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# Do Males Vary More Across the Board? The Extended Bateman's Principle Hypothesis

Geher, G.[1], Aydin, G.[2], Baroni, A.[1], Chapleau, D.[1], Dawson, B. [1], Eisenberg, J.[1], Gleason, M.[3], Montgomery, J. [1], Postol, N.[1], Shimkus, A.[4], Tripoli, C. [5] & Wedberg, N.[1]

[1]State University of New York at New Paltz
[2]Bozok University
[3]DePaul University
[4]University of Hartford
[5]American University

## ABSTRACT

In 1948, Bateman published a landmark paper bearing on the evolutionary variable of reproductive success (RS). Drawing on data regarding the life cycle of fruit flies, Bateman discovered that mating rates in various experiments all demonstrated higher variability in males than in females. Females were more likely to mate a moderate number of times while data from males were characterized by a clear variability in RS (with males likely to encounter low, moderate, high, or even extremely high levels of RS). This phenomenon, now known as *Bateman's Principle*, has shown to be generally operative across various species including our own (Brown, Laland, & Mulder, 2013; Brown, Laland, & Mulder, 2009). The current work aims to address whether this basic asymmetry in variability across the sexes generalizes to trait domains that bear on RS. In other words, do males, relative to females, show higher variability in measures of morphological traits (e.g., height), social-emotional traits (e.g., emotional intelligence), cognitive traits (e.g., short-term memory ability), and important life outcome variables (e.g., markers of physical and financial health)? To address this issue, our methods included an intensive examination of the literature on male/female differences across a broad array of human domains. The literature review presented here addresses this idea, often referred to as *the variability hypothesis* (see Feingold, 1992), across a broad-reaching suite of physical and behavioral dimensions. Ultimately, our results and conclusions provide strong evidence for the variability hypothesis in humans.

## KEYWORDS

Sex Differences, Gender Differences, Variability, Evolutionary Psychology, Bateman's Principle

AUTHOR NOTE: Correspondence concerning this article should be addressed to Glenn Geher, State University of New York at New Paltz, Wooster Hall 347, 1 Hawk Dr., New Paltz, NY 12561. Contact: geherg@newpaltz.edu

## INTRODUCTION

One of the great benefits of applying evolutionary principles to the behavioral sciences is that such approaches allow for the application of integrative concepts that can help connect many different phenomena together. Trivers' (1971) theory of reciprocal altruism, for example, which posits that altruism between non-kin can evolve in relatively long-lived species that possess conspecific-recognition abilities, has been used to explain such disparate phenomena as logical reasoning (Cosmides & Tooby, 1997), the evolution of mathematical abilities (Trivers, 1985), and egalitarian social systems (Bingham & Souza, 2009). Other famous examples of powerful and integrative evolution-based concepts in the behavioral sciences include kin selection theory (Hamilton, 1964), sexual selection theory (see Miller, 2000), and parental investment theory (Trivers, 1972). Armed with such a powerful set of theories, all connected by the single metatheory of evolution (see Ketelaar & Ellis, 2000), evolutionary behavioral scientists are uniquely positioned in in the field in psychology in that the concepts from this perspective all connect within a single unifying and coherent framework (see Geher, 2014).

As we argue in this paper, Bateman's Principle (1948), which specifically bears on predicting *reproductive success* (RS), is such a concept within the evolutionary behavioral sciences. Here, we argue that Bateman's Principle may well help shed light on such disparate phenomena as morphological variability across the sexes, social and emotional variability across the sexes, cognitive processes as they vary across the sexes, and various life outcome variables such as achievement in the domains of intellectual and economic achievement. The basic hypothesis being examined here, consistent with what has been called the *variability hypothesis* (see Feingold, 1992), is that across a broad array of behavioral and physical traits, we expect to see more variability in males than in females. This prediction follows from an elaboration of Bateman's Principle to humans.

