Too many men: the violence problem?

Ryan Schacht¹, Kristin Liv Rauch¹, and Monique Borgerhoff Mulder¹,²,³

¹Department of Anthropology, University of California at Davis, Davis, CA 95616, USA
²Graduate Group in Ecology, University of California at Davis, Davis, CA 95616, USA
³Center for Population Biology, University of California at Davis, Davis, CA 95616, USA

There is a strong intuitive expectation in both popular lore and conventional evolutionary thinking that more males lead to more violence. Here, we untangle the logic behind this widely held notion with a specific focus on humans. We first review the relation between the intensity of sexual selection in human populations and the adult sex ratio (ASR), and find that it is more in line with recent reformulations of sexual selection theory than with conventional models. We then turn directly to the patterning of violence across human societies in relation to the sex ratio. Although the ‘more men, more violence’ expectation is not met, it is clear that the patterning of violence is undertheorized and we offer recommendations for steps forward.

More men, more violence?

A popular explanation for violence (see Glossary) centers on male-biased sex ratios. Paradigmatic is the concern of heightened violence in both India and China in response to growing numbers of extra men (in China termed ‘bare branches’) that result from son preference and daughter-biased abortion, infanticide, and neglect [1–4]. Given that men are typically more prone to engage in violent competition than are women [5], the inference is that more men will necessarily lead to more violence. This logic is implicit in how many of us understand sexual selection. Essentially, when there are more males than females in a population, males are expected to compete vigorously for the limited number of mating opportunities available [6]. In applying this idea to humans, it is therefore appealing to attribute elevated rates of violent crime to male-biased sex ratios, where there are, essentially, too many men (e.g., [7,8]).

Although this reasoning is intuitive, we question both its underlying theoretical basis and empirical support, focusing here on violence in human societies. We first highlight recent reformulations within sexual selection theory that challenge our intuitions and generate predictions regarding competition over mates that differ from those derived from conventional sexual selection thinking. We then examine how the opportunity for sexual selection is related to ASR across selected human populations.

Finally, we review how crime is related to sex ratios, and find no consistent evidence in support of the ‘more men, more violence’ view. The poor fit between sex ratio and population crime statistics suggests that new lines of evolutionary-ecological investigation, both theoretical and empirical, are needed to better understand the patterning of violence in human societies.

Where does ‘more men, more violence’ come from?

The ‘more men, more violence’ expectation derives from multiple sources. The first is simply mathematical. Given that most perpetrators and victims of violence are men, it logically follows that male-biased populations will show higher rates of violent crime compared with similarly sized populations with sex ratios near parity. However, this tells us nothing about male responses to varying sex ratios, it simply assumes additive effects of male violence as men are added to (or women subtracted from) a population.

The second source for this idea lies in the social sciences. During the 1980s, concerned researchers typically linked the escalating rates of violence in communities across Asia to the abnormally high sex ratios of the region [1] and, indeed, murder rates were particularly high in Indian populations.

---

Glossary

Adult sex ratio (ASR): the ratio of adult males to adult females in a population.

Competition: the process by which two or more individuals attempt to get access to a resource of shared interest; the term is neutral with respect to actual behavior.

Contest competition: an antagonistic interaction between individuals over resources (e.g., mates) where success comes through direct engagement [56].

Evolutionary social science: studies conducted by psychologists, anthropologists, biologists, economists, sociologists, and others that use evolutionary theory to model and/or explain aspects of human behavior typically addressed by their discipline.

Female-biased (i.e., low) sex ratio: more females than males in a population.

Male-biased (i.e., high) sex ratio: more males than females in a population.

Mating competition: scramble or contest competition directed at same-sex individuals.

Operational sex ratio (OSR): the ratio of sexually active males to sexually receptive females in a population [6].

Potential reproductive rates (PPR): the hypothetical maximum number of independent offspring produced by males and females per unit time [12].

Scramble competition: a resource attainment strategy where success is determined by differential access [56].

Sex ratio: measures are typically calculated as number of males per 100 females; however, some social scientists and demographers use number of females per 100 males, such that quick reference to cited articles might prove confusing. We use this term here when we are not being specific about the life stage (e.g., birth, adult, operational, or population-wide).

