misgurnus anguillicaudatus*	1	0.6
24	*Hemiculter leucisculus*	1	0.6
	Total	177	100

3.2.2.3 Niche Response Type

In a community consisting of species A, B, C, D, and E, the relationship between A and B is defined as competition if the absence of A results in the increase of B. If the absence of A results in the decrease of C, the relationship between A and C is defined as mutually beneficial. If the absence of A does not cause a change in D, then the relationship between A and D is defined as non-competitive. The responses of 103 fish species were analyzed in response to the absence of each of the 104 species of fish. If most of the other 103 species increased or decreased less than 10% in response to the absence of the removed species, the relationship between the removed species and the other species in the community was considered non-competitive. Across the 104 species, we identified 26 competitive species, 36 mutually beneficial species, and 42 intermediate species. Some fish in the same genus (*e.g.*, *Acrossocheilus* and *Cyprinus*) were grouped in the same category, reflecting the complex relationships among communities. Interspecific relationships among communities reflect the unity of competitive constraints and mutual benefits, and mutually beneficial fish may be better able to coexist with other fish.