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Ecological effects of predator chemical cues in aquatic ecosystem

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Abstract: Predator chemical cues are chemical signals released by predators that inform potential prey of the presence of predators. Predator cues allow prey to detect and evade predators from a distance. In aquatic ecosystem predator chemical cues have been shown to play an important role in information transmission and evolutionary race between prey and predator. The effect of predator cues on aquatic organisms has received increased attention recently. This paper summarized the current understanding on the nature of predator chemical cues and the ecological effects of predator chemical cues on the behavior morphology and life-history of aquatic organisms. Recent work on the effects of predator cues on disturbing the toxicity of contaminants was also reviewed. Predator chemical cues origin from the skin exudates faeces or injured tissue of predators. It was sometimes confused with conspecific cues since conspecific cues could induce similar responses. Studies examining the effects of predator cues often used predator conditioned water as the sources of predator chemical cues. Although knowledge about the chemical nature of predator chemical cues is still scarce considerable advances have been made especially for the identification of cues inducing anti-predator defenses in ciliates and cues originated from fishes. It

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was found that the effects of predator cues are associated with predator species predator′s diet concentration of cues and many other factors. The identification and isolation of predator cues is an important step towards understanding the nature and ecological effects of predator cues. Numerous studies have shown that predator-released chemical cues could induce behavioral morphological and life-historical anti-predator responses in preys. Behavioral responses to predator cues include avoidance of the area where cues is detected decreased activity levels or freezing and increased use of shelter. Behavioral responses of prey to predator cues have been found in cladocerans gastropods fishes and amphibians. Morphological defenses have been found in a wide range of aquatic taxa including algae protozoans rotifers cladocerans gastropods insects fishes and amphibians. Among them *Chaoborus*-induced morphological defense in *Daphnia* have received the most attention. Life-history responses to predator cues were mainly studied in cladocerans and amphibians and the responses include adaptive changes in life-history switch points (such as timing of hatching and metamorphosis) longevity and reproduction. The anti-predation responses make prey less vulnerable to predation and is believed to cause costs that are saved in the absence of predators. Interestingly it was found that predator cues may interact with contaminants and influence their toxicity to the survival growth and life-history of prey. The interaction may be influenced by the sources of predator cues classes of contaminants and their concentrations endpoints of prey and so on. These findings indicate that predatory stress plays an important role in the process of how contaminants exert their effects within the aquatic environment. The mechanisms of interaction between predator cues and contaminants are still unclear. Although considerable progress has been made several key questions in this area remain. Future studies are needed to explore the chemical nature of predator cues and to examine the signal transmission process in predator-prey interaction. Knowledge of the chemistry and signal transmission process of predator chemical cues may improve our ability to design meaningful experiments so as to gain better understanding on predator-prey interaction in aquatic ecosystem.

Key Words: predator chemical cues; kairomones; predator-prey interaction; ecological effects; aquatic ecosystem

(infochemicals)   **1**

[1]。   (

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。   。

、   " (disturbance cues conspecific cue) "。

(pheromones) [2]。   (*Strongylocentrotus*

franciscanus) 、   (*Orconectes virilis*) 、

[3]。   (*Etheostoma exile*) 、   (*Salvelinus fontinalis*) 、

、   、   、   (*Archocentrus nigrofasciatus*) 、

(*Cottus cognatus*)   (*Rana auroa*)

[4]。   [3]。

。   [5]。

                " (damaged-released alarm

、   、   cues) "。

                                                              。

。   [6]。

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”　“　　　　　（predator cues　　kairomones）”。　　　　　　　　　　　　　　[23]。

　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　[3 8 24]。Rosell

　　　　[3]。

　　　　　　　　　　　　　　　　　　　　　　　　　。

　　　　　　　　　　　　　　　　　　　　　　　　　　　　　[8]。Chivers

　　　　　　　　　　　　　　　　　　　（*Enallagma* spp.）

　　　　　　　　　　　　　　　　　　　　　　　　　　　（*Pimephales promelas*）

　　　　　　　　　　“　　　　　　　　　　　　　　　　　（*Esox lucius*）

”　　　　　　　　　　　　　　　。　　　　　　　　　　　（*Tenebrio molitor*）

　　　、　　　　、　　　　　　　　　　　　　　　　　　　　　　　　　　　[24]。

、　　　　　　　　　　　　[7]。　　　　　　　（*Neovision vison*）

　　　　　　　　　　（*Salmo trutta*）

　　　　　　　[8]。　　　　　　　（*Melanotaenia*　　　　　、

duboulayi)　　　　　　　　　　　　　　　　　　　　　　　　　　　。

（*Ceriodaphnia dubia*）　　　　　[9]。　　　　　　　　　Hazlett

　　　　　　　　　　　　　　　　　　　　　　　　　　[20]　Wisenden

[10–11]。Ringelberg　　Van Gool　　　　　　　　　　　　　[25]。

　　　　　　　　　　　　　　　　　　　　　　　　　　　　　[26–27]。von Elert

　　　　　　　　[10]。

　　　　　　　　　　　　　：　　　　　　　　　　　　　　。

　　　　　　　　（　　　　　　　　　　　　　、　　　　、　　　　　pH

　　　　　　　　　　　　　　　　　　[27]。Weber

）[12–13]

