

# Cognitive and Governance Gaps in China's Management of Biological Invasions

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The phenomenon of biological invasions has become one of the most severe ecological and economic problems in China. Although there exists an effective legal foundation—and recently a Biosafety Law in particular—some of the management approaches used by authorities still fail to correspond to scientific evaluations of danger. Hence, in this paper, the author will summarize the current literature on the problem and discuss three case studies related to different invasive species: the alligator gar, the Hercules beetle, and cases when local flora and fauna were incorrectly classified. As a result, based on the analysis of these examples, the author will introduce the concept of a *cognitive disconnect*. This term implies the discrepancy between scientific facts, popular awareness, and governmental actions in dealing with invasive species. Thus, in conclusion, the paper will discuss how this cognitive disconnect might cause difficulties in estimating dangers, recognizing the importance of the invaded ecosystem, and implementing unified policies. This problem is usually associated with weak coordination between authorities, unclear motivation, and a shortage of professional skills among frontline practitioners. Therefore, it is necessary to introduce a more adaptive approach to governance that would include a closer integration of science, better flexibility of policies, and enhanced capacities of practitioners.

**Keywords:** biological invasions; China; risk assessment; governance; alien species; cognitive disconnect

## Introduction

Biological invasions represent one of the major sources of global environmental changes with negative consequences for biodiversity, agriculture, infrastructure, and even human health (Pyšek et al., 2020<sup>1</sup>; Diagne et al., 2021<sup>2</sup>). The problem of biological invasions has received growing attention in China recently. As the economic development of the country accelerates, its interaction with the rest of the world deepens through international cooperation and internet commerce. Hence, species migration becomes more common, which raises the number of introduced alien species in China (Liu et al., 2021<sup>3</sup>; Wang et al., 2023<sup>4</sup>). In response to the emerging threat, the government introduces policies and legislation that provide a framework for risk assessment and quarantine of foreign species (Cao, 2021<sup>5</sup>). For example, an earlier national survey aimed at the identification of invasive alien species in China was used in developing relevant legislation (Xu et al., 2012<sup>6</sup>). Therefore, it can be stated that the biosecurity system in China is rather elaborate from the legal standpoint.

However, there seems to be a gap between legislation and practice. As an illustration, Ruzhou city pumped out an ur-

ban lake in order to catch a single alligator gar in August 2022 (Gao & Guo, 2022<sup>7</sup>). Previous research shows that the species cannot survive winter in such climatic conditions (Bartnicki et al., 2021<sup>8</sup>). Moreover, Xiamen Customs prevented the delivery of five Hercules beetles as exotic pets. Media extensively informed about the potential hazards of importing these animals (CCTV News, 2021<sup>9</sup>). However, the climate of mainland China would not allow the creatures to survive (Jarošík et al., 2015<sup>10</sup>). Therefore, it could be argued that there is a disparity between the risk assessments conducted within a scholarly setting and managerial actions taken in response to those assessments. Policy literature refers to such cases as “reactions to ecological alarms” because they lack evidence backing. In terms of China, it is probably more appropriate to refer to this phenomenon as cognitive dissonance due to the alien status of the species concerned.

This type of dissonance may have several consequences. The resources are likely to be allocated to the assessment of low-potential threats while more significant issues will remain unnoticed. Moreover, a general view of alien species as extremely hazardous may arise, thus creating uncertainty in this field. In addition, a poor understanding of taxonomy may confuse invasive organisms with protected ones. All these issues can be considered typical implications of cognitive dissonance, which is characteristic of risk assessment and man-

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agement in the public sector and general population (Cheng et al., 2026<sup>11</sup>; Verloove, 2010<sup>12</sup>).

The following are the main goals of the proposed study. First, to identify previous research focused on causes and processes of biological invasions in China—both ecological and human aspects. Second, to review existing management practices using a case study method and understand what types of cognitive dissonance take place. Third, to find possible approaches to solving the issue in the future.

## Methodological Approach

In order to analyze the relationship between scientific knowledge and the governance of the phenomena, this paper employs a critical interpretative methodology, recognizing the fact that meta-analytical synthesis will be limited by its inherent inability to address the complexity. However, an attempt was made to apply systematic review techniques to increase transparency and minimize source bias (Moher et al., 2009<sup>13</sup>).

