Do bushmeat consumers have other fish to fry?

J. Marcus Rowcliffe[1], E.J. Milner-Gulland[2] and Guy Cowlishaw[1]

[1]Institute of Zoology, Zoological Society of London, Regent's Park, London, UK, NW1 4RY
[2]Imperial College London, Division of Biology, Manor House, Silwood Park Campus, Buckhurst Road, Ascot, Berkshire, UK, SL5 7PY

The overexploitation of tropical forests for bushmeat and of the oceans for fish are two of the most important threats to global biodiversity. Both phenomena also have manifold implications for human livelihoods and food security. A recent article by Brashares *et al.* indicates that these two resources are linked: when regional fish supplies are low, local bushmeat hunting intensifies. Although coordinated management of bushmeat and fisheries is thus needed, gaps in our knowledge of these systems must first be filled.

New evidence for linkage

The policy debate traditionally treats different types of resource in a highly compartmentalized way, effectively assuming that there are no significant linkages between resources. However, as the exploitation of, and trade in, natural resources become increasingly global, it seems likely that large-scale economic interactions between different resources will become apparent. Such cross-sectoral influences will require the development of management policies that look beyond traditional boundaries.

Research interest in linkages between meat and fish resources in the tropics has recently increased, driven by an urgent need to find solutions to the problem of overexploitation, which represents a major threat to many fish and bushmeat species [1,2]. There is evidence that some consumers might freely substitute meat and fish for one another, based on positive correlations between the price of one and consumption of the other [3,4]. However, whether the observed degree of linkage would be strong enough to exert a large-scale economic effect has, until recently, been an open question.

Now, Brashares and colleagues provide good evidence that national levels of fish production and wild meat consumption in Ghana are directly linked [5]. The strength of their analysis lies in the use of a range of supporting evidence. Drawing on trends over almost 30 years, they show that bushmeat hunting increased in wildlife reserves across the country during periods of low national fish production (Figure 1a), giving rise to accelerated declines in wildlife abundance during these periods (Figure 1b). They then demonstrate that this large-scale linkage is mediated by small-scale processes: at times of low fish availability, the price of fish and the volume of bushmeat sold in rural markets both increase, suggesting that consumers treat bushmeat as a substitute for fish. This economic link between ecologically very different resources indicates a need for their coordinated management.

Managing demand

An important question that the paper by Brashares *et al.* [5] provokes is whether the linkage between fish and bushmeat operates in both directions. Their analysis showed that the price of fish in a given month was most strongly related to the supply of bushmeat in the following month, but not at all to supply in the previous month,