Sexual selection: selection that favors traits that aid in mate acquisition at the expense of same-sex rivals [67].

Violence: the use of physical force to harm individuals or to acquire property, used here to refer to that which might occur between men or intersexually; typically associated with contest competition but can also characterize competition over resources for parental investment (e.g., robbery).
states and districts with strongly male-biased sex ratios (e.g., [2]). Investigators differ with respect to the implied mechanisms, but typically emphasize male predispositions to violence as motivating this relation (due to elevated testosterone levels; [9]), arguing that the risk of violence is greatest when sex ratios are high because the pool of unmarried men (those most prone to violence) is larger in male-biased rather than female-biased populations [10].

A third source derives from a long-standing model of sexual selection, laid out by Trivers [11], and developed in influential papers by Emlen and Oring [6] and Clutton-Brock and Vincent [12], the former with the concept of operational sex ratio (OSR) and the latter with sex differences in potential reproductive rates (PRR). According to the traditional parental investment (PI) model, when one sex is tied up with parental care, or more generally with activities that lower its PRR, the other sex competes over this limited resource, leading to the prediction that the sex in abundance competes more intensely for mating opportunities than does the rarer sex. An ancillary expectation is that this will generate more violence in the more abundant sex. However, this is based on an often unstated assumption that male competition over mating opportunities will entail violence, either through contest interactions with other males, scramble competition over resources, or directly against females. Accordingly, in the evolutionary social science literature, researchers commonly attribute the propensity for violence in men to sexual selection [13–15]. From this perspective, men engage in more violence than do women because female mammals have obligate parental responsibilities and constitute a prize for the most competitively successful males (e.g., [16]).

**A closer look at the parental investment model and mate competition**

Plausible though it might seem to link violence to competition over scarce mates, we take a closer look at the current state of thinking about mate competition, starting with the basics.

Building on Bateman’s [17] early evidence of greater sexual selection in males than in females, Trivers [11] proposed that the relative PI of the sexes is a key variable controlling the operation of sexual selection. The higher-investing sex becomes a limiting resource for the sex that invests less, leading to escalated levels of mate competition in the latter. Often, and especially for mammals, females invest more in parental care than do males; therefore, males face higher levels of competition for access to the limited number of females.

Emlen and Oring [6] added the concept of OSR, which is the ratio of sexually active males to sexually receptive females and is highly influenced by patterns of PI. Higher investment by females decreases the amount of time they are ‘receptive’ to fertilization. Such sex differences in the availability of gametes skew the OSR towards males, leading to the claim that males, due to their overrepresentation in the mating pool, face a greater intensity of sexual selection on the traits that make them competitive for relatively scarce females. The same PI that makes females scarce in the OSR also lowers their PRRs and, accordingly, Clutton-Brock and Vincent [12] (see also [18]) proposed that PRRs of males and females can be used to predict patterns of competition over mates (scramble or contest) between the sexes.

According to this perspective, when males are in abundance, they are expected to compete for mating opportunities. In so far as some males are more successful than others in monopolizing these opportunities as a result of heritable traits [19], this is expected to lead to intensified levels of sexual selection on males. Although this competition is often thought of as violent, it need not be (Figure 1).

**New thinking about sexual selection alerting us to the importance of ASRs**

In recent years, several flaws have emerged in the conventional model of parental investment [11], in particular its implications for sexual selection [20,21] (Box 1). Building on this work, Kokko and Jennions [22] provide a more dynamic approach to modeling parental investment by endogenizing into the model the availability of males and females. One consequence of this is to think more carefully about the role of the ASR in affecting competition over mates. As noted above, the traditional PI model, especially in conjunction with Emlen and Oring [6], predicts that an abundance of males will lead to greater mating competition among males, whereas the newer model challenges this. It shows that, all things being equal (a sticky point to which we return), in male-biased populations, males, at least those that have offspring, should be more committed to provisioning parental care compared with males in female-biased populations [22]. In so far as mating and parental effort are not entirely compatible, which typically they are not, this suggests that, in populations with a male-biased ASR, we should generally see less male–male mate competition and more monogamy [23]. Indeed, further models focusing specifically on competition show that, contrary to the intuitions drawn from Emlen and Oring [6], a male-biased OSR only accurately predicts intense sexual selection among males under a limited set of circumstances, most specifically where it is possible for one male to monopolize multiple mates (e.g., temporal ‘clumping’ of females arriving on a lek; [24]) and even then mate monopolization generally becomes more difficult when there are more competitors [25].