To that end, the following databases were searched for relevant publications within the time frame from January 2000 to March 2026: Web of Science, CNKI, Scopus, and Google Scholar (as a supplementary database). The search keywords included: “biological invasion,” “alien species,” “China,” “risk assessment,” “governance,” “invasive species management,” and “biosecurity policy.” Furthermore, the case study terms included *alligator gar* (*Atractosteus spatula*) and *Hercules beetle* (*Dynastes hercules*). In the case of Chinese sources, Chinese versions of keywords were used (生物入侵, 外来物种, 风险评估).

At the very first stage, articles were selected based on certain basic requirements. As a result, the focus of the study narrowed down to peer-reviewed journal articles and government reports, as well as international guidelines (such as those developed by IPPC and IUCN) and news reports. The documents should have been available in English or Chinese, and methodologically incomplete publications were excluded from consideration.

Based on the large number of sources obtained at the previous stage, thirty-two articles entered the next stage of the analysis. The whole process is illustrated by the PRISMA diagram (Appendix A). Information related to the species involved, their possible modes of biological invasion, governance issues, and policy recommendations was gathered from all publications. Appendix B summarizes these data.

When it comes to case studies mentioned in results, they were selected as exemplifying different aspects of the research question rather than being representative examples. Each case study addresses a specific problem—risk underestimation, low evaluation of the ecological potential of a species, and implementation limitations, correspondingly.

## Results

### Mechanisms of Biological Invasions

What are the key determinants of a successful or failed establishment of an invading species? Ecosystem vulnerability, species’ traits, and anthropogenic dispersal emerge as the consistent variables associated with invasions across the literature base (Lockwood et al., 2013<sup>14</sup>; Wilson et al., 2009<sup>15</sup>; Pyšek & Richardson, 2007<sup>16</sup>). From the perspective of the Chinese ecosystem, vulnerability seems to be the defining factor of invasion success in freshwater environments. An example in point could be the depletion of apex predators in the Yangtze River system. Extinction of *Lipotes vexillifer* (Yangtze river dolphin) has already been confirmed, although the mammal can be considered as functionally extinct (Turvey et al., 2007<sup>17</sup>).

The substantial reduction of population of *Psephurus gladius* (Chinese paddlefish) (Zhang et al., 2020<sup>18</sup>) leads to the loss of ecological balance. Therefore, invasive species may establish themselves in the absence of the natural top predators. Species like *Trachemys scripta elegans* (red-eared slider) and tilapia (*Oreochromis niloticus* and *O. zillii*) are abundant despite that fact. On the contrary, those species remain at low levels of abundance in ecosystems with intact apex predator populations.

As far as the biological characteristics of successful invaders are concerned, rapid reproduction, high mobility, phenotypic plasticity, and tolerance to varying environmental conditions are typical for them (Newsome & Noble, 1986<sup>19</sup>; Cuthbert et al., 2025<sup>20</sup>). Nevertheless, even possessing those traits, a species will be incapable of spreading if the habitat does not provide necessary conditions for expansion. Hence, the invasion potential is a highly context-dependent variable, implying a relationship between species traits and ecosystem properties (Lockwood et al., 2013<sup>14</sup>).

Finally, there should be discussed the matter of human-mediated dispersal. Anthropogenic transport of species has evolved dramatically in recent decades. With increasing globalization, characterized by expanded trade networks, e-commerce, international tourism, and enhanced migration flows, species jump dispersal becomes more frequent (Wilson et al., 2009<sup>15</sup>; Lockwood et al., 2019<sup>21</sup>). As for China, the pet trade and fishery represent the most prominent ways for introducing species into new territories (Liu et al., 2021<sup>3</sup>; Weber & Li, 2008<sup>22</sup>). Introduced species may be transported both deliberately and unintentionally. It can be stated with reasonable certainty that the probability of invasion is easier to predict taking into account the propagule pressure rather than individual biological attributes (Lockwood et al., 2013<sup>14</sup>).

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## Cognitive Disconnect in Practice: Three Cases

In some policy discussions, certain management actions have been described as responses to “unverified ecological alarms.” Our analysis suggests that these situations reflect a form of *cognitive disconnect*, in which key scientific factors are not fully considered and decisions are influenced more by visible traits, media attention, or administrative pressure. The following three cases illustrate risk misjudgment, value neglect, and implementation failure.