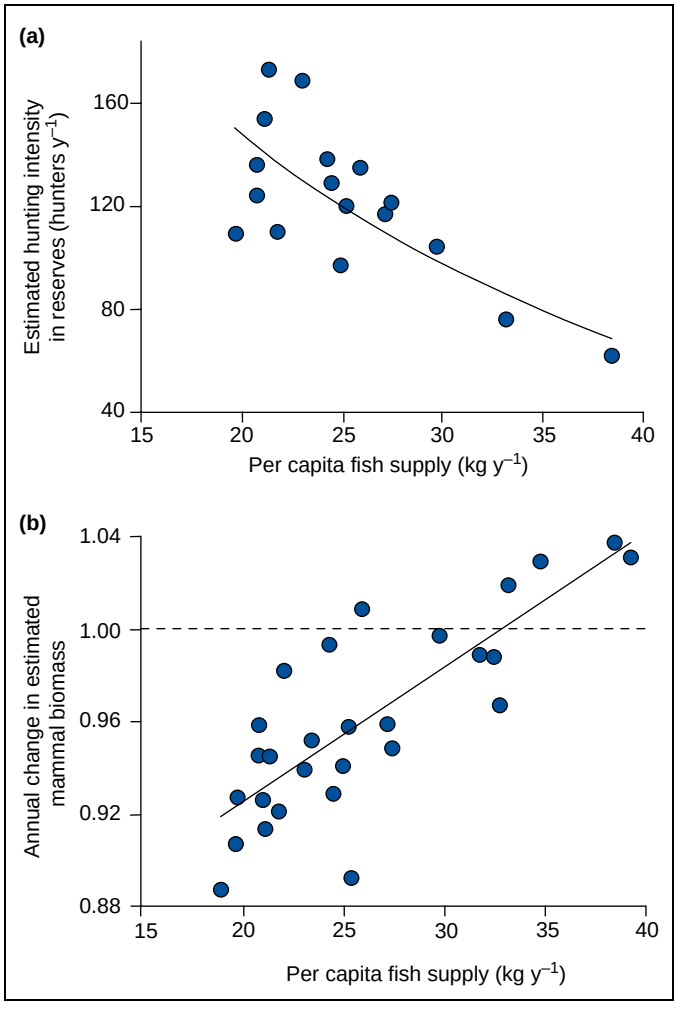

Figure 1. Relationships between survey results from five reserves and annual *per capita* national fish supply in Ghana (landings+imports−exports): **(a)** Annual counts of hunters from 1976 to 1992 ($R=-0.52$, $p=0.03$). **(b)** Annual change in the biomass of mammals, derived from transect counts and body weights of all species from 1971 to 1998 ($R=0.73$, $p<0.001$); a value of 1 indicates no change. Reproduced, with permission, from [5].

Corresponding author: Rowcliffe, J.M. (marcus.rowcliffe@ioz.ac.uk).
Available online 23 March 2005

suggesting that it is fish availability that affects bushmeat, and not vice versa. However, the annual consumption of bushmeat in Ghana is estimated to be at least 385 000 tonnes, compared with 490 000 tonnes of fish [6]. It would therefore be surprising if a large restriction in the supply of bushmeat did not have an impact on the demand for fish. This is an important consideration when seeking ways of reducing demand for bushmeat through the improved supply of alternatives: currently, fish stocks in the Gulf of Guinea are heavily depleted [7] and would be unlikely to meet the demand that might be released by the effective control of bushmeat hunting. Recent evidence from Gabon suggests that bushmeat availability can affect the consumption of fish [4], although further analyses are required to determine the generality of this result.

If fish stocks cannot supply the additional demand that might arise from a reduced availability of bushmeat, what alternatives are there? The most important potential substitute is livestock [8]. Surprisingly, however, hard evidence that demand for bushmeat would lessen if livestock were more available is sparse and equivocal [4]. Furthermore, even if a shift from the consumption of bushmeat to livestock could be readily achieved, there are difficult issues surrounding livestock production. Meat production in the African moist tropics is currently limited by disease and low animal productivity, and research and extension services are inadequate [1]. However, if livestock production was increased, it would impact on land use, perhaps echoing developments in Amazonia, where livestock ranching is a contributory factor driving deforestation [9]. A clear analysis of the costs and benefits of increased livestock production would thus be timely.

The generality of the fish–bushmeat linkage also deserves more attention. Brashares *et al.*'s market data [5] are based primarily on bushmeat hunted in the savannah zone rather than forests, and on villages rather than towns and cities. Variation in local conditions, such as differences in the availability of, and tastes for, fish and bushmeat, might cause the linkage to break down. In one coastal city in Ghana, for example, fish is cheap whereas bushmeat is an expensive luxury food [10], and the two are unlikely to be directly substitutable. Nevertheless, the cross-price sensitivity that is necessary to drive the relationship between bushmeat and fish appears to be present in at least one other tropical African country [4]. Further research at a variety of spatial scales is likely to reveal interesting geographical variations in the strength and form of the linkage.

Managing multiple commons

A clear implication of Brashares *et al.*'s findings [5] is that fisheries and bushmeat can no longer be managed in isolation. Fish and bushmeat harvesting systems are both characterized by the open-access extraction of multiple prey species, many of which are vulnerable to overexploitation, and this suggests that similar management models could apply in both cases. However, there are also important contrasts. Fisheries are exploited at artisanal and industrial scales, and have an important national and international regulatory dimension spanning developing and developed countries. By contrast, bushmeat systems are entirely artisanal, poorly regulated and concerned primarily with domestic trade in developing countries.