Importantly, this paper is designed largely as an exercise in demonstrating the integrative power of evolutionary principles in the human-related sciences. This goal, which is consistent with the broader interdisciplinary Evolutionary Studies (EvoS) initiative, seeks to provide a model, using Bateman's Principle, of how an evolutionarily informed approach can join together seemingly disparate research traditions on a broad suite of topics within a single organizing framework. This paper, which is essentially a literature review, does not seek to serve as the foundational analysis on the topic of how Bateman's Principle applies to human attributes. Nor does it include meta-analytic statistical processes. Rather, this paper's focus is to demonstrate how deeply and broadly a solid evolution-based concept, such as Bateman's Principle, can shed light on a broad set of phenomena. This goal is, in fact, highly consistent with the goals of the EvoS initiative within academia. As such, this paper largely has a pedagogical function.

### Evolutionary Psychology and Sex Differences

The evolutionary perspective in psychology has shed great light on the behavioral differences between males and females. Largely based on Trivers' (1972) theory of parental investment, researchers have found that females, who,

due to physiological factors, have relatively high levels of required parental investment are more likely than are males to pursue long-term mating strategies (see Buss, 2016) while males are more likely, across various behavioral domains, to pursue short-term mating strategies. Our understanding of why men and women differ in general behavioral patterns, particularly when it comes to mating, has been quite elucidated by the evolutionary perspective (see Geher & Kaufman, 2013).

Cutting-edge research in the evolutionary behavioral sciences continues to uncover important behavioral sex differences in humans. For instance, Barash (2016) makes a strong case for human mating systems, across time and place, as shaped by such important evolutionarily relevant factors such as sex differences in required parental investment. Similarly, Johnsen, Kruger, Geher, Wiegand, Shaiber, and Garcia (2017) provide evidence that such factors as risk-taking, proneness toward physical injuries, mating strategies, and life history strategy map strongly onto male/female differences in humans. When it comes to understanding why men and women behave differently from one another in the mating domain, the evolutionary perspective has been of great heuristic value.

## What is Bateman's Principle? Beyond Differences Between Means Across the Sexes

Most work on male/female differences in behavior from an evolutionary perspective focuses on differences between means (which is a standard way to approach many statistical questions). Bateman's Principle, described in this section, suggests that differences in patterns of variability across the sexes might of just as much evolutionary significance.

Bateman (1948) was a biologist working with fruit flies when he made a grand discovery. His discovery was essentially this: The number of matings, and therefore offspring, produced by a single fruit fly varies across the sexes such that the number of offspring produced by males *varies* considerably more than does the number of offspring produced by females. Embedded in Bateman's Principle is an important statistical nuance the idea here is not that the sexes differ in terms of some mean difference – i.e., it is not that one sex has more offspring, on average, than the other sex. Rather, the point is that the *variability itself varies dramatically across the sexes*.

The primary evolutionary explanation for this phenomenon relates to the fact that female fruit flies invest more than do males in parenting—by producing the physiologically costly gamete, eggs, which provide nourishment for developing fruit fly larvae. As a result of this long-term, high-investing strategy (see Trivers, 1972), any individual female is likely to be able to attract a mate and reproduce. However, she is not likely to reproduce *to a very large degree* in her lifetime (as eggs are costly and finite and their reproductive opportunities are, thus, limited).

On the other hand, male fruit flies possess a relatively non-costly gamete in spermatophores, which are produced in mass quantity. With such a different reproductive system, males follow markedly different mating patterns. In particular, Bateman (1948) documented that male fruit flies seem to try to mate with a larger number of partners compared with their female counterparts. However, as females

are highly discriminating in their mate choices, only a small proportion of males end up successfully mating.

This setup, of having females generally showing a single strategy of reproducing in a restricted and selective manner (given their finite number of costly gametes), and males showing less of a discriminating strategy by trying to mate with increased frequency and with an increased diversity of partners, leads to an interesting result related to reproductive outcomes. In short, this setup leads to females being more likely to produce a limited amount of progeny and, further, for females to (a) be unlikely to get shut out of mating entirely, and (b) to be unlikely to reproduce a very high number of times.

Things are different in males. While all males try to optimize their RS by mating with a high number of females, females do not show such a non-discriminating pattern. Thus males end up varying much more from one another in RS compared with their female counterparts. So while some males would be expected to show a near-average score in RS, some are expected to obtain zero mates, while other very high-quality males are likely to score very high on the RS variable, producing an exceptionally high number of offspring.