### Risk Misjudgment: The Alligator Gar

For example, there is the alligator gar (*Atractosteus spatula*), being the representative of the Lepisosteidae family and one of the largest species of fish found in freshwater environments of North and Central America (Han, 2022<sup>23</sup>). The species had been imported into China several times in order to be used as ornamental fish (Han, 2022<sup>23</sup>). In the recent example, there was just one individual caught in Yunchan Lake of Ruzhou City in the Henan Province in August 2022 (Gao & Guo, 2022<sup>7</sup>).

However, the current situation is much less threatening than the activity carried out in response to the threat posed by the aforementioned alien fish species. In the first place, judging by currently available information, risks of the alien fish invading into temperate regions of China are rather minimal. For instance, the optimal range of temperature necessary for raising the alligator gar is within 24–28°C; at the same time, temperatures lower than 9°C appear to be lethal for the species (Bartnicki et al., 2021<sup>8</sup>). It goes without saying that winter temperatures in the country’s northern parts will not match those, besides they lead to ice covering the surface of the water bodies. Second, it is noted that the species achieves sexual maturity at the age of 5–6 years; however, there has been no information on the presence of the species in China until now (Xie et al., 2023<sup>24</sup>). Third, there have been no reports on aggression of this ambush predator toward humans because the fish is unable to attack any prey larger than itself. Hence, in scientific terms, there is no need to be worried about the current situation.

Nonetheless, regardless of the situation described above, introduction of invasive species certainly should not be neglected; on the contrary, a preliminary risk assessment needs to be conducted. Unfortunately, however, there seems to be no way to prevent alien species from spreading in China in the described case.

### Value Neglect: The Hercules Beetle

There is the case in which, in 2021, five individuals of the Hercules beetle (*Dynastes hercules*) were seized during importation to Xiamen for usage as exotic pets. According to

local and national sources, the incident attracted attention due to the power possessed by the insects, enabling them to resist a weight eight times heavier than their own body mass, as well as potential threats associated with their spread in ecosystems. However, in spite of it, the insects were seized anyway. The case is regarded as an illustration showing how biological invasion could be prevented successfully (People’s Daily App Fujian Channel, 2021<sup>25</sup>).

Nevertheless, taking into account scientific literature on the subject, there may be a different viewpoint on the situation. The condition necessary for insect invasion into the new territory is, among others, specific thermal conditions (Jarošík et al., 2015<sup>10</sup>). The native habitat of the Hercules beetles refers to tropical rainforests of Central America (Myers et al., 2024<sup>26</sup>); therefore, necessary temperature regimes will include temperatures from 24 to 28°C as well as high humidity. Thus, seasonal temperature changes observed throughout almost all regions of China will not fit. Besides, the fact should be kept in mind that the mentioned insects have not ever survived in the natural environment; hence, they pose no real threat to the ecosystem.

Apart from that, it should also be noted that there is yet another aspect connected with the problem. Being exotic pets, the Hercules beetles become part of a multibillion-dollar industry (Lockwood et al., 2019<sup>21</sup>). China also experiences rapid development of this sector, with approximately 17 million people earning up to 10 billion yuan annually (Global Times, 2025<sup>27</sup>). Although a number of exotic pets require certain climatic conditions and are unable to multiply in captivity, legislative measures have already been undertaken.

### Implementation Failure: Misidentification of Native Species

The third facet involves the possibility for frontline enforcement officers to discern aliens from natives. Past cases indicate that such ability is inconsistent. For instance, in 2021, the local authorities in Zhangjiagang City of Jiangsu Province issued a notice to the public naming *Ophiophagus hannah*, the king cobra—a native and nationally protected species—as an invasive alien species (Nanjing Customs, 2021<sup>28</sup>; The Paper, 2021<sup>29</sup>). In the second case, in 2022, the police of Shijiazhuang City, Hebei Province, confused *Physignathus cocininus*, the native Chinese water dragon, with *Iguana iguana*, the alien green iguana, while erroneously labelling the latter as an endangered species (Shijiazhuang Daily, 2022<sup>30</sup>). Lastly, in 2022, the fisheries department of Siyang County, Jiangsu Province, mistook *Apalone ferox*, the Florida softshell turtle, for *Pelodiscus sinensis*, the native Chinese softshell turtle, and released it into the environment despite current regulations on alien species management (Liu, 2022<sup>31</sup>).