The stronger regulatory framework of fisheries provides the potential for national and international policies to influence the management of this industry. However, although West African coastal waters are fished by foreign vessels, it is not currently possible to trace a simple causal chain from over-fishing by foreign fleets through fish stock depletion to unsustainable bushmeat hunting [11]. Access agreements with developed countries tend to act as subsidies for these foreign fleets, encouraging the overexploitation of local fish stocks [12], and there is a need to eliminate such damaging distortions. However, it has been suggested that artisanal fishers exploit largely different components of the fish resource to industrial fleets [11]. It is therefore important to disentangle the degree of overlap between these sectors if we are to understand fully the impact of industrial fishing on bushmeat use.

Alternative resources with no apparent connection to the region might also have unexpected linkages. Much of the livestock consumed in West and Central Africa currently comes in the form of frozen offcuts from the poultry industries of developed countries and, through their reliance on fishmeal feed, these industries affect fisheries. Another substitute for bushmeat in the region is imported frozen fish, and the provenance and sustainability of this protein source is also unclear. There is thus a need to ensure that fisheries supplying the western poultry industry and African import market are well managed, particularly if they operate in waters that also supply the domestic fisheries of countries that consume bushmeat.

Given strong constraints on the supply of any one protein source, limiting the damaging effects of the bushmeat trade will depend on balancing the supplies of all sources, including bushmeat itself. Some of the species involved in the bushmeat trade, such as cane rats *Thryonomys* spp., are productive, resilient to exploitation and not currently threatened [13]. Legal bushmeat hunting involving resilient species usually occurs within the informal, unregulated economy alongside the illegal trade in vulnerable species. The bushmeat trade is thus a hidden and undervalued part of national economies [14]. Bringing the trade in resilient species into the formal economy could provide the impetus needed to monitor and manage stocks effectively while improving protection of vulnerable species. This could make bushmeat amenable to the kinds of policy tools open to fisheries. However, this possibility is hampered by a lack of good governance and a failure to implement and enforce existing legislation.

Prospects

Richer nations consume more fish and meat [15], so the questions raised here will become increasingly urgent as the populations of developing countries grow and become more wealthy. In response, policies for the regulation of fisheries and the bushmeat trade must take account of their interdependence. Before the bushmeat trade can be effectively managed, uncertainty over its impact on fisheries must be clarified, and a workable regulatory framework should be put in place. Because regulatory

frameworks already exist for fisheries, and there is now good evidence that fisheries do affect bushmeat consumption [5], there is a clear imperative for future developments in national and international fisheries policy to take account of impacts on the bushmeat trade. Policy makers would benefit from a better understanding of the form and generality of large-scale economic interactions between such protein sources.

Acknowledgements

We thank Justin Brashares, John Robinson, Johan du Toit, Nick Isaac and Richard Pettifor, for insightful comments on earlier drafts of this article.