In short, the asymmetry in required parental investment across the sexes is predicted here to lead to significant *variability in variability* of markers of RS across the sexes. And this is exactly what Bateman (1948) found. Females show small intra-sex variability in RS while males show a higher degree of intra-sex variability in RS. This, pattern, marked by the fact that males show more variability than do females in RS, is Bateman's Principle.

Importantly, from a statistical standpoint, Bateman's Principle is literally about variability in markers of statistical variability. The point is not about how much males and females differ from each other on average on RS. It is, rather, how they differ (vary) from one another in terms of patterns of within-sex variability across the sexes. This is what we mean by *variability in variability*.

## Bateman's Principle and the Human Experience

The current work focuses on the potentially dramatic implications of Bateman's Principle for various aspects of what it means to be human. In a species that shows relatively high parental investment by females (such as in humans), based on Bateman's Principle, females should show less variability in RS compared with males. This point is interesting given how many significant variables, across behavioral and physical domains, have been shown by modern evolutionary psychologists to relate to RS (see Geher & Kaufman, 2013). From this perspective, it may well be that the battery of variables that predict RS in humans show the same pattern of across-sex variability that is found in RS based on Bateman's Principle. In other words, since RS is so significant from an evolutionary perspective, consistent variability in variability across the sexes in RS may well co-occur with consistent variability in variability across the entire host of variables that bear on RS in humans.

Such variables could include physical variables, such as size. In this case, it may be that height, for instance, which is related to mating outcomes in a number of ways, may vary more in males than in females. Similarly, a mating-relevant

psychological variable such as emotional intelligence (see Brackett, Warner, & Bosco, 2005) might show the same outcome. The basic point of this review is to explore the rich data on sex differences in humans to see if the data across a broad suite of human attributes ultimately speak to males having more within-sex variability compared with females. Such a broad-scale pattern would demonstrate the long reach of Bateman's Principle in helping understand (a) the nature of human sex differences and, more specifically, (b) the nature of variability in traits across the sexes.

This basic idea of more variability on important dimensions for males than for females has been dubbed the *greater male variability hypothesis* (see Feingold, 1992). As is shown in many of the subsequent sections, this hypothesis matches many data sets on cognitively relevant variables along with other classes of variables. The current review examines this broad set of studies while being rooted in the evolutionarily focused ideas found in Bateman's Principle, thereby providing a coherent theoretical framework for such findings.

In a meta-analysis on the topic of sex differences in variability in humans, Archer and Mehdikhani (2003) provided evidence that partly supports the thesis of this paper. For several psychological characteristics, these researchers found that males do, in fact, vary more than do females. Further, this effect was particularly true for such dimensions as physical aggression, evaluation of chastity in potential partners, and other mate-choice-related variables. In a similar exploration of this topic that explored various social and emotional variables, Hyde (2014) also provided evidence for more male variability.

In humans, culture matters quite a bit when it comes to psychological and behavioral processes (Hofstede, 1980). One major socio-cultural factor that might shape differences in variability of RS across the sexes is found in the prevailing mating system. On this point, Brown et al. (2009) found that relatively non-monogamous groups have significantly higher male-to-female reproductive success ratios than more monogamous groups. In other words, in non-monogamous groups, differences in variability in RS across the sexes are exacerbated (see Henrich, Boyd, & Richerson, 2012).

Past work on the connections between Bateman's Principle and the human experience has largely demonstrated that, as with fruit flies, in humans, males show greater variability in RS compared with females (e.g., Brown et al., 2009). With an eye toward demonstrating how evolutionarily informed concepts, such as Bateman's Principle can help integrate a broad range of concepts in a single conceptual framework, the next section focuses on a various human attributes that relate to RS and that, as a result of Bateman's Principle, might demonstrate higher variability within male populations compared to within female populations.

## THE EXTENDED BATEMAN'S PRINCIPLE HYPOTHESIS

Darwin's bottom line can be thought of as RS. Traits that ultimately facilitate RS are more likely to be selected than are other traits. This is, essentially, a short-hand version of the idea of natural selection.