Such errors could negatively impact the biosecurity poli-

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cies' effectiveness by undermining public trust in its implementation or diverting attention from other potentially hazardous species. At times, they might cause additional ecological challenges, particularly when alien species are released into their habitats. In this regard, they do not constitute one-off mistakes, but reflect a more complex problem linked to the professional capability of the relevant officials. In some cases, such individuals may lack adequate tools, training, or timely expertise to make proper distinctions.

At the same time, it would be misleading to claim that all cases of enforcing policies on biosecurity entail such challenges. Indeed, there are examples of efficient differentiation and handling of high-risk species. Specifically, *Bursaphelenchus xylophilus*, the pine wood nematode, was monitored systematically via surveillance in the country's forests (Ding et al., 2021<sup>32</sup>). Furthermore, *Brontispa longissima*, the coconut leaf beetle, was under special control in the southern regions of China (Peng et al., 2019<sup>33</sup>; Lu et al., 2019<sup>34</sup>). Hence, the presented issue cannot be associated with a broad failure of the biosecurity governance system in China, but rather reflects a specific flaw that could emerge during the management of visually apparent low-risk species.

### China's Governance Framework in Comparative Perspective

None of the listed examples provide us with grounds to state that China is completely inefficient in its biosecurity policy regulations. To begin with, over the past few years, China managed to achieve rather decent results in terms of biosecurity policy regulations. First of all, the adoption of The Biosafety Law in 2021 serves as the basis for quarantine and risk assessment (Cao, 2021<sup>5</sup>). Furthermore, it is worth mentioning that there is a list of invasive alien species which could be revised periodically (Xu et al., 2012<sup>6</sup>). Also, the surveillance and monitoring of such high-risk species as coconut leaf beetle and pine wood nematode is currently underway (Peng et al., 2019<sup>33</sup>; Ding et al., 2021<sup>32</sup>). From the standpoint of international recommendations, including IPPC (2019<sup>35</sup>), all of the mentioned means could be considered efficient.

That said, there is certainly room for improvement regarding the regulation of low-risk species with regard to the use of the abovementioned methods. In general, according to international guidelines, the risk assessment procedure should always be scientific and aligned with the actual level of risks (IUCN, 2000<sup>36</sup>). In real life, however, the influence of social fears on policy-making tends to exceed the impact of the actual level of risks involved, which might be intensified during pandemic times (Hulme, 2021<sup>37</sup>; Li et al., 2022<sup>38</sup>). Therefore, it seems that visual and striking events tend to attract more attention than the issues of capacity building and risk assessment itself.

## Discussion

### Why Does Cognitive Disconnect Persist?

The aforementioned examples demonstrate that this type of discrepancy is rather common. What is the reason for this to occur time after time?

One of the explanations involves institutional arrangements. In the case of China, risk assessment and public communications often belong to different institutions with rather poor coordination among them (Cheng et al., 2026<sup>11</sup>). Thus, species may be intercepted by the customs authority, reported in mass media, acted upon by local governments—without a single risk assessment being conducted beforehand. There appears to be no point at which scientific evaluation is required before taking action.

Motivational aspects serve as another reason. Local governments and enforcement agencies face strong pressure to react swiftly to potential dangers and show the effectiveness of their actions. Draining a lake just to catch a “strange fish” is certainly a very obvious reaction. Inaction, on the contrary, is almost invisible and difficult to justify even when science suggests that risk is minimal. In short, action prevails over inaction.

Knowledge and technical support comprise yet another factor. Personnel may act in good faith, yet have no reliable tools to perform proper species identification or receive advice from experts. Misidentification of king cobras and Chinese water dragons are not isolated instances. These problems stem from insufficient training, lack of access to information sources, and other related factors (Verloove, 2010<sup>12</sup>; Cheng et al., 2026<sup>11</sup>).

### Towards Intelligent Governance: A Science-Informed Framework

What does an adaptive response look like in this case? According to Lockwood et al. (2013<sup>14</sup>) and Yemshanov et al. (2019<sup>39</sup>), an “intelligent governance” strategy based on scientific risk assessment and professional expertise proves to be efficient (Figure 1). The problem lies in operationalizing this approach, however. Based on international guidelines (IPPC, 2019<sup>35</sup>; IUCN, 2000<sup>36</sup>) and Chinese practice, there appear to be three key aspects.