There is empirical support in the nonhuman literature for the general prediction that male-biased sex ratios do not enhance mating competition among males, and might reduce reproductive variance. For example, in shorebirds with male-biased ASRs, female–female competition and male parental care (and even polyandry) prevail, as in the jacanas (Jacanidae) and greater painted-snipe (Rostratula benghalensis), whereas species with polygyny, such as the ruff (Philomachus pugnax), have female-biased ASRs [26]. Similarly in insects, males invest heavily in guarding their mates in response to partner shortages rather than continuing to invest in competitive efforts to acquire additional mates, as in soapberry bugs (Serinethinae) [27]. So what is the evidence for this in humans?

**Turning to humans**

As a first step in considering the relation between sex ratio and violence, and following the theoretical advances
outlined above, we need a clearer picture of the relation between sexual selection and ASR. To take an empirical approach to this question in humans, we collated the data of human behavioral ecologists who have collected largely comparable demographic data in primarily predemographic transition, small-scale communities across the world [28,29]. Using both published sources and personal communications on these 15 populations, we examine the

**Box 1. Changing the direction of the causal arrow between PI and sexual selection**

The traditional PI model [11] has been influential in the development of sexual selection theory, but it is logically flawed. The conventional reasoning goes that, because females produce large, costly eggs, male fitness is constrained by access to mates, producing (in most cases) female-biased care and male-biased competition. Criticisms include: (i) sex differences in PI cannot be taken as a determinant of the intensity of sexual selection because this entails committing the faulty logic of the ‘Concorde Fallacy’ [22,61]. Past investment alone is irrelevant to decisions about future behavior; (ii) As with Maynard Smith’s [62] classic model relating parental care evolution to sex differences in mating opportunities, Trivers’ verbal model lacks internal consistency, violating the requirement of equal average fitness for females and males and effectively making females exogenous to the model [63,64]. Although males do have higher PRRs [12], it is actual and not potential rates that matter in terms of selection [65]. To make the model self-consistent, the additional paternity of deserting males must be accounted for, and comes at a cost to the paternity of other males (i.e., the extra mates of successful males must come from somewhere; [21]); and (iii) in the traditional PI model, a male-biased OSR leads to more intense intrasexual selection and greater competition among males due to a shortage of females [6]. However, male-biased OSRs do not necessarily lead to greater intensity of sexual selection. Klug et al. [25] showed how OSR only accurately predicts sexual selection under a limited set of circumstances, most specifically when mate monopolization is strong. In fact, a wise strategy for a male who might face a long wait in between reproductive events if he were to desert, would instead be to stay with his current partner [22]. Thus, the OSR can equally be thought of as a frequency-dependent mechanism that selects for care in the sex that is in abundance.

In sum, the relative abundance of gametes (i.e., more sperm than eggs) generates the conditions for sexual selection. If selection occurs, then patterns of care and competition are affected [47]. Therefore, sexual selection is not an outcome of patterns of PI as posed in traditional models, but instead care and competition coevolve with the strength of sexual selection [24].
Box 2. The sex ratio and opportunity for sexual selection across 15 populations

We calculated the opportunity for sexual selection ($I_s$) of males against the sex ratio for each population, selected from the work of human behavioral ecologists working in nonindustrial societies. The $I_s$ is a standardized measure of variance in reproductive success (RS) calculated by dividing the variance in RS by the squared mean of mating success [66–68]. It represents the upper limit of the potential strength of sexual selection in a given population (importantly, not the actual strength of sexual selection on specific traits). The $I_s$ is useful for cross-population comparisons because it is standardized by mean fitness and describes the variation in mating success, which can indicate sexual selection within a population. Sex ratio is determined from the ethnographers’ data on the number of individuals of mating age in their population, hence it approximates ASR.