So if RS, as a result of Bateman's Principle, shows marked differences in patterns of variability across the sexes in humans, then we might predict that attributes that significantly correlate with RS (which we may think of as various evolved psychological adaptations) might also show the same patterns of more variability in male than in female populations. We can think of these other attributes as "upstream" processes.

Clearly, this topic is large in scope. We can think of such a broad range of human attributes that might qualify as being "relevant to RS" and, thus, as viable candidates to be examined relevant to the basic question being addressed here.

**Methodological Process for Selecting Attributes for Inclusion.** This paper has a largely pedagogical function. The primary point here is to spell out the evolutionary reasoning that underlies Bateman's Principle and then to provide a model of how to apply this evolutionary-based concept to a broad array of topics. The below sections explore an array of sample human attributes that we thought of as viable candidate attributes. Such attributes were chosen if they (a) had a clear bearing on fitness/RS and (b) are known to show variability among individuals. Members of our team were given the task of finding published research on such variables and examining descriptive statistics from these publications to see if markers of variability (e.g., standard deviation; standard error of the mean) were higher in males than in females. Team members were instructed to report cases that were both consistent and inconsistent with this general prediction when they found studies that fit the inclusion criteria.

Importantly, while our work on this front followed an algorithmic process, the data here do not comprise a formal meta-analysis. Rather, the second-hand data that we examined through the process described herein were included in our examination largely to put together a summary of findings from the relevant literature to see if these findings, based on the criteria demarcated in this section, are consistent with the Extended Bateman's Principle hypothesis that we propose here.

**Physical Attributes.** For this section, traits were selected based on the process and criteria spelled out in the prior section titled *The Extended Bateman's Principle Hypothesis*. Several traits in humans that affect RS are physical. Consider, for instance, height. Evolutionary psychologists such as David Buss (2017) have documented that taller males are rated as more attractive by females than are shorter males. Thus, based on the reasoning of the current paper, we can predict that males would show more variability in height compared with females. In an analysis of this topic using a large sample of adults, this is exactly what Sauro (2013) found.

A very different physical attribute is found in the Major Histocompatibility Complex, or MHC, which refers to a set of cell surface molecules that play a dominant role in determining the immune system of vertebrates. The MHC determines the ability to discriminate endogenous from foreign proteins, thereby recognizing potentially infectious pathogens. Studies have shown that the MHC has a significant effect on body odor, and also on mate choice due to body odor attraction. Thornhill et al. (2002) examined the role of body odor in mate choice by asking males and females to rate the attractiveness of members of the opposite sex based only on the smell of the other person's t-shirt after being worn. The results

revealed more variability in males in their scent attractiveness ratings. Men's scents were rated with a mean of 4.54 out of the 110 attractiveness scale, while women's scents received a mean rating of 4.71. The important factor in this study in regards to Bateman's principle, is the standard deviation. Thornhill et al.'s (2002) study found the standard deviation for men was 0.95, while for women it was 0.63. Per the current work: Males vary more from one another on this mating-relevant dimension than do females.

Importantly, the two attributes, height and MHC, included here only represent sample physical attributes. The point of this paper is not to be comprehensive in scope but, rather, to show how Bateman's Principle may relate to a divergent set of human attributes.

**Personality.** A primary point of this paper is to demonstrate that increased male variability should extend across a broad spectrum of traits. Personality traits are no exception. The current section explores the variability hypothesis regarding various personality trait dimensions. Traits were selected based on the process and criteria spelled out in the prior section titled *The Extended Bateman's Principle Hypothesis*. The first dimension explored is life history strategy (see Figueredo, Vasquez, Brumbach, Sefcek, Kirsner, & Jacobs, 2005). This dimension, often seen as a foundational personality dimension that cuts across other dimensions, pertains to variability in focusing on either a long-term approach to life (focusing on developing one's health, having relatively few sexual partners, and focusing on raising offspring) or focusing on a short-term approach to life.

Research conducted by Peterson, Geher, and Kaufman (2011), which was heavily based on Figueredo's previous work, administered the Arizona Life History Battery to a large group of participants. This measure, developed by Figueredo and his team, taps the construct of life history strategy. These researchers found that males scored as having a *faster* (more short-term oriented) life history approach, on average, compared with females in the sample. Further, they found that males had a higher standard deviation in life history scores than did females as well—thus, supporting the variability hypothesis.