Aspect 1: Risk Assessment Incorporation into Decision-Making Process. As seen from the present paper, the problem in question has nothing to do with the absence of scientific data. Rather, it consists in the integration of the latter into decision-making process. One solution could be a procedural mandate: before applying any actions towards alien species control, a risk assessment based on criteria such as climate suitability, reproductive conditions, propagule pressure, and previous establishments should be made. Had the managers



**Fig. 1** "Intelligent Governance" Model for Biological Invasions

from Ruzhou acted on this principle, the outcome would have been different.

Aspect 2: Differentiation by Risk and Value. Instead of assuming that all alien species have the same detrimental effect, a simple matrix of decisions based on ecological risk and economic value can be created to regulate appropriate actions (Figure 2). Four types of species may be differentiated:

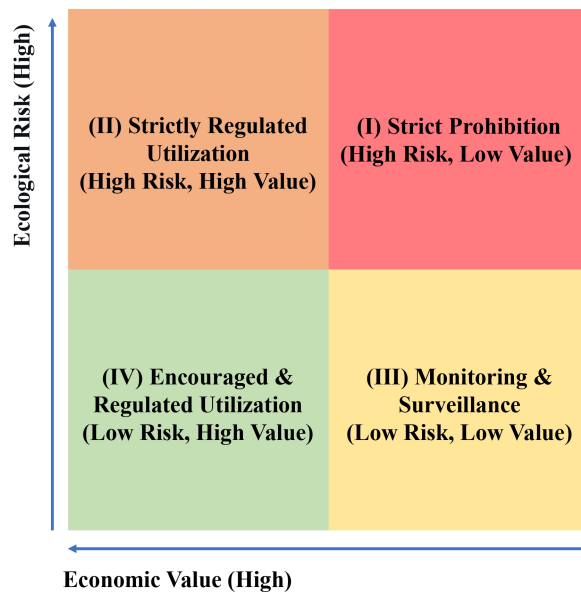
High-risk / Low-value species (e.g. red imported fire ant, pine wood nematode, water hyacinth): extremely dangerous for the environment but worthless economically; should be controlled with strict measures, including restriction of introductions/movements/releases and field management.

High-risk / High-value species (e.g. crayfish, bullfrog, tilapia): carry both ecological risks and economic value; regulated uses should be encouraged through closed farms, traceability systems, and escape tracking.

Low-risk / High-value species (e.g. Hercules beetles, captive reptiles, ornamental fish): usually do not pose risks and contribute to economic/cultural activity; regulation should be lighter, limited to whitelist systems, quarantine, and registration.

Low-risk / Low-value species (e.g. accidentally introduced small invertebrates): usually harmless; regular monitoring is sufficient.

To be more practical, this study recommends the creation of a National Biosafety Committee (NBC) comprising approximately 10–12 people—invasion ecologists, taxonomists, trade



**Fig. 2** Decision Matrix for Classified Management of Alien Species

economists, and representatives of MEE, MARA, and GAC. This committee will evaluate annually the National List of Invasive Alien Species in terms of risk–value classification, while enabling any species to change status within 30 days following the presentation of peer-reviewed articles providing evidence of establishment in comparable regions of similar climate.

Additional criteria can be applied for changing a species' status. For instance, it should be moved from the category of *Observation* to *Control* in the following cases: survival through winters for two consecutive years, generation of more than 1,000 individuals per year, and occurrence of hybridisation with local species. Conversely, when it is demonstrated that a species' presence significantly and irreversibly harms native species by reducing their population by 30% while requiring costs higher than CNY 100 million for controlling the species, it should be moved from *Control* to *Prohibition*.

On the other hand, it should be moved from *Control* back to *Observation* if it is proven that no introductions or establishments took place during five consecutive years, and it was estimated that risks are low. Although lacking empirical validation, this system may be considered a reasonable initial step toward development of an improved system.

Aspect 3: Investment into Frontline Capacity. The third aspect that requires attention is investment into frontline capacity. It could be implemented by developing unified guidelines to identify species throughout the country by means of im-

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age recognition software and expert judgement, increasing the expertise of customs, fisheries, and forestry workers regarding taxonomy, and improving cross-departmental cooperation through platforms combining risk assessments, interceptions data, and management experience. Without a sufficient front-line capacity, no risk assessment scheme can be utilised.