Summary measures from 15 human populations show the relation between the sex ratio of the local mating pool and $I_s$ is negative (Figure 2, main text), suggesting that traditional assumptions regarding a positive relation between the abundance of males and the fitness of sexual selection are not supported. Rather, as the sex ratio becomes more female biased, the opportunity for sexual selection among males increases (see also [31] for a similar conclusion for human populations based on normative mating system categorizations).

We acknowledge that $I_{ev}$ as a measure of the opportunity for sexual selection, has flaws. First, high values of $I_{ev}$ will have no significance for selection if variance in mating success is random [19]. Second, there is an inherent systematic positive biasing of $I_{ev}$ with high ASR [28]. That said, the pattern reported here, showing a negative relation between the sex ratio of the mating pool and the maximum potential for sexual selection, is all the more remarkable. Furthermore, we note that future studies of how the opportunity for sexual selection is related to sex ratios using individual-level data can correct for the inherent bias of $I_{ev}$ with high ASR by using the measure of $I_{av}$ suggested by Rios Moura and Peixoto [89].

The association between the $I_s$ of males and the sex ratio of the mating pool is negative, which suggests that there is more mating competition among men in female-biased than in male-biased populations. Despite being consistent with the reformulations of sexual selection, this result (albeit of primarily illustrative significance, given the small sample and use of population averages) will still undoubtedly be viewed as counter-intuitive, and prompts the question, ‘what is going on here?’

One might be tempted to point to polygyny, especially given Ember’s demonstration that normative polygynous marriage is most common in female-biased populations [30,31]. Our data do not support this possibility; some high $I_s$ populations are polygynous (e.g., Kipsigis, where some men have up to 12 wives), whereas others exhibit almost exclusively monogamous marriage (e.g., the Hadza). In fact, there is no apparent patterning of the societies in terms of type or stability of marriage, or indeed of the economy (farming, foraging, or herding), although more systematic comparative analysis with bigger samples using individual level data is warranted [28,29]. Furthermore, it is worth noting that, in nonhumans, higher rates of polygyny do not necessarily mean greater sexual selection on males [32,33].

Demographic and social science literature points to other possible explanations for the finding in Box 2. In a famous book entitled Too Many Women, Guttentag and Secord [34] draw from historical accounts and quantitative analyses to demonstrate how sex ratios affect many aspects of the relations between men and women. They show that, in societies with a surplus of women, men find themselves in demand and can leverage their scarcity, behaving promiscuously and offering little parental investment; whereas, when women are in short supply, marriage and a commitment to family are highly valued. A more recent example comes from Colombia, where high male mortality rates, yielding an abundance of women in some regions, are associated with decreased marriage rates and higher proportions of men in concurrent relationships [35]. Cross-cultural research corroborates this pattern, revealing female-biased sex ratios associated with lower levels of male parental investment and higher rates of female-headed households [36]. Indeed, when there are too many men, the nature of relationships change. For example, Angrist found that, among immigrants to the USA, high sex ratios had a large positive effect on the likelihood of female marriage and a large negative effect on female labor force participation; with men providing investment, women could avoid wage labor [37]. In general, male-biased sex ratios are associated with a greater proportion of males being married [34,38], less promiscuity in both sexes [36,39,40], and greater conjugal stability [41], all of which might contribute to the lower $I_s$ values for men shown in Box 2.

Evidence for more men more violence

To summarize so far, there are good theoretical and empirical reasons why male mate competition might be more intense where there is an excess of women, not men. How
Table 1. Sex ratio and violence: a literature review