Beyond life history strategy, much current work on the topic of personality focuses on the Big Five personality trait dimensions, openness, extraversion, neuroticism, agreeableness, and conscientiousness. These dimensions have been found to underlie much in the way of individual differences in human personality (see Larsen & Buss, 2017). And research that has explored sex differences in the Big 5 has found that males show more variability on these traits than do females. For instance, Peterson et al. (2011) found male standard deviations to be greater than female standard deviations for four out of five personality traits. Males were especially variable as compared to females in extraversion and openness (*SD* = .91 vs. .79; *SD* = .71 vs. .60), two traits thought to be especially closely related to Life History Strategy.

**Cognitive Processes.** Continuing our exploration of psychological differences in variance across the sexes, we may also examine cognitive processes and dimensions, such as general intelligence, a topic that has been studied in detail in terms of patterns of variability across the sexes. It is true that males often have more outliers in the extremes of intelligence on both ends than females. A comprehensive study was conducted in Scotland that examined differences in IQ

scores between males and females (Deary, Thorpe, Wilson, Starr & Whalley, 2003). In an examination of IQ score statistics for nearly 80,000 11-year-old students, these researchers found that boys outnumbered girls both in low scores and in high scores. Means were not significantly different, but standard deviations were significantly different between the sexes. Girls had a much more normal distribution, while boys overrepresented the low and high extremes of cognitive capability.

Feingold and Noddings (1992) examined more closely the differences in standard deviations of test scores between males and females. Analyses of four separate Differential Aptitude Tests revealed more variance among boys than in girls. These included numerical ability, mechanical reasoning, space relations, and spelling. In the same article, the authors also examined scores for males and females ranging from grades 311 for the California Achievement Test. After analyzing the scores and variance ratios, the authors found that boys, when averaged for all grade levels, varied more than girls in every single subset of the CAT including vocabulary, reading comprehension, language, spelling, and arithmetic. These findings provide us more evidence for heterogeneity of variance between the sexes in cognitive ability.

A final example of males varying more than females in cognitive ability can be seen in a 2008 global study and analysis of test scores. Researchers analyzed differences in test score performance (across various cognitive skills) between sexes using international data (Machin & Pekkarinen, 2008). Again, regardless of test score means between the sexes, the variance for males was greater than for females. Because this study was international, it implies that greater male variance in cognitive ability is a widespread phenomenon that can emerge in different institutional, educational, and cultural settings.

These findings on differences in variability across the sexes are generally consistent with the findings from Archer and Mehdikhani's (2003) work which shows that for various cognitive attributes, male variability tends to be higher than female variability (although this effect seemed less reliable when examining spatial, quantitative, and verbal test).

**Social/Emotional Processes.** Traits and studies that were included in this section were selected based on the process and criteria spelled out in the prior section titled *The Extended Bateman's Principle Hypothesis*. Hyde (2014) explored the ratio of male to female variance on a variety of social and emotional domains. This analysis found that the pattern still holds, but to a lesser degree than is found with work on cognitive kinds of variables. Hyde's (2014) research found greater variability in males on measures of persistence, inhibitory control, and activity. In contrast, interestingly, females show greater variability for two of the temperament domains measured: emotionality and fear. Interestingly, other studies have also documented a larger variability among females on emotional domains (Else-Quest et al., 2006).

Other studies concerning emotional abilities have documented a similar pattern with respect to the variance ratio of males compared to that of females. Siegling et al. (2012) specifically examined differences in emotional intelligence domains and social behaviors. Males tended to show a small but consistently larger standard deviation on most variables including Trait Emotional Intelligence (EI) (Males, SD = .76; Females, SD = .70), Emotionality (Males, SD = .89; Females, SD

= .87), Sociability (Males, SD = 1.01; Females, SD = .93), and Ability EI (Males, SD = .07; Females, SD = .06).

Further, Siegling et al. (2012) examined various socio-emotional dimensions by calculating the Variance Ratios (Male:Female) across studies. The authors' findings support the male-variability hypothesis. Overall, males show greater variability than do females across a wide range of behaviors and temperament dimensions, including Trait EI, Wellbeing, and Sociability.

