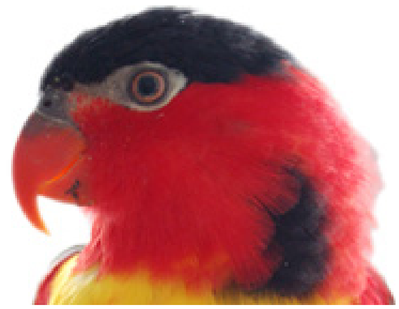


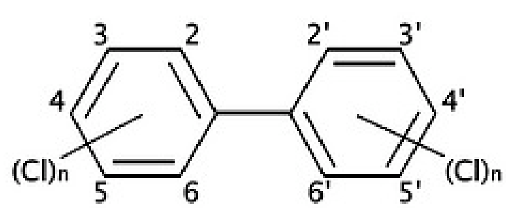
PCBs cause birds to sing a different tune

Low level exposures to PCBs cause neurological changes in birds that alter a critical behaviour: birdsong.

Songbirds living along the Hudson River in New York state are exposed to levels of PCBs that don't kill them but do disrupt the songs they sing, reports a team of researchers from Cornell University. Their study reveals that birds residing in regions with higher environmental PCB contamination levels have higher total blood PCBs, which affects their singing behaviour: the team found these species' songs varied predictably based on their PCB load, and also based upon the type of PCBs. Thus, the scientists suggest that another of the many toxic effects of sublethal environmental PCB pollution are neurological effects that translate into observable behaviour changes that disrupt song quality used by birds to communicate.

Below the jump, I share more detail about this study and how the researchers sussed out their findings.

Polychlorinated biphenyls (PCBs) are man-made chemicals that were widely used as chemical coolants and electrical insulators in electrical motors and transformers. Built upon two benzene rings (basic structure, see right), there are 209 PCB congeners, each of which is distinguished by the unique placement of one or more chlorine atoms within the basic structure [PDF].



Some PCB congeners are known as "endocrine disruptors" because they accumulate in body fat and other tissues of humans and wildlife where they mimic or interfere with natural hormone activities. This biochemical disruption causes a variety of developmental and physiological effects that lead to health problems, such as cancer. Additionally, since PCBs decompose slowly, they move up the food chain to become concentrated in the bodies of large long-lived animals, such as whales, at higher trophic levels.

Several previous studies have suggested that PCBs may have neurological effects too. Since many complex behaviors are regulated by hormones, it's possible that PCB exposure may have widespread behavioral effects, but we actually don't know the magnitude of the problem since only a few field studies in tree swallows, *Tachycineta bicolor* have investigated this possibility (such as doi:10.1002/etc.5620180713).

Although PCBs were banned in the United States in 1979, they still are present as environmental pollutants due to unsafe disposal practices or illegal dumping in the past. Since PCBs are present in the environment and in the bodies of all living animals, which serve to further spread them throughout the environment, it is important to understand the full magnitude and extent of PCB effects on physiology and behavior so low-level PCB exposures can be diagnosed and addressed in wildlife populations -- which of course are unwitting sentinels for human PCB exposures.

In passerines, song is a critical form of communication that is used to identify and attract mates, and to defend a territory. We know that birdsong is sensitive to DDT and to heavy metals, but no one knows whether or how PCBs may affect birdsong. However, considering that birdsong is dependent upon endocrine hormones, and since endocrine hormone action is mimicked or disrupted by PCBs, it is reasonable to suspect that PCB exposure may cause observable changes in birdsong. There is some evidence to suggest this may be the case: lab experiments have found that PCB exposures decrease the volume of a particular brain region that is correlated with the structure of song in songbirds.

Since PCBs affect the development of at least one songbird brain region that is associated with song, Sara DeLeon, a graduate student at Cornell University's Laboratory of Ornithology at the time, wanted to know if PCBs might directly influence the characteristics of birdsong, and if so, she wanted to identify how song differs between wild free-living birds exposed to higher levels of PCBs and those with lower levels of PCB exposure.

To address these questions, Ms DeLeon teamed up with Timothy DeVoogd, a professor of psychology at Cornell University, and André Dhondt, a professor of ornithology and the director of Bird Population Studies at the Cornell Lab of Ornithology, to design a series of experiments that formed part of her dissertation work. Rayko Halitschke, a research associate in Cornell's Department of Ecology and Evolutionary Biology and co-author on this study, contributed by modifying the PCB chemical analysis process so that the birds' PCB levels could be established from just a small drop of blood.

The team studied two commonly occurring wild songbird species that live along a PCB gradient in northeastern New York State (figure 1; larger view):

This PCB gradient was established by the General Electric (GE) electronic manufacturing plants at Fort Edward and Hudson Falls in New York State when they dumped as much as 1.3 million pounds of PCBs into the Hudson River between 1947 and 1977. As the PCBs washed downstream from the contamination source, a concentration gradient formed along the length of the river. Even today, the Hudson River drainage basin still contains high PCB levels.

The team studied black-capped chickadees, *Poecile atricapillus*, and song sparrows, *Melospiza melodia*, because their life history traits make them particularly vulnerable to PCB exposure: both species primarily consume insects during the breeding season and they feed insects to their growing nestlings; both species are non-migratory, they tend not to disperse far from where they were born and they remain on their territories throughout their lifetimes. Further, the songs of both species have been well-studied and the social functions of specific song characters are well-documented.

All birds in this study were mist-netted on their territories during the breeding season, blood samples and physical measurements were taken within 20 minutes of capture, and then the birds were released.