<table>
<thead>
<tr>
<th>Sample</th>
<th>Sex ratio measure</th>
<th>Type of violence</th>
<th>Violence measure</th>
<th>Relation between violence and sex ratio</th>
<th>Refs</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 countries: UN and World Bank</td>
<td>Complete sex ratio</td>
<td>Homicide</td>
<td>Rate per 100 000</td>
<td>Negative</td>
<td>[55]</td>
</tr>
<tr>
<td>US: FBI</td>
<td>Men and women (18+)</td>
<td>Female homicide</td>
<td>Rate per 100 000</td>
<td>Positive</td>
<td>[44]</td>
</tr>
<tr>
<td>Countries (n = 70): UN, Interpol, and CIA</td>
<td>Men and women (15–64-years old)</td>
<td>Murders, rapes, and violent assault</td>
<td>Rate per 100 000</td>
<td>Negative</td>
<td>[43]</td>
</tr>
<tr>
<td>Review</td>
<td>Mixed</td>
<td>Historical accounts</td>
<td>N/A</td>
<td>Positive</td>
<td>[83]</td>
</tr>
<tr>
<td>US: NIBRS (FBI) and census</td>
<td>Men (18+-years old) and women (18–34-years old)</td>
<td>Male-on-female partner violence</td>
<td>Rate per 100 000</td>
<td>Positive</td>
<td>[46]</td>
</tr>
<tr>
<td>India: Government data</td>
<td>Complete sex ratio</td>
<td>Homicide</td>
<td>Rate per 1 000 000</td>
<td>Positive</td>
<td>[3]</td>
</tr>
<tr>
<td>China: Government data</td>
<td>Men and women (16–25-years old)</td>
<td>Violent and property crime</td>
<td>Arrests per 10 000</td>
<td>Positive</td>
<td>[84]</td>
</tr>
<tr>
<td>HRAF and Ethnographic Atlas</td>
<td>Complete sex ratio</td>
<td>Warfare mortality</td>
<td>Low versus high</td>
<td>Negative</td>
<td>[30]</td>
</tr>
<tr>
<td>Review</td>
<td>Mixed</td>
<td>Historical accounts</td>
<td>N/A</td>
<td>Positive</td>
<td>[10]</td>
</tr>
<tr>
<td>US: State data</td>
<td>Complete sex ratio</td>
<td>Homicide and suicide</td>
<td>Rate per 100 000</td>
<td>Mixed</td>
<td>[85]</td>
</tr>
<tr>
<td>Countries (n = 56): WHO and UN</td>
<td>Complete sex ratio</td>
<td>Homicide</td>
<td>Rate per 100 000</td>
<td>Negative</td>
<td>[86]</td>
</tr>
<tr>
<td>US cities (n = 156): FBI and census</td>
<td>Men and women (15–59-years old)</td>
<td>Murder and robbery</td>
<td>Arrest rate</td>
<td>Negative</td>
<td>[54]</td>
</tr>
<tr>
<td>Nation sample (n = 45): WHO and UN</td>
<td>Complete sex ratio</td>
<td>Homicide</td>
<td>Rate per 100 000</td>
<td>Negative</td>
<td>[87]</td>
</tr>
<tr>
<td>US: census and FBI</td>
<td>Five-year groupings</td>
<td>Rape</td>
<td>Arrest per 100 000</td>
<td>Negative</td>
<td>[42]</td>
</tr>
<tr>
<td>India: crime in India database</td>
<td>Complete sex ratio</td>
<td>Homicide</td>
<td>Rate per 1 000 000</td>
<td>Positive</td>
<td>[2]</td>
</tr>
<tr>
<td>Nations (n = 46): WHO and UN</td>
<td>Complete sex ratio</td>
<td>Homicide</td>
<td>Rate per 100 000</td>
<td>Negative</td>
<td>[88]</td>
</tr>
<tr>
<td>Nations (n = 46): World Values Survey</td>
<td>Men and women (18+-years old)</td>
<td>Homicide</td>
<td>Rate per 100 000</td>
<td>Negative</td>
<td>[89]</td>
</tr>
<tr>
<td>US counties; FBI and census</td>
<td>Unmarried men and women (18–44-years old)</td>
<td>Homicide</td>
<td>Rate per 100 000</td>
<td>Unassidated</td>
<td>[90]</td>
</tr>
<tr>
<td>US cities (n = 217): FBI</td>
<td>Complete sex ratio</td>
<td>Female homicide</td>
<td>Rate per 100 000</td>
<td>Positive</td>
<td>[45]</td>
</tr>
<tr>
<td>Chinese cities (n = 37)</td>
<td>Men (17–23-years old) and women (15–2- years old)</td>
<td>Forced sex</td>
<td>Survey report (n = 1338)</td>
<td>Positive</td>
<td>[4]</td>
</tr>
</tbody>
</table>

*We performed a literature search for violence and sex ratio in humans on Web of Science (11 November 2013, n = 64). Some search results were excluded due to redundancies, lack of empirical data (e.g., book reviews), or irrelevance to the question at hand (e.g., studies looking at the sex ratio of criminal offenders without reference to the population sex ratio). Here, we summarize the results of the remaining papers (n = 20), highlighting inconsistencies in the relation between the sex ratio and violence as well as critical methodological differences. Abbreviations: CIA, Central Intelligence Agency; FBI, Federal Bureau of Investigation; HRAF, Human Relations Area Files; NIBRS; National Incident Based Reporting System; WHO, World Health Organization; UN, United Nations.