Of course, it would be misleading to draw a conclusion based on the examples mentioned above. Indeed, it is incorrect to state that all biosecurity measures taken in China were based on cognitive dissonance. High-profile species, e.g., pine wood nematode and coconut leaf beetle, were addressed by the government in terms of surveillance and control that align with scientific recommendation (Peng et al., 2019<sup>33</sup>; Ding et al., 2021<sup>32</sup>). Cognitive dissonance is not ubiquitous in China; it emerges under certain conditions, e.g., when a species is aesthetically pleasing but carries low risks, risk assessment methods are inapplicable, or frontline capacity is insufficiently developed.

## Limitations

These include several points. The case studies were chosen in line with the aim of raising awareness of certain examples of cognitive disconnects. Although there can be found other examples where science and governance were less disconnected, they are not considered here. Information obtained solely from publicly accessible sources was used, as any evaluations and discussions held internally within the Chinese government remained inaccessible.

The comparison of China and international experience presented here cannot be regarded as a thorough one; the point that deserves noting is that a full-fledged comparative study will certainly exceed the bounds of the current paper. Besides, even though a new framework was suggested theoretically, its applicability needs to be confirmed by means of pilot testing and further research. Furthermore, there exists some possibility of linguistic bias since, owing to the focus on the Chinese experience, the literature review involved, among other sources, those written in Chinese.

Finally, another problem is associated with the use of sources: events discussed here (identification errors, Shijiazhuang, etc.) were supported mostly by government documents and media coverage instead of academic sources. However, it should be mentioned that only a confirmation of the occurrence of such instances was necessary; therefore, no conclusions about their frequency or reasons can be drawn based on these sources.

## Conclusion

The situations discussed in the cases above demonstrate that there was a connection between the response of policymakers

to biological invasions in China and emergency procedures despite the existence of scientific knowledge proving otherwise about the relatively low level of risks. It appears that this discrepancy is not only the result of poor communication. On the contrary, its roots may lie in the institutional arrangements, incentives, and professionalism involved in dealing with biological invasions.

It should be noted that much progress has been made in building institutional infrastructure and legal mechanisms related to biosecurity in China. The Biosafety Law and the national List of Invasive Alien Species provide favourable circumstances for biosecurity. Yet, implementation of these notions and their consistency with scientific evidence pose difficulties. The development of novel risk assessment methodologies as well as flexibility in alien species classification and management is required to solve this problem.

There are several areas worth investigating further. For instance, a comparative analysis of various governance frameworks in terms of the science-policy-making gap in biological invasions management can be carried out. Another research direction may involve empirical analysis of pilot programs employing risk-based management techniques. Moreover, it would be useful to explore the adverse consequences resulting from inadequate reactions to high-risk species and excessive reactions to low-risk species.

Consequently, managing biological invasions does not imply the extermination of all alien species due to potential inefficiency and irrationality of such measures. Rather, it requires effective application of limited economic, technological, and human resources based on scientific evidence and flexible governance mechanisms.