Blood samples analysed for PCBs showed that both black-capped chickadees and song sparrows have elevated total PCB concentrations (figure 2; larger view), and those levels were consistent with previous reports from tree swallows living in the same regions (doi:10.1002/etc.276):

Although the analysis found that total PCB concentrations did not differ between black-capped chickadees and song sparrows in any area (figure 2A), when Ms DeLeon tested the levels of 41 PCB congeners, she found significant differences between the two species (figure 2B-D). Black-capped chickadees' PCB congener profile contained more highly chlorinated PCBs, especially for those birds residing in the + Hudson region whereas song sparrows; PCB congener profile contained a higher proportion of lower chlorinated

PCBs (figure 2B).

Ms DeLeon noted that the PCB profile of song sparrows more closely resembled the PCB congener profile found on the Hudson River and further, song sparrows had a larger proportion of lower chlorinated PCBs in the ++ Hudson region than in any other region (figure 2B). Additionally, both species' PCB congener profiles showed a greater proportion of higher chlorinated PCBs in regions further away from the Hudson River.

Thus, the team concluded that this difference likely reflects foraging differences between the two species: black-capped chickadees live in dry woodlands and forage high in the canopy, whereas song sparrows are riparian birds that forage on the ground, and in and near shallow water.

But how do these PCB profiles translate into song -- a complex, observable behaviour? To answer this question, Ms DeLeon went into the field to record the songs of the birds that she had collected blood samples from. Since these birds are sedentary and territorial, the team could easily find the specific individuals they'd sampled and record their songs.

Black-capped chickadees sing a "species identity signal" that consists of two notes; one high note ("fee") and lower note ("bee"). Dominant high-quality male black-capped chickadees produce songs with consistent glissando and interval ratios (listen here) throughout their singing bouts. In contrast, male black-capped chickadees with higher levels of PCBs sang a song that varied in the glissando ratio of the higher "fee" note (listen here).

Computer analysis of specific characters of the male black-capped chickadee "species identity signal" songs revealed that individuals with higher levels of PCB exposure produced songs with more variable glissando ratios (data not show here, but can be viewed at this link).

Song sparrow songs also showed distinct effects (data not shown here, but can be viewed at this link).

Song sparrows sing long, complex songs with trills. The sonograms revealed that song sparrows with higher levels of PCBs had longer trills in their songs. (listen here -- and compare to normal song sparrow song -- listen here.) Longer trills in a song sparrow's song indicates a higher quality male, so males with higher PCB levels sang songs that sound like those produced by higher-quality males.

As the result of this study, the authors concluded:

birds living in environments with higher PCB contamination show higher total blood PCB levels
the PCB congener profile can vary substantially based upon life history traits (black-capped chickadees had higher proportions of *highly* chlorinated PCBs whilst song sparrows showed a significantly higher proportion of *lower* chlorinated PCBs)
specific PCB congeners significantly disrupted specific characters of birdsong in predictable ways (black-capped chickadees showed greater variability in the "glissando" ratio of the first note of their two-note "species identity signal" song; song sparrows' much longer songs showed longer trills)

As this study finds, environmental PCB contamination lasts a long time and the effects are pervasive.

"We have to take that into account when we study species in these disturbed environments and be aware of how environmental changes are affecting them", said Ms DeLeon.

Additionally, the effects of different PCB congeners are distinct, complex and often subtle.

"We found the greatest variation among birds in areas with higher levels of certain types of PCBs -- their songs just were not coming out right", said Ms DeLeon.

"Since dominant males produce the most consistent songs, this variation could have important biological consequences."

"What Sara did was not easy. She found effects on the song and wanted to do more than just document that there was an effect, but to isolate what was causing it", said co-author Professor Dhondt in a press release.

"What this demonstrates is that most previous PCB studies may not give us the whole picture because they did not look at the specific type of PCB involved but just measured overall levels."

This study adds valuable detail to a growing body of research that indicates that PCBs affect song characteristics, breeding behavior, reproduction, song preferences, and brain anatomy in birds. Therefore, PCBs are changing a critical component of communication and reproductive success in birds, their song.

"This type of dedicated field research can tease out the impact of organic contaminants in the environment on creatures that are known to all of us", said William Wise, Interim Director of New York Sea Grant. Dr Wise was not part of this study, but the New York

Sea Grant provided some of the funding for this research.

"Sara and colleagues are drawing the connections between contaminant, animal behavior and, ultimately, a population's health."

This short video tells more about this study:

[Video link]

Ms DeLeon is now a doctor: she received her Ph.D. from Cornell University in 2012 and currently is postdoctoral researcher at Drexel University in Philadelphia, where she studies interactions between tropical birds and army ants.

Sources:

DeLeon S., Halitschke R., Hames R.S., Kessler A., DeVoogd T.J., Dhondt A.A. & Iwaniuk A. (2013). **The Effect of Polychlorinated Biphenyls on the Song of Two Passerine Species**, *PLoS ONE*, 8 (9) e73471. doi:10.1371/journal.pone.0073471.s006

Barbara Branca, New York Sea Grant Communications Manager [emails; 19 September 2013]

Also cited:

McCarty J.P. & Secord A.L. (1999). **Reproductive ecology of tree swallows (*Tachycineta bicolor*) with high levels of polychlorinated biphenyl contamination**, *Environmental Toxicology and Chemistry*, 18 (7) 1433-1439. doi:10.1002/etc.5620180713

Custer C.M., Custer T.W. & Dummer P.M. (2010). **Patterns of organic contaminants in eggs of an insectivorous, an omnivorous, and a piscivorous bird nesting on the Hudson River, New York, USA**, *Environmental Toxicology and Chemistry*, 29 (10) 2286-2296. doi:10.1002/etc.276

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