*We performed a literature search for violence and sex ratio in humans on Web of Science (11 November 2013, n = 64). Some search results were excluded due to redundancies, lack of empirical data (e.g., book reviews), or irrelevance to the question at hand (e.g., studies looking at the sex ratio of criminal offenders without reference to the population sex ratio). Here, we summarize the results of the remaining papers (n = 20), highlighting inconsistencies in the relation between the sex ratio and violence as well as critical methodological differences. Abbreviations: CIA, Central Intelligence Agency; FBI, Federal Bureau of Investigation; HRAF, Human Relations Area Files; NIBRS; National Incident Based Reporting System; WHO, World Health Organization; UN, United Nations.

*We performed a literature search for violence and sex ratio in humans on Web of Science (11 November 2013, n = 64). Some search results were excluded due to redundancies, lack of empirical data (e.g., book reviews), or irrelevance to the question at hand (e.g., studies looking at the sex ratio of criminal offenders without reference to the population sex ratio). Here, we summarize the results of the remaining papers (n = 20), highlighting inconsistencies in the relation between the sex ratio and violence as well as critical methodological differences. Abbreviations: CIA, Central Intelligence Agency; FBI, Federal Bureau of Investigation; HRAF, Human Relations Area Files; NIBRS; National Incident Based Reporting System; WHO, World Health Organization; UN, United Nations.

*We performed a literature search for violence and sex ratio in humans on Web of Science (11 November 2013, n = 64). Some search results were excluded due to redundancies, lack of empirical data (e.g., book reviews), or irrelevance to the question at hand (e.g., studies looking at the sex ratio of criminal offenders without reference to the population sex ratio). Here, we summarize the results of the remaining papers (n = 20), highlighting inconsistencies in the relation between the sex ratio and violence as well as critical methodological differences. Abbreviations: CIA, Central Intelligence Agency; FBI, Federal Bureau of Investigation; HRAF, Human Relations Area Files; NIBRS; National Incident Based Reporting System; WHO, World Health Organization; UN, United Nations.

We performed a literature search for violence and sex ratio in humans on Web of Science (11 November 2013, n = 64). Some search results were excluded due to redundancies, lack of empirical data (e.g., book reviews), or irrelevance to the question at hand (e.g., studies looking at the sex ratio of criminal offenders without reference to the population sex ratio). Here, we summarize the results of the remaining papers (n = 20), highlighting inconsistencies in the relation between the sex ratio and violence as well as critical methodological differences. Abbreviations: CIA, Central Intelligence Agency; FBI, Federal Bureau of Investigation; HRAF, Human Relations Area Files; NIBRS; National Incident Based Reporting System; WHO, World Health Organization; UN, United Nations.

—

given the variety of forms that mate acquisition strategies can take (Figure 1), it is inaccurate to assume that mating competition will necessarily involve violent behavior. Likewise, the causes of violent behavior can be unrelated to mating competition, as with mental illness, substance abuse, political uprisings, or anger management (such as ‘road rage’). Therefore, expectations of straightforward positive or negative associations between ‘violence’ and sex ratio are overly simplistic. With this in mind, we can venture explanations for some of the variable patterning of violence with sex ratio shown in Table 1. Comparative studies in the USA and cross-nationally found an abundance of males associated with lower rates of rape
and sexual assault [42, 43]. However, several USA studies looking to intimate partner violence and female homicide victimization found more violence directed against women by their partners when men were in excess [44–46]. From these results, one might conclude that the findings here are mixed and unpatterned. However, although ‘violence’ is present in both high and low sex ratio conditions, rates of particular measures vary. Is the prevalence of rape and sexual assault in female-biased sex ratios consistent with modern predictions of elevated mating effort in males when partners are abundant? Are the higher rates of intimate partner violence in male-biased sex ratios evidence of male mate-guarding strategies when mates are rare and, therefore, difficult to replace? The answers lie in identifying how a particular violent act relates to mating competition, which of course is important for understanding the strength and direction of sexual selection at a particular sex ratio.