References

1 Milner-Gulland, E.J. *et al*. (2003) Wild meat: the bigger picture. *Trends Ecol. Evol.* 18, 351–357
2 Pauly, D. *et al*. (2002) Towards sustainability in world fisheries. *Nature* 418, 689–695
3 Apaza, L. *et al*. (2002) Meat prices influence the consumption of wildlife by the Tsimane Amerindians of Bolivia. *Oryx* 36, 382–388
4 Wilkie, D.S. *et al*. (2005) Role of prices and wealth in consumer demand for bushmeat in Gabon, Central Africa. *Conserv. Biol.* 19, 268–274
5 Brashares, J.S. *et al*. (2004) Bushmeat hunting, wildlife declines and fish supply in West Africa. *Science* 306, 1180–1183
6 Ntiamoa-Baidu, Y. (1998) *Sustainable Harvesting, Production and Use of Bushmeat*, Wildlife Department, Ministry of Lands and Forestry, Accra, Ghana
7 Atta-Mills, J. *et al*. (2004) The decline of a regional fishing nation: the case of Ghana and West Africa. *Nat. Res. Forum* 28, 13–21
8 Fa, J.E. *et al*. (2003) Bushmeat and food security in the Congo Basin: linkages between wildlife and people's future. *Env. Conserv.* 30, 71–78
9 Laurance, W.F. *et al*. (2004) Deforestation in Amazonia. *Science* 304, 1109
10 Cowlishaw, G. *et al*. (2005) Structure and operation of a bushmeat commodity chain in southwestern Ghana. *Conserv. Biol.* 19, 139–149
11 Watson, I. and Brashares, J. (2004) *The Bushmeat Trade and Fishing Licence Agreements in West Africa*, Overseas Development Institute (http://www.odi-bushmeat.org/download_files/wpb4.pdf)
12 Kaczynski, V.M. and Fluharty, D.L. (2002) European policies in West Africa: who benefits from fisheries agreements? *Marine Pol.* 26, 75–93
13 Cowlishaw, G. *et al.* Evidence for post-depletion sustainability in a mature bushmeat market. *J. Appl. Ecol.* (in press)
14 Brown, D. and Williams, A. (2003) The case for bushmeat as a component of development policy: issues and challenges. *Int. For. Rev.* 5, 148–155
15 York, R. and Gossard, M.H. (2004) Cross-national meat and fish consumption: exploring the effects of modernization and ecological context. *Ecol. Econ.* 48, 293–302

0169-5347/$ - see front matter
doi:10.1016/j.tree.2005.03.007

Intimidating butterflies

Graeme D. Ruxton

Institute of Biomedical and Life Sciences, Graham Kerr Building, University of Glasgow, Glasgow, UK, G12 8QQ

Many butterfly species feature two or four conspicuously coloured eyespots on their wings; the most commonly heard explanation for these markings is that they are used to intimidate predators. However, this explanation has stood, until recently, on the flimsiest of empirical foundations. Now, Adrian Vallin and colleagues have demonstrated empirically the effectiveness of these signals in dissuading avian predators from attacking the bearers. Their work suggests that predators can be intimidated by bold displaying by otherwise defenceless prey, and opens up an interesting challenge to evolutionary ecologists to explain how this apparently maladaptive behaviour is retained in predator populations.

Behavioural observations

The first line of defence of many organisms faced with the threat of predation is to avoid detection by potential predators. This can lead to some impressive physiological and behavioural adaptations. For example, the peacock butterfly *Inachis io* typically rests on tree trunks. When resting, only the dark ventral side of the wings is shown, which, in combination with the irregularly shaped wing margins, enable the butterfly to mimic a fallen leaf [1]. However, should an insectivorous bird see through this disguise, the butterfly has a second line of defence: it changes its appearance dramatically, repeatedly opening its wings to expose suddenly their brightly coloured dorsal sides, which feature four prominent eyespots. This visual display is complemented by a hissing noise, generated by the rubbing together of the basal thirds of the anal veins of the forewings and costal veins of the hindwings. This wing-flicking behaviour has been suggested to intimidate the predator into delaying or aborting their attack on the butterfly [2]. Similarly acting startle signals (also sometimes called frightening or deimatic signals [3]) have been reported in a wide variety of vertebrates and invertebrates. However, in comparison to anecdotal reports of this interesting piece of natural history, hypothesis-based investigations of the phenomenon have been severely lacking [4]. The recent paper by Adrian Vallin and colleagues [5] is an important step towards filling this gap.

Experimental manipulations and results

Vallin and colleagues placed single laboratory-reared individuals of *I. io* on a specified place on a log in an

Corresponding author: Ruxton, G.D. (g.ruxton@bio.gla.ac.uk).
Available online 28 March 2005