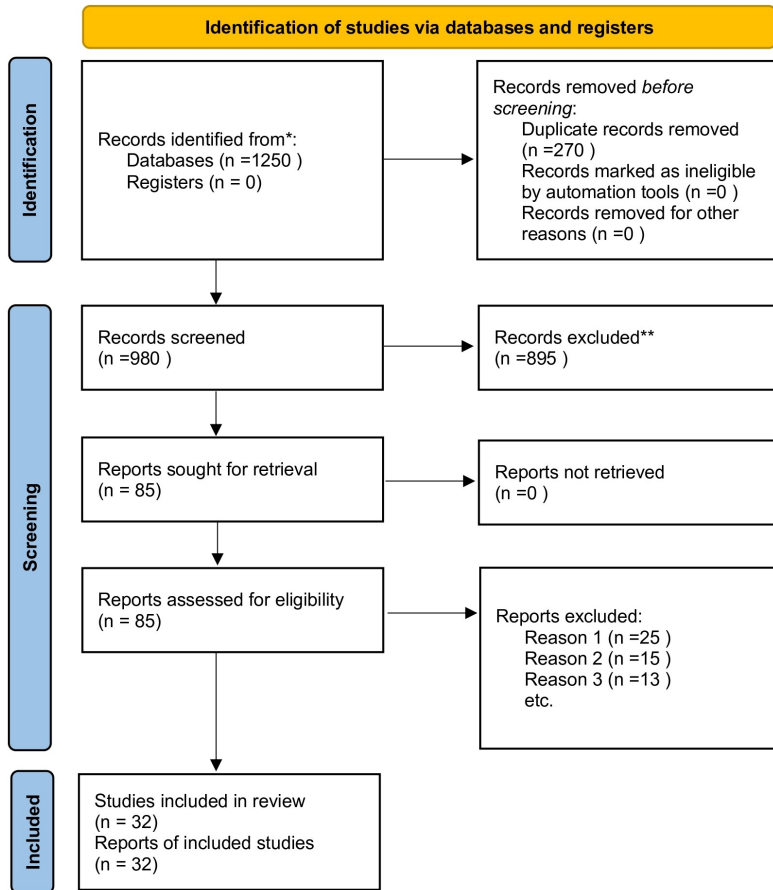
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  - 33 Z. Peng, B. Lyu, W. Qin and Z. Li, *Ecological basis and control technology system of invasion and outbreak of alien pest Brontispa longissima*, 2019, Original work published in Chinese.
  - 34 B. Lu, Z. Peng, H. Lu, F. Yang and F. Lin, *Inter-country trade, genetic diversity and bio-ecological parameters upgrade pest risk maps for the coconut hispid Brontispa longissima*, 2019.
  - 35 International Plant Protection Convention (IPPC), *International standards for phytosanitary measures (ISPMs)*, Fao technical report, 2019.
  - 36 IUCN, *IUCN guidelines for the prevention of biodiversity loss caused by alien invasive species*, Iucn species survival commission technical report, 2000.
  - 37 P. E. Hulme, *Advancing One Biosecurity to address the pandemic risks of biological invasions*, 2021.
  - 38 L. Li, Z. Wang and Y. Li, *The dynamic evolution mechanism of public health risk perception and the choice of policy tools in the post-epidemic era: Evidence from China*, 2022.
  - 39 D. Yemshanov, R. G. Haight, F. H. Koch, R. C. Venette, T. Swystun, R. E. Fournier, M. Marcotte, Y. Chen and J. J. Turgeon, *Optimizing surveillance strategies for early detection of invasive alien species*, 2019.

## Appendix A: PRISMA Flow Diagram

PRISMA 2020 flow diagram for new systematic reviews which included searches of databases and registers only



\*Consider, if feasible to do so, reporting the number of records identified from each database or register searched (rather than the total number across all databases/registers).

\*\*If automation tools were used, indicate how many records were excluded by a human and how many were excluded by automation tools.