**Additional complicating factors**

Although ASRs are negatively associated with competition among men over reproduction (Box 2), the patterning of violence across human populations is less easily explained. We have shown that an uncritical acceptance of the ‘more males, more violence’ prediction from traditional theory is unwarranted, but otherwise there is no straightforward pattern of violence in relation to sex ratio in the studies summarized in Table 1.

This varied relation between violent crime and sex ratio is unsurprising. Modern sexual selection theory identifies additional factors influencing male strategies which might complicate predictions about the effect of ASR on either mating competition or violent behavior. Key factors are the degree of intrasexual variation in quality [47], and the shape of the Bateman gradients that capture the marginal returns to agonistic competition [48]; accordingly, simple predictions might not hold and more encompassing theoretical models are needed.

Other factors that should be taken into consideration when addressing the relation between violent crime and sex ratios are outlined in Box 3. First, as we have stressed above, mate competition is not necessarily violent and violence among men is not necessarily mate competition. Additionally, we note that: (i) behavioral polymorphisms in mating strategies most likely lead some individuals into violence and others not, irrespective of the sex ratio; (ii) the nature and extent of female choice can dramatically influence whether the optimal male mating strategy should include violence; (iii) mating and parental effort are not necessarily mutually exclusive; and (iv) even PI can sometimes entail violence (as in some forms of property crime). Clearly, we have a lot more thinking to do when attempting to use sexual selection to understand patterns of violence in humans.

**More theory to the rescue**

Although our understanding of how men use violence to compete for women and, more generally, how their optimal reproductive strategies are affected by sex ratio, is greatly undertheorized, current models point to some potential avenues towards a more precise understanding of the patterning of violence across human societies. Kokko & Jennions show, counter intuitively, that a particular behavior might be selected for even when it increases mortality rates due to frequency dependent selection. If violent contests entail a higher risk of mortality (which is quite likely), the competing sex will remain the rare one, favoring even more competition among those who survive (a ‘vicious’ cycle). Conversely, if caring brings a higher mortality risk, the caring sex will become rare and selection will favor elevated rates of care in the opposite sex (a more ‘virtuous’ cycle; [49]). The relative mortality costs of caring and competing is critical: this is likely why most birds, for which caring brings higher mortality than fighting, show biparental care, whereas most mammals, for whom fighting (and the development of associated traits) brings higher mortality than caring, show so little paternal care [31]. The upshot is that empiricists committed to explaining the patterning of human violence should be quantifying the relative mortality costs associated with caring and

**Box 3. Why violent crime and sex ratio show such messy patterning**

- Mate competition is not necessarily violent. For example, one man steals, another fights, and a third stays in the office, each gaining resources or status to acquire a mate; similarly, some men might display good genes through violence, others through artistic expression. In these examples, the motivation and outcomes might be the same, but the context can impose different constraints on behavioral options, thereby influencing patterns of violent crime. Social scientists rarely delineate the range of possible responses to female shortages: unmarried men might migrate to regions with more women, patronize prostitutes, resort to polyandrous marriage, or even set up bachelor households and ‘bachelor villages’, as reported for contemporary China [31].
- Male violence is not necessarily mate competition. Accordingly, crime statistics must be carefully disaggregated to allow precise tests of the ideas presented here. Equating mate competition with violence likely conceals more interesting patterns.
- Behavioral polymorphisms in male mating strategies abound in many species, including humans [92–94]. Models show that, in male-biased ASRs, mated males are selected to provide care [22], but what should unmated males without offspring do? Advertise their caring natures to secure a mate [95], or resort to nastier tactics, such as bar-room brawls (contest competition), property heists (scramble competition), or rape of unguarded females? Decisions here will depend on many factors, such as the man’s relative quality, his fighting ability, or the severity of sanctions on criminal behavior if detected, which are all issues that need more attention in new studies.
- Female choice affects the relation between ASR and male violence. For example, if females exert choice on male provisioning qualities (and provisioning does not entail violence), then the lowest levels of violence would be observed at highest ASRs [22]. However, if successful provisioning depends on the control of resources through physical competition, high ASRs might be associated with violence.
- Much of the logic above assumes a tradeoff between parenting effort and mating effort, which is not always the case [98]. In some species, providing parental care can be a key element of the mate competition strategy of a male, as in two-spotted goby (Gobiusculus flavescens) [39]. In many human populations, controlling resources enhances a man’s mating success and the survival of his children [50].
- Clearly, expecting a positive association between sex ratio and violence entails multiple assumptions that might not necessarily hold across different human populations.
mate competition across different human societies, a difficult but perhaps not impossible task. Furthermore, evolutionary social scientists and lay commentators alike should not be shocked to find high levels of violence in the rarer sex.