**Life Outcomes.** As the variability hypothesis seems to have such broad-reaching effects on so many aspects of the human experience, we might expect that various kinds of important life outcomes might also show this same pattern of higher variability in males than in females. This section focuses on this question.

Traits for this section were selected based on the process and criteria spelled out in the prior section titled *The Extended Bateman's Principle Hypothesis*. The first trait examined was that all-important variable of mortality. Male mortality rates have been shown to vary enormously when compared with female mortality rates (Kraemer, 2000). This fact seems to relate to the well-documented finding regarding differential rates of death and injury across the sexes (see Kruger & Nesse, 2006; Johnsen et al., 2017) with males across the life cycle being more likely to die or get injured compared with females. This tendency is exacerbated during adolescence and young adulthood, suggesting that it may be rooted in relatively risky courtship strategies that males employ as part of mate-acquisition processes.

The fact that males vary in mortality rates more so than do females may simply result from the fact that males vary more so than do females on so many different attributes that ultimately bear on mortality itself.

Another life-outcome variable examined pertained to academic success. As seen in many life outcomes, male levels of academic achievement have been shown to be more variable when compared to females. Jansen, Schroeders, and Lüdtke (2014) showed that male students have higher standard deviations than female students in all academic-self-concept scales related to science (biology, chemistry and physics). On academic performance tests in general (algebra, English, social studies and overall GPA), males have been shown to have higher standard deviations in terms of mean scores and thus significantly more variability than females (Duckworth & Seligman, 2006). Gutman, Schoon, and Sabates (2012) independently found strong evidence suggesting that males show more intra-sex variability regarding academic performance compared with females.

The next life outcome variable examined with income. Across cultures, income levels in men have been shown to be closely related to reproductive success (Hopcroft, 2006; Kruger, 2008). Wealth and social status are clearly central elements in human mate choice (Kruger, 2008), and males with high income levels have been shown to be perceived as being more attractive for both long and short-term relationships (Townsend & Levy, 1990). Pérusse (1993), for example, showed that males with higher levels of education, higher occupational status, and higher income levels had significantly higher rates of reproductive success, a phenomenon that has been found cross-culturally (Hopcroft, 2006; Kruger, 2008). Even in more egalitarian cultures, research shows that males with higher status may have more mating opportunities (Hill & Hurtado, 1996).

In line with Bateman's principle, we would expect that males would be more variable in income levels compared with women. In a study that explored this topic across 25 different countries, Plantenga and Remery (2006), showed that men earn more than do women on average across cultures. Speaking to the variability hypothesis, Blau and Kahn (2000) showed not only that men earn more money than women on average, but also that the standard deviations for male income are higher than those for female income. Thus, there is more variability in males compared to females in terms of income. Consistent with this general theme, it is noteworthy that Archer and Mehdikhani (2003) found that males vary more than do females in evaluations of whether partners are good financial prospects.

## DISCUSSION

The findings reviewed in this article are generally consistent with the prediction that Bateman's principle is broadly operative in human beings across a wide range of domains. We call this the Extended Bateman's Principle Hypothesis. Not only do human males, as is true for males in most species, clearly display more variability in their reproductive success compared to females (Brown, Laland, & Mulder, 2009) but, further, males appear to be more variable in the great majority of physical, cognitive, behavioral traits that have been investigated. Further, this pattern seems to extend to important outcomes in life such as when one dies, how well one does in school, and how much money one earns.

Specific domains in which men have been shown to have higher levels of variation compared to women include morphological/physiological features such as height (Sauro, 2013); core behavioral traits such as one's scores on basic personality trait measures (see Peterson, Geher, & Kaufman, 2011); complex behavioral patterns such as Life History Strategies (Peterson et al., 2011); higher-level traits such as cognitive or intellectual capacities (Feingold and Noddings, 1992; Deary, Thorpe, Wilson Starr, & Whalley, 2003) and emotional intelligence (Siegling et al., 2012); and outcomes such as academic achievement (Jansen, Schroeders, & Lüdtke, 2014), income level (Blau & Kahn, 2000), and mortality rate (Kraemer, 2000).