## Appendix B: Summary Table of 32 Included Articles

**Table 1** Summary of 32 Included Articles

ID	Author(s) (Year)	Species / Topic	Main Findings (Relevance to Risk/Governance)
1	Bartnicki <i>et al.</i> <sup>8</sup>	<i>Atractosteus spatula</i> (alligator gar)	Determined critical thermal minimum ( $\approx 11-12^{\circ}\text{C}$ ) during early life stages; supports low-risk classification for temperate China.
2	Cao <sup>5</sup>	China's Biosafety Law	Reviewed 11 institutional mechanisms (risk assessment, listing, information sharing); provides academic basis for the legal framework.
3	Cheng <i>et al.</i> <sup>11</sup>	China's IAS governance policies	Identified systemic problems including insufficient coordination and weak basic support; supports institutional design analysis.
4	Cuthbert <i>et al.</i> <sup>20</sup>	Economic impact prediction of IAS	Proposed trait-based framework to predict economic impacts; supports species-traits discussion.
5	Diagne <i>et al.</i> <sup>2</sup>	Global economic costs of IAS	Quantified worldwide invasion costs; provides introductory background.
6	Ding <i>et al.</i> <sup>32</sup>	<i>Bursaphelenchus xylophilus</i> (pine wood nematode)	Studied population differentiation via whole-genome sequencing; supports positive case of systematic surveillance.
7	Gao and Guo <sup>7</sup>	<i>Atractosteus spatula</i> (alligator gar)	Documented the Ruzhou lake-draining incident; academic source for event occurrence.
8	Han <sup>23</sup>	<i>Atractosteus spatula</i> (alligator gar)	Indicated entry of alligator gar into China via the ornamental fish trade; supports introduction-pathway discussion.
9	Hulme <sup>37</sup>	Biosecurity and biological invasions	Discussed how COVID-19 reinforced precautionary biosecurity policies globally; supports pandemic-amplification argument.
10	International Plant Protection Convention (IPPC) <sup>35</sup>	International phytosanitary standards	Provides international norms for plant quarantine; serves as the standard against which China's framework is benchmarked.
11	IUCN <sup>36</sup>	Guidelines on IAS prevention	Stipulates that risk assessment should be science-based, transparent, and proportionate; supports citation of international guidelines.
12	Jarošík <i>et al.</i> <sup>10</sup>	Thermal requirements of invasive insects	Found that invasive insects have higher developmental threshold temperatures; supports climatic mismatch principle.
13	Li <i>et al.</i> <sup>38</sup>	Risk perception and policy tools	Analysed post-pandemic increase in public risk perception and its interaction with policy choices in China.
14	Liu <i>et al.</i> <sup>3</sup>	Belt & Road invasion risks	Analysed introduction pathways including pet trade and aquaculture; supports human-mediated dispersal discussion.
15	Lockwood <i>et al.</i> <sup>14</sup>	Invasion ecology (textbook)	Synthesised the three-factor framework (ecosystem vulnerability, species traits, propagule pressure); primary theoretical source.
16	Lockwood <i>et al.</i> <sup>21</sup>	Exotic pet trade and invasions	Discussed mechanisms of the pet trade as an invasion pathway and its multi-billion-dollar scale.
17	Lu <i>et al.</i> <sup>34</sup>	<i>Brontispa longissima</i> (coconut leaf beetle)	Quantitatively assessed invasion drivers and produced pest risk maps; supports positive management case.
18	Moher <i>et al.</i> <sup>13</sup>	PRISMA methodology	Provides the standard framework for systematic literature review methodology.
19	Myers <i>et al.</i> <sup>26</sup>	<i>Dynastes hercules</i> (Hercules beetle)	Records species distribution in Central American tropical rainforests; supports geographic and thermal background.
20	Newsome and Noble <sup>19</sup>	Traits of invading species	Classic work summarising successful invader traits (rapid reproduction, high dispersal, etc.).
21	Peng <i>et al.</i> <sup>33</sup>	<i>Brontispa longissima</i> (coconut leaf beetle)	Summarised ecological basis and control technology for invasion outbreaks; supports positive management case.
22	Pyšek and Richardson <sup>16</sup>	Invasive plant traits	Reviewed traits associated with invasiveness (phenotypic plasticity, broad tolerance, etc.).
23	Pyšek <i>et al.</i> <sup>1</sup>	Scientists' warning on IAS	Comprehensively reviewed drivers, impacts, and governance needs; serves as background citation.
24	Turvey <i>et al.</i> <sup>17</sup>	<i>Lipotes vexillifer</i> (Yangtze river dolphin)	Declared species functionally extinct; supports apex-predator decline discussion.
25	Verloove <sup>12</sup>	Misidentifications in IAS management	Emphasised serious consequences of misidentifications and the need for taxonomic training.
26	Wang <i>et al.</i> <sup>4</sup>	Online ant trade in China	Monitored online pet trade revealing high biological invasion risk; supports pet-trade argument.
27	Weber and Li <sup>22</sup>	Plant invasions in China	Discussed drivers of plant invasions under economic development.
28	Wilson <i>et al.</i> <sup>15</sup>	Dispersal pathways and invasion success	Discussed how human-mediated dispersal affects invasion success through propagule pressure.
29	Xie <i>et al.</i> <sup>24</sup>	<i>Atractosteus spatula</i> (alligator gar)	Assessed establishment risk in Chinese freshwaters; concluded no wild populations established.
30	Xu <i>et al.</i> <sup>6</sup>	Inventory of IAS in China	Provided early scientific inventory, laying groundwork for subsequent regulatory lists.
31	Yemshanov <i>et al.</i> <sup>39</sup>	Surveillance strategy optimisation	Developed mathematical models to optimise early-detection surveillance strategies.
32	Zhang <i>et al.</i> <sup>18</sup>	<i>Psephurus gladius</i> (Chinese paddlefish)	Declared species extinct; supports apex-predator decline discussion.