Concluding remarks

Humans are a good species in which to investigate how violent competition and other traits are related to sex ratio because there are such variable mating systems, from harem polygyny attained through violence among men against women (e.g., Yanomamö; [13]), through resource defense polygyny attained through economic competition among men who are chosen by women or their kin (e.g., Kipsigis; [50]), to situations where men and women choose each other on the basis of individual qualities (e.g., such as the Makushi and Tsimane; [51,60]). This review has suggested that violence is not structured according to predictions from the traditional parental investment model, or to the more intuitive lay rationale that we presented at the outset. Major reasons are that violence in men cannot be entirely attributed to mate competition, mate competition can take many forms, and female-biased sex ratios can create the conditions for intense mating competition among men.

In short, the belief that violence and crime are exacerbated in human populations by an excess of males is overly simplistic. We show in Table 1 that the patterning of violent crime shows no simple association with sex ratio. We discuss reasons why current understandings of sexual selection are as yet inadequately articulated to deal with several critical intervening considerations that we identified in Box 3. We also recognize that empiricists have failed to quantify some of the key parameters needed to model the relation between violence and sex ratio, such as the relative costs of care and competition, and the role of violence in attaining mates. Finally, we point to a need for a much richer ethology (and ethno- graphy) of human violence; data are primarily drawn from police reports and national statistics that, for the most part (for a remarkable exception see [14]), combine inter- and intrasexual attacks, crime directed at people and property, and crime emanating from different sectors of the population.

The simple message to take from this review is that the often-related claim that when men are more numerous than women, men create a potential social problem (e.g., [52]), rests on a specific set of assumptions about the nature of male–male competition and the extent to which females can make choices over mating. There are policy applications of this research, with serious practical implications for people’s lives. Recommendations that a female-biased sex ratio will alleviate problems of male violence, although well intentioned, could exacerbate the problem (e.g., attempting to reduce bullying by lowering the sex ratio in a classroom; [53]). Likewise, ‘tough on crime’ policies that incarcerate increasing numbers of men might be contributing to higher rates of violence, rather than alleviating them, through the resulting sex ratio imbalance in highly policed communities (e.g., [54]). Similarly appeals to abolish polygyny because of the dangerous emergence of a class of unmarried men rely on equally flawed logic [7], especially given the evidence that rates of rape, sexual assault [42,43], and male–male homicide [55] are lower where men are in excess. In short, the ‘more men more violence’ expectation derives from a simplistic interpretation of Trivers’ original paper and a failure to appreciate more recent theoretical developments.

Acknowledgments

For financial support, we thank the University of California, Davis (UCD) (R.N.S.) and the Wissenschaftskolleg zu Berlin (M.B.M.); for discussions and comments on the manuscript, our colleagues in the Human Behavioral Ecology and Cultural Evolution labs at UCD, as well as Alan Krakauer, Gillian Brown, David Lawson, and anonymous reviewers. Hanna Kokko provided particularly detailed and constructive suggestions. Finally, we are indebted to the generous anthropologists whose populations are included in Figure 2, and whose high-quality fieldwork makes comparative anthropology possible.

References

57 Darwin, C. (1871) The Descent of Man, and Selection in Relation to Sex, Murray
Trends in Ecology & Evolution