　　（　　　　　　　　　　　　　　　　）[14–17]　　　　　（N—H）　　　　（CH$_3$）

　　　　　　　　　　　　　[18]

[8]。　　　　　　　　　　　　　　　　　　　　　　　　　　　。

　　　　　　　　　　　　　　　。

　　　　　　[12 19]

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　　　　　　　　　　　　　　　　　　　　　　　　　　　[30]。

　　　　　　　　　　　　　（*Culex restuans*）[31]、　　（*Carassius aurarus*）[32]、

　（*Orconectes virilis*）　　　　　　　　（*Rana sylvatica*）[33]

[20]。　　　　　　（*Lembadion* sp.）

31500 Da　　　　　　　　　　　　　　　　　　。　　　、　　　、

[21]；

（*Stenostomum* sp.）　　　　17500 Da　　　　　　　　　　　Jacobsen　　Stabell

　　　　　　　　　　　　　　　　　　　　　　（*Littorina littorea*）

[22]。　　　　　　　　　　　　　　　[34]。UV-B

[35]。Ferrari   (*Daphnia galeata*)
(*Rana sylvatica*)
                    2h   [36]。Smith   [16]。
        pH   : Neill   (*Chaoborus*)
                        [37]。
                                                                            [17]。

                                                    [47]、   [48]、   [49]
            。   、   。Rosell   (*Salmo trutta*)
                        。   (*Neovision vison*)   [8]。
2   Scheurer   (*Salvelinus malma*)   (*Oncorhynchus mykiss*)

                                                                        [41]。Martin
                。   (*Esox lucius*)
                                        (*Rutilus rutilus*)
                [4]。   (*Perca fluviatilis*)
        。   [48]。

            、   、
                                                                    。Hein   Crowl
                    ((*Atya lanipes*)   (*Gobiomorus dormitor   Agonostomus monticola*)
)   [3]。   [50]。Epp   Gabor
                                        (*Eurycea nana*)   [42]。   (*Amoeba proteus*)
                        [38]。
2.1   ——   (*Euplotes* sp.)   [22]。

            。

                                            [51–52]。
    、   。   **2.2**
        [39]、   [40]、   [41]
    [42]
                                                                    。
            。
                        [40]   [3]。
                                                            。
            [44]、   [53–54]、   [19] [55]、   [56]
    [45]   。   [57]   [58]、   [59]、   [60]、
        (*Poecilia reticulata*)   [61]
    (*Daphnia magna*)   、   。
[46]。

                                    (*Scenedesmus subspicatus*)
        [15]。   van Gool   Ringelberg

[62]。

。

[62]。Lampert 、 、

[73]。

[63]。Verschoor [74]。

（*Brachionus calyciflorus*）

[64]。 [75]。

（*Daphnia pulex*） （*Chaoborus*）

。 。 （*Phagocotus gracilis*）

（*Ambystoma barbouri*）

（neck teeth） [76]。Johnson

[38 65]。 （*Procambarus*

（tail *nigrocinctus*）

spines）、 （helmets）、 （crests） 。 （*Rana sphenocephala*）

（*Anax junius*）

。 （*Tinca tinca*） [77]。

（*Radix balthica*） 、

[58]。 。

（spines）

。 Hoverman [78]。

（*Helisoma trivolvis*）

[12]。Stabell

[79–80]。

[66]。Fässler Kaiser 。

： （ ） （

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（*Mytilus edulis*） [67]。

。 Hoverman [81]。

Relyea （*Helisoma trivolvis*） **3**

（*Belostoma flumineum*）

[68]。

2.3 。Hanazato Dodson （*Chaoborus*

[69]、 *americanus*） （*D. pulex*）

[70]、 [71]、 [72] （carbaryl）

。

。 [82–83]。Barry [84–87]

Rose [9]

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93—94

。   Relyea   95—97。

(*Notophthalmus viridescens*)   (*Daphnia carinata*)

                                                        (
46   ) 13 。   95。

        、   、

        、   18 88—91   95。

                                                                                                                。

        、   、
                    。   Campero   。
(*Lepomis gibossus*)
        (Atrazine)   (*Coenagrion puella*)
                            (Carbaryl)   。
        92。

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                14。   。

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