One notable exception to this general trend is that women appear to show higher levels of variability compared to men in some emotional traits, such as emotionality, anger, discomfort, fear, negative affectivity, and soothability (Else-Quest, et al., 2006). One possibility is that the apparently extensive history of patrilocal residence during human evolution (Saxon, 2012) may have generated substantial selective pressure for women to form social bonds with other women who are not blood relatives, and this selective pressure may have led to higher levels of emotional variability or plasticity to accommodate the formation of such social bonds.

Perhaps because a broad range of traits is likely to be involved in reproductive success, and perhaps also because nearly every trait may come under some form of sexual selection during evolution (Miller, 1999), Bateman's principle appears to a very broad and diverse range of human attributes. With the notable

exception of some traits related to emotionality, nearly all morphological, cognitive, and behavioral properties and capacities appear to be more variable in men than in women.

The current work could be elaborated by future research in multiple ways. For one, while the research here is extensive, it does not include a formal meta-analysis as was conducted by Archer and Mehdikhani (2003), which included a subset of the conceptual variables of interest in the current paper. The current work takes a broader view on the kinds of variables that should be examined vis a vis Bateman's principle. This said, a large-scale statistical assessment of the conceptual variables addressed in this paper (beyond those that were examined by Archer and Mehdikhani (2003)) would be a significant follow-up contribution. And given the importance of mating systems on variability in male RS, including mating system (polygynous or monogamous) as a factor to be examined would likely lead to illuminating findings.

### Evolutionary Studies and the Variability Hypothesis

The interdisciplinary EvoS approach to higher education focuses on the basic idea that Darwin's ideas have the capacity to lead to novel and broad-reaching approaches to understanding all kinds of academic questions (see Wilson, Geher, Mativetsky, & Gallup, 2019). This paper is designed largely to provide a model of how an evolutionarily informed theory, such as Bateman's Principle, can shed light on a far-reaching set of concepts related to the human experience. As such, the work summarized in this paper, provides a strong example of the powerful and interdisciplinary nature of scholarship in the field of evolutionary studies. From its outset, the Evolutionary Studies (EvoS) consortium sought to advance research across a broad range of areas, all using evolutionary principles as a guide (see Wilson, Geher, & Waldo, 2009).

The Extended Bateman's Principle Hypothesis uses an evolutionary framework to explore a far-reaching phenomenon that cuts across sexually reproducing species. With this in mind, the hypotheses included here connect with such distinct fields as biology, anthropology, public health, and psychology—among others.

## LIMITATIONS AND FUTURE RESEARCH

This paper largely serves a pedagogical goal of providing a model for how evolutionary principles can tie together a broad array of phenomena. The methodology included in this work is limited. While this paper supports the basic idea of the Extended Bateman's Principle Hypothesis, it must be noted that findings that were included for analysis were limited and were selected via a limited process.

Criteria for including attributes in this work were designed to provide a clear system for members of our research team to find relevant articles. This said, the process was hardly comprehensive. A formal meta-analysis, or, perhaps, a set of meta-analyses, in the tradition of the work by Archer and Mehdikhani (2003), would

comprise a strong methodological improvement to the work described here. Similarly, this work did not explore the issues of statistical significance or effect size in a systematic manner. Future work designed to obtain a more fine-grained understanding of the issues studied here would benefit from more closely examining such statistical criteria.

## CONCLUSION

Using an evolutionary framework, Bateman (1948) discovered that RS varies considerably across the sexes in fruit flies. More recently, scholars such as Brown et al. (2009) have found that RS varies in this same way in human populations (with males showing higher levels of variability in RS compared with females).

In an extension of the work of Archer and Mehdikhani (2003), the current project was designed to see if human attributes that clearly bear on RS show similar patterns of sex differences in variability as found in RS. Across a broad range of attributes (from height to basic personality traits to income levels), we found evidence supporting this Extended Bateman's Principle Hypothesis.

Further, relevant to the goals of EvoS Journal, this work provides an example of how a simple yet power evolutionarily based idea, such as Bateman's Principle, can shed light on a broad spectrum of human-related phenomena.

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